Project name: Middle Grand River E. coli Monitoring and Source Tracking
Grantee name: Eaton Conservation District
MDEQ tracking code: #2013-0504

Introduction

The Middle Grand River Watershed is approximately 258 square miles (165,000 acres) in Mid-Michigan's Eaton, Ingham, Clinton, and Ionia counties (Figure 2). The Middle Grand Watershed begins in Eaton Rapids and flows north, crossing back and forth across the Ingham and Eaton county line, and then flows through downtown Lansing and Old Town. Just north of Old Town Lansing, the Grand River begins to flow westerly, crossing the Clinton and Eaton county line to Grand Ledge and continues westerly into the City of Portland in Ionia County. The Middle Grand River Watershed is one small subwatershed of the entire Grand River Watershed, which is the second largest watershed in Michigan (5,570 square miles). Nine HUC12 creeksheds (Columbia Creek, Skinner Extension Drain, Silver Creek, Carrier Creek, Sandstone Creek, Frayer Creek, Winchell and Union Drain, Sebewa Creek, and Cryderman Lake Drain) compose the Middle Grand River Watershed.

The Watershed includes twenty-one local units of government that make decisions influencing the land uses, and subsequent water quality, of the Watershed. The Middle Grand River section is approximately 129 miles in stream length, has nine subwatersheds (HUC 12), and joins together the Upper Grand River and the Lower Grand River. Together, the entire Grand River Watershed, comprising the Upper, Middle, Lower, Red Cedar, Looking Glass, Thornapple, Flat, Rogue, and Maple rivers, make up the second largest watershed in Michigan. The Middle Grand River Watershed Management plan was developed by the Eaton Conservation District and approved by MDEQ and EPA in 2015 for both 319 and CMI.

Land Use and Development Trends

Land use varies across the Watershed, however, agriculture is dominant. Winchell Union Drain and Sebewa Creek subwatersheds have the highest percentage of agriculture land use in the Watershed (Table 4). Seven of the nine subwatersheds have greater than 55% agriculture land use. The Greater Lansing Metropolitan Region (Silver Creek and Carrier Creek subwatersheds) by far has the most intense land development when comparing the amount of open space and urban areas. Infrastructure includes transportation corridors, sewer and water services. The Capital City Airport, located north of Lansing, is the largest in the area. It is a full-service, all-weather, commercial-airline airport, serving the entire Lansing metropolitan area. The I-96/Grand River Corridor is 15 miles long and stretches across the Watershed. The I-69 corridor also runs through the Watershed. Development along these areas includes small to medium sized industrial parks, businesses and residential areas.
Development within the Watershed has gradually pushed outward from the Greater Lansing Metropolitan Region.. Townships within the Watershed are more largely characterized as rural and agricultural with pockets of housing developments popping up as agricultural land is purchased.

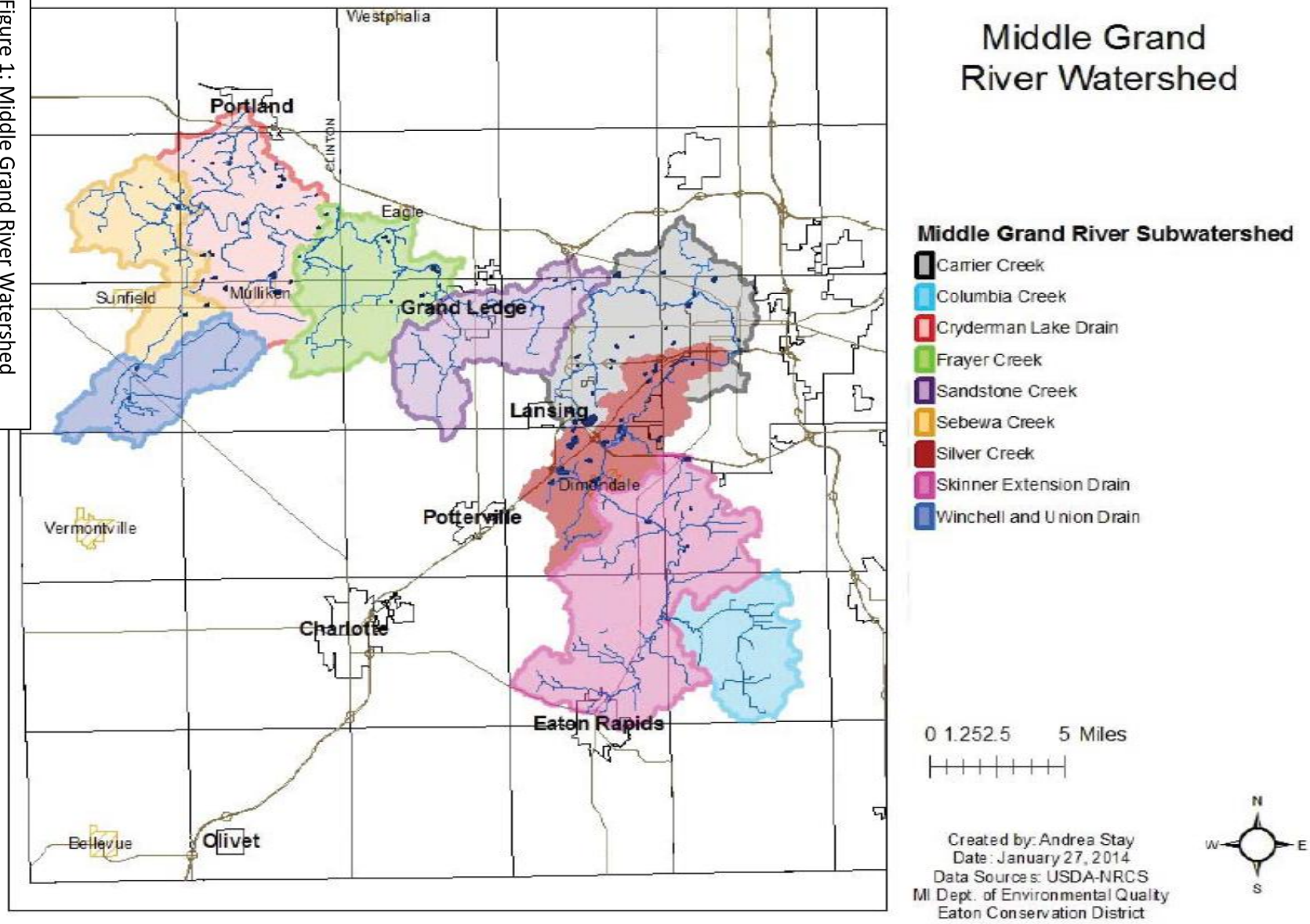
Table 1: Land Use Percentages by Subwatershed

Subwatershed	Urban	Agriculture	Open Field	Forest	Water	Wetland
Columbia Creek	6.63	73.91	4.8	12.27	0.06	2.33
Skinner Extension Drain	11.56	56.08	12.56	17.56	0.76	1.5
Silver Creek	35.7	31.9	17.2	12.13	0.03	0.4
Winchell Union Drain	0.21	81.3	6.1	12.11	0.13	0.18
Cryderman Lake Drain	5.2	68.14	5.3	17.7	2.35	1.4
Sandstone	20.1	57.3	9.35	12.14	1.04	0.12
Frayer Creek	4.78	71.63	5.5	15.73	1.8	0.32
Sebewa Creek	1.74	79.5	5.13	11.93	0.09	1.63
Carrier Creek	59.4	15.93	14.18	8.88	1.19	0.42

Recreation

The Watershed has an active recreational paddling community that enjoys utilizing the meandering Grand River. There are both public and private access points to the Grand River. Every 10 years, paddlers organize the Grand River Expedition. Paddlers from across Michigan participate and take a trip down the 225 navigable miles of the Grand. A major goal of the Expedition is to document and explain to the public the recreational, economic and environmental benefits the Grand River Watershed provides. These efforts contribute to the public's knowledge and appreciation of the Grand River, and how it connects communities across the region. It helps generate enhanced stewardship of the river and watershed related values (Middle Grand River Organization of Watersheds 2014). Outside of paddling, recreational opportunities such as fishing, hiking, and biking along the river, are also available through the extensive park systems managed by county and municipal entities.

Figure 1: Middle Grand River Watershed



Project Goals and Objectives and the Extent Met

Goal 1: *Further delineate the areas that are contributing Human Sources of E. coli to the TMDL reach of the Middle Grand River Watershed.*

> Objective A: Contract with Environmental Canine Services to walk the drains in Silver and Columbia creek where Human Sources have been positively identified in September 2012.

Extent Met: Eaton Conservation District contracted with Environmental Canine Services in June of 2014 to walk the creeks, drains, and tributaries in the Silver and Columbia Creek sub-watersheds to locate potential sources of human fecal contamination.

> Objective B: Notify stakeholder committee and local health department of results. Utilize results in targeting implementation efforts for septic concerns.

Extent Met: Results were shared with local health department and conservation district staff. Results were shared via email listserve to Middle Grand River stakeholders.

Goal 2: *Undertake a baseline study to determine whether E. coli is present, and if so, whether E. coli levels exceed Water Quality Standards in the following Middle Grand River subwatersheds: Sandstone Creek, Frayer Creek, Winchell/Union Drain, Sebewa Creek, and Cryderman Lake Drain*

> Objective A: Conduct E. coli monitoring from monitoring points in select Middle Grand River tributaries. Use data to help assess sources of *E. coli* pollution within the watershed. Provide new and/or current data from tributaries where there little to no existing data.

Extent Met: In 2014, E. coli monitoring was conducted at 15 locations in the western portion of the Middle Grand River watershed (subwatersheds: Sandstone Creek, Frayer Creek, Winchell/Union Drain, Sebewa Creek, Cryderman Lake Drain) from August 4th to October 20th. Eaton Conservation District staff, along with Ionia Conservation District staff and volunteers conducted the monitoring according to the sampling protocol set up in the QAPP. All samples were analyzed by the DEQ Drinking Water Laboratory.

> Objective B*:* Notify the public and relevant agencies of monitoring results. ECD will notify DEQ if sample exceeds water quality standards for partial and/or total body contact recreation. Present monitoring results on websites, email newsletters and steering committee meetings.

Extent Met: Results were sent to the monitoring committee, DEQ, and local Health Departments. Project information shared to Middle Grand River Steering Committee Stakeholders and posted to Eaton Conservation District website. Results discussed at regional meetings such as Celebrate Rivers event on 9/17/15.

Goal 3: Determine probable sources for E. coli found through monitoring in the Sandstone Creek, Frayer Creek, Winchell/Union Drain, Sebewa Creek, Cryderman Lake Drain subwatersheds.

> Objective A: Review land use survey data collected in 2012 and aerial maps on areas upstream of E. coli positive locations to identify potential point and/or non-point pollutant sources.

Extent Met: Reviewed agriculture practice inventory from 2012 to identify livestock presence/quantity and resource concerns upstream of monitoring sites. Reviewed MSU Septic Report to identify Highly Likely Impact septic sites within Subwatershed. Linked probable sources with critical areas based on monitoring results.

Study Methodology

In order to determine the status of partial and total body contact recreation in the western portion of the Middle Grand River Watershed and delineate areas of Human impact, the Eaton Conservation District undertook a multi-faceted approach.

Source Tracking Monitoring Protocols: Eaton Conservation District contracted with Environmental Canine Services to investigate sources for each identified human sewage location (Eifert Rd and Windsor Hwy), to walk the drains in Silver and Columbia creek for a total of 12 miles. ECS has dogs (e.g., Sable) trained to signal when human sources of *E. coli* are detected. Another MDEQ grantee (e.g., Ottawa County Health Department) has subcontracted with ECS for detecting human sources of *E. coli* in surface waters and beaches.

A complete description of monitoring protocols for this project can be found in Quality Assurance Project Plan (QAPP) Middle Grand River Watershed Monitoring 2014 (Attachment A).

Monitoring Protocols: Monitoring protocols for determining *E. coli* levels were modeled on "Considerations for *E. coli* Studies – Guidance for Grant Administrators" by Molly Rippke to assure that results could be utilized by DEQ. In summary, each site was monitored weekly for 10 consecutive weeks between 8/4/2014 and 10/20/2014. Each stream site was grab sampled at three locations – left, center, and right. In addition, duplicate samples were collected every fifth sample (20%) and field blanks, utilizing sealed, bottled drinking water were collected at a rate of 10%. Collected samples were dropped off at the DEQ Drinking Water Laboratory to be analyzed within six hours of collection. A complete description of monitoring protocols for this project can be found in Quality Assurance Project Plan (QAPP) Middle Grand River Watershed Monitoring 2014 (Attachment A).

Site selection: Site selection was made by the monitoring committee, consisting of representatives from the Eaton and Ionia Conservation Districts, USDA – NRCS field office staff, and Barry Eaton Health Department Staff. The committee reviewed aerial photography, agriculture practice survey results, and TOST records, to identify the 10 sites. Monitoring sites are listed in the Middle Grand River Results Spreadsheet (Attachment B).

Training and Quality Control: Volunteers assisted the Eaton Conservation District staff with monitoring throughout the project. All volunteers and staff were required to attend a 3 hour training session prior to the monitoring season. Sites 1-4, 6, 7, and 11 were assigned to Rachael Loucks, staff member of Eaton Conservation District, and sites 5, 8-10, 12-15 were assigned to David Wood, staff member of the Ionia Conservation District. Volunteers were overseen by the main site leader. David Wood met Rachael Loucks after collecting samples and she reviewed all data sheets and samples and then delivered his sites and her sites to the drinking water laboratory. All monitoring data sheets, were

reviewed before submitting samples to the lab for analysis. A total of 405 samples were taken during the monitoring season. In addition, 22 duplicate and 21 blanks were taken.

Monitoring results

The Michigan Department of Environmental Quality (MDEQ) develops water quality standards for the Great Lakes and connecting waters and all surface waters of the state through its Water Resources Protection Act. These standards are generally intended to guide discharge permitting and as such, standards which are numerically based often reflect allowable levels of change. Other standards, such as those for physical characteristics are less specific in nature. Additional information including specific numeric criteria and exceptions can be found at www.michigan.gov/deq. Water quality standards listed below for partial and total body contact recreation are derived from the Department of Environmental Quality's Part 4 – Water Quality Stands rules of 2006.

- **Partial body contact Recreation:** All surface waters of the state protected for partial body contact recreation shall not contain more than a maximum of 1,000 per 100 milliliters. Compliance shall be based on the geometric mean of 3 or more samples, taken during the same sampling event, at representative locations within a defined sampling area. [R323.1062 (2)]
- **Total body contact recreation:** May 1-October 31. All surface waters of the state protected for total body contact recreation shall not contain more than 130 *E. coli* per 100 milliliters, as a 30-day geometric mean. Compliance shall be based on the geometric mean of all individual samples during 5 or more sampling events representatively spread over a 30-day period. Each sampling event shall consist of 3 or more samples taken at representative locations within a defined sampling area. At no time shall the surface waters of the state protected for total body contact recreation contain more than a maximum of 300 E. coli per 100 milliliters. Compliance shall be based on the geometric mean of 3 or more samples taken during the same sampling event at representative locations within a sampling area. [R323.1062 (1)]

Source Tracking Results

Environmental Canine Services conducted canine source tracking in the Silver and Columbia Creek sub-watersheds based on the two positive 2012 bucket sample results. The scope of work included walking creeks, drains, and tributaries to locate potential sources of human fecal contamination. Their full report of results, recommendations, and next steps is included as Appendix C - Canine Source Tracking Project Middle Grand River Watershed 2014

Table 2: 2014 E. coli Concentration results

2014 ECD Data Collection	TBC Exceedances	%	PBC Exceedances	%	Total Samples	Wet Weather TBC Exceedances (samples)	Wet Weather PBC Exceedances (samples)	Highest Daily Geomean During Wet Weather
Summary	99	66%	27	18%	150	45 out of 76	12 of 76	Yes, 9045 cfu/100 mL
Sandstone Creek Subwatershed	13	62%	2	10%	21	7 of 11	1 of 11	Yes, 2390 cfu/100 mL
Frayer Creek Subwatershed	20	67%	7	23%	30	8 out of 15	3 of 15	Yes, 9045 cfu/100 mL
Cryderman Lake Drain Subwatershed	26	87%	12	40%	30	12 out of 15	4 of 15	No
Winchell and Union Drain Subwatershed	12	60%	4	20%	20	6 out of 10	2 of 10	No
Sebewa Creek Subwatershed	28	56%	2	4%	50	12 out of 25	2 of 25	Yes, 1207 cfu/100 mL

For the purposes of this report, the results are broken down by subwatershed. In the narrative that follows, the monitoring is discussed per month, then a summary is provided per subwatershed, followed by a discussion of potential sources and causes, critical zones, and recommended future monitoring. Critical zones were defined as areas upstream of monitoring sites where the TBC and PBC Water quality standard were not being met.

Subwatershed Results

Cryderman Lake Drain Subwatershed

During the months of August, September, and October, *E. coli* concentration samples were collected at ECD Sites 8, 9, and 10. All three sites were located on separate tributaries leading into the main stem.

ECD E. coli Monitoring August 2014

Three weeks of data were collected for ECD Site 8 during October. During the first week of sampling, 8/4/14, the center sample was accidentally omitted from the collection. To correct this error ECD Site 8 was sampled for an additional week in October per the instruction of MDEQ.

ECD Site 8 had a daily geomean ranging from 425 – 448 cfu/100mL. One wet weather event occurred on 8/11/14 resulting in a rainfall of 0.35 inches and a daily geomean of 425 cfu/100mL. The highest daily geomean of 448 cfu/100mL occurred during dry weather the third week of sampling in August. Samples exceeded TBC 100% of the time and never exceeded PBC.

ECD Site 9 had a daily geomean ranging from 833 – 3,132 cfu/100mL. Two wet weather events occurred - one on 8/4/14 resulting in a rainfall of 0.5 inches and a daily geomean of 833 cfu/100mL, and one on 8/11/14 resulting in a rainfall of 0.35 inches and a daily geomean of 1,147 cfu/100mL. The wet weather sample on 8/11/14 was a significant increase from the wet weather sample the previous week on 8/4/14. This was despite a lower rainfall recorded on 8/11/14. The highest daily geomean of 3,132 cfu/100mL occurred during dry weather the third week of sampling in August. Samples exceeded TBC 100% of the time and PBC 75% of the time.

ECD Site 10 had a daily geomean ranging from 484 – 1,200 cfu/100mL. Two wet weather events occurred - one on 8/4/14 resulting in a rainfall of 0.5 inches and a daily geomean of 1,200 cfu/100mL (the highest *E. coli* concentration for that site), and one on 8/11/14 resulting in a rainfall of 0.35 inches and a daily geomean of 681 cfu/100mL. The wet weather sample on 8/11/14 was a significant decrease from the wet weather sample the previous week on 8/4/14. Samples exceeded TBC 100% of the time and PBC 50% of the time.

ECD E. coli Monitoring September 2014

ECD Site 8 had a daily geomean ranging from 213 – 708 cfu/100mL. One wet weather event occurred on 9/29/14 resulting in a rainfall of 0.11 inches and a daily geomean of 708 cfu/100mL (the highest *E. coli* concentration for that site). Samples exceeded TBC 75% of the time and never exceeded PBC.

ECD Site 9 had a daily geomean ranging from 1,206 – 2,545 cfu/100mL. One wet weather event occurred on 9/29/14 resulting in a rainfall of 0.11 inches and a daily geomean of 2,215 cfu/100mL. The highest daily geomean of 2,331 cfu/100mL occurred during dry weather the third week of sampling in September. Samples exceeded both TBC and PBC 100% of the time.

ECD Site 10 had a daily geomean ranging from 536 – 2,331 cfu/100mL. One wet weather event occurred on 9/29/14 resulting in a rainfall of 0.11 inches and a daily geomean of 1,984 cfu/100mL. The wet weather daily geomean was an increase from the dry weather daily geomean (1,622 cfu/100mL) recorded the previous week (9/22/14). The highest daily geomean of 2,331 cfu/100mL occurred during dry weather the second week of sampling in September. This was a significant increase from the daily geomean (536 cfu/100mL) recorded the previous week on 9/8/14. Samples exceeded TBC 100% of the time and PBC 75% of the time.

ECD E. coli Monitoring October 2014

ECD Site 8 was sampled for three weeks in October to complete the 10 week cycle.

ECD Site 8 had a daily geomean ranging from 158 – 242 cfu/100mL. Three wet weather events occurred -one on 10/6/14 resulting in a rainfall of 0.26 inches and a daily geomean of 242 cfu/mL (the highest *E. coli* concentration for that site), one on 10/13/14 resulting in a rainfall of 0.11 inches and a daily geomean of 222 cfu/100mL 100mL, and one on 10/20/14 resulting in a rainfall of 0.06 inches and a daily geomean of 158 cfu/100mL. Samples never exceeded TBC or PBC.

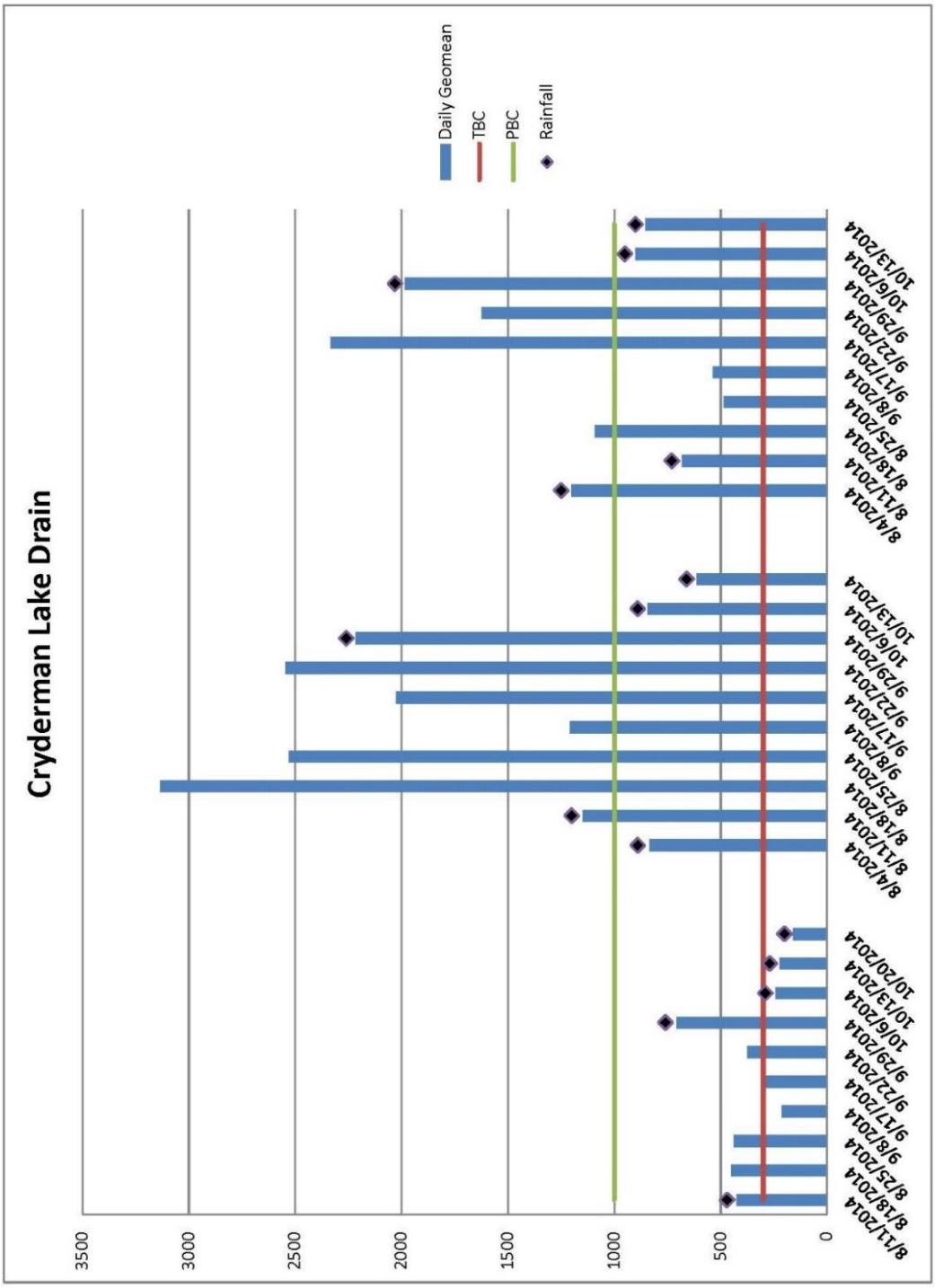
ECD Sites 9 and 10 were samples for two weeks in October to complete the 10 week cycle.

ECD Site 9 had a daily geomean ranging from 612 – 841 cfu/100mL. Two wet weather events occurred - one on 10/6/14 resulting in a rainfall of 0.26 inches and a daily geomean of 841 cfu/100mL (the highest *E. coli* concentration for that site), and one on 10/13/14 resulting in a rainfall of 0.11 inches and a daily geomean of 612 cfu/100mL. Samples exceeded TBC 100% of the time and never exceeded PBC.

ECD Site 10 had a daily geomean ranging from 851 – 900 cfu/100mL. Two wet weather events occurred - one on 10/6/14 resulting in a rainfall of 0.26 inches and a daily geomean of 900 cfu/100mL (the highest *E. coli* concentration for that site), and one on 10/13/14 resulting in a rainfall of 0.11 inches and a daily geomean of 851 cfu/100mL. Samples exceeded TBC 100% of the time and never exceeded PBC.

Graph 1
Cryderman
Lake Drain
Data
Results

Cryderman Lake Drain



Subwatershed Summary

Three sites in Cryderman Lake Drain subwatershed were monitored for *E. coli* with a total of 30 samples taken. Of those samples, 26 exceeded TBC (87%) and 12 exceeded PBC (40%).

Fifteen wet weather samples were taken. Four of the samples exceeded PBC and twelve of the samples exceeded TBC. Rainfall ranged from 0.11 - 0.50 inches.

Out of the three sites monitored, the highest daily geomean (3,132 cfu/100mL) was recorded during dry weather at ECD Site 9.

Overall, ECD Site 8 exceeded TBC 60% of the time (lowest percentage in the subwatershed). ECD Site 8 never exceeded PBC for the entire sampling period (lowest percentage in the subwatershed). Five wet weather events were recorded and two of those samples exceeded the TBC water quality standard. The highest daily geomean (708 cfu/100mL) occurred during wet weather the third week of sampling in September. ECD Site 8 was the only site to have the highest daily geomean during wet weather in Cryderman Lake Drain subwatershed.

Overall, ECD Site 9 exceeded TBC 100% of the time. ECD Site 9 exceeded PBC 70% of the time (highest percentage in the subwatershed). When exceeding PBC, daily geomeans ranged from 1,147 – 3,132 cfu/100mL. Five wet weather events were recorded and five of those samples exceeded the TBC water quality standard, two exceeded PBC standard. The highest daily geomean (3,132 cfu/100mL) occurred during dry weather the third week of sampling in August. This was a significant increase from the two wet weather samples recorded the previous weeks (8/4/14 and 8/11/14).

Overall, ECD Site 10 exceeded TBC 100% of the time. ECD Site 10 exceeded PBC 50% of the time. When exceeding PBC, daily geomeans ranged from 1,090 – 2,331 cfu/100mL. Five wet weather events were recorded and five of those samples exceeded the TBC, and two exceeded PBC. The highest daily geomean (2,331 cfu/100mL) occurred during dry weather the second week of sampling in September. This was a significant increase from the two wet weather samples recorded previously in August, as well as, for the three dry weather samples recorded at the end of August and beginning of September. In total, there were five weeks of sampling prior to the highest daily geomean recorded for ECD Site 10.

Table 3. Cryderman Lake Drain Subwatershed 2014 ECD Data Collection Summary

2014 ECD Data Collection		TBC Exceedances	PBC Exceedances	Total Samples	Wet Weather Samples that Exceeded TBC	Wet Weather Samples that Exceeded PBC	Rainfall (inches)	Was the Highest Daily Geomean During Wet Weather (cfu/100mL)
Scope	Subwatershed	26	12	30	12 out of 15	4 out of 15	0.11 - 0.50	No
	ECD 8	6	0	10	2 out of 5	0 out of 5		Yes, 708
	ECD 9	10	7	10	5 out of 5	2 out of 5		No
	ECD 10	10	5	10	5 out of 5	2 out of 5		No

Cryderman Lake Drain – Potential Sources and Causes

Cryderman Lake Drain subwatershed has the second highest acreage (14,860) of the Watershed (Table 4). Of the subwatersheds that were monitored for *E. coli* concentrations in 2014, Cryderman Lake Drain has the highest cropland acreage. Cryderman Lake Drain has the third highest livestock density (12.92) of the Watershed (Table 4). Across the Watershed, Cryderman Lake Drain has the highest number of livestock observations near a waterway (13), yet only one resource concern was noted (direct access) (Table 4). When assessing the potential for sources outside of livestock for the subwatersheds lacking BST monitoring, Cryderman Lake Drain, has the third highest number of septic areas of HLI and sedimentation estimate (0.077 tons/ac/yr) (Table 4).

Table 4. Cryderman Lake Drain Subwatershed 2012 Inventory Collection Summary

Subwatershed: Cryderman Lake Drain	
2012 Inventory	**Results**
Horses	28
Beef Cattle	391
Dairy Cattle	165
Other Livestock	6
Livestock Density (#/sq. mi.)	12.92
Livestock Farms Near Waterway (200 ft)	13
Resource Concern Observations (# of sites)	Direct Access-1
Tillage Practices	NT- 25%, RT- 12.5%, CT- 62.5%
Sedimentation (tons/ac/yr)	0.077
Cropland Acres	14,860
Septic Areas of HLI	66

Cryderman Lake Drain Critical Zones Linked to Monitoring

During monitoring, Cryderman Lake Drain subwatershed had the highest percentage of exceedances for both TBC (87%) and PBC (40%). Cryderman Lake Drain also had the highest ranking for wet weather TBC

exceedances. Livestock sources are a high priority given the high density of livestock, land application of manure, and wet weather monitoring results. Critical areas are upstream of Site 9 and Site 10. Septic systems are likely a significant contributor given the number of septic areas of HLI and the dry weather exceedances. Future BST tracking to delineate human, livestock, and other sources is recommended.

Frayer Creek

Figure 2: Cryderman Lake Drain Subwatershed 2014 Data Collection Results

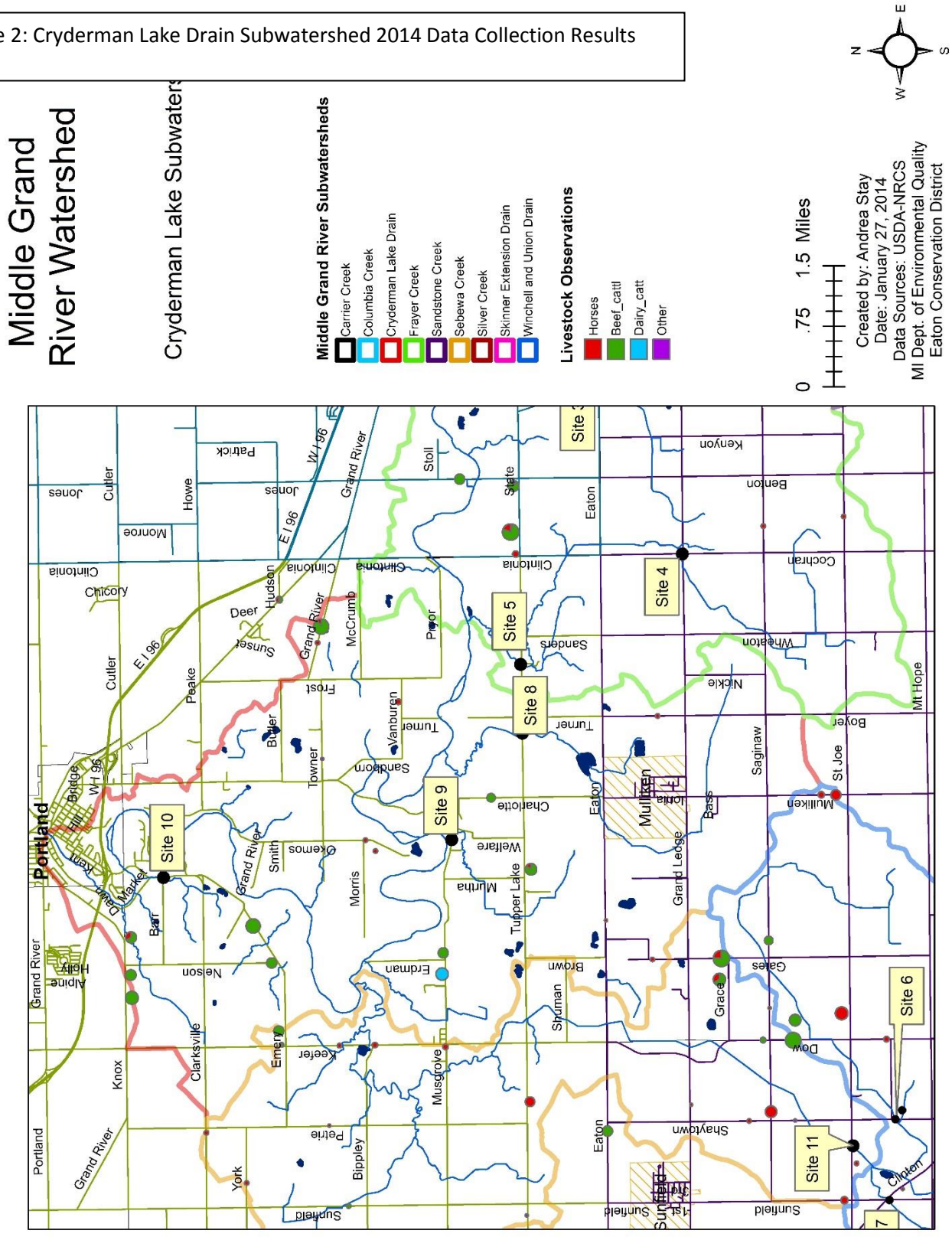


Figure 2: Cryderman Lake Drain Subwatershed livestock observations

Subwatershed

During the months of August, September, and part of October, *E. coli* concentration samples were collected at ECD Sites 3, 4, and 5. ECD Site 4 is upstream of ECD Site 5.

ECD E. coli Monitoring August 2014

ECD Site 3 had a daily geomean ranging from 737 – 2,023 cfu/100mL. Two wet weather events occurred - one on 8/4/14 resulting in a rainfall of 0.5 inches and a daily geomean of 2,023 cfu/100mL (the highest *E. coli* concentration for that site), and one on 8/11/14 resulting in a rainfall of 0.35 inches and a daily geomean of 990 cfu/100mL. Samples exceeded TBC 100% of the time and PBC 50% of the time. It is worth noting that the second highest daily geomean (1,290 cfu/100mL) which exceeded PBC occurred during dry weather.

ECD Site 4 had a daily geomean ranging from 769 – 9,045 cfu/100mL. Two wet weather events occurred - one on 8/4/14 resulting in a rainfall of 0.5 inches and a daily geomean of 9,045 cfu/100mL (the highest *E. coli* concentration for that site), and one on 8/11/14 resulting in a rainfall of 0.35 inches and a daily geomean of 8,221 cfu/100mL. Samples exceeded TBC 100% of the time and PBC 75% of the time. The highest *E. coli* concentrations for ECD Site 4 occurred during the first three weeks of sampling with daily geomeans ranging from 3,547 – 9,045 cfu/100mL. During this time period two of these exceedances were during the wet weather events. The third was during dry weather and was significantly lower (3,547 cfu/100mL) from the wet weather daily geomeans.

ECD Site 5 had a daily geomean ranging from 215 – 335 ccfu/100mL. Two wet weather events occurred - one on 8/4/14 resulting in a rainfall of 0.5 inches and a daily geomean of 335 cfu/100mL (the highest *E. coli* concentration for that site), and one on 8/11/14 resulting in a rainfall of 0.35 inches and a daily geomean of 285 cfu/100mL. Samples exceeded TBC 25% of the time and never exceeded PBC.

Comparison: Upstream (ECD Site 4) and Downstream (ECD Site 5)

During the wet weather events ECD Site 4 experienced significantly higher daily geomeans (9,045 cfu/100mL and 8,221 cfu/100mL) than ECD Site 5 (335 cfu/100mL and 285 cfu/100mL). For all samples taken on the same day, ECD Site 4 always had *E. coli* concentrations exceeding that of ECD Site 5. This would suggest that the source of the *E. coli* originates closer to ECD Site 4 as it is upstream of ECD Site 5.

ECD E. coli Monitoring September 2014

ECD Site 3 had a daily geomean ranging from 349 – 942 cfu/100mL. One wet weather event occurred on 9/29/14 resulting in a rainfall of 0.11 inches and a daily geomean of 696 cfu/100mL. The highest daily geomean of 942 cfu/100mL occurred during dry the first week of sampling in September. Samples exceeded TBC 100% of the time and never exceeded PBC.

ECD Site 4 had a daily geomean ranging from 190 – 3,350 cfu/100mL. One wet weather event occurred on 9/29/14 resulting in a rainfall of 0.11 inches and a daily geomean of 190 cfu/100mL (the lowest *E. coli* concentration for that site). The highest daily geomean of 3,350 cfu/100mL occurred during dry

weather the second week of sampling in September. This was significantly higher than the daily geomean of 373 cfu/100mL the week prior. It is interesting to note that on 9/22/14 ECD Site 4 had a daily geomean of 1,159 cfu/100mL and the decreased significantly the following week to its lowest daily geomean (190 cfu/100mL). Samples exceeded TBC 75% of the time and exceeded PBC 50% of the time.

ECD Site 5 had a daily geomean ranging from 141 – 316 cfu/100mL. One wet weather event occurred on 9/29/14 resulting in a rainfall of 0.11 inches and a daily geomean of 141 cfu/100mL (the lowest *E. coli* concentration for that site). The highest daily geomean of 316 cfu/100mL occurred during dry weather the first week of sampling in September. Samples exceeded TBC 50% of the time and never exceeded PBC.

Comparison: Upstream (ECD Site 4) and Downstream (ECD Site 5)

As in August, the trend of ECD Site 4 experiencing a higher daily geomean (190 cfu/100mL) during a wet weather event continued (ECD Site 5 141 cfu/100mL). For all samples taken on the same day, ECD Site 4 always had *E. coli* concentrations exceeding that of ECD Site 5. This holds true to the hypothesis in August that the source of *E. coli* originates closer to ECD Site 4 as it is upstream of ECD Site 5.

ECD E. coli Monitoring October 2014

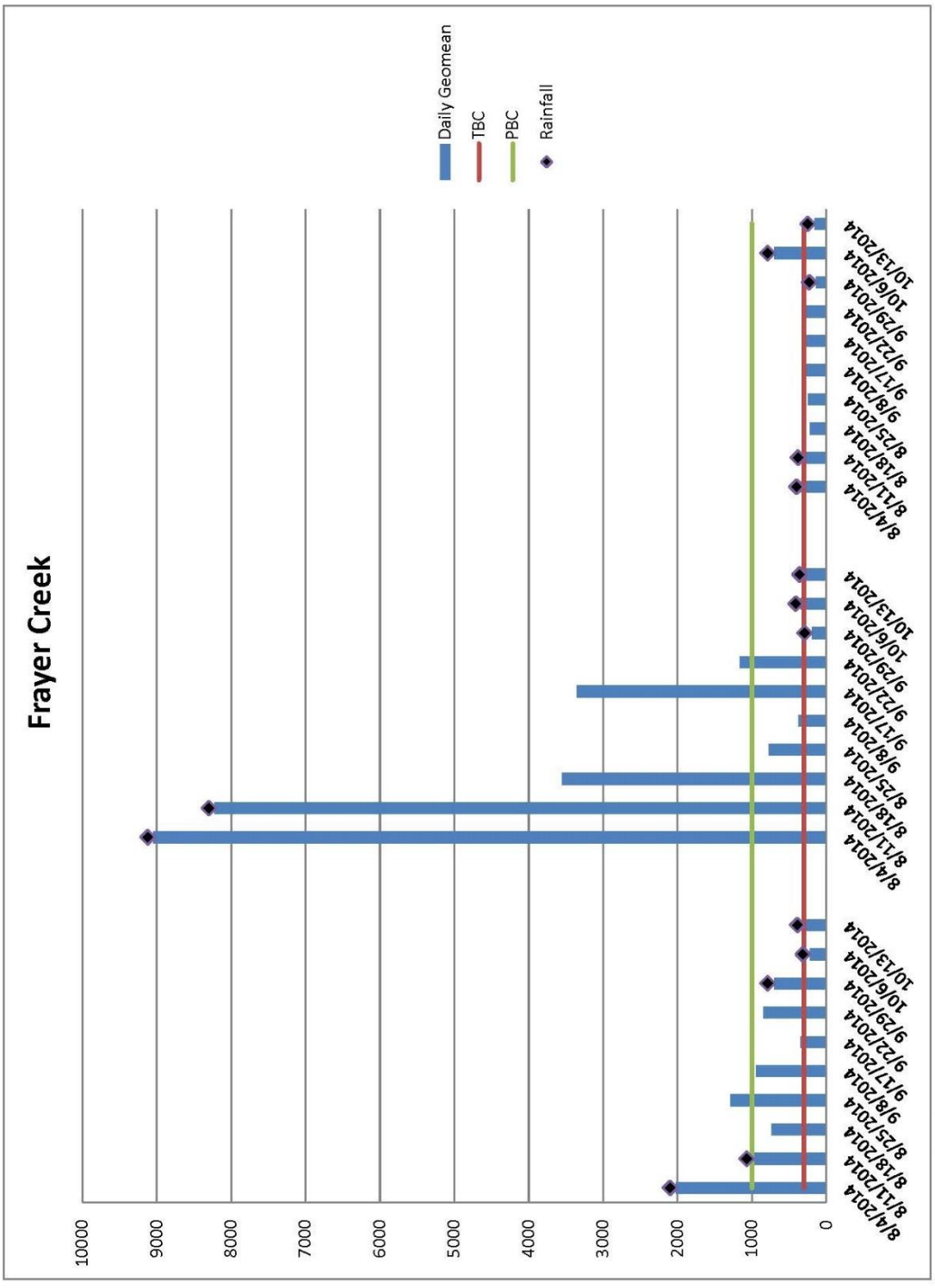
ECD Sites 3, 4, and 5 were sampled for two weeks in October to complete the 10 week cycle.

ECD Site 3 had a daily geomean ranging from 216 – 266 cfu/100mL. Two wet weather events occurred - one on 10/6/14 resulting in a rainfall of 0.26 inches and a daily geomean of 216 cfu/100mL, and one on 10/13/14 resulting in a rainfall of 0.11 inches and a daily geomean of 266 cfu/100mL (the highest *E. coli* concentration for that site). Samples never exceeded TBC or PBC.

ECD Site 4 had a daily geomean ranging from 261 – 323 cfu/100mL. Two wet weather events occurred - one on 10/6/14 resulting in a rainfall of 0.26 inches and a daily geomean of 342 cfu/100mL (the highest *E. coli* concentration for that site), and one on 10/13/14 resulting in a rainfall of 0.11 inches and a daily geomean of 261 cfu/100mL. Samples exceeded TBC 50% of the time and never exceeded PBC.

ECD Site 5 had a daily geomean ranging from 151 – 697 cfu/100mL. Two wet weather events occurred - one on 10/6/14 resulting in a rainfall of 0.26 inches and a daily geomean of 697 cfu/100mL (the highest *E. coli* concentration for that site), and one on 10/13/14 resulting in a rainfall of 0.11 inches and a daily geomean of 151 cfu/100mL. Samples exceeded TBC 50% of the time and never exceeded PBC.

Frayer Creek



Graph 2: Frayer Creek Subwatershed ECD Data Collection Results

Subwatershed Summary

Three sites in Frayer Creek subwatershed were monitored for *E. coli* with a total of 30 samples taken. Of those samples, 20 exceeded TBC (67%) and seven exceeded PBC (23%). PBC exceedances ranged from a daily geomean of 1,159 – 9,045 cfu/100mL.

Fifteen wet weather samples were taken. Eight of the samples exceeded TBC and five of the samples exceeded PBC. For all three sites monitored, the highest daily geomean was recorded during wet weather. Rainfall ranged from 0.11 - 0.50 inches.

Overall, ECD Site 3 exceeded TBC 80% of the time. ECD Site 3 during the sampling period exceeded PBC 20% of the time. When exceeding PBC, daily geomeans ranged from 1,290 – 2,023 cfu/100mL. Five wet weather events were recorded and three of those samples exceeded TBC, and one exceeded PBC. The highest daily geomean (2,023 cfu/100mL) occurred during wet weather the first week of sampling in August when the largest amount of rainfall was recorded (0.50 inches).

Comparison: Upstream (ECD Site 4) and Downstream (ECD Site 5)

When comparing ECD Sites 4 and 5 against one another, ECD Site 4 had a greater amount of TBC exceedances (80%) than ECD Site 5 (40%) and Site 4 had higher percentage of PBC exceedances (50%) than ECD Site 5 (0%). ECD Site 4 also had a greater amount of TBC wet weather exceedances (3 out of 5) than ECD Site 5 (2 out of 5).

For all samples taken on the same day in August and September, ECD Site 4 always had E. *coli* concentrations exceeding that of ECD Site 5. This trend did not continue during the two week sampling period in October. The daily geomean for ECD Site 5 (697 cfu/100mL) on 10/6/14 was greater than that of ECD Site 4 (342 cfu/100mL) for the first time during the entire sampling period. This was also a wet weather event with a rainfall of 0.26 inches. The daily geomean recorded for ECD Site 5 on 10/6/14 was the highest overall daily geomean for that site. It is important to note that the daily geomean recorded the following week (10/13/14) for ECD Site 5 dropped significantly (151 cfu/100mL) and it was a wet weather event (0.11 inches of rainfall).

For the sampling period the highest daily geomean was recorded at ECD Site 4 (9,045 cfu/100mL) during a wet weather event (0.50 inches of rainfall).

Based on the sampling results, it is hypothesized that the source of *E. coli* originates closer to ECD Site 4 as it is upstream of ECD Site 5.

Table 5. Frayer Creek Subwatershed 2014 Data Collection Summary

2014 ECD Data Collection		TBC Exceedances	PBC Exceedances	Total Samples	Wet Weather Samples that Exceeded TBC	Wet Weather Samples that Exceeded PBC	Rainfall (inches)	Highest Daily Geomean During Wet Weather (cfu/100mL)
Scope	**Subwatershed**	20	7	30	8 out of 15	3 out of 15	0.11 - 0.50	Yes, 9,045
	ECD 3	8	2	10	3 out of 5	1 out of 5		Yes, 2,023
	ECD 4	8	5	10	3 out of 5	2 out of 5		Yes, 9,045
	ECD 5	4	0	10	2 out of 5	0 out of 5		Yes, 697

Frayer Creek Subwatershed– Potential Sources and Causes

Frayer Creek subwatershed has the second highest livestock density (17.1/sq. mi.) of the Watershed (Table 6). Of the subwatersheds that were monitored for *E. coli* concentrations in 2014, Frayer Creek has the highest number of resource concern observations (3) (Table 6). Direct access to surface water was observed at two sites and overgrazing was observed at one site. Frayer Creek has the second highest cropland acreage (12,414) of the subwatersheds monitored in 2014 (Table 6). When comparing across the Watershed and with the subwatersheds monitored in 2014, Frayer Creek has a significantly lower number of septic areas of HLI (7) (Table 6).

Table 6. Frayer Creek 2012 Inventory Collection Summary

Subwatershed: Frayer Creek	
2012 Inventory	**Results**
Horses	29
Beef Cattle	77
Dairy Cattle	0
Other Livestock	48
Livestock Density (#/sq. mi.)	17.1
Livestock Farms Near Waterway (200 ft)	2
Resource Concern Observations (# of sites)	Direct Access-2, Overgrazed-1
Tillage Practices	NT- 22.5%, RT- 22.5%, CT- 55%
Sedimentation (tons/ac/yr)	0.070
Cropland Acres	12,414
Septic Areas of HLI	7

Frayer Creek Critical Zones Linked to Monitoring

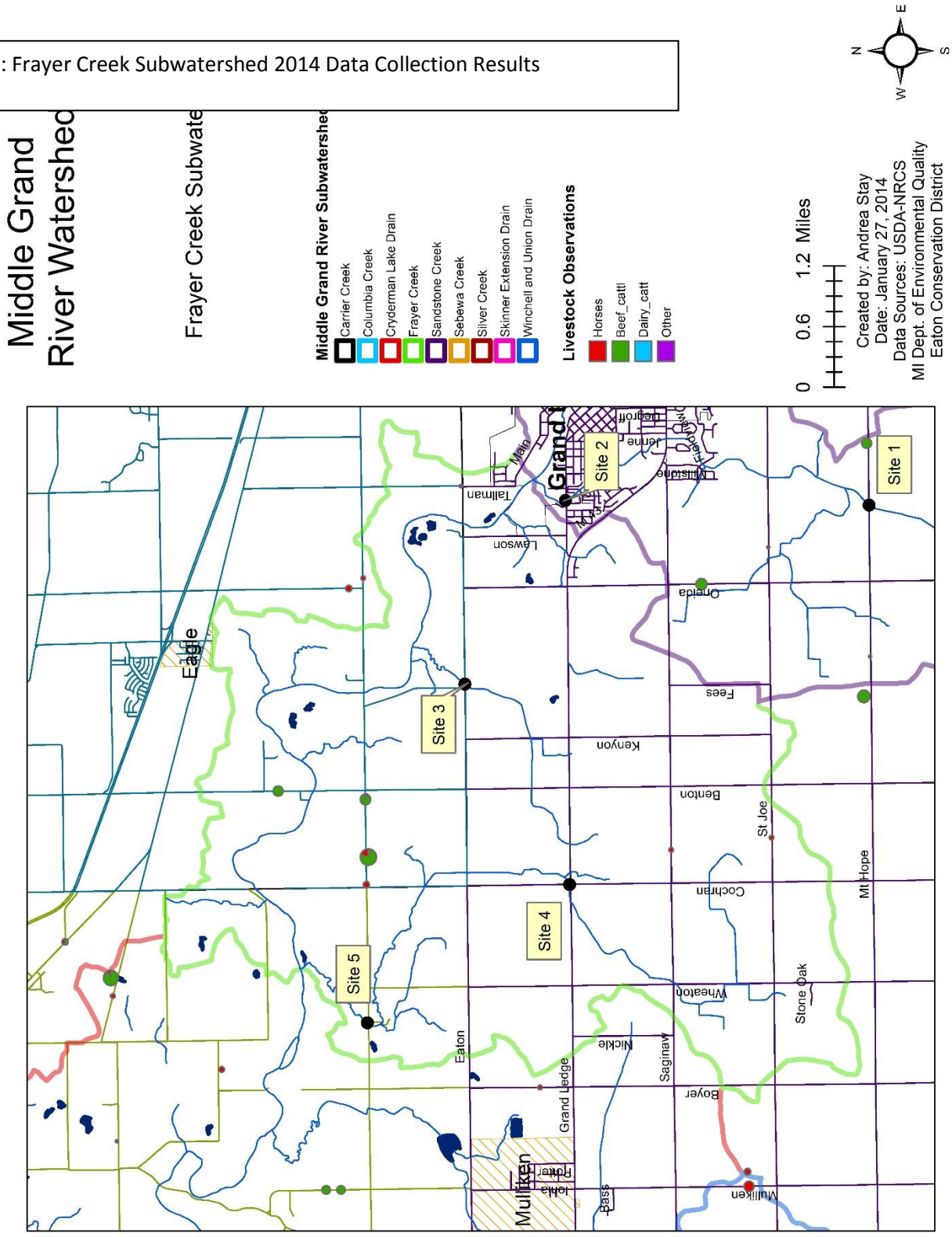
During monitoring, Frayer Creek subwatershedhad the second highest percentage of exceedances for both TBC (67%) and PBC (23%). Frayer Creek had the third highest ranking for wet weather TBC exceedances.

Critical areas are upstream of Site 4 and Site 4. The wet weather results indicate a potential agriculture runoff from manure on Sites 3 and 4.

Septic systems are likely not a significant contributor given the low number of septic areas of HLI. Future BST tracking to delineate human, livestock, and other sources is recommended.

Sebew
Creek

Figure 3: Frayer Creek Subwatershed 2014 Data Collection Results



Sub

Figure 3: Frayer Creek Subwatershed Livestock Observations

During the months of August, September, and part of October, *E. coli* concentration samples were collected at ECD Sites 11, 12, 13, 14, and 15. ECD Site 11 is upstream of ECD Site 12.

ECD E. coli Monitoring August 2014

ECD Site 11 had a daily geomean ranging from 281 – 733 cfu/100mL. Two wet weather events occurred - one on 8/4/14 resulting in a rainfall of 0.5 inches and a daily geomean of 281 cfu/100mL, and one on 8/11/14 resulting in a rainfall of 0.35 inches and a daily geomean of 703 cfu/100mL. Although the wet weather event on 8/11/14 had a lower amount of rainfall recorded than the previous week, the daily geomean increased significantly from 8/4/14. The highest daily geomean of 733 cfu/100mL occurred during dry weather the fourth week of sampling. Samples exceeded TBC 75% of the time and never exceeded PBC.

ECD Site 12 had a daily geomean ranging from 128 – 225 cfu/100mL. Two wet weather events occurred - one on 8/4/14 resulting in a rainfall of 0.5 inches and a daily geomean of 205 cfu/100mL, and one on 8/11/14 resulting in a rainfall of 0.35 inches and a daily geomean of 225 cfu/100mL (the highest *E. coli* concentration for that site). Samples never exceeded TBC or PBC.

ECD Site 13 had a daily geomean ranging from 359 – 429 cfu/100mL. Two wet weather events occurred- one on 8/4/14 resulting in a rainfall of 0.5 inches and a daily geomean of 364 cfu/100mL, and one on 8/11/14 resulting in a rainfall of 0.35 inches and a daily geomean of 359 cfu/100mL. The highest daily geomean of 429 cfu/100mL occurred during dry weather the third week of sampling. Samples exceeded TBC 100% of the time and never exceeded PBC.

ECD Site 14 had a daily geomean ranging from 291 – 435 cfu/100mL. Two wet weather events occurred - one on 8/4/14 resulting in a rainfall of 0.5 inches and a daily geomean of 319 cfu/100mL, and one on 8/11/14 resulting in a rainfall of 0.35 inches and a daily geomean of 435 cfu/100mL (the highest *E. coli* concentration for that site). Samples exceeded TBC 50% of the time and never exceeded PBC.

ECD Site 15 had a daily geomean ranging from 10 – 28 cfu/100mL. Two wet weather events occurred - one on 8/4/14 resulting in a rainfall of 0.5 inches and a daily geomean of 20 cfu/100mL, and one on 8/11/14 resulting in a rainfall of 0.35 inches and a daily geomean of 28 cfu/100mL (the highest *E. coli* concentration for that site). Samples never exceeded TBC or PBC.

ECD E. coli Monitoring September 2014

ECD Site 11 had a daily geomean ranging from 249 – 532 cfu/100mL. One wet weather event occurred on 9/29/14 resulting in a rainfall of 0.11 inches and a daily geomean of 249 cfu/100mL. The highest daily geomean of 532 cfu/100mL occurred during dry weather the third week of sampling in September. It is interesting to note that the highest daily geomean occurred the week before the wet weather event which resulted in the lowest *E. coli* concentration for ECD Site 11 during September. Samples exceeded TBC 75% of the time and never exceeded PBC.

ECD Site 12 had a daily geomean ranging from 521 – 574 cfu/100mL. One wet weather event occurred on 9/29/14 resulting in a rainfall of 0.11 inches and a daily geomean of 544 cfu/100mL. The highest

daily geomean of 574 cfu/100mL occurred during dry weather the first week of sampling in September. Samples exceeded TBC 100% of the time and never exceeded PBC. This was an increase in exceedances from the August sampling.

ECD Site 13 had a daily geomean ranging from 352 – 562 cfu/100mL. One wet weather event occurred on 9/29/14 resulting in a rainfall of 0.11 inches and a daily geomean of 550 cfu/100mL. The highest daily geomean occurred during dry weather the second week of sampling in September. Samples exceeded TBC 100% of the time and never exceeded PBC. This was the same trend as found in the August sampling.

ECD Site 14 had a daily geomean ranging from 393 – 602 cfu/100mL. One wet weather event occurred on 9/29/14 resulting in a rainfall of 0.11 inches and a daily geomean of 393 cfu/100mL. The highest daily geomean of 602 cfu/100mL occurred during dry weather the first week of sampling in September Samples exceeded TBC 100% of the time and never exceeded PBC. This was a slight increase from the *E. coli* concentrations found in August.

ECD Site 15 had a daily geomean ranging from 10 – 31 cfu/100mL. One wet weather event occurred on 9/29/14 resulting in a rainfall of 0.11 inches and a daily geomean of 10 cfu/100mL. The highest daily geomean of 31 cfu/100mL occurred during dry weather the first week of sampling in September. Samples never exceeded TBC or PBC. This was the same trend as found in the August sampling.

ECD E. coli Monitoring October 2014

ECD Sites 11, 12, 13, 14, and 15 were sampled for two weeks in October to complete the 10 week cycle.

ECD Site 11 had a daily geomean ranging from 216 – 1,025 cfu/100mL. Two wet weather events occurred - one on 10/6/14 resulting in a rainfall of 0.26 inches and a daily geomean of 1,025 cfu/100mL (the highest *E. coli* concentration for that site), and one on 10/13/14 resulting in a rainfall of 0.11 inches and a daily geomean of 216 cfu/100mL. Samples exceeded TBC and PBC 50% of the time.

ECD Site 12 had a daily geomean ranging from 205 – 1,207 cfu/100mL. Two wet weather events occurred - one on 10/6/14 resulting in a rainfall of 0.26 inches and a daily geomean of 1,207 cfu/100mL (the highest *E. coli* concentration for that site), and one on 10/13/14 resulting in a rainfall of 0.11 inches and a daily geomean of 205 cfu/100mL. There was a significant decrease from the sample collected on the first week to the sample collected on the second week in October. Samples exceeded TBC and PBC 50% of the time.

ECD Site 13 had a daily geomean ranging from 284 – 481 cfu/100mL. Two wet weather events occurred - one on 10/6/14 resulting in a rainfall of 0.26 inches and a daily geomean of 481 cfu/100mL (the highest *E. coli* concentration for that site), and one on 10/13/14 resulting in a rainfall of 0.11 inches and a daily geomean of 284 cfu/100mL. Samples exceeded TBC 50% of the time and never exceeded PBC.

ECD Site 14 had a daily geomean ranging from 541 – 205 cfu/100mL. Two wet weather events occurred - one on 10/6/14 resulting in a rainfall of 0.26 inches and a daily geomean of 541 cfu/100mL (the highest

E. coli concentration for that site), and one on 10/13/14 resulting in a rainfall of 0.11 inches and a daily geomean of 205 cfu/100mL. Samples exceeded TBC 50% of the time and never exceeded PBC.

ECD Site 15 had a daily geomean ranging from 34 – 73 cfu/100mL. Two wet weather events occurred - one on 10/6/14 resulting in a rainfall of 0.26 inches and a daily geomean of 34 cfu/100mL, and one on 10/13/14 resulting in a rainfall of 0.11 inches and a daily geomean of 73 cfu/100mL (the highest *E. coli* concentration for that site). Samples never exceeded TBC or PBC. This was the same trend as found in the August and September sampling.

Sebewa Creek Subwatershed Summary

Five sites in Sandstone Creek subwatershed were monitored for *E. coli* with a total of 50 samples taken. Of those samples, 28 exceeded TBC (56%) and two exceeded PBC (4%). PBC exceedances ranged from a daily geomean of 1025 – 1207 cfu/100mL.

Twenty five wet weather samples were taken. Twelve of the samples exceeded TBC and two of the samples exceeded PBC. Rainfall ranged from 0.11 - 0.50 inches.

Comparison: Upstream (ECD Site 11) and Downstream (ECD Site 12)

When comparing ECD Sites 11 and 12 against one another, it was found that ECD Site 11 had a slightly higher amount of TBC exceedances (70%) than ECD Site 12 (50%). During wet weather, they had the same amount of exceedances (2 out of 5 for TBC, 1 out of 5 for PBC).

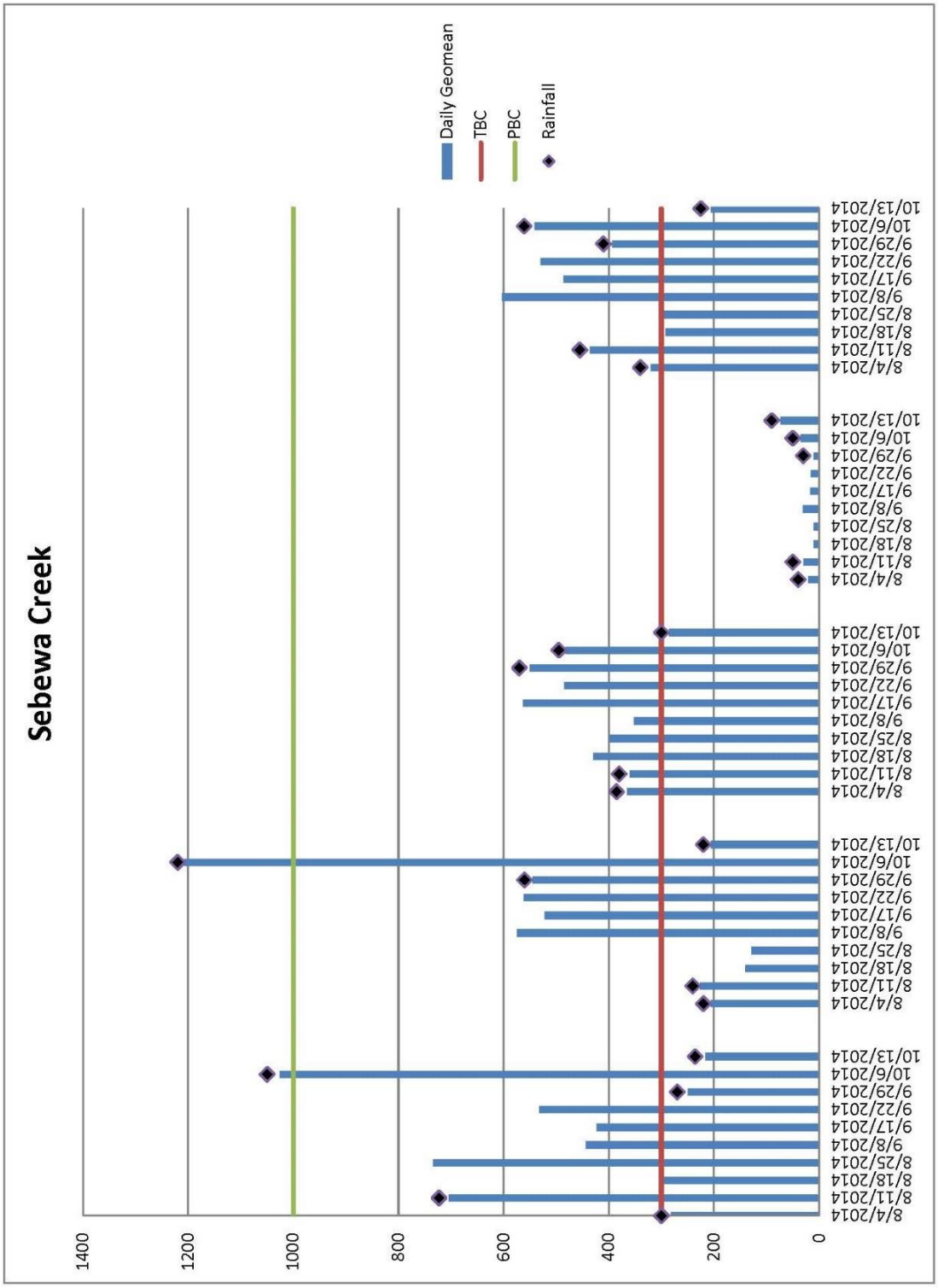
Each site only exceeded PBC once, during a wet weather event on 10/6/14.

Based on the sampling results, it is hypothesized that the source of *E. coli* originates closer to ECD Site 11 as it is upstream of ECD Site 12.

Comparison: Downstream (ECD Site 11) and two tributaries (ECD Site 6 and site 7

ECD Site 11 is just downstream of two sites (site 6 and site 7) in the Winchell and Union Subwatershed. Site 6 exceeded more often than Site 7. Site 6 exceeded TBC eight times (compared to 4 for Site 7) and exceeded PBC four times (compared to 0 for Site 7). Both Sites 6 and 7 exceeded TBC on 10/6/14, but did not have the high spike that was seen downstream at Sites 11 and 12. The source for that spike is likely found upstream of 11. Based on the sampling results, the land upstream of Site 6 is contributing more E. coli than to downstream.

Table 7.



Graph 3: Sebewa Creek 2014 Data Collection Results

Sebewa Creek Subwatershed 2012 Inventory Collection Summary

2014 ECD Data Collection	TBC Exceedances	PBC Exceedances	Total Samples	TBC Wet Weather Exceedances	PBC Wet Weather Exceedances	Rainfall	Highest Daily Geomean During Wet Weather
Subwatershed	28	2	50	12 out of 25 samples	2 out of 25 samples	0.11-0.50 inches	Yes, 1207 cfu/100 mL
ECD 11	7	1	10	2 out of 5 samples	1 out of 5 samples		Yes, 1025 cfu/100 mL
ECD 12	5	1	10	2 out of 5 samples	1 out of 5 samples		Yes, 1207 cfu/100 mL
ECD 13	9	0	10	4 out of 5 samples	0 out of 5 samples		No
ECD 15	0	0	10	0 out of 5 samples	0 out of 5 samples		N/A
ECD 14	7	0	10	4 out of 5 samples	0 out of 5 samples		No

Sebewa Creek Subwatershed– Potential Sources and Causes

Sebewa Creek subwatershed has the lowest percentage of conservation tillage (no till and reduced till) (25) of the Watershed (Table 8). Interestingly, Sebewa Creek subwatershed has the second highest number of livestock observations near a waterway (11) of the Watershed and three resource concerns were noted due to direct access (Table 8). Of the subwatersheds that were monitored for *E. coli* concentrations in 2014, Sebewa Creek has the second lowest number of septic areas of HLI (19) (this is also true when comparing the entire Watershed) and the second highest sedimentation estimate (0.085 tons/ac/yr) (Table 8).

Table 8. Sebewa Creek 2012 Inventory Collection Summary

Subwatershed: Sebewa Creek	
2012 Inventory	**Results**
Horses	41
Beef Cattle	111
Dairy Cattle	0
Other Livestock	16
Livestock Density (#/sq. mi.)	7.615
Livestock Farms Near Waterway (200 ft)	11
Resource Concern Observations (# of sites)	Direct Access-3
Tillage Practices	NT- 25%, RT- 0%, CT- 75%
Sedimentation (tons/ac/yr)	0.085
Cropland Acres	11,192
Septic Areas of HLI	19

Sebewa Creek Subwatershed Critical Zones Linked to Monitoring

During monitoring, Sebewa Creek subwatershed had the lowest percentage of exceedances for TBC (56%) and PBC (4%). Sebewa Creek had the second highest ranking for wet weather TBC exceedances. Site 14 never exceeded TBC or PBC so this might have brought down the overall percentage of samples exceeding. Upstream of sites 11, 12, 13, and 15 are priority areas, especially in locations where livestock have access to surface water.

Future BST tracking to delineate human, livestock, and other sources is recommended.

Figure 4: Sebewa Creek Subwatershed 2014 Data Collection Results

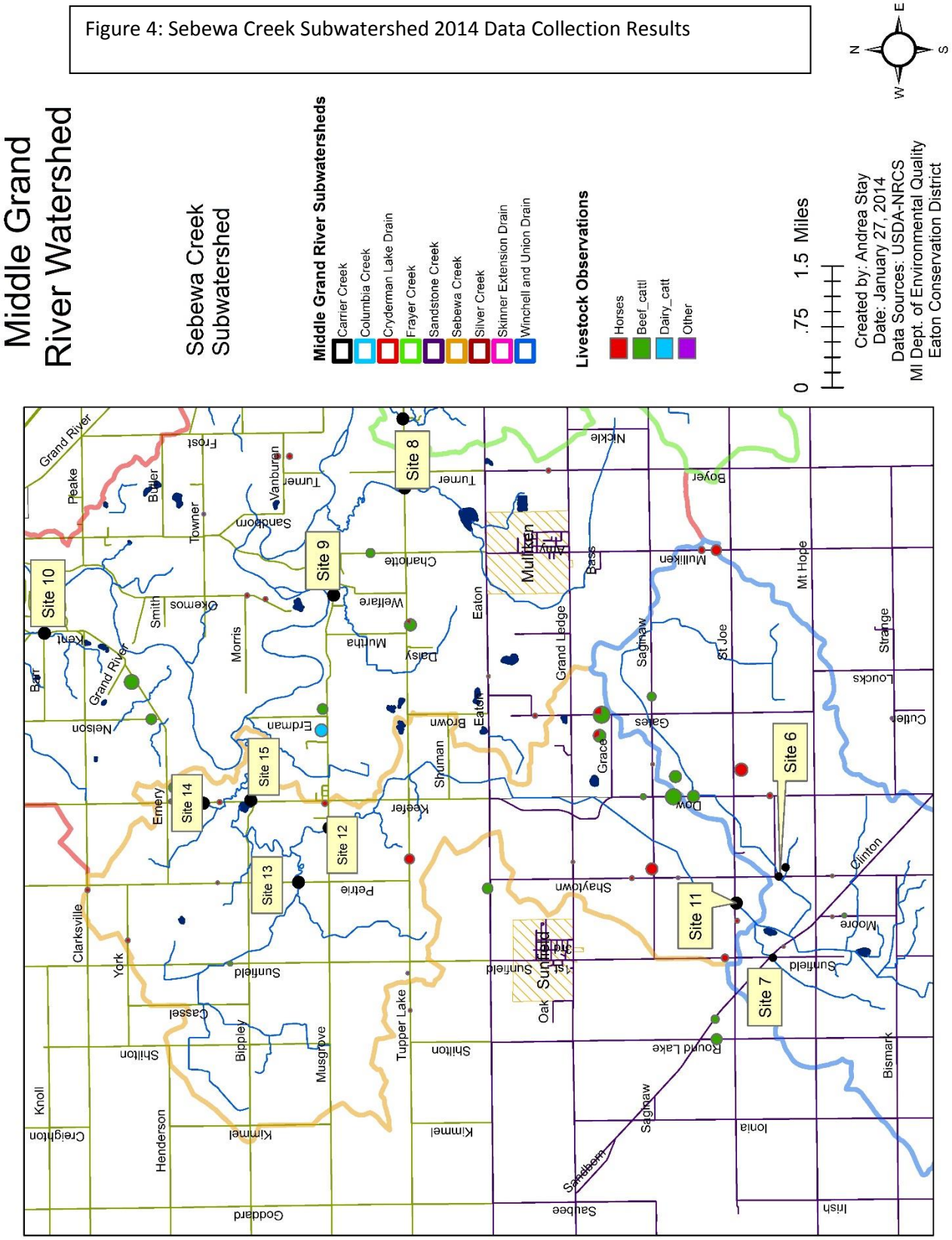


Figure 4 Sebewa Creek Subwatershed Livestock observations

Sandstone Creek Subwatershed

During the months of August, September, and part of October, *E. coli* concentration samples were collected at ECD Site 1 and further downstream at ECD Site 2. ECD Site 1 is rural, surround by agriculture fields, small livestock operation across the road, and there are rural residences. ECD Site 2 is urban residential site near the edge of town.

ECD E. coli Monitoring August 2014

ECD Site 1 had a daily geomean ranging from 623 – 986 cfu/100mL. Two wet weather events occurred - one on 8/4/14 resulting in a rainfall of 0.5 inches and a daily geomean of 642 cfu/100mL, and one on 8/11/14 resulting in a rainfall of 0.35 inches and a daily geomean of 623 cfu/100mL. The highest daily geomean of 986 cfu/100mL occurred during dry weather the third week of sampling. Samples exceeded TBC 100% of the time and never exceeded PBC.

ECD Site 2 had a daily geomean ranging from 92 – 397 cfu/100mL. Two wet weather events occurred - one on 8/4/14 resulting in a rainfall of 0.5 inches and a daily geomean of 161 cfu/100mL, and one on 8/11/14 resulting in a rainfall of 0.35 inches and a daily geomean of 397 cfu/100mL (the highest *E. coli* concentration for that site in August). The wet weather sample on 8/11/14 was a significant increase from the wet weather sample the previous week on 8/4/14. Samples exceeded TBC 25% of the time and never exceeded PBC.

Comparison: Upstream (ECD Site 1) and Downstream (ECD Site 2)

During the wet weather events ECD Site 1 experienced significantly higher daily geomeans (642 cfu/100mL and 623 cfu/100mL) than ECD Site 2 (161 cfu/100mL and 397 cfu/100mL). For all samples taken on the same day, ECD Site 1 always had *E. coli* concentrations exceeding that of ECD Site 2. This would suggest that the source of the *E. coli* originates closer to ECD Site 1 as it is upstream of ECD Site 2.

E. coli Monitoring September 2014

ECD Site 1 had a daily geomean ranging from 352 – 1,528 cfu/100mL. One wet weather event occurred on 9/29/14 resulting in a rainfall of 0.11 inches and a daily geomean of 352 cfu/100mL. The highest daily geomean of 1,528 cfu/100mL occurred during dry weather the first week of sampling in September. Samples exceeded TBC 100% of the time and PBC 25% of the time.

ECD Site 2 had a daily geomean ranging from 135 – 478 cfu/100mL. One wet weather event occurred on 9/29/14 resulting in a rainfall of 0.11 inches and a daily geomean of 135 cfu/100mL. The highest daily geomean of 478 cfu/100mL occurred during dry weather the third week of sampling in September. This was a significant increase from the dry weather sample (170 cfu/100mL) the previous week on 9/17/14.

Samples exceeded TBC 25% of the time and never exceed PBC. This rate of exceedances was the same trend found in August sampling.

Comparison: Upstream (ECD Site 1) and Downstream (ECD Site 2)

As in August, the trend of ECD Site 1 experiencing a significantly higher daily geomean (352 cfu/100mL) during a wet weather event continued (ECD Site 2 135 cfu/100mL). For all samples taken on the same day, ECD Site 1 always had *E. coli* concentrations exceeding that of ECD Site 2. This holds true to the hypothesis in August that the source of *E. coli* originates closer to ECD Site 1 as it is upstream of ECD Site 2.

E. coli Monitoring October 2014

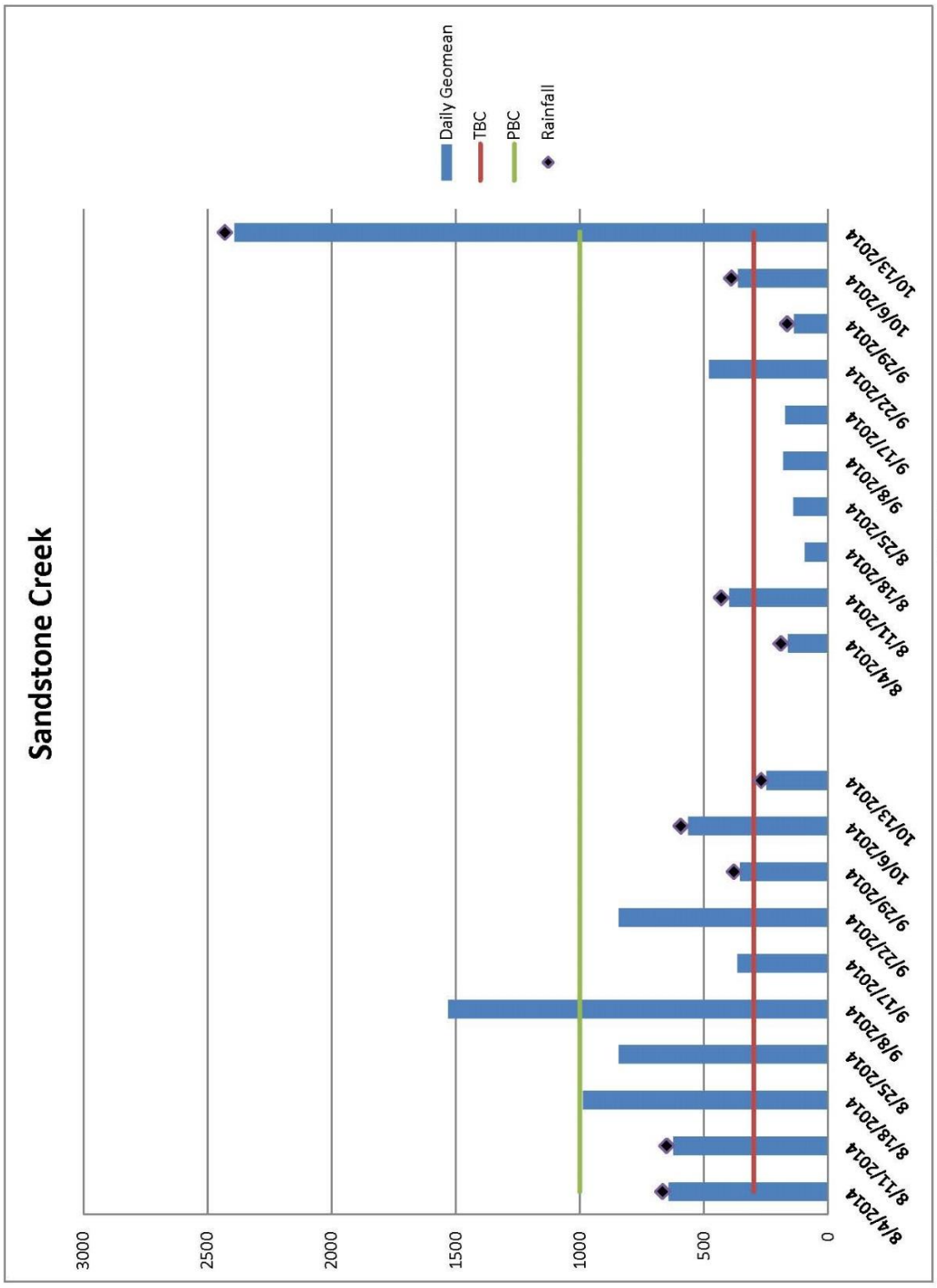
ECD Site 1 was sampled for two weeks in October to complete the 10 week cycle.

ECD Site 1 had a daily geomean ranging from 563 – 256 cfu/100mL. Two wet weather events occurred - one on 10/6/14 resulting in a rainfall of 0.26 inches and a daily geomean of 563 cfu/100mL (the highest *E. coli* concentration for that site), and one on 10/13/14 resulting in a rainfall of 0.11 inches and a daily geomean of 246 cfu/100mL. Samples exceeded TBC 50% of the time and never exceeded PBC.

ECD Site 2 was sampled for three weeks in October due to the significantly high daily geomean on 10/13/14.

ECD Site 2 had never surpassed a daily geomean of 478 cfu/100mL, and on 10/13/14 the daily geomean was 2,390 cfu/100mL. To capture whether or not that upward spike continued a third week of sampling was conducted. The third week of sampling on 10/20/14 resulted in a significant drop in the daily geomean to 74 cfu/100mL compared to 2,390 cfu/100mL the week prior.

ECD Site 2 had a daily geomean ranging from 362-2390 cfu/100mL. Three wet weather events occurred - one on 10/6/14 resulting in a rainfall of 0.26 inches and a daily geomean of 362 cfu/mL, one on 10/13/14 resulting in a rainfall of 0.11 inches and a daily geomean of 2,390 cfu/100mL 100mL (the highest *E. coli* concentration for that site), and one on 10/20/14 resulting in a rainfall of 0.06 inches and a daily geomean of 74 cfu/100mL. Samples exceeded TBC 75% of the time and PBC 25% of the time.



Graph 4: Sandstone Creek Subwatershed 2014 Data Collection Summary

Table 9: Sandstone Creek Subwatershed 2014 Data Collection Summary

Subwatershed: Sandstone Creek							
2014 ECD Data Collection	**TBC Exceedances**	**PBC Exceedances**	**Total Samples**	**TBC Wet Weather Exceedances (samples)**	**PBC Wet Weather Exceedances (samples)**	**Rainfall**	**Highest Daily Geomean During Wet Weather**
Subwatershed	13	2	21	7 out of 11	1 out of 11	0.11 - 0.50 inches	Yes, 2,390 cfu/100 mL
ECD 1	9	1	10	4 out of 5	0 out of 5		No
ECD 2	4	1	11	3 out of 6	1 out of 6		Yes, 2,390 cfu/100 mL

Sandstone Creek Subwatershed– Potential Sources and Causes

Sandstone Creek subwatershed has the highest livestock density (20.77/sq. mi.) of the Watershed (Table 10). Only one resource concern (direct access to surface water) was observed (Table 10). Given the high livestock density it would have been expected to observe a higher number of resource concerns or observations near waterways (3) (Table 10). Of the subwatersheds that were monitored for *E. coli* concentrations in 2014, Sandstone Creek has the highest number of septic areas of HLI (81) (Table 10). Sandstone Creek also has the second highest percentage of conventional tillage (70%) observed (Table 10).

Table 10: Sandstone Creek Subwatershed 2012 Inventory Collection Summary

Subwatershed: Sandstone Creek	
2012 Inventory	**Results**
Horses	180
Beef Cattle	143
Dairy Cattle	0
Other Livestock	6
Livestock Density (#/sq. mi.)	20.77
Livestock Farms Near Waterway (200 ft)	3
Resource Concern Observations (# of sites)	Direct Access-1
Tillage Practices	NT- 25%, RT- 5%, CT- 70%
Sedimentation (tons/ac/yr)	0.059
Cropland Acres	9,068
Septic Areas of HLI	81

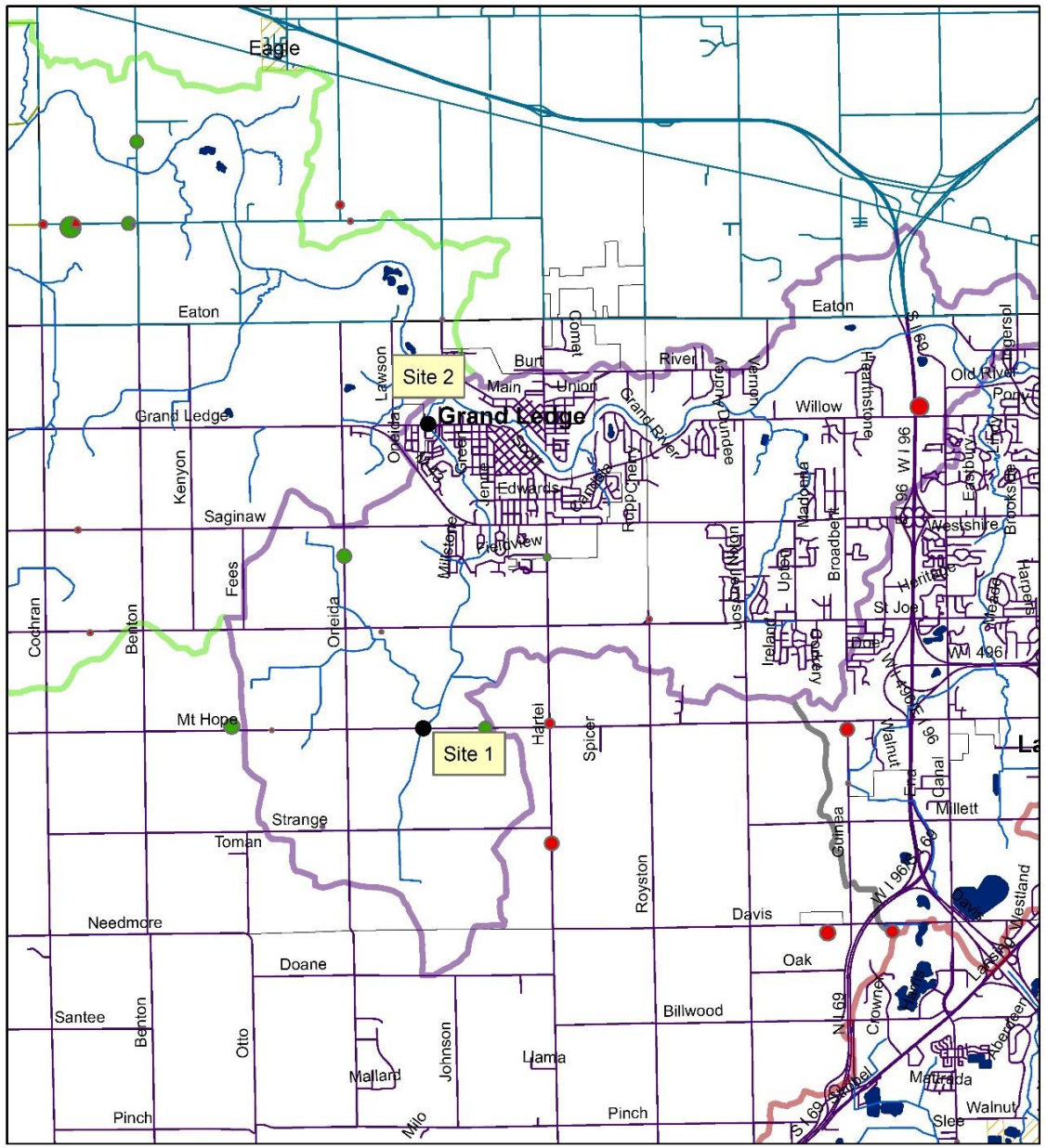
Sandstone Creek Critical Zones Linked to Monitoring

During monitoring, Sandstone Creek subwatershed had the third highest percentage of exceedances for TBC (62%) and PBC (10%). Sandstone Creek subwatershed had the fourth highest ranking for wet weather TBC exceedances.

The critical area in this subwatershed is upstream of Site 1. Additional monitoring during dry and wet weather may explain the odd spike on the 10/31/14 sampling date.

Septic systems may be significant contributor given the high number of septic areas of HLI. Future BST tracking to delineate human, livestock, and other sources is recommended.

Figure 5: Sandstone Creek Subwatershed Livestock Observations



Middle Grand River Watershed

Sandstone Creek Subwatershe

Middle Grand River Subwatersheds

- Carrier Creek
- Columbia Creek
- Cryderman Lake Drain
- Frayer Creek
- Sandstone Creek
- Sebewa Creek
- Silver Creek
- Skinner Extension Drain
- Winchell and Union Drain

Livestock Observations

- Horses
- Beef_cattl
- Dairy_catt
- Other

0 .75 1.5 Miles

Created by: Andrea Stay
Date: January 27, 2014
Data Sources: USDA-NRCS
MI Dept. of Environmental Quality
Eaton Conservation District

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W E
S

Figure 5: Sandstone Creek Subwatershed 2014 Data Collection Results

Winchell and Union Drain Subwatershed

During the months of August, September, and part of October, *E. coli* samples were collected at ECD Sites 6 and 7. Both sites were located on separate tributaries leading into the main stem.

ECD E. coli Monitoring August 2014

ECD Site 6 had a daily geomean ranging from 1,045 – 1,220 cfu/100mL. Two wet weather events occurred - one on 8/4/14 resulting in a rainfall of 0.5 inches and a daily geomean of 1,197 cfu/100mL, and one on 8/11/14 resulting in a rainfall of 0.35 inches and a daily geomean of 1,161 cfu/100mL. The highest daily geomean of 1,220 cfu/100mL occurred during dry weather the fourth week of sampling in August. Samples exceeded TBC and PBC 100% of the time.

ECD Site 7 had a daily geomean ranging from 117 – 362 cfu/100mL. Two wet weather events occurred - one on 8/4/14 resulting in a rainfall of 0.5 inches and a daily geomean of 117 cfu/100mL, and one on 8/11/14 resulting in a rainfall of 0.35 inches and a daily geomean of 226 cfu/100mL. The highest daily geomean of 362 cfu/100mL occurred during dry weather the fourth week of sampling in August. Samples exceeded TBC 25% of the time and never exceeded PBC.

ECD E. coli Monitoring September 2014

ECD Site 6 had a daily geomean ranging from 153 – 511 cfu/100mL. This was a significant decrease from the August daily geomean range. One wet weather event occurred on 9/29/14 resulting in a rainfall of 0.11 inches and a daily geomean of 153 cfu/100mL. The highest daily geomean of 511 cfu/100mL occurred during dry weather third week of sampling in September. Samples exceeded TBC 75% of the time and never exceeded PBC.

ECD Site 7 had a daily geomean ranging from 83 – 539 cfu/100mL. One wet weather event occurred on 9/29/14 resulting in a rainfall of .11 inches and a daily geomean of 539 cfu/100mL (the highest *E. coli* concentration for that site). Samples exceeded TBC 25% of the time and never exceeded PBC. This was the same rate of exceedance for TBC and PBC as recorded in August.

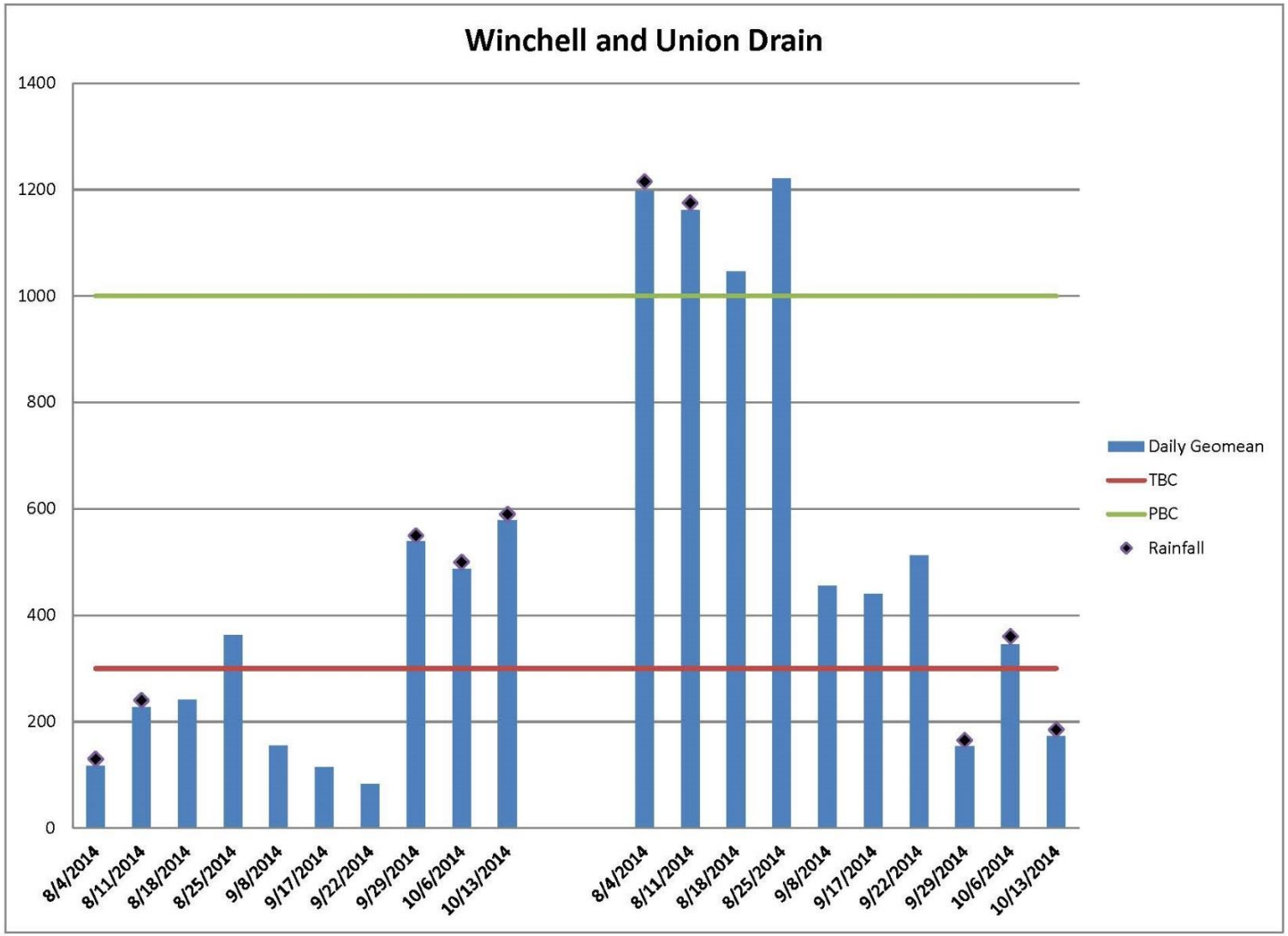
E. coli Monitoring October 2014

ECD Sites 6 and 7 were sampled for two weeks in October to complete the 10 week cycle.

ECD Site 6 had a daily geomean ranging from 173 – 344 cfu/100mL. Two wet weather events occurred - one on 10/6/14 resulting in a rainfall of 0.26 inches and a daily geomean of 344 cfu/100mL, and one on 10/13/14 resulting in a rainfall of 0.11 inches and a daily geomean of 173 cfu/100mL. Samples exceeded TBC 50% of the time and never exceeded PBC.

ECD Site 7 had a daily geomean ranging from 487 – 578 cfu/100mL. Two wet weather events occurred - one on 10/6/14 resulting in a rainfall of 0.26 inches and a daily geomean of 487 cfu/100mL, and one on 10/13/14 resulting in a rainfall of 0.11 inches and a daily geomean of 578 cfu/100mL(the highest *E. coli* concentration for that site). Samples exceeded TBC 100% of the time and never exceeded PBC.

Graph 5: Winchell and Union Drain Subwatershed 2014 Data Collection Results



Winchell and Union Drain Subwatershed Summary

Two sites were monitored in Winchell and Union subwatershed for *E. coli* with a total of 20 samples taken. Of those samples, 12 exceeded TBC (60%) and four exceeded PBC (20%). PBC exceedances ranged from a daily geomean of 1,045 – 1,220 cfu/100mL.

Ten wet weather samples were taken. Two of the samples exceeded PBC and six of the samples exceeded TBC. Rainfall ranged from 0.11 - 0.50 inches. Out of the two sites monitored the highest daily geomean (1,220 cfu/100mL) was recorded during dry weather at ECD Site 6.

Overall, ECD Site 6 exceeded TBC 80% of the time. ECD Site 6 exceeded PBC 40% (highest percentage in the subwatershed) of the time as well. When exceeding PBC, daily geomeans ranged from 1,045 – 1,220 cfu/100mL. Five wet weather events were recorded and three of those samples exceeded the TBC water quality standard. The highest daily geomean (1,220 cfu/100mL) occurred during the fourth week of sampling in August.

Overall, ECD Site 7 exceeded TBC 40% of the time. Three of the TBC exceedances occurred the last three weeks of sampling during wet weather. ECD Site 7 never exceeded PBC for the entire sampling period (lowest percentage in the subwatershed). Five wet weather events were recorded and three of those samples exceeded the TBC, and exceeded PBC twice. The highest daily geomean (578 cfu/100mL) occurred during wet weather the final week of sampling in October. This wet weather event was the lowest amount of rainfall recorded (.11 inches).

Table 11. Winchell and Union Drain 2012 Inventory Collection Summary

2014 ECD Data Collection	TBC Exceedances	PBC Exceedances	Total Samples	TBC Wet Weather Exceedances (samples)	PBC Wet Weather Exceedances (samples)	Rainfall (inches)	Highest Daily Geomean During Wet Weather (cfu/100mL)
Subwatershed	12	4	20	6 out of 10	2 out of 10	0.11 - 0.50	No
ECD 6	8	4	10	3 out of 5	2 out of 5		Yes, 578
ECD 7	4	0	10	3 out of 5	0 out of 5		No

Winchell and Union Drain Subwatershed – Potential Sources and Causes

Winchell and Union Drain subwatershed has the highest percentage of conservation tillage (no till and reduced till) (80) of the Watershed (Table 12). Considering the livestock density (5.605) and the number of livestock observations near a waterway (9), it would have been expected to observe at least one resource concern in Winchell Union Drain subwatershed; however, this was not the case (Table 12). In fact, across the Watershed, Winchell Union Drain was the only subwatershed to have no resource concerns of note (Table 12). Of the subwatersheds that were monitored for *E. coli* concentrations in

2014, Winchell Union Drain subwatershed had the highest sedimentation estimate (0.086 tons/ac/yr) and the third lowest number of septic areas of HLI (22) (Table 12). This subwatershed also ranked as the third lowest in number of septic areas of HLI when comparing the entire Watershed.

Table 12. Winchell and Union Drain Subwatershed 2012 Inventory Collection Summary

Subwatershed: Winchell and Union Drain	
2012 Inventory	**Results**
Horses	50
Beef Cattle	168
Dairy Cattle	150
Other Livestock	2
Livestock Density (#/sq. mi.)	5.605
Livestock Farms Near Waterway (200 ft)	9
Resource Concern Observations (# of sites)	No resource concerns of note
Tillage Practices	NT-50%, RT-30%, CT-20%
Sedimentation (tons/ac/yr)	0.086
Cropland Acres	9,130
Septic Areas of HLI	22

Winchell and Union Drain Subwatershed Critical Zones Linked to Monitoring

During monitoring, Winchell and Union Drain subwatershed had the fourth highest percentage of exceedances for TBC (60%) and third highest for PBC (20%). Winchell and Union Drain subwatershed had the lowest ranking for wet weather TBC exceedances.

The critical area is upstream of Site 6. Several beef cattle and horse farms were identified upstream of this site. Livestock farms and cropland application of manure should be a priority. This critical area is likely affecting sites 11 and 12 downstream as well. BST tracking to delineate human, livestock, and other sources is recommended.

Figure 6: Winchell and Union Drain Subwatershed 2014 Data Collection Results

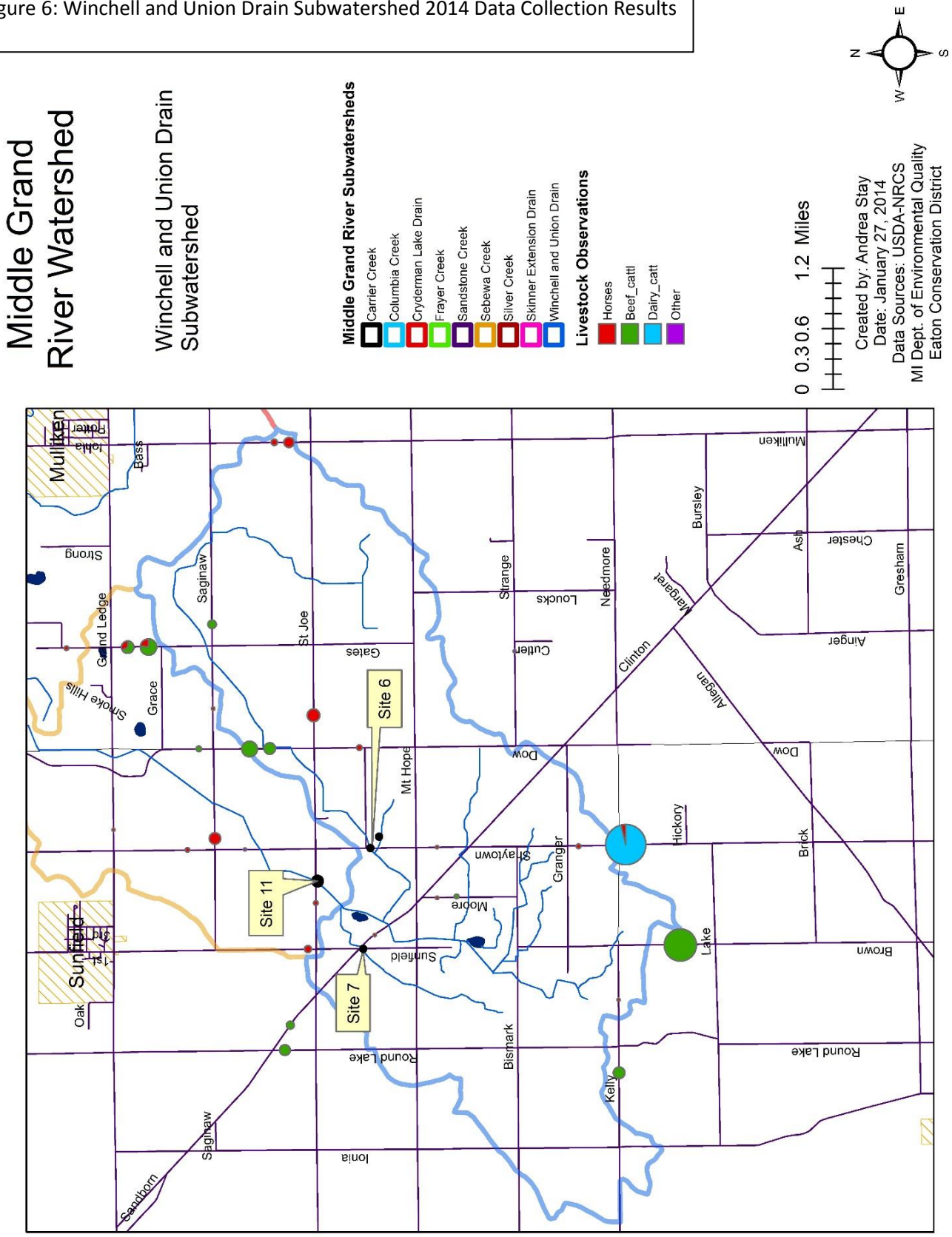


Figure 6 Winchell and Union Drain Subwatershed Livestock Observations

Sustainability

The Eaton Conservation District has applied for FY 2016 319 Nonpoint Source funding to complete an implementation project in the Middle Grand River Watershed. As part of this application, ECD requested to complete an update to the approved Middle Grand River Watershed Management Plan to incorporate these findings from the CMI monitoring grant. Data Results have also been shared with MDEQ for consideration of adding this stream reaches to the upcoming *E. coli* TMDL revision. The data and final report has been shared with the Ionia Conservation District, Barry Eaton Health Department, USDA Natural Resources Conservation Service, and Michigan Agriculture Environmental Assurance Program (MAEAP) Technicians in Eaton and Ionia Counties. The MAEAP Technicians have received the listing of farms with resources concerns and have begun to contact them to offer voluntary and confidential risk assessments. To date, two have begun the assessment process. BMP funding for targeted areas will be sought through Farm Bill programs and watershed restoration grants. Septic system Inspection, repair, and replacement will be promoted in partnership with the Barry Eaton Health Department Time of Sale or Transfer (TOST) Program and environmental staff.

Attachments:

Appendix A - Quality Assurance Project Plan (QAPP) Middle Grand River Watershed Monitoring 2014

Appendix B - Middle Grand River Results Spreadsheet

Appendix C - Canine Source Tracking Project Middle Grand River Watershed 2014