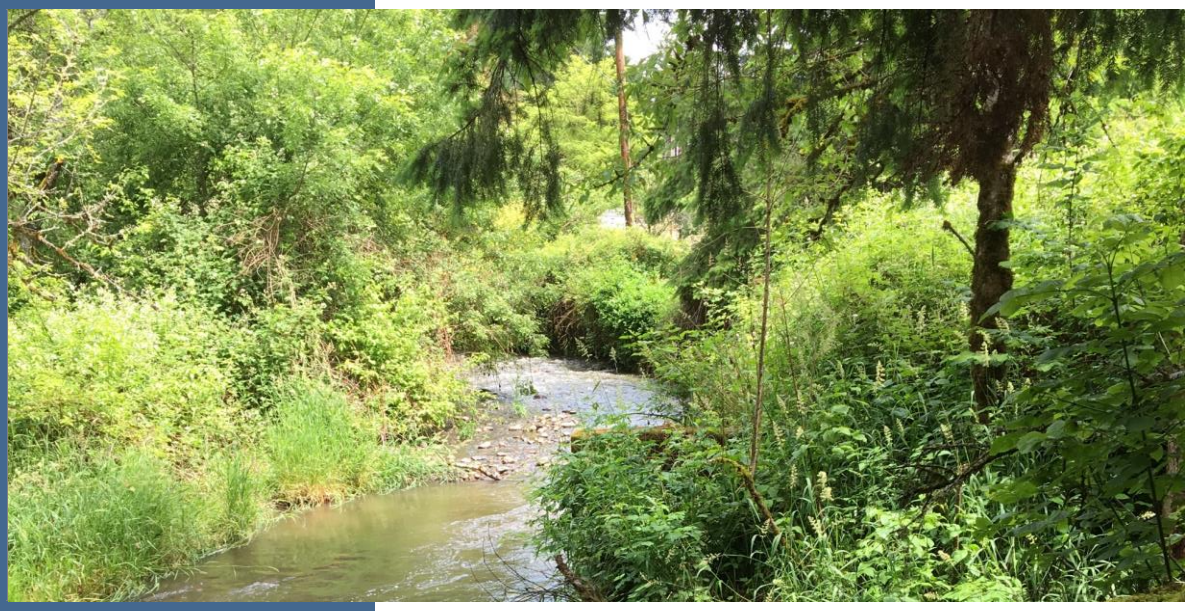

East Fork Lewis River Watershed

Bacteria Monitoring and Nonpoint Source Identification

By

Molly Gleason

For the

Water Quality Program

Washington State Department of Ecology

Southwest Regional Office

Olympia, Washington

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- WRIA: 27
- Data for this project is available in Ecology's EIM Database,[1] Study ID: EFLewis_WQ
- Results are displayed on the project Tableau[2] page.

Cross-referenced or relevant documents:
Publication 20-10-016: Quality Assurance Project Plan[3]

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[1] https://www.ecology.wa.gov/Research-Data/Data-resources/Environmental-Information-Management-database
[2]https://public.tableau.com/views/EFLewisRiverWatershedBacteriaMonitoring/Dashboard1?:language=en&:display_count=y&:origin=viz_share_link
[3] https://apps.ecology.wa.gov/publications/SummaryPages/2010016.html
[4] www.ecology.wa.gov/contact

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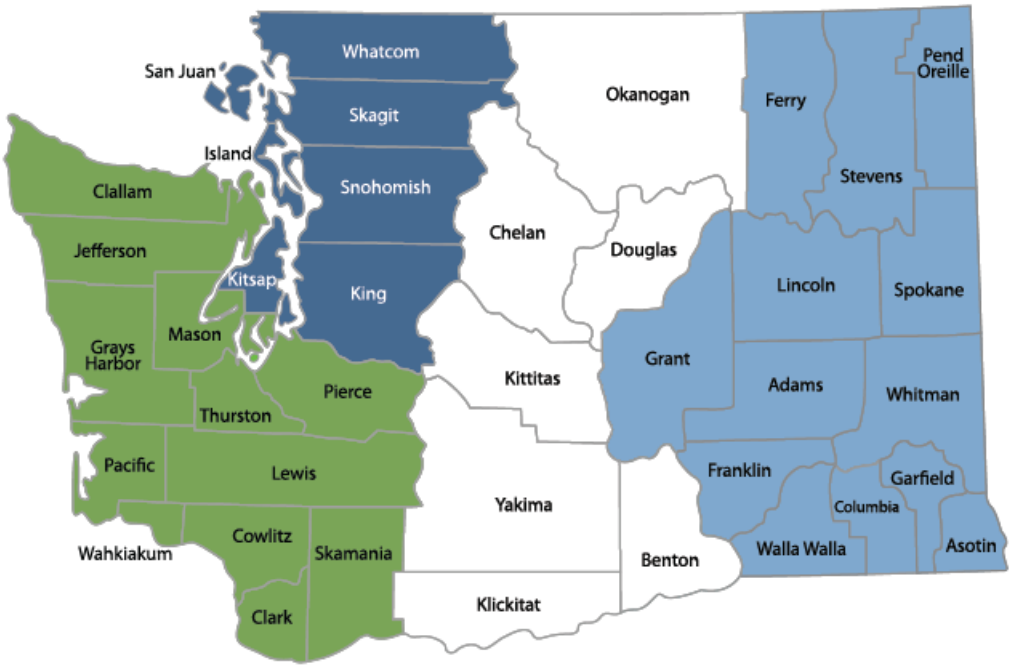
Map of Counties Served



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East Fork Lewis River Watershed Bacteria Monitoring and Nonpoint Source Investigation

Water Quality Program
Washington State Department of Ecology
SWRO Regional Office
Olympia, WA

February 2021 | Publication 21-10-003

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Abstract

The Department of Ecology (Ecology) identified bacteria impairments across the East Fork (EF) Lewis River and major streams (tributaries) in the watershed. In a 2017 source assessment, Ecology identified tributaries that exceed fecal coliform (FC) and temperature criteria defined by Washington State's water quality standards. This follow-up study further investigates bacteria levels across sections of those tributaries and areas not previously monitored in order to better locate pollution sources and prioritize areas for future nonpoint work.

Report Summary

- The 2020 bacteria data confirmed areas of concern (McCormick Creek, Breeze Creek, Jenny Creek, and Rock Creek North) from the 2017 source assessment and identified specific sections of the streams with high bacteria levels.
- The highest exceedances were detected at a stormwater conveyance to Brezee Creek that flows through the City of La Center. Both an upstream stormwater culvert on 5th avenue (BRZ-5th) and the downstream culvert (BRZ-SW2) had the highest exceedances out of all sites.
- The highest bacteria levels for most of the sites were from a single sampling event on June 15 following heavy rainfall. This highlights the impact of urban stormwater and agricultural runoff on bacteria levels in the watershed.
- High FC and *E. coli* concentrations were found at a previously unmonitored tributary (Bolen Creek) which revealed another tributary of concern in the lower watershed.
- McCormick Creek still had high exceedances, yet there was substantial improvement in bacteria levels at an upstream tributary, MCC-Trib2, compared to results from 2017. This tributary was downstream of a former manure lagoon that was decommissioned in 2019.
- Bacteria concentrations tended to increase moving downstream, from the upper to lower sections of the tributaries. Jenny Creek did not follow this trend, indicating a pollution source near an upstream site (JEN-2.8).

Background

The EF Lewis River watershed was determined to be a high priority for water quality improvement. Sections of the EF Lewis River and surrounding tributaries currently do not meet the state's water quality standards for bacteria and temperature. Meeting these standards is essential to protect public health and recreational use and improve conditions for fish and other wildlife.

Bacteria monitoring by Ecology, Clark County, and other entities have shown bacteria problems in this watershed (Clark County Department of Environmental Services, 2013; Ecology, 2018). Ecology's 2017 EF Lewis River Source Assessment confirmed the continued FC exceedances and identified specific tributaries with FC problems. The highest FC concentrations were detected in the lower watershed at McCormick and Brezee Creeks, including a stormwater outfall on Brezee Creek. The study also found that most of the water quality exceedances were located in the lower watershed, which has more agricultural and developed areas.

The source assessment served as a guide for a draft EF Lewis River Water Cleanup Plan published in August 2020. This plan outlines the priorities for long-term implementation by addressing water quality impacts from septic systems, stormwater, and agriculture. The results of the source assessment also guided follow-up implementation work by Ecology and local partners. Since 2018, Ecology has focused nonpoint investigation and outreach efforts in the McCormick Creek subwatershed. Ecology's nonpoint specialists delivered outreach materials and provided on-site technical assistance in this area. In addition, investigation of a tributary to McCormick Creek with high FC levels resulted in the discovery of a large manure lagoon from a former dairy operation. Ecology worked with Washington State Department of Agriculture, City of Ridgefield and the developers who owned the property to successfully decommission this bacteria pollution source in 2019.

In addition to Ecology's work, the City of La Center has made efforts to reduce urban sources of bacteria pollution particularly to Brezee Creek. The City has invested in improving the stormwater infrastructure. In 2019, the city identified and corrected multiple illicit cross connections to the stormwater system.

The Poop Smart Clark pollution identification and correction (PIC) program has also been instrumental in promoting nonpoint implementation work in the watershed. The program was developed to address bacteria issues associated with septic systems and agriculture, and involves the collaboration of local partners which include Clark County Clean Water Division, Clark County Conservation District, Clark County Public Health, Watershed Alliance of Southwest Washington, and Washington State University Extension. The PIC program uses expertise from these partners to develop targeted education and outreach to promote best management practices (BMPs) and provide landowners with the tools and guidance for correcting pollution issues.

In order to support and further guide these nonpoint implementation efforts, this study focused on further investigating high priority tributaries in the lower and middle watersheds to better locate pollution sources. This involved expanding the study area by adding multiple sampling sites at upstream locations of the high priority tributaries. This monitoring design provides a comprehensive view of critical areas within the tributaries that can help prioritize areas for future nonpoint and source correction work.

This study was also intended to provide updated bacteria data to compare to the State's newly adopted water quality criteria, which were revised in January 2019 to align with nationally recommended standards. The new criteria relies on *E. coli* as the main indicator for protecting water contact recreation and assessing risks to public health. Ecology's past assessments involved the collection of only FC, yet this study's sampling involved the collection of both *E. coli* and FC samples. The paired sampling design was chosen in order to compare results to past FC data and determine the current impairments based on *E. coli* data following the new water quality criteria guidelines.

Goals and objectives

The goal of this study was to further investigate the high priority tributaries and identify areas with high bacteria levels and potential sources. The specific objectives of the study include:

- Identify segments of tributaries with high bacteria levels to prioritize where nonpoint staff should focus further investigation and implementation efforts.
- Detect potential pollution sources by collecting source identification samples and providing observations from field surveys.
- Collect short term ambient samples at a network of sites to determine which sites currently meet water quality criteria for both FC and *E. coli*.

Study area

The EF Lewis River Watershed is located in southwestern Washington within Water Resource Inventory Area (WRIA) 27 in Clark County. The EF Lewis River is divided into three sections: the lower (RM 0 – 5.7), middle (RM 5.7 – 20.3), and upper (RM 20 - 32.3) watersheds. This study focused on the lower and middle sections of the watershed. Ecology's Source Assessment found all upper watershed sites, including the section of one location on Yacolt Creek, met water quality criteria for bacteria and were therefore not included in this study.

The middle watershed consists of agricultural, forested, and residential and developed areas. Rock Creek North was the only tributary in this study located in the middle watershed. Samples were collected at two branches of the tributary and downstream of the confluence of the branches in order to cover all types of land use.

Compared to the middle watershed, the lower section consists of a similar mixed land use but with greater agricultural use and developed areas. The priority tributaries in the lower watershed include Brezee Creek, Jenny Creek, Bolen Creek, and McCormick Creek. Clark County

Conservation District's recent analysis and mapping of parcels in the lower subwatersheds with agricultural use shows that a majority of these parcels are within 200 feet of the stream (Clark Conservation District, 2020; see Appendix D).

Sites on Brezee Creek were located on two northeast (NE) branches that feed to the creek's mainstem and a stormwater outfall. The NE branches flow through forested private properties and then to a downstream site on the mainstem (BRZ-14th). The stormwater conveyance runs through the City of La Center until it is directed under the city at 5th avenue (BRZ-5th) and emerges at a culvert (BRZ-SW2) at Sternwheeler Park below La Center Waste Water Treatment Center.

Jenny and Bolen Creeks are located north of the City of La Center and run through forested private properties and agricultural lands. McCormick Creek runs south of the EF Lewis River along the I-5 in similar mixed-use landscape. This study included an upstream branch of McCormick Creek downstream of a developing subdivision and a recently decommissioned manure lagoon (MCC-TRIB2).

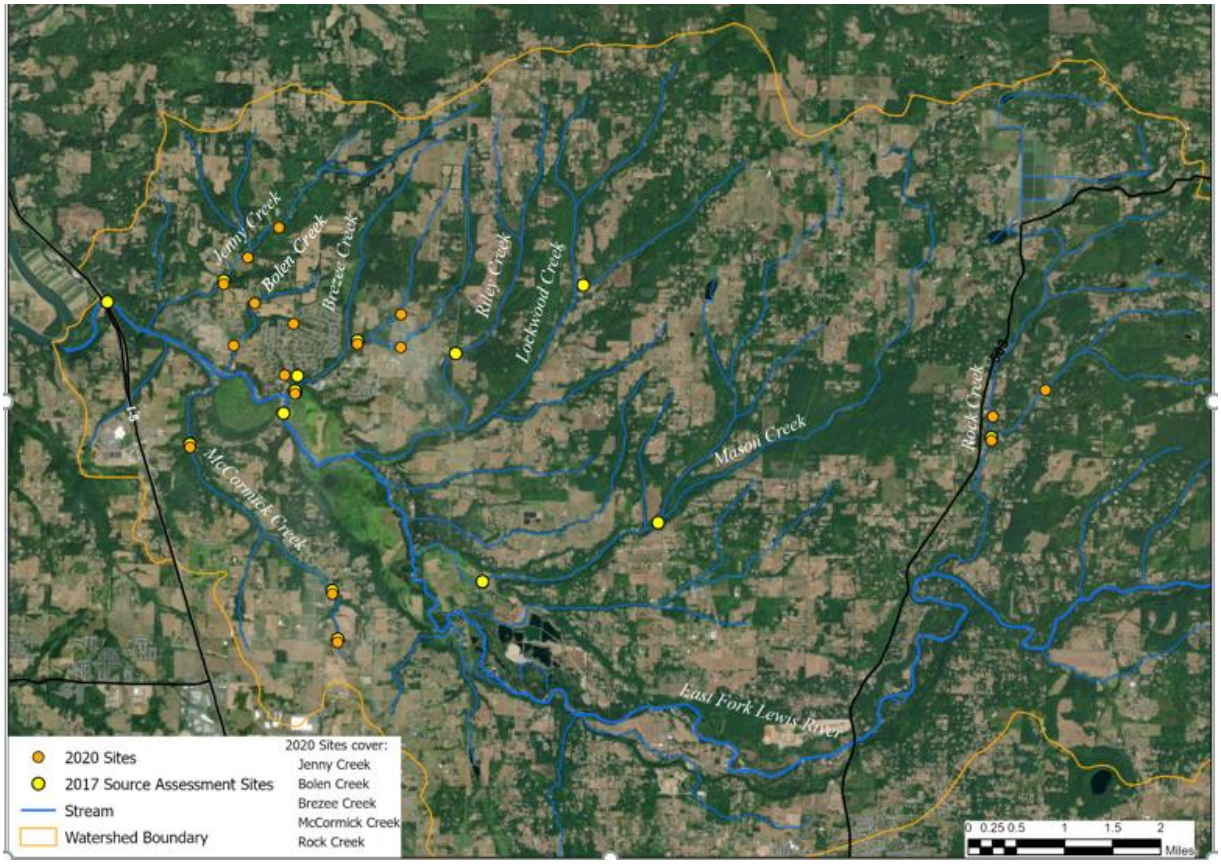

Figure 1. Ecology sampling sites for 2020 and past source assessment.

Methods

Routine sampling for *E. coli* and FC was conducted at a fixed-network of 17 sites (see Figure 1 and Table 1). There were at least three sampling sites for each of the five tributaries. Several of the locations were sites previously monitored in Ecology's source assessment; most of the sites were new locations added to expand the study range to upstream sections of the tributaries. Additional investigative samples were added in order to pinpoint potential sources of pollution. These investigative samples were collected at Bolen and McCormick Creek. Flow measurements were not collected due to time and resource limitations for this project.

Sampling was conducted June to September 2020 based on the sampling schedule outlined in Table A1 in Appendix A. This sampling time frame focused on the dry season, which was determined to be a critical season with higher FC concentrations compared to the wet season (McCarthy, 2018).

Field sampling protocols outlined in the QAPP (Hood, 2014; Riedmayer, 2020) and Ecology's Standard Operating Procedures (Ward, 2018) were followed in order to ensure the quality of samples. Field staff collected grab samples directly into pre-cleaned/sterilized containers supplied by Ecology's Manchester Environmental Laboratory (MEL). Relevant technical notes related to sampling conditions were documented and maintained in a field notebook. Field staff stored samples for laboratory analysis on ice and delivered to MEL within the associated holding time via an Ecology courier. All samples were processed by MEL following standard analytical methods outlined in the lab user manual (MEL, 2016).

Sites were evaluated for compliance with water quality standards based on meeting two bacteria criteria, a geometric mean and an upper limit value that 10% of the samples cannot exceed. These criteria determine the bacteria levels that will likely not cause a significant risk to human health. The criteria are as follows:

1. *E. coli* and FC levels must not exceed a geometric mean 100 cfu/100 mL (WAC 173-201A-200(2)(b)).
2. Not more than 10 percent of samples (calculated as the 90th percentile), or any single sample when less than ten, should exceed 320 cfu/100mL for *E. coli* or 200 cfu/100mL for FC (WAC 173-201A-200(2)(b)).

The bacteria criteria for each site were evaluated on a three-month rolling period based on the state's new criteria guidelines. Two sampling periods were evaluated: June to August and July to September. Site criteria were evaluated if there were at least three samples over the three-month period.

Details about the data quality assessment of the results are in Appendix B.

Table 1. Ecology's 2020 sampling sites. Sites from the 2017 Source Assessment were marked.

Creek	Site ID	Description	Latitude	Longitude	River-mile	2017 ECY Site
Jenny Creek	JEN-1.03	Jenny Creek at NW 14th Avenue, upstream culvert, near 354th Street	45.87660	-122.68566	1.03	X
Jenny Creek	JEN- 1.48	Jenny Creek @ #818 NW 359th	45.88069	-122.68061	1.48	
Jenny Creek	JEN- 2.8	Jenny Creek @ downstream driveway (#36601/36525) of Jenny Creek Road	45.88529	-122.67412	2.8	
Bolen Creek	BCK-1.02	Bolen Creek culvert on Aspen Avenue	45.87094	-122.67037	1.02	
Bolen Creek	BCK-0.37	Bolen Creek culvert @ NW Pacific Hwy	45.86740	-122.68315	0.37	
Bolen Creek	BCK-0.46	Bolen Creek culvert at driveway to 34901 NW 9th Avenue	45.87382	-122.67891	0.46	
Bolen Creek	BCK-0.75	Investigative site on Bolen Creek downstream of Gordon Crest subdivision II	45.87065	-122.67755	0.75	
Brezee Creek	BRZ-SW2	Stormwater ditch to Brezee Creek along downstream path below La Center WWTP	45.86118	-122.67072	0.118	X
Brezee Creek	BRZ-5TH	Upstream culvert west of 105 West 5th	45.86315	-122.67204	0.351	
Brezee Creek	BRZ-14TH	Branch of Breeze Creek at 14th at upstream culvert	45.86815	-122.65651	0.411	
Brezee Creek	BRZ-EAST	Eastern Tributary to Brezee Creek @ NE 23rd Avenue	45.87279	-122.64717	1.73	
Brezee Creek	BRZ-MID	Middle Tributary to Brezee Creek @ NE 23rd Avenue	45.87279	-122.64727	1.56	
Rock Creek North	RCN-1.87	Rock Creek North near 14710 NE 319th Street	45.85339	-122.52084	1.87	X
Rock Creek North	RCN-2.36	Upstream of bridge @ 32809 NE Sako Drive	45.85976	-122.51928	2.36	
Rock Creek North	RCN-2.78	Upstream bridge @ NE 159th Avenue	45.86395	-122.50810	2.78	
McCormick Creek	MCC-1.18	McCormick Creek - La Center Road, upstream culverts @ sewer station.	45.85192	-122.69197	1.18	X
McCormick Creek	MCC-3.4	NE 289th Street, upstream culvert, near #1200	45.83052	-122.66045	3.4	X
McCormick Creek	MCC-TRIB2	Culvert on NE 279th Street, east of #1019 279th	45.82313	-122.65897	3.96	X
McCormick Creek	MCC-TRIB-Pipe	Investigative site at pipe upstream of MCC-TRIB2	45.82313	-122.65897	3.96	

Results

All tributaries had bacteria exceedances at least at two sites as shown in Table 2 and 3 and Figures 2 and 3. Most of the exceedances were during the first period of sampling from June to August. None of the sites met the 90th criterion for this first period.

Table 2. *E. coli* and FC criteria results for both criteria for the first sampling period (June-August). Values that do not meet the geometric mean or 90th percentile criteria are red and in bold. All results from the 2020 sampling are listed in Appendix B.

Site	n	*E. coli* Geometric mean	FC Geometric mean	*E. coli* % Exceed 90th Criterion	FC % Exceed 90th Criterion
JEN-1.03	8	85.9	**113.3**	**12.5**	**12.5**
JEN-1.48	8	**107.5**	**143.4**	**12.5**	**12.5**
JEN-2.8	8	**223.4**	**291.9**	**37.5**	**50**
BCK-0.37	8	**235.0**	**324.3**	**37.5**	**50**
BCK-0.46	8	**115.6**	**135.6**	**14.286**	**25**
BCK-1.02	5	30.4	38.5	**20**	**20**
BRZ-SW2	8	**322.3**	**536.9**	**50**	**87.5**
BRZ-5TH	8	**561.4**	**831.3**	**75**	**87.5**
BRZ-14TH	8	**206.4**	**253.8**	**25**	**37.5**
BRZ-EAST	8	77.1	93.1	**12.5**	**12.5**
BRZ-MID	8	62.5	77.9	**12.5**	**12.5**
MCC-1.18	8	**214.6**	**280.8**	**12.5**	**62.5**
MCC-3.4	8	**160.2**	**225.8**	**12.5**	**50**
MCC-TRIB2	6	31.4	45.5	**37.5**	**20**
RCN-1.87	8	**121.3**	**143.7**	**12.5**	**25**
RCN-2.36	8	**109.6**	**128.3**	**25**	**50**
RCN-2.78	8	33.3	41.7	**12.5**	**25**

Table 3. *E. coli* and FC criteria results for both criteria for the second sampling period (July-September). Values that do not meet the geometric mean or 90th percentile criteria are red and in bold. All results from the 2020 sampling are listed in Appendix B.

Site	n	*E. coli* Geometric mean	FC Geometric mean	*E. coli* % Exceed 90th Criterion	FC % Exceed 90th Criterion
JEN-1.03	7	58.2	65.5	0.0	0.0
JEN-1.48	7	71.8	92.1	0.0	0.0
JEN-2.8	7	**165.3**	**202.0**	**42.9**	**42.9**
BCK-0.37	7	**182.9**	**216.1**	**28.6**	**57.1**
BCK-0.46	7	80.8	89.2	0.0	**14.3**
BCK-1.02	7	40.8	42.0	**20.0**	**33.3**
BRZ-SW2	7	**352.9**	**527.2**	**57.1**	**85.7**
BRZ-5TH	6	**423.7**	**646.9**	**66.7**	**85.7**
BRZ-14TH	7	**163.1**	**187.8**	0.0	**14.3**
BRZ-EAST	7	94.5	**110.2**	**14.3**	**14.3**
BRZ-MID	7	51.1	66.2	0.0	0.0
MCC-1.18	7	**201.8**	**250.5**	**28.6**	**57.1**
MCC-3.4	7	**142.5**	**182.7**	0.0	**42.9**
MCC-TRIB2	3	17.8	21.0	0.0	0.0
RCN-1.87	7	78.5	91.1	0.0	**14.3**
RCN-2.36	7	87.4	**105.5**	**14.3**	**42.9**
RCN-2.78	7	33.6	42.2	0.0	**14.3**

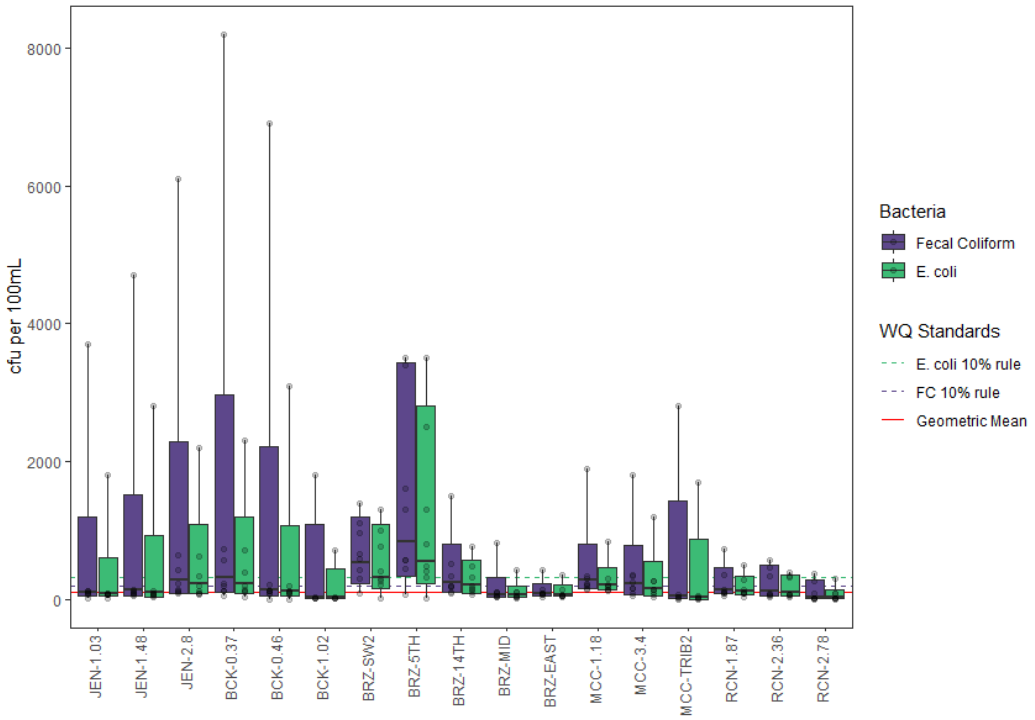

Figure 2. Boxplot of bacteria results for the first sampling period (June to August). Horizontal black bars represent geometric mean, the boxes represent the 10th and 90th percentiles with the maximum and minimum values delineated by whiskers. Water quality standards are shown for geometric mean criteria (solid red line) and FC and *E. coli* 10 percent rule (dotted lines).

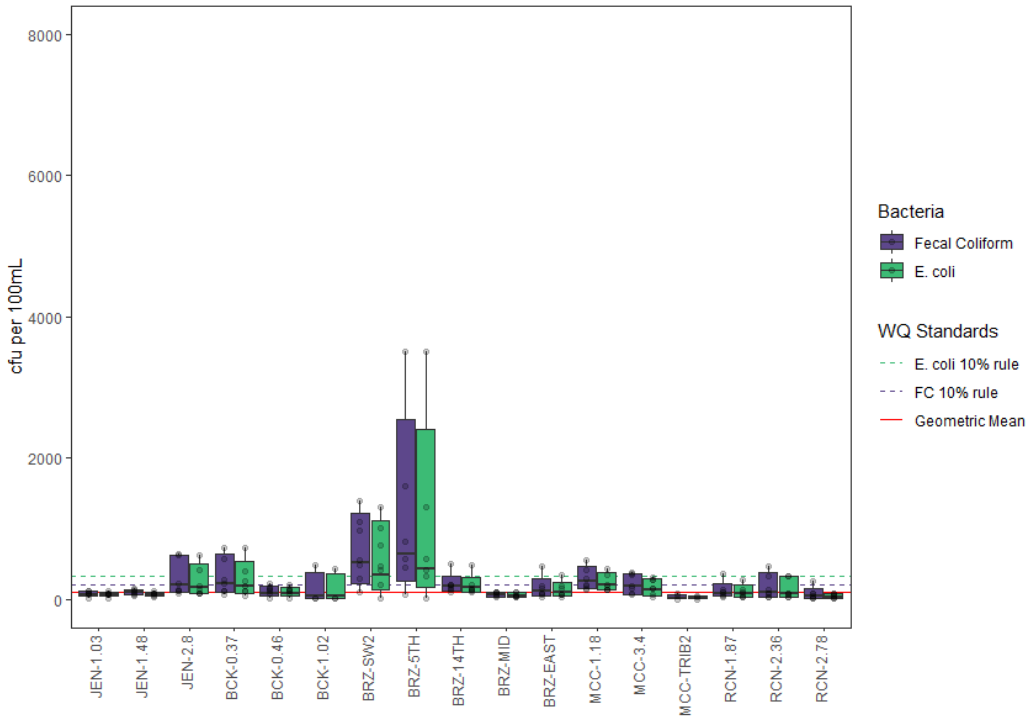

Figure 3. Boxplot of bacteria results for the second sampling period (July to September).

The exceedance of the 90th percentile criterion during the first sampling period was likely due to a single sampling event on June 15 following heavy precipitation. There was a total rainfall of 0.64 inches on that sampling day and 1.16 inches the week before (see Appendix C for daily rainfall totals). Most of the sites had the highest bacteria levels from this sampling day. All bacteria levels were above 100 cfu/100mL and ranged from 260 to 8200 cfu/100mL for *E. coli*. Sites located near more agricultural landscapes (i.e. Bolen Creek and Jenny Creek) had the highest results.

The stormwater outfall on Brezee Creek had the highest water quality exceedances. BRZ-5th had the highest calculated geometric mean for FC and *E. coli* (831.3 and 561.4 cfu/100mL, respectively), while the downstream site, BRZ-SW2, had the second highest calculated geometric mean for FC and *E. coli* (536.9 and 352.9 cfu/100mL, respectively). More than half of the samples did not meet the second criterion at both stormwater sites for both sampling periods and for both FC and *E. coli*. In comparison to the La Center stormwater sites, the NE branches to the Brezee Creek that flow to the mainstem had relatively low bacteria levels.

Bolen Creek, a relatively smaller tributary not previously monitored by Ecology, had the highest detected FC levels. Both BCK-0.37 and BCK-0.46 had the highest detected FC levels (8200 and 6900 cfu/100mL, respectively). BCK-0.46 had the next highest *E. coli* levels (3100 cfu/100mL) after Brezee Creek. These high bacteria concentrations were detected on the June 15th sampling event following heavy rainfall. Bacteria levels following the June sampling were relatively lower. Despite the slight decrease in bacteria levels over time, the most downstream site (BCK-0.37) did not meet criteria for both sampling periods.

McCormick Creek, a tributary designated as a high priority by Ecology, continued to have high bacteria exceedances. The most downstream site MCC-1.18 did not meet either criteria for both sampling periods. Despite the exceedances, there was substantial improvement in bacteria levels at the upstream tributary, MCC-TRIB2, compared to results from 2017. The 2017 investigative sampling at this site resulted in an annual geometric mean of 591 cfu/100mL for FC; the site met the geometric mean criteria for both FC and *E. coli* for all sampling periods in 2020.

Compared to the lower watershed, the middle watershed tributary, Rock Creek North, had relatively low bacteria levels. Most of the exceedances occurred at the downstream site RCN-1.87) and western branch (RCN-2.78).

Bacteria levels for most of the tributaries were more elevated at the downstream sections of the tributary as shown in a site map in Figure 4. Typically, concentrations increased from upstream to downstream. Yet, Jenny Creek did not follow this typical trend which differentiates it from other creeks in the watershed. The upstream site (JEN-2.8) exceeded criteria throughout the summer and had consistently higher levels than the downstream sites. These results suggest a localized pollution source near this upstream site.

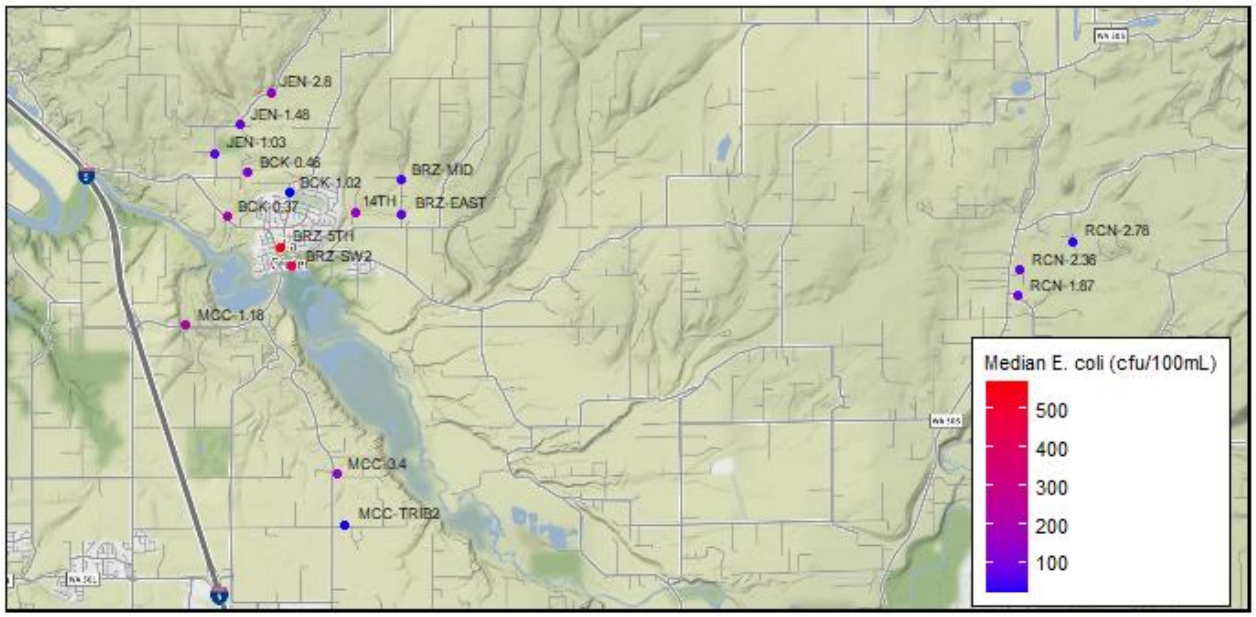

Figure 4**.** Map of 2020 sites with median *E. coli* (cfu/100mL). Median values are listed in Table 4.

Table 4. Median *E. coli* and FC (cfu/100mL) for 2020 sampling.

Site	*E. coli*	FC
JEN-1.03	71.5	94
JEN-1.48	74.5	93
JEN-2.8	160	185
BCK-0.37	185	230
BCK-0.46	115	125
BCK-1.02	20	24
BRZ-SW2	415	575
BRZ-5TH	570	810
BRZ-14TH	150	190
BRZ-MID	47	66.5
BRZ-EAST	64.5	82
MCC-1.18	200	265
MCC-3.4	155	220
MCC-TRIB2	24	35.5
RCN1.87	90	98
RCN-2.36	72.5	80.5
RCN2.78	33	39

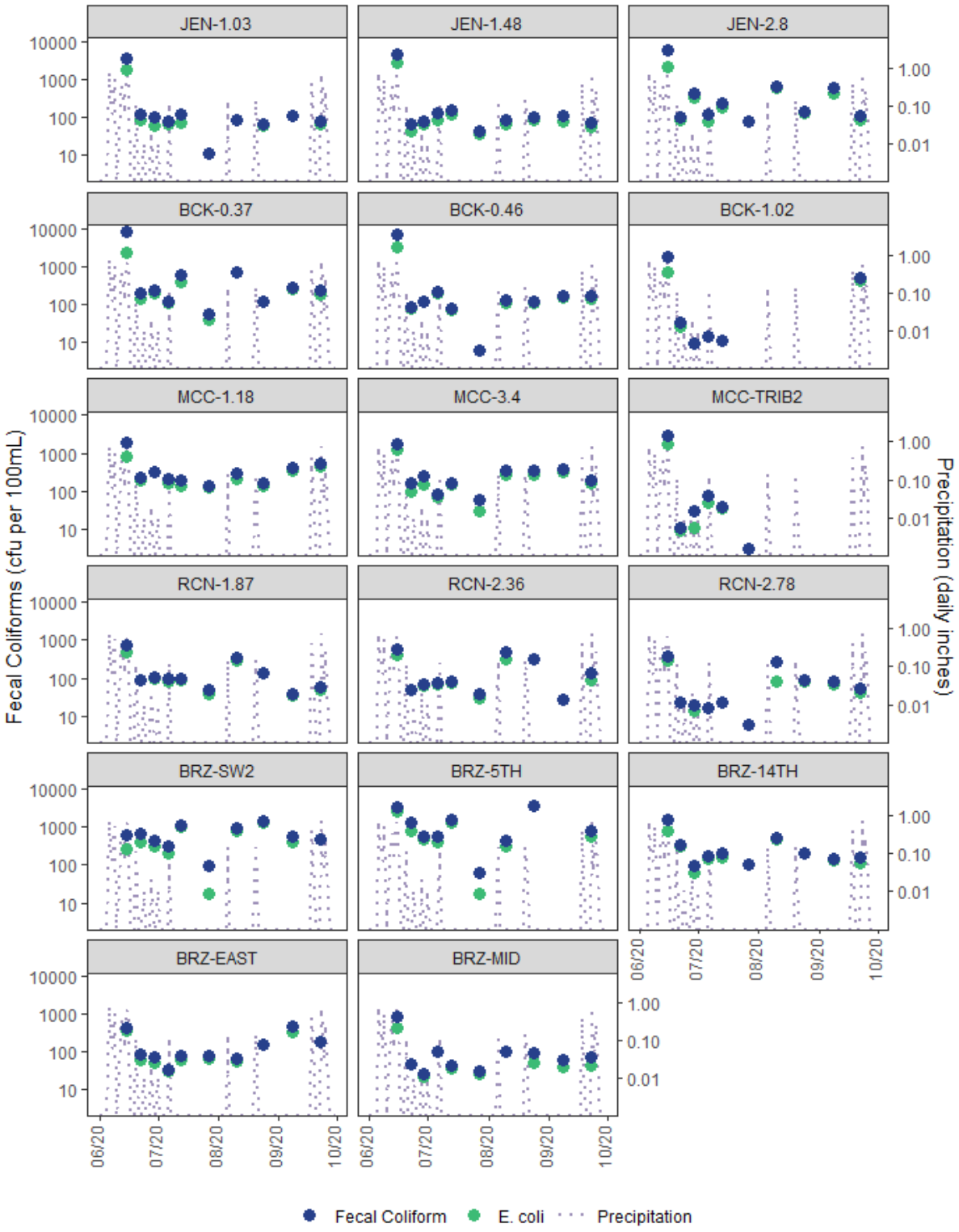

Figure 5. Time series of bacteria results with precipitation data from Clark County rain gauge at Ridgefield (RDGFLD). The primary and secondary y-axes are log transformed. Rainfall data provided by Clark County Public Works, Clean Water Division.

Conclusions

The 2020 bacteria results confirmed the continued bacteria exceedances at the tributaries of concern identified in the 2017 Source Assessment. This study expanded on the previous data by bracketing and identifying specific areas within the tributaries that had higher bacteria levels. By identifying these critical areas, further conclusions can be made about the source of pollution and the type of corrective work that should be prioritized in these areas.

This study was able to determine a critical area at an upstream location on Jenny Creek that had persistent elevated bacteria levels higher than downstream locations. These results suggest a localized pollution source around the upstream site. Recent analysis and mapping of septic records by Clark County Conservation District shows that the site of concern is located near a collection of properties with noncompliant septic systems within 200 feet of the stream (Clark Conservation District, 2020; see Appendix D). This information suggests that a human source of pollution may be contributing to high bacteria levels in this creek.

Additionally, Clark County Clean Water Division conducted water quality sampling during the summer of 2020 which involved microbial source tracking (MST) to identify the specific DNA markers associated with bacteria. Jenny Creek sites had a high presence of human DNA which further supports the hypothesis that human waste may be a serious source of pollution in this area (Clark County Clean Water Division, unpublished data). Reaching out to landowners bordering Jenny Creek to promote sanitary surveys of properties and upgrade to compliant systems would be the next approach to find and reduce this pollution source.

The results also showed the substantial improvement in bacteria levels at a former high priority site on McCormick Creek. These results show the effectiveness of the collaborative clean-up efforts at a former manure lagoon. Exceedances are still an issue for the tributary, yet this study has determined that the upstream tributary is not a main contributor for bacteria pollution.

Data from areas not previously monitored, such as Bolen Creek, showed high bacteria levels in new locations in the watershed. This new information highlights the importance of further investigation in the watershed to find other areas of concern. The results also indicated Bolen Creek may be impacted by agricultural runoff from the nearby rural landscape and by the stormwater runoff from the City of La Center, since this creek had the highest bacteria levels compared to most sites following a heavy rainfall.

Elevated bacteria levels following a heavy rain event during the early stages of the study highlighted the influence of stormwater runoff in the watershed. The rise in bacteria may be generated from multiple urban and agricultural sources such as runoff from fields with livestock waste or stormwater that washes the surfaces of urban landscapes and pavement with pet waste. The rapid development and urbanization in this lower watershed have increased impervious surfaces and consequently increased the level of stormwater runoff. Though it was not within the scope of this study which focused on a mostly dry season, continued wet season

sampling after storm events could illuminate the correlation between bacteria levels and rainfall in the watershed and show the impact of this nonpoint problem.

Figure 6. Photos of Bolen Creek site BCK-0.46 taken by Shawn Ultican, nonpoint source specialist, on June 10, 2020 (left) and June 15, 2020 (right) following heavy rainfall. Bolen Creek had the highest FC and *E. coli* results out of all sites on June 15.

Ecology's 2020 results confirmed Brezee Creek remains a high priority for bacteria improvement. Clark County's water quality monitoring efforts complemented Ecology's findings by confirming high bacteria levels in Brezee Creek. Clark County's MST samples determined the presence of bacteria from dogs, humans, cows, and horses with a greater prevalence of dog DNA in Brezee Creek sites in the proximity of City of La Center (Clark County Clean Water Division, unpublished data). This shows the necessity of continuing outreach to raise public awareness of animal waste management in order to mitigate these sources of bacteria pollution.

There was clear evidence of nonpoint sources of bacteria around the area just from field observations. As an example, horse waste was found on pavement in Sternwheeler Park directly above the lower Brezee Creek culvert (BRZ-SW2) during a sampling event for this study (see Figure 7). There is high potential for this waste to be directly discharged or washed into the creek and contribute to bacteria pollution in Brezee Creek and the EF Lewis River. This further emphasizes the importance of pet waste management in these urban areas.

The Brezee Creek stormwater conveyance remains a main contributor of bacteria to the subwatershed. The results determined a serious pollution source may be located in the proximity of 5th Ave (BRZ-5th) in downtown La Center. The City of La Center has recently

corrected illicit cross connections of sewer to stormwater, yet these results show the problem persists from either existing cross-connections or illicit discharges to the stormwater system.

Figure 7. Photo of horse waste taken by Molly Gleason above sample site BRZ-SW2 with La Center Waste Water Treatment Plan in the background taken on August 24, 2020.

There have already been advancements to conduct source identification efforts in this area. The City of La Center has conducted follow-up intensive sampling upstream of BRZ-5th and sections of Bolen Creek to continue the investigative source tracing. Future plans involve additional mapping and surveying of the City's stormwater and sewer systems upstream of BRZ-5th which may identify pollution problems related to cross-connections with the stormwater system.

These ongoing efforts have also garnered support from interagency partners of the PIC program. The partners are developing a future collaborative effort with the City of La Center to collect MST samples in the Brezee Creek stormwater conveyance. These source tracing techniques will be instrumental in finding the source of bacteria and working towards correcting the pollution issue in this critical area. Ultimately, this support of partners and guidance from existing data such as this study's results to prioritize implementation work will be essential for water quality improvement in the EF Lewis River watershed.

Recommendations

The following are recommendations for water quality improvement in the EF Lewis River watershed based on results from this study:

- Focus nonpoint investigation and implementation efforts in the identified high priority areas which include:
    - McCormick Creek between river miles 1.18-3.4.
    - Upstream of Jenny Creek site JEN-2.8.
    - Upstream of Bolen Creek site BCK-0.37.
    - Upstream of Brezee Creek site BRZ-5th.
- Continue source identification and illicit discharge detection and elimination efforts to detect pollution sources within the Brezee Creek stormwater system.
- Implement urban stormwater management and appropriate BMPs to reduce water quality impacts within the Brezee Creek stormwater system.
- Utilize inter-agency partnership collaborations and PIC program tools to work towards addressing nonpoint source bacteria issues associated with septic system and agriculture.
- Communicate to homeowners with septic systems adjacent to streams to promote and provide resources for septic system compliance. This effort should be focused in areas with high bacteria levels and current non-compliant systems such as around Jenny Creek site JEN-2.8.
- Work with landowners to encourage BMPs to reduce FC runoff from agricultural areas. This effort should be focused at sites with high bacteria levels located in agricultural areas such as McCormick Creek, Jenny Creek, and Bolen Creek.
- Continue education and outreach work in the watershed community to emphasize the importance of practices for reducing bacteria pollution. These efforts include the workshops hosted by the Washington State University (WSU) Extension's Small Acreage Program and outreach efforts by the PIC program's Canines for Clean Water.
- Continue raising awareness of bacteria issues in the watershed through virtual outreach such as this project's Tableau[5] page, Clark County's Explore Your Watershed[6] portal and a StoryMap that is in development by Ecology.
- Maintain relationship with EF Lewis River Partnership to promote and share the ongoing monitoring efforts, new projects and programs being implemented in the watershed.

[5]https://public.tableau.com/views/EFLewisRiverWatershedBacteriaMonitoring/Dashboard1?:language=en&:display_count=y&:origin=viz_share_link
[6] https://arcg.is/iGXrq

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Appendix A. Results

Table A1. 2020 sampling dates and results for *E. coli* and FC. Cells without a value signifies no sample was collected. Samples were not collected if the site had low flow or dry conditions.

Site ID	Parameter	6/15	6/22	6/29	7/6	7/13	7/27	8/10	8/24	9/8	9/22
JEN-1.03	*E. coli*	1800	88	63	69	74	11	84	63	110	69
JEN-1.03	FC	3700	120	100	80	120	11	88	66	110	77
JEN-1.48	*E. coli*	2800	43	66	83	120	37	69	88	80	55
JEN-1.48	FC	4700	66	80	130	150	43	86	100	110	71
JEN-2.8	*E. coli*	2200	88	340	80	190	77	620	130	420	85
JEN-2.8	FC	6100	100	430	120	230	80	650	140	620	110
BCK-0.37	*E. coli*	2300	140	190	110	400	40	720	120	250	180
BCK-0.37	FC	8200	190	230	120	570	57	730	120	280	230
BCK-0.46	*E. coli*	3100	80	120	200	74	6	110	110	150	140
BCK-0.46	FC	6900	84	120	220	80	6	130	120	160	170
BCK-1.02	*E. coli*	720	26	9	14	11	-	-	-	-	440
BCK-1.02	FC	1800	34	9	14	11	-	-	-	-	480
BCK-0.75	*E. coli*	-	-	-	-	-	-	-	-	-	250
BCK-0.75	*FC*	-	-	-	-	-	-	-	-	-	430
BRZ-SW2	*E. coli*	260	410	310	210	1000	17	760	1300	420	460
BRZ-SW2	FC	590	660	430	300	1100	92	970	1400	560	490
BRZ-5TH	*E. coli*	2500	810	480	410	1300	17	320	3500	-	570
BRZ-5TH	FC	3400	1300	570	570	1600	63	450	3500	-	810
BRZ-14TH	*E. coli*	760	320	63	140	160	100	480	200	130	110
BRZ-14TH	FC	1500	340	92	180	200	100	510	200	140	160
BRZ-MID	*E. coli*	420	49	23	100	37	26	100	51	41	45
BRZ-MID	FC	830	49	26	100	43	31	100	96	59	74
BRZ-EAST	*E. coli*	350	60	54	31	60	69	57	150	340	180
BRZ-EAST	FC	420	84	71	34	80	80	69	150	460	190
MCC-1.18	*E. coli*	840	190	310	170	140	130	210	140	340	440
MCC-1.18	FC	1900	230	330	210	190	140	300	160	420	550

Site ID	Parameter	6/15	6/22	6/29	7/6	7/13	7/27	8/10	8/24	9/8	9/22
MCC-3.4	*E. coli*	1200	100	150	71	150	31	270	270	310	160
MCC-3.4	FC	1800	160	250	80	160	60	340	360	380	190
MCC-TRIB2	*E. coli*	1700	9	11	51	37	3	-	-	-	-
MCC-TRIB2	FC	2800	11	31	77	40	3	-	-	-	-
MCC-TRIB-PIPE	*E. coli*	-	-	-	-	-	3	-	-	-	-
MCC-TRIB-PIPE	FC	-	-	-	-	-	3	-	-	-	-
RCN-1.87	*E. coli*	500	88	100	80	92	37	280	140	35	49
RCN-1.87	FC	730	92	110	96	100	51	360	140	37	57
RCN-2.36	*E. coli*	400	49	66	71	74	29	320	330	27	90
RCN-2.36	FC	570	49	71	77	84	37	470	330	28	140
RCN-2.78	*E. coli*	300	23	14	17	23	6	80	84	72	43
RCN-2.78	FC	370	23	20	17	23	6	260	88	81	55

Appendix B. Data Quality

Quality assurance procedures were performed at multiple points of the study to ensure the quality of the data. Results were reviewed and quality checked before being uploaded to Ecology's Environmental Information Management (EIM) database. Relevant notes, data qualifiers for the results, and explanations for data qualifiers were also included.

Results with a high colony count over 150 colonies were typically qualified as an estimate based on MEL guidelines. Due to the high colony count, the true value may be greater than or equal to reported result.

Field replicate samples were collected to evaluate the precision of field sampling procedures. Precision of field replicates was calculated as percent relative standard deviation (%RSD). Results were evaluated based whether they met the measurement quality objectives (MQOs) for field replicates which state that at least 50% of replicate pairs are less than 20% RSD and at least 90% of replicate pairs are less than 50% RSD (Hood, 2014; Riedmayer, 2020). The precision assessment as shown in Table B1 verified the field replicate results met the MQOs for precision.

MEL performs quality control checks in order to evaluate the lab analysis procedures. Method blanks were prepared and analyzed along with the samples to check for sample contamination in the laboratory process (MEL, 2016). All lab blanks analyzed for this study met quality control criteria by having negative contamination growth. Precision was also evaluated for lab analysis which involved duplicate sample analysis. MEL routinely analyzes duplicates from a randomly selected sample in the lab. The results of the analysis provides an estimate of lab analytical precision and the homogeneity of the sample matrix (MEL, 2016).

The MQO for precision of lab duplicates states the relative percent difference (RPD) should not be above the limit of 40% (Hood, 2014; Riedmayer, 2020). Overall, the average RPD for *E. coli* (21.8%) and for FC (17.2%) was below the 40% RPD limit and met the MQO as shown in Table B2. Results that did not meet this MQO were qualified as estimates. Only two samples did not meet this criteria.

Table B1. MQO Results for Field Replicates.

Parameter	MQO Criteria for Field Replicates	% Samples Meeting MQO for Field Replicates	Meets MQO Criteria
E. coli	50% of replicate pairs <20% RSD	9.02%	Yes
E. coli	90% of replicate pairs <50% RSD	34.62%	Yes
FC	50% of replicate pairs <20% RSD	13.68%	Yes
FC	90% of replicate pairs <50% RSD	30.21%	Yes

Table B2. MQO Results for Lab Duplicates.

Parameter	MQO Criteria for Lab Duplicates (RPD)	Average %RPD for Lab Duplicates	Meets MQO Criteria
E. coli	40%	21.8%	Yes
FC	40%	17.2%	Yes

Appendix C. Precipitation Data

Table C1. Daily precipitation in inches at Clark County Ridgefield rain gauge (RDGFLD) from June to September 2020. Data provided by Clark County Public Works, Clean Water Division.

Date	Precipitation (inches)
6/1/20	0.00
6/2/20	0.00
6/3/20	0.00
6/4/20	0.00
6/5/20	0.00
6/6/20	0.74
6/7/20	0.09
6/8/20	0.06
6/9/20	0.50
6/10/20	0.00
6/11/20	0.01
6/12/20	0.20
6/13/20	0.33
6/14/20	0.06
6/15/20	0.64
6/16/20	0.35
6/17/20	0.00
6/18/20	0.00
6/19/20	0.00
6/20/20	0.11
6/21/20	0.00
6/22/20	0.00
6/23/20	0.00
6/24/20	0.01
6/25/20	0.00
6/26/20	0.00
6/27/20	0.00
6/28/20	0.02
6/29/20	0.00
6/30/20	0.00
7/1/20	0.01
7/2/20	0.00
7/3/20	0.00
7/4/20	0.00
7/5/20	0.00
7/6/20	0.00

Date	Precipitation (inches)
7/7/20	0.12
7/8/20	0.00
7/9/20	0.00
7/10/20	0.00
7/11/20	0.00
7/12/20	0.00
7/13/20	0.00
7/14/20	0.00
7/15/20	0.00
7/16/20	0.00
7/17/20	0.00
7/18/20	0.00
7/19/20	0.00
7/20/20	0.00
7/21/20	0.00
7/22/20	0.00
7/23/20	0.00
7/24/20	0.00
7/25/20	0.00
7/26/20	0.00
7/27/20	0.00
7/28/20	0.00
7/29/20	0.00
7/30/20	0.00
7/31/20	0.00
8/1/20	0.00
8/2/20	0.00
8/3/20	0.00
8/4/20	0.00
8/5/20	0.00
8/6/20	0.14
8/7/20	0.00
8/8/20	0.00
8/9/20	0.00
8/10/20	0.00
8/11/20	0.00
8/12/20	0.00
8/13/20	0.00
8/14/20	0.00
8/15/20	0.00

Date	Precipitation (inches)
8/16/20	0.00
8/17/20	0.00
8/18/20	0.00
8/19/20	0.00
8/20/20	0.14
8/21/20	0.02
8/22/20	0.00
8/23/20	0.00
8/24/20	0.00
8/25/20	0.00
8/26/20	0.00
8/27/20	0.00
8/28/20	0.00
8/29/20	0.00
8/30/20	0.00
8/31/20	0.00
9/1/20	0.00
9/2/20	0.00
9/3/20	0.00
9/4/20	0.00
9/5/20	0.00
9/6/20	0.00
9/7/20	0.00
9/8/20	0.00
9/9/20	0.00
9/10/20	0.00
9/11/20	0.00
9/12/20	0.00
9/13/20	0.00
9/14/20	0.00
9/15/20	0.00
9/16/20	0.00
9/17/20	0.00
9/18/20	0.39
9/19/20	0.02
9/20/20	0.00
9/21/20	0.00
9/22/20	0.00
9/23/20	0.71
9/24/20	0.03

Date	Precipitation (inches)
9/25/20	0.25
9/26/20	0.03
9/27/20	0.00
9/28/20	0.00
9/29/20	0.00
9/30/20	0.00

Appendix D. Subwatershed Maps

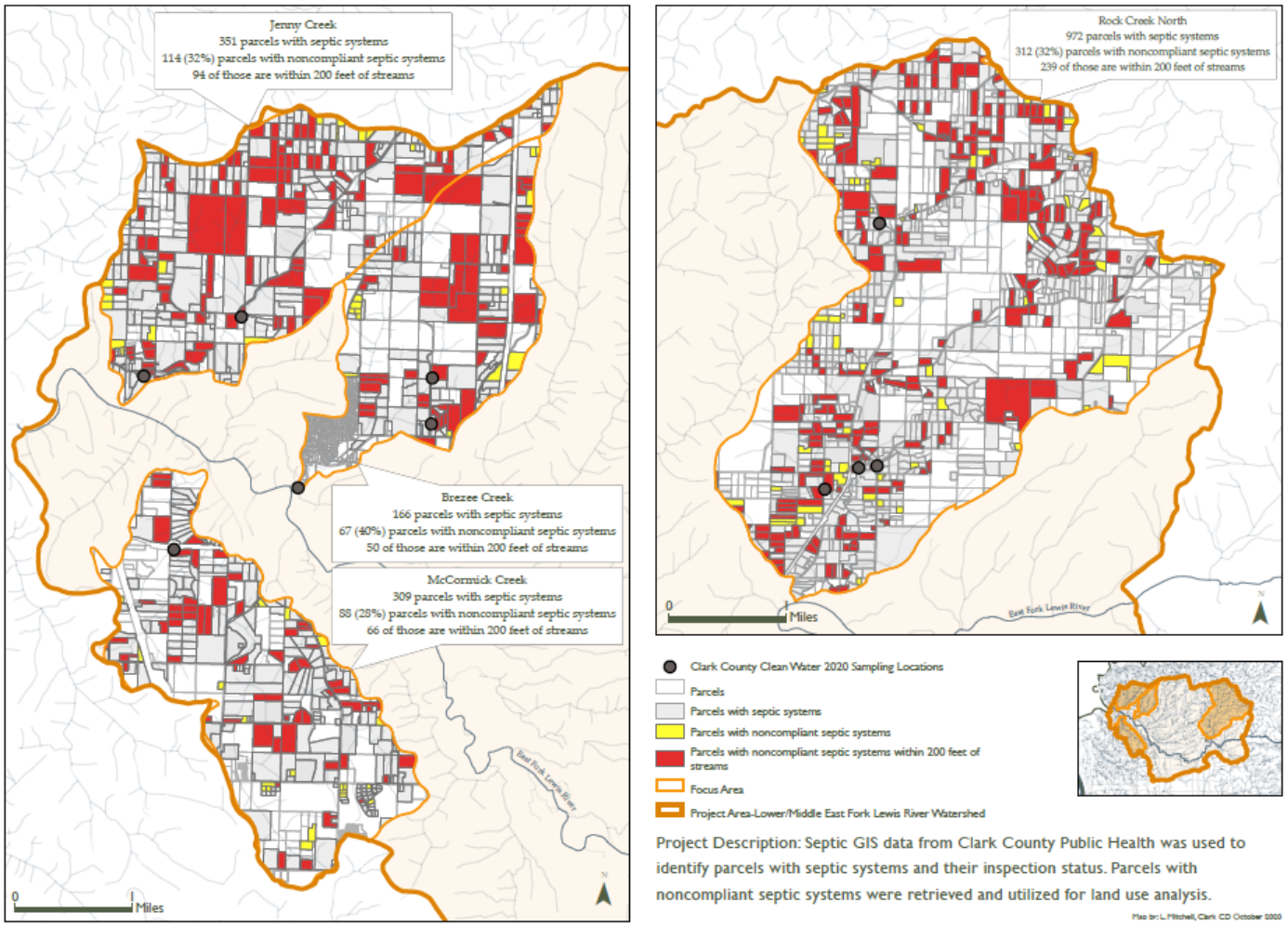

Figure D-1. Map of parcels with septic systems and associated inspection status in the high priority subwatersheds. Septic GIS data from Clark County Public Health. Maps created by Laura Mitchell, GIS Specialist for Clark Conservation District.

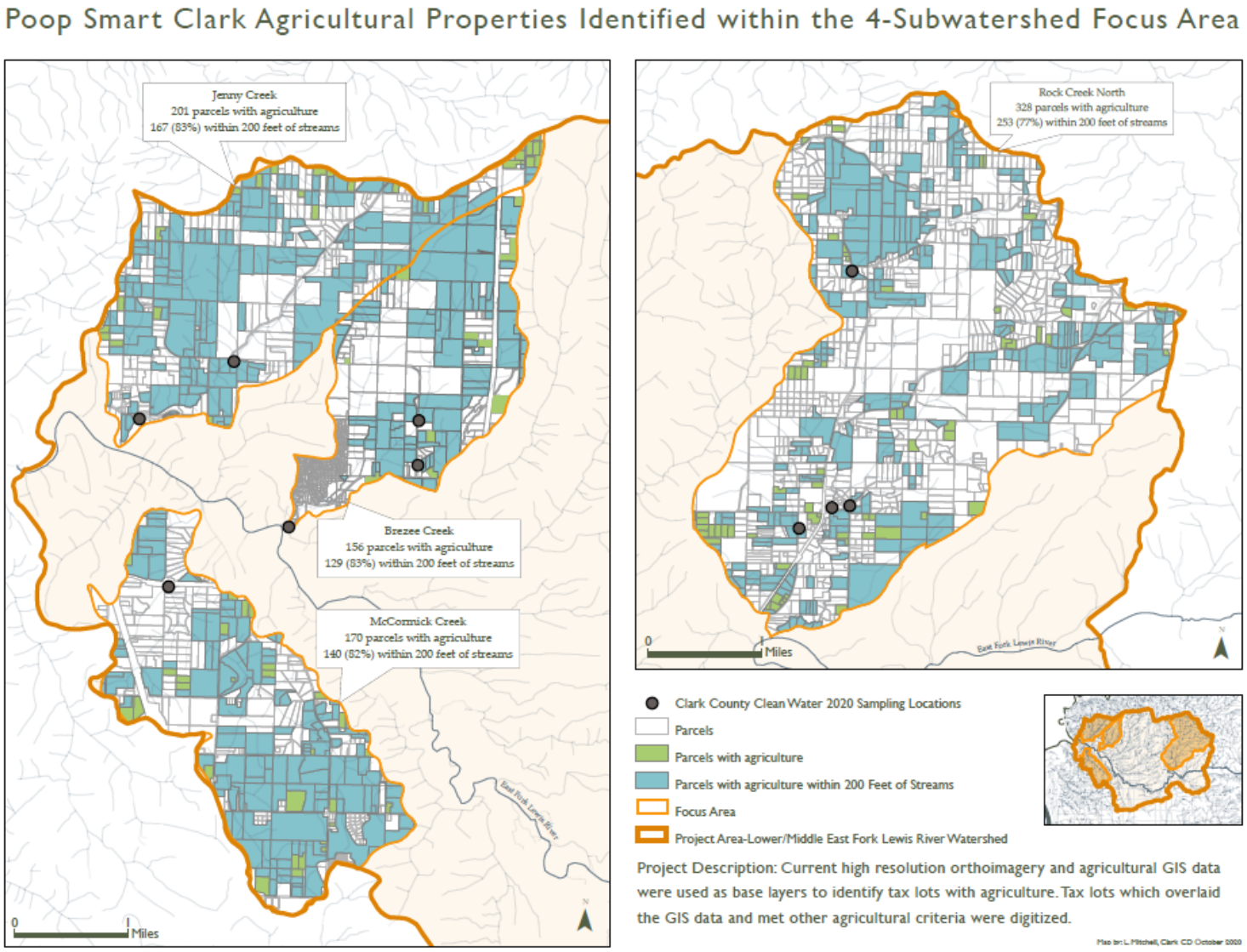

Figure D-2. Map of parcels with agricultural use in the high priority subwatersheds. Maps created by Laura Mitchell, GIS Specialist for Clark Conservation District