

3. WATER QUALITY IN THE RED CEDAR RIVER WATERSHED – AN OVERVIEW

A number of organizations and agencies have assessed water quality conditions throughout the Red Cedar River Watershed (RCRW) over the past decade. An overview of the pollutants of concern and sampling results are presented in this chapter. Detailed assessments by subwatershed for each of the pollutant categories are included in [Chapter Four](#).

3.1 Designated Uses

Pollutants are assessed by their potential impact on designated uses. Part 4 Rules issued in accordance with Part 31 of the Michigan Natural Resources and Environmental Protection Act (NREPA) (1994 PA 451, as amended) identify eight designated uses for surface waters of the state:

- Agriculture – Surface water must be of the quality that it can be used for livestock watering, irrigation and other agricultural activities.
- Industrial water supply – Surface waters must meet quality standards for use in commercial or industrial applications.
- Public water supply - after conventional treatment methods, surface waters must provide a source of water that is safe for human consumption, food processing, and cooking.
- Navigation – Surface waters must be of the quality sufficient for passage of boat traffic.
- Warmwater fishery – Water bodies designated as warmwater fisheries should be able to sustain populations of fish species such as panfish.
- Habitat for other indigenous aquatic life and wildlife – Surface waters must support fish, other aquatic life and wildlife that use the water for any stage of their life cycle.
- Partial body contact recreation – Residents of the state should be able to use surface waters for activities that involve direct contact with the water but does not involve the immersion of the head, such as fishing and kayaking.
- Total body contact recreation between May 1 and October 31 – The waters of the state should allow for activities that involve complete submersion of the head such as swimming.

Surface waters of the state can be defined as any of the following:

- The Great Lakes and their connecting waters
- All inland lakes
- Rivers
- Streams
- Impoundments
- Open drains
- Wetlands
- Other surface bodies of water within the confines of the state

As noted in the Water Quality and Pollution Control in Michigan 2012 Sections 303(d), 305(b), and 314 Integrated Report, the Michigan Department of Environmental Quality (MDEQ) assessed designated uses of the RCRW (MDEQ, 2012d). It should be noted that not all subwatersheds were assessed for each criteria.

If monitoring efforts demonstrate that water bodies are not meeting designated uses, the MDEQ may place portions of the water body on the state listing of impaired waterways. Once waterways are listed as impaired, the MDEQ is required to develop a Total Maximum Daily Load (TMDL) for the corresponding waterway(s) and its watersheds. A TMDL is the maximum amount of a particular pollutant a water body can assimilate without violating numerical and/or narrative Water Quality Standards (WQS).

Portions of the RCRW fail to meet minimum WQS in order to meet some designated uses. They are considered *impaired* on the State's 303(d) list of impaired waters requiring TMDL establishment. A final TMDL for *Escherichia coli* (*E. coli*) bacteria was developed in 2012. During the development of the *E. coli* TMDL, a stressor analysis was conducted for the TMDL area to determine priority areas in the watershed.

Several small catchments were identified as top priorities as well as top ranked subgroups. A TMDL for dissolved oxygen (DO) has been drafted. Figures 3.1 and 3.2 show the TMDL reaches for *E. coli* and DO, respectively. A statewide TMDL for mercury and polychlorinated biphenyls (PCBs) is scheduled for 2014.

3.2 Pollutants that May Impair or Threaten Designated Uses

Through literature review, site investigations and stakeholder input, a variety of nonpoint source pollutants have been identified that may threaten or impair water quality within the watershed. These are discussed below.

E. coli

E. coli is identified as a primary pollutant of concern in the watershed. *E. coli* is a type of bacteria associated with warm-blooded animal waste, and is used as an indicator of other disease-causing organisms in the water that are more difficult to measure (US EPA, 2008b). The presence of bacteria in quantities greater than the WQS may impair the designated use of partial and total body contact water recreation.

Michigan's WQS (established by Part 4 Rules issued in accordance with Part 31 of NREPA) set limits on the concentration of microorganisms allowed in surface waters of the state and surface water discharges. Waters of the state must meet a limit of 130 *E. coli* per 100 mL of water as a 30-day geometric mean of five sampling events (3 samples per event) and 300 *E. coli* per 100 mL of water for any single sampling event during the May 1 through October 31 period in order to meet the Total Body Contact (TBC) recreation standard. The limit for the Partial Body Contact (PBC) recreation standard is a geometric mean of 1000 *E. coli* per 100 mL water for any single sampling event at any time of the year.

Each of these TMDL reaches identified by MDEQ is identified by a unique Assessment Unit Identification (AUID) number, listed in Table 3.1. A map of these TMDL reaches is shown in Figure 3.1. Please note that not all subwatersheds were assessed by MDEQ as part of the TMDL development process. One objective of this planning project was to conduct additional monitoring in areas not previously assessed.

Table 3.1 Red Cedar River Watershed *E. coli* TMDL AUIDs

Description	AUID	Size (miles)
Handy Howell Drain-Red Cedar River	040500040401-02	21
Middle Branch Red Cedar River	040500040402-01	11
Handy Drain No 5-Red Cedar River	040500040403-02	15
West Branch Red Cedar River	040500040405-01	21
Kalamink Creek	040500040406-01	21
Wolf Creek-Red Cedar River	040500040407-01	17
Wolf Creek-Red Cedar River	040500040407-02	8
Dietz Creek	040500040409-01	19
Doan Creek and Doan Deer Creek	040500040410-01	23
Red Cedar River and Sullivan Creek	040500040411-01	17
Red Cedar River	040500040411-02	5
Squaw Creek	040500040411-03	8
Sloan Creek	040500040502-02	13
Coon Creek and Red Cedar River	040500040503-03	26
Sycamore Creek	040500040506-01	25
Willow Creek	040500040506-03	11
Cook and Thorburn Drain	040500040506-04	6
Banta Drain and Sycamore Creek	040500040507-01	29
Red Cedar River	040500040508-02	2
Red Cedar River	040500040508-03	18

*Based on data in the 2014 Draft MDEQ Integrated Report

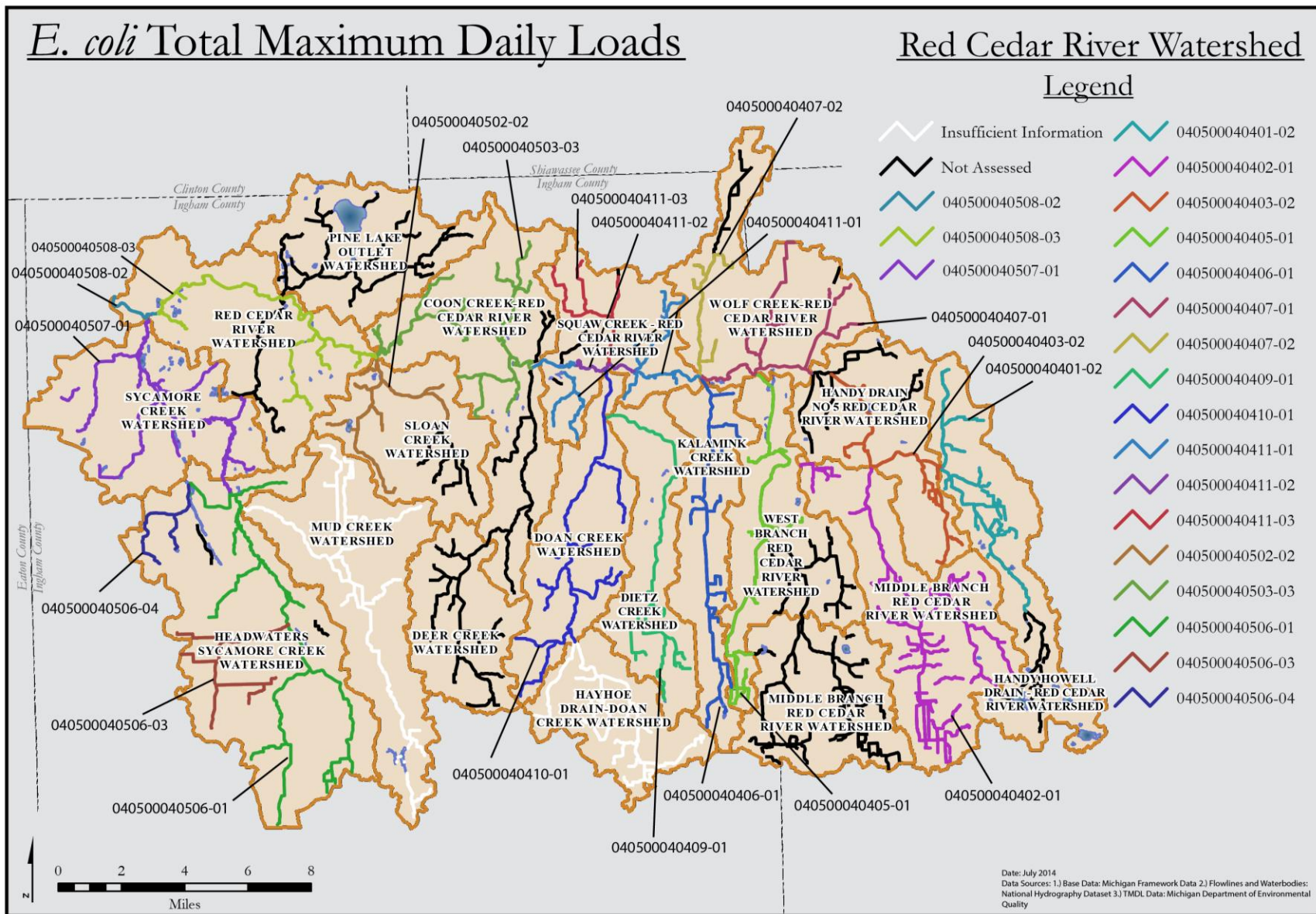


Figure 3.1 Red Cedar River Watershed *E. coli* TMDL

Sediment and Dissolved Oxygen

Excessive sediment in a stream can degrade fish and macroinvertebrate habitat by lowering DO levels as well as burying potential habitat for fish and aquatic macroinvertebrates. In addition, sediment can carry other pollutants to the watershed such as nutrients and *E. coli* bacteria. Although Michigan's WQS do not include numerical limits for total suspended solids, they do require that waters not have any of these physical properties: unnatural turbidity, unnatural color, oil films, floating solids, foam, settleable solids, suspended solids, and deposits (Rule 323.1050). They also state that in no instance shall total dissolved solids in the waters of the state exceed a concentration of 500 milligrams per liter as a monthly average nor more than 750 milligrams per liter at any time, as a result of controllable point sources (Rule 323.1051). Those numbers were used as reference values when assessing the subwatershed data.

Portions of the RCRW are considered impaired due to DO levels and sedimentation/siltation affecting the warmwater fishery and other aquatic life use designation (AUIDs 040500040505-01, 40500040508-02). Michigan WQS specify that a minimum of 5 mg/l of DO be maintained for certain waters of the state. That level was used as a reference value when evaluating the data available for the Red Cedar River. The MDEQ's draft TMDL for DO and sediment is under review. A map of the DO TMDL based on the 2014 draft report is shown in Figure 3.2.

Dissolved Oxygen Total Maximum Daily Loads

Red Cedar River Watershed

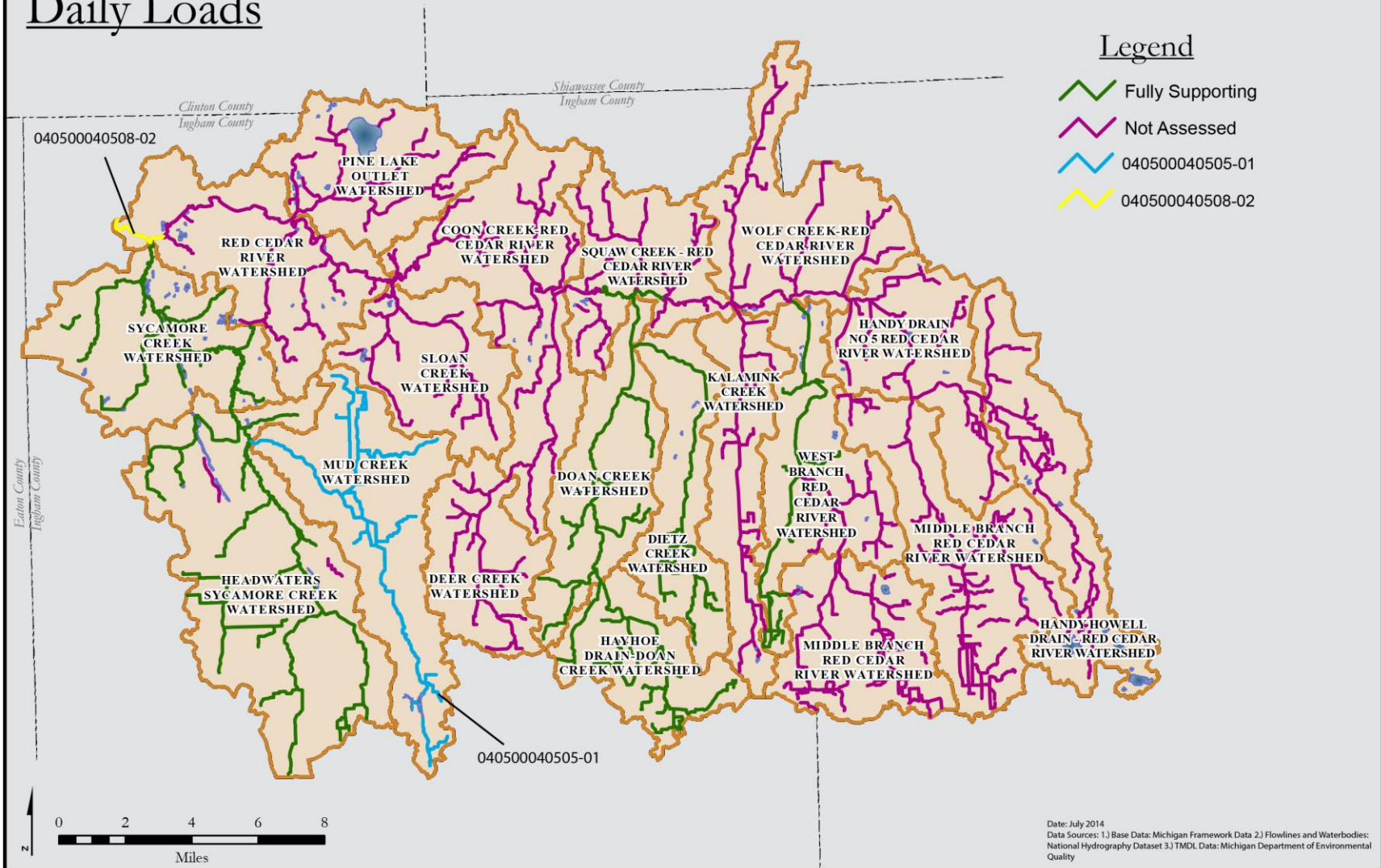


Figure 3.2 Red Cedar River Dissolved Oxygen TMDL

Mercury and PCBs

Most of the RCRW is considered impaired due to mercury and PCBs in the water column and/or fish tissue, which affects fish consumption. The MDEQ is scheduled to develop a statewide TMDL in 2014. Due to this forthcoming TMDL, mercury and PCBs are considered to be causing an impairment to this watershed. However, these pollutants are not addressed in this plan.

Nutrients

Excess nutrients can have a negative impact on water quality. Although nutrient data have not been collected as part of this planning process, nutrient data were collected by stakeholders in previous studies and are summarized in this plan. Nutrient data were collected in 2001 by the Livingston County Health Department (LCHD) and the MDEQ in 2011 for some, but not all, subwatersheds. These data are discussed in [Chapter Four](#).

When available, Michigan Part 4 WQS Rules were used to understand where nutrient concentrations were excessive throughout the watershed. If a WQS does not exist, sampling results were compared to those collected across EPA Ecoregion VII, or the Southern Michigan/Northern Indiana Drift Plains Ecoregion (SMNIDP). The total Kjeldahl nitrogen comparison concentration used was 0.3 mg/L, which is the 25th percentile EPA Ecoregion VII concentration calculated for the decade (US EPA, 2000). The ammonia as nitrogen comparison concentration used was 0.042 mg N/L, which is the SMNIDP Ecoregion mean concentration (Lungdren, 1994 as cited in MDEQ, 2013a). The total phosphorous comparison concentration used was the median value, 0.32mg/L, reported for the state from 250 sites between 2005 and 2009. Total organic carbon (TOC) concentrations were compared against the SMNIDP Ecoregion median concentration of <10 mg/L, calculated from 2000-2008 (Roush, 2013 as cited in MDEQ, 2013a). Nutrient concentrations are reported in the [Chapter Four](#) only when exceedances were measured above the WQS or comparison concentrations.

Table 3.2 summarizes the target values used to assess pollutants of concern within the watershed.

Table 3.2. Target Values Used to Assess Pollutants of Concern

Parameter	Target Value	Units	Standard or Comparable	Type	Source
<i>E. coli</i>	130	cfu/100 mL	S	Total Body Contact Recreation in all waters of the state. Calculated as a 30-day geometric mean from 5 or more sampling events.	Michigan Department of Environmental Quality Water Bureau Water Resources Protection. (2006, January 13). Part 4 Water Quality Standards
<i>E. coli</i>	300	cfu/100 mL	S	Total Body Contact in all waters of the state	Michigan Department of Environmental Quality Water Bureau Water Resources Protection. (2006, January 13). Part 4 Water Quality Standards
<i>E. coli</i>	1,000	cfu/100 mL	S	Partial Body Contact in all waters of the state	Michigan Department of Environmental Quality Water Bureau Water Resources Protection. (2006, January 13). Part 4 Water Quality Standards
Dissolved Oxygen	7	mg/L	S	Waters connected to Great Lakes. Coldwater fishery.	Michigan Department of Environmental Quality Water Bureau Water Resources Protection. (2006, January 13). Part 4 Water Quality Standards.
	5	mg/L	S	All other waters. Warmwater fishery 5 mg/l as a daily minimum.	Michigan Department of Environmental Quality Water Bureau Water Resources Protection. (2006, January 13). Part 4 Water Quality Standards.
Ammonia	0.042	mg/L	C	Mean concentration calculated from SMNIDP ecoregion sites	Lundgren, R. 1994. Reference Site Monitoring Report 1992-1993. Michigan Department of Natural Resources, Surface Water Quality Division, Lansing, Michigan. Report No. MI/DNR/SWQ-94-048.
Total Phosphorus	0.032	mg/L	C	Median value calculated using probabilistic data from 250 sites in State from 2005-2009	Roush, D. 2013. Michigan's Water Chemistry Monitoring Program: A Report of Statewide Spatial Patterns 2005-2009 and Fixed Station Status and Trends 1998-2008. MDEQ Staff Report No. MI/DEQ/WRD-13/005
	0.058	mg/L	C	75th percentile calculated using probabilistic data from 250 sites in State from 2005-2009	Roush, D. 2013. Michigan's Water Chemistry Monitoring Program: A Report of Statewide Spatial Patterns 2005-2009 and Fixed Station Status and Trends 1998-2008. MDEQ Staff Report No. MI/DEQ/WRD-13/005
Total Dissolved Solids	500	mg/L monthly avg	S	Point Source	Michigan Department of Environmental Quality Water Bureau Water Resources Protection. (2006, January 13). Part 4 Water Quality Standards.
	750	mg/L at any time	S	Point Source	Michigan Department of Environmental Quality Water Bureau Water Resources Protection. (2006, January 13). Part 4 Water Quality Standards.
Total Suspended Solids	80	mg/L	C	Informal target	
Total Organic Carbon	<10	mg/L	C	SMNIDP ecoregion median from 2000-2008	Roush, D. 2013. Michigan's Water Chemistry Monitoring Program: A Report of Statewide Spatial Patterns 2005-2009 and Fixed Station Status and Trends 1998-2008. MDEQ Staff Report No. MI/DEQ/WRD-13/005
Total Kjeldahl Nitrogen	0.24	mg/L	C	Ambient WQ criteria recommendations; 25th percentile of region stream population	United State Environmental Protection Agency Office of Water Office of Science and Technology Health and Ecological Criteria Division. (2000, December). Ambient Water Quality Criteria Recommendations: Information Supporting the Development of State and Tribal Nutrient Criteria: Rivers and Streams in Nutrient Ecoregion VII. EPA 822-B-00-018). Washington D.C.

Reviewing the data available, in this watershed, ammonia as nitrogen, total dissolved solids (TDS), total Kjeldahl nitrogen, total phosphorus, and TOC were nutrients that were found above the reference values. Chemical oxygen demand (COD) was reported as high by MDEQ (2013a). These data are further discussed in [Chapter Four](#).

3.3 Data Collection and Analysis

E. coli Monitoring

E. coli sampling has been conducted in the watershed by a number of partner organizations. The MDEQ collected samples for 16 weeks in 2009 from May to August as part of the *E. coli* TMDL development. The Ingham County Health Department (ICHHD) has collected *E. coli* data at sites along the main river channel throughout the recreational season since 2004. The Ingham Conservation District (ICD) conducted both *E. coli* and DO sampling in the watershed in summer 2013. A number of older, previous studies have been conducted in the watershed. For example, the Livingston County and Ingham County Drain Commissioner offices collected *E. coli* samples in 2000 and 2001 at 38 sampling locations. Individual jurisdictions occasionally also collect data in the watershed.

One objective of this watershed planning project was to address gaps in the data by sampling locations that had not previously been assessed. *E. coli* sampling was conducted by Michigan State University (MSU) as part of this watershed planning project for four weeks in 2012 to address some of these data gaps, and one sampling event was conducted in 2013, specifically for the purpose of microbial source tracking. The approved quality assurance project plan (QAPP) for this project is within Appendix B.

A map of sampling locations and site IDs for data collected in 2009-2013 by the various organizations listed above is shown in Figure 3.3.

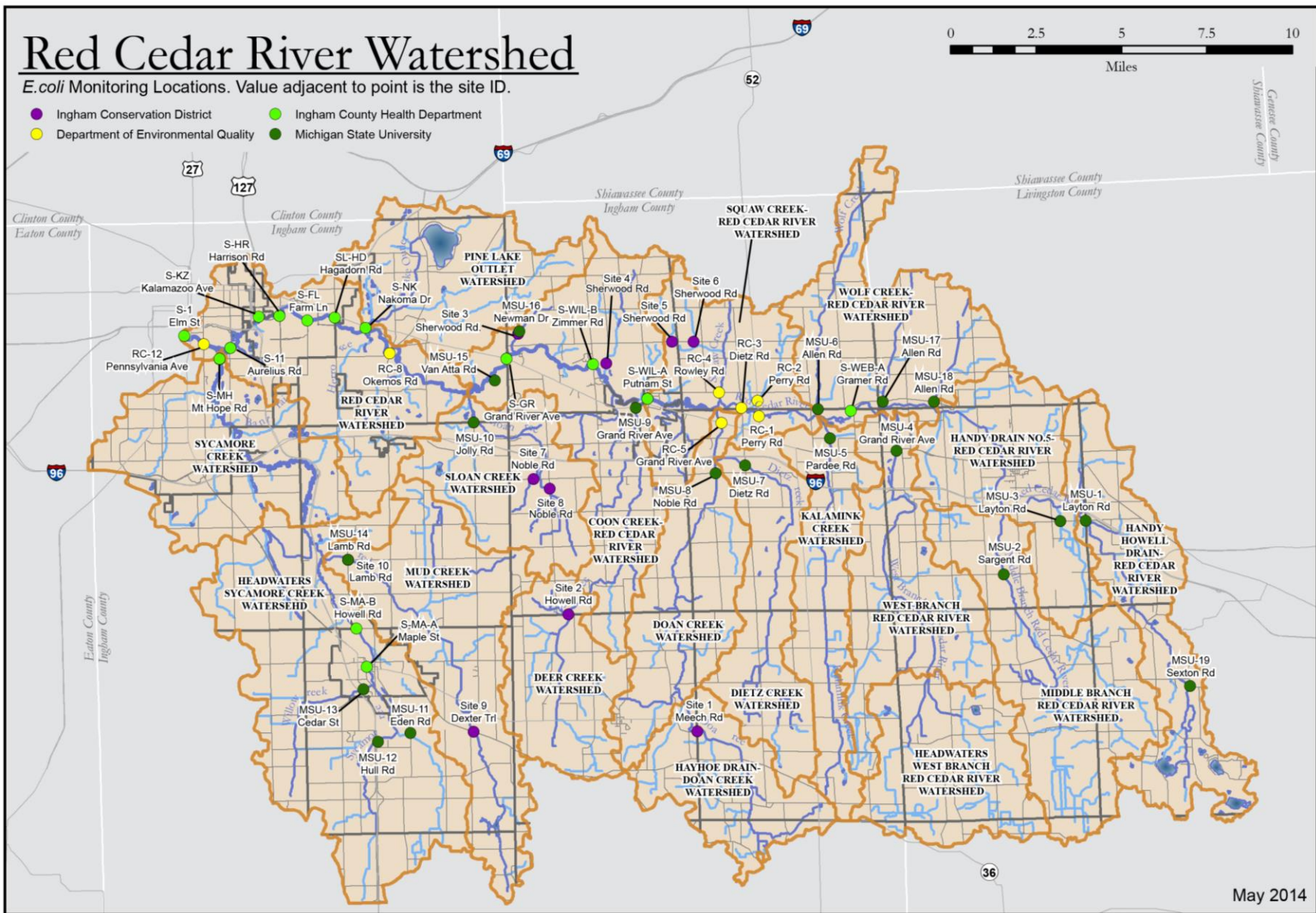


Figure 3.3 *E. coli* Monitoring Locations. Note: MSU-14 is also Site 10 Mud Creek @ Hagadorn/Lamb Rd for the ICD.

Results from these sampling activities are briefly summarized below. Full sampling results are included in table format in Appendix C.

E. coli samples are typically collected weekly over multiple weeks in a summer sampling season. *E. coli* is measured by bacterial colony forming units (cfu) present in 100 milliliters of water. Sampling results in the RCRW frequently exceed both the WQS for TBC of 300 cfu/100 mL and for PBC of 1,000 cfu/100 mL. To account for variability within the stream channel, a geometric mean of samples taken from the left, right and center of the river channel is calculated and compared to the WQS for *E. coli*.

Results are often not consistent across the weeks of sampling, as they are affected by various parameters such as temperature, rainfall, and flow. *E. coli* levels vary both spatially and temporally, as bacteria go through growth and die-off phases, and the presence of *E. coli* can be directly related to runoff or may be attributed to dry weather conditions. Caution must be used when comparing *E. coli* results across different sampling events due to this variability.

Precipitation and flow conditions were contrasting in the years that *E. coli* data were collected by MSU (2012 and 2013). In 2012, the MSU Enviro-Weather East Lansing “MSUHort” station reports that 23.71 inches of rain fell in 526 hours, demonstrating that 2012 was much drier than 2013 which had 36.77 inches of rain in 536 hours (MSU, 2014). To further illustrate the flow differences, water depths collected as part of the MSU sampling activities in 2012 and 2013 are shown in Table 3.3 below.

Table 3.3 Stream Depth

Site ID	Avg. depth measured 08-09/2012 (cm)	Depth Measured 7/1/2013 (cm)
MSU-1	21.5	76.2
MSU-6	14.1	99.06
MSU-7	15.8	32
MSU-8	8.9	20
MSU-10	17.4	29
MSU-11	28.6	57
MSU-12	9.3	32
MSU-13	23.3	32

Data analysis is further complicated because each organization used a different strategy for selecting sampling locations. Although caution must be used when assessing the monitoring results due to this variability, the data can be used to better understand impairments and assess changes over time.

E. Coli Sampling – General Observations Across the Watershed

Water samples were taken in 2012 and 2013 by the ICHD and the ICD and measured for *E. coli*. Four weeks of data from 8/29-9/20, 2012, and one week of data from 7/1/13 were also collected MSU. For all sites, samples were taken at three locations across a stream, and *E. coli* results were averaged by taking the geomean for each site. The ICHD sampling took place in 2012 and 2013 for 20 and 22 consecutive weeks from 5/7 - 9/24 and 5/6 - 9/30, respectively, along the main branch of the Red Cedar River. Rainfall data were determined for each corresponding collection date.

The ICD data was collected for 10 consecutive weeks from 6/11 - 8/13 in 2013. Samples were taken at three locations across a stream site from tributaries to the Red Cedar, and were averaged by taking the geomean for each site. *E. coli* counts above 10,000 cfu were recorded at 10,000 as the lab methodology used for this analysis had a maximum sensitivity of 10,000 cfu. Rainfall data were determined for each corresponding collection date.

Ingham County Health Department - Main Branch of Red Cedar River

For 2013, along the main stem of the Red Cedar, which was considered a wet year, sampling was conducted by the ICHD from May 6 - September 30. Except for Site S-MA-B (Howell Rd. in Mason) in the headwaters of the Sycamore Creek for two sampling dates and Site S-MH (Mount Hope Ave in Lansing) for one sampling date, geomeans for *E. coli* were always below the PBC standard when rainfall was less than 0.1" up to 48 hours prior to sampling. For TBC standards, results were much more variable, making it difficult to correlate *E. coli* concentrations with rainfall.

Geomeans for *E. coli* when rainfall was above 0.1" up to 48 hours prior to sampling varied substantially, and there was no apparent correlation between high rainfall and high geomeans across sites or within sites. Thus, at the highest rainfall occurrence at 1.82" on May 28, four of the twelve sites had geomeans above the PBC standard with the rest below the TBC standard. Conversely, at a lesser rainfall of .86" on June 11, all but one site had *E. coli* geomeans above the PBC standard. Refer to Figure 3.4.

Red Cedar ICHD Data 2013 – Geomean vs. Date

Geomean

(cfu *E. coli*/100ml)

■ S-1 ■ S-11 ■ S-KZ ■ S-HR ■ S-FL ■ S-HD ■ S-NK ■ S-GR ■ S-WEB-A ■ S-MA-A ■ S-MA-B ■ S-MH

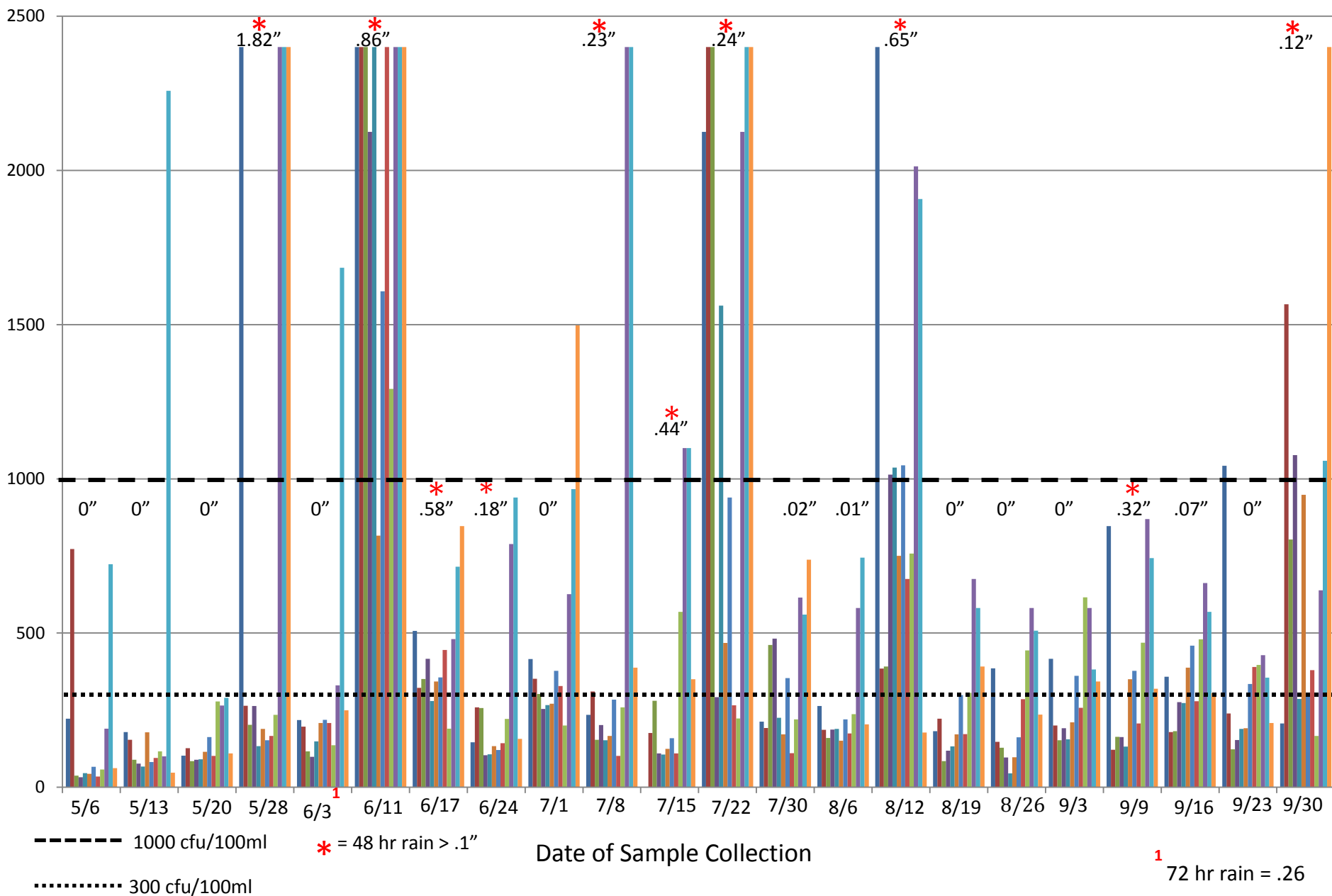
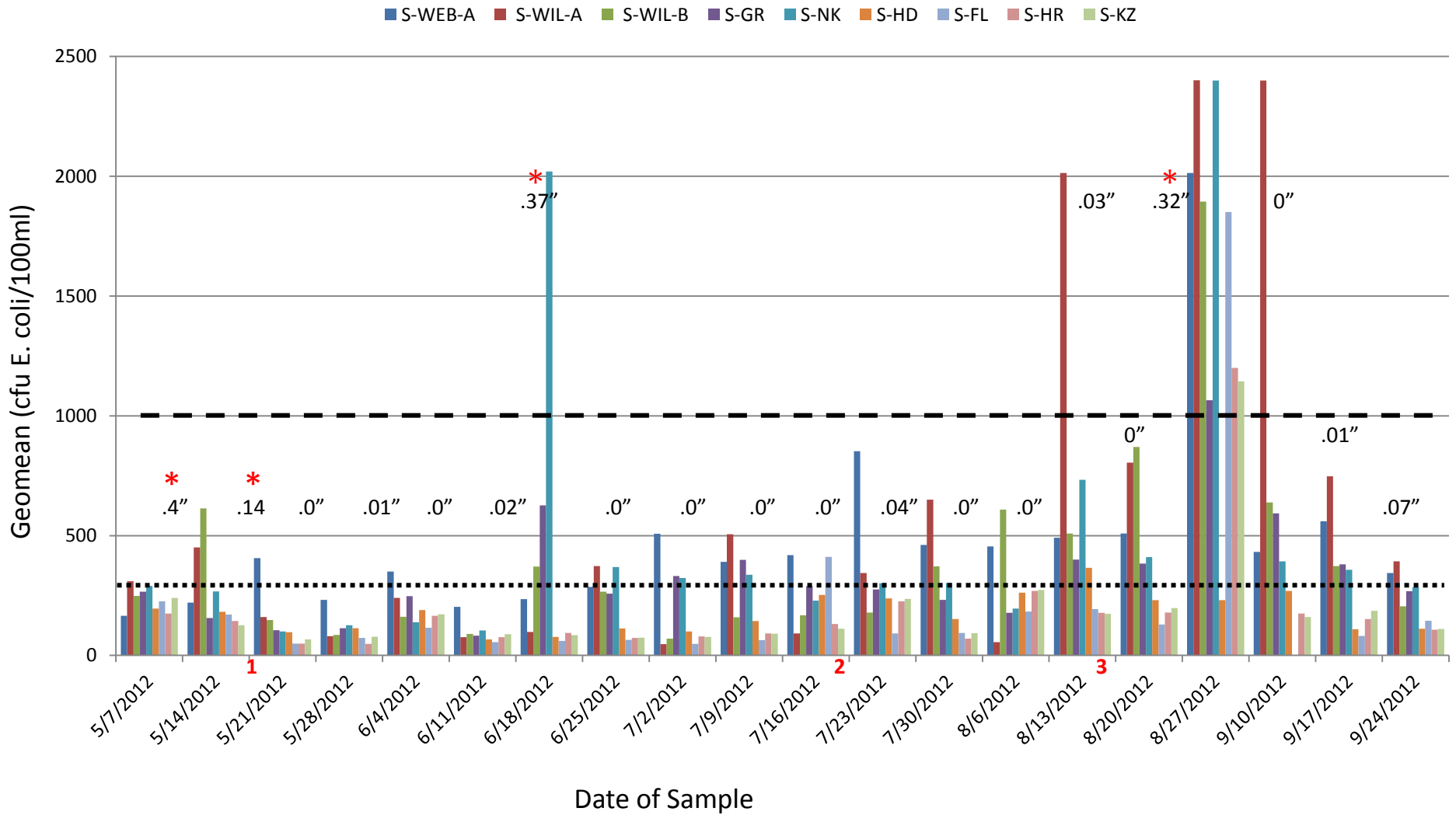


Figure 3.4: ICHD 2013 *E. coli* Geomean vs. Date

Sampling was also conducted in 2012 by the ICHD, which was considered a very dry year, from May 7 - September 24 along the main stem of the Red Cedar. Except for Site S-WIL-A (Putnam St. in Williamston) for two sampling dates, geomeans for *E. coli* were always below the PBC standard when rainfall was less than 0.1" up to 48 hours prior to sampling. For TBC standards, results were much more variable, making it difficult to correlate *E. coli* concentrations with rainfall. Under low rainfall conditions, *E. coli* concentrations on the main branch of the Red Cedar River tend to be low and usually below PBC standards. However, when rain conditions exceed 0.1", *E. coli* concentrations are much more variable and difficult to predict. See Figure 3.5.

Red Cedar ICHD Data 2012 – Geomean vs. Date



----- 1000 cfu/100ml

* = 48 hr rain > .1"

..... 300 cfu/100ml

- 1 72 hr rain = .46
- 2 72 hr rain = .2
- 3 72 hr rain = .41

Figure 3.5 ICHD 2012 *E. coli* Geomean vs. Date

MSU Red Cedar Tributaries Sampling

For 2012, data were collected for four weeks from August 29 – September 24. *E. coli* geomeans were often above the PBC level and sometimes above the TBC even under low (<0.1") to no rainfall. Refer to Figure 3.6. Geomeans for *E. coli* when rainfall was above 0.1" up to 48 hours prior to sampling varied substantially, and there was no apparent correlation between high rainfall and high geomeans across sites.

For the four-week sampling period, the Wolf Creek subwatershed showed *E. coli* concentrations substantially above PBC standards. In all sampling weeks, Wolf Creek had higher *E. coli* counts than any of the other sampling sites. The concentrated animal feeding operation (CAFO) located in this subwatershed may be a contributing factor. The land use in this watershed is discussed in [Chapter Four](#).

MSU Data 2012 – Geomean vs. Date

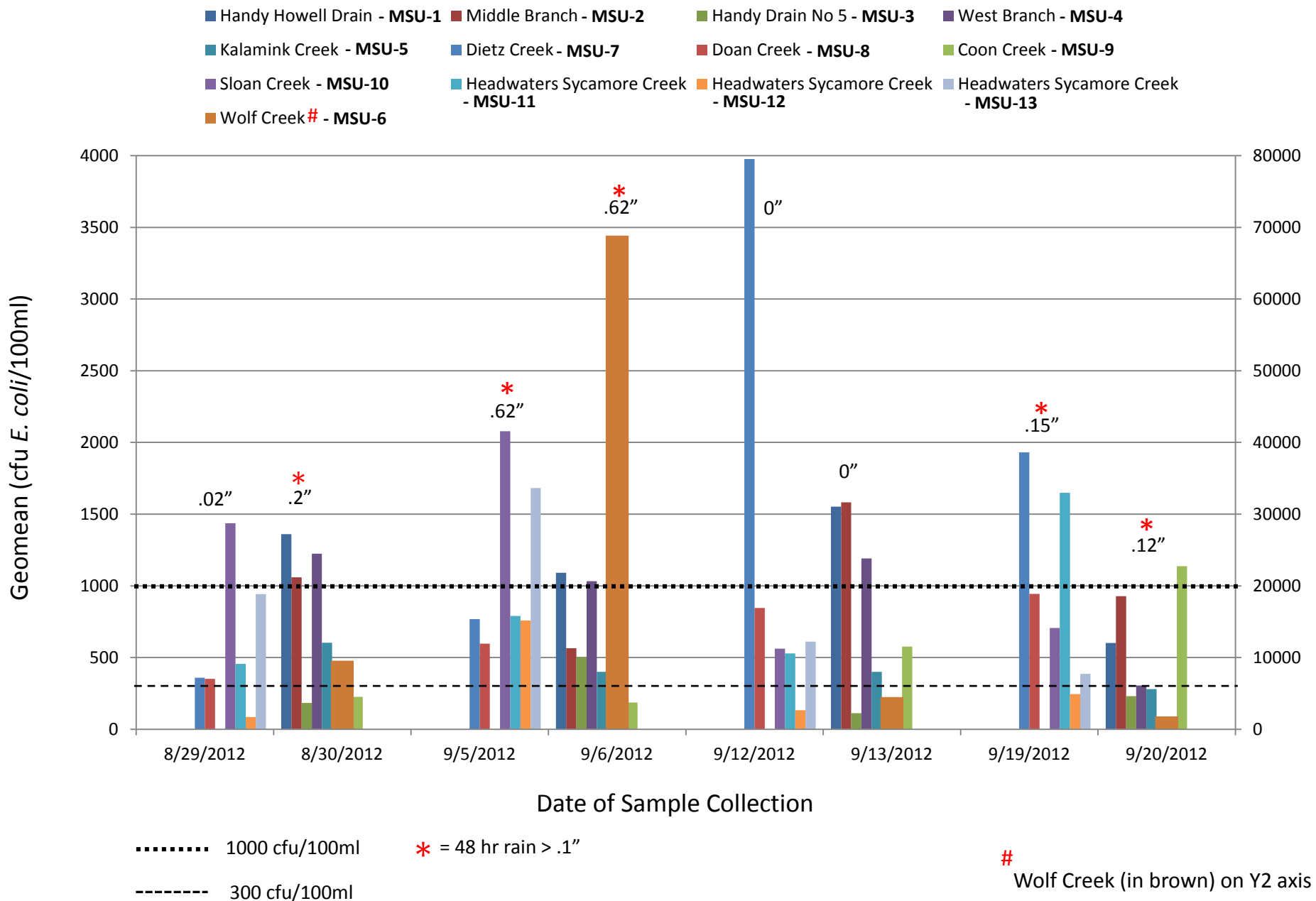


Figure 3.6 MSU 2012 *E. coli* Geomean vs. Date

Ingham Conservation District Tributaries Sampling

For 2013, a wet year, data were collected at 10 sites over 10 weeks from June 11 – August 13. *E. coli* geomeans were often above both the PBC and TBC levels even under low (<0.1”) to trace amounts of rainfall. Geomeans for *E. coli* when rainfall was above 0.1” up to 48 hours prior to sampling were above both the PBC and TBC standards the majority of the time at all sites. Figure 3.7 highlights these results.

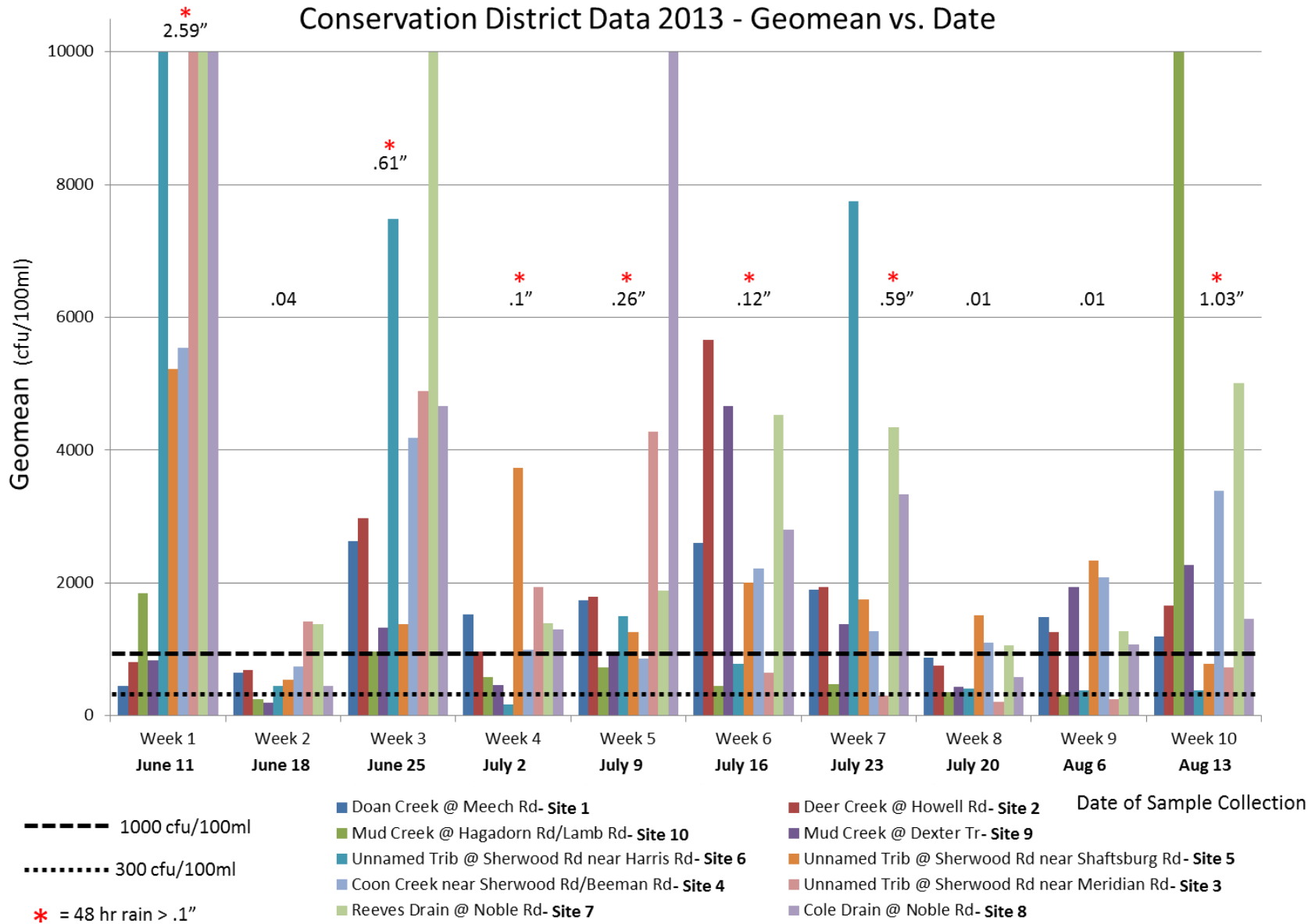


Figure 3.7 Conservation District 2013 *E. coli* Geomean vs. Date

E. coli General Observations Summary

In the RCRW, there is a tendency for *E. coli* concentrations to spike following rain events above 0.1" in both the main branch and in the subwatersheds. This is not always the case, however. In some instances, *E. coli* concentrations remain below the TBC and/or PBC after a rain event above 0.1". Additionally, *E. coli* concentrations are sometimes above both TBC and PBC standards during periods with no rainfall. While this is not predominant, the trend tends to be seen more often in the subwatersheds than in the main branch, possibly due to lower discharge levels associated with smaller watersheds.

E. coli Sampling Results 2012-2013 Analyzed by Subwatershed

Results from the 2012 and 2013 sampling seasons were also analyzed to prioritize at the subwatershed level. Table 3.4 represents the average percent of geomeans over the TBC and PBC standards for all samples that were taken from the main branch of the Red Cedar River. The subwatershed associated with the sample is provided. On average, *E. coli* geomeans in the Sycamore subwatershed are higher than those in other subwatersheds. PBC standards were exceeded in 27% of the sampling events for Sycamore Creek subwatershed. Only one site in this subwatershed, site S-MH, exceeded TBC standards in less than 50% of the sampling events. On average, the other sites in Sycamore Creek exceeded TBC standards in 90% of the sampling events. The only other site with average TBC exceeding standards more than 50% of the time occurred in the Wolf Creek subwatershed.

Table 3.4. Averaged data from the Main Branch of the Red Cedar River

Associated Subwatershed	Number of Sampling Event Geomeans	Total Number of Sample Geomeans	Average % TBC in Main Branch	Average % PBC in Main Branch	Average Geomean
Coon	4	82	43	5	258
Sycamore	6	126	77	27	627
Wolf	2	42	55	5	342
Red Cedar	14	292	26	9	225

For samples taken directly from the subwatersheds, the average %TBC standard was exceeded in 100% of the sampling event geomeans for Deer, Dietz, Doan, Middle Branch, Sloan, West Branch and Wolf subwatersheds (Table 3.5). Squaw Creek and Mud Creek had average %TBC exceedences of 95% and 90%, respectively. All subwatersheds except Handy Howell Drain exceeded the TBC standard in 75% of the sampling event geomeans. Wolf had the highest average geomean at 8,539 cfu/100ml followed by Sloan at 2,051 cfu/100ml. It should be noted that Wolf Creek had one geomean of over 68,000 while the other geomeans were 9,560, 4,483, and 1,802 for the four weeks that samples were collected in 2012. In 2013, average geomeans for one date (July 1) at three different sites in the Wolf Creek subwatershed were 441,782, and 1,160 cfu/100ml. However, stagnant water was observed at these locations.

Subwatersheds that exceeded the PBC standard 75% of the sampling event geomeans or more included Wolf Creek (100%) and Sloan Creek (83%), and West Branch (75%).

Table 3.5. Averaged data within subwatersheds of the Red Cedar River

Subwatershed	Number of Sampling Event Geomeans	Total Number of Sample Geomeans	Average % TBC Exceedences	Average % PBC Exceedences	Average Geomean
Coon	3	24	87.5	62.5	1,116
Deer Creek	1	10	100	60	1,474
Dietz Creek	1	10	100	50	1,206
Doan Creek	2	14	100	50	977
Handy Howell Drain	2	8	62.5	37.5	653
Kalamink Creek	1	4	75	0	406
Middle Branch	1	4	100	50	968
Mud Creek	2	20	90	40	873
Sloan	3	24	100	83	2,051
Squaw Creek	2	20	95	65	1,395
Sycamore	3	12	75	17	582
West Branch	1	4	100	75	823
Wolf	1	4	100	100	8,539

Microbial Source Tracking

One sampling event was conducted in the summer of 2013 by MSU at 14 locations. *E. coli* concentrations were measured at the State of Michigan Water Quality Laboratory. In addition, samples were sent to a private laboratory for microbial source tracking to test for the presence of bovine and equine sources of fecal waste. Samples were also collected for canine scent tracking, which was used to indicate potential human sources of fecal waste. Source tracking showed the presence of both equine and bovine DNA in a majority of the subwatersheds analyzed. Furthermore, the canine scent analysis was positive at eight sampling locations. Figure 3.8 depicts the results for the 2013 *E.coli* and microbial source tracking sampling event.

Based on the 2012 and 2013 monitoring data, the subwatersheds most frequently exceeding the WQS for *E. coli* are: Headwaters Sycamore Creek, Doan Creek, Squaw Creek, Sycamore Creek, Handy-Howell, Sloan Creek, Middle Branch, Dietz Creek, and Coon Creek. In addition, the Wolf Creek subwatershed had the highest geomean recorded.

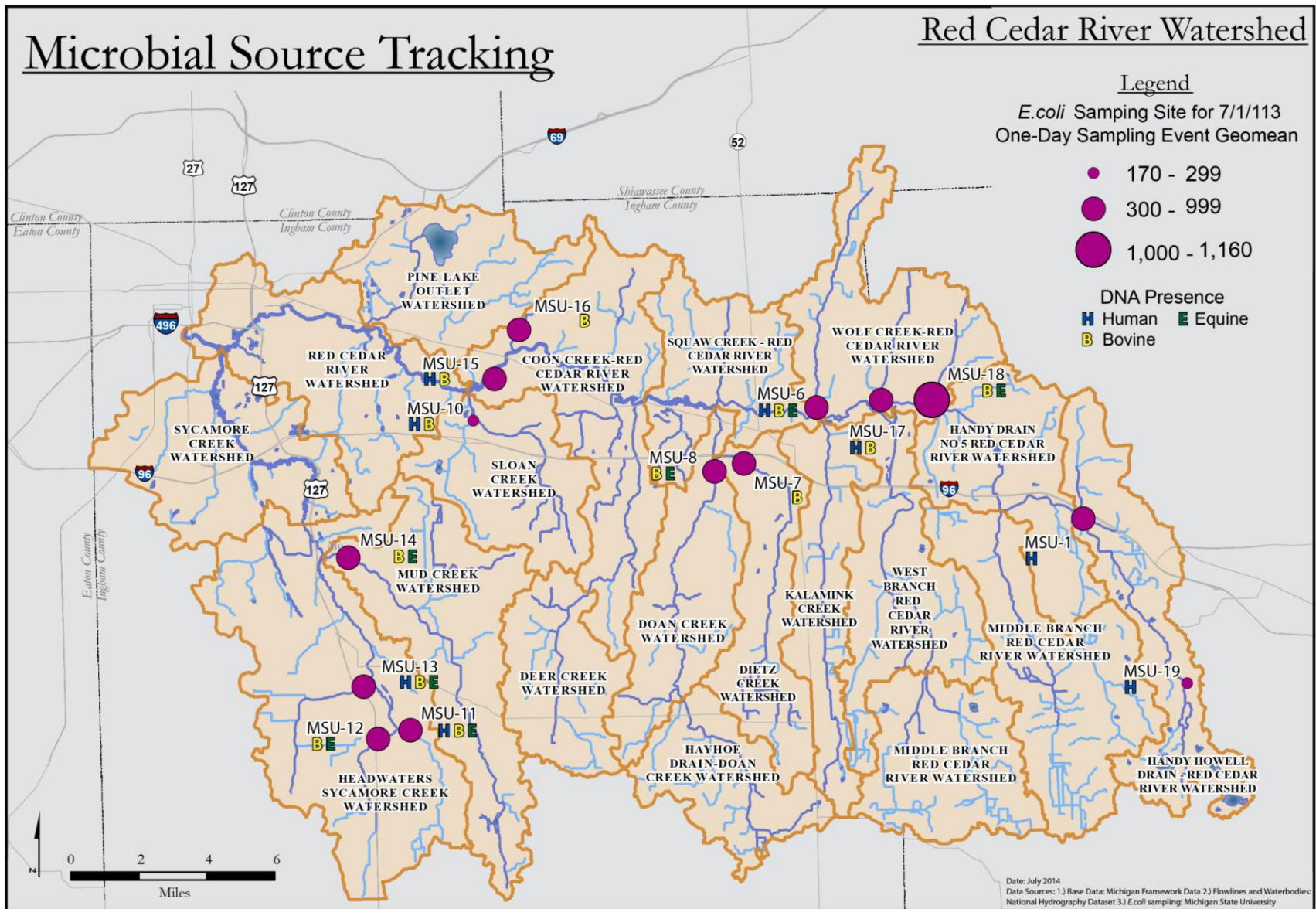


Figure 3.8 Microbial Source Tracking

Sediment Modeling

Modeling was completed for the RCRW using the High-Impact Targeting (HIT) model (MSU IWR, 2009). The HIT model combines two GIS-based models to prioritize areas at risk for sediment loading: the Revised Universal Soil Loss Equation (RUSLE) to estimate soil erosion and the Spatially Explicit Delivery Model (SEDMOD) to estimate the delivery of eroded soil to the stream network. Model inputs include the following: digital elevation model, soil survey (1:100K), rainfall, landuse (with tillage information incorporated if available).

Using the HIT model, sedimentation loading in tons per acre per year by subwatershed was estimated following methods developed by the MSU Institute of Water Research (Ouyang, Bartholic, & Selegan, 2005). A map of the modeling results is shown in Figure 3.9. The HIT model only accounts for sheet erosion and associated sediment loading that originates from agricultural lands (O'Neil, 2010). Therefore, HIT is likely underestimating sediment loading from agricultural fields and is not suitable for urban analysis.

The Ingham and Livingston County Drain Commissioners completed a streambank erosion inventory in 2000; results of those studies were reviewed and conversations with personnel from their offices were used to determine if any of these erosion sites remain. Signs of erosion and sedimentation were also identified through this watershed planning project by conducting a windshield survey (see Appendix D for the methodology). In addition, an erosion assessment was completed on the MSU campus in 2006 (Hamilton Anderson Associates, 2007).

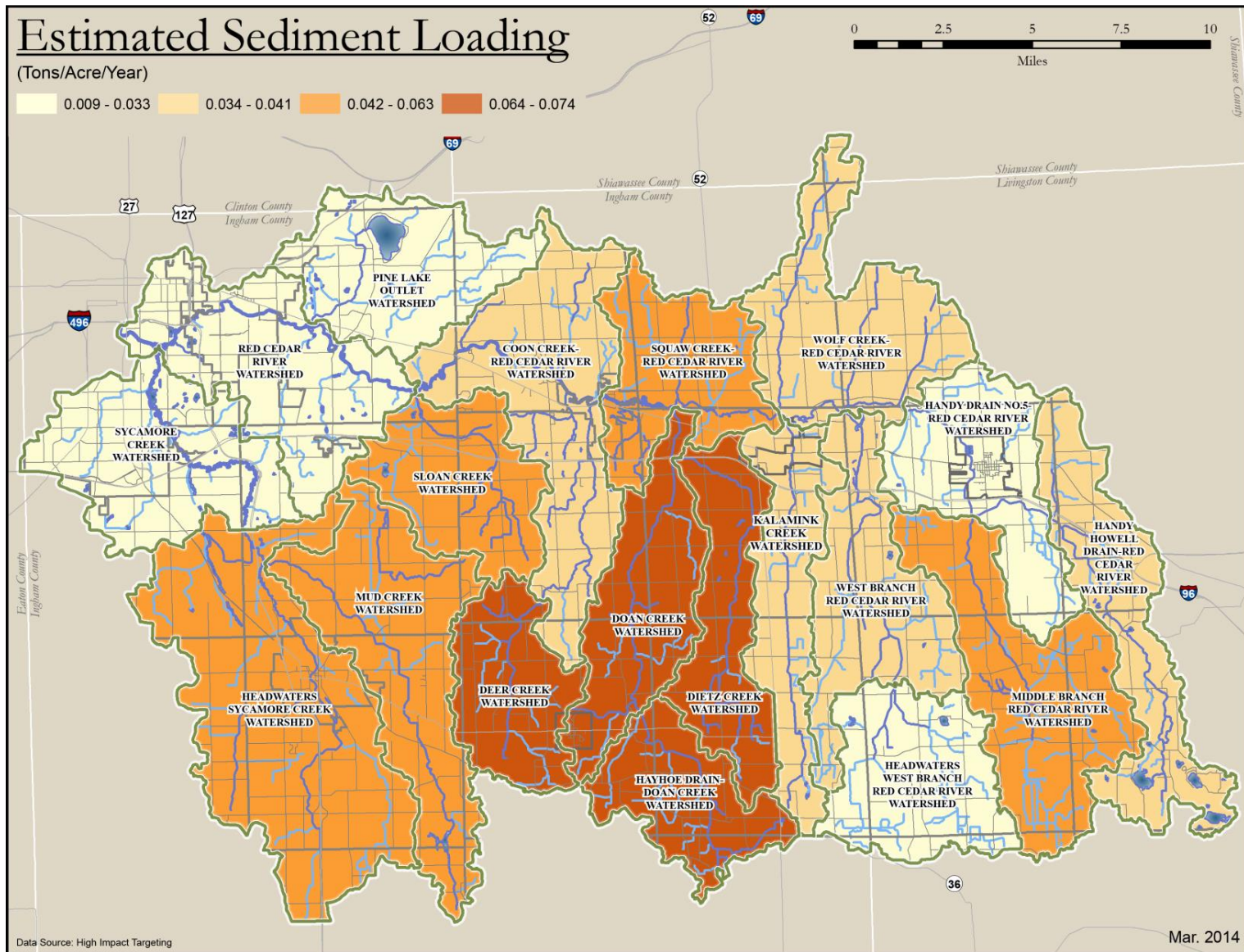


Figure 3.9 HIT modeling results in tons of sediment per acre delivered to surface water per year

Biological Monitoring

Macroinvertebrate diversity and abundance are indicators of stream water quality. A high diversity and abundance of macroinvertebrates present are indicative of higher quality water, but other characteristics also affect water quality ratings, such as the types of macroinvertebrates present and the distribution between sites (MDEQ, 2009 rev.). Macroinvertebrate samples are collected and analyzed for the presence and quantities of various macroinvertebrates. Using a standard procedure and analysis method, a score is calculated based on the quantities of certain macroinvertebrates present in the sample. Results compared over time can signal changes in a stream's health, which may indicate changes in pollutant loadings to the stream.

Biological sampling was not collected specifically as a part of this planning process, but data were retrieved from other stakeholders and included in the plan development. MDEQ collected macroinvertebrate samples following Great Lakes and Environmental Assessment Section Procedure No. 51 (P51) (MDEQ, 2008 rev.). The most recent revision (2008) of P51 includes methods for assessment of macroinvertebrate and fish communities, as well as physical habitat. For macroinvertebrates, the process results in a score based upon on a scale of -9 to 9; -9 to -5 is rated as Poor, -4 to 4 is rated as Acceptable, and anything greater than 4 is rated as Excellent. Generally speaking, flowing waters which harbor a high diversity of macroinvertebrates, specifically different types of mayfly, caddisfly and stonefly, are of higher water quality than those waters that have few taxa. Water bodies with low diversity often have very high numbers of tolerant individuals due to their ability to thrive in degraded water with relatively little competition. The scoring criteria for the fish community are similar, with a total of ten metrics used in the scoring process. For physical habitat, 10 metrics are scored on an individual basis and then compiled, resulting in an overall score of up to 200 points for each site (Pre-2008 P51 habitat metrics were scored on a different scale). Sites scoring less than 56 are considered to be Poor, those scoring between 56 and 104 are Marginal, between 105 and 154 points are Good, and sites scoring over 154 are Excellent. Individual metrics are often used to describe conditions directly affecting the biological community, while overall score describes the general environment at the site.

The Mid-Michigan Environmental Action Council (Mid-MEAC) collected macroinvertebrate samples bi-annually from 2006 to 2012 in six subwatersheds following the MiCorps Volunteer Stream Monitoring Procedures manual (Latimore, 2006). Through simple calculations using the macroinvertebrates found, volunteers calculated a stream score. A score of 49 or higher is an indicator of excellent water quality, 34-48 is good quality, 19-33 is fair quality, and 0-18 is poor quality. More information about this methodology can be found at: <http://www.micorps.net/streamresources.html>.

The biological assessments of the Red Cedar River indicate that the river, in large part, harbors a diverse community of fish and aquatic insects. Latimore (2005) found diverse fish assemblages near the MSU campus in 2001-2003, with a total of 31 fish species found, representing 11 different families. A large number of macroinvertebrate studies conducted by MSU, MDEQ and Mid-MEAC indicate that, with few exceptions, sampling stations throughout the watershed contain Acceptable communities. [Chapter Four](#) of this WMP provides more detail about the aquatic biota within each of the subwatersheds.

Windshield Survey

As part of this planning project, in 2012 and 2013, the watershed was surveyed by driving and collecting data about land use practices and conditions (the methodology is included in Appendix D). In the rural areas, each road was driven, land uses were observed and estimates of the number of large farm animals in each subwatershed were recorded. Smaller livestock such as chickens were not measured as their relative contributions of waste and ultimately *E. coli* to the watershed are considered to be smaller than that of larger livestock. In the urban areas, due to high density and the large number of roads, a general overview was conducted by driving a random pattern of roads and observing the various types of neighborhoods and land use patterns. Each basic "type" of neighborhood, based upon age and size of the homes, size of the parcels, etc. was identified for further inspection using the Unified Subwatershed and Site Reconnaissance guidance, specific to the neighborhood source assessment field sheets and methodology (Center for Watershed Protection, 2005).

The windshield survey found a diversity of land uses in the more rural settings. A large number of farms were located and documented, many of which are small acreages with few animals, where homes and farms are mixed with woodlots, wetlands and other natural areas. In general, the larger farms, which presumably operate as income generators, are noticeably different in that the density of animals is higher and the fields are more intensely managed for crop production. In those locations, there are fewer fence rows, cropland is maintained closer to the edges of roads and streams/drains, and wetlands, forests and other natural areas are fewer in number.

Wetlands

MDEQ analyzed wetland data for the watershed in a landscape level functional wetland assessment (LLFWA) in order to understand wetland trends. Table 3.6 summarizes the percentage of wetland acreage lost in the watershed. Comparing the land from pre-settlement to 2005, on average each subwatershed went from approximately 4,800 acres of wetlands to 2,095 acres of wetlands (MDEQ, 2012b). The Dietz and Sycamore Creek subwatersheds lost the most wetland acreage, with losses around 80% of their original wetlands. Handy-Howell Drain and Handy Drain No. 5 and subwatersheds lost the least amount of wetlands, with 24% and 31% of their original wetlands lost, respectively (MDEQ, 2012b). A copy of the LLFWA is included in Appendix E.

Table 3.6 Red Cedar River Watershed Wetland Resources Status and Trends (MDEQ, 2012b)

Subwatershed	Presettlement Wetland Acreage	2005 Wetland Acreage	Lost Acres	% Wetland Loss
Dietz Creek	4,126	862	3,264	80
Sycamore Creek	6,684	1,429	5,255	79
Red Cedar River	5,185	1,398	3,787	74
Kalamink Creek	4,461	1,234	3,227	73
Headwaters Sycamore Creek	10,306	3,013	7,293	70
Sloan Creek	3,196	1,023	2,173	68
Deer Creek	3,551	1,310	2,241	64
Doan Creek	3,301	1,243	2,058	63
Hayhoe Drain- Doan Creek	3,665	1,509	2,156	59
Coon Creek	4,839	2,077	2,762	58
Mud Creek	6,298	2,875	3,423	55
Wolf Creek	5,025	2,458	2,567	52
Squaw Creek	3,229	1,610	1,619	50
West Branch Red Cedar	4,909	2,790	2,119	44
Pine Lake Outlet	4,828	2,910	1,918	40
Headwaters West Branch	4,596	2,759	1,837	40
Middle Branch Red Cedar	5,912	3,958	1,954	34
Handy Drain No. 5	3,738	2,598	1,140	31
Handy-Howell Drain	3,606	2,743	863	24

Potential Conservation Areas

High quality areas in the watershed contribute to improved ecological watershed health. With watershed efforts meant to prevent ecological degradation, these high quality areas should be conserved. A Potential Conservation Areas (PCA) Assessment was completed by the Michigan Natural Features Inventory (MNFI) in 2008 in Ingham County (Paskus and Enander, 2008). PCAs were defined as “places on the landscape dominated by native vegetation that have various levels of potential for harboring high quality natural areas and unique natural features”. Using land cover data, pre-settlement vegetation maps, and the MNFI database of rare species, this assessment was meant to identify the last remaining areas of native ecosystems, natural plant communities and scenic qualities. Based upon several criteria determined to be important indicators of ecological health, such as total size of a natural area, landscape connectivity, vegetation quality and more, each PCA was ranked on a scale of 1 to 45.

Other Data Analyzed by Subwatershed

In order to assess the subwatersheds for *E. coli* concerns, known, suspected and potential sources of *E. coli* were identified. The number of septic systems was estimated by acquiring an estimated number of drinking water wells. Assuming each household with a drinking water well also uses an onsite septic system, a percentage was calculated for failing septic systems, using a failure percentage of 26%, which is based upon recent studies completed by the Barry-Eaton District Health Department (2011). Dog populations were estimated using each subwatershed’s census population, assuming that 37.2 percent of households have 1.7 dogs each (AVMA, 2007 as cited in MDEQ, 2012c). The percentages of land use types were calculated using the 2006 Coastal Change Analysis Program (C-CAP) dataset to understand

which sources were the primary contributors of *E. coli* and other pollutants in each subwatershed (NOAA, 2008). An approximate population of livestock was collected through a windshield survey. Suspected areas of pollutant sources were collected from stakeholders and from a windshield survey. Data collected were used to generalize conditions within the subwatersheds. Data summaries are provided for each subwatershed in [Chapter Four](#).