

MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY  
WATER RESOURCES DIVISION  
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STAFF REPORT

## Bacterial Monitoring Results for Michigan Rivers and Streams: 2019

### 1 Introduction

Staff from the Michigan Department of Environment, Great Lakes, and Energy (EGLE), Water Resources Division (WRD), and its contractors, collected samples from 91 sites on rivers and streams throughout the Lower Peninsula of Michigan in 2019 (Figure 1; site locations are described in Appendix 1). Samples from these sites were analyzed for *E. coli* on a weekly basis, for 5-8 weeks, and results are shown in Appendix 2. Site locations and data summaries can be viewed on EGLE's interactive map, accessible through [Michigan.gov/EcoliTMDL](https://Michigan.gov/EcoliTMDL) (click on the image of the map and visit the “*E. coli* Monitoring” tab). Monitoring objectives were to:

1. Assess the current status and condition of individual waters of the state and determine whether the Total Body Contact (TBC) and Partial Body Contact (PBC) designated uses are being met. Michigan is committed to assessing the waters of the state to determine the attainment status of the designated uses. All data were considered in the upcoming 2020 Clean Water Act Sections 303(d) and 305(b) list.
2. Conduct microbial source tracking (MST) in impaired priority waters.
3. Obtain screening level dissolved oxygen (D.O.) and Total Dissolved Solids (TDS) measurements, as well as conductivity, turbidity, temperature and pH data to assist in interpretation of water quality data.

### 2 Water Quality Standards (WQS)

#### 2.1 *E. coli*

Michigan's designated use rule states that all water bodies shall be protected for TBC recreation from May 1 through October 31 and PBC recreation year-round (Rule 100 [R 323.1100] of the Part 4 Rules, WQS, promulgated pursuant to Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended). To maintain these designated uses, Michigan has established ambient *E. coli* WQS in Rule 62 of the Part 4 Rules.

*E. coli* is a type of bacteria (single cell organism) that is used as an indicator of the presence of fecal contamination in surface water, such as lakes, streams, and wetlands. Ensuring that waters meet the *E. coli* WQS also ensures that other disease-causing microorganisms (pathogens) are kept below harmful levels. Pathogens in a stream or lake can infect humans through ingestion or skin contact, resulting in diseases such as gastroenteritis, giardia, hepatitis, or cholera.

The WQS of 130 *E. coli* per 100 milliliters (mL) as a 30-day geometric mean, and 300 *E. coli* per 100 mL as a daily maximum are established to protect the TBC use from May 1 through October 31. To protect the PBC use (year-round), 1,000 *E. coli* per 100 mL as a daily maximum is used.

## 2.2 D.O.

D.O. minimum WQS are described in R 323.1064 of the Part 4 Rules and rely upon the coldwater and warmwater fishery designations set forth in the 1997 Michigan Department of Natural Resources (MDNR) Directors Order DFI-101.97 (MDNR, 1997). In surface waters of the state designated to protect coldwater fish, the D.O. shall not fall below a minimum of 7 milligrams per liter (mg/L). In the remainder of streams, the WQS is a minimum of 5 mg/L, to protect warmwater fish species. D.O. results (with violations of the minimum WQS highlighted) and the coldwater or warmwater designations are found in Appendix 3. D.O. is lowest before sunrise because plants and microorganisms respire (and do not photosynthesize) throughout the night using up oxygen. Photosynthesis begins at sunrise releasing and replenishing oxygen.

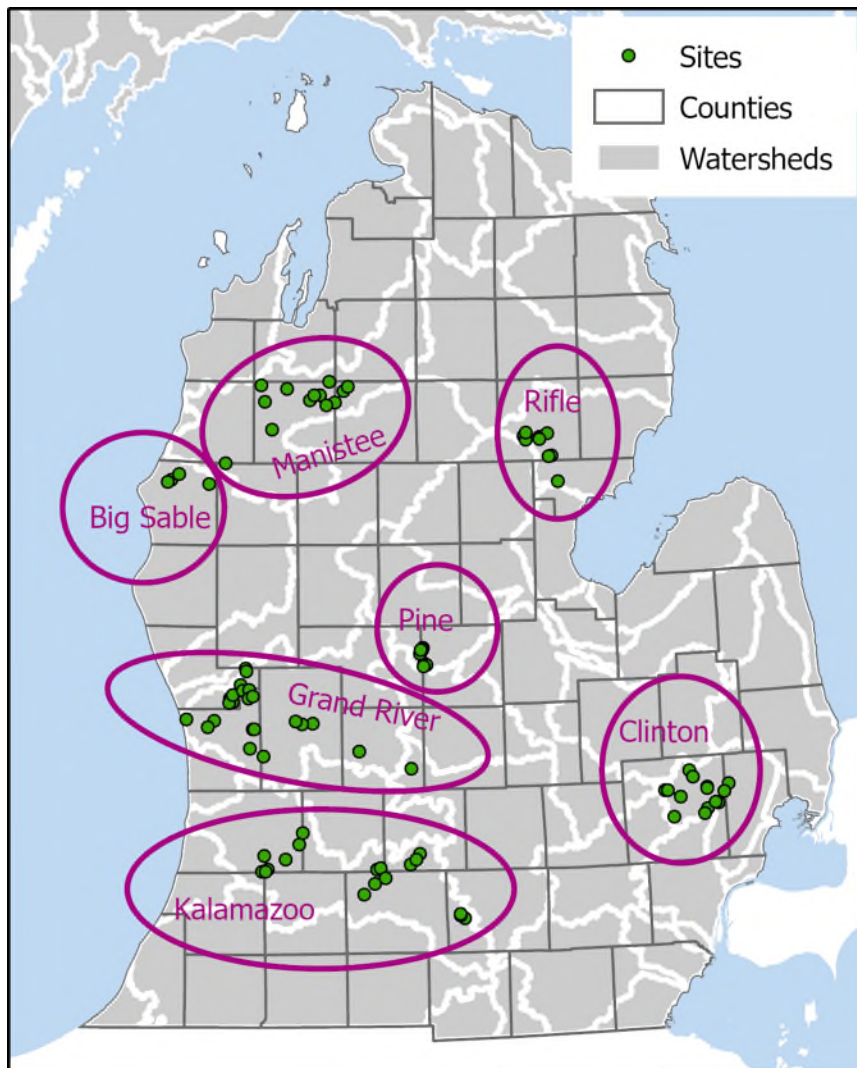


Figure 1. Project groupings and site locations for *E. coli* and D.O. monitoring in 2019.

## 3 Interpretation of *E. coli* Results

Many environmental factors may affect the concentrations of *E. coli* in surface water, including precipitation, flow, settling of *E. coli* through the water column (particularly in a lake or impoundment), and the mortality of *E. coli* due to the passage of time or exposure to sunlight,

proximity to sources, etc. In trying to determine sources of *E. coli* to a sampling site, it is helpful to look at results in the context of precipitation prior to sampling (shown in Appendix 2). When *E. coli* concentrations are high regardless of the weather conditions, the sources may be different from a location where *E. coli* is only high following rainfall. The results in Appendix 2 are color-coded to indicate TBC and PBC WQS exceedances, as described in Section 2.1.

Dry weather exceedances, or exceedances during low flows, indicate a constant source of *E. coli* is impacting the site, such as failing septic systems, illicit sanitary connections, livestock or wildlife congregating in the water, or shallow groundwater contamination.

Wet weather exceedances, or exceedances during high flows, indicate that the source is flushed into water bodies during precipitation events or inundated during flooding. Examples of wet weather sources include urban or rural storm water, runoff from agricultural fields or pastures, illicit sanitary connections to storm drains or field tiles, accumulated waste (animal or human) in storm drains or on the ground surface, or pet or wildlife waste on lawns or parks.

## 4 Sampling Methods

### 4.1 *E. coli*

Each *E. coli* sampling event consisted of 3 samples taken at representative locations within a defined sampling area. In a flowing water body, these locations are referred to as left, center, and right. The center sample was collected in the spatial center of the stream, the right sample was collected midway between the center and the right bank, and the left sample was collected midway between the center location and the left bank. Care was taken to ensure that all samples were collected in the moving portion of the stream, avoiding stagnant areas near the banks, debris dams, or pilings. Samples were collected directly from the stream, just below the surface, into sterile wide-mouthed polypropylene bottles. Collection occurred using a sampler lowered from the bridge by a rope or by wading in and sampling upstream of the body. Care was exercised to avoid the surface microlayer of water and bottom sediment layer, both of which may be enriched in bacteria and not representative of the water column. Clean latex gloves were worn and replaced after sample collection at each site.

Field blanks were collected at a rate of 5 percent, by filling a sample bottle with deionized water. Duplicates were taken by collecting a larger volume of sample and pouring alternately between the sample bottle and the duplicate bottle at a rate of 10 percent of events. At randomly selected events and sites, duplicates were collected for the left, center, and right samples at the same sampling event (date and location). For example, the first sampling event at Site 1 was randomly selected for quality control sampling, and duplicates were collected for left, center, and right samples resulting in 6 samples (L, C, R, L<sup>dup</sup>, C<sup>dup</sup>, and R<sup>dup</sup>). These sample results were used to calculate a daily geometric mean (DGM) to be used in comparison with the daily TBC WQS, and the duplicate results were used to calculate a geometric mean for quality assurance (DGM<sup>dup</sup>). Samples were submitted to the EGLE Drinking Water Laboratory within the 6-hour bacterial hold time and chain-of-custody was maintained at all times.

Precipitation data for the 24 hours and 48 hours prior to each sampling event are recorded in Appendix 2, and graphed in Appendix 4, and were obtained from nearby weather stations (Michigan State University (MSU) Extension, 2020; NOAA, 2020). Where possible, the relative water level was determined at each sampling event by measuring the distance in centimeters from a set point on the bridge or culvert to the surface of the river using a weighted metal tape (Appendices 4 and 5) (Figure 2).



Figure 2. Mark on culvert for determining the relative water level. Measurements are from this point to the water's surface and were recorded on each sampling visit.

#### 4.2 MST

For the source tracking studies, samples were collected using different methods. For the Big Sable, Manistee, and Flower Creek testing, an MST sample volume (100 mL) was collected from the center portion of the stream, and an additional 100 mL was analyzed for *E. coli*. The MST portion was filtered and frozen according to the MSU laboratory's standard operating procedures, then shipped to the laboratory on dry ice. For the Grand River mainstem and Crockery Creek studies, a large sample volume was collected from the center portion of the stream in a sterile bottle (1 L) and 100 mL was poured off to be analyzed for *E. coli*. The Pine River storm drain sample (EHSS) was collected in a 100 mL bacterial bottle directly from the pipe. MST samples for the Grand River, Crockery Creek, and Pine River storm drain were then taken directly to the MSU laboratory where MSU staff filtered and froze them. Chain-of-custody was maintained at all times for all MST samples.

#### 4.3 D.O. and Other Parameters

Field water quality parameter measurements were recorded weekly during *E. coli* sample collection using a YSI EXO Multiparameter Water Quality Sonde. Parameters included: D.O., conductivity, turbidity, temperature and pH (not all parameters were collected at all events). The sondes were calibrated weekly following the manufacturer's instructions. When violations of the D.O. WQS were recorded in the field, or the D.O. seemed abnormally high (above 10 mg/L), the sonde was recalibrated on site and the measurement was verified. This verification was completed no more than once per day. The D.O. measurements collected during this study were collected between 6:00 a.m. and 1:30 p.m., thereby missing the most critical time for D.O. depletion (just prior to sunrise). Results are contained in Appendix 3.

### 5 **Quality Control**

#### 5.1 Goals

The goals for quality assurance and quality control sampling were:

- Blanks – Field blanks should not contain detectable levels of *E. coli*. The detection level for *E. coli* in surface water is <10 *E. coli* per 100 mL.
- Duplicates - If both the DGM and the DGM<sup>dup</sup> for a randomly selected event fall within 0-299 *E. coli* per 100 mL (attainment with the TBC WQS), or conversely, both are more than 300 *E. coli* per 100 mL (nonattainment with the TBC WQS), then the data are considered acceptable. When the DGM and DGM<sup>dup</sup> would result in a different



attainment decision, then the results of duplicate analyses should be used to calculate a relative percent difference between the DGM and DGM<sup>dup</sup>. The target for the relative percent difference is ≤50 percent.

## 5.2 Quality Control Results

The results for quality assurance and quality control in this study were as follows:

- Blanks – All field blanks contained less than 10 *E. coli* per 100 mL (reporting level).
- Duplicates - Of the 437 sampling events, 44 sampling events (10.1 percent) were randomly selected for duplicate sample collection. The DGM and DGM<sup>dup</sup> were not in agreement on TBC attainment status at 2 of the selected events. The Relative Percent Differences for these events were 10 percent and 15 percent; therefore, the quality control goal was met.

## 6 **Conclusions**

### 6.1 Monitoring Objective 1 and 2

#### 6.1.1 General Information

Water levels relative to a fixed point (relative water levels) were measured at most sites. Measurements are listed in Appendix 2 and graphed in Appendix 5. The lowest water level recorded at each site was the baseline measurement (represented as 0) in the Appendices and relative water level change is calculated as the difference between baseline and the event measurement for the sampling event (e.g., for Spring Arbor/Concord Drain - King Road, on May 17, 2019, the water levels were 5 centimeters above baseline, which occurred three weeks after on June 4, 2019). As water levels at some sites were very stable during the study, water level relationships could not be discerned (these are not shown in Appendix 5).

*E. coli* concentrations had a positive relationship with increased water levels (increased as the water level increased) at most of the sites in this study although the strength of the relationship varied. This indicates that high flow issues are impacting these sites, such as urban storm water or tiles and ditches flowing during times of high water table. High flow events were not captured in all of the 5-week studies. Conversely, increasing *E. coli* concentrations with decreasing water levels were less common in this study, and reveal impacts from dry weather and low flow sources such as illicit connections, failing septic systems, or livestock with direct access to the water body.

To assist in determining the sources of *E. coli* to water bodies, MST analysis was conducted for selected sites and projects (Table 1). The presence of a host-specific genetic source tracking marker (either human or bovine) indicates the presence of a potential source of that type in the sample. *Bacteroides thetaiotaomicron* (*B. theta*) was used as a human marker (Yampara-Iquise et al., 2008) and CowM2 as the bovine marker (Shanks et al., 2008). *B. theta* dies almost immediately on exposure to the environment and degrades quickly at surface water temperatures. Studies have shown that only 10 percent is detectable using qPCR after about 3 days in riverine conditions (Balleste and Blanch, 2010), and its presence therefore indicates recent contamination by treated or untreated human sewage.

There are a few considerations when interpreting MST data:

- Deoxyribonucleic acid (DNA), used in MST, does survive wastewater treatment and composting processes. DNA may appear in the sample, while the source bacteria are dead. It is important to consider the presence of wastewater treatment facilities upstream of sites, which would not contribute significantly to live *E. coli* (if in compliance with their permit) but could contribute human MST markers.

- The MST genetic targets are based on host-specific *Bacteroides* bacteria, which are very different from *E. coli*. As an example, *E. coli* may live many months in soil, whereas the longevity of *B. theta* is significantly shorter.
- DNA degrades over time, once the host cell is dead. The decay occurs at variable rates due to many factors, including the taxa of the MST target; sunlight; substrate where the bacteria are residing (water vs. sediment); and ambient temperature (Murphy, 2018). The detection of a marker with a short persistence time indicates more recent pollution by the host animal. The absence of a marker may indicate that it has decomposed to the point of non-detection.
- A non-detect result does not rule out the host animal as a source in the upstream areas. MST markers may not be detected due to decomposition, dilution below detection levels, the presence of compounds in the sample, which inhibit the detection using qPCR techniques (known as 'inhibition'), or the complete absence of the target marker in the sample.
- Weather at the time the sample was collected and location of known sources (such as National Pollutant Discharge Elimination System discharges) are important considerations in determining potential sources.
- Knowledge of the *E. coli* concentration at the time of sampling assists in interpreting results. Higher bacterial concentrations would be more likely to yield a positive detection, while low bacterial densities would be more likely to result in a non-detect. Additionally, if *E. coli* levels were below the daily maximum TBC WQS, EGLE typically chose not to analyze the source tracking samples.
- A false negative occurs when the target marker is not found in the sample (the result is non-detect), but the marker is present. It is not possible to know if a negative result indicates the source is absent from the sample, or if the marker is not detectable due to inhibition, decomposition, or other reason.

*Table 1. Selected sites and dates analyzed for bovine and human markers. MST results are in gene copies per 100 mL (average of 2-3 detectable results) and are presented alongside the E. coli DGM. Results are the average (in gene copies/100 mL) of 2-3 detectable results. Results lower than the method detection limit (354 copies/100 mL) are non-detect (ND).*

Site ID	Site Description	Sample Date	<i>E. coli</i> DGM (cfu/100mL)	DNA Concentration in Extract (ng/uL)	Human (B. theta)	Bovine (CowM2)	Porcine
530292	Big Sable River - N Darr Rd	8/6/2019	346	33.74	ND	ND	ND
530219	Freeman Creek - N Alexander Rd	7/16/2019	319	40.45	ND	ND	ND
530219	Freeman Creek - N Alexander Rd	7/23/2019	2420*	130.98	566.4	ND	ND
530219	Freeman Creek - N Alexander Rd	7/30/2019	479	22.84	ND	ND	ND
530219	Freeman Creek - N Alexander Rd	8/6/2019	1,535	38.18	ND	511.33	ND
530219	Freeman Creek - N Alexander Rd	8/14/2019	332	29.28	ND	ND	ND
530304	Davis Creek - N Quarterline Rd	7/16/2019	517	12.71	ND	ND	ND
530304	Davis Creek - N Quarterline Rd	7/23/2019	787	23.71	ND	ND	ND
530304	Davis Creek - N Quarterline Rd	7/30/2019	443	13.49	ND	ND	ND
530304	Davis Creek - N Quarterline Rd	8/6/2019	2,165	20.75	ND	ND	ND
430639	Cool Creek (West Crossing) - W 12 Mile Rd	7/16/2019	358	12.37	ND	ND	ND
430639	Cool Creek (West Crossing) - W 12 Mile Rd	8/14/2019	388	6.5	ND	ND	ND
640350	Flower Creek -Roosevelt Rd - W of 48th St - FC4	7/15/2019	395	21.9	ND	ND	ND
640350	Flower Creek -Roosevelt Rd - W of 48th St - FC4	7/22/2019	1,195	27.05	ND	ND	ND
640350	Flower Creek -Roosevelt Rd - W of 48th St - FC4	7/29/2019	716	26.11	ND	ND	ND
640350	Flower Creek -Roosevelt Rd - W of 48th St - FC4	8/5/2019	361	18.11	ND	590	ND
640350	Flower Creek -Roosevelt Rd - W of 48th St - FC4	8/14/2019	283	15.57	ND	ND	ND
340262	Grand River - Bridge St	6/17/2019	2,270	36.57	1,478.93	ND	n/a
700546	North Branch Crockery Creek - 40th Ave	9/30/2019	6,311	37.34	1,298	472	n/a
610508	Crockery Creek - Blackmer	9/30/2019	8,732	37.1	23,364	786.67	n/a
610380	Crockery Creek - Ellis Rd	9/30/2019	6,341	43.56	1,132.80	ND	n/a
610476	Rio Grande Creek - Blackmer Rd - RG7A	9/30/2019	9,835	59.78	23,914.70	ND	n/a
610479	Crockery Creek - Laketon Ave	9/30/2019	2,694	44.7	5,192	ND	n/a
610507	Crockery Creek - Patterson Rd	9/30/2019	8,339	50.11	1,038.40	ND	n/a
610507-D	DUPLICATE- Crockery Creek - Patterson Rd	9/30/2019	8,339	55.29	3,618.67	786.67	n/a
EHSS	Storm Sewer to Pine River - S of Van Buren Rd	9/25/2019	See App. 2	57.54	ND	487.73	n/a

### 6.1.2 Watershed Summaries:

The following are summaries by watershed, accompanied by a table of results color coded to indicate value relative to other events (Tables 2-4 and 7-14). Cells with warmer colors (red and orange) indicate *E. coli* results above the median of all data (yellow cells). Cooler colors (blues) indicate results below the median. Data are summarized by weekly averages and the 30-day geometric mean to allow spatial and temporal visualization of results. The relationship between flow and *E. coli* concentrations, weather information, and MST results are also summarized in each of the watershed summaries below.

#### a. Kalamazoo River (19 sites)

In the Spring Arbor/Concord Drain, 2 of 3 sites exceeded the daily TBC WQS; none exceeded the PBC (*Table 2*). In 2018, *E. coli* concentrations were also measured at the King and N Concord Roads and were higher in that study (Rippke, 2019). Water temperature can have a significant impact on the survival and reproduction of *E. coli* in the environment. These sites were sampled beginning in mid-May in both 2018 and 2019. Overall, 2019 had a relatively cold spring; thus, the lower concentrations of *E. coli* could be due to colder water temperatures during 2019 sampling (45-60°F) (Appendix 3). Water temperatures were about 10 degrees higher in 2018 (54-70°F). The tributary to Spring Arbor Drain at Railroad Access Drive (380513) had very low D.O. readings on 4 of the 5 events and follow-up investigations are recommended.

In the tributaries to the lower Kalamazoo, several sites exceeded the daily maximum TBC on all 5 events; including, Schnable Brook, Base Line Creek, and two Gun River Sites (116th and 10th Avenues) (*Table 3*). The PBC WQS was only exceeded at Gun River (116th Avenue) during a high-water event with no immediately preceding precipitation (Appendix 2). Although the WQS were rarely exceeded in the Gun River at Patterson Road, located just below Gun Lake, this site had a very strong relationship between water level and *E. coli*, with *E. coli* clearly the highest at lower water levels indicating a constant source of pollution being diluted (Appendix 5).

Crooked Brook at Huff Road exceeded the PBC WQS on all 5 events. On the second week of sampling, a site was added immediately upstream of this one, at Wing Road. Crooked Brook at Wing Road exceeded the PBC on 2 of 4 events, and consistently had lower *E. coli* levels than the Huff Road site, indicating a likely pollution source in the 1 mile stretch between these sites. In addition to other potential pollution sources (including failing septic and illicit discharges), a menagerie of livestock (pigs, goats, poultry, horses and cows) were observed to have direct access to the brook immediately upstream of Huff Road.

Battle Creek at the pedestrian bridge in Battle Creek, Michigan, was another site with notably high concentrations of *E. coli* (*Table 4*). Staff frequently observed both geese and trash at this site, indicating waterfowl and storm sewer discharges as potential local sources in addition to upstream sources.

As follow-up to a previous study at that site in 2015, general water chemistry samples were collected four times throughout the summer of 2019 at Schnable Brook (Site ID 030504) (*Table 5*).

The range of total phosphorus and ammonia found in reference streams in the Southern Michigan Northern Indiana Till Plain (SMNITP) ecoregion, in a 1992-1993 EGLE study, was 0.012-0.28 mg P/L and 0.004-0.2 mg ammonia N/L (Lundgren, 1994). In that same study, the mean concentration of total phosphorus for the ecoregion was 0.058 mg/L, and the mean of total ammonia for the ecoregion was 0.042 mg/L. The total phosphorus and ammonia in

Schnable Brook (Site ID 030504) were within the expected range and were below the averages from the Lundgren study.

As part of Michigan's Water Chemistry Monitoring Program (WCMP), 250 randomly located sites on inland tributaries were monitored for general water chemistry parameters. Median values of total ammonia collected in the years 2005-2009 as part of the WCMP were between .007-0.14 mg/L (Roush, 2013). The value of total ammonia cannot be compared to the unionized portion of ammonia, which is the most toxic to aquatic life and is the basis of Michigan WQS. Total nitrogen is the sum of Kjeldahl nitrogen, nitrate, and nitrite. Median total nitrogen from the WCMP monitoring (2005-2009) was 0.22-3.2 mg/L. The highest Schnable Brook total nitrogen sample (1.98 mg/L) and fell within the range of WCMP results. All other chemistry parameters were within the expected reference ranges for the SMNITP ecoregion (Lundgren, 1994).

In the 48-hours prior to the June 26 sampling event, about 0.7 inches of rain fell, which may explain the higher chemical oxygen demand, nutrient and suspended solids levels on that date (MSU Extension, 2020). Trace amounts or no rain occurred prior to the other sampling events.

In general, the nutrient values and *E. coli* were lower in 2019 than they were in 2015; however, one event in 2015 (August 17, 2015) had very high ammonia (0.41 mg/L) and total phosphorus levels (0.18 mg/L) and raised the averages for that dataset (Rippke, 2016). Weather and climate differences prior to sampling likely cause significant variation.



Table 2. *E. coli* DGM, 30-day geometric means, and weekly averages for Spring Arbor/Concord Drain.

Site Description	5/14	5/21	5/28	6/4	6/11	30-Day Geometric Mean
Spring Arbor / Concord Drain - King Rd	18	65	81	167	323	88
Spring Arbor / Concord Drain - N Concord Rd	102	182	387	308	434	249
Trib to Spring Arbor Drain - Railroad Access Dr	49	139	129	110	106	101
Weekly Average	56	129	199	195	288	

Table 3. *E. coli* DGM, 30-day geometric means, and weekly averages of Lower Kalamazoo Tributary sites.

Site Description	7/29	8/5	8/13	8/19	8/26	30-Day Geometric Mean
Gun River - 116th Ave	1069	619	908	656	489	719
Gun River - Patterson Rd	45	180	171	266	426	173
Gun River - 10th St	712	547	386	636	541	553
Base Line Creek - 24th St	410	769	368	748	549	544
Pine Creek - 21st St	425	272	259	443	256	321
Pine Creek - 101st Ave	364	295	456	523	516	421
Schnable Brook - M89	429	404	583	625	388	476
Weekly Average	493	441	447	557	452	

Table 4. *E. coli* DGM, 30-day geometric means, and weekly averages at Battle Creek sites.

Site Description	7/30	8/6	8/12	8/20	8/27	30-Day Geometric Mean
Big Creek - Marshall Rd	800	1018	794	587	826	793
Indian Creek - N Main St	870	1208	363	1134	1196	876
Battle Creek - W Spicerville Hwy	542	702	427	577	1612	686
Battle Creek - Burrows Rd	204	272	206	241	521	270
Crooked Creek - Huff Rd	1641	2220	1090	1189	2169	1,592
Wonadoga Creek - Huff Rd	333	398	402	665	2986	638
Crooked Brook - Wing Rd	na	1816	775	573	1522	1,053
Wanadoga Creek - Pennfield Rd	382	1301	363	306	757	530
Battle Creek - Pedestrian Bridge (off Hamblin)	237	6348	2230	628	1132	1,190
Weekly Average	626	1,698	739	656	1,413	

Table 5. General chemistry results from Schnable Brook; June-September 2019.

Parameter	Unit	Result Detection Limit	06/26/19	08/05/19	08/26/19	09/18/19	2019 Mean	2015 Mean
Ammonia-N	mg/L	0.01	0.05	0.01	<0.02	0.01	0.02	0.12
Chemical Oxygen Demand	mg/L	5	23	<5	12	16	14.00	19.50
Kjeldahl Nitrogen-N	mg/L	0.2	0.88	0.42	0.44	0.46	0.55	0.77
Nitrate/Nitrite-N	mg/L	0.01	1.1	0.65	0.52	0.57	0.71	1.40
Total Nitrogen (calculated)	mg/L		1.98	1.07	0.96	1.03	1.26	2.17
Ortho Phosphate-P	mg/L	0.01	0.03	0.014	0.019	0.017	0.02	0.06
Total Organic Carbon	mg/L	0.5	9.4	4.4	4.7	5.5	6.00	7.05
Total Phosphorus-P	mg/L	0.01	0.076	0.023	0.033	0.034	0.04	0.10
Total Suspended Solids	mg/L	4	25	4	6	5	10.00	21.25
Hardness - Calculated	mg/L	4.6	200	240	260	240	235.00	265.00
Calcium	mg/L	1	50	59	63	60	58.00	67.75
Magnesium	mg/L	0.5	17	22	25	22	21.50	23.75

#### b. Grand River Mainstem (6 sites)

The Grand River receives uncontrolled Combined Sewer Overflows (CSO) from the city of Lansing, which discharge substantial volumes of diluted raw sewage to the Red Cedar and Grand Rivers (Table 6). EGLE monitored six sites on the mainstem Grand River, located from the towns of Portland (most upstream) to Grand Haven (near the mouth), for 8 weeks (Table 7). Of these, only the site near Grand Haven (Grand River - US 31 [700705]) met all applicable *E. coli* WQS. PBC exceedances occurred at the Portland (Kent St [340262]), Saranac (Bridge Street [340024]), and 231/Spoonville Trail (700704) sites. CSO discharges occurred within the 48 hours prior to the first three sampling events (June 3, 10, and 17). Also on June 10, Sanitary Sewer Overflows (SSO) occurred discharging to the Grand River, Red Cedar and Sycamore Creek (a tributary to the Red Cedar River) from the city of Lansing (9.25 million gallons), and from the city of East Lansing (9.6 million gallons). The SSO events on June 10 began in the early morning and continued throughout the day due to several large rain events occurring on June 9 and 10. MST results found human bacteriodes marker (*B. theta*), indicative of fresh human sewage, at the Portland site (340262) on June 17, 2019, following a CSO event (Table 6). An isolated PBC exceedance occurred in the Grand River at the 231/Spoonville Trail site (700704) on July 8. MST samples were not collected on this date thus it is unknown what may have caused this exceedance; however, given the results from nearby Crockery Creek later in the summer (Table 9), it is possible that sources from that watershed may have caused this exceedance. Crockery Creek discharges to the lower Grand River less than 1 mile upstream of the 231/Spoonville Trail site. While this seems likely, it remains possible that sources further up stream may also have taken some time to reach the 231/Spoonville Trail site.

Table 6. CSO discharged by the city of Lansing Wastewater Treatment Plant during the study period (Source: MiWaters Database, May 5, 2020). Bolded font with asterix indicates a discharge event that occurred within 48-hours prior to EGLE sampling.

Date	Grand River	Red Cedar River	Grand Total
<b>1-Jun*</b>	<b>24.0</b>	<b>1.5</b>	<b>25.6</b>
5-Jun	2.3	0.1	2.3
<b>9-Jun*</b>	<b>31.5</b>	<b>2.7</b>	<b>34.1</b>
<b>10-Jun*</b>	<b>1.2</b>		<b>1.2</b>
13-Jun	2.8	0.1	2.9
<b>16-Jun*</b>	<b>2.6</b>	<b>0.1</b>	<b>2.7</b>
19-Jun	53.6	2.5	56.1
20-Jun	1.3		1.3
2-Jul	4.4	0.5	4.8
4-Jul	1.5	0.0	1.6
16-Jul	22.9	1.5	24.4
21-Jul	2.8	0.1	2.9
29-Jul	2.0	0.1	2.1
<b>Grand Total</b>	<b>152.8</b>	<b>9.1</b>	<b>161.9</b>

Table 7. *E. coli* DGM, weekly and site averages for sites on the mainstem Grand River (see Appendix 2 for 30-day geometric means).

Site Description	6/3	6/10	6/17	6/24	7/1	7/8	7/15	7/24	Site Average
Grand River - Kent St (Portland, MI)	1182	449	2270	173	63	102	55	86	547
Grand River - Bridge St (Saranac, MI)	1258	n/a	104	99	76	149	89	86	266
Grand River - Northland Dr NE	772	338	75	96	8	75	43	10	177
GRAND RIVER - M-11 BRIDGE - GR06	164	521	138	179	36	292	94	137	195
Grand River - 231/Spoonville Trail	463	356	77	130	20	2439	21	16	440
Grand River - US 31	229	73	52	104	18	125	7	2	76
Weekly Average	678	348	453	130	37	530	52	56	

### c. Lower Grand Tributaries (17 sites)

All tributary sites in the Lower Grand watershed exceeded the daily and 30-day geometric mean TBC WQS (Appendix 1, Table 8 and 9).

For sites listed in Table 8, *E. coli* levels were lowest on the first sampling event in early June, when no rain had occurred prior to sampling, and generally highest on the third event, where more than a half inch of rain fell. All sites on Sand and Bear Creeks exceeded the PBC on 3 of 5 events (2nd, 3rd, and 5th events). These high *E. coli* levels were related to rainfall events (Appendix 4) which were frequent in June 2019. *E. coli* levels in Bear Creek at Shiloh Drive NE (410855) were strongly related to water level (Appendix 5). *E. coli* reached particularly high levels (34,171 *E. coli* per 100 mL) the tributary to Crockery Lake at 16th Avenue on the 3rd event (June 20, 2019). Manure trucks were noted conducting land applications east of this area during sampling, although it is unknown if those applications were in the immediate watershed of the study site. Water levels could not be safely measured at this site, but high prior rainfall, high turbidity on the wet weather sampling dates (Appendix 3), and land use upstream of this site indicates that likely sources are manure runoff from fields or illicit discharges to field tiles, the ground, or roadside ditches.

Table 8. *E. coli* DGM, 30-day geometric means, and weekly averages at Sand and Bear Creek sites, as well as tributaries to Crockery Lake.

Site Description	6/6	6/13	6/20	6/27	7/2	30-Day Geometric Mean
Bear Creek - Meandering Creek Dr NE	243	7447	1761	551	14,216	1,903
Bear Creek - Shiloh Dr NE	196	8692	3038	500	3,093	1,516
Trib to Crockery Lake - Gooding St	153	1,520	1097	321	3,432	776
Trib to Crockery Lake - 16th Ave	521	10,027	34,171	2,175	4,755	4,500
Sand Creek - Hayes St (east)	339	2517	4230	856	4,871	1,720
Sand Creek - Hayes St (west)	686	7,988	21,472	1419	7,403	4,153
Sand Creek - Luce St SW	111	9,865	2077	226	3,365	1,117
Weekly Average	321	6,865	9,692	864	5,876	

*E. coli* levels in Crockery Creek had a weak-moderate positive relationship with water levels at almost all sites (Appendix 5). Rain events contributed to almost all sites exceeding the PBC WQS on the 2nd, 4th, and 5th weekly events (Appendix 4 and Table 9). Following a large rain event, Crockery Creek had extremely high levels of *E. coli* (almost 87,000 *E. coli* per 100mL) on September 24 at Patterson Road (610507). As a result, MST samples were collected the following week (September 30) to assist in locating a source. Water levels were high on September 30 and although a rain event also occurred prior to the September 30 event, *E. coli* levels were not as elevated as in the previous event. The results showed a high amount of human marker at all sites where MST samples were collected, and lesser amounts of bovine detected at Blackmer and the duplicate collected at Patterson (Table 1). The presence of the human marker, *B. theta*, on a high water and wet weather event indicates fresh raw sewage being discharged or flushed into the waterways. Examples of wet weather sources of human sewage are illicit discharges to ditches, drainage tiles, roadside ditches, or sewage on the ground surface.

Sand Creek at Hayes sites (both east and west), and the tributary to Crockery Lake at Gooding Street, fell just slightly below the D.O. WQS designed to protect coldwater fisheries on more than one occasion (Appendix 3). The D.O. readings at the remainder of the Crockery Creek sites were above the WQS at the time of measurement.



Table 9. *E. coli* DGM, 30-day geometric means, and weekly averages at Crockery Creek sites.

Site Description	9/3	9/10	9/17	9/24	9/30	30-Day Geometric Mean
North Branch Crockery Creek - 40th Ave	1,290	3,312	768	9,345	6,311	2,866
North Branch Crockery Creek - 24th Ave	701	1,364	1,457	7,897	5,996	2,311
Crockery Creek - Laketon Ave	502	1,993	454	1,277	2,694	1,094
Crockery Creek - Shaw Rd	1,232	2,287	716	800	2,320	1,302
Ovidhall Lake Creek - Bailey Rd	864	1,476	478	1,366	2,625	1,170
Crockery Creek - Ellis Rd					6,341	
Rio Grande Creek - Blackmer Rd - RG7A	175	1,673	426	7,395	9,835	1,553
Crockery Creek - Blackmer					8,732	
Crockery Creek - Patterson Rd	289	9,493	469	86,895	8,339	3,926
Crockery Creek - Fitzgerald St	236	572	344	5,520	7,365	1,135
Weekly Average	661	2,771	639	15,062	6,056	

#### d. Big Sable (4 sites)

Of the four sites in the Big Sable watershed study (Table 10), one site met all applicable *E. coli* WQS (Big Sable at N Taylor Road - 530223), despite extremely high water levels and several rain events that could potentially cause WQS exceedances. Two of the sites exceeded the PBC (Freeman and Davis Creeks; 530219 and 530304), with those events related to either high water levels or rain events. Water level measurements during this study fluctuated widely. On July 23, 2019 (2nd event), water levels were so high that the Big Sable River flowed over N Taylor Road, making water level measurement impossible. Of all the sites, only Freeman Creek had a strong positive relationship of increasing *E. coli* with increasing water levels (Appendix 5). The remainder of the sites had no relationship between these parameters. D.O. readings taken in the Big Sable River at N Taylor Road were well below the WQS to protect the coldwater fishery and warrant further investigation. The D.O. at Freeman Creek and Big Sable at North Darr Road (530292) also fell below the WQS, but to a lesser extent.

Table 10. *E. coli* DGM, 30-day geometric means, and weekly averages at Big Sable sites.

Site Description	7/16	7/23	7/30	8/6	8/14	30-Day Geometric Mean
Big Sable River - N Taylor Rd	88	122	57	238	54	97
Freeman Creek - N Alexander Rd	319	2420	479	1535	332	716
Big Sable River - N Darr Rd	106	213	143	346	75	153
Davis Creek - N Quarterline Rd	517	786	443	2165	233	619
Weekly Average	257	885	281	1,071	173	

#### e. Manistee (14 sites)

Most of the sites in the Manistee met all applicable *E. coli* WQS (Table 11). The exceptions were daily maximum TBC WQS exceedances in the two Fletcher Creek sites (830145 and 830235) and the west crossing of Cool Creek (430639) (Table 12). Water levels were very stable throughout this study at the following creeks: Morrisy, Manton (both sites), Buttermilk, Silver, and the Tributary to Lake Billings. Weak negative relationships showing lower *E. coli* with high water levels were found at both Cool Creek sites (430638 and 430639) and Slagle Creek (830236). Weak positive relationships of higher *E. coli* with higher water levels were found at Anderson Creek (830159) and Fletcher Creek at West 12 ¾ Road (830145) (Appendix 5). Rain in the 24-hours immediately prior to sampling did not occur at sites listed in Table 11, which may partially explain the lack of WQS exceedances at those sites; however, dry weather exceedances occurred, in addition to wet weather exceedances, at the west crossing of Cool Creek and both Fletcher Creek sites.

Table 11. *E. coli* DGM, 30-day geometric means, and weekly averages at Manistee sites.

Site Description	7/17	7/24	7/31	8/7	8/15	30-Day Geometric Mean
Hopkins Creek - N Lanning Rd	49	30	24	21	34	30
Hopkins Creek - N Lucas Rd	43	64	73	80	70	65
Fife Lake Creek - Number Two Rd	75	26	32	28	24	33
Morrisy Creek - N Seeley Rd	109	114	116	93	53	93
Manton Creek - E 10 Rd	86	43	53	46	46	53
Manton Creek - E Main St	89	58	107	75	55	75
Trib to Lake Billings - E Main St	39	20	40	53	31	35
Silver Creek - E 12 1/2 Rd	91	91	87	54	64	76
Buttermilk Creek - E 10 Rd	62	79	67	79	114	78
Anderson Creek - W 6 Rd	27	21	22	18	9	19
Weekly Average	67	55	62	55	50	

Table 12. *E. coli* DGM, 30-day geometric means, and weekly averages at Fletcher, Slagle, and Cool Creek sites.

Site Description	7/16	7/23	7/30	8/6	8/14	30-Day Geometric Mean
Fletcher Creek - W 12 3/4 Rd	311	176	174	345	192	229
Fletcher Creek - W 4 Rd	802	144	101	106	327	210
Slagle Creek - W 30 Rd	16	35	24	265	18	36
Cool Creek (East Crossing) W 12 Mile Rd	42	34	24	28	53	35
Cool Creek (West Crossing) - W 12 Mile Rd	358	76	43	141	388	145
Weekly Average	306	93	73	177	195	

#### f. Rifle River (9 sites)

Of the nine sites in the Rifle River study, two met all applicable *E. coli* WQS; Flowage Creek (650038) and West Branch Rifle River at M-33 (650125). Rainfall occurred prior to the only two PBC WQS exceedances recorded in this watershed; these occurred in the Rifle River at Melita Road (060105) and Campbell Creek (650097) (Appendix 4). Ogemaw Creek did not exceed the PBC WQS but had the highest 30-day geometric mean of all the sites and was the only site to exceed the TBC WQS on all five events regardless of precipitation (Table 13). Most sites had a positive relationship between *E. coli* and water levels, with the exception of Rifle Creek at Dam Road (650121) (Appendix 5).

D.O. measurements were within the range of the WQS for all of these sites at the time they were visited; however, it was noted that the calculated TDS was above the threshold of 500 mg/L in Campbell Creek and Flowage Creeks (Appendix 3).

Table 13. *E. coli* DGM, 30-day geometric means, and weekly averages at Rifle River sites.

Site Description	7/15	7/22	7/29	8/5	8/13	30-Day Geometric Mean
Ogemaw Creek - I 75 BL	478	886	517	637	373	554
Rifle Creek - Dam Rd	129	165	101	166	198	148
Flowage Creek - S Flowage Lake Rd	88	188	62	47	45	74
Campbell Creek - M 33	236	1062	561	488	183	416
West Branch Rifle River - M 33	71	226	96	78	116	107
Rifle River - M 55	62	271	470	86	104	148
Silver Creek - Greenwood Rd	326	498	637	286	337	398
Rifle River - Greenwood Rd	103	590	674	94	66	191
Rifle River - Melita Rd	46	860	2027	116	52	217
Weekly Average	171	527	571	222	164	

#### g. Pine River (7 sites).

Seven surface water sites in the Pine River watershed, and one storm water pipe on the south side of Van Buren (east bank), were monitored at one event on September 25, 2019 (Appendix 2). For the surface water sites, this was a dry weather event with no precipitation within the prior 48 hours; however, the water levels were relatively high compared to previous baseline water levels measured during 2017 monitoring at E McBrides Road (590364) (Rippke, 2018). All of the sites, except the unnamed tributary to the Pine River west of Elm Hall (590371) exceeded the daily maximum TBC WQS. After completing the surface water sites, it began to rain, and at that time the storm water discharge east of Van Buren Road bridge (adjacent to site 290235) was sampled and had 73,000 and 85,000 *E. coli*/100 mL. The precipitation event was local and was not recorded at any nearby weather stations. This storm pipe had not been flowing when the Van Buren site (290235) was sampled earlier that morning, and therefore, could not have impacted those results. MST analysis of the storm water found undetectable levels of *B. theta*, and a relatively small amount of Bovine marker (Table 1). Visual inspection of areas upstream of this pipe indicate cattle, horses, and homes (older sewage or pet waste), in addition to wildlife, could potentially be contributing to the very high *E. coli* in the runoff.

#### h. Clinton River (14 sites).

All 14 sites in the Clinton River portion of this study exceeded the daily maximum TBC WQS and 30-day geometric mean TBC WQS, while half of the sites also exceeded the PBC WQS at least once (Appendix 2). The Clinton River at Cooley Lake Road (630630) had the lowest overall *E. coli* and fewest exceedances (Table 14). The site with the highest 30-day geometric mean, and the most PBC WQS exceedances was Paint Creek at Rochester Road (631285) (Table 15), which exceeded the PBC under both dry and wet conditions. Strong relationships of increasing *E. coli* with increasing water levels were found at Paint Creek at Rochester Road and Sashabaw Creek (631077). At Galloway Creek (631032), the opposite was found, with decreasing levels of *E. coli* at higher water levels indicating dilution of a constant source (Appendix 5).

D.O. results were of no concern at most sites, most of the time. Low D.O. was recorded on one occasion at each of two warm water sites: Tributary to Lake Michelson - Seymour Lake Road (631284) and Clinton River - Cooley Lake Road (630630) (Appendix 3). Conversely, conductivity and calculated TDS were above the level of concern at all sites, except the tributary to Lake Michelson and Stony Creek at Inwood Road (500554) (Appendix 3).

Table 14. *E. coli* DGM, 30-day geometric means, and weekly averages at Clinton River sites.

Site Description	8/8	8/15	8/28	8/29	9/5	9/12	30-Day Geometric Mean
Trib to Deer Lake - Deerhill Rd.	192	252	310	345	243		263
Clinton River - Bluegrass Rd.	295	1,904	283	364	422		476
Trib to Duck Lake - Deer Path Rd.	943	1,066	753	533	810		799
Trib to Lake Michelson - Seymour Lake Rd.	529	376	530	206	245		351
Sashabaw Creek - Pine Knob Trail		1437	331	314	179	18,155	866
Clinton River - Cooley Lake Rd.	162	224	335	201	296		236
Paint Creek - Adams Rd. (north)	492	730	728	492	483		574
Trout Creek - Adams Rd. (south)	509	741	529	513	394		526
Weekly Average	446	841	475	371	384		

Table 15. *E. coli* DGM, 30-day geometric means, and weekly averages at Clinton River sites.

Site Description	8/7	8/14	8/21	8/28	9/4	30-Day Geometric Mean
Clinton River - Riverwoods Trail	176	623	311	172	618	325
West Branch Stony Creek - Stony Creek Metropark	312	612	516	396	1,483	566
Stony Creek - Inwood Rd	576	551	1,061	603	684	674
Paint Creek - Rochester Rd - CR12	861	1,048	2,226	1,292	2,675	1,473
Sargent Creek - N. Livernois Rd.	520	1,386	864	821	281	678
Galloway Creek - Butler Rd.	751	841	237	403	470	490
Weekly Average	533	844	869	615	1035	

## 6.2 Monitoring Objective 3

Field water quality data including turbidity, conductivity, calculated TDS, D.O., pH and temperature are presented in Appendix 3.

All pH measurements were within the expected range. Turbidity had a notable relationship with *E. coli* concentration (all data was log transformed). Higher *E. coli* was generally associated with higher turbidity measurements (Figure 3).

D.O. met the applicable minimum WQS at most sites at the time of sampling (Appendix 3); however, because these events were instantaneous readings, it cannot be determined if the applicable fisheries designated use is being met. Because these measurements were not collected prior to sunrise, during the time that is generally critical for low D.O., it is recommended that continuous D.O. studies be conducted at the sites listed in Table 3 as resources allow.

Michigan's TDS WQS states that TDS should not rise above 500 mg/L due to a controllable point source (R 323.1051). The standard is general and not component specific. Different components of TDS have different impacts on aquatic life, with chloride and sulfate being two of the most common and toxic components. A TDS value above 500 mg/L does not mean that the sites have chloride and sulfate values higher than the water quality standards; thus, the impact on aquatic life is unknown. The TDS components and associated source(s) at the sites in Table 17 may be natural (due to surficial geology or soils), but may also be attributed to development including road salt or other pollutants (particularly the more urban sites in the Clinton River and Battle Creek). The WCMP in Michigan concluded that chloride median site concentrations were greatest in southeast Michigan and specifically the Clinton River (EGLE, 2019).

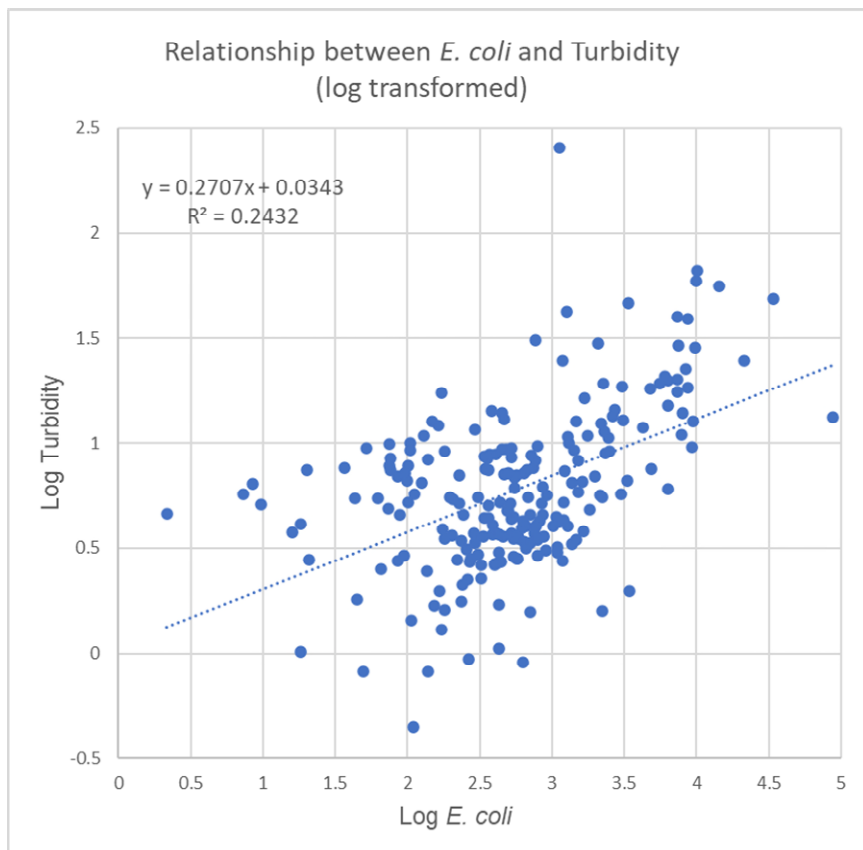


Figure 3. Log transformed *E. coli* concentrations vs. turbidity.



Table 16. Summary of instantaneous D.O. WQS violations for cold (CW) and warmwater (WW) streams in this study.

<b>Watershed</b>	<b>Site ID</b>	<b>Site description</b>	<b>CW or WW</b>	<b>Count of instantaneous violations</b>
Clinton	630630	Clinton River - Cooley Lake Rd.	WW	1
	631284	Trib to Lake Michelson - Seymour Lake Rd.	WW	1
Kalamazoo	030736	Gun River - 116th Ave	CW	2
	130004	Wanadoga Creek - Pennfield Rd	WW	1
	130416	Battle Creek - Burrows Rd	WW	3
	380513	Trib to Spring Arbor Drain - Railroad Access Dr	WW	4
Lower Grand	700699	Trib to Crockery Lake - Gooding St	CW	2
	700701	Sand Creek - Hayes St (west)	CW	4
	700702	Sand Creek - Hayes St (east)	CW	2
	700705	Grand River - US 31	WW	1
Manistee	280429	Fife Lake Creek - Number Two Rd	CW	3
	830238	Trib to Lake Billings - E Main St	CW	1
Pere Marquette-White	530219	Freeman Creek - N Alexander Rd	CW	2
	530223	Big Sable River - N Taylor Rd	CW	5
	530292	Big Sable River - N Darr Rd	CW	1

Table 17. Summary of sites, by watershed, with calculated TDS above the threshold of 500 mg/L.

Watershed	Site ID	Site description	Count of TDS results above 500 mg/L
Au Gres-Rifle	650038	Flowage Creek - S Flowage Lake Rd	3
	650075	Campbell Creek - M 33	4
Clinton	630616	Paint Creek - Adams Rd. (north)	1
	630617	Trout Creek - Adams Rd. (south)	5
	630630	Clinton River - Cooley Lake Rd.	5
	631032	Galloway Creek - Butler Rd.	5
	631041	Trib to Deer Lake - Deerhill Rd.	5
	631077	Sashabaw Creek - Pine Knob Trail	5
	631100	West Branch Stony Creek - Stony Creek Metropark	2
	631280	Clinton River - Riverwoods Trail	5
	631283	Clinton River - Bluegrass Rd.	3
	631285	Paint Creek – Rochester Rd - CR12	4
	631286	Sargent Creek - N. Livernois Rd.	3
	631307	Trib to Duck Lake - Deer Path Rd.	4
Kalamazoo	130175	Battle Creek - Pedestrian Bridge (off Hamblin)	4
	130416	Battle Creek - Burrows Rd	5
	230014	Battle Creek - W Spicerville Hwy	5
	230220	Indian Creek - N Main St	1
	230281	Big Creek - Marshall Rd	2
	380443	Spring Arbor / Concord Drain - N Concord Rd	1
Lower Grand	410856	Grand River - Northland Dr NE	1
	700634	North Branch Crockery Creek - 24th Ave	1
	700702	Sand Creek - Hayes St (east)	2
Pine	290236	Carpenter Creek - Washington Rd	1

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Appendix 1. Site location information including watershed name, 12-digit HUC, Site ID (WQX/Storet) and description, county, coordinates, and weather station . All weather stations are from the Michigan State University weather network ([mawn.geo.msu.edu/](http://mawn.geo.msu.edu/)) except for the West Branch station ([ncdc.noaa.gov/ghcnd-data-access](http://ncdc.noaa.gov/ghcnd-data-access)).

Watershed	12-Digit HUC	Site ID	Site Description	County	Latitude	Longitude	Weather Station
Kalamazoo	040500030102	380442	Spring Arbor / Concord Drain - King Rd	Jackson	42.21831	-84.61447	albion
	040500030102	380443	Spring Arbor / Concord Drain - N Concord Rd	Jackson	42.22999	-84.64045	albion
	040500030102	380513	Trib to Spring Arbor Drain - Railroad Access Dr	Jackson	42.23600	-84.63900	albion
	040500030303	230281	Big Creek - Marshall Rd	Eaton	42.46886	-84.89095	charlotte
	040500030305	230220	Indian Creek - N Main St	Eaton	42.44825	-84.92229	charlotte
	040500030306	230014	Battle Creek - W Spicerville Hwy	Eaton	42.49452	-84.86921	charlotte
	040500030309	130416	Battle Creek - Burrows Rd	Calhoun	42.39184	-85.06634	ceresco
	040500030311	080249	Crooked Brook- Huff Rd	Barry	42.42833	-85.10741	ceresco
	040500030311	080307	Wonadoga Creek - Huff Rd	Barry	42.42825	-85.11728	ceresco
	040500030311	080308	Crooked Brook - Wing Rd	Barry	42.43557	-85.09649	ceresco
	040500030311	130004	Wanadoga Creek - Pennfield Rd	Calhoun	42.37000	-85.12886	ceresco
	040500030312	130175	Battle Creek - Pedestrian Bridge (off Hamblin)	Calhoun	42.32241	-85.19026	ceresco
	040500030702	030736	Gun River - 116th Ave	Allegan	42.53777	-85.56291	kalamazoo
	040500030702	080306	Gun River - Near Lake Outlet - Patterson Rd	Barry	42.58731	-85.54320	kalamazoo
	040500030703	030737	Gun River - 10th St	Allegan	42.47473	-85.64184	kalamazoo
	040500030902	030618	Base Line Creek - 24th St	Allegan	42.42484	-85.77796	oshtemo
	040500030903	030738	Pine Creek - 21st St	Allegan	42.43403	-85.74499	oshtemo
	040500030903	030739	Pine Creek - 101st Ave	Allegan	42.42422	-85.76006	oshtemo
	040500030904	030504	Schnable Brook - M89	Allegan	42.49191	-85.76774	oshtemo
Upper Grand	040500040709	340262	Grand River - Kent St	Ionia	42.85682	-84.91209	charlotte
Lower Grand	040500060312	340024	Grand River - Bridge St	Ionia	42.93319	-85.21335	clarksville
	040500060501	410854	Bear Creek - Meandering Creek Dr NE	Kent	43.05403	-85.48244	belding
	040500060501	410855	Bear Creek - Shiloh Dr NE	Kent	43.05191	-85.54388	sparta
	040500060502	410856	Grand River - Northland Dr NE	Kent	43.06333	-85.57996	sparta
	040500060512	410052	Grand River - M11 -GR06	Kent	42.91522	-85.76702	standale
	040500060601	700546	North Branch Crockery Creek - 40th Ave	Ottawa	43.19484	-85.88927	kentcity
	040500060601	700634	North Branch Crockery Creek - 24th Ave	Ottawa	43.19764	-85.84956	kentcity
	040500060601	700699	Trib to Crockery Lake - Gooding St	Ottawa	43.16233	-85.85330	sparta

Watershed	12-Digit HUC	Site ID	Site Description	County	Latitude	Longitude	Weather Station
Lower Grand	040500060601	700700	Trib to Crockery Lake - 16th Ave	Ottawa	43.16988	-85.82971	sparta
	040500060602	610479	Crockery Creek - Laketon Ave	Muskegon	43.22129	-85.90244	kentcity
	040500060602	610482	Crockery Creek - Shaw Rd	Muskegon	43.28954	-85.86947	kentcity
	040500060602	610819	Ovidhall Lake Creek - Bailey Rd	Muskegon	43.27864	-85.86907	kentcity
	040500060603	610380	Crockery Creek - Ellis Rd	Muskegon	43.16167	-85.96389	kentcity
	040500060603	610476	Rio Grande Cr - Blackmer Rd - RG7A	Muskegon	43.14637	-85.94738	sparta
	040500060603	610508	Crockery Creek - Blackmer	Muskegon	43.17606	-85.94796	kentcity
	040500060604	610507	Crockery Creek - Patterson Rd	Muskegon	43.14407	-85.96622	westolive
	040500060605	700703	Crockery Creek - Fitzgerald St	Ottawa	43.06828	-86.05633	westolive
	040500060701	700702	Sand Creek - Hayes St (east)	Ottawa	43.03105	-85.82200	standale
	040500060702	700701	Sand Creek - Hayes St (west)	Ottawa	43.03111	-85.83050	standale
	040500060703	620218	Sand Creek - Luce St SW	Ottawa	42.94981	-85.84939	standale
	040500060712	700704	Grand River - 231 / Spoonville Trail	Ottawa	43.04011	-86.09258	westolive
	040500060712	700705	Grand River - US 31	Ottawa	43.07467	-86.21827	westolive
Pere Marquette-White	040601010102	530223	Big Sable River - N Taylor Rd	Mason	44.07707	-86.08546	bearlake
	040601010103	530219	Freeman Creek - N Alexander Rd	Mason	44.09540	-86.30820	ludington
	040601010103	530292	Big Sable River - N Darr Rd	Mason	44.12087	-86.26152	ludington
	040601010104	530304	Davis Creek - N Quarterline Rd	Mason	44.08700	-86.33040	ludington
Manistee	040601030203	570108	Hopkins Creek - N Lanning Rd	Missaukee	44.48895	-85.25828	arlene
	040601030204	570106	Hopkins Creek - N Lucas Rd	Missaukee	44.47054	-85.28589	arlene
	040601030206	280429	Fife Lake Creek - Number Two Rd	Grand Traverse	44.51238	-85.37026	arlene
	040601030207	570107	Morrisy Creek - N Seeley Rd	Missaukee	44.42400	-85.33834	arlene
	040601030208	830154	Manton Creek - E 10 Rd	Wexford	44.45373	-85.42611	arlene
	040601030208	830237	Manton Creek - E Main St	Wexford	44.41096	-85.39031	arlene
	040601030208	830238	Trib to Lake Billings - E Main St	Wexford	44.41098	-85.38914	arlene
	040601030209	830239	Silver Creek - E 12 1/2 Rd	Wexford	44.43214	-85.48474	arlene
	040601030209	830240	Buttermilk Creek - E 10 Rd	Wexford	44.45392	-85.46105	arlene
	040601030301	830159	Anderson Creek - W 6 Rd	Wexford	44.48209	-85.62061	arlene
	040601030304	830145	Fletcher Creek - W 12 3/4 Rd	Wexford	44.42785	-85.75570	benzonias
	040601030304	830235	Fletcher Creek - W 4 Rd	Wexford	44.49764	-85.77669	benzonias



Watershed	12-Digit HUC	Site ID	Site Description	County	Latitude	Longitude	Weather Station
Manistee	040601030307	830236	Slagle Creek - W 30 Rd	Wexford	44.30894	-85.71384	arlene
	040601030603	430638	Cool Creek (East Crossing) W 12 Mile Rd	Lake	44.16613	-85.98706	bearlake
	040601030603	430639	Cool Creek (West Crossing) - W 12 Mile Rd	Lake	44.16622	-85.98803	bearlake
Au Gres-Rifle	040801010405	650002	Ogemaw Creek - I 75 BL	Ogemaw	44.26779	-84.21748	West Branch
	040801010405	650121	Rifle Creek - Dam Rd	Ogemaw	44.28122	-84.20590	West Branch
	040801010406	650038	Flowage Creek - S Flowage Lake Rd	Ogemaw	44.25125	-84.20648	West Branch
	040801010406	650075	Campbell Creek - M 33	Ogemaw	44.26371	-84.12564	West Branch
	040801010406	650125	West Branch Rifle River - M 33	Ogemaw	44.25474	-84.12576	West Branch
	040801010407	650097	Rifle River - M 55	Ogemaw	44.27678	-84.07983	West Branch
	040801010410	650098	Silver Creek - Greenwood Rd	Ogemaw	44.18345	-84.05532	West Branch
	040801010410	650126	Rifle River - Greenwood Rd	Ogemaw	44.17940	-84.07333	West Branch
	040801010412	060105	Rifle River - Melita Rd	Arenac	44.07257	-84.01984	West Branch
Pine	040802020308	290226	Pine River - St. Charles Rd	Gratiot	43.30679	-84.82558	entrican
	040802020308	290233	Pine River - Lumberjack Rd - S of Riverdale	Gratiot	43.37221	-84.83573	entrican
	040802020308	290235	Pine River - W Van Buren Rd	Gratiot	43.36486	-84.83960	entrican
	040802020308	290236	Carpenter Creek - Washington Rd	Gratiot	43.29224	-84.83123	entrican
	040802020308	590364	Pine River - E McBrides Rd	Montcalm	43.34989	-84.85012	entrican
	040802020308	590364	Pine River - E McBrides Rd	Montcalm	43.34989	-84.85012	mecosta
	040802020308	590371	Unnamed Trib to Pine (W of Elm Hall) - NE Kendall Ave	Montcalm	43.36464	-84.84933	entrican
	040802020308	EHSS	Storm Sewer (Elm Hall) S side of W Van Buren	Gratiot	43.36485	-84.83912	entrican
	040802020309	290234	Pine River - Ferris Rd	Gratiot	43.29935	-84.81580	entrican
Clinton	040900030101	631041	Trib to Deer Lake - Deerhill Rd.	Oakland	42.74127	-83.44540	commercetwp
	040900030101	631283	Clinton River - Bluegrass Rd.	Oakland	42.74351	-83.42501	commercetwp
	040900030102	631307	Trib to Duck Lake - Deer Path Rd.	Oakland	42.79700	-83.28005	romeo
	040900030104	631280	Clinton River - Riverwoods Trail	Oakland	42.63972	-83.21811	commercetwp
	040900030105	631284	Trib to Lake Michelson - Seymour Lake Rd.	Oakland	42.82370	-83.30090	lapeer
	040900030107	631077	Sashabaw Creek - Pine Knob Trail	Oakland	42.71423	-83.35384	commercetwp
	040900030108	630630	Clinton River - Cooley Lake Rd.	Oakland	42.62757	-83.39490	commercetwp
	040900030108	631100	West Branch Stony Creek - Stony Creek Metropark	Oakland	42.73150	-83.10186	romeo
	040900030109	500554	Stony Creek - Inwood Rd	Macomb	42.76342	-83.07498	romeo
	040900030110	630616	Paint Creek - Adams Rd. (north)	Oakland	42.75058	-83.19738	romeo
	040900030110	630617	Trout Creek - Adams Rd. (south)	Oakland	42.74733	-83.19716	romeo

Watershed	12-Digit HUC	Site ID	Site Description	County	Latitude	Longitude	Weather Station
Clinton	040900030110	631285	Paint Cr- Rochester Rd - CR12	Oakland	42.68393	-83.13453	romeo
	040900030110	631286	Sargent Creek - N. Livernois Rd.	Oakland	42.68579	-83.15342	romeo
	040900030111	631032	Galloway Creek - Butler Rd.	Oakland	42.65950	-83.20043	commercetwp

Appendix 2. *E. coli* results by 10-digit Hydrologic Unit Code (HUC), including prior precipitation (in inches) and relative water level change (in cm). Relative water level change was calculated using the lowest levels recorded during the study as the zero baseline. Exceedances of the WQS are indicated in light red (TBC) and black (PBC).

	L	C	R	Daily Geometric Mean	30-Day Geometric Mean	24-Hour Prior Rain	48-Hour Prior Rain	Relative Water Level Change
Watershed:	Kalamazoo			North Branch Kalamazoo River				
8-Digit HUC:	04050003			10-Digit HUC:		0405000301		
Site ID/Storet:	380442	Description	Spring Arbor / Concord Drain - King Rd					
5/14/2019	10	30	20	18		0.00	0.24	5
5/21/2019	40	70	100	65		0.00	0.45	5
5/28/2019	50	120	90	81		0.10	0.46	2
6/4/2019	220	100	210	167		0.00	0.00	0
6/11/2019	390	280	310	323	88	0.00	1.06	3
Site ID/Storet:	380443	Description	Spring Arbor / Concord Drain - N Concord Rd					
5/14/2019	80	120	110	102		0.00	0.24	6
5/21/2019	190	150	210	182		0.00	0.45	0
5/28/2019	320	370	490	387		0.10	0.46	0
6/4/2019	320	260	350	308		0.00	0.00	2
6/11/2019	500	390	420	434	249	0.00	1.06	14
Site ID/Storet:	380513	Description	Trib to Spring Arbor Drain - Railroad Access Dr					
5/14/2019	40	50	60	49		0.00	0.24	
5/21/2019	160	140	120	139		0.00	0.45	
5/28/2019	120	200	90	129		0.10	0.46	
6/4/2019	120	100	110	110		0.00	0.00	
6/11/2019	120	100	100	106	101	0.00	1.06	
Watershed:	Kalamazoo			Battle Creek				
8-Digit HUC:	04050003			10-Digit HUC:		0405000303		
Site ID/Storet:	230281	Description	Big Creek - Marshall Rd					
7/30/2019	810	780	810	800		0.26	0.26	2
8/6/2019	1,100	1,600	600	1,018		0.10	0.12	0
8/12/2019	490	430	370	794		0.00	0.00	0
8/20/2019	670	540	560	587		0.71	0.76	2
8/27/2019	800	830	850	826	793	0.53	0.53	0

	L	C	R	Daily Geometric Mean	30-Day Geometric Mean	24-Hour Prior Rain	48-Hour Prior Rain	Relative Water Level Change
Site ID/Storet:	230220	Description	Indian Creek - N Main St					
7/30/2019	780	960	880	870		0.26	0.26	
8/6/2019	1,800	700	1,400	1,208		0.10	0.12	
8/12/2019	800	720	870	363		0.00	0.00	
8/20/2019	1,500	810	1,200	1,134		0.71	0.76	
8/27/2019	1,400	940	1,300	1,196	876	0.53	0.53	
Site ID/Storet:	230014	Description	Battle Creek - W Spicerville Hwy					
7/30/2019	530	510	590	542		0.26	0.26	8
8/6/2019	810	690	620	702		0.10	0.12	4
8/12/2019	390	340	360	427		0.00	0.00	3
8/20/2019	590	640	510	577		0.71	0.76	0
8/27/2019	1,300	1,400	2,300	1,612	686	0.53	0.53	4
Site ID/Storet:	130416	Description	Battle Creek - Burrows Rd					
7/30/2019	190	250	180	204		0.10	0.10	20
8/6/2019	270	340	220	272		0.00	0.00	12
8/12/2019	270	180	180	206		0.00	0.00	10
8/20/2019	200	240	290	241		0.00	0.19	5
8/27/2019	460	590	520	521	270	0.30	0.30	0
Site ID/Storet:	080249	Description	Crooked Brook- Huff Rd					
7/30/2019	1,300	1,700	2,000	1,641		0.10	0.10	3
8/6/2019	2,800	1,700	2,300	2,220		0.05	0.05	1
8/12/2019	1,100	840	1,400	1,090		0.00	0.00	0
8/20/2019	1,000	1,400	1,200	1,189		0.00	0.19	0
8/27/2019	2,400	1,700	2,500	2,169	1,592	0.30	0.30	2
Site ID/Storet:	080307	Description	Wonadoga Creek - Huff Rd					
7/30/2019	380	360	270	333		0.10	0.10	3
8/6/2019	360	390	450	398		0.02	0.02	2
8/12/2019	380	380	450	402		0.00	0.00	2
8/20/2019	610	670	720	665		0.00	0.19	0
8/27/2019	2,900	2,700	3,400	2,986	638	0.30	0.30	4
Site ID/Storet:	080308	Description	Crooked Brook - Wing Rd					
8/6/2019	1,700	1,600	2,200	1,816		0.07	0.07	
8/12/2019	850	830	660	775		0.00	0.00	
8/20/2019	600	550	570	573		0.00	0.19	
8/27/2019	1,200	1,400	2,100	1,522		0.30	0.30	

	L	C	R	Daily Geometric Mean	30-Day Geometric Mean	24-Hour Prior Rain	48-Hour Prior Rain	Relative Water Level Change
Site ID/Storet:	130004	Description	Wanadoga Creek - Pennfield Rd					
7/30/2019	370	350	430	382		0.10	0.10	8
8/6/2019	2,500	1,100	800	1,301		0.00	0.00	3
8/12/2019	330	380	380	363		0.00	0.00	0
8/20/2019	280	310	330	306		0.00	0.19	30
8/27/2019	740	760	770	757	530	0.30	0.30	1
Site ID/Storet:	130175	Description	Battle Creek - Pedestrian Bridge (off Hamblin)					
7/30/2019	190	280	250	237		0.10	0.10	
8/6/2019	6,600	6,800	5,700	6,348		0.00	0.00	
8/12/2019	1,100	2,400	4,200	2,230		0.00	0.00	
8/20/2019	630	480	820	628		0.00	0.19	
8/27/2019	1,200	1,100	1,100	1,132	1,190	0.30	0.30	
Watershed:	Kalamazoo			Gun River				
8-Digit HUC:	04050003			10-Digit HUC:		0405000307		
Site ID/Storet:	030736	Description	Gun River - 116th Ave					
7/29/2019	1,300	980	960	1,069		0.00	0.00	12
8/5/2019	390	790	770	619		0.14	0.14	6
8/13/2019	820	940	970	908		0.00	0.00	0
8/19/2019	630	650	690	656		0.22	0.22	2
8/26/2019	480	540	450	489	719	0.07	0.07	0
Site ID/Storet:	080306	Description	Gun River - Near Lake Outlet - Patterson Rd					
7/29/2019	60	50	30	45		0.00	0.00	10
8/5/2019	190	170	180	180		0.14	0.14	7
8/13/2019	210	150	160	171		0.00	0.00	7
8/19/2019	260	240	300	266		0.21	0.22	5
8/26/2019	370	550	380	426	173	0.09	0.09	0
Site ID/Storet:	030737	Description	Gun River - 10th St					
7/29/2019	650	720	770	712		0.00	0.00	11
8/5/2019	530	550	560	547		0.14	0.14	5
8/13/2019	410	360	390	386		0.00	0.00	1
8/19/2019	500	620	830	636		0.22	0.22	6
8/26/2019	530	490	610	541	553	0.06	0.06	0

				Daily Geometric Mean	30-Day Geometric Mean	24-Hour Prior Rain	48-Hour Prior Rain	Relative Water Level Change
L		C		R				
Watershed:	Kalamazoo			Kalamazoo River				
8-Digit HUC:	04050003		10-Digit HUC:		0405000309			
Site ID/Storet:	030618	Description	Base Line Creek - 24th St					
7/29/2019	390	430	410	410		0.00	0.01	7
8/5/2019	790	670	860	769		0.00	0.00	3
8/13/2019	440	290	390	368		0.00	0.00	3
8/19/2019	640	860	760	748		0.15	0.15	4
8/26/2019	570	500	580	549	544	0.00	0.00	0
Site ID/Storet:	030738	Description	Pine Creek - 21st St					
7/29/2019	400	400	480	425		0.00	0.01	7
8/5/2019	220	260	350	272		0.00	0.00	4
8/13/2019	220	360	220	259		0.00	0.00	3
8/19/2019	440	470	420	443		0.15	0.15	4
8/26/2019	240	250	280	256	321	0.00	0.00	0
Site ID/Storet:	030739	Description	Pine Creek - 101st Ave					
7/29/2019	320	420	360	364		0.00	0.01	8
8/5/2019	340	260	290	295		0.00	0.00	3
8/13/2019	410	420	550	456		0.00	0.00	3
8/19/2019	590	440	550	523		0.15	0.15	3
8/26/2019	410	480	700	516	421	0.00	0.00	0
Site ID/Storet:	030504	Description	Schnable Brook - M89					
7/29/2019	440	360	500	429		0.00	0.01	3
8/5/2019	380	340	510	404		0.00	0.00	0
8/13/2019	570	610	570	583		0.00	0.00	0
8/19/2019	700	600	580	625		0.15	0.15	1
8/26/2019	520	350	320	388	476	0.03	0.03	0

	L	C	R	Daily Geometric Mean	30-Day Geometric Mean	24-Hour Prior Rain	48-Hour Prior Rain	Relative Water Level Change
Watershed:	Upper Grand			Sebewa Creek-Grand River				
8-Digit HUC:	04050004			10-Digit HUC:		0405000407		
Site ID/Storet:	340262	Description	Grand River - Kent St					
6/3/2019	1,500	1,000	1,100	1,182		0.00	0.55	
6/10/2019	470	420	460	449		0.96	1.08	
6/17/2019	2,800	2,200	1,900	2,270		0.07	0.27	
6/24/2019	210	190	130	173		0.16	0.16	
7/1/2019	70	70	50	63	420	0.00	0.00	
7/8/2019	70	150	100	102	257	0.00	0.00	
7/15/2019	40	60	70	55	169	0.00	0.00	
7/24/2019	140	90	50	86	88	0.00	0.00	
Watershed:	Lower Grand			Prairie Creek-Grand River				
8-Digit HUC:	04050006			10-Digit HUC:		0405000603		
Site ID/Storet:	340024	Description	Grand River - Bridge St					
6/3/2019	900	1,300	1,700	1,258		0.00	0.41	
6/10/2019		180	150			0.48	0.79	
6/17/2019	80	140	100	104		0.00	0.04	
6/24/2019	40	300	80	99		0.08	0.08	
7/1/2019	60	80	90	76		0.00	0.00	
7/8/2019	130	120	210	149		0.00	0.15	
7/15/2019	70	100	100	89	100	0.00	0.00	
7/24/2019	140	90	50	86	97	0.00	0.00	
Watershed:	Lower Grand			Rush Creek-Grand River				
8-Digit HUC:	04050006			10-Digit HUC:		0405000605		
Site ID/Storet:	410854	Description	Bear Creek - Meandering Creek Dr NE					
6/6/2019	250	240	240	243		0.00	0.04	1
6/13/2019	6,200	7,400	9,000	7,447		0.53	0.53	11
6/20/2019	1,300	2,000	2,100	1,761		0.44	0.44	7
6/27/2019	630	510	520	551		0.00	0.00	0
7/2/2019	13,000	17,000	13,000	14,216	1,903	0.02	0.02	1

				Daily Geometric Mean	30-Day Geometric Mean	24-Hour Prior Rain	48-Hour Prior Rain	Relative Water Level Change
L	C	R						
Site ID/Storet:	410855	Description	Bear Creek - Shiloh Dr NE					
6/6/2019	150	180	280	196		0.00	0.04	3
6/13/2019	12,000	7,600	7,200	8,692		0.86	0.86	20
6/20/2019	3,300	3,400	2,500	3,038		0.62	0.62	14
6/27/2019	480	490	530	500		0.00	0.07	1
7/2/2019	3,400	2,900	3,000	3,093	1,516	0.32	0.32	0
Site ID/Storet:	410856	Description	Grand River - Northland Dr NE					
6/3/2019	730	820	770	772		0.00	0.20	
6/10/2019	200	430	450	338		0.75	0.93	
6/17/2019	70	60	100	75		0.00	0.00	
6/24/2019	160	70	80	96		0.15	0.15	
7/1/2019	30	20	1	8	110	0.00	0.00	
7/8/2019	140	30	100	75	69	0.00	0.32	
7/15/2019	40	40	50	43	46	0.00	0.00	
7/24/2019	30	30	1	10	30	0.00	0.00	
Site ID/Storet:	410052	Description	Grand River - M11 -GR06					
6/3/2019	230	160	120	164		0.00	0.41	
6/10/2019	430	540	610	521		0.79	0.97	
6/17/2019	140	170	110	138		0.00	0.00	
6/24/2019	190	160	190	179		0.42	0.42	
7/1/2019	10	80	60	36	150	0.00	0.00	
7/8/2019	330	270	280	292	169	0.00	0.22	
7/15/2019	100	120	70	94	120	0.00	0.00	
7/24/2019	160	100	160	137	120	0.00	0.00	
Watershed:	Lower Grand			Crockery Creek				
8-Digit HUC:	04050006			10-Digit HUC:		0405000606		
Site ID/Storet:	700546	Description	North Branch Crockery Creek - 40th Ave					
9/3/2019	1,300	1,500	1,100	1,290		0.01	0.02	1
9/10/2019	6,300	7,300	790	3,312		0.25	0.26	0
9/17/2019	640	770	920	768		0.00	0.00	6
9/24/2019	8,500	9,600	10,000	9,345		0.00	0.70	11
9/30/2019	4,200	7,300	8,200	6,311	2,866	0.29	0.45	27



	L	C	R	Daily Geometric Mean	30-Day Geometric Mean	24-Hour Prior Rain	48-Hour Prior Rain	Relative Water Level Change
Site ID/Storet:	700634	Description	North Branch Crockery Creek - 24th Ave					
9/3/2019	780	660	670	701		0.01	0.02	0
9/10/2019	1,300	1,500	1,300	1,364		0.23	0.24	1
9/17/2019	1,400	1,300	1,700	1,457		0.00	0.00	10
9/24/2019	8,300	8,600	6,900	7,897		0.00	0.70	20
9/30/2019	6,300	5,900	5,800	5,996	2,311	0.31	0.45	33
Site ID/Storet:	700699	Description	Trib to Crockery Lake - Gooding St					
6/6/2019	100	200	180	153		0.00	0.04	2
6/13/2019	1,300	900	3,000	1,520		0.90	0.90	9
6/20/2019	1,100	1,200	1,000	1,097		0.72	0.72	5
6/27/2019	380	300	290	321		0.00	0.07	1
7/2/2019	3,300	3,500	3,500	3,432	776	0.32	0.32	0
Site ID/Storet:	700700	Description	Trib to Crockery Lake - 16th Ave					
6/6/2019	490	640	450	521		0.00	0.04	1
6/13/2019	1,500	24,000	28,000	10,027		0.90	0.90	9
6/20/2019	30,000	38,000	35,000	34,171		0.71	0.71	4
6/27/2019	2,600	1,800	2,200	2,175		0.00	0.07	1
7/2/2019	4,400	5,200	4,700	4,755	4,500	0.32	0.32	0
Site ID/Storet:	610479	Description	Crockery Creek - Laketon Ave					
9/3/2019	530	460	520	502		0.01	0.02	
9/10/2019	2,000	2,200	1,800	1,993		0.30	0.31	
9/17/2019	440	410	520	454		0.00	0.00	
9/24/2019	1,300	1,000	1,600	1,277		0.00	0.70	
9/30/2019	2,300	2,500	3,400	2,694	1,094	0.26	0.45	
Site ID/Storet:	610482	Description	Crockery Creek - Shaw Rd					
9/3/2019	1,700	1,000	1,100	1,232		0.01	0.02	0
9/10/2019	2,000	2,600	2,300	2,287		0.21	0.22	0
9/17/2019	680	750	720	716		0.00	0.00	9
9/24/2019	750	750	910	800		0.00	0.71	7
9/30/2019	2,400	2,600	2,000	2,320	1,302	0.43	0.45	21

	L	C	R	Daily Geometric Mean	30-Day Geometric Mean	24-Hour Prior Rain	48-Hour Prior Rain	Relative Water Level Change
Site ID/Storet:	610819	Description	Ovidhall Lake Creek - Bailey Rd					
9/3/2019	840	960	800	864		0.01	0.02	1
9/10/2019	1,900	1,800	940	1,476		0.22	0.23	0
9/17/2019	520	390	540	478		0.00	0.00	7
9/24/2019	1,300	1,400	1,400	1,366		0.00	0.71	7
9/30/2019	2,400	2,900	2,600	2,625	1,170	0.40	0.45	14
Site ID/Storet:	610380	Description	Crockery Creek - Ellis Rd					
9/30/2019	5,200	5,700	8,600	6,341		0.19	0.45	0
Site ID/Storet:	610476	Description	Rio Grande Cr - Blackmer Rd - RG7A					
9/3/2019	190	200	140	175		0.01	0.01	0
9/10/2019	1,300	1,500	2,400	1,673		0.32	0.33	2
9/17/2019	460	420	400	426		0.00	0.00	6
9/24/2019	7,800	7,200	7,200	7,395		0.00	1.29	10
9/30/2019	9,200	9,400	11,000	9,835	1,553	0.09	0.59	20
Site ID/Storet:	610508	Description	Crockery Creek - Blackmer					
9/30/2019	9,500	7,300	9,600	8,732		0.23	0.45	0
Site ID/Storet:	610507	Description	Crockery Creek - Patterson Rd					
9/3/2019	300	260	310	289		0.02	0.02	0
9/10/2019	7,200	12,000	9,900	9,493		0.25	0.25	2
9/17/2019	540	490	390	469		0.00	0.00	20
9/24/2019	85,000	93,000	83,000	86,895		0.00	1.14	29
9/30/2019	9,700	9,800	6,100	8,339	3,926	0.18	0.65	65
Site ID/Storet:	700703	Description	Crockery Creek - Fitzgerald St					
9/3/2019	160	210	390	236		0.02	0.02	1
9/10/2019	630	450	660	572		0.25	0.25	0
9/17/2019	410	330	300	344		0.00	0.00	33
9/24/2019	5,800	5,000	5,800	5,520		0.00	1.14	50
9/30/2019	7,900	6,400	7,900	7,365	1,135	0.12	0.65	97

				Daily Geometric Mean	30-Day Geometric Mean	24-Hour Prior Rain	48-Hour Prior Rain	Relative Water Level Change
	L	C	R					
Watershed:	Lower Grand			Grand River				
8-Digit HUC:	04050006			10-Digit HUC:		0405000607		
Site ID/Storet:	700702	Description	Sand Creek - Hayes St (east)					
6/6/2019	310	370	340	339		0.00	0.18	4
6/13/2019	2,200	2,900	2,500	2,517		0.68	0.68	16
6/20/2019	4,400	4,000	4,300	4,230		0.59	0.59	16
6/27/2019	810	880	880	856		0.00	0.01	0
7/2/2019	5,200	5,700	3,900	4,871	1,720	0.62	0.62	1
Site ID/Storet:	700701	Description	Sand Creek - Hayes St (west)					
6/6/2019	660	730	670	686		0.00	0.18	7
6/13/2019	24,000	5,900	3,600	7,988		0.68	0.68	24
6/20/2019	22,000	25,000	18,000	21,472		0.57	0.57	19
6/27/2019	1,200	1,700	1,400	1,419		0.00	0.01	0
7/2/2019	6,100	9,500	7,000	7,403	4,153	0.62	0.62	2
Site ID/Storet:	620218	Description	Sand Creek - Luce St SW					
6/6/2019	70	110	180	111		0.00	0.18	43
6/13/2019	10,000	9,600	10,000	9,865		0.72	0.72	37
6/20/2019	1,600	2,800	2,000	2,077		0.64	0.64	38
6/27/2019	230	280	180	226		0.00	0.01	111
7/2/2019	3,300	3,300	3,500	3,365	1,117	0.62	0.62	0
Site ID/Storet:	700704	Description	Grand River - 231 / Spoonville Trail					
6/3/2019	290	560	610	463		0.00	0.49	
6/10/2019	150	430	700	356		1.38	1.38	
6/17/2019	80	70	80	77		0.00	0.21	
6/24/2019	100	130	170	130		0.20	0.20	
7/1/2019	10	40	20	20	127	0.00	0.00	
7/8/2019	1,800	3,100	2,600	2,439	177	0.00	0.59	
7/15/2019	30	10	30	21	100	0.00	0.00	
7/24/2019	10	20	20	16	73	0.00	0.00	

	L	C	R	Daily Geometric Mean	30-Day Geometric Mean	24-Hour Prior Rain	48-Hour Prior Rain	Relative Water Level Change
Site ID/Storet:	700705	Description	Grand River - US 31					
6/3/2019	260	290	160	229		0.00	0.50	
6/10/2019	120	110	30	73		1.37	1.37	
6/17/2019	50	40	70	52		0.00	0.21	
6/24/2019	160	100	70	104		0.20	0.20	
7/1/2019	10	20	30	18	70	0.00	0.00	
7/8/2019	110	110	160	125	62	0.00	0.59	
7/15/2019	1	20	20	7	39	0.00	0.00	
7/24/2019	10	1	1	2	21	0.00	0.00	
Watershed:	Pere Marquette-White			Big Sable River				
8-Digit HUC:	04060101			10-Digit HUC:		0406010101		
Site ID/Storet:	530223	Description	Big Sable River - N Taylor Rd					
7/16/2019	84	91	89	88		0.02	0.02	0
7/23/2019	124	138	108	122		0.00	0.00	
7/30/2019	60	54	58	57		0.18	0.18	44
8/6/2019	291	238	345	238		0.63	0.63	35
8/14/2019	51	54	57	54	99	0.00	0.00	21
Site ID/Storet:	530219	Description	Freeman Creek - N Alexander Rd					
7/16/2019	344	308	308	319		0.00	0.00	0
7/23/2019	2,420	2,420	2,420	2,420		0.00	0.00	64
7/30/2019	411	613	436	479		0.00	0.00	8
8/6/2019	1,204	1,733	1,733	1,535		0.91	0.91	6
8/14/2019	308	345	345	332	716	0.00	0.00	4
Site ID/Storet:	530292	Description	Big Sable River - N Darr Rd					
7/16/2019	99	93	130	106		0.00	0.00	0
7/23/2019	260	162	228	213		0.00	0.00	156
7/30/2019	160	115	162	143		0.00	0.00	30
8/6/2019	276	387	387	346		0.91	0.91	17
8/14/2019	96	69	63	75	153	0.00	0.00	10
Site ID/Storet:	530304	Description	Davis Creek - N Quarterline Rd					
7/16/2019	649	435	488	517		0.00	0.00	0
7/23/2019	816	866	687	786		0.00	0.00	47
7/30/2019	387	435	517	443		0.00	0.00	43
8/6/2019	2,420	1,733	2,420	2,165		0.91	0.91	44
8/14/2019	214	214	276	233	619	0.00	0.00	41

				Daily Geometric Mean	30-Day Geometric Mean	24-Hour Prior Rain	48-Hour Prior Rain	Relative Water Level Change
L		C		R				
Watershed:	Manistee			Silver Creek-Manistee River				
8-Digit HUC:	04060103		10-Digit HUC:			0406010302		
Site ID/Storet:	570108	Description	Hopkins Creek - N Lanning Rd					
7/17/2019	41	59	49	49		0.00	0.04	8
7/24/2019	41	28	25	30		0.00	0.00	8
7/31/2019	21	19	33	24		0.00	0.15	9
8/7/2019	23	22	18	21		0.01	0.35	4
8/15/2019	33	31	40	34	30	0.00	0.00	0
Site ID/Storet:	570106	Description	Hopkins Creek - N Lucas Rd					
7/17/2019	40	39	51	43		0.00	0.03	3
7/24/2019	51	68	75	64		0.00	0.00	4
7/31/2019	61	75	86	73		0.00	0.07	4
8/7/2019	91	83	69	80		0.01	0.35	0
8/15/2019	88	66	59	70	65	0.00	0.00	0
Site ID/Storet:	280429	Description	Fife Lake Creek - Number Two Rd					
7/17/2019	93	66	69	75		0.00	0.06	1
7/24/2019	27	30	22	26		0.00	0.00	13
7/31/2019	40	28	30	32		0.00	0.22	2
8/7/2019	24	30	31	28		0.01	0.35	2
8/15/2019	28	20	24	24	33	0.00	0.00	0
Site ID/Storet:	570107	Description	Morrisy Creek - N Seeley Rd					
7/17/2019	81	133	120	109		0.00	0.03	0
7/24/2019	88	111	150	114		0.00	0.00	1
7/31/2019	114	152	91	116		0.00	0.03	1
8/7/2019	102	91	86	93		0.00	0.35	0
8/15/2019	54	51	55	53	93	0.00	0.00	0
Site ID/Storet:	830154	Description	Manton Creek - E 10 Rd					
7/17/2019	70	99	93	86		0.00	0.00	3
7/24/2019	52	42	36	43		0.00	0.00	3
7/31/2019	50	50	59	53		0.00	0.03	3
8/7/2019	50	51	38	46		0.00	0.35	0
8/15/2019	48	59	34	46	53	0.00	0.00	0

				Daily Geometric Mean	30-Day Geometric Mean	24-Hour Prior Rain	48-Hour Prior Rain	Relative Water Level Change
L	C	R						
Site ID/Storet:	830237	Description	Manton Creek - E Main St					
7/17/2019	99	84	86	89		0.00	0.00	0
7/24/2019	50	58	68	58		0.00	0.00	1
7/31/2019	150	93	88	107		0.00	0.03	2
8/7/2019	73	81	70	75		0.00	0.35	3
8/15/2019	44	66	58	55	75	0.00	0.00	3
Site ID/Storet:	830238	Description	Trib to Lake Billings - E Main St					
7/17/2019	35	48	36	39		0.00	0.00	3
7/24/2019	18	22	21	20		0.00	0.00	2
7/31/2019	41	49	32	40		0.00	0.03	2
8/7/2019	47	57	55	53		0.00	0.35	2
8/15/2019	36	34	25	31	35	0.00	0.00	0
Site ID/Storet:	830239	Description	Silver Creek - E 12 1/2 Rd					
7/17/2019	86	96	91	91		0.00	0.00	1
7/24/2019	93	89	91	91		0.00	0.00	1
7/31/2019	75	99	88	87		0.00	0.03	2
8/7/2019	60	52	50	54		0.00	0.35	2
8/15/2019	53	63	79	64	76	0.00	0.00	0
Site ID/Storet:	830240	Description	Buttermilk Creek - E 10 Rd					
7/17/2019	48	91	54	62		0.00	0.00	1
7/24/2019	88	60	93	79		0.00	0.00	2
7/31/2019	77	70	55	67		0.00	0.03	0
8/7/2019	71	88	78	79		0.00	0.35	1
8/15/2019	120	105	119	114	78	0.00	0.00	2
Watershed:	Manistee			Peterson Creek-Manistee River				
8-Digit HUC:	04060103			10-Digit HUC:		0406010303		
Site ID/Storet:	830159	Description	Anderson Creek - W 6 Rd					
7/17/2019	30	23	30	27		0.00	0.00	12
7/23/2019	20	23	20	21		0.00	0.00	0
7/31/2019	39	17	16	22		0.00	0.03	8
8/7/2019	25	16	15	18		0.00	0.35	6
8/15/2019	13	10	7	10	19	0.00	0.00	6

				Daily Geometric Mean	30-Day Geometric Mean	24-Hour Prior Rain	48-Hour Prior Rain	Relative Water Level Change
L	C	R						
Site ID/Storet:	830145	Description	Fletcher Creek - W 12 3/4 Rd					
7/16/2019	276	299	365	311		0.06	1.16	9
7/23/2019	158	179	194	176		0.00	0.00	5
7/30/2019	210	179	140	174		0.00	0.00	9
8/6/2019	326	345	365	345		0.65	0.65	6
8/14/2019	308	152	152	192	229	0.00	0.00	0
Site ID/Storet:	830235	Description	Fletcher Creek - W 4 Rd					
7/16/2019	687	816	921	802		0.06	1.16	5
7/23/2019	148	130	155	144		0.00	0.00	5
7/30/2019	91	113	102	101		0.00	0.00	4
8/6/2019	113	105	102	106		0.65	0.65	4
8/14/2019	261	387	345	327	210	0.00	0.00	0
Site ID/Storet:	830236	Description	Slagle Creek - W 30 Rd					
7/16/2019	16	12	20	16		0.00	0.22	0
7/23/2019	31	31	46	35		0.00	0.00	10
7/30/2019	21	28	23	24		0.03	0.22	11
8/6/2019	329	206	276	265		0.35	0.35	2
8/14/2019	12	21	22	18	36	0.00	0.00	9
Watershed:	Manistee			Little Manistee River				
8-Digit HUC:	04060103			10-Digit HUC:		0406010306		
Site ID/Storet:	430638	Description	Cool Creek (East Crossing) W 12 Mile Rd					
7/16/2019	34	49	46	42		0.00	0.02	2
7/23/2019	28	47	30	34		0.00	0.00	4
7/30/2019	22	26	24	24		0.17	0.18	3
8/6/2019	27	31	28	28		0.63	0.63	3
8/14/2019	47	49	64	53	35	0.00	0.00	0
Site ID/Storet:	430639	Description	Cool Creek (West Crossing) - W 12 Mile Rd					
7/16/2019	365	272	461	358		0.00	0.02	3
7/23/2019	72	76	80	76		0.00	0.00	4
7/30/2019	33	40	60	43		0.17	0.18	2
8/6/2019	157	130	137	141		0.63	0.63	4
8/14/2019	172	345	980	388	145	0.00	0.00	0

	L	C	R	Daily Geometric Mean	30-Day Geometric Mean	24-Hour Prior Rain	48-Hour Prior Rain	Relative Water Level Change
Watershed:	Au Gres-Rifle			Rifle River				
8-Digit HUC:	04080101		10-Digit HUC:		0408010104			
Site ID/Storet:	650002	Description	Ogemaw Creek - I 75 BL					
7/15/2019	411	649	411	478		0.00	0.00	1
7/22/2019	980	866	816	885		0.77	1.07	2
7/29/2019	461	517	579	517		0.20	0.20	2
8/5/2019	687	687	548	637		0.15	0.15	2
8/13/2019	345	488	308	373	553	0.07	0.07	0
Site ID/Storet:	650121	Description	Rifle Creek - Dam Rd					
7/15/2019	138	110	142	129		0.00	0.00	1
7/22/2019	172	155	167	165		0.77	1.07	5
7/29/2019	96	108	99	101		0.20	0.20	5
8/5/2019	187	155	157	166		0.15	0.15	1
8/13/2019	249	167	186	198	148	0.07	0.07	0
Site ID/Storet:	650038	Description	Flowage Creek - S Flowage Lake Rd					
7/15/2019	105	59	111	88		0.00	0.00	2
7/22/2019	172	201	192	188		0.77	1.07	3
7/29/2019	62	59	64	62		0.20	0.20	3
8/5/2019	36	58	49	47		0.15	0.15	3
8/13/2019	37	40	62	45	74	0.07	0.07	0
Site ID/Storet:	650075	Description	Campbell Creek - M 33					
7/15/2019	201	236	276	236		0.00	0.00	1
7/22/2019	1,414	921	921	1,062		0.77	1.07	3
7/29/2019	525	548	613	561		0.20	0.20	2
8/5/2019	517	411	548	488		0.15	0.15	2
8/13/2019	205	167	179	183	416	0.07	0.07	0
Site ID/Storet:	650125	Description	West Branch Rifle River - M 33					
7/15/2019	66	76	71	71		0.00	0.00	1
7/22/2019	172	219	308	226		0.77	1.07	6
7/29/2019	104	88	96	96		0.20	0.20	6
8/5/2019	61	84	93	78		0.15	0.15	1
8/13/2019	138	120	96	116	107	0.07	0.07	0



			Daily Geometric Mean		30-Day Geometric Mean	24-Hour Prior Rain	48-Hour Prior Rain	Relative Water Level Change
L	C	R						
Site ID/Storet:	650097	Description	Rifle River - M 55					
7/15/2019	75	51	62	62		0.00	0.00	0
7/22/2019	308	210	308	271		0.77	1.07	8
7/29/2019	461	488	461	470		0.20	0.20	9
8/5/2019	79	88	91	86		0.15	0.15	3
8/13/2019	111	91	111	104	148	0.07	0.07	1
Site ID/Storet:	650098	Description	Silver Creek - Greenwood Rd					
7/15/2019	308	308	365	326		0.00	0.00	11
7/22/2019	461	488	548	498		0.77	1.07	10
7/29/2019	579	687	649	637		0.20	0.20	8
8/5/2019	228	222	461	286		0.15	0.15	8
8/13/2019	308	378	328	337	398	0.07	0.07	0
Site ID/Storet:	650126	Description	Rifle River - Greenwood Rd					
7/15/2019	83	115	115	103		0.00	0.00	2
7/22/2019	687	613	488	590		0.77	1.07	13
7/29/2019	687	687	649	674		0.20	0.20	12
8/5/2019	104	108	75	94		0.15	0.15	3
8/13/2019	54	64	82	66	191	0.07	0.07	0
Site ID/Storet:	060105	Description	Rifle River - Melita Rd					
7/15/2019	49	42	49	46		0.00	0.00	9
7/22/2019	727	1,203	727	860		0.77	1.07	28
7/29/2019	1,733	2,419	1,986	2,027		0.20	0.20	24
8/5/2019	108	122	118	116		0.15	0.15	8
8/13/2019	46	56	55	52	217	0.07	0.07	0
Watershed:	Pine	Honeyoey Creek-Pine Creek						
8-Digit HUC:	04080202	10-Digit HUC: 0408020203						
Site ID/Storet:	290226	Description	Pine River - St. Charles Rd					
9/25/2019	970	950	870	929		0.00	0.00	
Site ID/Storet:	290233	Description	Pine River - Lumberjack Rd - S of Riverdale					
9/25/2019	510	580	620	568		0.00	0.00	
Site ID/Storet:	290235	Description	Pine River - W Van Buren Rd					
9/25/2019	590	690	630	635		0.00	0.00	
Site ID/Storet:	290236	Description	Carpenter Creek - Washington Rd					
9/25/2019	650	480	520	545		0.00	0.00	

	L	C	R	Daily Geometric Mean	30-Day Geometric Mean	24-Hour Prior Rain	48-Hour Prior Rain	Relative Water Level Change
Site ID/Storet:	590364	Description	Pine River - E McBrides Rd					
9/25/2019	650	660	710	673		0.00	0.00	27
Site ID/Storet:	590371	Description	Unnamed Trib to Pine (W of Elm Hall) - NE Kendall Ave					
9/25/2019	260	180	230	221		0.00	0.00	
Site ID/Storet:	EHSS	Description	Storm Sewer (Elm Hall) S side of W Van Buren					
9/25/2019	73,000	85,000						
Site ID/Storet:	290234	Description	Pine River - Ferris Rd					
9/25/2019	800	890	860	849		0.00	0.00	
Watershed:	Clinton			Stony Creek-Clinton River				
8-Digit HUC:	04090003			10-Digit HUC:	0409000301			
Site ID/Storet:	631041	Description	Trib to Deer Lake - Deerhill Rd.					
8/8/2019	230	140	220	192		0.00	0.01	0
8/15/2019	210	330	230	252		0.12	0.12	1
8/22/2019	310	370	260	310		0.09	0.31	1
8/29/2019	310	380	350	345		0.00	0.00	0
9/5/2019	190	290	260	243	263	0.00	0.57	4
Site ID/Storet:	631283	Description	Clinton River - Bluegrass Rd.					
8/8/2019	320	310	260	295		0.00	0.02	0
8/15/2019	1,500	2,300	2,000	1,904		0.12	0.12	0
8/22/2019	250	350	260	283		0.09	0.31	2
8/29/2019	370	450	290	364		0.00	0.00	0
9/5/2019	390	460	420	422	476	0.00	0.57	0
Site ID/Storet:	631307	Description	Trib to Duck Lake - Deer Path Rd.					
8/8/2019	960	930	940	943		0.00	0.00	3
8/15/2019	1,100	1,000	1,100	1,066		0.02	0.02	1
8/22/2019	760	760	740	753		0.00	0.07	2
8/29/2019	630	600	400	533		0.00	0.00	2
9/5/2019	790	850	790	810	799	0.01	0.02	0
Site ID/Storet:	631280	Description	Clinton River - Riverwoods Trail					
8/7/2019	190	150	190	176		0.01	0.04	11
8/14/2019	860	530	530	623		0.00	0.49	12
8/21/2019	330	260	350	311		0.09	0.31	25
8/28/2019	110	170	270	172		0.00	0.03	0
9/4/2019	680	630	550	618	325	0.58	0.66	11

	L	C	R	Daily Geometric Mean	30-Day Geometric Mean	24-Hour Prior Rain	48-Hour Prior Rain	Relative Water Level Change
Site ID/Storet:	631284	Description	Trib to Lake Michelson - Seymour Lake Rd.					
8/8/2019	480	550	560	529		0.15	0.18	3
8/15/2019	370	350	410	376		0.00	0.00	0
8/22/2019	590	400	630	530		0.00	0.67	4
8/29/2019	200	190	230	206		0.00	0.00	3
9/5/2019	190	250	310	245	351	0.00	0.02	0
Site ID/Storet:	631077	Description	Sashabaw Creek - Pine Knob Trail					
8/15/2019	1,100	1,500	1,800	1,437		0.12	0.12	0
8/22/2019	280	300	430	331		0.09	0.31	3
8/29/2019	420	370	200	314		0.00	0.00	2
9/5/2019	160	200	180	179		0.00	0.57	0
9/12/2019	16,000	17,000	22,000	18,155	866	0.78	0.78	20
Site ID/Storet:	630630	Description	Clinton River - Cooley Lake Rd.					
8/8/2019	190	160	140	162		0.00	0.04	17
8/14/2019	160	270	260	224		0.00	0.68	12
8/21/2019	230	390	420	335		0.22	0.22	9
8/28/2019	200	240	170	201		0.00	0.37	0
9/4/2019	240	350	310	296	236	0.58	0.66	4
Site ID/Storet:	631100	Description	West Branch Stony Creek - Stony Creek Metropark					
8/7/2019	280	350	310	312		0.00	0.00	4
8/14/2019	570	610	660	612		0.00	0.00	0
8/21/2019	380	710	510	516		0.07	0.07	6
8/28/2019	380	410	400	396		0.00	0.35	1
9/4/2019	1,700	1,200	1,600	1,483	566	0.01	0.54	12
Site ID/Storet:	500554	Description	Stony Creek - Inwood Rd					
8/7/2019	600	580	550	576		0.00	0.00	0
8/14/2019	620	550	490	551		0.00	0.00	0
8/21/2019	1,000	1,300	920	1,061		0.07	0.07	10
8/28/2019	580	640	590	603		0.00	0.35	3
9/4/2019	740	480	900	684	674	0.01	0.54	3

	L	C	R	Daily Geometric Mean	30-Day Geometric Mean	24-Hour Prior Rain	48-Hour Prior Rain	Relative Water Level Change
Site ID/Storet:	630616	Description	Paint Creek - Adams Rd. (north)					
8/8/2019	510	530	440	492		0.00	0.00	4
8/15/2019	710	740	740	730		0.02	0.02	2
8/22/2019	800	710	680	728		0.00	0.07	10
8/29/2019	440	510	530	492		0.00	0.00	0
9/5/2019	450	490	510	483	574	0.01	0.02	17
Site ID/Storet:	630617	Description	Trout Creek - Adams Rd. (south)					
8/8/2019	470	520	540	509		0.00	0.00	1
8/15/2019	830	830	590	741		0.02	0.02	0
8/22/2019	630	420	560	529		0.00	0.07	5
8/29/2019	500	550	490	513		0.00	0.00	2
9/5/2019	320	390	490	394	526	0.01	0.02	5
Site ID/Storet:	631285	Description	Paint Cr- Rochester Rd - CR12					
8/7/2019	1,000	850	750	861		0.00	0.00	4
8/14/2019	960	1,200	1,000	1,048		0.00	0.00	0
8/21/2019	2,100	2,100	2,500	2,226		0.07	0.07	11
8/28/2019	1,400	1,100	1,400	1,292		0.00	0.35	3
9/4/2019	2,600	2,300	3,200	2,675	1,473	0.01	0.54	6
Site ID/Storet:	631286	Description	Sargent Creek - N. Livernois Rd.					
8/7/2019	450	590	530	520		0.00	0.00	0
8/14/2019	1,400	1,000	1,900	1,386		0.00	0.00	1
8/21/2019	850	760	1,000	864		0.07	0.07	5
8/28/2019	740	830	900	821		0.00	0.35	5
9/4/2019	390	210	270	281	678	0.02	0.55	3
Site ID/Storet:	631032	Description	Galloway Creek - Butler Rd.					
8/7/2019	670	810	780	751		0.01	0.04	0
8/14/2019	1,100	730	740	841		0.02	0.68	0
8/21/2019	180	320	230	237		0.22	0.22	10
8/28/2019	410	380	420	403		0.00	0.37	5
9/4/2019	330	630	500	470	490	0.58	0.66	6

Appendix 3. Weather information, water temperature, turbidity, conductivity, calculated total dissolved solids (TDS), pH, and dissolved oxygen (D.O.) results by watershed. Instantaneous readings below the minimum D.O. standards (coldwater [CW] or warmwater [WW], as applicable) are shaded red. TDS results of concern (above the 500 mg/L threshold) are highlighted in red. NOTE: Blanks indicate that the parameter is not available for that event. Daily average D.O. measurements are not available.

Date and Time	24-Hour Precip (in)	Air Temp (F)	D.O. (mg/L)	Water Temp (F)	Turbidity (NTU)	Cond (us/L)	TDS (mg/L)	pH	CW or WW
Watershed	Kalamazoo		HUC-12	040500030102					
Site ID	380442	Site Description		Spring Arbor / Concord Drain - King Rd					
5/14/2019 8:34:00 AM	0	45.4	9.66	45.1	1.02	461	452		WW
5/21/2019 8:37:00 AM	0	43.3	8.87	46.8	2.5	491	470	7.6	WW
5/28/2019 8:17:00 AM	0.1	68.2	6.58	58.3		587	476	7.45	WW
6/4/2019 8:29:00 AM	0	58.9	7.22	55	1.98	565	479	7.73	WW
6/11/2019 8:30:00 AM	0	57.9	6.26	56.3	2.64	540	453	7.68	WW
Site ID	380443	Site Description		Spring Arbor / Concord Drain - N Concord Rd					
5/14/2019 9:09:00 AM	0	49.4	9.3	46.8	7.82	537	514		WW
5/21/2019 8:51:00 AM	0	44.3	8.64	48.1	3.5	506	475	7.7	WW
5/28/2019 8:30:00 AM	0.1	68.9	6.52	60.4		614	484	7.57	WW
6/4/2019 8:50:00 AM	0	60.4	7.1	56	5.5	575	481	7.8	WW
6/11/2019 8:48:00 AM	0	60	6.47	55.4	5.25	532	448	7.67	WW
Site ID	380513	Site Description		Trib to Spring Arbor Drain - Railroad Access Dr					
5/14/2019 9:33:00 AM	0	53.4	6.77	47.1	0.82	339	323		WW
5/21/2019 9:07:00 AM	0	45.3	4.92	50.5	0.82	352	318	7.2	WW
5/28/2019 8:57:00 AM	0.1	69.7	3.02	64		454	342	7.05	WW
6/4/2019 9:14:00 AM	0	61.9	2.8	58.5	0.45	397	321	7.22	WW
6/11/2019 8:30:00 AM	0	57.9	2.36	59	1.43	359	288	7.17	WW
Watershed	Kalamazoo		HUC-12	040500030303					
Site ID	230281	Site Description		Big Creek - Marshall Rd					
7/30/2019 11:16:00 AM	0.26	77.6	9.07	66.6	3.45	684	499	7.87	WW
8/6/2019 11:19:00 AM	0.1	67.7	7.65	67.6	4.02	672	496	7.83	WW
8/12/2019 11:21:00 AM	0	78.7	9.3	66.2	2.92	695	511	7.88	WW
8/20/2019 11:20:00 AM	0.71	78.3	8.46	66.2	3.52	700	513	7.91	WW
8/27/2019 1:16:00 PM	0.53	72.6	10.04	64.2	4.27	665	500	7.98	WW
Watershed	Kalamazoo		HUC-12	040500030305					
Site ID	230220	Site Description		Indian Creek - N Main St					
7/30/2019 11:02:00 AM	0.26	77	8.05	68	3.6	727	522	7.88	WW
8/6/2019 11:04:00 AM	0.1	67.1	7.1	67.5	4.31	638	461	7.82	WW
8/12/2019 11:05:00 AM	0	79.3	8.12	67.5	5.03	652	471	7.9	WW
8/20/2019 10:56:00 AM	0.71	76.4	7.69	67.7	4.22	644	464	7.91	WW
8/27/2019 1:04:00 PM	0.53	71.4	9.21	64.8	5.21	567	423	7.97	WW

Date and Time	24-Hour Precip (in)	Air Temp (F)	D.O. (mg/L)	Water Temp (F)	Turbidity (NTU)	Cond (us/L)	TDS (mg/L)	pH	CW or WW
Watershed	Kalamazoo		HUC-12	040500030306					
Site ID	230014	Site Description		Battle Creek - W Spicerville Hwy					
7/30/2019 11:35:00 AM	0.26	77.3	7.73	67.6	3.51	869	627	7.73	WW
8/6/2019 11:32:00 AM	0.1	67.7	7.12	64.6	3.36	876	656	7.75	WW
8/12/2019 11:38:00 AM	0	82.6	8.51	65.9	3.02	831	612	7.84	WW
8/20/2019 11:36:00 AM	0.71	79.6	8.03	66.7	2.83	971	798	7.86	WW
8/27/2019 11:12:00 AM	0.53	70.1	7.07	64	6.56	859	558	7.7	WW
Watershed	Kalamazoo		HUC-12	040500030309					
Site ID	130416	Site Description		Battle Creek - Burrows Rd					
7/30/2019 9:34:00 AM	0.1	71.5	4.26	72.7	3.62	771	525	7.71	WW
8/6/2019 9:53:00 AM	0	70	4.45	73.2	2.82	802	543	7.72	WW
8/12/2019 9:39:00 AM	0	74.8	5.19	71.2	5.42	813	562	7.84	WW
8/20/2019 9:22:00 AM	0	71.9	4.78	72.3	2.11	840	575	7.86	WW
8/27/2019 9:24:00 AM	0.3	69.5	5.84	66.3	3.69	854	555	7.85	WW
Watershed	Kalamazoo		HUC-12	040500030311					
Site ID	080249	Site Description		Crooked Brook- Huff Rd					
7/30/2019 10:22:00 AM	0.1	74.2	8.59	65.1	3.79	622	462	7.98	WW
8/6/2019 10:25:00 AM	0.05	68.3	7.9	63.9	5.53	596	450	7.93	WW
8/12/2019 10:17:00 AM	0	76.5	9.32	64.3	3.19	617	464	8.01	WW
8/20/2019 10:12:00 AM	0	76.7	8.18	63.8	2.76	618	467	7.98	WW
8/27/2019 10:07:00 AM	0.3	69.3	8.14	61.9	5.63	688	448	7.97	WW
Site ID	080307	Site Description		Wonadoga Creek - Huff Rd					
7/30/2019 10:07:00 AM	0.1	73.4	5.9	68	3.58	555	398	7.72	WW
8/6/2019 10:12:00 AM	0.02	69	5.34	69.4	2.62	570	404	7.73	WW
8/12/2019 10:04:00 AM	0	76.1	5.88	68.2	3.74	579	415	7.75	WW
8/20/2019 9:55:00 AM	0	75	5.85	66.8	4.03	576	415	7.79	WW
8/27/2019 9:50:00 AM	0.3	69.8	6.63	63.2	5.69	515	392	7.77	WW
Site ID	080308	Site Description		Crooked Brook - Wing Rd					
8/6/2019 10:35:00 AM	0.07	68.4	7.93	63.7	4.83	624	472	7.92	WW
8/12/2019 10:31:00 AM	0	77.3	8.33	63.2	4.04	636	485	7.95	WW
8/20/2019 10:27:00 AM	0	77.8	8.25	63.6	2.81	641	486	7.94	WW
8/27/2019 10:25:00 AM	0.3	69.8	8.09	61.3	5.84	713	463	7.93	WW
Site ID	130004	Site Description		Wanadoga Creek - Pennfield Rd					
7/30/2019 9:10:00 AM	0.1	69.8	4.96	70.5	14.27	590	412	7.74	WW
8/6/2019 9:25:00 AM	0	71.3	5.29	70.9	10.04	583	405	7.79	WW
8/12/2019 9:09:00 AM	0	72.9	5.89	68.7	7.46	590	420	7.82	WW
8/20/2019 8:51:00 AM	0	72	6.08	69.4	2.95	593	419	7.91	WW
8/27/2019 8:53:00 AM	0.3	68.8	6.84	64.2	3.71	636	415	7.91	WW

Date and Time	24-Hour Precip (in)	Air Temp (F)	D.O. (mg/L)	Water Temp (F)	Turbidity (NTU)	Cond (us/L)	TDS (mg/L)	pH	CW or WW
Watershed	Kalamazoo		HUC-12	040500030312					
Site ID	130175	Site Description		Battle Creek - Pedestrian Bridge (off Hamblin)					
7/30/2019 8:40:00 AM	0.1	68.7	6.91	73	1.77	748	507	7.87	WW
8/6/2019 8:49:00 AM	0	69.6	7.06	72.1	6.05	614	421	7.88	WW
8/12/2019 8:45:00 AM	0	72.7	7.32	70.7	1.6	771	538	7.88	WW
8/20/2019 8:16:00 AM	0	69.3	6.88	71.6	0.91	770	531	7.93	WW
8/27/2019 8:17:00 AM	0.3	68.2	7.46	66.6	258	693	507	7.92	WW
Watershed	Kalamazoo		HUC-12	040500030702					
Site ID	030736	Site Description		Gun River - 116th Ave					
7/29/2019 11:08:00 AM	0	77.6	6.7	70.9	4.46	489	340	7.73	CW
8/5/2019 11:18:00 AM	0.14	80.4	7.03	68	3.91	480	345	7.71	CW
8/13/2019 10:45:00 AM	0	73.6	6.77	68.7	3.09	512	365	7.76	CW
8/19/2019 10:46:00 AM	0.22	76.6	7.3	66	3.17	499	368	7.77	CW
8/26/2019 11:00:00 AM	0.07	62.3	7.6	63.1	4.79	494	377	7.85	CW
Site ID	080306	Site Description		Gun River - Near Lake Outlet - Patterson Rd					
7/29/2019 11:32:00 AM	0	78.3	7.06	80.6	1.81	332	208	8.31	WW
8/5/2019 11:48:00 AM	0.14	81.5	7.23	81.1	1.61	322	200	8.35	WW
8/13/2019 11:09:00 AM	0	74.9	7.45	79	1.3	339	216	8.39	WW
8/19/2019 11:09:00 AM	0.21	79.5	7.23	76.5	0.94	337	220	8.2	WW
8/26/2019 11:32:00 AM	0.09	62.5	7.99	71.1	1.05	316	219	8.38	WW
Watershed	Kalamazoo		HUC-12	040500030703					
Site ID	030737	Site Description		Gun River - 10th St					
7/29/2019 10:37:00 AM	0	76.7	7.13	67.8	4.54	513	369	7.81	CW
8/5/2019 10:57:00 AM	0.14	79.5	7.46	64.9	3.54	500	373	7.8	CW
8/13/2019 10:23:00 AM	0	72.2	7.33	64.9	4.08	528	394	7.82	CW
8/19/2019 10:30:00 AM	0.22	77.6	7.61	63.7	3.4	518	392	7.83	CW
8/26/2019 10:34:00 AM	0.06	61.2	7.9	61.3	4.47	507	395	7.91	CW
Watershed	Kalamazoo		HUC-12	040500030902					
Site ID	030618	Site Description		Base Line Creek - 24th St					
7/29/2019 9:18:00 AM	0	74.6	6.37	68.2	8.84	388	278	7.73	WW
8/5/2019 9:23:00 AM	0	68	7.02	63.5	8.22	376	285	7.75	WW
8/13/2019 9:05:00 AM	0	68.9	6.79	64.9	8.81	400	298	7.75	WW
8/19/2019 9:05:00 AM	0.15	67	7.12	63.1	7.64	390	297	7.67	WW
8/26/2019 9:08:00 AM	0	62.9	7.54	59.5	6.84	384	306	7.72	WW

Date and Time	24-Hour Precip (in)	Air Temp (F)	D.O. (mg/L)	Water Temp (F)	Turbidity (NTU)	Cond (us/L)	TDS (mg/L)	pH	CW or WW
Watershed	Kalamazoo		HUC-12	040500030903					
Site ID	030738	Site Description		Pine Creek - 21st St					
7/29/2019 9:50:00 AM	0	75.6	7.85	69.4	2.7	533	376	8.01	WW
8/5/2019 10:04:00 AM	0		8.25	65.2	2.73	502	373	8	WW
8/13/2019 9:37:00 AM	0	69.8	7.82	66.9	2.23	536	390	8.03	WW
8/19/2019 9:36:00 AM	0.15	70.6	8.01	65.5	2.71	517	383	8	WW
8/26/2019 9:37:00 AM	0	62.4	8.5	61.5	3.13	495	385	8.03	WW
Site ID	030739	Site Description		Pine Creek - 101st Ave					
7/29/2019 9:31:00 AM	0	74.5	8.07	64.9	4.4	526	392	7.99	CW
8/5/2019 9:41:00 AM	0	69	8.41	62.4	3.35	501	386	8.02	CW
8/13/2019 9:24:00 AM	0	69.6	8.31	62.6	3.57	523	401	8.05	CW
8/19/2019 9:29:00 AM	0.15	70.1	8.39	61.9	4.34	513	397	8.01	CW
8/26/2019 9:24:00 AM	0	62.8	8.67	59.9	5.18	503	399	8.06	CW
Watershed	Kalamazoo		HUC-12	040500030904					
Site ID	030504	Site Description		Schnable Brook - M89					
7/29/2019 10:10:00 AM	0	74.9	7.54	70.5	1.71	513	359	7.97	WW
8/5/2019 10:28:00 AM	0	76	8	66.4	2.66	490	359	7.96	WW
8/13/2019 10:04:00 AM	0	70.9	7.03	67.6	3.63	517	373	7.96	WW
8/19/2019 10:08:00 AM	0.15	72.9	7.95	66.4	4.24	503	369	7.35	WW
8/26/2019 9:59:00 AM	0.03	60.5	7.86	62.4	3.67	481	369	8	WW
Watershed	Upper Grand		HUC-12	040500040709					
Site ID	340262	Site Description		Grand River - Kent St					
6/3/2019 1:17:00 PM	0	60.4	7.57	64.5	24.76	513	384	7.98	WW
6/10/2019 1:21:00 PM	0.96	60.4	6.79	68.1	13.87	601	432	8.12	WW
6/17/2019 1:15:00 PM	0.07	64.8	7.16	62.1	19.2	522	403	8.05	WW
6/24/2019 1:03:00 PM	0.16	78.4	6.52	68.4	17.34	509	364	7.98	WW
7/1/2019 12:37:00 PM	0	83.5	8.65	78.1	5.47	762	490	8.2	WW
7/8/2019 12:35:00 PM	0	74.6	8.3	76.1	5.23	721	474	8.7	WW
7/15/2019 12:43:00 PM	0	86.6	10.72	79.7	0.18	667	421	8.58	WW
7/24/2019 8:48:00 AM	0	64	8.1	76.8	6.95	667	434	8.04	WW
Watershed	Lower Grand		HUC-12	040500060312					
Site ID	340024	Site Description		Grand River - Bridge St					
6/3/2019 12:39:00 PM	0	58.6	6.93	64	42.45	467	352	7.88	WW
6/10/2019 12:46:00 PM	0.48	59.2	6.04	68.8	9.13	592	422	8.01	WW
6/17/2019 12:40:00 PM	0	65.2	6.52	62.1	9.27	518	399	8	WW
6/24/2019 12:18:00 PM	0.08	75.3	5.36	68.7	6.6	474	338	7.82	WW
7/1/2019 11:55:00 AM	0	80.3	6.8	76.6	7.44	682	445	8.02	WW
7/8/2019 11:59:00 AM	0	74.2	6.08	75.6	12.8	647	426	7.94	WW
7/15/2019 12:03:00 PM	0	82.9	7.06	77.4	4.56	624	404	8.21	WW
7/24/2019 12:22:00 PM	0	72.4	10.41	75.7	2.76	706	465	8.32	WW



Date and Time	24-Hour Precip (in)	Air Temp (F)	D.O. (mg/L)	Water Temp (F)	Turbidity (NTU)	Cond (us/L)	TDS (mg/L)	pH	CW or WW
Watershed	Lower Grand		HUC-12	040500060501					
Site ID	410854	Site Description		Bear Creek - Meandering Creek Dr NE					
6/6/2019 8:35:00 AM	0	60.4	7.84	62.9	4.55	389	298	8.14	CW
6/13/2019 8:40:00 AM	0.53	55.2	7.59	59.7	29.4	312	248	8.03	CW
6/20/2019 8:25:00 AM	0.44	58	7.4	61.7	10.86	369	286	8.11	CW
6/27/2019 8:24:00 AM	0	69.5	8.84	64	6.11	431	324	8.11	CW
7/2/2019 8:28:00 AM	0.02	69.6	8.11	67.6	55.3	426	307	8.02	CW
Site ID	410855	Site Description		Bear Creek - Shiloh Dr NE					
6/6/2019 9:00:00 AM	0	63.1	8.15	60.3	5.51	428	337	8.18	CW
6/13/2019 8:58:00 AM	0.86	54.7	7.67	58.1	39.02	389	316	8.09	CW
6/20/2019 8:43:00 AM	0.62	58.6	7.51	59.7	18.59	404	322	8.12	CW
6/27/2019 8:52:00 AM	0	73.2	9.19	61.3	7.19	468	365	8.12	CW
7/2/2019 8:47:00 AM	0.32	68.3	8.65	64.6	12.91	497	372	8.09	CW
Watershed	Lower Grand		HUC-12	040500060502					
Site ID	410856	Site Description		Grand River - Northland Dr NE					
6/3/2019 12:15:00 PM	0	57.8	7.27	65	31.11	494	368	8	WW
6/10/2019 11:41:00 AM	0.75	55.7	6.5	68.9	8.68	543	386	8.06	WW
6/17/2019 11:40:00 AM	0	58.8	6.49	62.6	7.75	495	379	7.98	WW
6/24/2019 11:26:00 AM	0.15	73.3	5.4	68.9	7.17	446	317	7.79	WW
7/1/2019 11:06:00 AM	0	75.9	7.13	76.5	6.43	624	408	8.01	WW
7/8/2019 10:57:00 AM	0	70	6.79	77.4	9.91	617	399	8.03	WW
7/15/2019 11:04:00 AM	0	80.9	9.35	77.9	5.49	583	374	8.4	WW
7/24/2019 11:18:00 AM	0	69.2	7.53	75.9	5.1	773	508	8.16	WW
Watershed	Lower Grand		HUC-12	040500060512					
Site ID	410052	Site Description		Grand River - M11 -GR06					
6/3/2019 11:19:00 AM	0	58.4	7.76	64.3	12.1	509	382	8.02	WW
6/10/2019 10:45:00 AM	0.79	55.7	6.82	68.9	9.43	554	394	8.01	WW
6/17/2019 10:55:00 AM	0	57.6	6.81	62.6	8.32	505	388	7.99	WW
6/24/2019 10:41:00 AM	0.42	73	5.88	68.7	9.1	454	324	7.83	WW
7/1/2019 10:20:00 AM	0	76	7.3	75.9	7.58	636	418	7.95	WW
7/8/2019 10:10:00 AM	0	69.9	7.13	77.3	11.62	657	426	8.02	WW
7/15/2019 10:12:00 AM	0	80.4	9.08	77.7	2.9	618	398	8.44	WW
7/24/2019 10:32:00 AM	0	67.8	8.92	75.7	2.45	711	469	8.22	WW
Watershed	Lower Grand		HUC-12	040500060601					
Site ID	700546	Site Description		North Branch Crockery Creek - 40th Ave					
9/3/2019 10:03:00 AM	0.01	66.7	8.31	63.8	4.01	534	403	8.12	CW
9/10/2019 9:57:00 AM	0.25	65	8.74	60.3	6.65	546	431	8.15	CW
9/17/2019 10:06:00 AM	0	61.7	8.5	64	3.96	562	423	8.06	CW
9/24/2019 9:46:00 AM	0	62.9	8.39	62.2	9.53	522	402	8	CW
9/30/2019 9:52:00 AM	0.29	57.8	8.87	59.7	15.14	457	363	7.98	CW

Date and Time	24-Hour Precip (in)	Air Temp (F)	D.O. (mg/L)	Water Temp (F)	Turbidity (NTU)	Cond (us/L)	TDS (mg/L)	pH	CW or WW
Site ID	700634	Site Description		North Branch Crockery Creek - 24th Ave					
9/3/2019 9:49:00 AM	0.01	66.4	7.69	63.5	1.57	645	490	8.01	CW
9/10/2019 9:43:00 AM	0.23	64.9	8.06	60.4	3.3	607	579	8.03	CW
9/17/2019 9:52:00 AM	0	61	8.05	63.1	3.48	639	486	7.78	CW
9/24/2019 9:32:00 AM	0	61.2	8.2	60.7	10.96	611	479	7.94	CW
9/30/2019 9:38:00 AM	0.31	58	8.63	58.5	20.9	513	415	7.88	CW
Site ID	700699	Site Description		Trib to Crockery Lake - Gooding St					
6/6/2019 10:15:00 AM	0	64.4	7.79	59.2	1.68	428	343	7.96	CW
6/13/2019 9:59:00 AM	0.9	55.3	6.83	57.9	8.22	409	333	7.71	CW
6/20/2019 9:42:00 AM	0.72	59	6.85	58.5	3.01	437	353	7.84	CW
6/27/2019 9:54:00 AM	0	75.1	8.39	61.2	2.26	470	367	7.87	CW
7/2/2019 9:48:00 AM	0.32	70.4	7.59	62.1	1.98	477	368	7.82	CW
Site ID	700700	Site Description		Trib to Crockery Lake - 16th Ave					
6/6/2019 9:53:00 AM	0	63.8	8.23	59.7	8.54	501	339	8.08	CW
6/13/2019 9:52:00 AM	0.9	55.2	7.43	57.8	65.76	404	329	7.79	CW
6/20/2019 9:28:00 AM	0.71	58.9	7.1	59.4	48.7	446	356	7.9	CW
6/27/2019 9:44:00 AM	0	74.8	8.39	61.7	12.4	580	450	7.96	CW
7/2/2019 9:33:00 AM	0.32	70	7.39	65.7	18.13	620	458	7.94	CW
Watershed	Lower Grand		HUC-12	040500060602					
Site ID	610479	Site Description		Crockery Creek - Laketon Ave					
9/3/2019 10:17:00 AM	0.01	66.8	8.69	63.2	4.79	502	391	8.06	CW
9/10/2019 10:17:00 AM	0.3	65.1	9.07	58.6	6.95	480	388	8.12	CW
9/17/2019 10:30:00 AM	0	62	8.7	62.2	9.39	499	384	8.04	CW
9/24/2019 10:11:00 AM	0	65.1	8.73	60.3	10.75	496	392	8.06	CW
9/30/2019 10:12:00 AM	0.26	58.6	9.23	57.2	14.36	409	336	8	CW
Site ID	610482	Site Description		Crockery Creek - Shaw Rd					
9/3/2019 9:25:00 AM	0.01	66.5	8.67	59.4	7.39	481	384	7.86	CW
9/10/2019 9:12:00 AM	0.21	64	9.01	57.2	11.3	460	379	7.89	CW
9/17/2019 9:13:00 AM	0	60.4	8.61	59.7	8.75	470	375	7.81	CW
9/24/2019 8:58:00 AM	0	58.5	8.76	56.7	9.66	459	380	7.88	CW
9/30/2019 9:06:00 AM	0.43	56.8	8.61	56.1	8.95	400	334	7.8	CW
Site ID	610819	Site Description		Ovidhall Lake Creek - Bailey Rd					
9/3/2019 9:36:00 AM	0.01	66.4	9.06	59.1	6.22	539	433	7.93	CW
9/10/2019 9:27:00 AM	0.22	64.5	9.28	56.8	12.8	519	428	7.91	CW
9/17/2019 9:26:00 AM	0	60.2	8.97	59.9	9.32	535	425	7.9	CW
9/24/2019 9:13:00 AM	0	59.6	9.11	56.7	6.52	520	430	7.93	CW
9/30/2019 9:17:00 AM	0.4	57.1	9.03	57.4	13.47	451	370	7.9	CW
Watershed	Lower Grand		HUC-12	040500060603					
Site ID	610380	Site Description		Crockery Creek - Ellis Rd					
9/30/2019 10:55:00 AM	0.19	60	9.27	58.6	19.9	435	351	8.12	WW

Date and Time	24-Hour Precip (in)	Air Temp (F)	D.O. (mg/L)	Water Temp (F)	Turbidity (NTU)	Cond (us/L)	TDS (mg/L)	pH	CW or WW
Site ID	610476	Site Description		Rio Grande Cr - Blackmer Rd - RG7A					
9/3/2019 10:44:00 AM	0.01	68.1	8.46	63.7	3.86	506	383	8.11	WW
9/10/2019 10:43:00 AM	0.32	65.4	8.81	60.8	16.39	479	375	8.13	WW
9/17/2019 10:45:00 AM	0	62.1	9.01	63.1	3.66	554	422	8.13	WW
9/24/2019 10:30:00 AM	0	66.2	8.96	61	17.52	464	363	8	WW
9/30/2019 11:26:00 AM	0.09	62.5	9.26	59.2	28.8	389	311	7.98	WW
Site ID	610508	Site Description		Crockery Creek - Blackmer					
9/30/2019 10:30:00 AM	0.23	59	9.21	58.5	18.41	429	347	8.06	WW
Watershed	Lower Grand	HUC-12		040500060604					
Site ID	610507	Site Description		Crockery Creek - Patterson Rd					
9/3/2019 10:59:00 AM	0.02	66.5	8.52	62.9	3.71	514	393	8.1	WW
9/10/2019 11:05:00 AM	0.25	65.4	8.9	60.3	12.71	478	378	8.14	WW
9/17/2019 11:09:00 AM	0	61.8	8.62	63.3	7.08	519	394	8.08	WW
9/24/2019 10:49:00 AM	0	66.7	8.41	61.5	13.34	538	418	8.04	WW
9/30/2019 11:11:00 AM	0.18	64.9	9.19	58.8	22.5	422	339	8.08	WW
Watershed	Lower Grand	HUC-12		040500060605					
Site ID	700703	Site Description		Crockery Creek - Fitzgerald St					
9/3/2019 11:30:00 AM	0.02	67.2	7.94	64	3.42	479	360	7.98	WW
9/10/2019 11:36:00 AM	0.25	65.4	8.54	61.7	3.58	503	390	8.15	WW
9/17/2019 11:35:00 AM	0	61.8	7.17	64.6	7.5	505	378	7.77	WW
9/24/2019 11:19:00 AM	0	66.7	7.17	63.7	19.18	475	360	7.82	WW
9/30/2019 11:57:00 AM	0.12	68.4	7.81	59	39.78	370	297	7.74	WW
Watershed	Lower Grand	HUC-12		040500060701					
Site ID	700702	Site Description		Sand Creek - Hayes St (east)					
6/6/2019 10:50:00 AM	0	68.2	7.24	62.6	4.42	553	424	7.94	CW
6/13/2019 10:51:00 AM	0.68	55.1	6.76	59.5	9.17	525	418	7.9	CW
6/20/2019 10:20:00 AM	0.59	59.6	6.56	61.5	11.94	544	424	7.93	CW
6/27/2019 10:44:00 AM	0	80.2	7.91	65.1	4.55	683	508	7.89	CW
7/2/2019 10:26:00 AM	0.62	72	7.11	67.3	7.52	733	530	7.87	CW
Watershed	Lower Grand	HUC-12		040500060702					
Site ID	700701	Site Description		Sand Creek - Hayes St (west)					
6/6/2019 10:36:00 AM	0	66.6	6.39	60.6	5.53	538	422	7.84	CW
6/13/2019 10:40:00 AM	0.68	56.1	6.35	58.5	13.94	487	394	7.85	CW
6/20/2019 10:10:00 AM	0.57	59.6	6.2	59.9	24.76	476	378	7.87	CW
6/27/2019 10:32:00 AM	0	80	7.18	62.2	9.21	610	470	7.81	CW
7/2/2019 10:13:00 AM	0.62	71.9	6.5	66	20.04	591	436	7.79	CW

Date and Time	24-Hour Precip (in)	Air Temp (F)	D.O. (mg/L)	Water Temp (F)	Turbidity (NTU)	Cond (us/L)	TDS (mg/L)	pH	CW or WW
Watershed	Lower Grand		HUC-12	040500060703					
Site ID	620218	Site Description		Sand Creek - Luce St SW					
6/6/2019 11:35:00 AM	0	70	7.49	61.6	5.69	542	421	8.05	CW
6/13/2019 11:22:00 AM	0.72	53.4	7.19	59.3	58.66	476	381	8.07	CW
6/20/2019 10:52:00 AM	0.64	59.9	7.12	60.7	29.85	525	413	8.11	CW
6/27/2019 11:16:00 AM	0	81.2	8.04	64	5.18	641	483	8.02	CW
7/2/2019 11:00:00 AM	0.62	74.9	7.96	67.1	46.45	667	484	8.08	CW
Watershed	Lower Grand		HUC-12	040500060712					
Site ID	700704	Site Description		Grand River - 231 / Spoonville Trail					
6/3/2019 10:44:00 AM	0	56.4	7.51	64.8	13.03	511	382	8	WW
6/10/2019 10:05:00 AM	1.38	54.1	6.49	69	8.48	578	411	8.02	WW
6/17/2019 10:02:00 AM	0	55.1	6.44	62.8	8.46	502	384	7.95	WW
6/24/2019 9:43:00 AM	0.2	69.6	5.75	68.7	10.86	455	324	7.85	WW
7/1/2019 9:30:00 AM	0	71.9	7	75.9	7.44	634	417	7.92	WW
7/8/2019 9:15:00 AM	0	64.5	6.46	78.1	10.61	646	416	8.02	WW
7/15/2019 9:22:00 AM	0	76.2	13.17	79	2.78	614	391	8.65	WW
7/24/2019 9:13:00 AM	0	63.7	8.4	74.8	3.74	731	487	8.18	WW
Site ID	700705	Site Description		Grand River - US 31					
6/3/2019 10:00:00 AM	0	56	7.22	64.4	7.03	501	376	7.99	WW
6/10/2019 9:10:00 AM	1.37	56.4	6.51	69.4	4.86	526	372	7.99	WW
6/17/2019 9:20:00 AM	0	54.8	5.78	63.1	9.43	488	372	7.84	WW
6/24/2019 9:03:00 AM	0.2	68.7	4.44	68.7	10	454	324	7.78	WW
7/1/2019 8:42:00 AM	0	71.5	6.21	76.1	4.1	613	401	7.75	WW
7/8/2019 8:45:00 AM	0	62.6	6.91	79.3	6.52	670	425	8.05	WW
7/15/2019 8:40:00 AM	0	73.3	12.47	79	5.69	548	349	8.42	WW
7/24/2019 8:48:00 AM	0	62.2	9.97	75.9	4.63	725	467	8.27	WW
Watershed	Pere Marquette-White		HUC-12	040601010102					
Site ID	530223	Site Description		Big Sable River - N Taylor Rd					
7/16/2019 8:30:00 AM	0.02	73.2	6.6	68.7		405	289	7.4	CW
7/23/2019 8:45:00 AM	0	60.3	2.1	68.5		106	76	6.59	CW
7/30/2019 8:20:00 AM	0.18	64.8	2.4	69.3		322	228	7.36	CW
8/6/2019 8:15:00 AM	0.63	63.3	4.2	68.2		340	244	7.49	CW
8/14/2019 8:15:00 AM	0	61.5	4.72	67.3		372	270	7.26	CW
Watershed	Pere Marquette-White		HUC-12	040601010103					
Site ID	530219	Site Description		Freeman Creek - N Alexander Rd					
7/16/2019 9:35:00 AM	0	71.9	8.2	55.9		512	429	7.54	CW
7/23/2019 9:45:00 AM	0	67.5	3	68.7		298	212	7.16	CW
7/30/2019 9:20:00 AM	0	69.2	6.7	59.9		441	350	7.72	CW
8/6/2019 9:20:00 AM	0.91	69	7.3	57.7		458	374	7.51	CW
8/14/2019 9:10:00 AM	0	63.5	8.52	55.6		516	434	7.66	CW

Date and Time	24-Hour Precip (in)	Air Temp (F)	D.O. (mg/L)	Water Temp (F)	Turbidity (NTU)	Cond (us/L)	TDS (mg/L)	pH	CW or WW
Site ID	530292	Site Description		Big Sable River - N Darr Rd					
7/16/2019 10:00:00 AM	0	73.1	8.8	65.8		351	259	8.08	CW
7/23/2019 10:00:00 AM	0	68.2	6.3	67.8		99	71	7.08	CW
7/30/2019 9:40:00 AM	0	69.3	7.2	67.5		297	215	7.88	CW
8/6/2019 9:45:00 AM	0.91	69.6	7.9	65.1		321	239	7.89	CW
8/14/2019 9:25:00 AM	0	64.2	8.3	64.2		333	250	8.09	CW
Watershed	Pere Marquette-White	HUC-12		040601010104					
Site ID	530304	Site Description		Davis Creek - N Quarterline Rd					
7/16/2019 9:20:00 AM	0	72.7	8.4	60.6		458	360	7.84	CW
7/23/2019 9:25:00 AM	0	66.5	7.8	61.9		243	188	7.63	CW
7/30/2019 9:00:00 AM	0	68.3	7.4	61.3		427	333	7.74	CW
8/6/2019 9:00:00 AM	0.91	68.7	7.6	61		412	323	7.45	CW
8/14/2019 8:50:00 AM	0	62.9	7.6	59.2		446	357	7.74	CW
Watershed	Manistee	HUC-12		040601030203					
Site ID	570108	Site Description		Hopkins Creek - N Lanning Rd					
7/17/2019 9:05:00 AM	0	71.5	8.1	61.9		332	257	7.85	CW
7/24/2019 8:05:00 AM	0	56.3	8.8	56.1		290	242	8.08	CW
7/31/2019 9:00:00 AM	0	58.1	8.5	57.7		313	256	7.97	CW
8/7/2019 7:10:00 AM	0.01	56.3	8.4	58.8		325	262	7.82	CW
8/15/2019 8:00:00 AM	0	59.2	8.6	57.2		337	277	7.81	CW
Watershed	Manistee	HUC-12		040601030204					
Site ID	570106	Site Description		Hopkins Creek - N Lucas Rd					
7/17/2019 9:15:00 AM	0	72.2	9.7	55.6		310	261	7.84	CW
7/24/2019 8:20:00 AM	0	58.4	10.2	50.7		308	278	8.11	CW
7/31/2019 9:20:00 AM	0	60.4	10.2	50.7		307	277	7.83	CW
8/7/2019 7:30:00 AM	0.01	58	9.7	53.2		310	269	8.23	CW
8/15/2019 8:20:00 AM	0	60.6	9.9	53.1		312	272	7.9	CW
Watershed	Manistee	HUC-12		040601030206					
Site ID	280429	Site Description		Fife Lake Creek - Number Two Rd					
7/17/2019 8:40:00 AM	0	70	6.7	71.1		249	173	7.5	CW
7/24/2019 7:40:00 AM	0	52.2	6.7	63.5		234	178	7.51	CW
7/31/2019 8:30:00 AM	0	55.6	7.4	62.1		243	188	7.59	CW
8/7/2019 6:50:00 AM	0.01	53.6	6.8	66		249	183	8.01	CW
8/15/2019 7:35:00 AM	0	59.2	7.3	64.6		254	190	7.59	CW

Date and Time	24-Hour Precip (in)	Air Temp (F)	D.O. (mg/L)	Water Temp (F)	Turbidity (NTU)	Cond (us/L)	TDS (mg/L)	pH	CW or WW
Watershed	Manistee		HUC-12	040601030207					
Site ID	570107		Site Description	Morrisy Creek - N Seeley Rd					
7/17/2019 9:40:00 AM	0	75.6	10	51.1		326	292	8.06	CW
7/24/2019 8:40:00 AM	0	60.8	10.3	48.4		345	322	8.04	CW
7/31/2019 9:40:00 AM	0	61.4	10.1	48.9		341	316	7.96	CW
8/7/2019 7:50:00 AM	0	60.3	9.9	49.5		343	315	8.16	CW
8/15/2019 8:35:00 AM	0	61.1	10	50.2		348	316	8.1	CW
Watershed	Manistee		HUC-12	040601030208					
Site ID	830154		Site Description	Manton Creek - E 10 Rd					
7/17/2019 10:30:00 AM	0	79	8.7	66		397	292	8.15	CW
7/24/2019 9:30:00 AM	0	65.8	9.6	58.1		392	319	8.15	CW
7/31/2019 10:20:00 AM	0	64.7	9.4	58.8		390	314	8.14	CW
8/7/2019	0	71.8	8.9	61.3		395	308	8.15	CW
8/15/2019 9:25:00 AM	0	61.7	9.1	60.8		399	313	8.2	CW
Site ID	830237		Site Description	Manton Creek - E Main St					
7/17/2019 10:05:00 AM	0	78.4	10.2	56.1		381	318	7.93	CW
7/24/2019 9:05:00 AM	0	63.4	10.5	50		378	344	8.03	CW
7/31/2019 10:00:00 AM	0	63.5	10.5	50.9		375	337	8.05	CW
8/7/2019 8:15:00 AM	0	63.3	9.6	51.8		378	335	8.04	CW
8/15/2019 9:00:00 AM	0	61.3	9.8	52.9		381	333	8.12	CW
Site ID	830238		Site Description	Trib to Lake Billings - E Main St					
7/17/2019 9:55:00 AM	0	75.6	7.1	51.8		522	463	7.8	CW
7/24/2019 8:55:00 AM	0	62.4	7.3	49.1		519	479	7.93	CW
7/31/2019 9:50:00 AM	0	62.1	7.4	49.8		519	474	7.87	CW
8/7/2019 8:05:00 AM	0	62.3	7	49.3		516	475	8.03	CW
8/15/2019 8:50:00 AM	0	61	6.9	50		524	477	7.91	CW
Watershed	Manistee		HUC-12	040601030209					
Site ID	830239		Site Description	Silver Creek - E 12 1/2 Rd					
7/17/2019 11:00:00 AM	0	82.8	9.8	54.7		352	300	8.04	CW
7/24/2019 9:55:00 AM	0	69.2	10.3	51.1		348	312	8.03	CW
7/31/2019 11:00:00 AM	0	67.4	10.2	51.4		344	307	8.06	CW
8/7/2019 9:15:00 AM	0	68.5	9.8	52.2		349	308	8.03	CW
8/15/2019 9:50:00 AM	0	63.9	10	52.3		350	308	8.2	CW
Site ID	830240		Site Description	Buttermilk Creek - E 10 Rd					
7/17/2019 10:45:00 AM	0	80	8.4	63.1		341	260	7.84	CW
7/24/2019 9:45:00 AM	0	67.5	8.9	54.7		341	290	8.1	CW
7/31/2019 10:45:00 AM	0	65.8	9	55.6		345	290	7.95	CW
8/7/2019 9:00:00 AM	0	67.4	8	56.8		338	279	7.92	CW
8/15/2019 9:35:00 AM	0	62.2	8	57.6		340	278	8.13	CW



Date and Time	24-Hour Precip (in)	Air Temp (F)	D.O. (mg/L)	Water Temp (F)	Turbidity (NTU)	Cond (us/L)	TDS (mg/L)	pH	CW or WW
Watershed	Manistee		HUC-12	040601030301					
Site ID	830159	Site Description		Anderson Creek - W 6 Rd					
7/17/2019 11:30:00 AM	0	82.2	8	72.1		383	262	8.06	CW
7/23/2019 12:45:00 PM	0	68.9	8.8	66.4		296	217	7.99	CW
7/31/2019 11:35:00 AM	0	69.2	9.1	61.7		384	298	8.04	CW
8/7/2019 9:45:00 AM	0	70.7	8.8	63.1		377	287	7.98	CW
8/15/2019 10:25:00 AM	0	63.7	8.9	63.9		388	293	8.16	CW
Watershed	Manistee		HUC-12	040601030304					
Site ID	830145	Site Description		Fletcher Creek - W 12 3/4 Rd					
7/16/2019 12:05:00 PM	0.06	76.8	8.8	64.9		339	253	8.09	CW
7/23/2019 11:55:00 AM	0	68.4	9.1	60.4		291	229	7.99	CW
7/30/2019 11:40:00 AM	0	66.5	8.8	64.2		351	264	8.17	CW
8/6/2019 11:45:00 AM	0.65	73.9	8.8	63.5		362	275	8.07	CW
8/14/2019 11:20:00 AM	0	69.3	9.1	58.3		310	251	8.08	CW
Site ID	830235	Site Description		Fletcher Creek - W 4 Rd					
7/16/2019 12:20:00 PM	0.06	77.5	8	62.2		377	291	7.74	CW
7/23/2019 12:15:00 PM	0	67.6	8.7	57		389	321	7.9	CW
7/30/2019 12:00:00 PM	0	67.7	8.2	59.7		388	309	7.89	CW
8/6/2019 12:10:00 PM	0.65	75.1	8.4	59.9		401	318	7.8	CW
8/14/2019 11:40:00 AM	0	69.6	9.1	57.9		417	340	7.97	CW
Watershed	Manistee		HUC-12	040601030307					
Site ID	830236	Site Description		Slagle Creek - W 30 Rd					
7/16/2019 11:40:00 AM	0	76.7	9.2	54		320	275	7.9	CW
7/23/2019 11:30:00 AM	0	66.8	9.4	51.8		313	278	7.85	CW
7/30/2019 11:15:00 AM	0.03	69	9.2	52.9		306	267	7.75	CW
8/6/2019 11:20:00 AM	0.35	68.5	9.1	54.5		301	257	7.74	CW
8/14/2019 10:55:00 AM	0	67.6	9.5	51.4		320	285	7.96	CW
Watershed	Manistee		HUC-12	040601030603					
Site ID	430638	Site Description		Cool Creek (East Crossing) W 12 Mile Rd					
7/16/2019 11:00:00 AM	0	80.6	8	73.6		303	204	8.12	CW
7/23/2019 10:55:00 AM	0	72.7	8	70.9		292	203	7.94	CW
7/30/2019 10:35:00 AM	0.17	68.8	8	71.8		291	200	8.1	CW
8/6/2019 10:35:00 AM	0.63	66.7	7.7	72.5		291	199	8.01	CW
8/14/2019 10:20:00 AM	0	66.2	8.2	70.5		297	207	8.09	CW
Site ID	430639	Site Description		Cool Creek (West Crossing) - W 12 Mile Rd					
7/16/2019 10:50:00 AM	0	80.5	8	73.4		304	205	8.11	CW
7/23/2019 10:45:00 AM	0	72.7	8	70.2		285	200	7.87	CW
7/30/2019 10:25:00 AM	0.17	68.1	8	71.6		291	201	8.09	CW
8/6/2019 10:25:00 AM	0.63	65.4	7.7	72		294	202	7.99	CW
8/14/2019 10:10:00 AM	0	65.2	8.5	70.3		299	209	8.11	CW

Date and Time	24-Hour Precip (in)	Air Temp (F)	D.O. (mg/L)	Water Temp (F)	Turbidity (NTU)	Cond (us/L)	TDS (mg/L)	pH	CW or WW
Watershed	Au Gres-Rifle		HUC-12	040801010405					
Site ID	650002	Site Description		Ogemaw Creek - I 75 BL					
7/15/2019 11:10:00 AM	0	76.2	9.8	58.8		440	354	8.11	CW
7/22/2019 10:50:00 AM	0.77	66.3	9.8	59.9		445	353	8.14	CW
7/29/2019 10:40:00 AM	0.2	78.9	9.2	62.8		436	334	8.12	CW
8/5/2019 11:00:00 AM	0.15	74.9	9.8	59.9		394	313	8.14	CW
8/13/2019 10:35:00 AM	0.07	72.3	9.9	58.6		448	362	8.37	CW
Site ID	650121	Site Description		Rifle Creek - Dam Rd					
7/15/2019 10:55:00 AM	0	77.1	8.8	67.3		357	259	8.18	CW
7/22/2019 10:35:00 AM	0.77	64.6	8.7	66.4		362	265	8.1	CW
7/29/2019 10:30:00 AM	0.2	78.2	8.1	69.6		353	249	8.06	CW
8/5/2019 10:45:00 AM	0.15	73.8	8.7	65.8		363	268	8.09	CW
8/13/2019 10:20:00 AM	0.07	72.2	8.9	64.9		361	269	8.33	CW
Watershed	Au Gres-Rifle		HUC-12	040801010406					
Site ID	650038	Site Description		Flowage Creek - S Flowage Lake Rd					
7/15/2019 11:30:00 AM	0	79.8	9.1	64.4		713	535	7.99	CW
7/22/2019 11:00:00 AM	0.77	65.1	8	66.6		710	519	7.8	CW
7/29/2019 10:55:00 AM	0.2	80.4	7.9	68.7		696	496	7.85	CW
8/5/2019 11:10:00 AM	0.15	76.1	8.4	67.5		647	468	7.9	CW
8/13/2019 11:00:00 AM	0.07	72.9	9.4	64.4		674	506	8.15	CW
Site ID	650075	Site Description		Campbell Creek - M 33					
7/15/2019 10:20:00 AM	0	76	9.7	59.2		688	551	8.03	CW
7/22/2019 9:55:00 AM	0.77	61.2	9.2	61.2		670	523	8.05	CW
7/29/2019 9:50:00 AM	0.2	75.8	8.8	63.7		653	494	8.18	CW
8/5/2019 10:00:00 AM	0.15	69.8	9.2	60.4		662	522	8.17	CW
8/13/2019 9:40:00 AM	0.07	71.6	9.6	58.6		696	562	8.38	CW
Site ID	650125	Site Description		West Branch Rifle River - M 33					
7/15/2019 10:05:00 AM	0	74	9.2	66		447	329	8.12	CW
7/22/2019 9:40:00 AM	0.77	62	8.2	67.1		360	261	8.02	CW
7/29/2019 9:30:00 AM	0.2	75.5	7.8	69.6		423	298	8.14	CW
8/5/2019 9:45:00 AM	0.15	70.2	8.7	66.2		435	319	8.31	CW
8/13/2019 9:25:00 AM	0.07	69.6	8.4	65.8		436	321	8.4	CW
Watershed	Au Gres-Rifle		HUC-12	040801010407					
Site ID	650097	Site Description		Rifle River - M 55					
7/15/2019 10:35:00 AM	0	76.8	11.2	63.9		436	329	8.4	CW
7/22/2019 10:15:00 AM	0.77	62.5	9.9	64.9		443	330	8.2	CW
7/29/2019 10:10:00 AM	0.2	76.2	8.9	67.1		433	314	8.18	CW
8/5/2019 10:15:00 AM	0.15	71.1	10.5	63.3		434	330	8.33	CW
8/13/2019 10:05:00 AM	0.07	70.9	10.5	63		433	331	8.49	CW



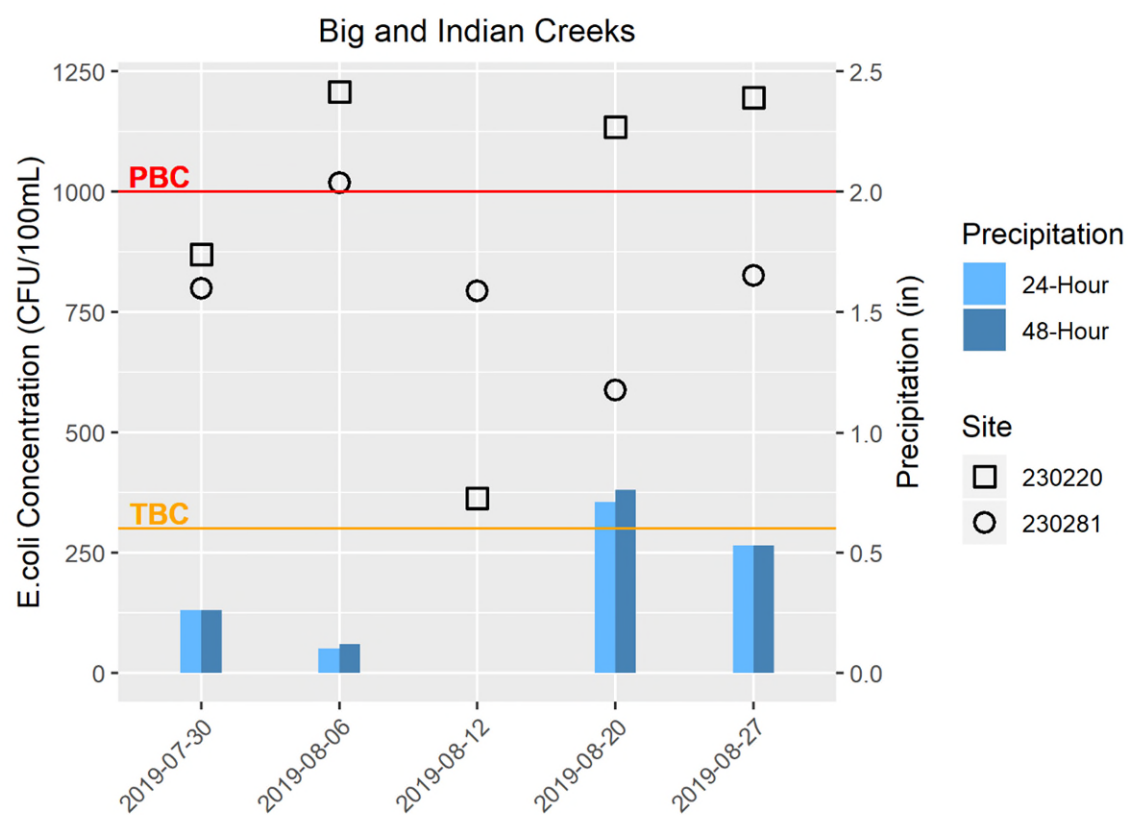
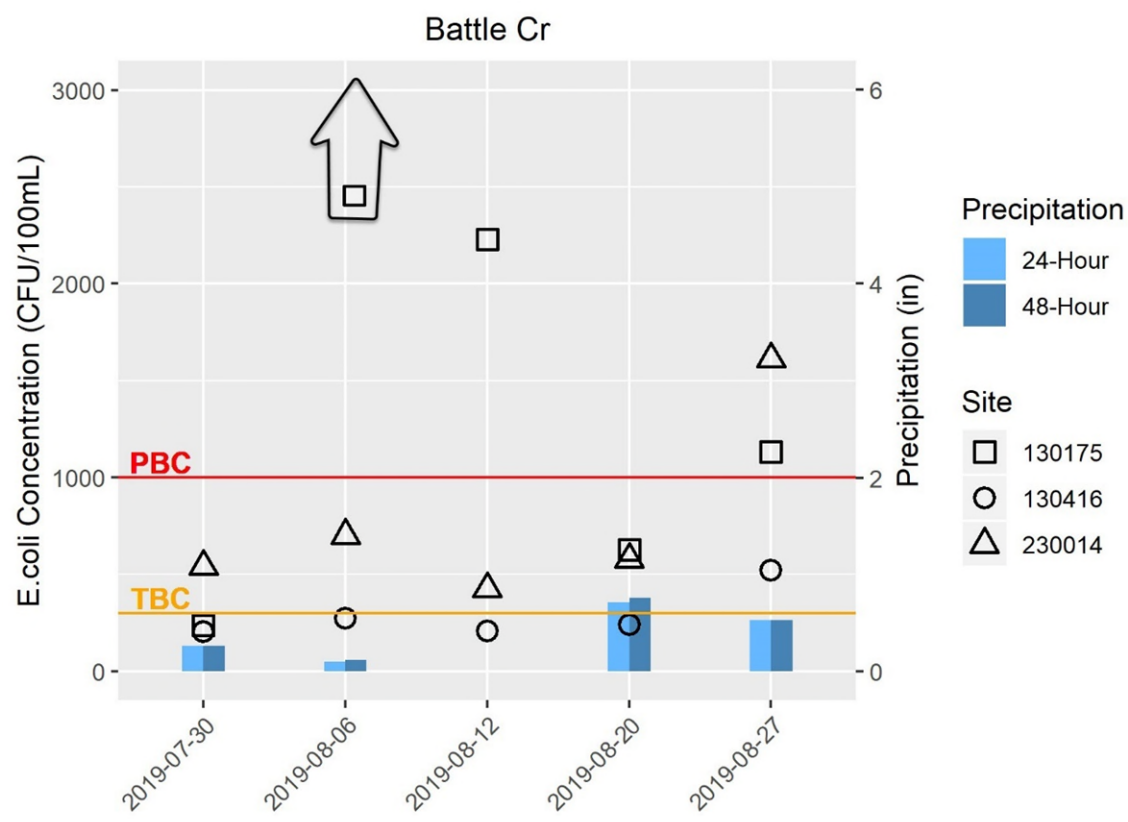
Date and Time	24-Hour Precip (in)	Air Temp (F)	D.O. (mg/L)	Water Temp (F)	Turbidity (NTU)	Cond (us/L)	TDS (mg/L)	pH	CW or WW
Watershed	Au Gres-Rifle		HUC-12	040801010410					
Site ID	650098	Site Description		Silver Creek - Greenwood Rd					
7/15/2019 9:30:00 AM	0	72	8.9	59.5		380	303	7.93	CW
7/22/2019 9:05:00 AM	0.77	62.9	9	59.7		398	317	7.96	CW
7/29/2019 9:00:00 AM	0.2	74.8	8.7	61		411	322	7.82	CW
8/5/2019 9:10:00 AM	0.15	64.6	9.2	56.8		410	339	8.11	CW
8/13/2019 8:50:00 AM	0.07	66.6	9.4	55.9		431	361	8	CW
Site ID	650126	Site Description		Rifle River - Greenwood Rd					
7/15/2019 9:45:00 AM	0	72.7	8.3	66.9		442	322	8.13	CW
7/22/2019 9:15:00 AM	0.77	62.8	8.1	66.9		433	315	8.13	CW
7/29/2019 9:15:00 AM	0.2	75.1	7.7	68.7		433	309	8.09	CW
8/5/2019 9:25:00 AM	0.15	65.3	8.1	65.7		445	329	8.22	CW
8/13/2019 9:05:00 AM	0.07	66	7.9	66		438	322	8.36	CW
Watershed	Au Gres-Rifle		HUC-12	040801010412					
Site ID	060105	Site Description		Rifle River - Melita Rd					
7/15/2019 8:45:00 AM	0	66.4	8.3	67.6		447	323	7.96	CW
7/22/2019 8:30:00 AM	0.77	61.4	8	67.5		420	304	7.87	CW
7/29/2019 8:25:00 AM	0.2	74	7.5	69.6		404	285	7.96	CW
8/5/2019 8:40:00 AM	0.15	62.7	8	66.9		453	330	7.98	CW
8/13/2019 8:25:00 AM	0.07	65.7	8	66.6		446	326	8.06	CW
Watershed	Pine		HUC-12	040802020308					
Site ID	290226	Site Description		Pine River - St. Charles Rd					
9/25/2019 9:01:00 AM	0	64.4	7.74	62.6	5.67	468	359	7.86	WW
Site ID	290233	Site Description		Pine River - Lumberjack Rd - S of Riverdale					
9/25/2019 8:01:00 AM	0	63.3	7.98	62.4	7.05	465	358	7.87	WW
Site ID	290235	Site Description		Pine River - W Van Buren Rd					
9/25/2019 8:16:00 AM	0	63.5	7.99	62.4	7.2	466	359	7.92	WW
Site ID	290236	Site Description		Carpenter Creek - Washington Rd					
9/25/2019 9:29:00 AM	0	64.7	7.93	59.4	2.87	794	635	7.78	WW
Site ID	590364	Site Description		Pine River - E McBrides Rd					
9/25/2019 8:46:00 AM	0	64.3	7.96	62.4	7.42	467	359	7.91	WW
Site ID	590371	Site Description		Unnamed Trib to Pine (W of Elm Hall) - NE Kendall Ave					
9/25/2019 8:27:00 AM	0	63.7	7.26	63.5	2.78	488	370	7.74	WW
Site ID	EHSS	Site Description		Storm Sewer (Elm Hall) S side of W Van Buren					
9/25/2019 10:30:00 AM									
Watershed	Pine		HUC-12	040802020309					
Site ID	290234	Site Description		Pine River - Ferris Rd					
9/25/2019 9:13:00 AM	0	64.5	7.63	62.6	5.17	484	371	7.85	WW

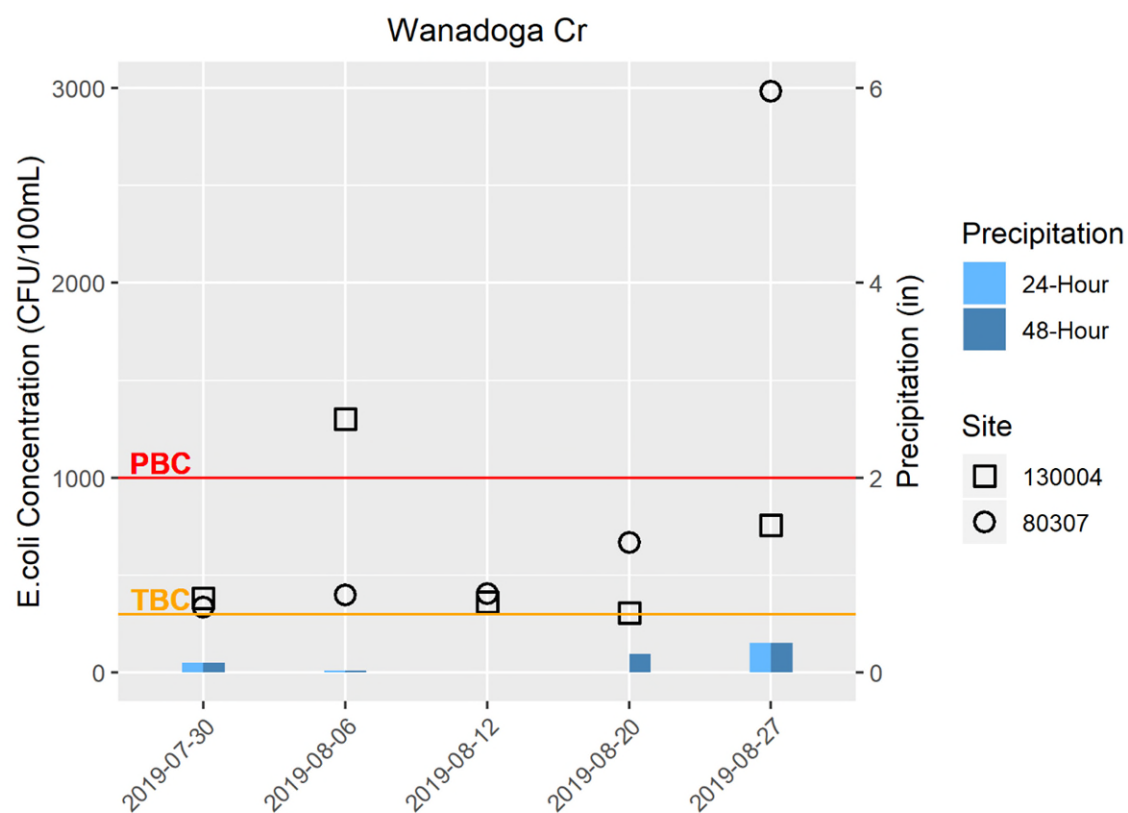
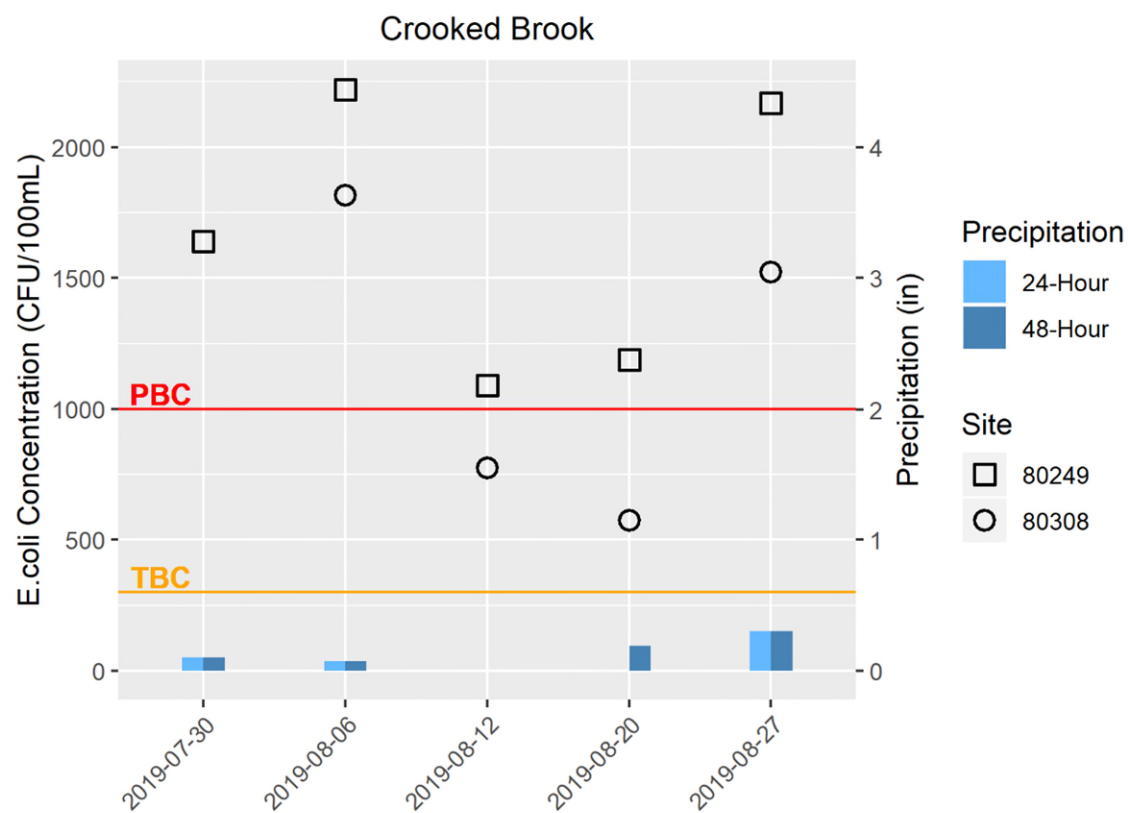
Date and Time	24-Hour Precip (in)	Air Temp (F)	D.O. (mg/L)	Water Temp (F)	Turbidity (NTU)	Cond (us/L)	TDS (mg/L)	pH	CW or WW
Watershed	Clinton	HUC-12		040900030101					
Site ID	631041	Site Description		Trib to Deer Lake - Deerhill Rd.					
8/8/2019 9:30:00 AM	0	66.9	7.67	65.2		823	611	7.92	WW
8/15/2019 10:08:00 AM	0.12	67	8.12	64.3		857	644	7.93	WW
8/22/2019 9:54:00 AM	0.09	67.1	7.71	66.9		845	615	8.01	WW
8/29/2019 10:17:00 AM	0	66.7	8.17	61.7		815	632	7.89	WW
9/5/2019 10:19:00 AM	0	62	8.54	61.8		843	653	7.84	WW
Site ID	631283	Site Description		Clinton River - Bluegrass Rd.					
8/8/2019 9:06:00 AM	0	67.7	6.36	66.7		698	509	7.88	WW
8/15/2019 9:50:00 AM	0.12	65.3	6.46	64.7		756	565	7.86	WW
8/22/2019 9:41:00 AM	0.09	65.7	6.24	68.8		672	479	7.95	WW
8/29/2019 9:58:00 AM	0	65.8	6.53	62.2		687	530	7.8	WW
9/5/2019 10:02:00 AM	0	61.1	6.92	62.6		575	441	7.72	WW
Watershed	Clinton	HUC-12		040900030102					
Site ID	631307	Site Description		Trib to Duck Lake - Deer Path Rd.					
8/8/2019 7:00:00 AM	0	68.3	5.81	64		651	491	7.8	WW
8/15/2019 7:56:00 AM	0.02	62.6	6.25	61.5		663	516	7.8	WW
8/22/2019 8:08:00 AM	0	63.2	5.94	64.5		673	504	7.9	WW
8/29/2019 8:17:00 AM	0	60.1	6.73	58.3		630	511	7.72	WW
9/5/2019 8:09:00 AM	0.01	58	6.86	58.4		644	522	7.74	WW
Watershed	Clinton	HUC-12		040900030104					
Site ID	631280	Site Description		Clinton River - Riverwoods Trail					
8/7/2019 12:30:00 PM	0.01	79	9.83	73		1030	699	8.09	WW
8/14/2019 9:39:00 PM	0	66	7.82	69.1		949	673	7.66	WW
8/21/2019 10:10:00 PM	0.09	71.5	8.73	75.9		908	597	7.87	WW
8/28/2019 10:48:00 PM	0	58.2	8.87	66.2		1247	915	7.41	WW
9/4/2019 10:25:00 AM	0.58	60.9	8.03	67.2		991	719	7.55	WW
Watershed	Clinton	HUC-12		040900030105					
Site ID	631284	Site Description		Trib to Lake Michelson - Seymour Lake Rd.					
8/8/2019 6:40:00 AM	0.15	61.9	4.79	73.1		422	286	7.62	WW
8/15/2019 7:53:00 AM	0	62.8	5.86	71.2		425	294	7.83	WW
8/22/2019 7:42:00 AM	0	60.2	5.64	73.7		442	298	7.94	WW
8/29/2019 7:56:00 AM	0	53.5	6.35	67.7		402	290	7.84	WW
9/5/2019 7:45:00 AM	0	50.6	6.86	66.9		397	289	7.86	WW

Date and Time	24-Hour Precip (in)	Air Temp (F)	D.O. (mg/L)	Water Temp (F)	Turbidity (NTU)	Cond (us/L)	TDS (mg/L)	pH	CW or WW
Watershed	Clinton		HUC-12	040900030107					
Site ID	631077		Site Description	Sashabaw Creek - Pine Knob Trail					
8/15/2019 9:28:00 AM	0.12	64.8	7.49	65.5		820	607	8.04	WW
8/22/2019 9:19:00 AM	0.09	64.8	7.14	68.7		793	565	8.07	WW
8/29/2019 9:36:00 AM	0	63.5	7.9	61.7		772	599	8	WW
9/5/2019 10:19:00 AM	0	62	8.34	60.8		764	600	7.97	WW
9/12/2019 7:40:00 AM	0.78	61.6	6.3	67.7		782	564	7.83	WW
Watershed	Clinton		HUC-12	040900030108					
Site ID	630630		Site Description	Clinton River - Cooley Lake Rd.					
8/8/2019 5:53:00 AM	0	67.6	4.9	73.4		855	578	7.77	WW
8/14/2019 10:29:00 AM	0	71.6	6.67	71		860	597	7.74	WW
8/21/2019 10:55:00 AM	0.22	75.7	7.46	73.7		849	572	7.5	WW
8/28/2019 11:26:00 AM	0	69.4	8.13	68.5		852	608	7.71	WW
9/4/2019 11:05:00 AM	0.58	60.8	7.5	67.4		806	583	7.75	WW
Site ID	631100		Site Description	West Branch Stony Creek - Stony Creek Metropark					
8/7/2019 9:14:00 AM	0	72.3	8.96	65.8		627	462	8.25	WW
8/14/2019 8:03:00 AM	0	68.3	8.22	64.9		702	524	8.03	WW
8/21/2019 8:32:00 AM	0.07	70.6	9.45	68.7		598	426	8.19	WW
8/28/2019 9:23:00 AM	0	67.2	8.89	62.7		672	515	8.09	WW
9/4/2019 8:40:00 AM	0.01	61.1	8.52	65.8		585	432	8.13	WW
Watershed	Clinton		HUC-12	040900030109					
Site ID	500554		Site Description	Stony Creek - Inwood Rd					
8/7/2019 8:25:00 AM	0	70.4	7.6	65.6		607	449	8.17	WW
8/14/2019 7:30:00 AM	0	64.6	7.45	67.5		644	465	8.12	WW
8/21/2019 7:59:00 AM	0.07	70.3	8.21	69.8		626	441	8.03	WW
8/28/2019 8:36:00 AM	0	64	7.67	64.3		582	437	8.03	WW
9/4/2019 8:05:00 AM	0.01	62.3	7.55	64.6		592	443	7.94	WW
Watershed	Clinton		HUC-12	040900030110					
Site ID	630616		Site Description	Paint Creek - Adams Rd. (north)					
8/8/2019 7:41:00 AM	0	68.1	8.21	66.3		620	455	8.2	CW
8/15/2019 8:28:00 AM	0.02	63.5	8.65	63.4		687	522	8.22	CW
8/22/2019 8:35:00 AM	0	64.5	8.13	68.8		577	411	8.31	CW
8/29/2019 8:45:00 AM	0	62.6	8.87	60.8		573	450	8.14	CW
9/5/2019 8:40:00 AM	0.01	59.3	8.95	62.1		542	418	8.09	CW
Site ID	630617		Site Description	Trout Creek - Adams Rd. (south)					
8/8/2019 7:56:00 AM	0	68.6	7.32	65.2		886	658	7.97	CW
8/15/2019 8:43:00 AM	0.02	63.6	7.6	63.6		805	610	7.97	CW
8/22/2019 8:46:00 AM	0	64.7	7.15	67.9		719	517	8.04	CW
8/29/2019 8:58:00 AM	0	63.8	7.99	60.1		712	564	7.91	CW
9/5/2019 8:56:00 AM	0.01	59.3	8.25	61		767	601	7.92	CW

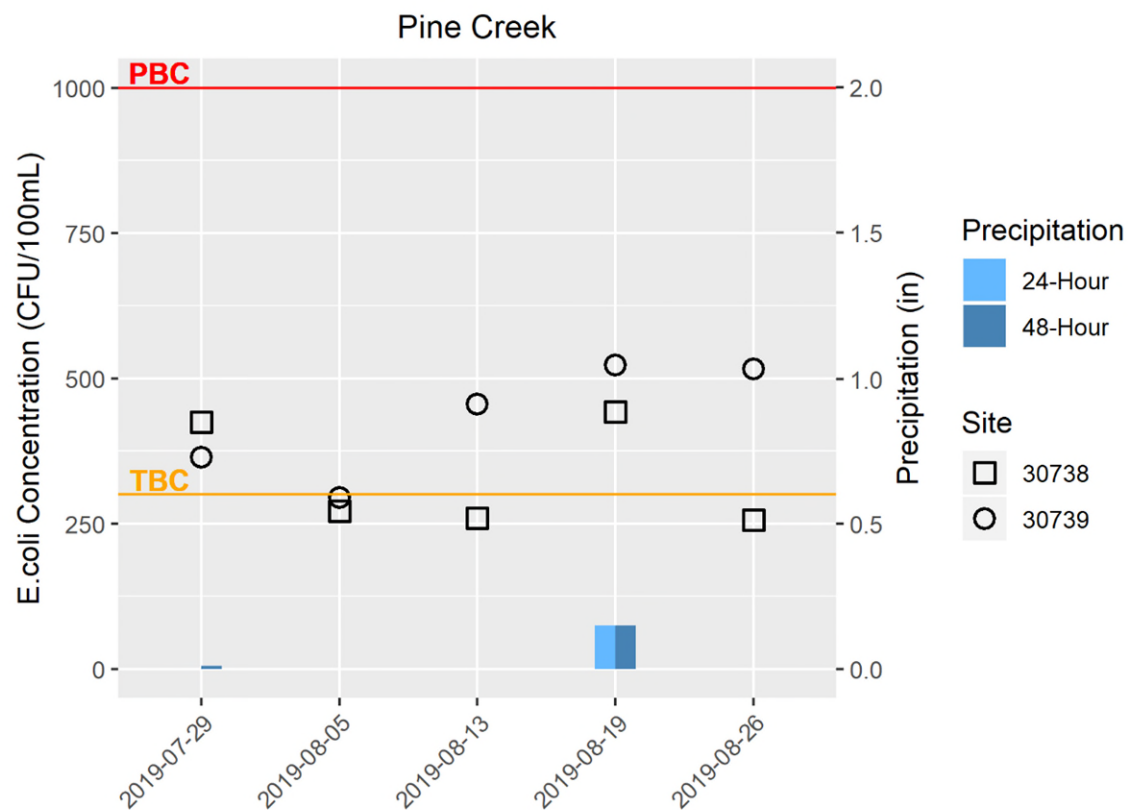
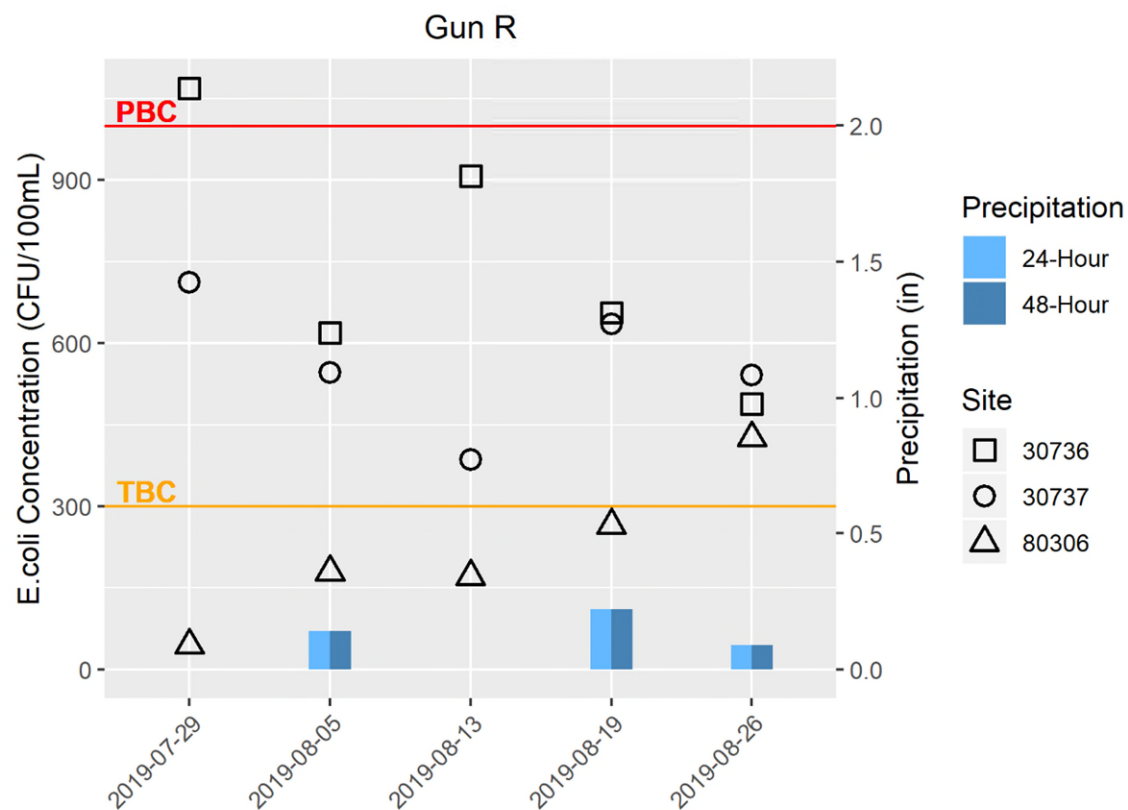
Date and Time	24-Hour Precip (in)	Air Temp (F)	D.O. (mg/L)	Water Temp (F)	Turbidity (NTU)	Cond (us/L)	TDS (mg/L)	pH	CW or WW
Site ID	631285	Site Description		Paint Cr- Rochester Rd - CR12					
8/7/2019 9:54:00 AM	0	75.9	9.38	65		746	556	8.31	CW
8/14/2019 8:31:00 AM	0	69.8	9.03	65.4		809	600	8.2	CW
8/21/2019 9:01:00 AM	0.07	71.5	9.89	69.4		702	496	8.22	CW
8/28/2019 9:48:00 AM	0	68.5	9.25	63.9		717	542	8.15	CW
9/4/2019 9:10:00 AM	0.01	62.1	9	64		691	521	8.09	CW
Site ID	631286	Site Description		Sargent Creek - N. Livernois Rd.					
8/7/2019 11:45:00 AM	0	80.6	7.46	69.3		897	635	8.11	WW
8/14/2019 8:52:00 AM	0	68.1	7.6	66.9		929	677	8.01	WW
8/21/2019 9:24:00 AM	0.07	72.3	8.45	73		570	387	8.04	WW
8/28/2019 10:08:00 AM	0	69.5	7.86	68.1		609	437	7.96	WW
9/4/2019 9:40:00 AM	0.02	61.9	7.62	66.3		824	604	7.98	WW
Watershed	Clinton	HUC-12		040900030111					
Site ID	631032	Site Description		Galloway Creek - Butler Rd.					
8/7/2019 11:00:00 AM	0.01	76.1	8.54	67.1		1299	943	7.95	WW
8/14/2019 9:16:00 AM	0.02	68.9	7.61	65.9		1209	891	7.8	WW
8/21/2019 9:48:00 AM	0.22	70	8.9	73		1169	793	8.01	WW
8/28/2019 10:30:00 AM	0	68	8.39	66.5		1418	1038	7.8	WW
9/4/2019 10:00:00 AM	0.58	61.2	8.2	66.4		1150	842	7.82	WW

Appendix 4. *E. coli* concentrations for each site graphed with prior precipitation (organized by watershed, with Kalamazoo first). Prior precipitation is represented by light (24-hour) and dark (48-hour) blue bars on the secondary axis. These graphs are a visual representation of the information in Appendix 2.

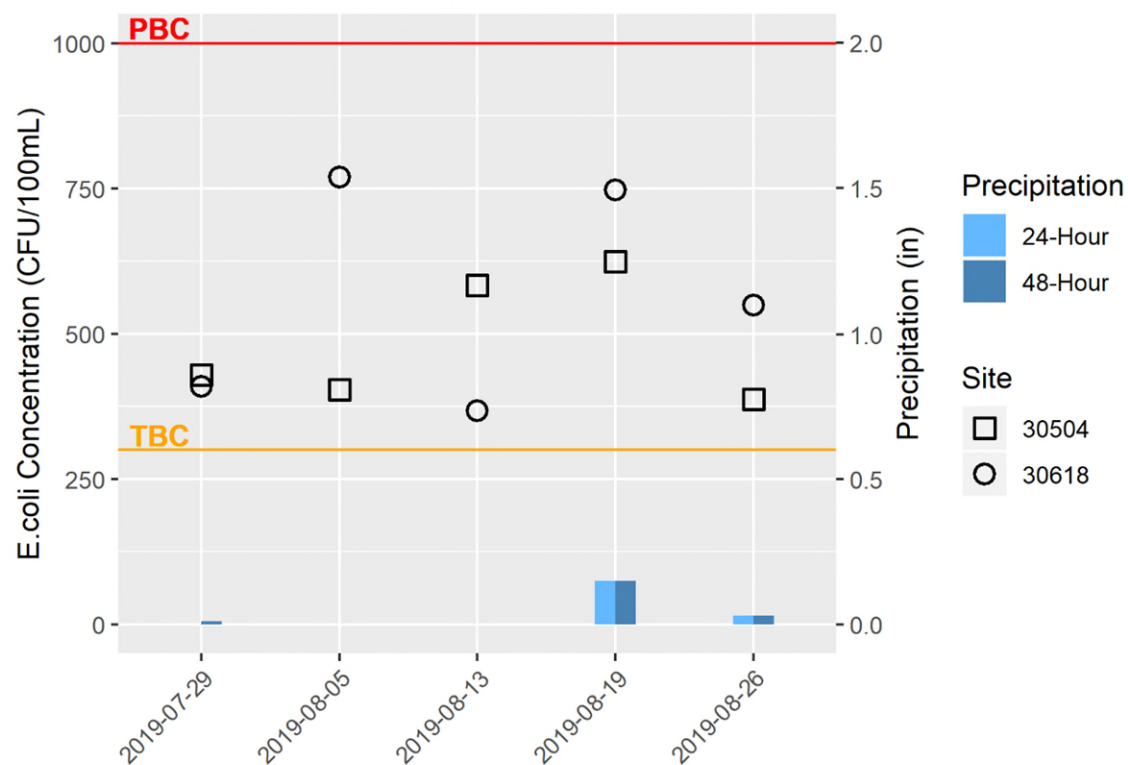




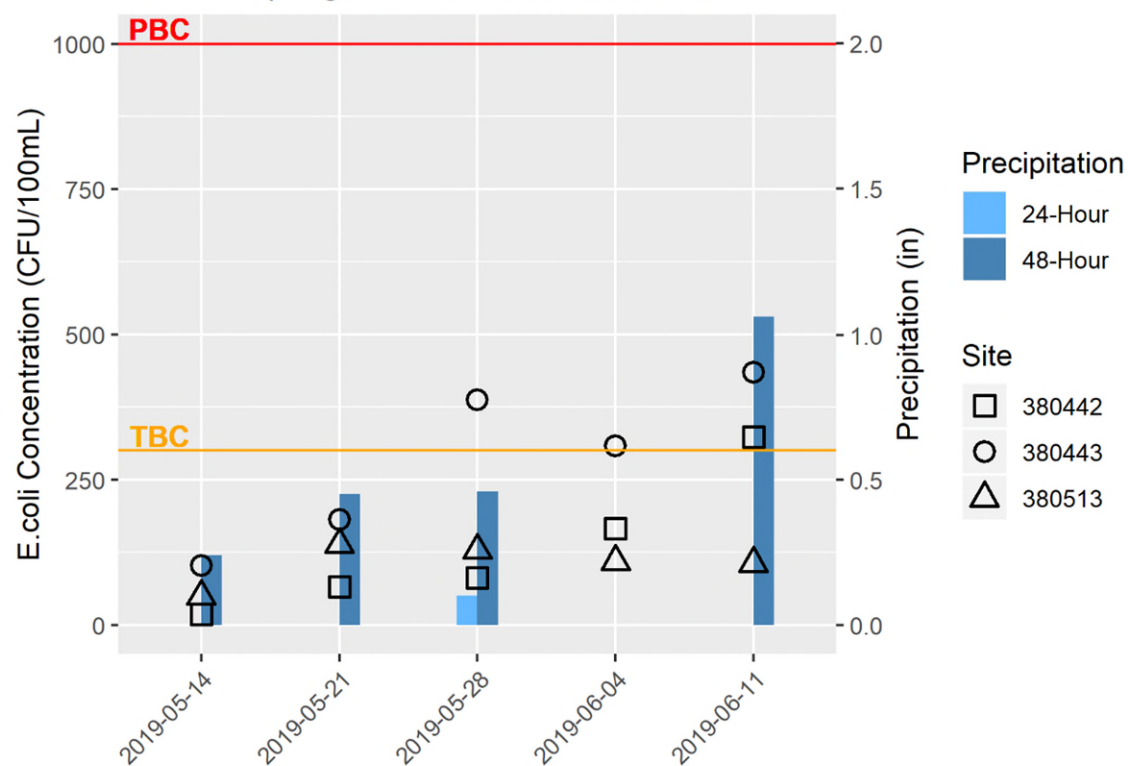
Appendix 4 (cont). Kalamazoo sites, grouped by watershed.



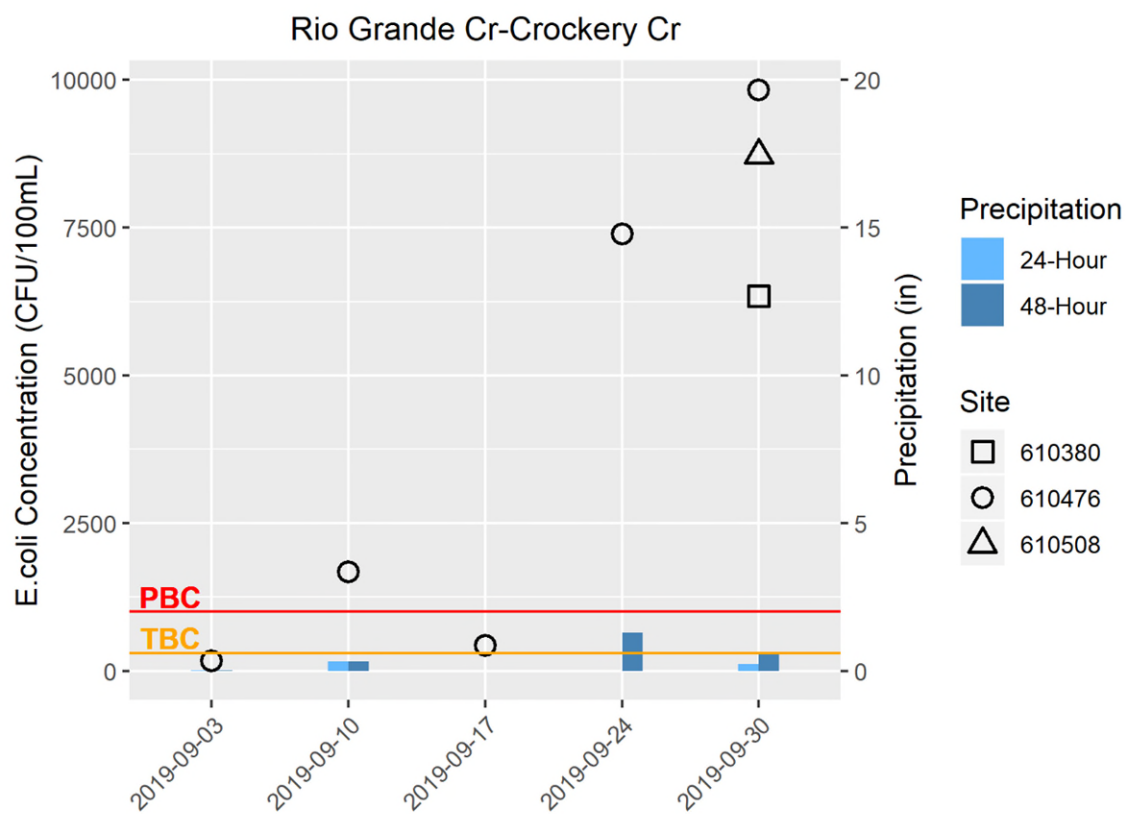
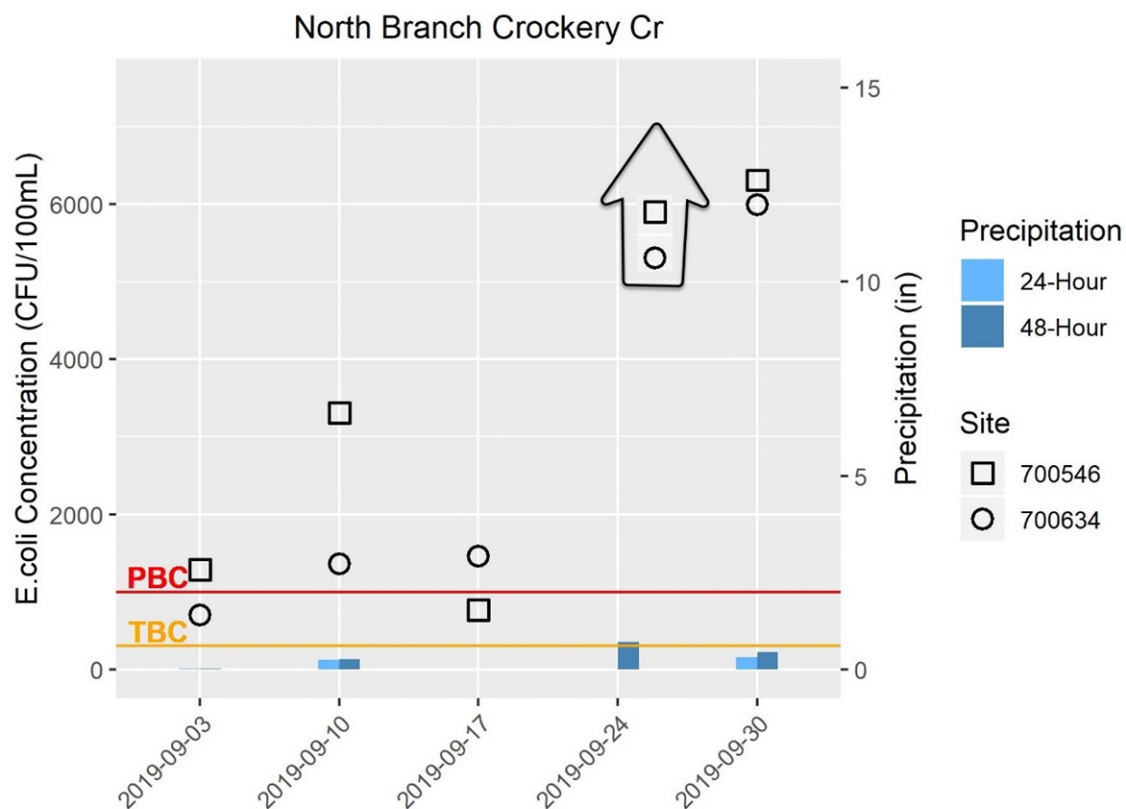
### Base Line Cr and Schnable Brook

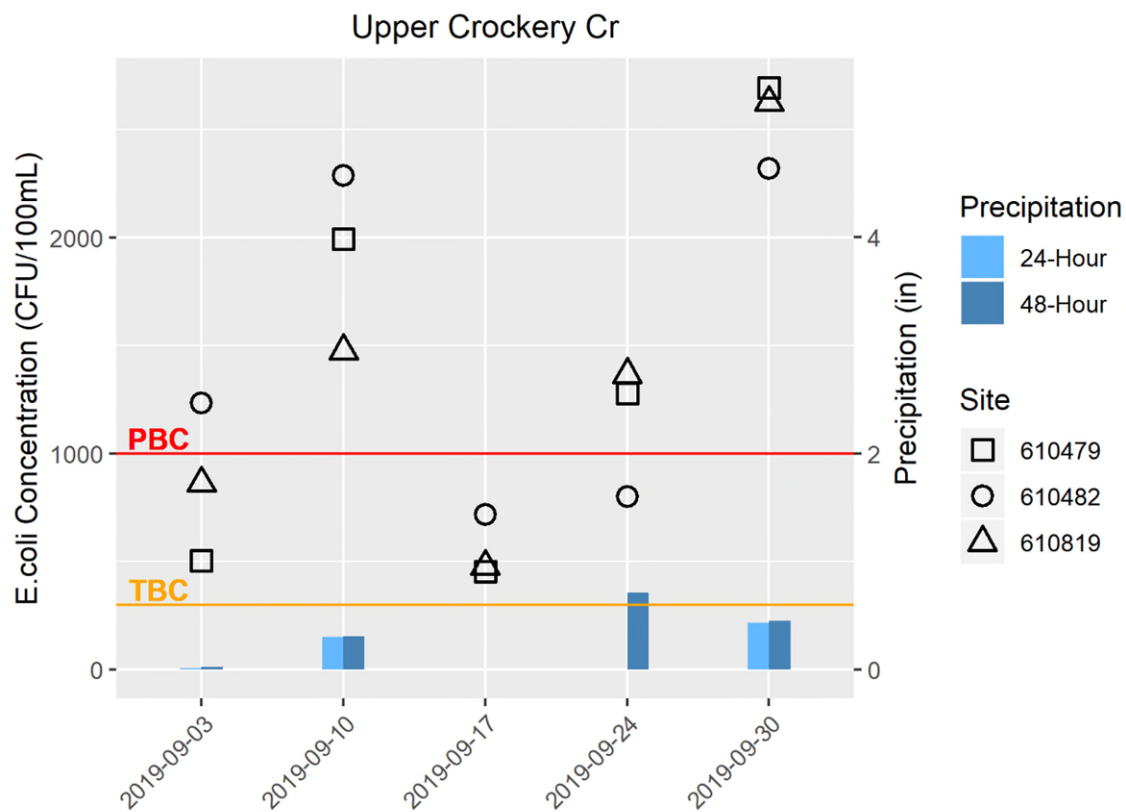
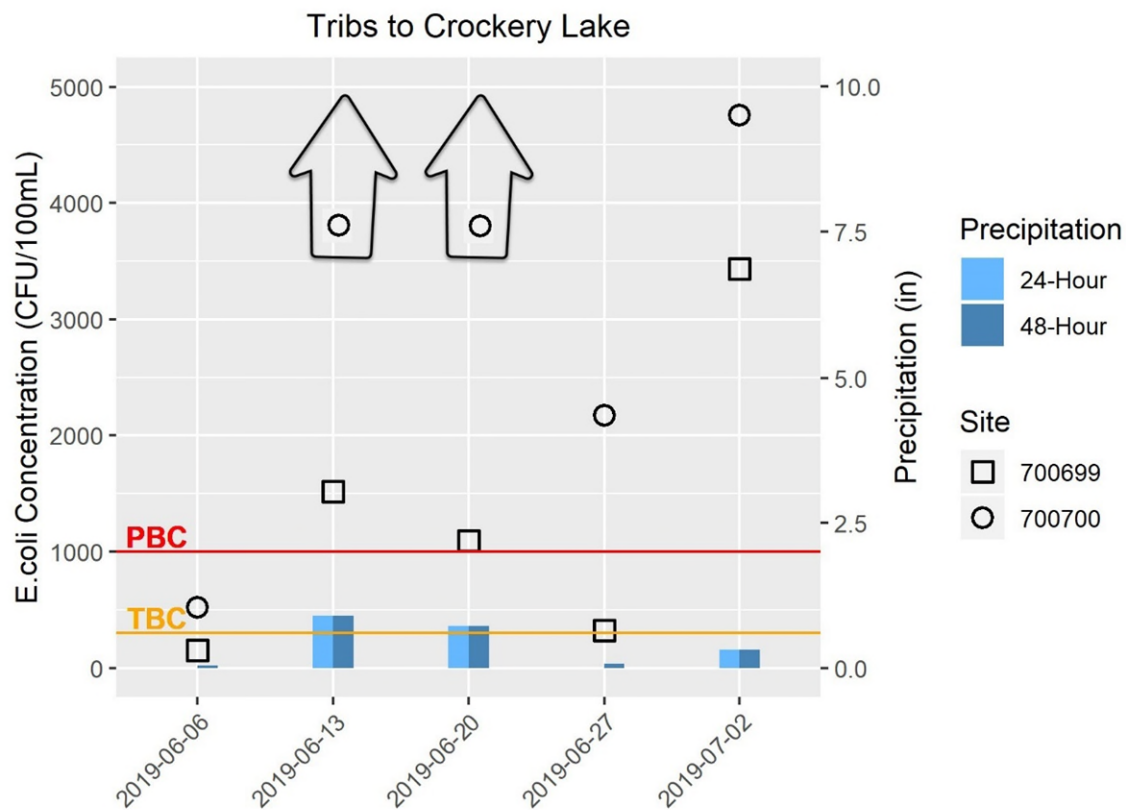


### Spring Arbor and Concord Drain

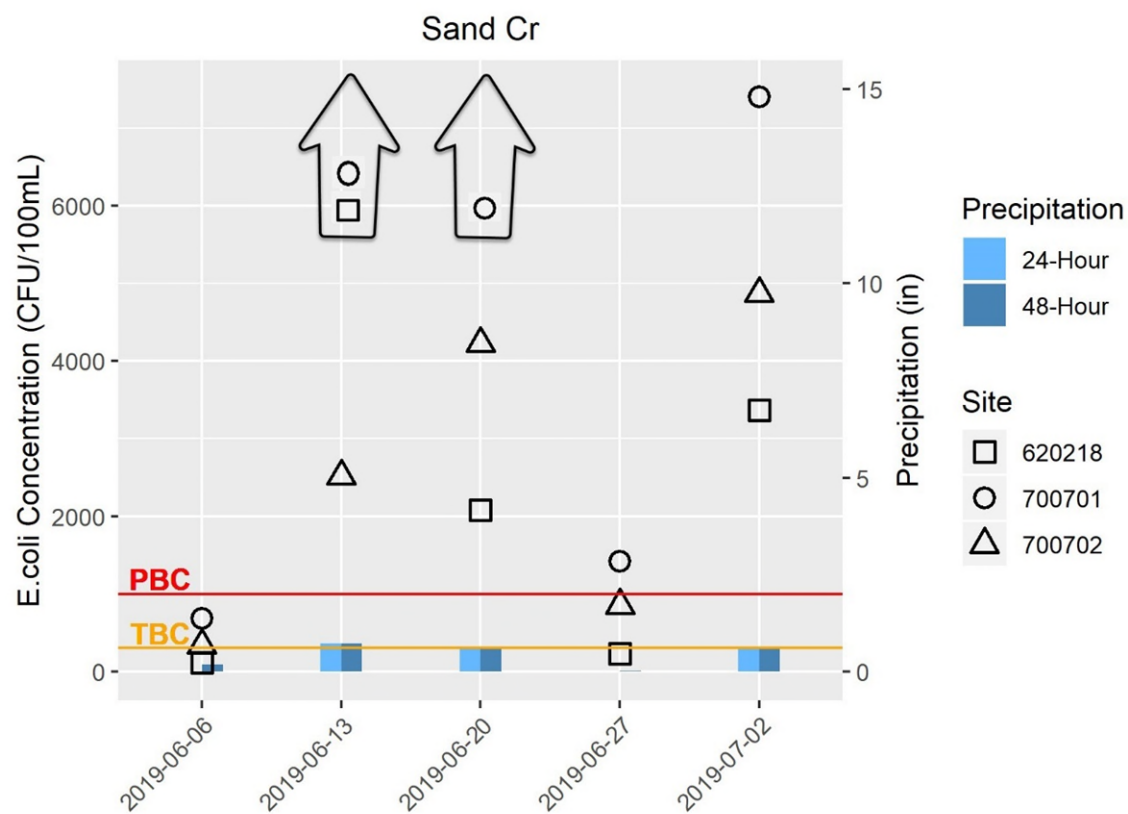
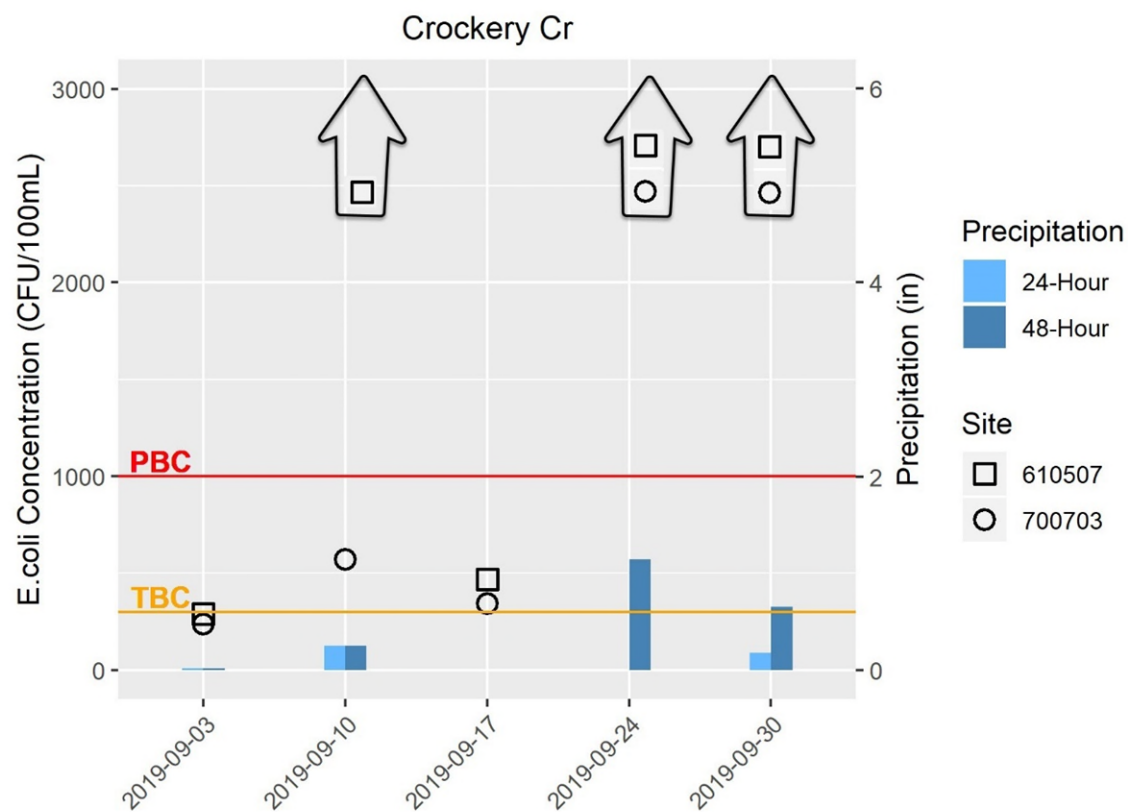


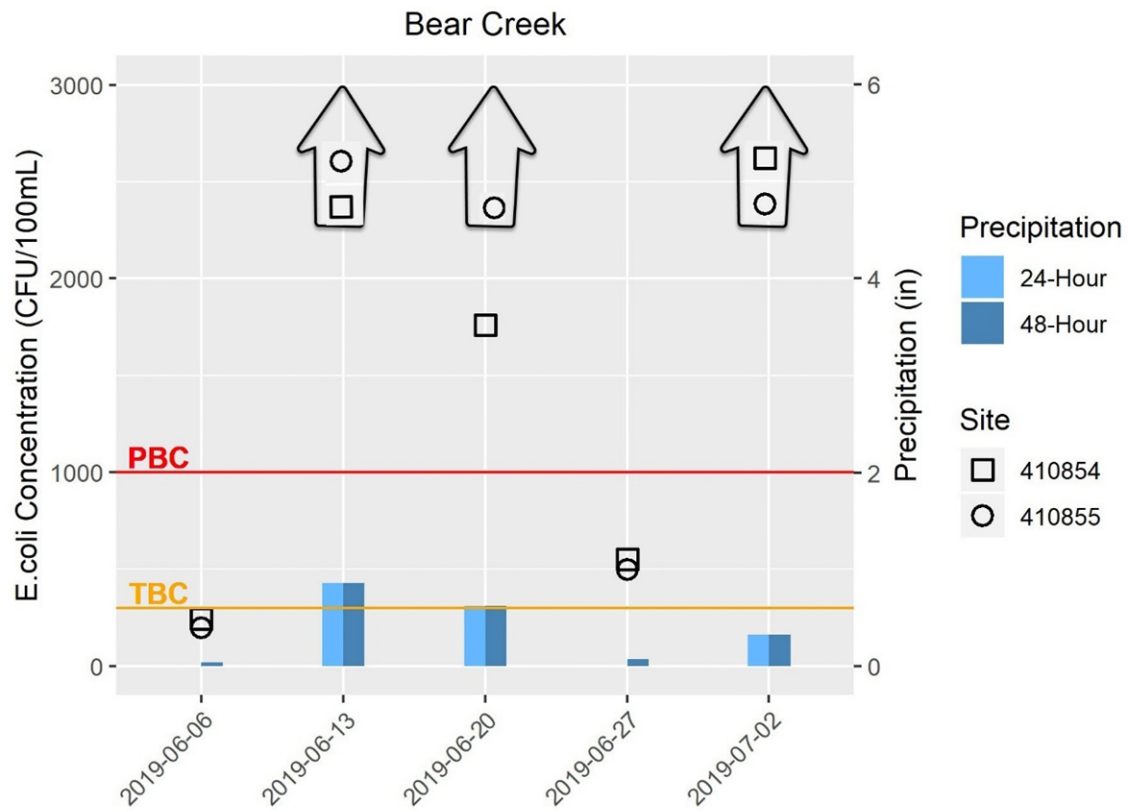


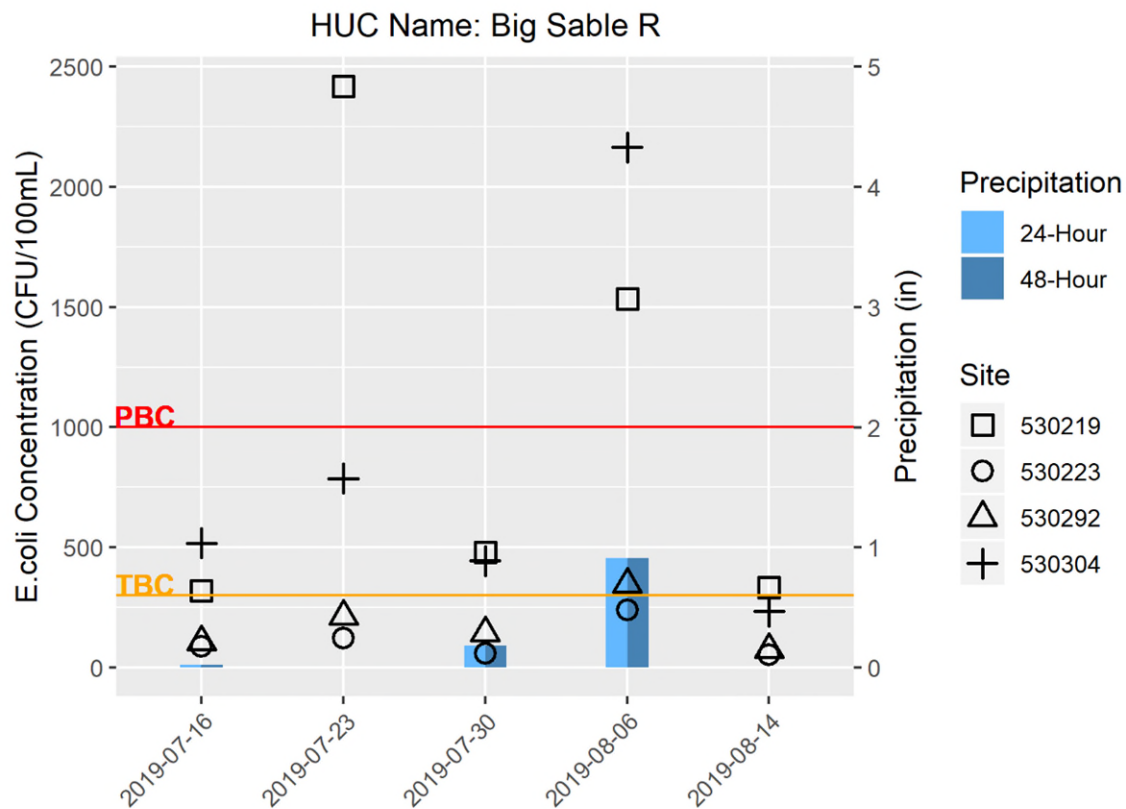


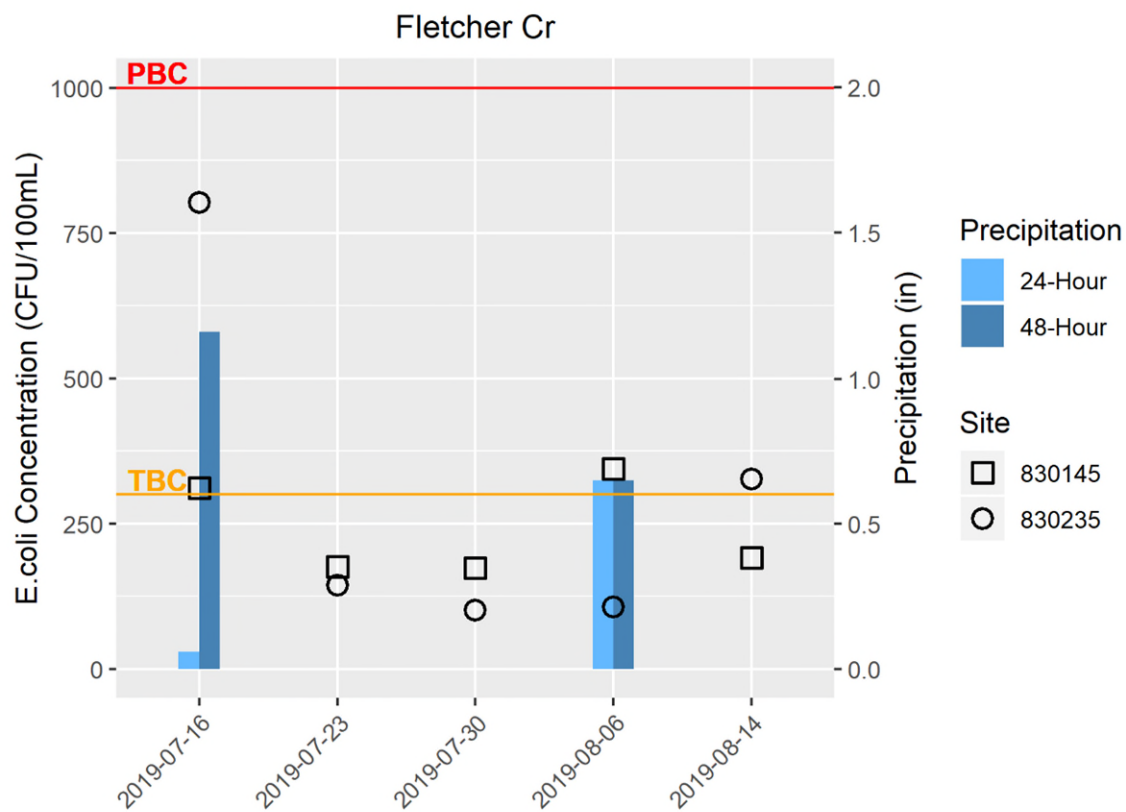
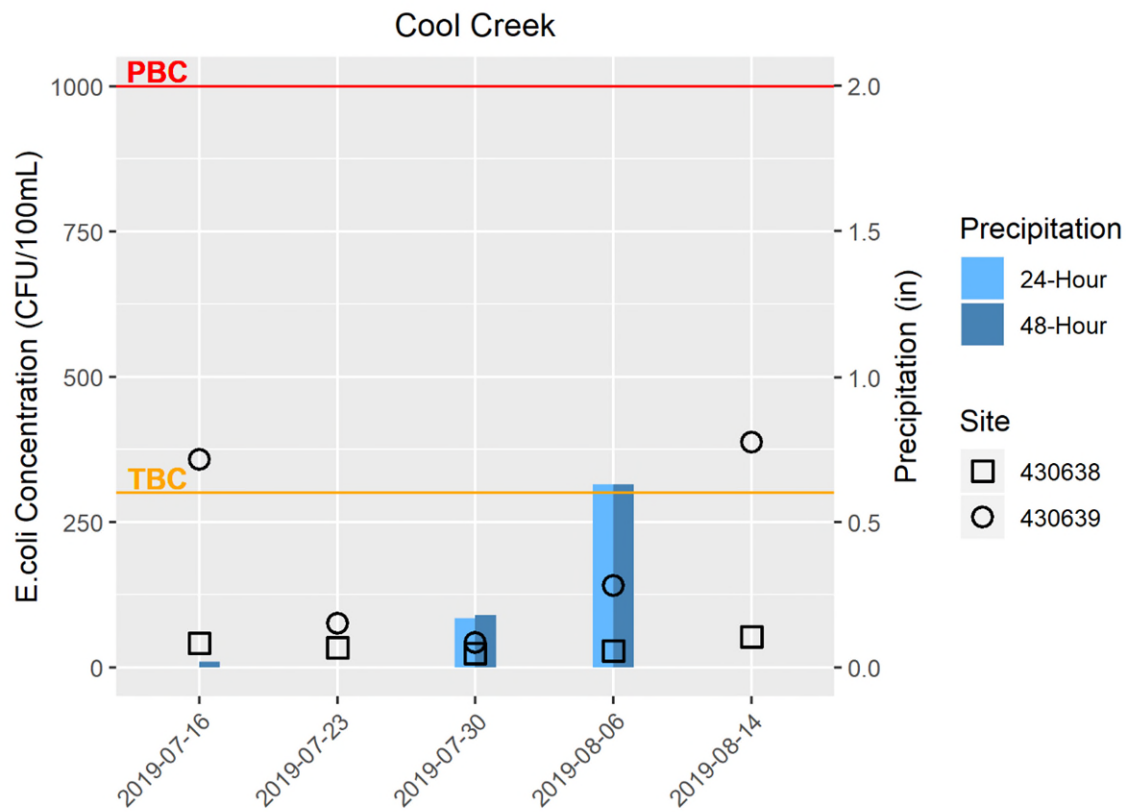


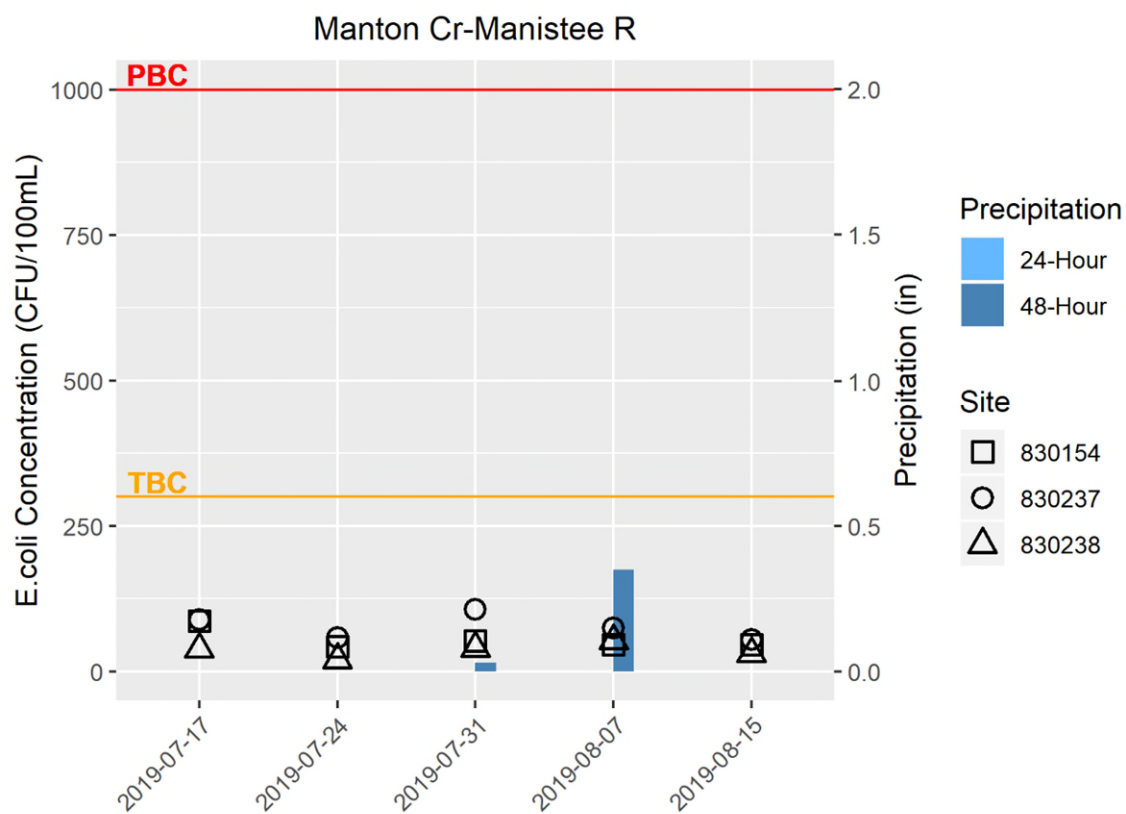
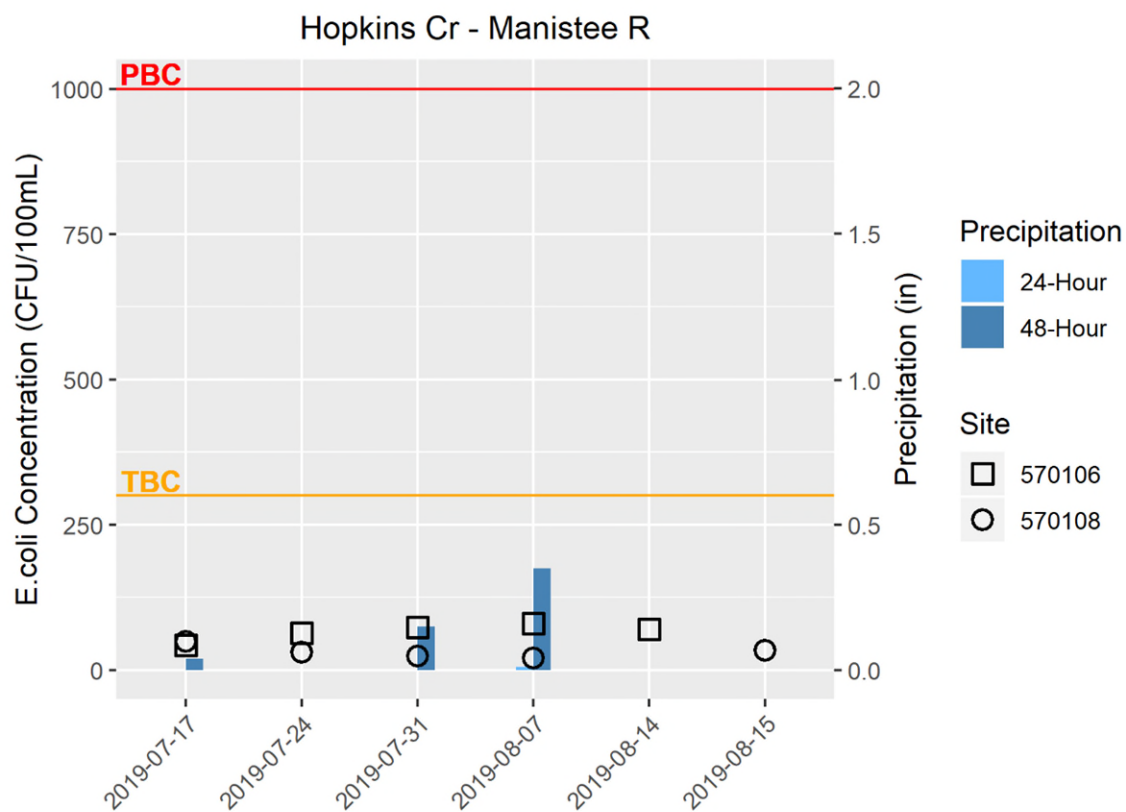
Appendix 4 (cont). Tributaries to the Lower Grand River.

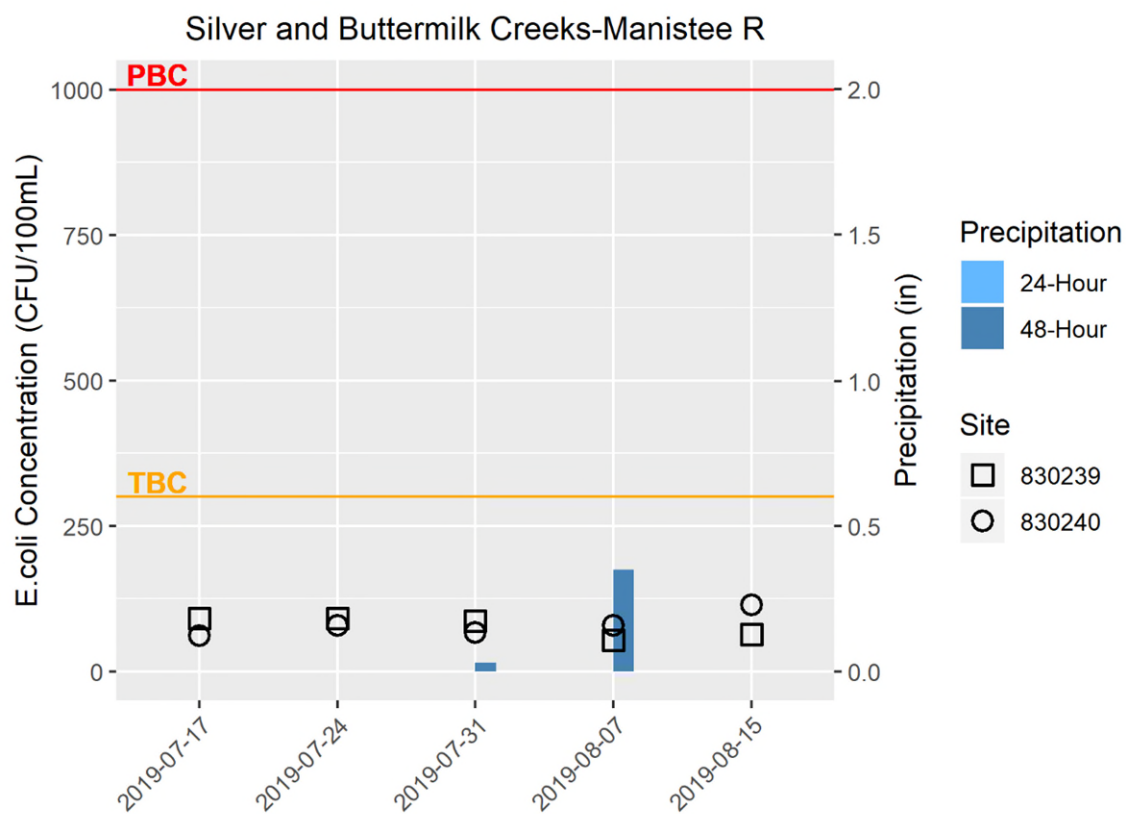
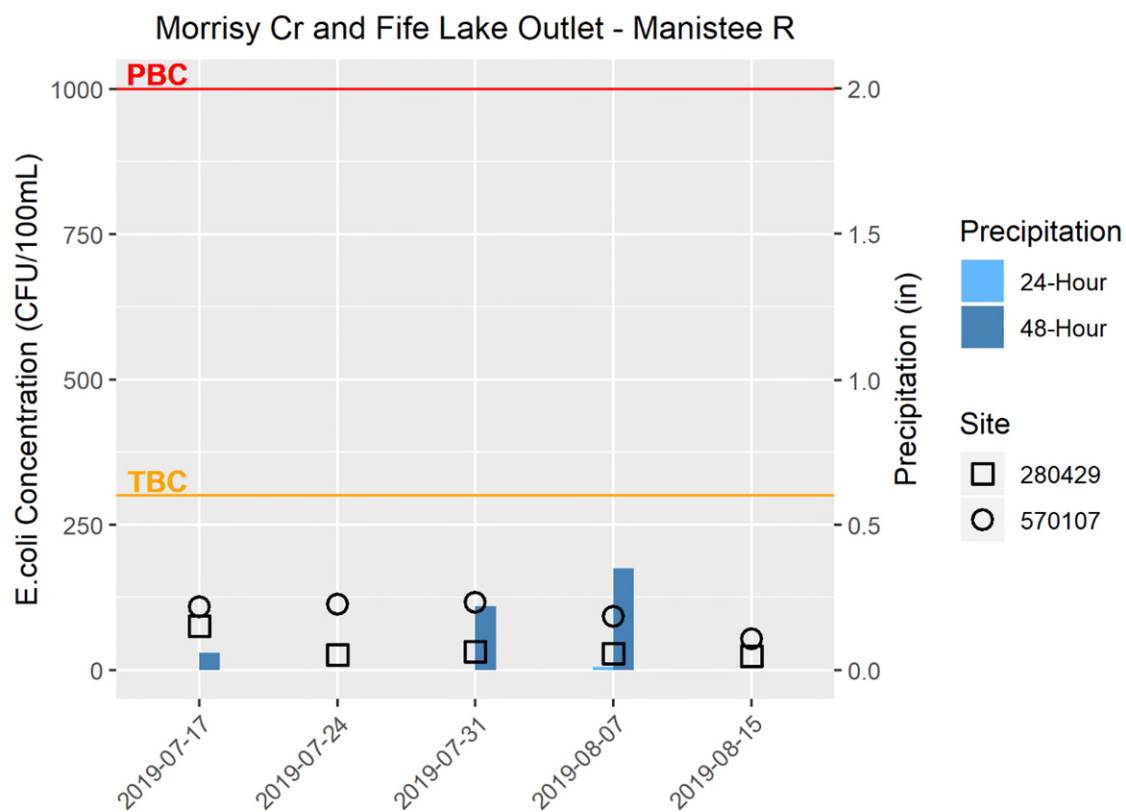




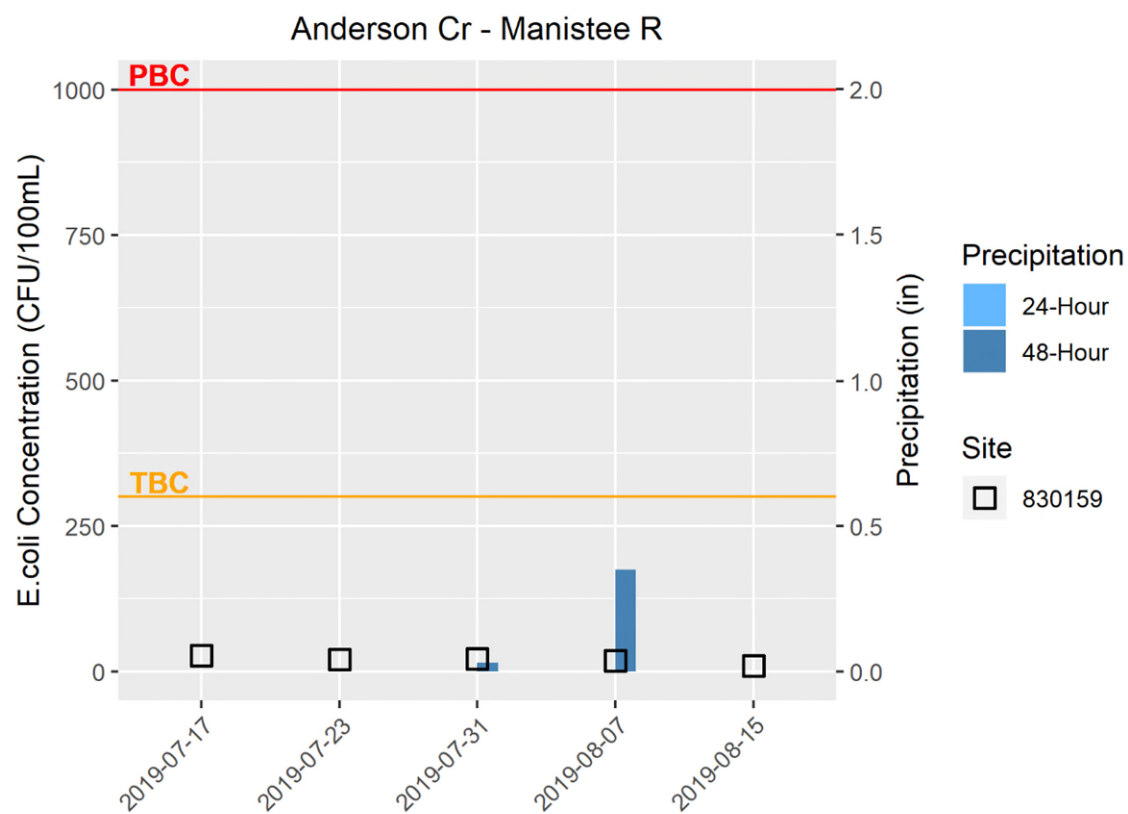
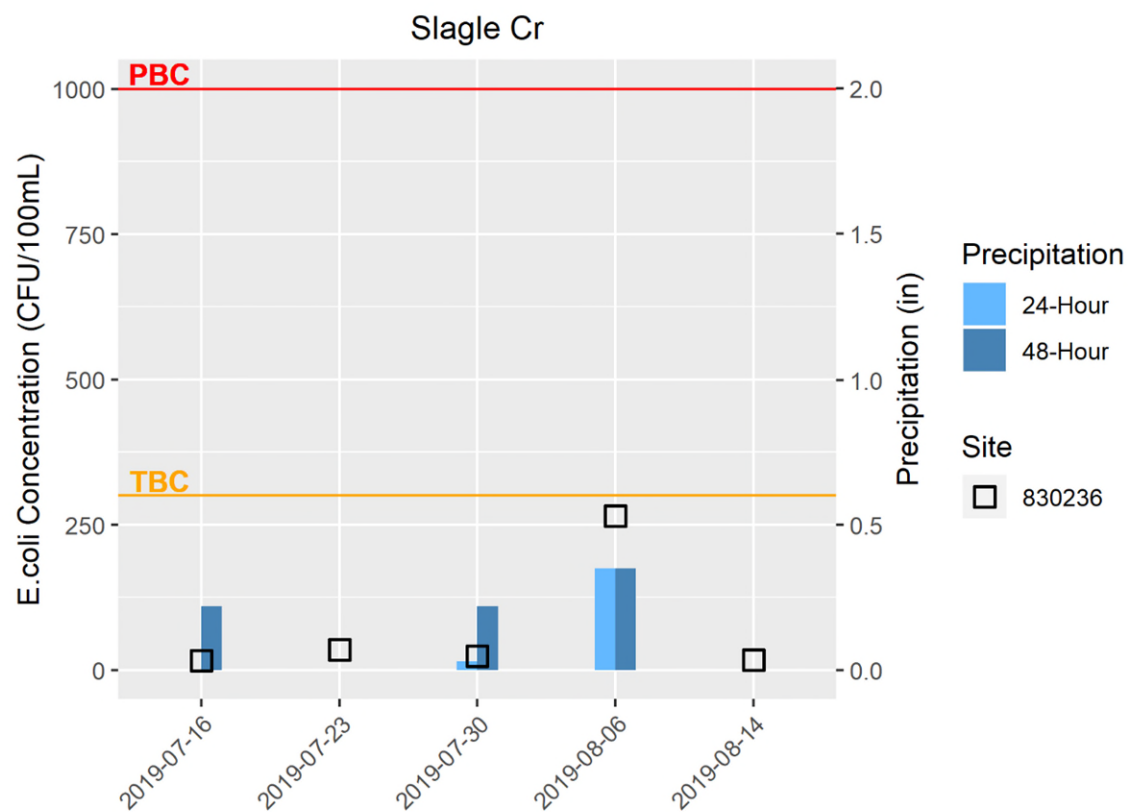


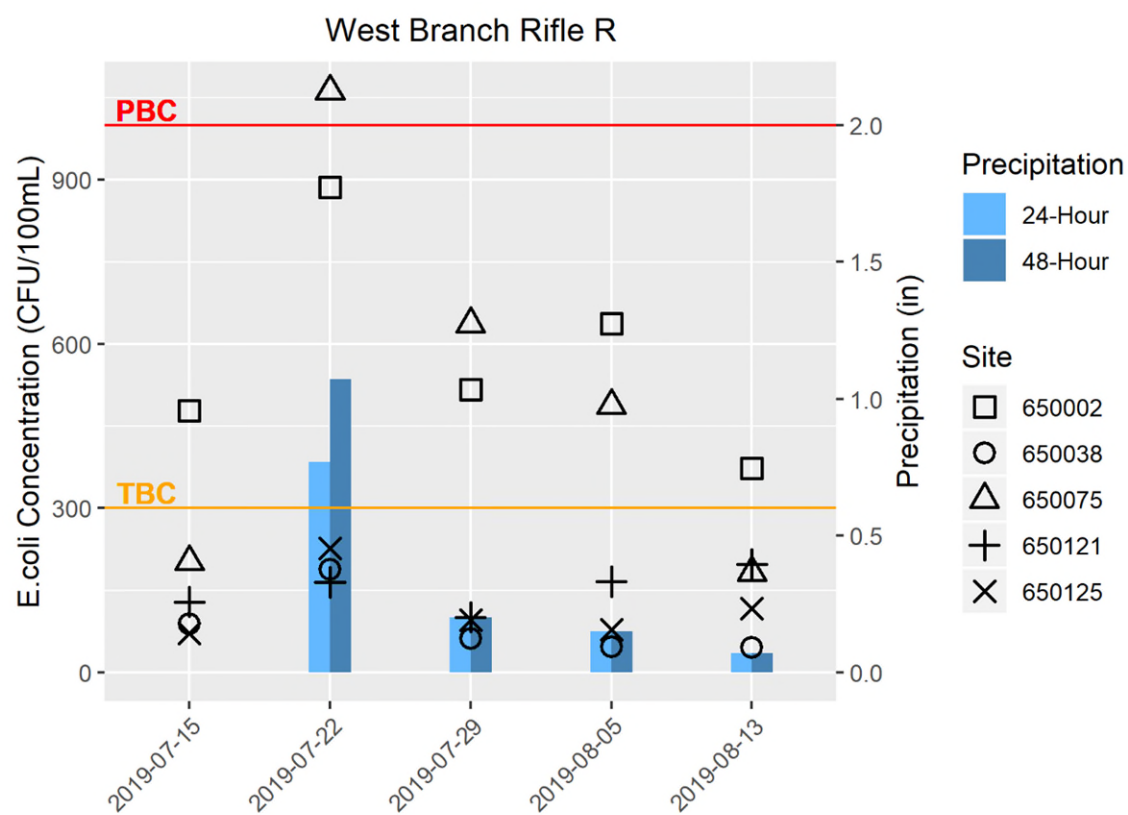
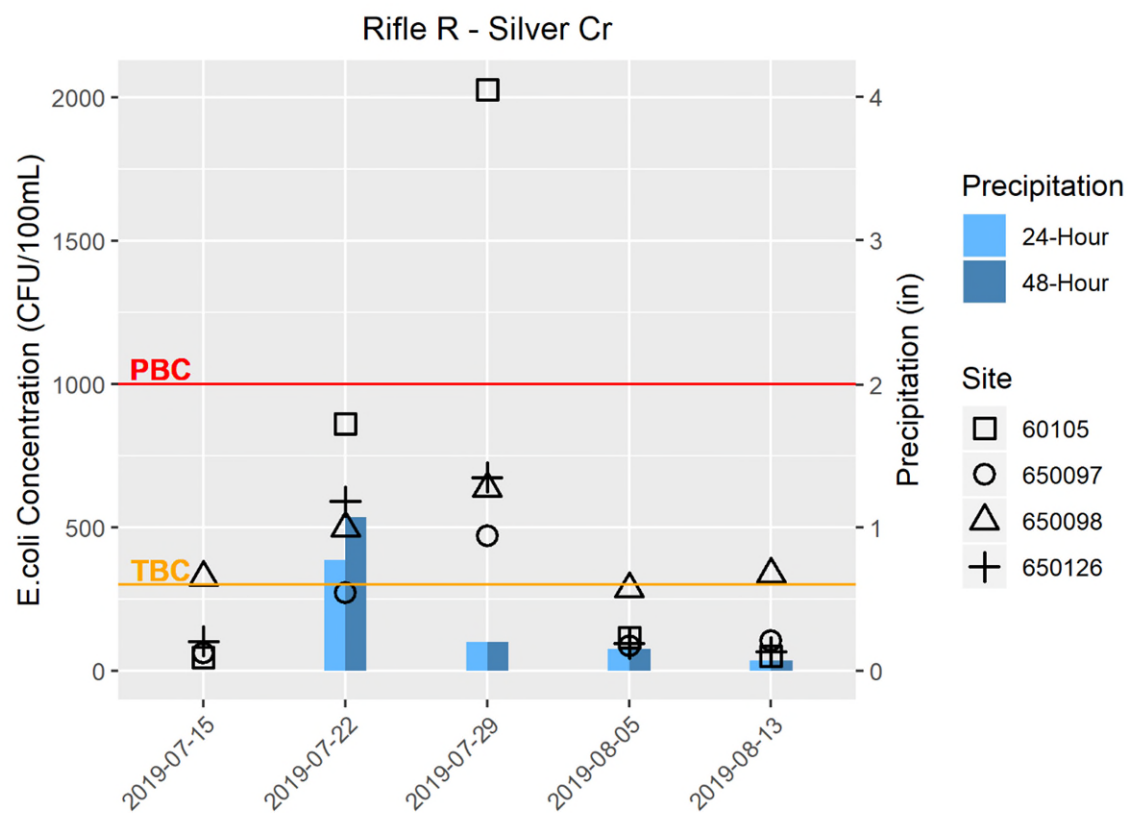


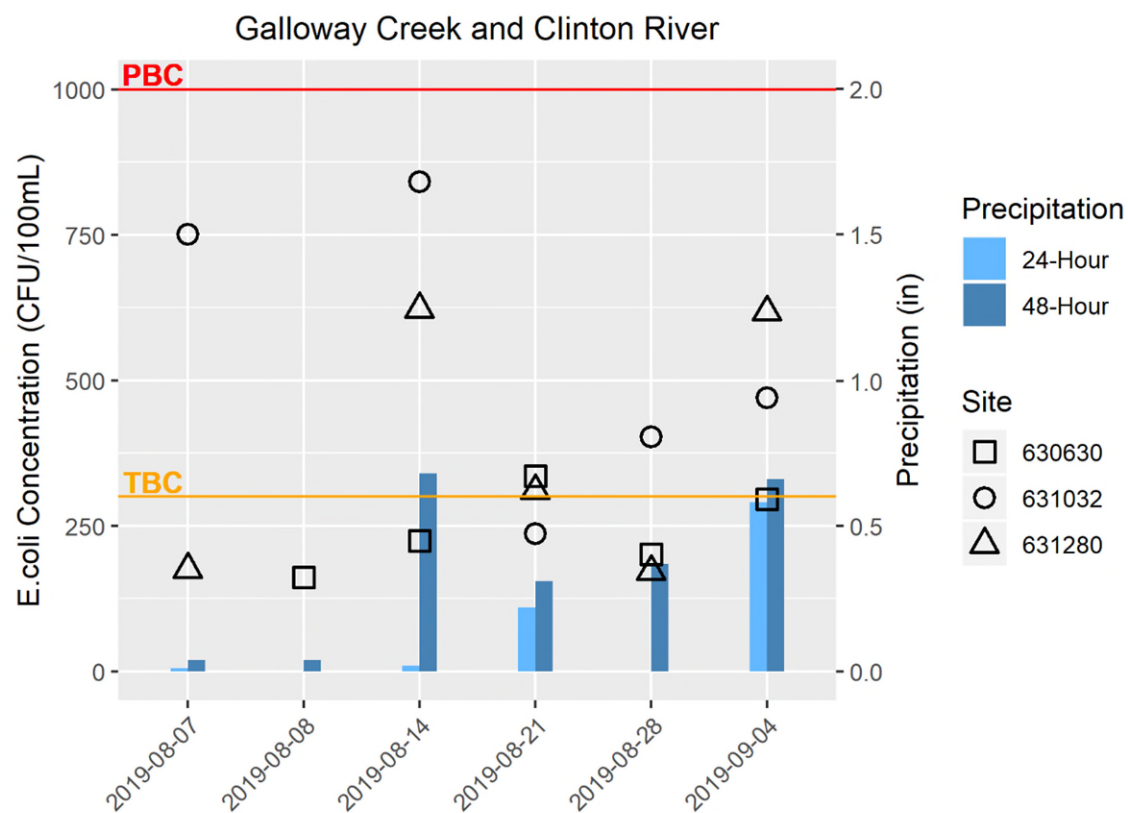
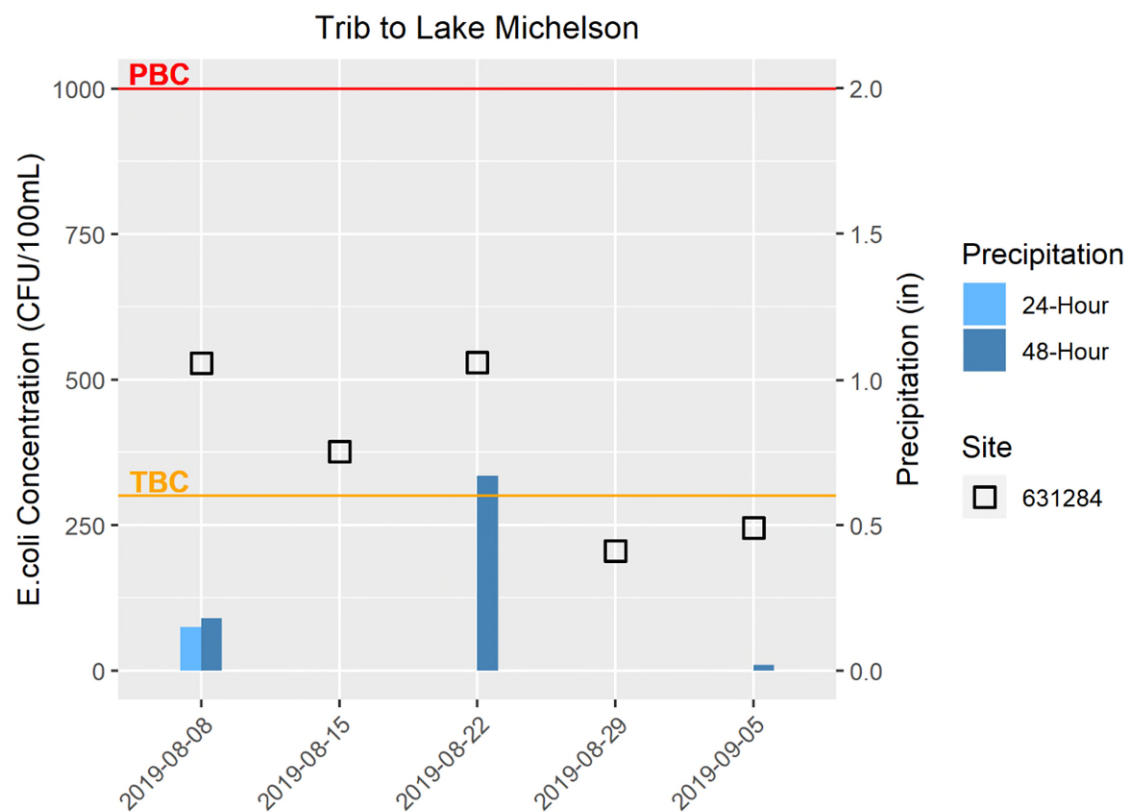


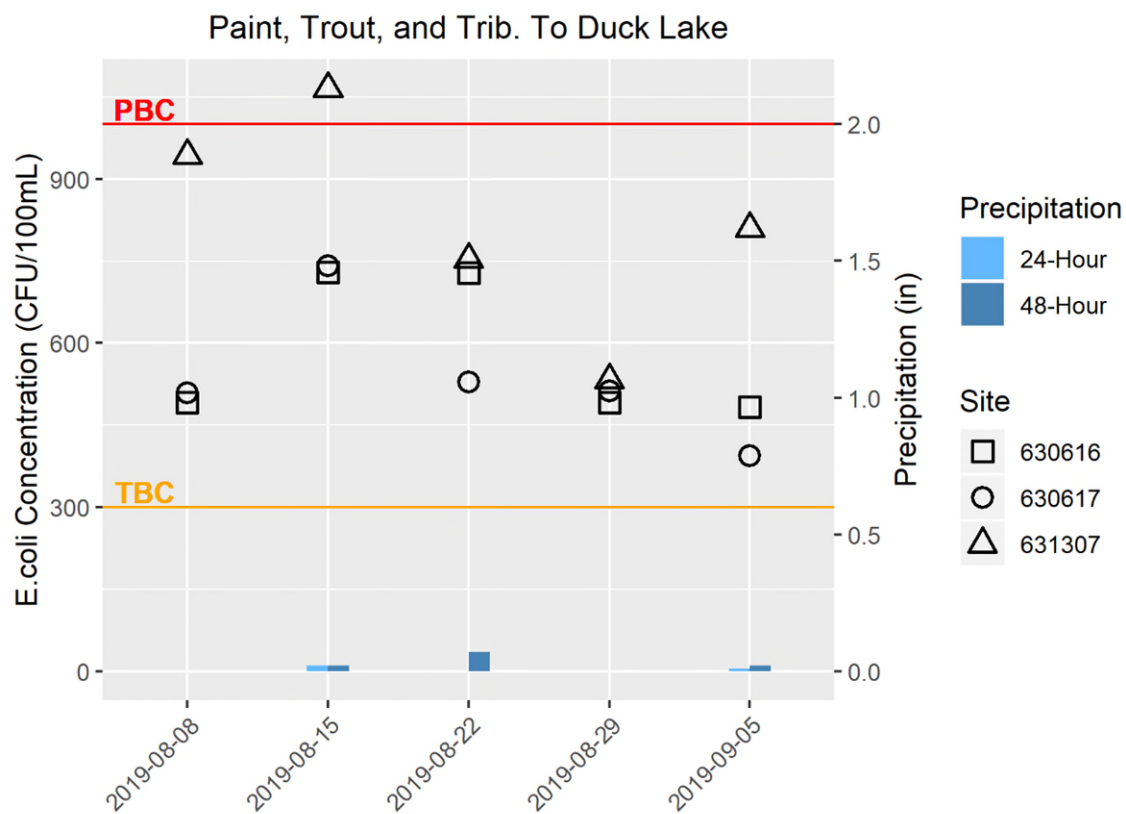
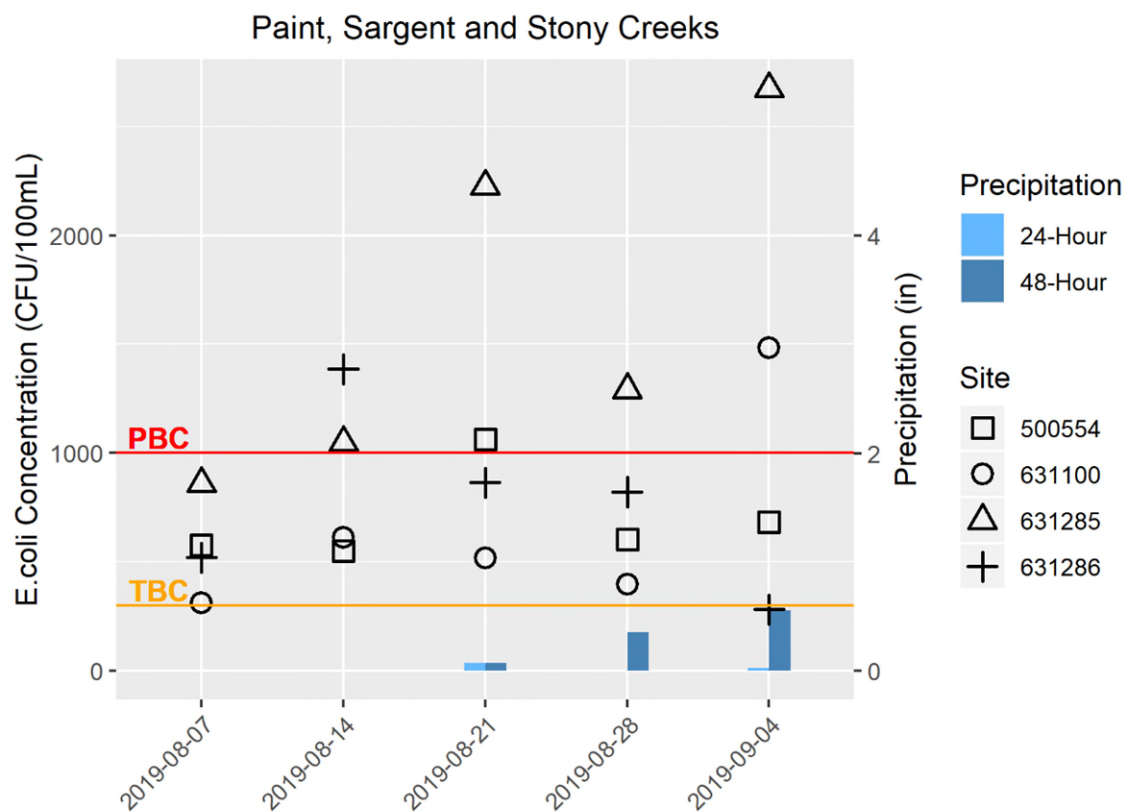


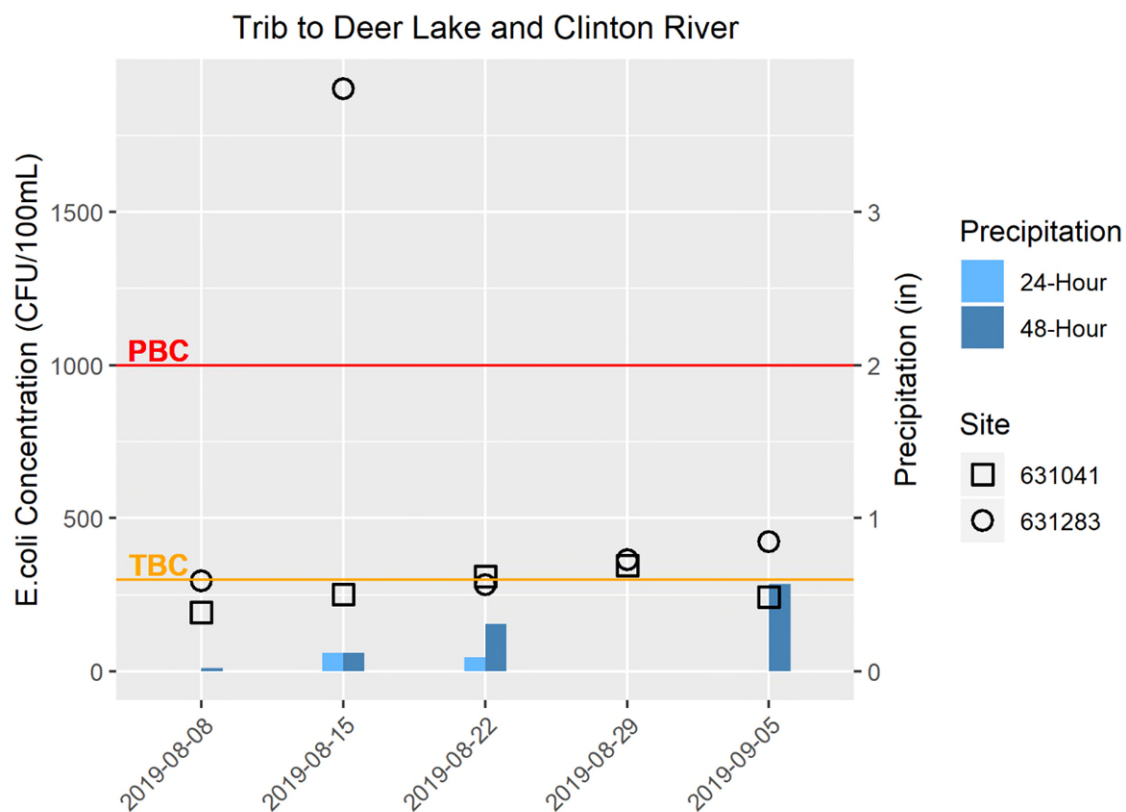
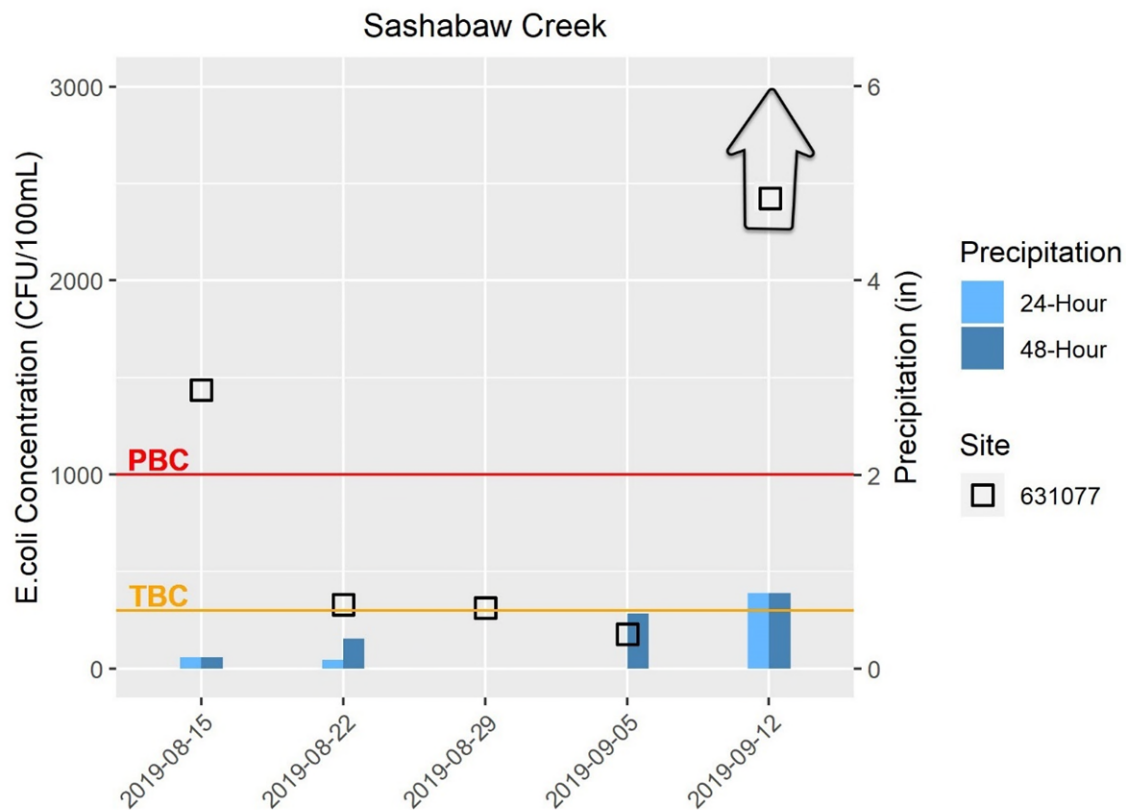


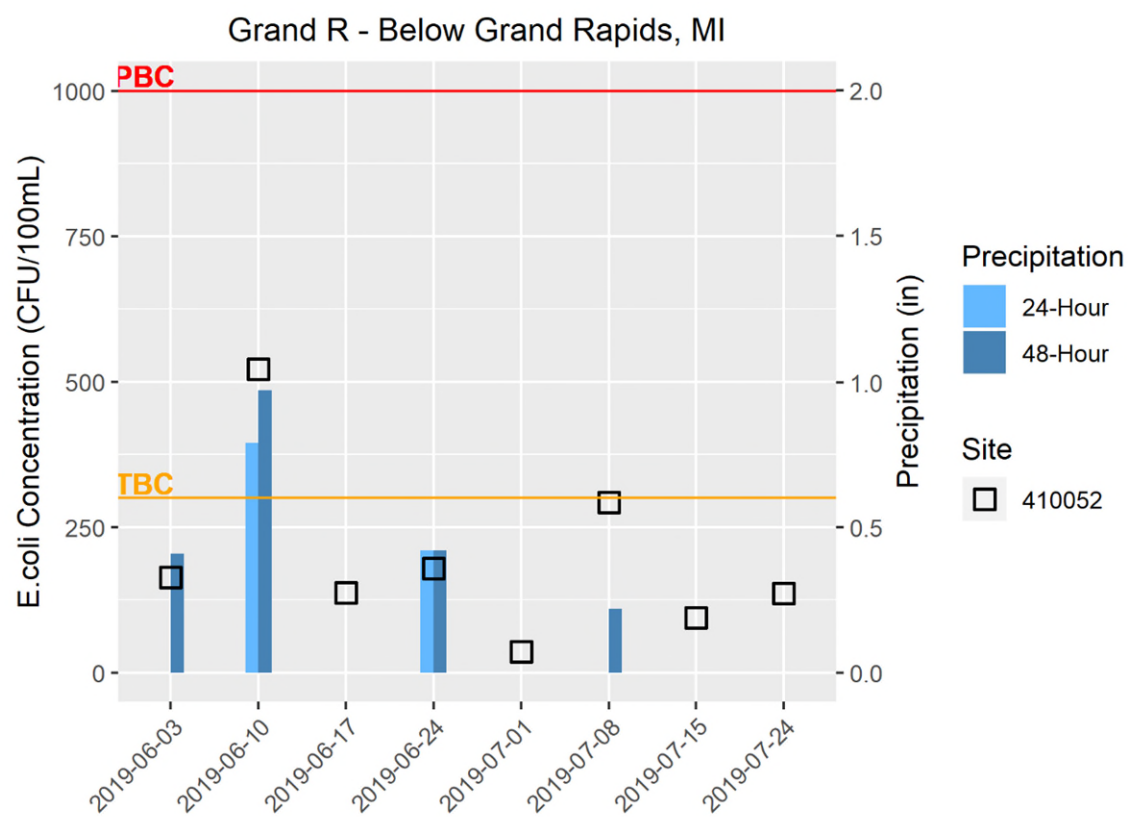
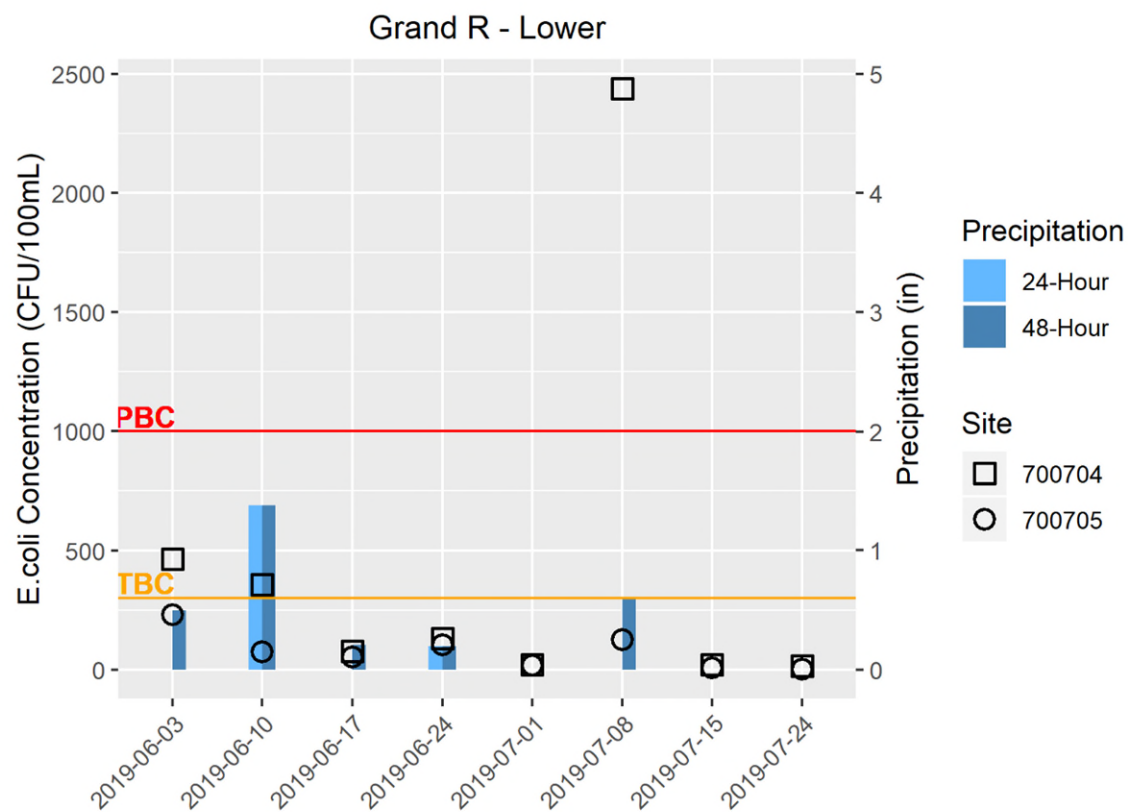


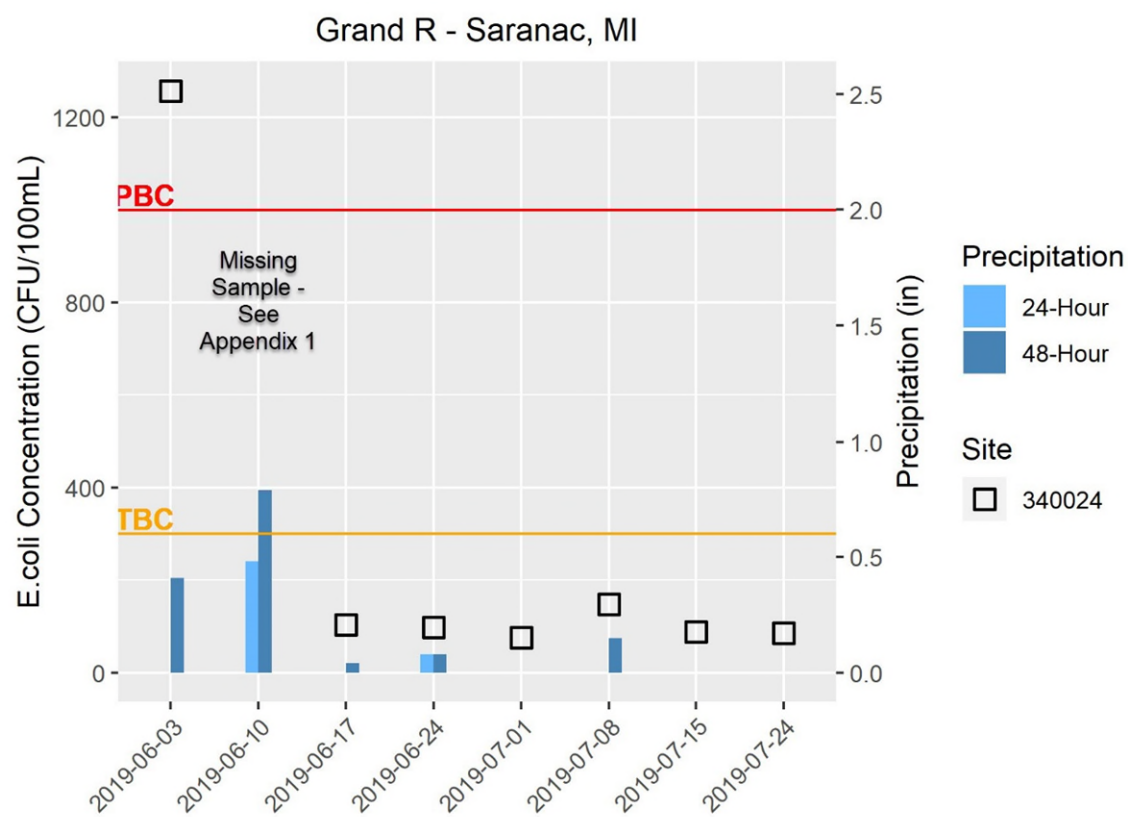
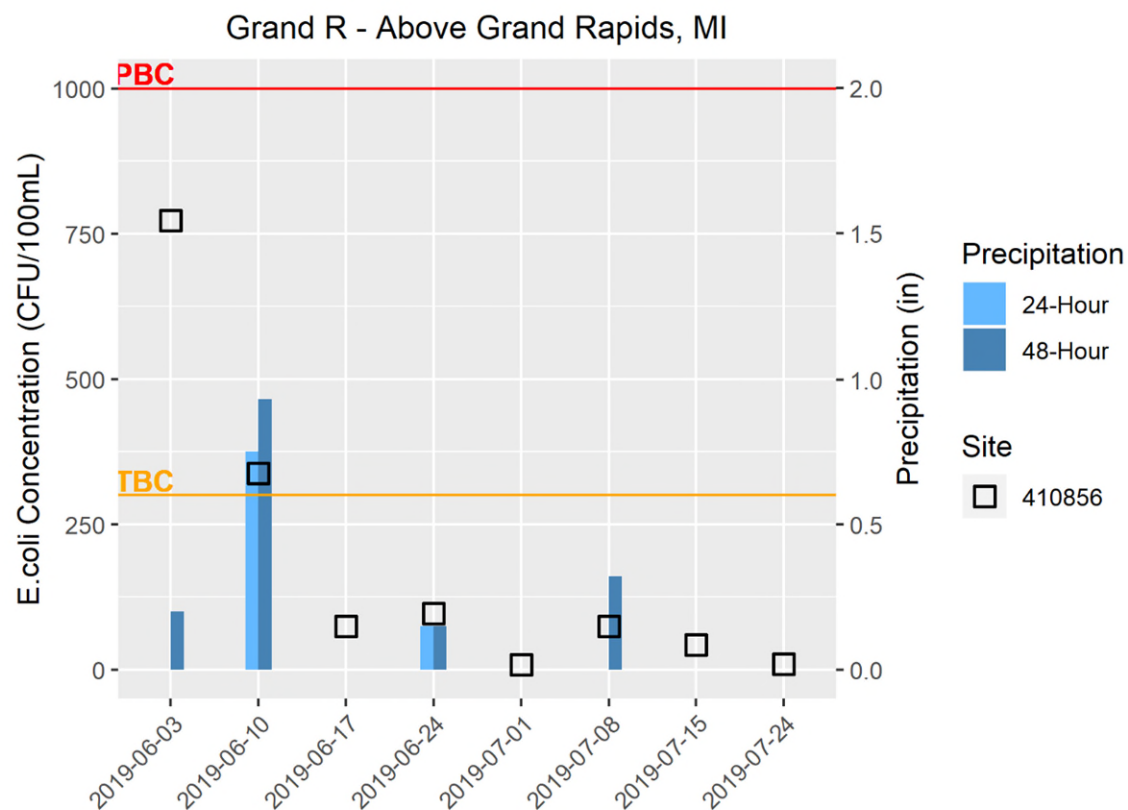


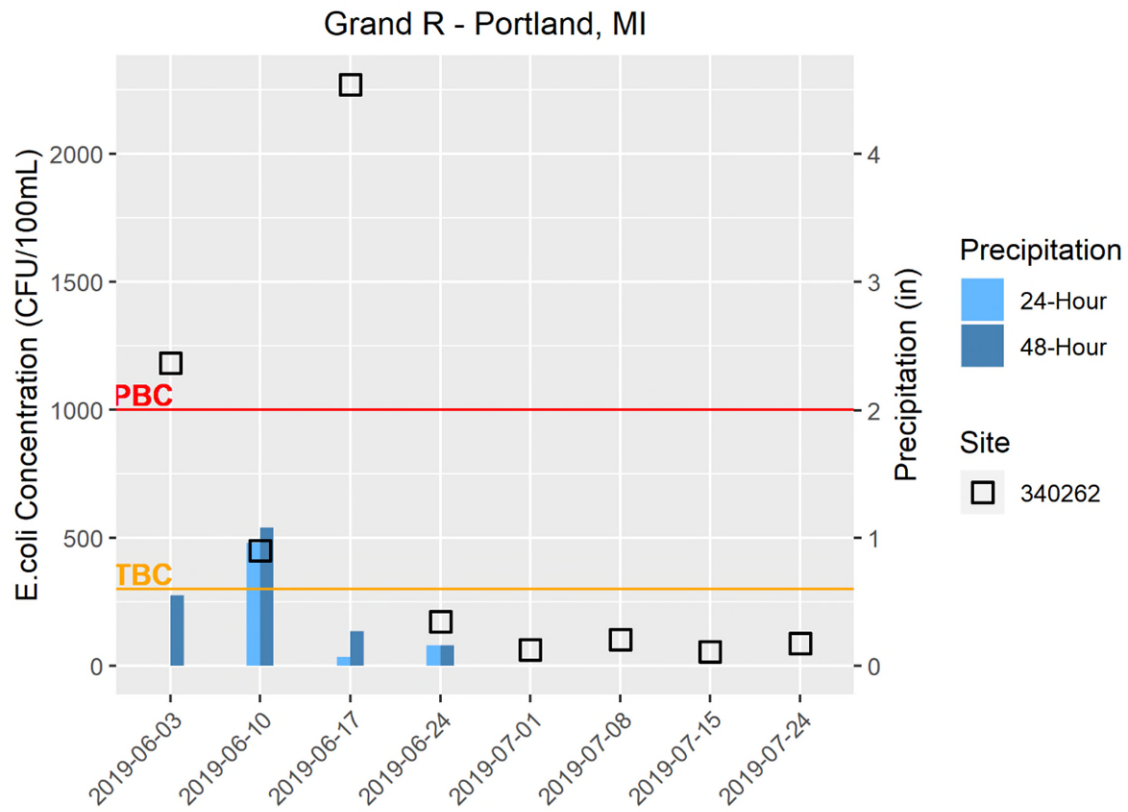










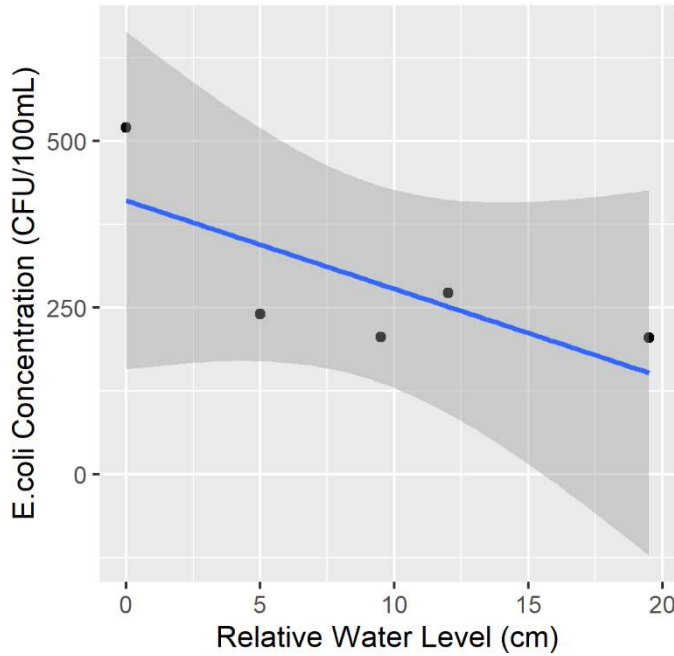




Appendix 5. Relationships between *E. coli* and water levels for selected sites in the 2019 study. Water levels are relative to the lowest recorded water level during the study. The blue lines show statistical trends (if any) while the gray shaded area shows the confidence interval (the narrower the gray band, the more confidence in the relationship). Only sites with water level changes more than 2 cm are shown.

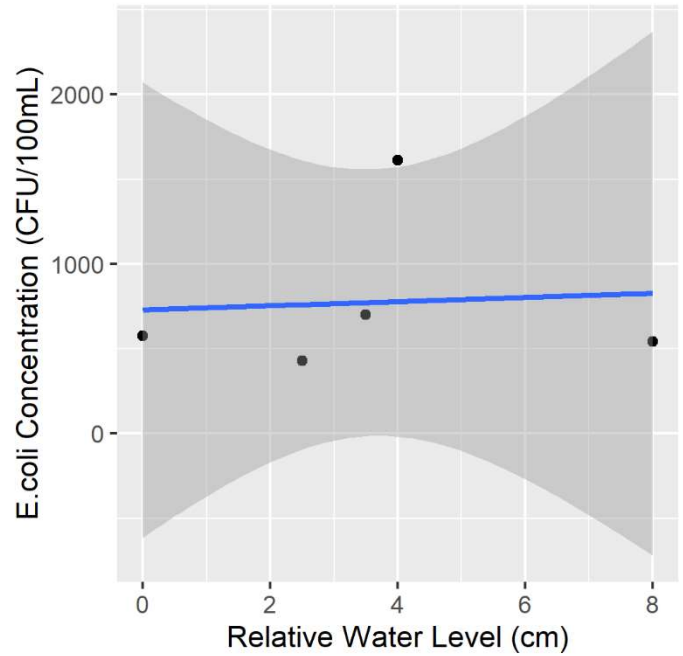
Site ID: 130416

Battle Creek - Burrows Rd



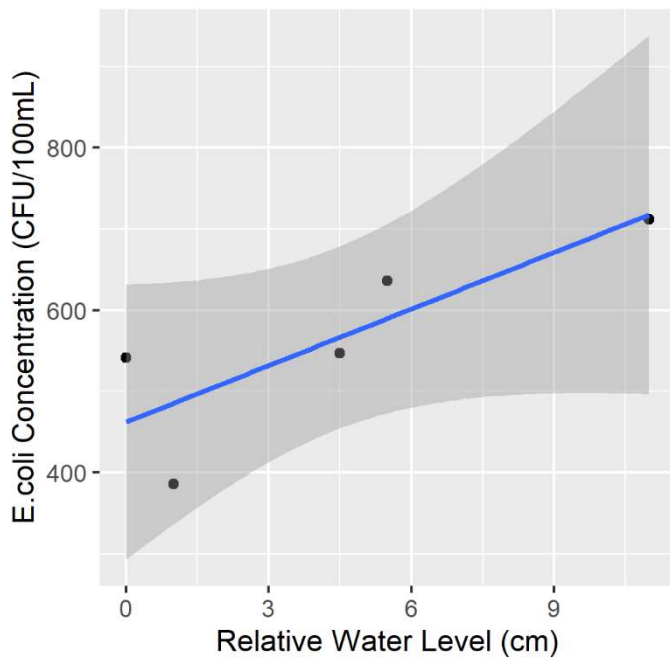
Site ID: 230014

Battle Creek - W Spicerville Hwy



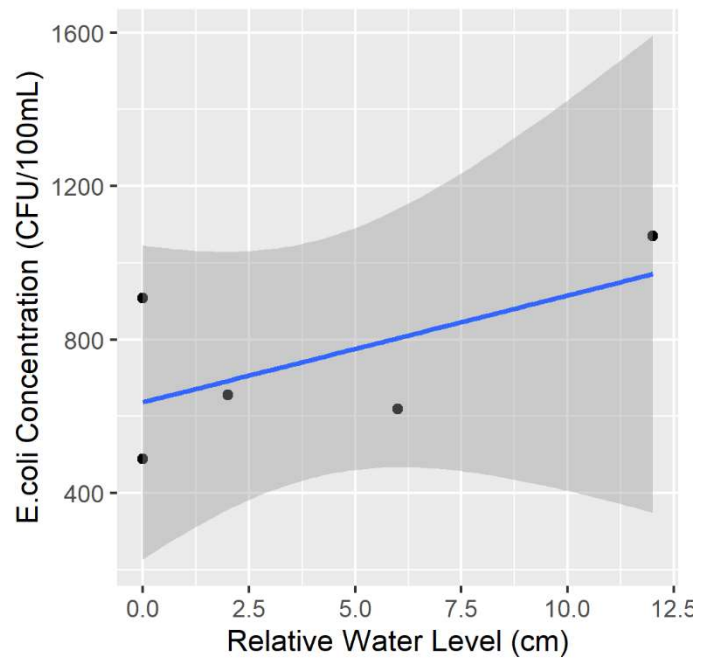
Site ID: 30737

Gun River - 10th St



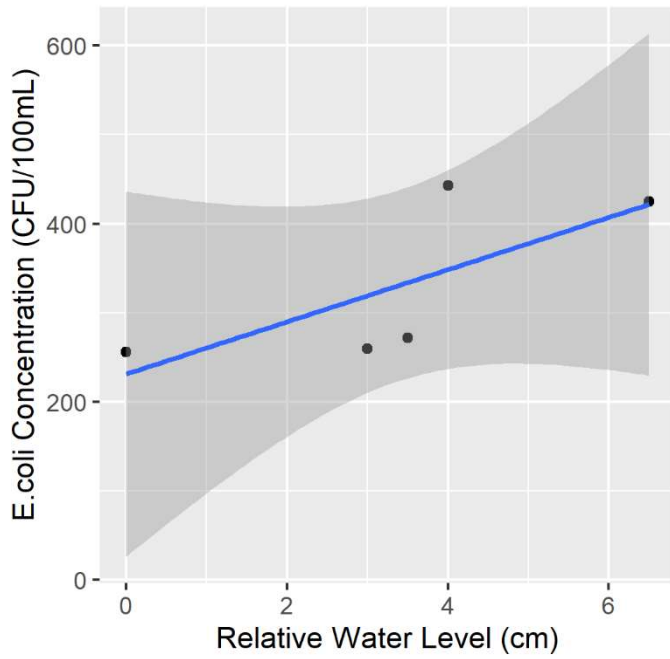
Site ID: 30736

Gun River - 116th Ave



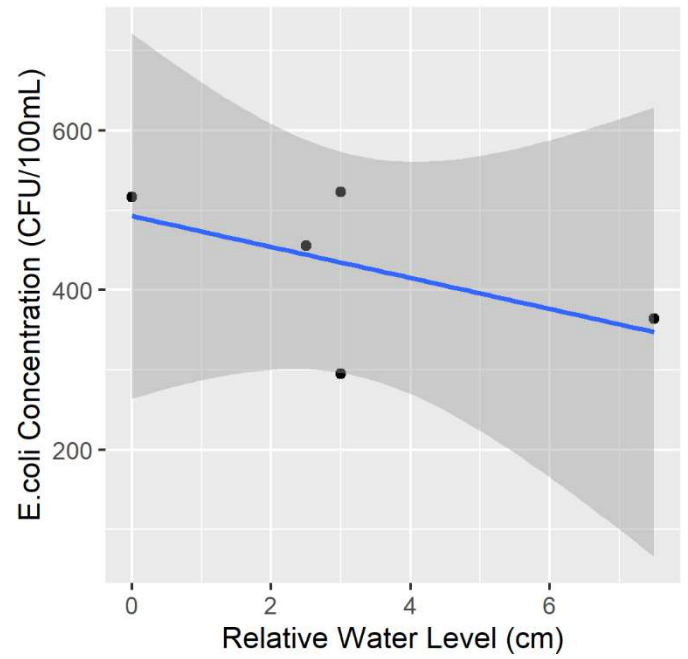
Site ID: 30738

Pine Creek - 21st St



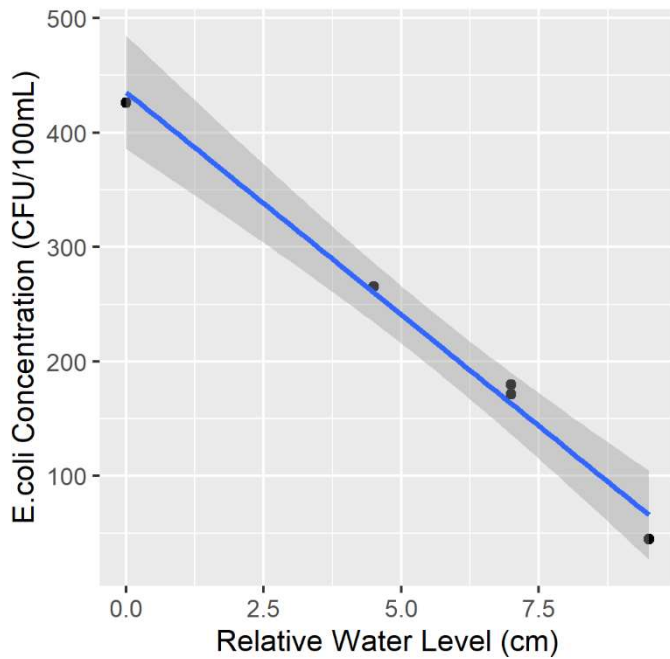
Site ID: 30739

Pine Creek - 101st Ave



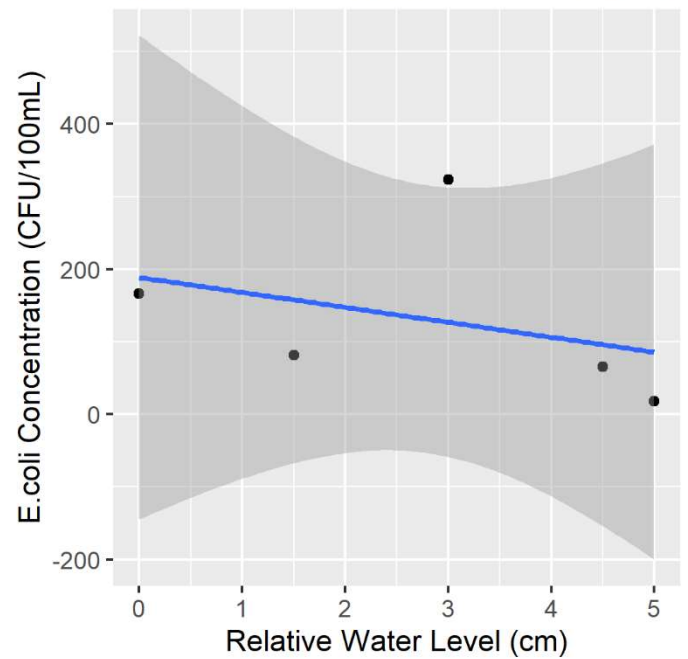
Site ID: 80306

Gun River - Patterson Rd



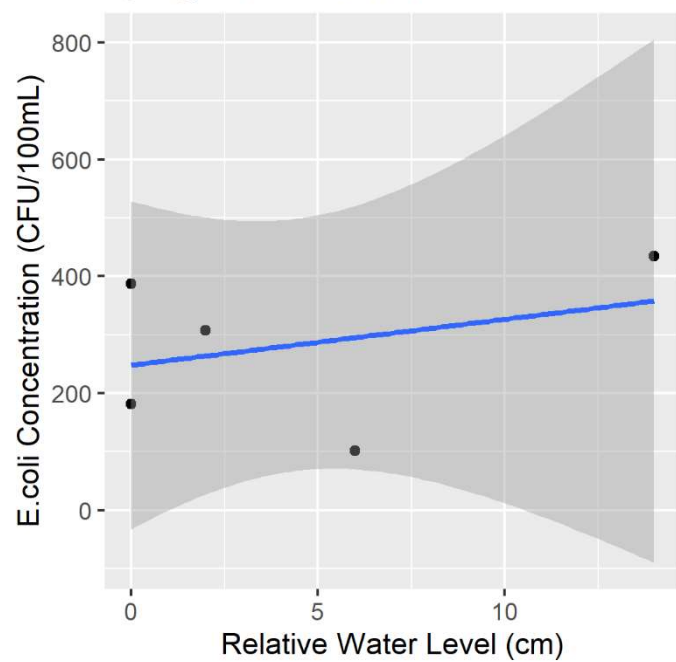
Site ID: 380442

Spring Arbor / Concord Drain - King Rd



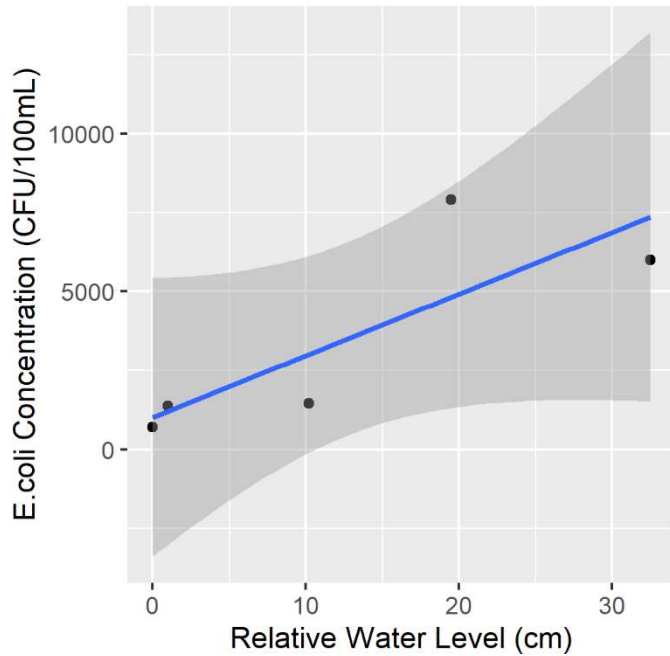
Site ID: 380443

Spring Arbor / Concord Drain - N Concorc



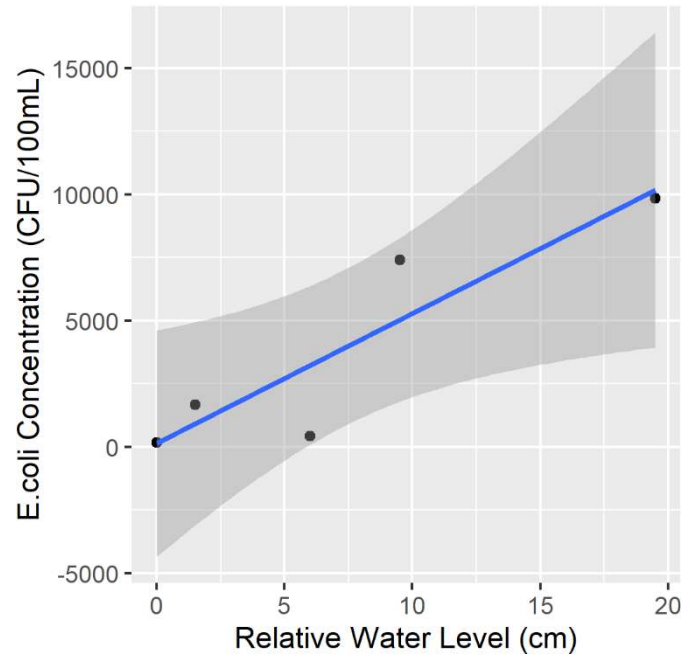
Site ID: 700634

North Branch Crockery Creek - 24th Av



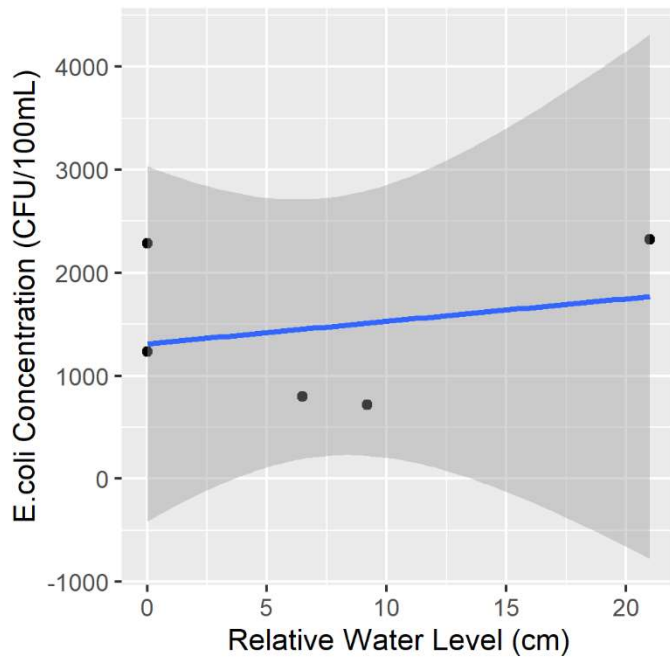
Site ID: 610476

RIO GRANDE CR - BLACKMER RD - F



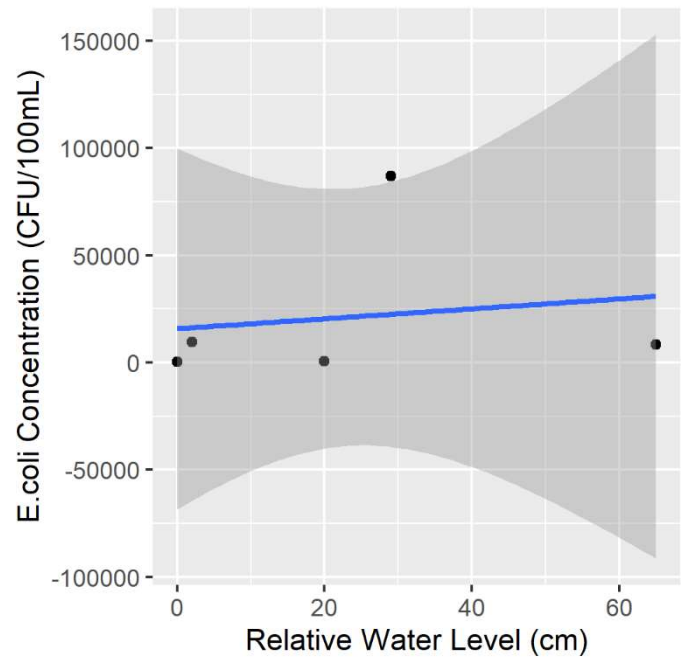
Site ID: 610482

Crockery Creek - Shaw Rd



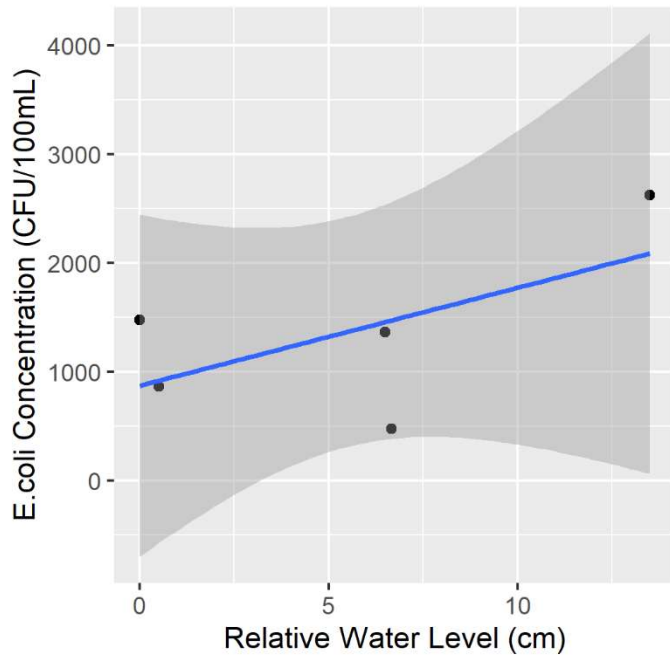
Site ID: 610507

Crockery Creek - Patterson Rd



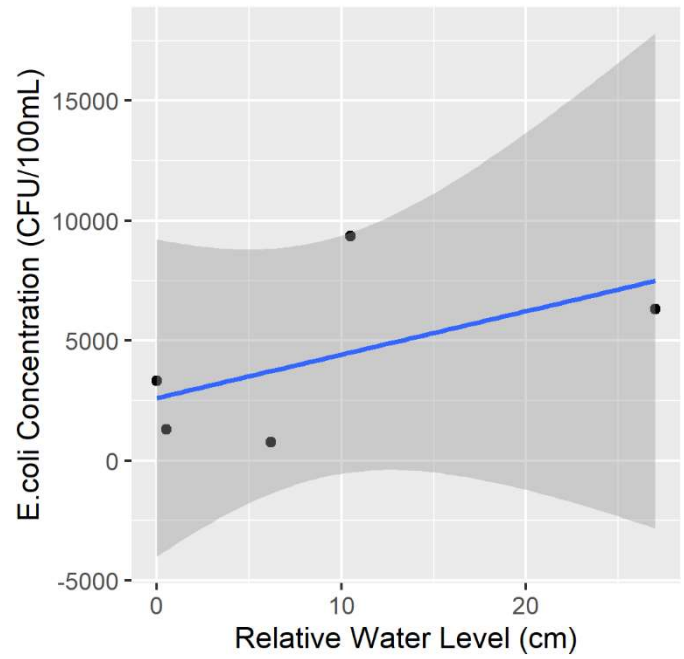
Site ID: 610819

Ovidhall Lake Creek - Bailey Rd



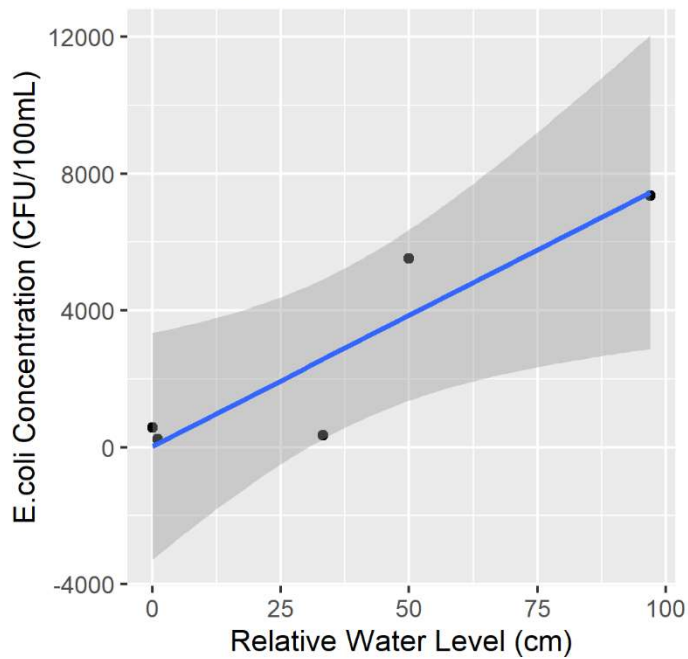
Site ID: 700546

North Branch Crockery Creek - 40th Av



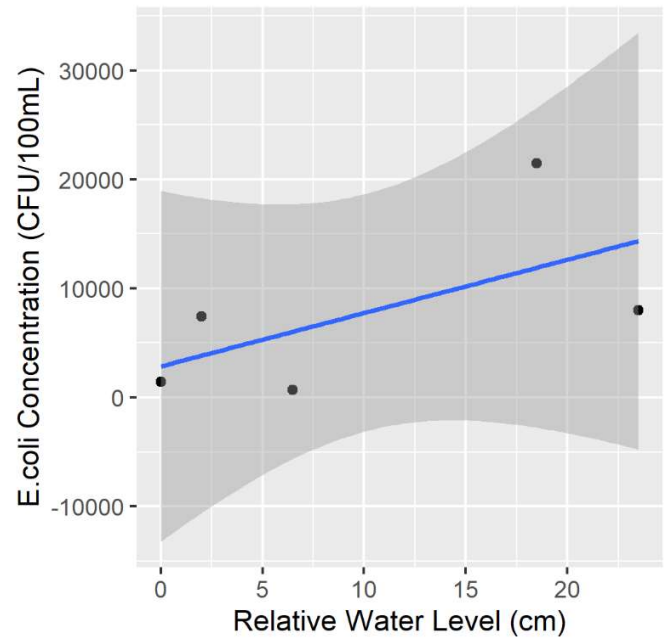
Site ID: 700703

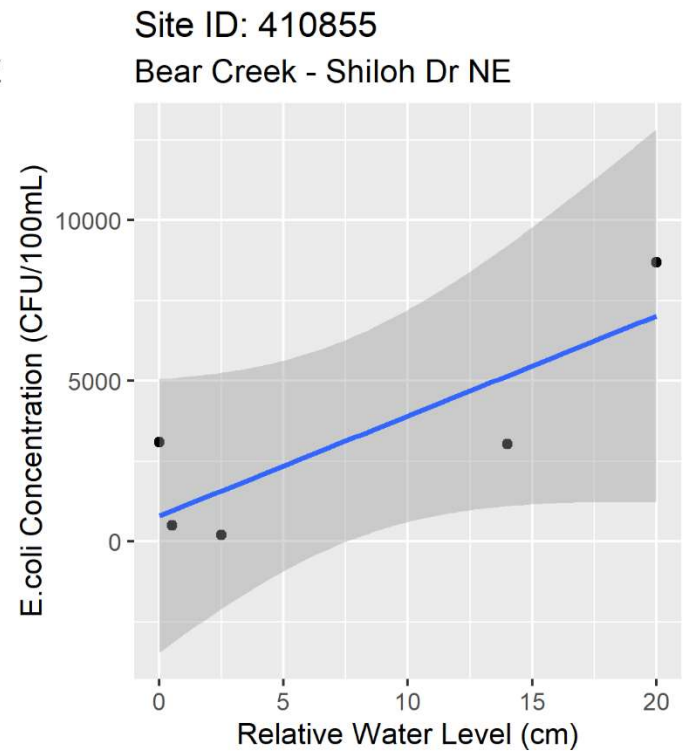
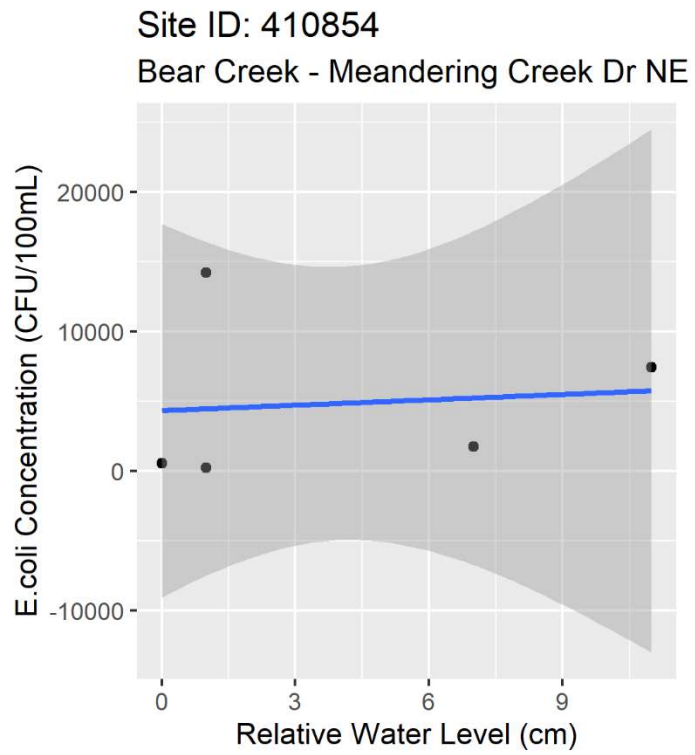
Crockery Creek - Fitzgerald St



Site ID: 700701

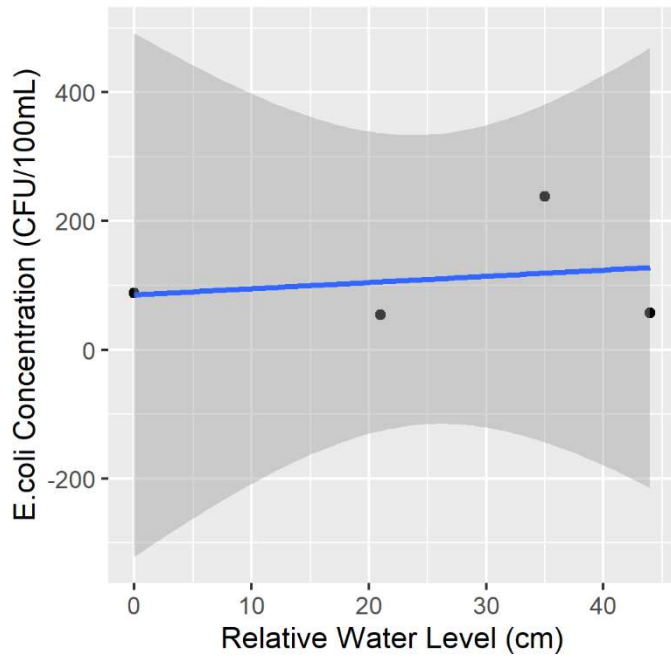
Sand Creek - Hayes St (west)





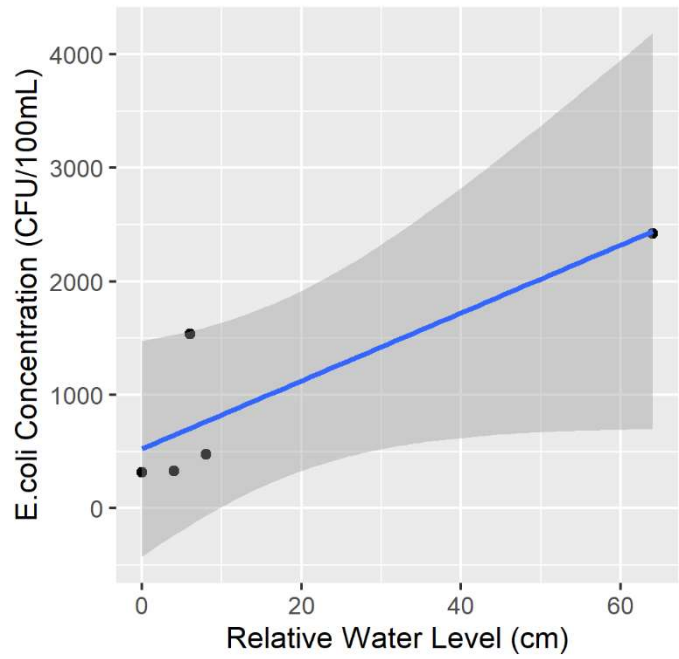
Site ID: 530223

Big Sable River - N Taylor Rd



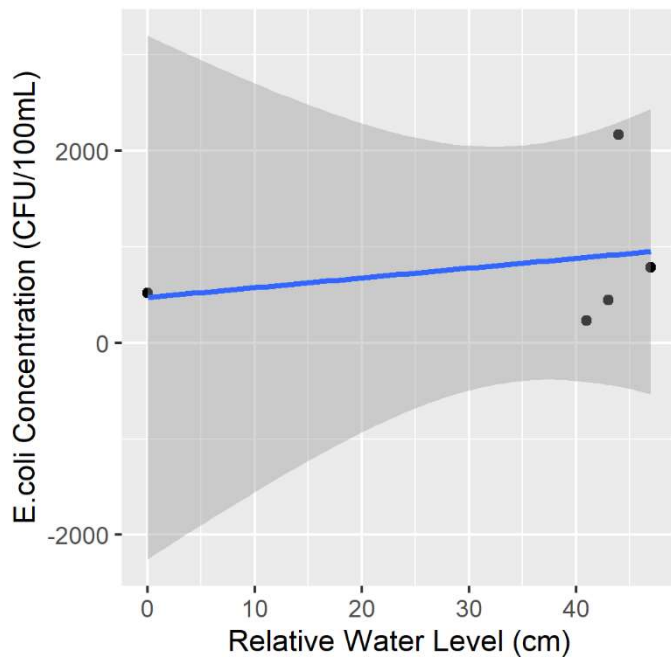
Site ID: 530219

Freeman Creek - N Alexander Rd



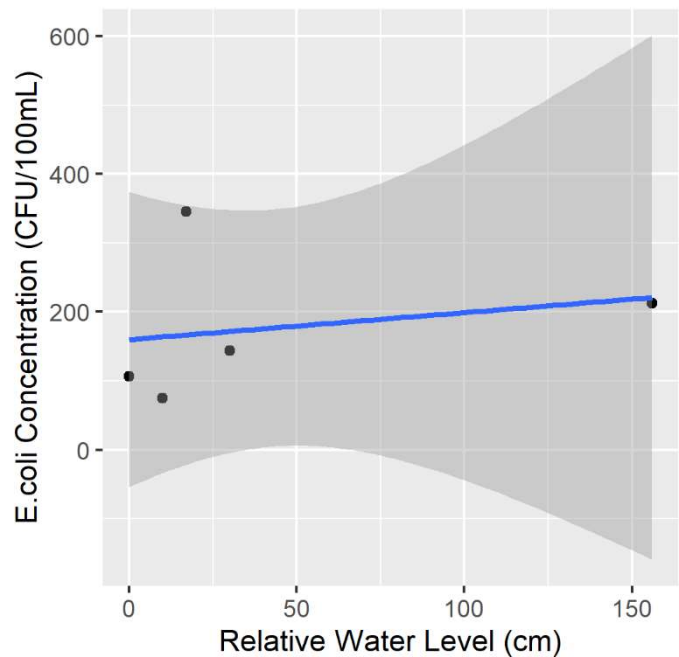
Site ID: 530304

Davis Creek - N Quarterline Rd



Site ID: 530292

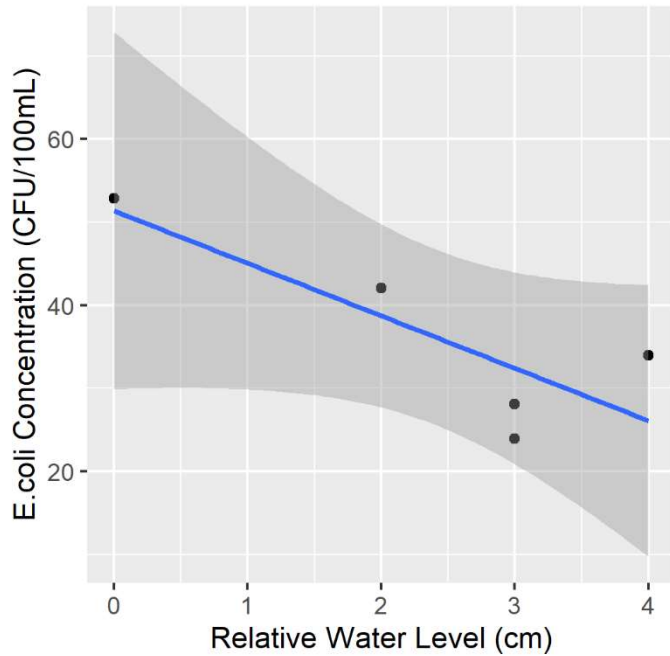
Big Sable River - N Darr Rd





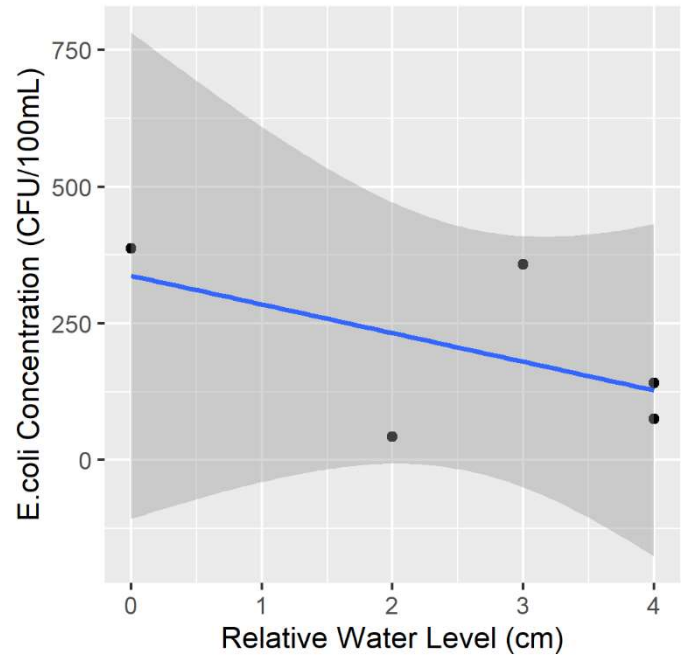
Site ID: 430638

Cool Creek (East Crossing) W 12 Mile Rd



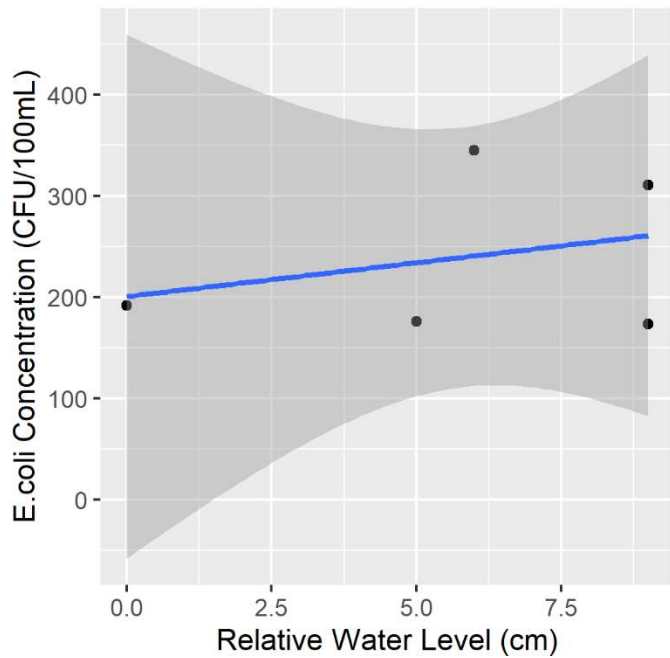
Site ID: 430639

Cool Creek (West Crossing) - W 12 Mile



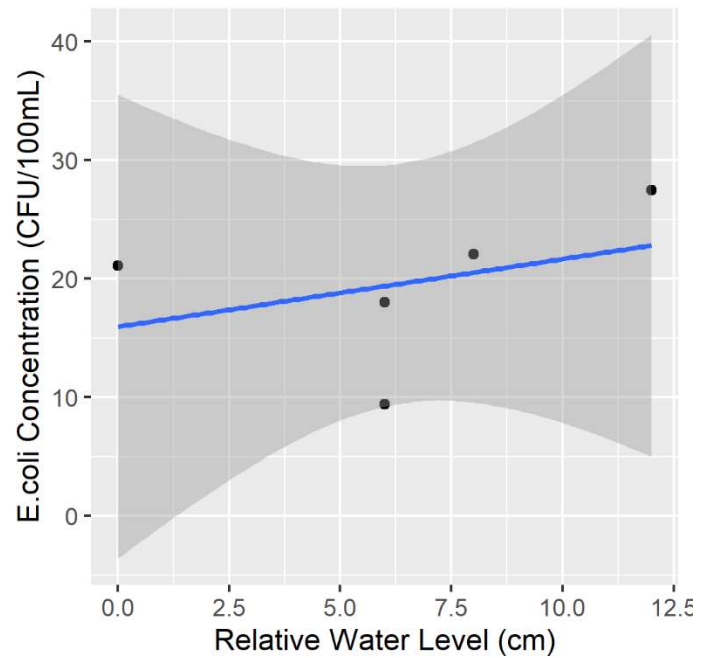
Site ID: 830145

Fletcher Creek - W 12 3/4 Rd



Site ID: 830159

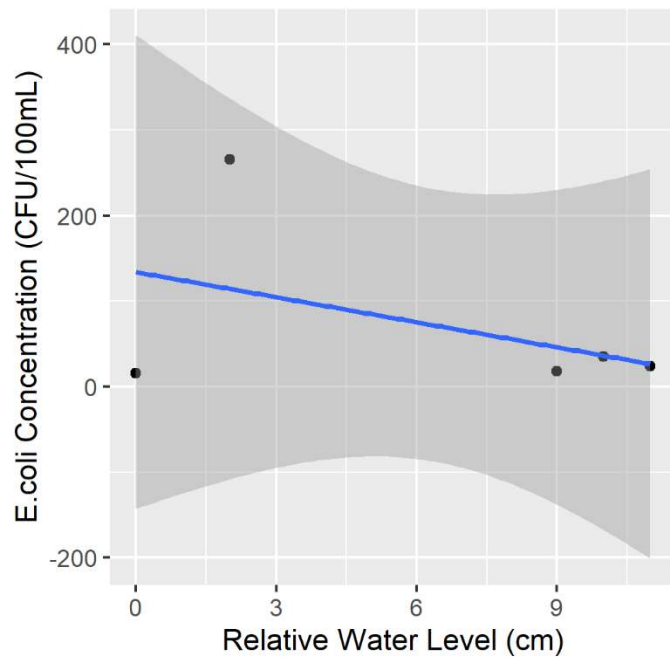
Anderson Creek - W 6 Rd





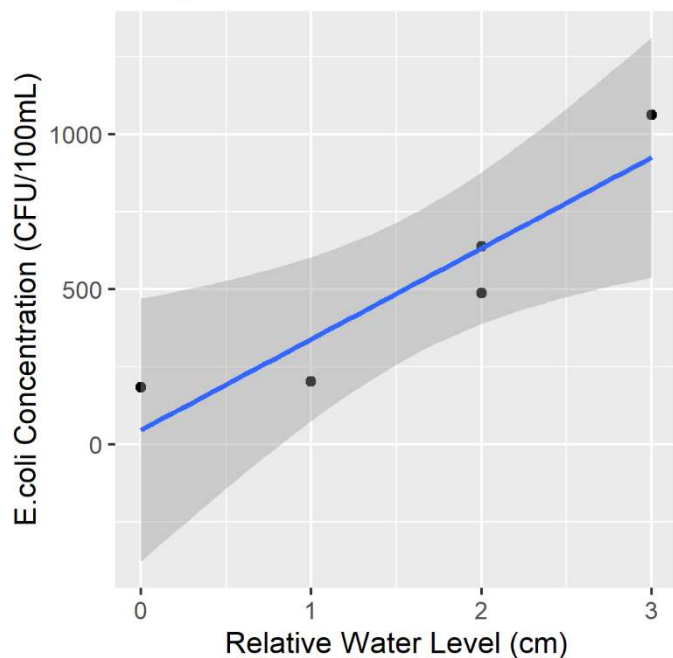
Site ID: 830236

Slagle Creek - W 30 Rd



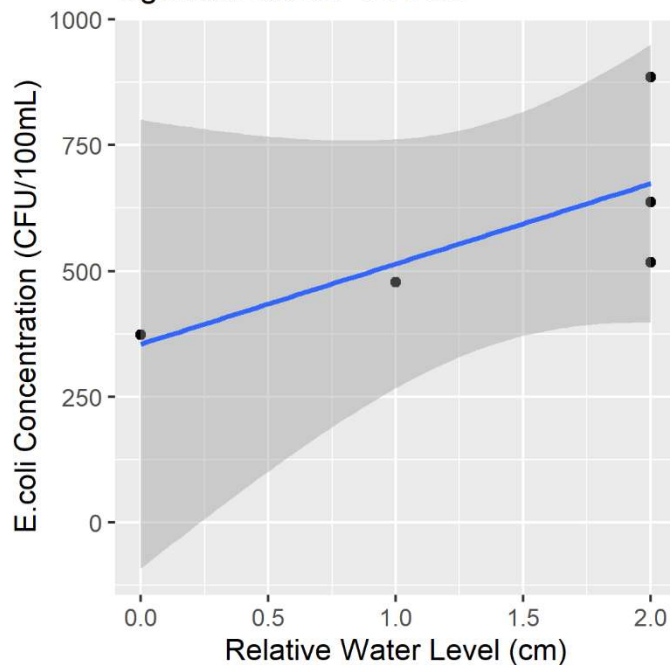
Site ID: 650075

Campbell Creek - M 33



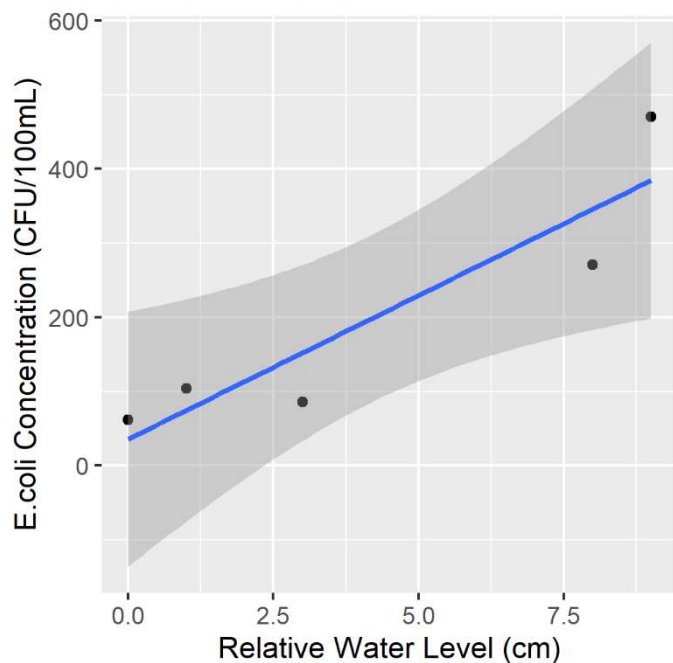
Site ID: 650002

Ogemaw Creek - I 75 BL



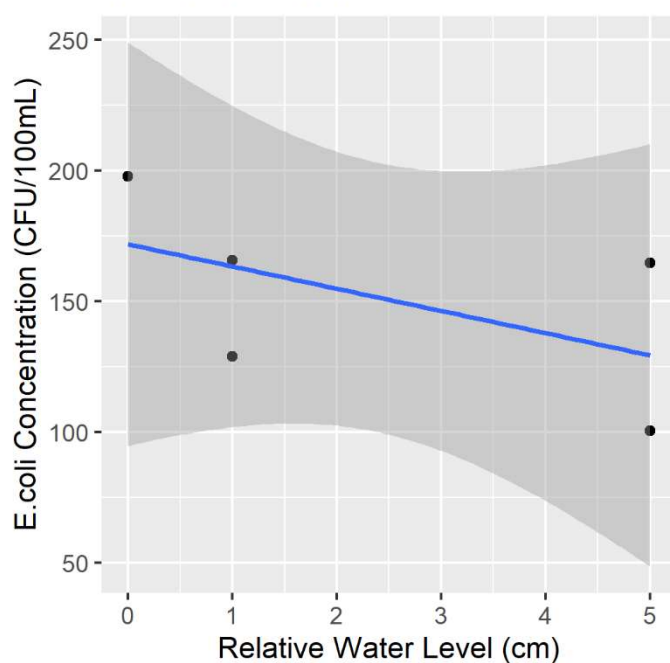
Site ID: 650097

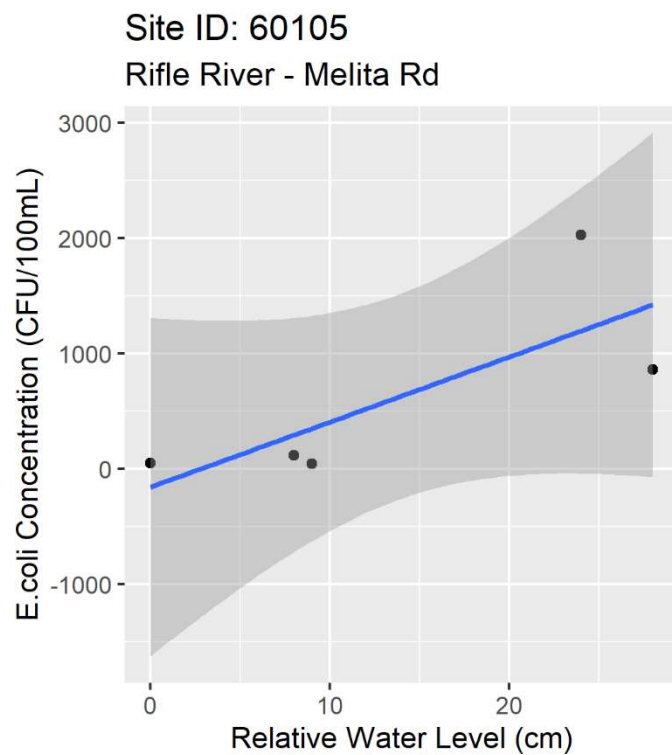
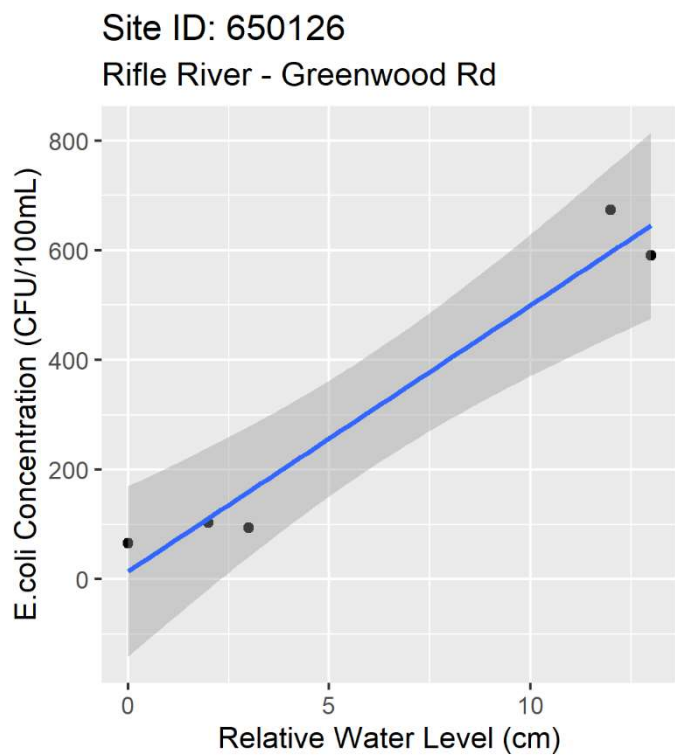
Rifle River - M 55



Site ID: 650121

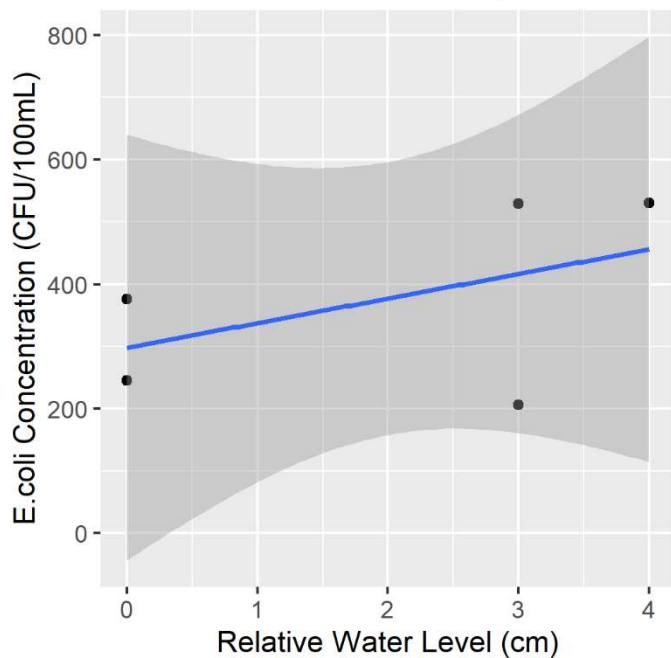
Rifle Creek - Dam Rd





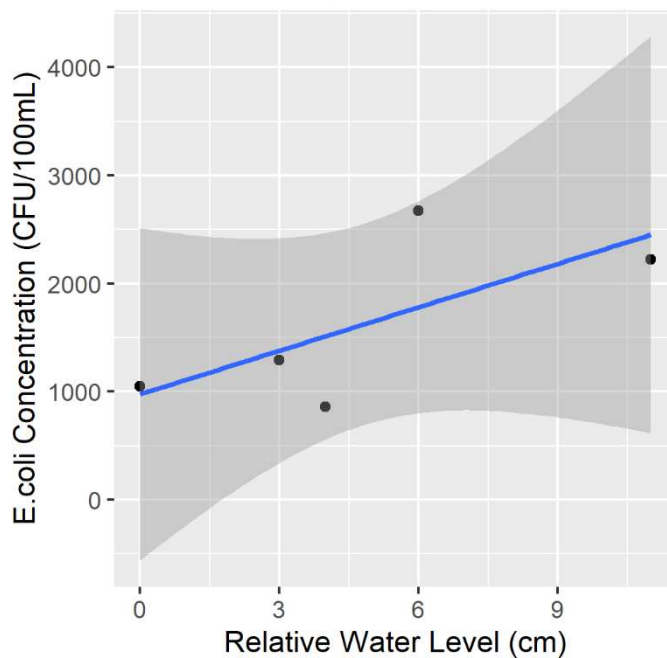
Site ID: 631284

Trib to Lake Michelson - Seymour Lake R



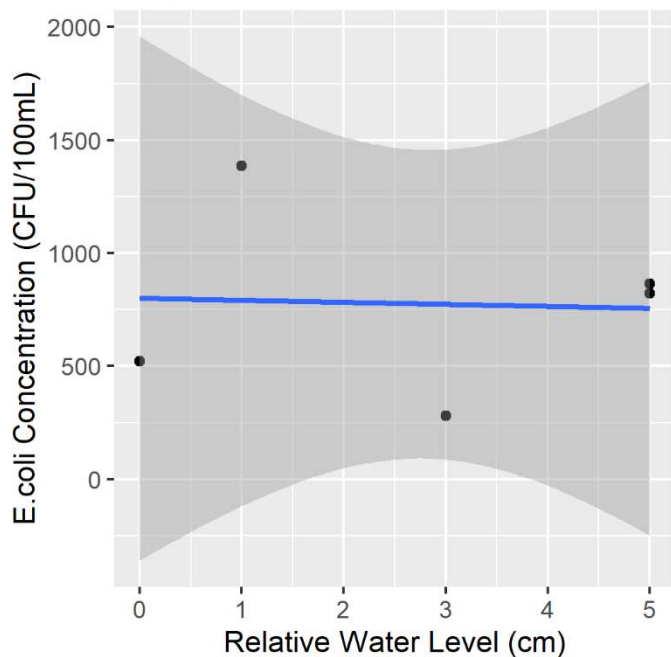
Site ID: 631285

CLINTON RIVER - PAINT CREEK - ROC



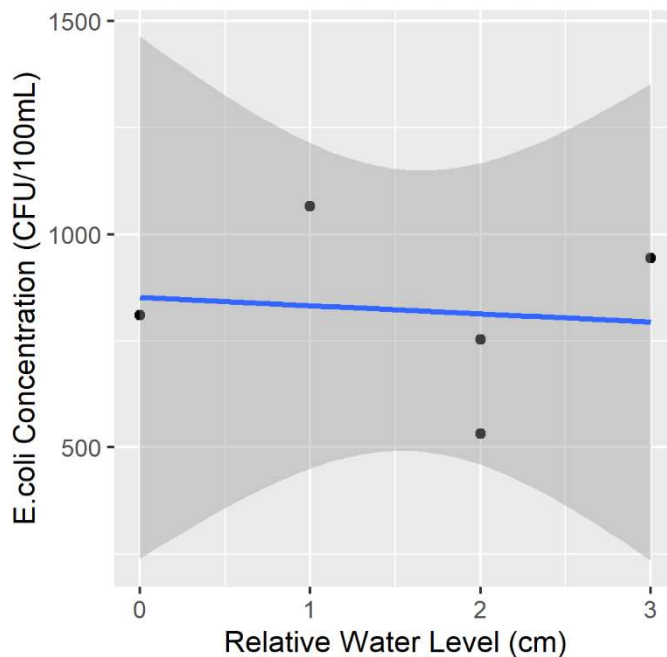
Site ID: 631286

Sargent Creek - N. Livernois Rd.



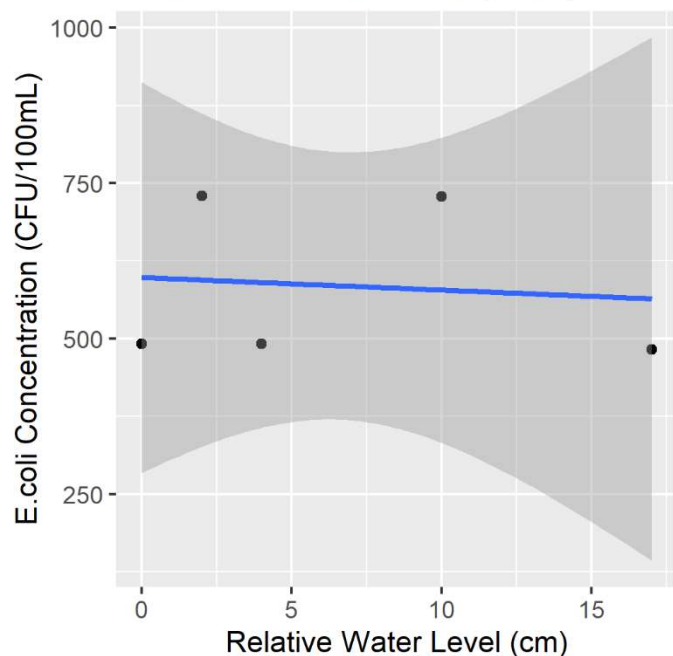
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Trib to Duck Lake - Deer Path Rd.



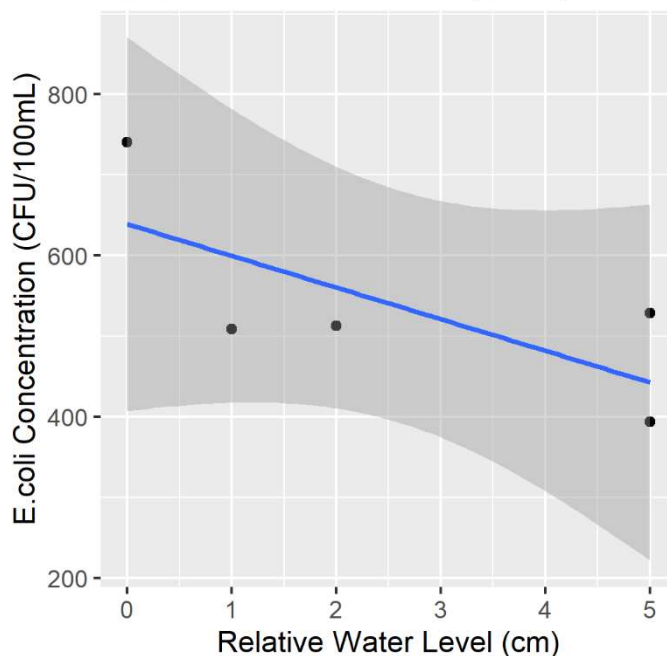
Site ID: 630616

Paint Creek - Adams Rd. (north)



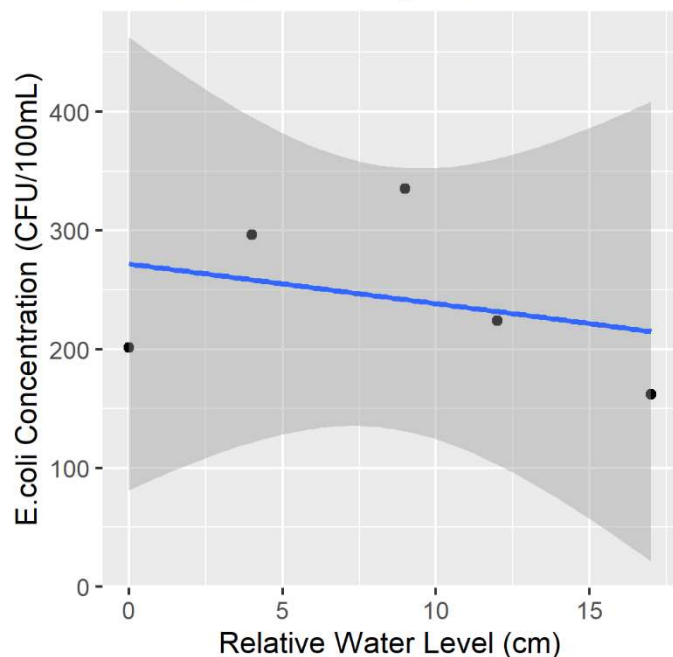
Site ID: 630617

Trout Creek - Adams Rd. (south)



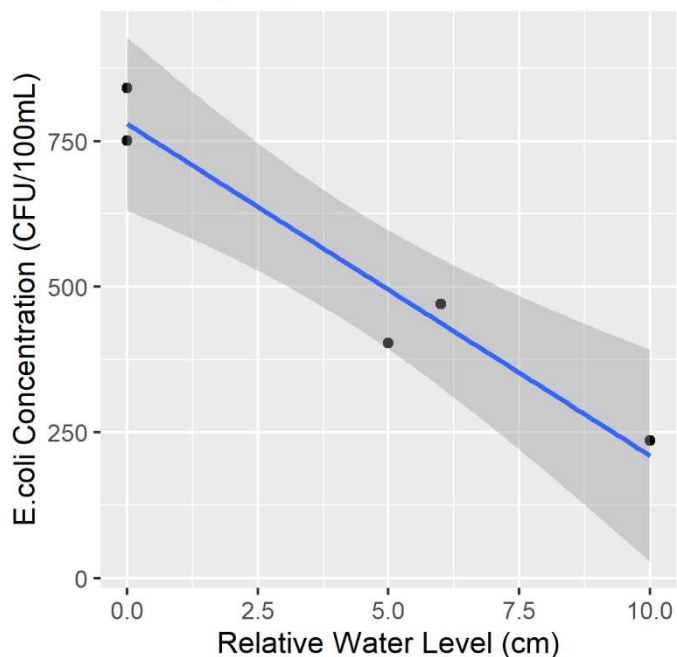
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Clinton River - Cooley Lake Rd.



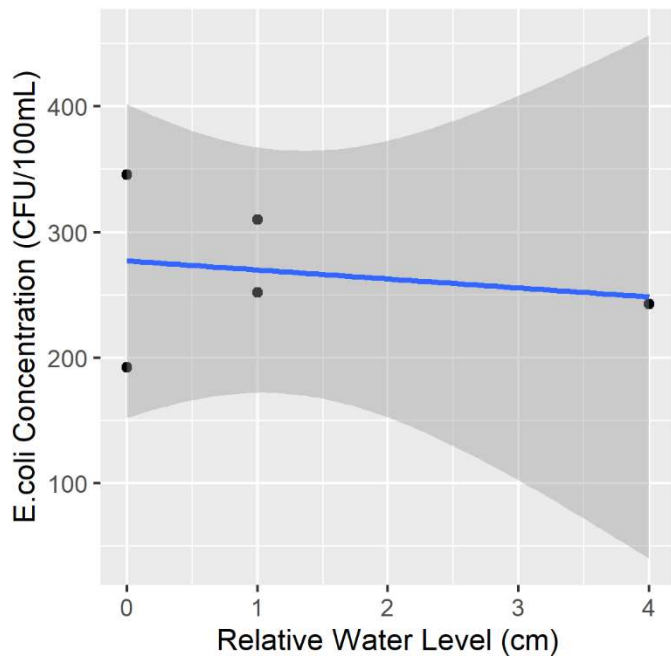
Site ID: 631032

Galloway Creek - Butler Rd.



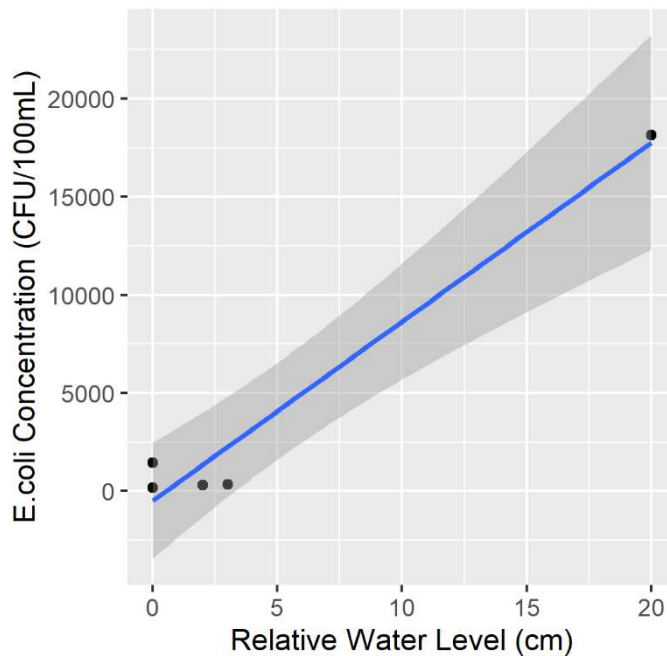
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Trib to Deer Lake - Deerhill Rd.



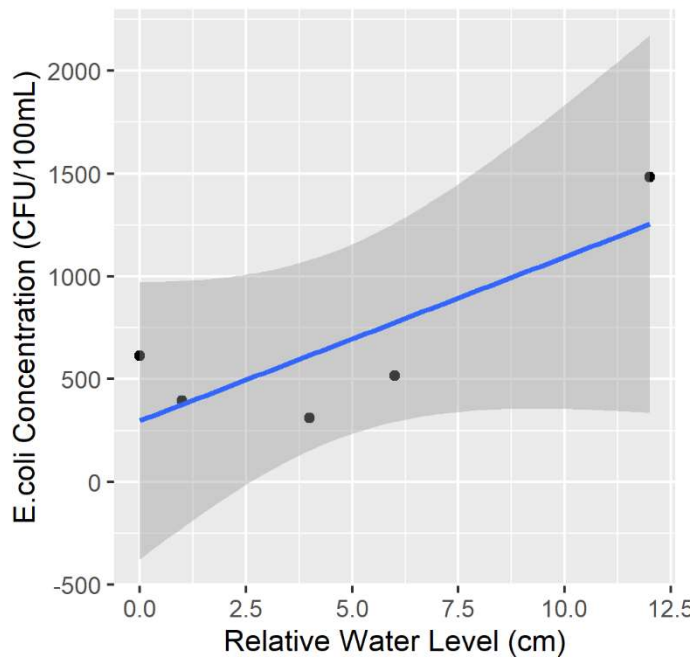
Site ID: 631077

Sashabaw Creek - Pine Knob Trail



Site ID: 631100

West Branch Stony Creek - Stony Creek



Site ID: 631280

Clinton River - Riverwoods Trail

