Total Maximum Daily Load and Implementation Plan for *E. coli* in Sault Sainte Marie Area Tributaries

Including the Charlotte River, Munuscong River, Little Munuscong River, Waishkey River, and Sault Area Creeks

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Prepared for

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ATV	All Terrain Vehicle
BMP	Best Management Practice
BST	Bacterial Source Tracking
CAFO	Concentrated Animal Feeding Operations
CCHD	Chippewa County Health Department
CFU	Colony Forming Units
CN	Copy Number
CWA	Clean Water Act
E. coli	*Escherichia coli*
EPA	United States Environmental Protection Agency
EQIP	Environmental Quality Incentive Program
GAAMP	Michigan Department of Agriculture Generally Accepted Agricultural and Management Practices
GIS	Geographic Information System
HUC	Hydrologic Unit Codes
LA	Load Allocations
LDC	Load Duration Curve
MDEQ	Michigan Department of Environmental Quality
mL	milliliter
MOS	Margin of Safety
NPDES	National Pollutant Discharge Elimination System
OSDS	Onsite Sanitary Disposal System
PBC	Partial Body Contact
rRNA	Ribosomal Ribonucleic Acid
SSO	Sanitary Sewer Overflow
TBC	Total Body Contact
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey
WLA	Waste Load Allocations
WMP	Watershed Management Plan
WQS	Water Quality Standards
WWSL	Wastewater Stabilization Lagoon
WWTF	Wastewater Treatment Facility
WWTP	Wastewater Treatment Plant

1.0 INTRODUCTION

1.1. Background

In April of 1991, the United States Environmental Protection Agency (EPA) Office of Water's Assessment and Protection Division published "Guidance for Water Quality-based Decisions: The Total Maximum Daily Load (TMDL) Process" (EPA, 1991a). In July 1992, EPA published the final "Water Quality Planning and Management Regulation" (40 CFR Part 130). Together, these documents describe the roles and responsibilities of EPA and the states in meeting the requirements of Section 303(d) of the Federal Clean Water Act (CWA) as amended by the Water Quality Act of 1987, Public Law 100-4. Section 303(d) of the CWA requires each state to identify those waters within its boundaries not meeting EPA-approved water quality standards for any given pollutant applicable to the water's designated uses.

Further, Section 303(d) requires EPA and states to develop TMDLs for all pollutants violating or causing violation of applicable water quality standards for each impaired water body. A TMDL determines the maximum amount of pollutant that a water body is capable of assimilating while continuing to meet the existing water quality standards. Such loads are established for all the point and nonpoint sources of pollution that cause the impairment at levels necessary to meet the applicable standards with consideration given to seasonal variations and a margin of safety. TMDLs provide the framework that allows states to establish and implement pollution control and management plans with the ultimate goal indicated in Section 101(a)(2) of the CWA: "water quality which provides for the protection and propagation of fish, shellfish, and wildlife, and recreation in and on the water, wherever attainable" (EPA, 1991a).

1.2. Problem Statement

Thirty-three water body segments (see Table 1 and Figure 1) located in eastern Chippewa County and eastern Mackinac County in Michigan's eastern Upper Peninsula are listed on the state's 303(d) Impaired Waters List for non-attainment of the total body contact (TBC) and/or partial body contact (PBC) designated uses due to exceedance of the water quality standards for *Escherichia coli* (*E. coli*). *E. coli* bacteria are found in the lower intestines of warm blooded animals. Humans, livestock, birds, wildlife, and domestic pets can all act as vectors for the introduction of *E. coli* to a water body. Ingestion of and contact with water containing *E. coli* bacteria can cause gastrointestinal infections and other health problems in humans.

As shown in Figure 1, the impaired water bodies are located in the following watersheds: 1) Charlotte River; 2) Little Munuscong River; 3) Munuscong River; 4) Waishkey River; 5) Ashmun Creek; 6) Mission Creek; 7) Frechette Creek; and 8) Seymour Creek. The Michigan Department of Environmental Quality (MDEQ) believes that a comprehensive, watershed-wide management approach is needed to address the ubiquitous nature of sources of *E. coli* in each of the watersheds listed above. Therefore, a watershed framework was used to develop the TMDLs. Under a watershed framework, TMDLs and the associated tasks (e.g., characterizing the impaired water body and its watershed, identifying sources, setting targets, calculating the loading capacity, identifying source allocations, preparing TMDL reports, and coordinating with stakeholders) are simultaneously completed for multiple water bodies in a watershed.

Consistent with Section 303(d) of the CWA, MDEQ has chosen to complete an *E. coli* source assessment for all of the water bodies in the watersheds listed above and shown in Figure 1. The information contained in this report is intended to guide management actions needed to meet water quality standards and designated uses for impaired segments while also helping to maintain and protect existing water quality for water bodies that are not currently impaired or that have not yet been assessed. Although this report identifies the TMDLs, wasteload allocations (WLAs), and load allocations (LAs) required for the 33 water bodies currently listed as impaired by *E. coli* (see Table 1), the watershed-based TMDL assessment conducted for the impaired water bodies also applies to all of the non-impaired segments in the watersheds. Therefore, the TMDLs, WLAs, and LAs identified in this report may apply to any additional water bodies in these watersheds that may potentially be listed as impaired for *E. coli* in subsequent Michigan 303(d) Impaired Waters Lists (such determination will be made by MDEQ in consultation with EPA, if and when additional water bodies are listed).

The Sault Ste. Marie Tribe of Chippewa Indians and Bay Mills Indian Community hold numerous trust parcels in the TMDL Watersheds. These trust parcels constitute Indian country as that term is used in 18 U.S.C. 1151, which is consistent with EPA's interpretation of reservation lands pursuant to the Clean Water Act. EPA's approval of Michigan's TMDLs does not extend to Indian country located within the watersheds. The goal of this TMDL is that all waters within the TMDL area meet applicable water quality standards. Cooperation between the EPA, State of Michigan, Bay Mills Tribe and Sault Ste. Marie Tribe of Chippewa Indians will be necessary to accomplish this goal.

Table 1: Impaired Waters on Michigan's Draft 2012 Integrated Report included in this TMDL [1]

Assessment Unit ID	Name	Impaired Designated Uses	Impairment Cause (pollutant)
040700010101-02	Ashmun Creek	TBC, PBC	*E. coli*
040700010101-04	Mission Creek	TBC	*E. coli*
040700010101-05	Frechette Creek	TBC	*E. coli*
040700010102-01	Charlotte River	TBC, PBC	*E. coli*
040700010103-01	Spring Creek (trib to Charlotte); Trib to Charlotte (highly modified)	TBC, PBC	*E. coli*
040700010104-01	Little Munuscong	TBC, PBC	*E. coli*
040700010105-01	Little Munuscong - School Creek	TBC, PBC	*E. coli*
040700010201-01	Munuscong River	TBC, PBC	*E. coli*
040700010202-01	Munuscong River	TBC, PBC	*E. coli*
040700010203-01	Munuscong Taylor Creek	TBC, PBC	*E. coli*
040700010204-01	Munuscong River	TBC, PBC	*E. coli*
040700010205-01	East Branch Munuscong - Hannah Creek	TBC, PBC	*E. coli*
040700010206-01	Munuscong – Rapson Creek	TBC, PBC	*E. coli*
040700010206-02	Rapson - East Branch Munuscong – Hannah Creeks	TBC, PBC	*E. coli*
040700010207-01	East Branch Munuscong – Demoreux Sanderson Creeks	TBC, PBC	*E. coli*
040700010207-02	Munuscong – Parker Creek	TBC, PBC	*E. coli*
040700010207-03	Munuscong – Parker Creek	TBC, PBC	*E. coli*
040202030105-08	Seymour Creek	TBC, PBC	*E. coli*
040202030201-02	South Branch East Branch Waishkey River	TBC	*E. coli*
040202030202-01	Waishkey River	TBC	*E. coli*
040202030202-02	Waishkey – South Branch Waishkey – Hutton Creek	TBC	*E. coli*
040202030204-01	East Branch Waishkey – Beaver Meadow Creek	TBC	*E. coli*
040202030205-01	Waishkey – Orrs Creek	TBC	*E. coli*
040202030206-01	Waishkey – Hickler Creek	TBC	*E. coli*
040202030202-02	Unassessed lake in HUC	TBC, PBC	*E. coli*
040202030206-01	Unassessed lake in HUC	TBC, PBC	*E. coli*
040202030205-02	Unassessed lake in HUC	TBC, PBC	*E. coli*
040700010201-03	Unassessed lake in HUC	TBC, PBC	*E. coli*
040700010104-02	Unassessed lake in HUC	TBC, PBC	*E. coli*
040700010105-02	Unassessed lake in HUC	TBC, PBC	*E. coli*
040700010204-02	Unassessed lake in HUC	TBC, PBC	*E. coli*
040700010206-03	Unassessed lake in HUC	TBC, PBC	*E. coli*
040700010207-05	Unassessed lake in HUC	TBC, PBC	*E. coli*

[1] Water bodies listed in this table are based on the draft 2012 Integrated Report. This list is subject to change pending approval of the final 2012 Integrated Report.

Figure 1: Locations of TMDL watersheds and impaired waterbodies.

2.0 WATERSHED CHARACTERIZATION

2.1. Watershed History and Characteristics

The eight TMDL watersheds (Figure 1) are part of the Eastern Upper Peninsula Watershed and the St. Marys River Watershed. The Waishkey River drains to Lake Superior at Waishkey Bay. Seymour Creek, Ashmun Creek, Mission Creek, Frechette Creek, the Charlotte River, the Little Munuscong River, and the Munuscong River drain to the St. Marys River between Sault Ste. Marie, Michigan and Munuscong Lake. The TMDL watersheds are primarily in eastern Chippewa County, with a portion of the Munuscong River watershed in northeastern Mackinac County. The larger watersheds (Waishkey River, Charlotte River, Little Munuscong River and Munuscong River) include multiple 12-digit Hydrologic Unit Code (HUC) subwatersheds, which are used throughout this report to describe watershed characteristics and potential bacteria sources (see Figure 1).

The Waishkey, Charlotte, Little Munuscong and Munuscong watersheds are predominantly rural, with large areas of forest, wetland, cropland and pasture (Figure 2 and Table 2 through Table 6). Soils in the TMDL watersheds are primarily the Rudyard and Pickford Series, which are poorly drained clays over limestone and dolomite bedrock (USDA, 1994 and Chippewa/East Mackinac Conservation District, 2008a and 2008b). Much of the area was wetland prior to settlement by colonists, but has been drained for agriculture, timber harvest and development. An average of approximately 32 inches of precipitation per year falls in the area, and there is typically thick snow cover in the winter (Chippewa/East Mackinac Conservation District 2008b).

This area has been inhabited by Native Americans for thousands of years and has been settled by Europeans since the 1600s. Currently, the primary human population centers are the City of Sault Ste. Marie and Pickford Township. The Seymour, Ashmun, and Mission Creek watersheds include parts of the City of Sault Ste. Marie, and developed areas comprise 17%, 49% and 46% of their watersheds, respectively (NOAA, 2006). The other TMDL watersheds (Waishkey, Charlotte, Little Munuscong and Munuscong) have only 2% to 4% developed areas. The 2010 U.S. Census (Figure 3 and Table 7) found a population of 35,900 people in the TMDL watersheds. Between the 2000 census and 2010 census, the population of Chippewa and Mackinac counties changed by -0.1% and -6.9%, respectively. Given the stable population, no adjustments for future population growth are included in this TMDL.

Human wastewater is collected and treated in municipal sanitary sewer systems in the City of Sault Ste. Marie, Pickford Township, Superior Township, and Kinross Township. Other areas are served by private, on-site sanitary disposal systems (OSDS). OSDS are used to provide treatment of sanitary wastewater when a building is not connected to sanitary sewers. Standard OSDS treat sewage by settling out solids, and allowing liquid waste to percolate downward in an adsorption field. This downward percolation provides both filtration and time for natural processes to treat the waste. Due to a predominance of soils poorly-suited for traditional OSDS adsorption fields, lagoons are frequently used as an alternative. OSDS lagoons function in place of an adsorption field, and are designed to allow evaporation and solar disinfection of liquid waste.

According to the National Agricultural Statistics Service 2007 Census of Agriculture profiles of Chippewa and Mackinac Counties, cows are the most numerous livestock, with 6,209 and 2,783 head of cattle in Chippewa and Mackinac Counties, respectively. Livestock tend to be concentrated in numerous small grazing operations throughout the TMDL watersheds. Many of these grazing operations are located near drainages and streams. A few beef farms spread manure on hay fields and pastures, but manure spreading is not common in the TMDL watersheds (Pat Carr, Natural Resource Conservation Service, personal communication, May 1, 2012). The Natural Resources Conservation Service actively works with local producers, with an emphasis on constructing fences to prevent cattle from freely accessing streams and drainages (Patrick Carr, Natural Resources Conservation Service, personal communication, May 1, 2012). There are no NPDES permitted Concentrated Animal Feeding Operations in the TMDL watersheds.

Deer are also common in the TMDL area, although the Michigan Department of Natural Resources does not have current estimates of deer population density in the area. Deer activity indicators suggest that the deer population density is higher in the southern portion of the TMDL area, near Pickford. The deer population fluctuates depending on the severity of preceeding winters, and it appears to be increasing after severe winters several years ago. Unlike cattle, deer tend to be dispersed throughout the area for grazing during the summer. In winter, deer congregate in cedar swamps which provide refuge from deep snow (personal communication, David Jentoft, Michigan Department of Natural Resources, May 1, 2012).

Geese and other waterfowl are common in riparian areas where vegetation is cropped short, particularly in areas such as golf courses and cemeteries that are managed for turf grass. Raccoons and other wildlife are also potential sources of *E. coli* in the TMDL area. Raccoons depend upon surface water for their food and grooming habits, and also tend to congregate in areas where human habitation provides them with a readily available food supply (such as improperly disposed of garbage) and shelter (such as outbuildings, culverts and enclosed storm drains).

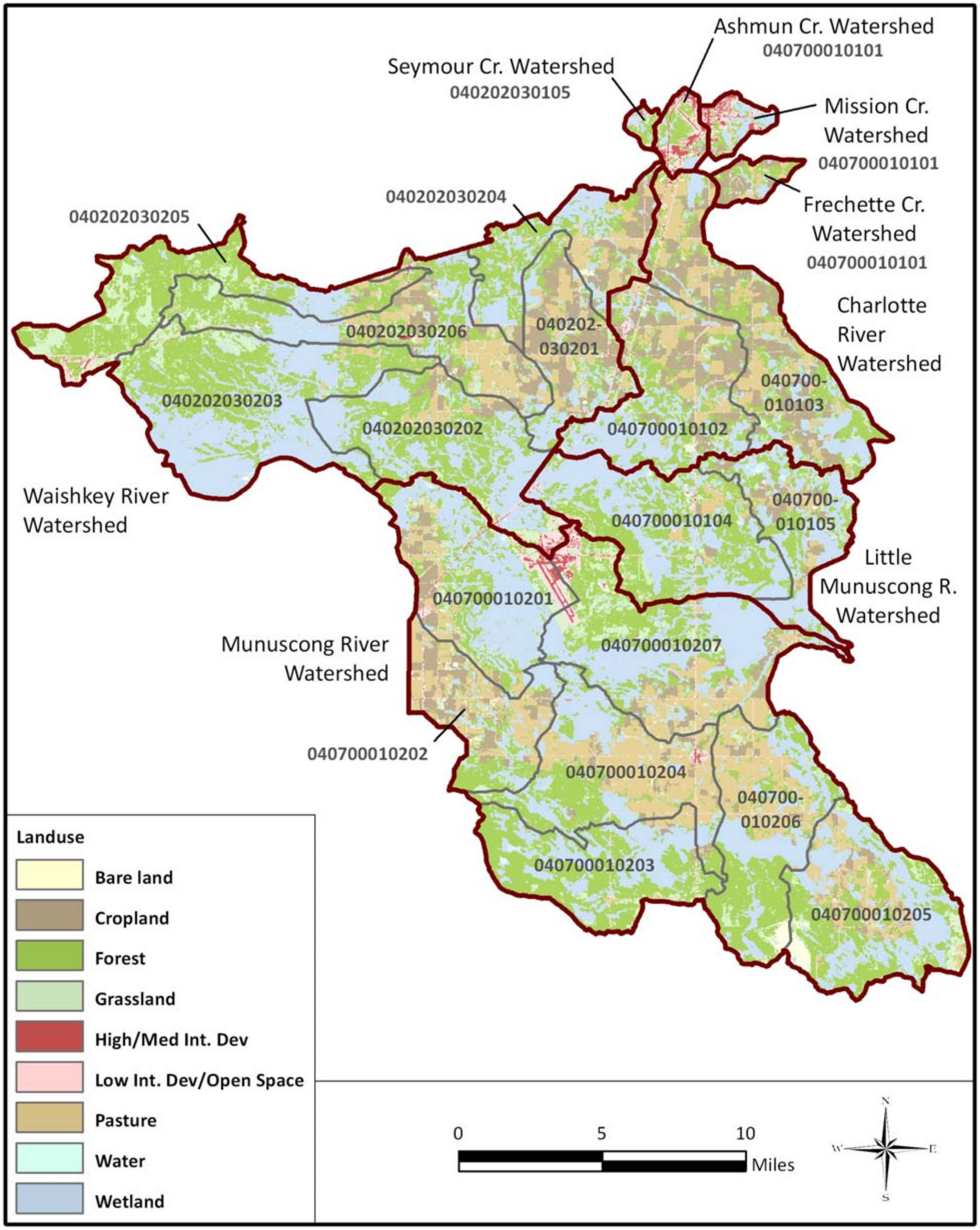

Figure 2: Generalized 2006-era land cover in the TMDL watersheds (NOAA, 2006).

Table 2: Generalized 2006-era land cover by subwatershed for the Ashmun, Frechette, Mission and Seymour Creeks Watersheds.

Land Cover Category	Ashmun Creek 040700010101		Frechette Creek 040700010101		Mission Creek 040700010101		Seymour Creek 040202030105	
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
Open Water	1	0.03%	0	0.01%	0	0%	0	0.1%
High & Medium Intensity Development	507	20%	3	0.1%	413	18%	24	3%
Low Intensity Development & Open Space	742	29%	102	5%	642	28%	107	14%
Cropland	61	2%	759	35%	67	3%	10	1%
Pasture	52	2%	332	15%	37	2%	13	2%
Grassland	59	2%	34	2%	16	1%	19	2%
Forests	772	30%	653	30%	397	17%	374	48%
Wetlands	340	13%	250	12%	724	31%	218	28%
Bare Land	26	1%	16	1%	8	0.4%	16	2%
TOTAL	**2,560**	**100%**	**2,149**	**100%**	**2,304**	**100%**	**781**	**100%**

Table 3: Generalized 2006-era land cover by subwatershed for the Charlotte River Watershed.

Land cover Category	Charlotte R. Headwaters 040700010102		Charlotte R. 040700010103		Entire Charlotte R. Watershed	
	Acres	Percent	Acres	Percent	Acres	Percent
Open Water	24	0.1%	5	0.0%	30	0.08%
High & Medium Intensity Development	56	0.3%	97	0.5%	154	0.4%
Low Intensity Development & Open Space	574	3%	631	3%	1,215	3%
Cropland	3,855	22%	5,009	25%	8,871	24%
Pasture	2,256	13%	4,362	22%	6,612	18%
Grassland	651	4%	416	2%	1,067	3%
Forests	4,699	27%	5,380	27%	10,069	27%
Wetlands	5,464	31%	3,691	19%	9,152	25%
Bare Land	81	0.5%	78	0.4%	158	0.4%
TOTAL	**17,659**	**100%**	**19,668**	**100%**	**37,328**	**100%**

Table 4: Generalized 2006-era land cover by subwatershed for the Little Munuscong River Watershed.

Land cover Category	Headwaters L. Mununuscong R. 040700010104		Little Munuscong R. 040700010105		Entire Little Munuscong R. Watershed	
	Acres	Percent	Acres	Percent	Acres	Percent
Open Water	48	0.3%	91	1%	138	0.5%
High & Medium Intensity Development	64	0.3%	3	0%	68	0.2%
Low Intensity Development & Open Space	387	2%	102	1%	487	2%
Cropland	204	1%	1,079	11%	1,282	4%
Pasture	717	4%	817	8%	1,533	5%
Grassland	794	4%	297	3%	1,091	4%
Forests	8,123	43%	3,092	30%	11,209	38%
Wetlands	8,673	45%	4,691	46%	13,368	46%
Bare Land	80	0.4%	47	0.5%	127	0.4%
TOTAL	**19,090**	**100%**	**10,217**	**100%**	**29,303**	**100%**

Table 5: Generalized 2006-era land cover by subwatershed for the Munuscong River Watershed.

Land cover Category	Headwaters Munuscong River 040700010201		Upper Munuscong R. 040700010202		Talyor Cr. 040700010203		Middle Munuscong R. 040700010204	
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
Open Water	59	0.3%	3	0%	56	0.4%	7	0%
High & Medium Intensity Development	406	2%	30	0.3%	11	0.1%	60	0.3%
Low Intensity Development & Open Space	1,101	6%	317	3%	157	1%	344	2%
Cropland	1,261	7%	2,336	21%	138	1%	920	5%
Pasture	1,600	9%	3,725	33%	604	4%	6,204	35%
Grassland	1,287	7%	461	4%	571	4%	384	2%
Forests	3,985	22%	2,231	20%	8,118	55%	4,819	27%
Wetlands	7,918	45%	2,002	18%	5,178	35%	4,736	27%
Bare Land	103	1%	176	2%	50	0.3%	57	0.3%
TOTAL	**17,721**	**100%**	**11,282**	**100%**	**14,883**	**100%**	**17,532**	**100%**

Land Cover Category	Hannah Cr. 040700010205		East Br. Munuscong R. 040700010206		Lower Munuscong R. 040700010207		Entire Munuscong R. Watershed	
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
Open Water	12	0.1%	7	0%	17	0.1%	161	0.1%
High & Medium Intensity Development	16	0.1%	9	0.1%	387	2%	921	1%
Low Intensity Development & Open Space	252	1%	182	1%	987	4%	3,347	3%
Cropland	796	4%	392	2%	1,392	6%	7,247	6%
Pasture	2,615	14%	4,481	27%	3,234	14%	22,464	19%
Grassland	1,352	7%	646	4%	1,809	8%	6,495	5%
Forests	6,506	35%	6,161	37%	6,410	28%	38,233	32%
Wetlands	6,385	35%	4,615	27%	8,719	38%	39,551	33%
Bare Land	571	3%	340	2%	168	1%	1,465	1%
TOTAL	**18,505**	**100%**	**16,834**	**100%**	**23,123**	**100%**	**119,884**	**100%**

Table 6: Generalized 2006-era land cover by subwatershed for the Waishkey River Watershed.

Land Cover Category	South Br. of East Br. of Waishkey River 040202030201		South Br. of Waishkey River 040202030202		West Br. of Waishkey River 040202030203		East Br. of Waishkey River 040202030204	
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
Open Water	7	0.1%	19	0.1%	80	0.3%	5	0%
High & Medium Intensity Development	45	0.4%	160	1%	16	0.1%	19	0.2%
Low Intensity Development & Open Space	342	3%	577	3%	95	0.4%	243	2%
Cropland	3,497	33%	677	4%	33	0.1%	1,717	15%
Pasture	2,090	19%	903	5%	307	1%	1,760	15%
Grassland	381	4%	811	5%	1,399	6%	262	2%
Forests	2,033	19%	6,716	38%	9,969	41%	3,814	33%
Wetlands	2,320	22%	7,804	44%	12,353	51%	3,729	32%
Bare Land	38	0.4%	48	0.3%	40	0.2%	65	1%
TOTAL	**10,754**	**100%**	**17,716**	**100%**	**24,292**	**100%**	**11,614**	**100%**

Land cover Category	Orrs Cr. 040202030205		Hickler Cr. – Waishkey River 040202030206		Entire Waishkey R. Watershed	
	Acres	Percent	Acres	Percent	Acres	Percent
Open Water	21	0.2%	36	0.2%	169	0.2%
High & Medium Intensity Development	76	0.5%	76	0.5%	388	0.4%
Low Intensity Development & Open Space	375	3%	395	2%	2,015	2%
Cropland	128	1%	1,932	12%	7,963	8%
Pasture	460	3%	3,137	19%	8,654	9%
Grassland	2,927	21%	1,343	8%	7,135	8%
Forests	8,392	60%	5,852	35%	36,807	39%
Wetlands	1,582	11%	3,732	23%	31,521	33%
Bare Land	26	0.2%	77	0.5%	296	0.3%
TOTAL	**13,987**	**100%**	**16,581**	**100%**	**94,948**	**100%**

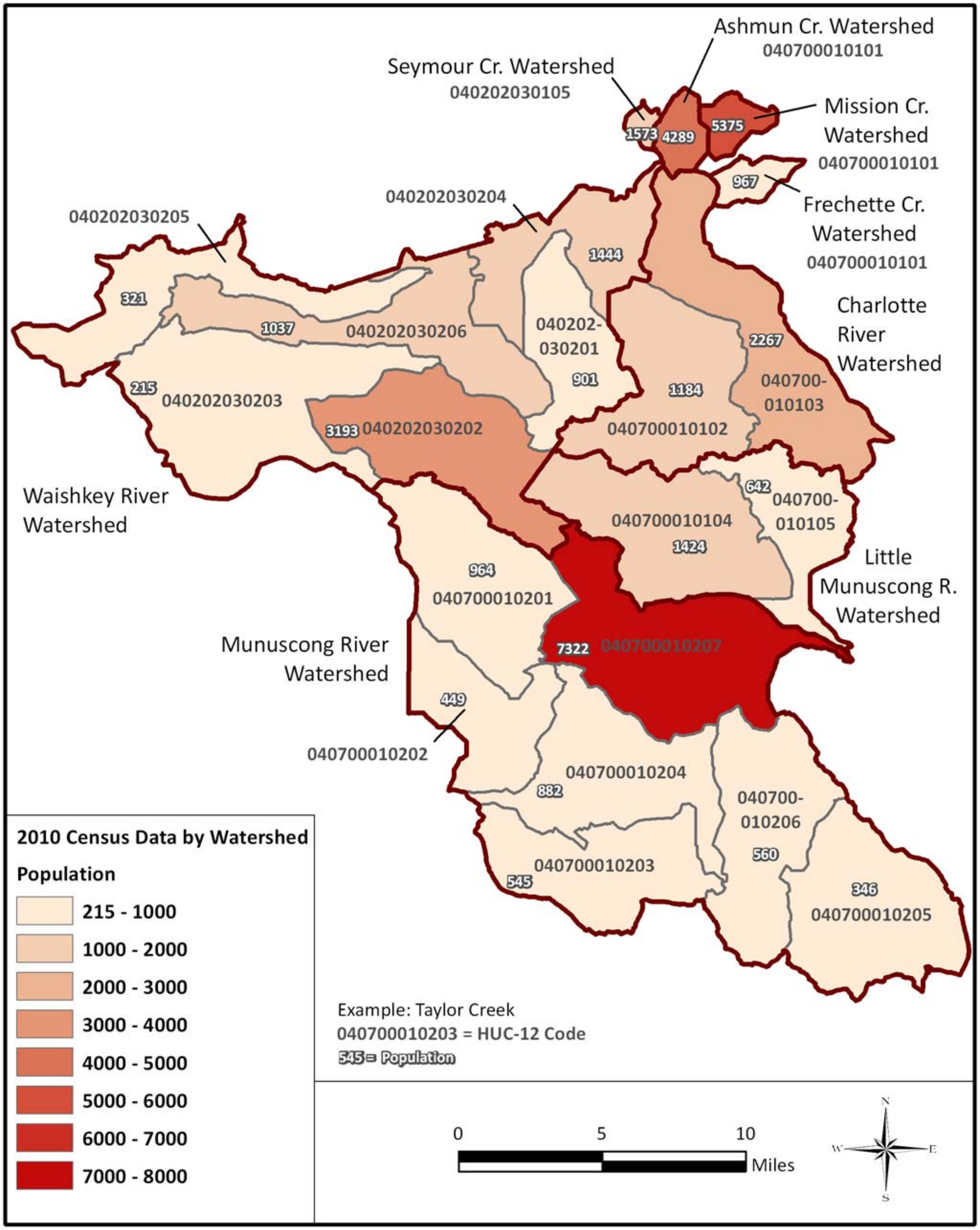

Figure 3: 2010 U.S. Census data by watershed.

Table 7: 2010 U.S. Census data by watershed

Watershed Name	HUC-12 subwatershed	Housing Units	Population
Ashmun Creek	40700010101	1787	4289
Frechette Creek	40700010101	373	967
Mission Creek	40700010101	2514	5375
Seymour Creek	40202030105	658	1573
Charlotte River Headwaters	40700010102	507	1184
Charlotte River	40700010103	1055	2267
Headwaters Little Mununuscong River	40700010104	670	1424
Little Mununuscong River	40700010105	352	642
Headwaters Munuscong River	40700010201	496	964
Upper Munuscong River	40700010202	256	449
Taylor Creek	40700010203	328	545
Middle Munuscong River	40700010204	473	882
Hannah Creek	40700010205	276	346
East Br. Munuscong River	40700010206	299	560
Lower Munuscong River	40700010207	1437	7322
South Branch of East Br. of Waishkey River	40202030201	394	901
South Branch of Waishkey River	40202030202	617	3193
West Branch of Waishkey River	40202030203	155	215
East Branch of Waishkey River	40202030204	660	1444
Orrs Creek	40202030205	171	321
Hickler Creek - Waishkey River	40202030206	617	1037
Totals		**14,095**	**35,900**

2.2. Water Quality

2.2.1. *E. coli* Monitoring

As part of a large monitoring effort in the St. Marys River Basin, *E. coli* samples were collected for 18 weeks of the 2010 total body contact recreation season at 21 locations on the water bodies that are the focus of these TMDLs. Figure 4 shows the 2010 monitoring locations and associated watersheds, and complete monitoring results are included in Appendix A. A description of the *E. coli* sample collection and analysis methods and results can be found in the St. Marys River Monitoring Project for TMDL Development Final Report (2010).

2.2.2. Bacterial Source Tracking Analysis

Bacterial Source Tracking (BST) sites were selected where elevated *E. coli* concentrations occurred in previous weeks. The BST tests were conducted only if the *E. coli* count of the concurrent sample was greater than 300 colony forming units per 100 milliliter (CFU/100mL) (although 750 CFU/100mL was preferred). Based on this approach, a total of seven BST samples from tributary sites were analyzed throughout the season, beginning in week 7. Additional details of BST testing are presented in Sections 2.4 and 3.2.

BST analysis was carried out on one sample from each of seven tributaries (Table 8). As reference, the proportion of human *Bacteroides* to total *Bacteroides* in untreated sewage from a major metropolitan area can range from 1 to 4%. The results are expressed in copy number (CN), which refers to the number of copies of the 16S Ribosomal Ribonucleic Acid (rRNA) gene that were detected. CN less than 100 is classified as background.

The BST results are presented in Table 8. The tributary sample from Seymour Creek (Se1) from 7/20/2010 had high levels of human *Bacteroides* sp. present and comprised 0.86% of the total *Bacteroides* present. The sample from the Munuscong River east of Pickford (Mu5) from 9/30/2010 was found to have high to moderate levels of human *Bacteroides* sp. with similar ratios of human to total *Bacteroides* as compared to the Se1 sample. Sample Mi2 taken at the downstream location on Mission Creek from 10/7/2010 also had moderate to high levels of human *Bacteroides* sp., however, the total *Bacteroides* levels were higher, indicating other sources of fecal pollution were also present. The Frechette Creek sample (Fr1) from 7/21/2010 had low amounts of human *Bacteroides* sp. detected, and also relatively low levels of total *Bacteroides*. Samples from Ashmun Creek (As1), Mission Creek (Mi1), and the Charlotte River (Ch2) had very low human levels of human *Bacteroides*, however, illicit connections and failing human sources are still considered potential sources to all TMDL waterbodies and sites because the number of BST samples was limited.

Table 8: Bacterial source tracking results

Site Code	Week of Sample Collection	Date of BST Sample Collection	*E. coli* Enumeration (CFU/100 ml)	*Bacteroides* Human (CN/100ml)	*Bacteroides* Total (CN/100ml)	Ratio Human/Total
Fr1	Week 7	7/20/2010	928	142	53,768	0.26%
Se1	Week 7	7/20/2010	1129	1,455	178,099	0.82%
As1	Week 11	8/19/2010	3450	18	22,115	0.08%
Mi1	Week 11	8/19/2010	4810	0	6,162	0.00%
Ch2	Week 11	8/19/2010	3450	10	4,105	0.24%
Mu5	Week 17	9/30/2010	2720	652	105,441	0.62%
Mi2	Week 18	10/7/2010	687	482	489,777	0.10%

Figure 4: Locations of sites monitored in 2010 within the TMDL watersheds.

3.0 APPLICABLE WATER QUALITY STANDARDS

3.1. Parameters of Concern and Applicable Water Quality Criteria

Due to exceedances of the WQS for *E. coli*, the water bodies listed in Table 1 are not currently meeting their TBC and PBC designated uses. The authority to designate beneficial uses and adopt WQS is granted through Part 31 (Water Resources Protection) of Michigan's Natural Resources and Environmental Protection Act (1994 PA 451, as amended). Pursuant to this statute, MDEQ promulgated its WQS as Michigan Administrative Code R 323.1041 – 323.1117, Part 4 Rules.

Designated uses to be protected in the surface waters identified in Table 1 are defined under R 323.1100, as follows:

> R 323.1100 Designated uses.
>
> Rule 100. (1) At a minimum, all surface waters of the state are designated and protected for all of the following uses:
>
> (a) Agriculture.
>
> (b) Navigation.
>
> (c) Industrial water supply.
>
> (d) Warm water fishery.
>
> (e) Other indigenous aquatic life and wildlife.
>
> (f) Partial body contact recreation.
>
> (g) Fish consumption.
>
> (2) All surface waters of the state are designated and protected for total body contact recreation from May 1 to October 31 in accordance with the provisions of R 323.1062. Total body contact recreation immediately downstream of wastewater discharges, areas of significant urban runoff, combined sewer overflows, and areas influenced by certain agricultural practices is contrary to prudent public health and safety practices, even though water quality standards may be met.

The applicable WQS for these designated uses are defined under R 323.1062, as follows:

> R 323.1062 Microorganisms.
>
> Rule 62. (1) All surface waters of the state protected for total body contact recreation shall not contain more than 130 *Escherichia coli* (*E. coli*) per 100 milliliters, as a 30-day geometric mean. Compliance shall be based on the geometric mean of all individual samples taken 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 defined sampling area.

(2) All surface waters of the state protected for partial body contact recreation shall not contain more than a maximum of 1,000 *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 defined sampling area.

3.2. Numeric Water Quality Targets

The TMDL specifies a numeric endpoint to represent the level of acceptable water quality that is to be achieved by implementing the TMDL. The numeric standard for the TMDLs developed for waters not currently meeting their TBC designated use (Table 1) is the WQS of 130 *E. coli* per 100 mL as a 30-day geometric mean <u>and</u> a daily maximum of 300 *E. coli* per 100 mL from May 1 to October 31. The numeric standard for the TMDLs developed for waters not currently meeting their PBC designated use (Table 1) is the WQS of a daily maximum of 1,000 *E. coli* per 100 mL year-round, in addition to the TBC water quality standard. The frequency of exceedances of the *E. coli* WQS are summarized in Table 9 and Figure 5 through Figure 7.

Table 9: Frequency of exceedances of water quality standards

	Total Body Contact Daily Maximum 300 CFU/100mL (18 weeks)		Total Body Contact 30-Day Geometric Mean 130 CFU/100mL (14 weeks)		Partial Body Contact Daily Maximum 1,000 CFU/100mL (18 weeks)	
Sample Site	**Number of samples above WQS**	**% of samples above WQS**	**Number of samples above WQS**	**% of samples above WQS**	**Number of samples above WQS**	**% of samples above WQS**
As1	13	72%	14	100%	8	44%
As2	5	28%	13	93%	1	6%
As3	8	44%	14	100%	4	22%
Ch1	11	61%	14	100%	6	33%
Ch2	8	44%	14	100%	5	28%
Ch3	8	44%	14	100%	5	28%
Ch4	2	11%	4	29%	1	6%
Fr1	12	67%	14	100%	4	22%
Lm1	8	44%	14	100%	2	11%
Lm2	8	44%	14	100%	3	17%
Mi1	12	67%	14	100%	6	33%
Mi2	12	67%	14	100%	4	22%
Mu1	11	61%	14	100%	4	22%
Mu2	15	83%	14	100%	3	17%
Mu3	16	89%	14	100%	5	28%
Mu4	7	39%	14	100%	4	22%
Mu5	15	83%	14	100%	7	39%
Se1	15	83%	14	100%	5	28%
Wa1	1	6%	1	7%	0	0%

	Total Body Contact Daily Maximum 300 CFU/100mL (18 weeks)		**Total Body Contact 30-Day Geometric Mean 130 CFU/100mL (14 weeks)**		**Partial Body Contact Daily Maximum 1,000 CFU/100mL (18 weeks)**	
Sample Site	**Number of samples above WQS**	**% of samples above WQS**	**Number of samples above WQS**	**% of samples above WQS**	**Number of samples above WQS**	**% of samples above WQS**
Wa2	4	22%	7	50%	0	0%
Wa3	3	17%	7	50%	0	0%

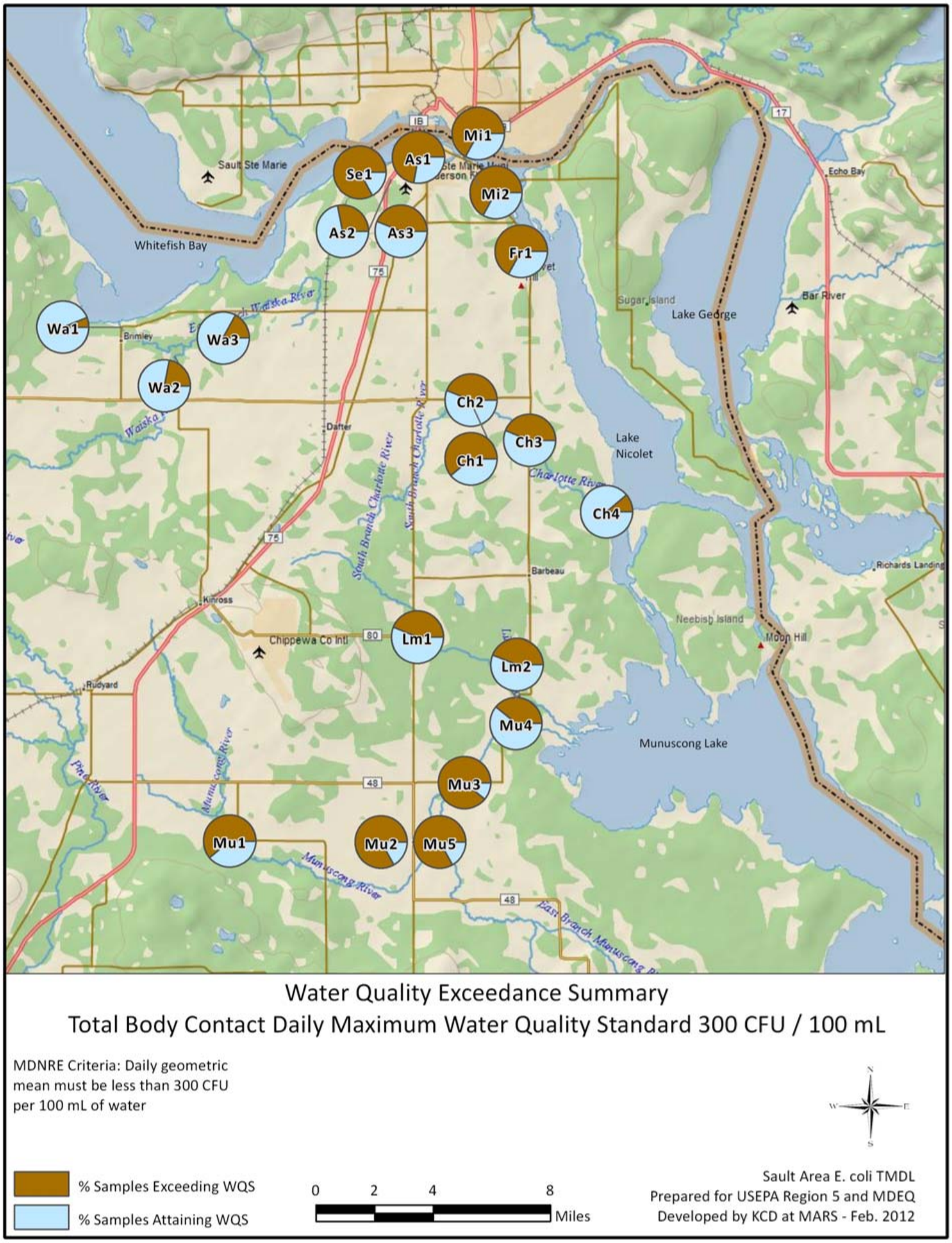

Figure 5: Summary of exceedances of the total body contact daily maximum WQS.

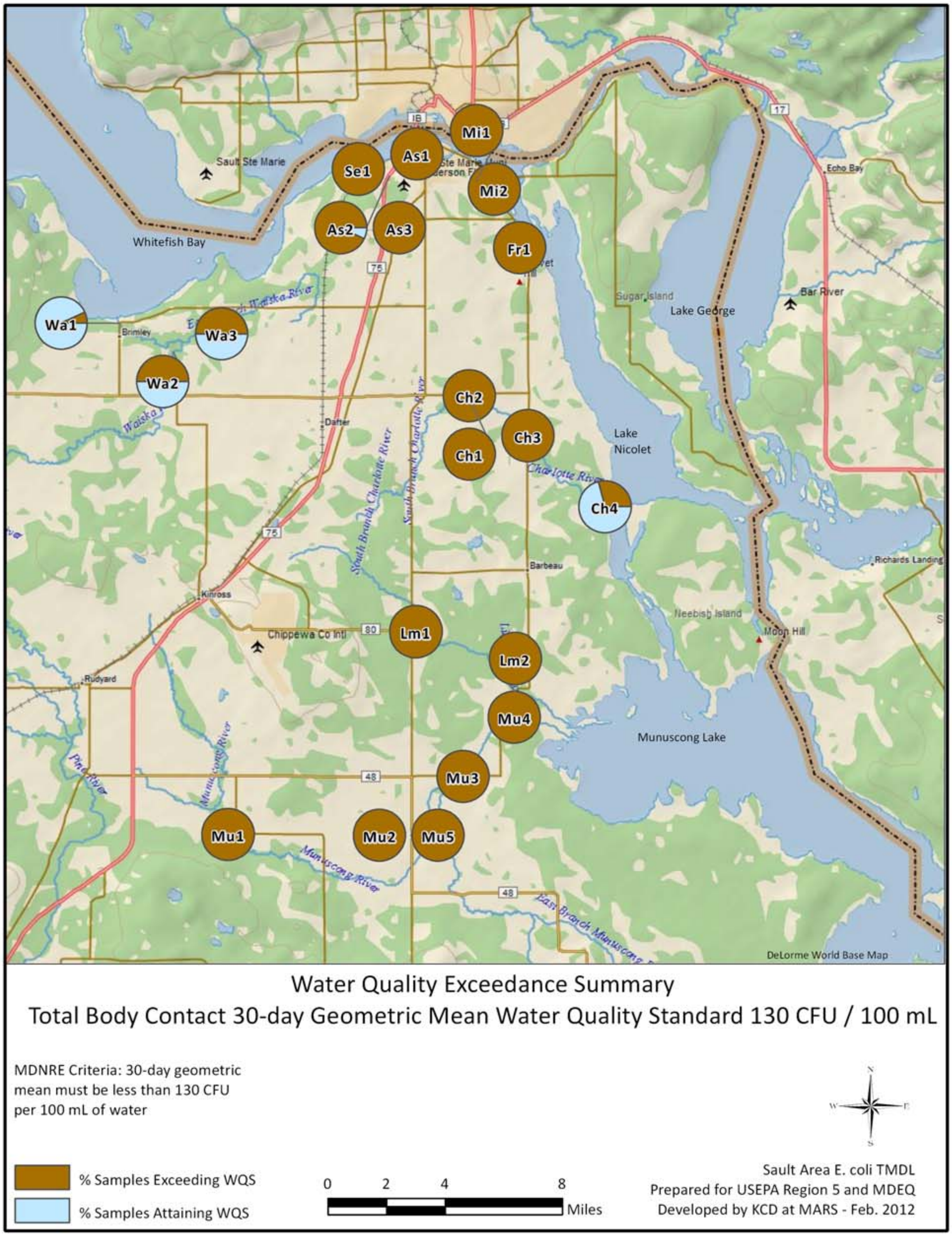

Figure 6: Summary of exceedances of the 30-day geometric mean total body contact WQS.

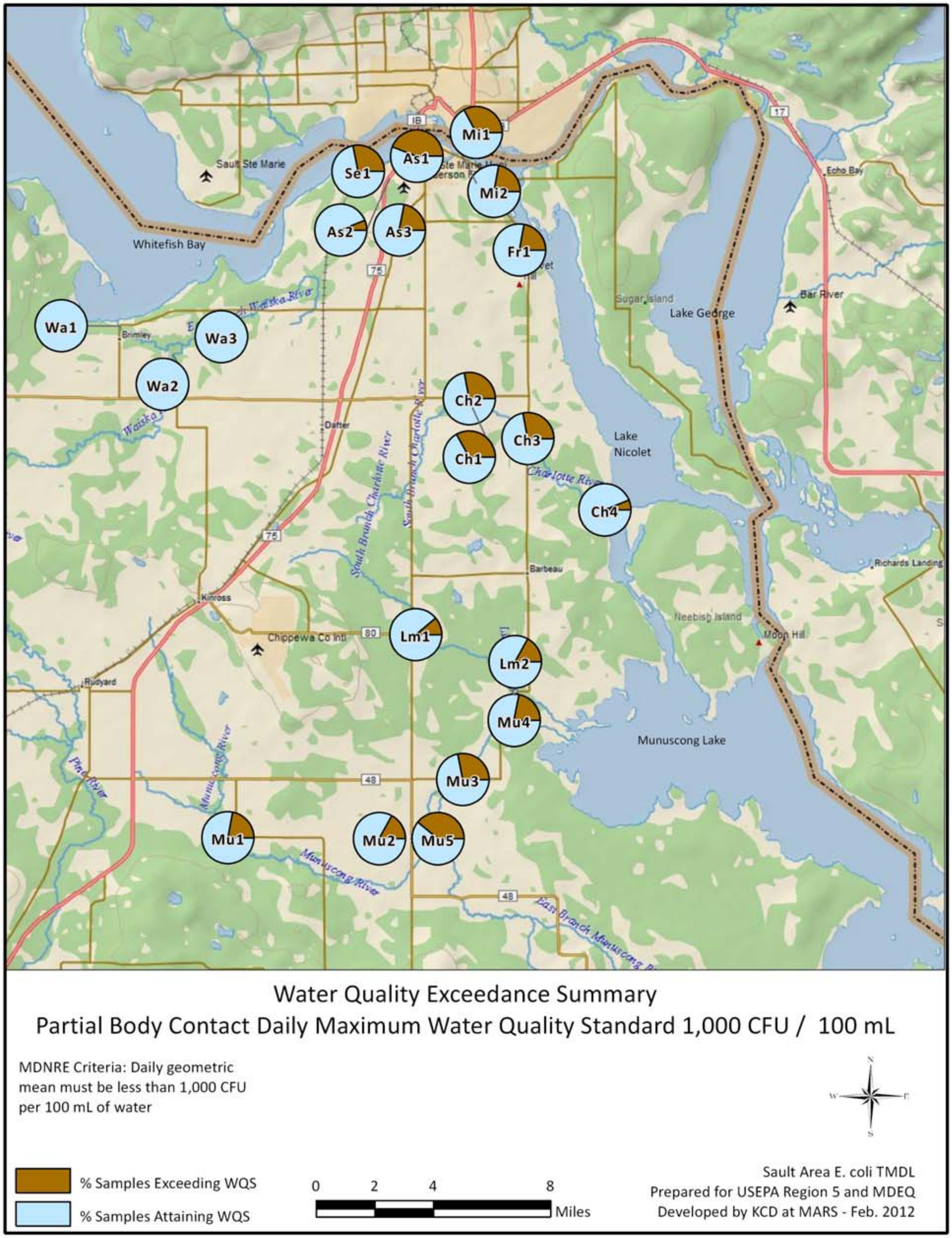

Figure 7: Summary of exceedances of the partial body contact daily maximum WQS.

4.0 SOURCE ASSESSMENT

4.1. Load Duration Curve Approach

Load duration curves (LDCs) were developed for each of the twenty-one 2010 monitoring locations to better understand the sources of *E. coli*. An example load duration curve is shown in Figure 8. A comprehensive description of this approach used to develop the LDCs is presented in *An Approach for Using Load Duration Curves in the Development of TMDLs* (EPA publication 841-B-07-006, 2007), which includes this overview:

> "The duration curve approach allows for characterizing water quality concentrations at different flow regimes. The method provides a visual display of the relationship between stream flow and loading capacity. Using the duration curve framework, the frequency and magnitude of water quality standard exceedances, allowable loadings, and size of load reduction are easily presented and can be better understood. … An underlying premise of the duration curve approach is correlation of water quality impairments to flow conditions."

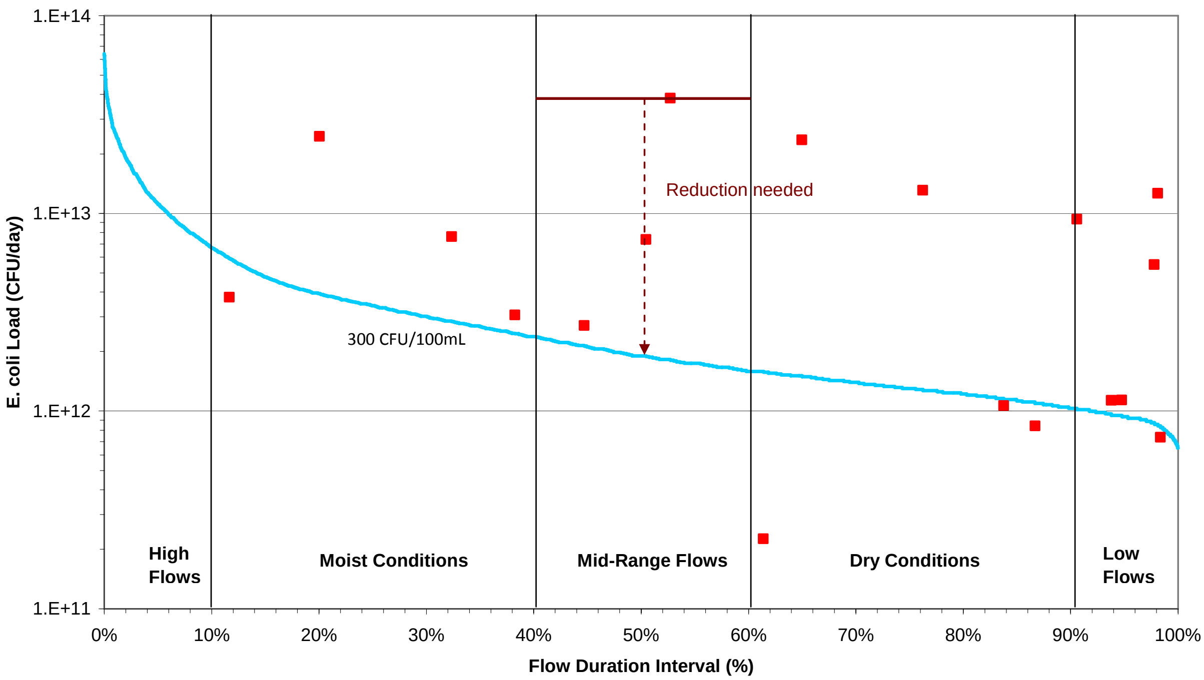

Figure 8: Example load duration curve representing Total Body Contact Daily Maximum WQS

The following steps were taken to develop the load duration curves.

1. A flow duration curve was constructed for a continuous daily flow record from the United States Geologic Survey (USGS) stream flow gaging station on the Pine River at Rudyard (USGS station number 04127918). The Pine River watershed borders several of the TMDL watersheds to the west, and this gaging station has a drainage area of 184 square miles (Figure 9).

Figure 9: Location of the Pine River watershed and the USGS gaging station used to develop load duration curves.

Flow data from October 1, 1972 – October 31, 2010, which includes the monitoring period, were used to construct the flow duration curve (Figure 10). The flow duration curve was developed by ranking daily flow values from highest to lowest, computing the percentage of days in the period of record with flows that exceed each daily value, and then plotting daily flow versus the exceedance percentage (or flow duration interval). The data reflect a range of natural occurrences from high flows to low flows. A discussion of the Pine River watershed characteristics is described in Section 4.1.1.

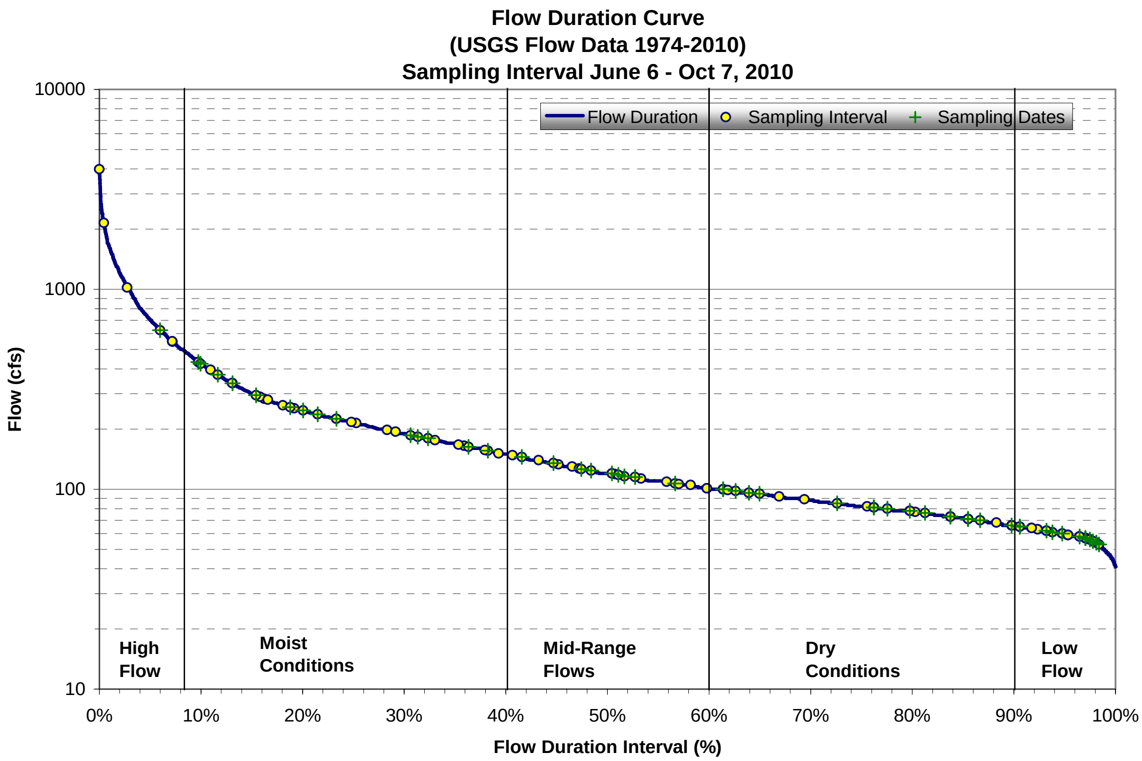

Figure 10: Flow duration curve for the Pine River USGS gage.

2. Flow duration curves were estimated for each of the twenty-one 2010 monitoring locations in the TMDL watersheds. This was conducted using the standard Area-Ratio method. The drainage basin upstream of each monitoring site was delineated from the Hydrologic Unit Code-12 (HUC-12) subwatershed boundaries, where applicable, and USGS topographic quadrangle maps (Table 10). For each monitoring site, the ratio of the upstream drainage area to the Pine River gage drainage area was computed, and the daily flow record for the Pine River gage was multiplied by this ratio to estimate daily flows at the monitoring site (Equation 1). These estimated flows represent the flow duration curve for each monitoring site. It is understood that this approach is not as accurate as flows that are measured or estimated using a calibrated watershed model, due to differences in the location, size, and hydrologic and hydraulic characteristics of each watershed.

Equation 1: Watershed area ratio

$$Q_{ungaged} = \frac{A_{ungaged}}{A_{gaged}} * Q_{gaged}$$

Table 10: Drainage area upstream of monitoring sites used for flow estimation

Monitoring Site	Area (mi^2)	Sample Location	Area (mi^2)
Pine River	184.0	Mi1	1.5
As1	4.0	Mi2	3.6
As2	3.2	Mu1	40.9
As3	0.7	Mu2	92.4
Ch1	28.0	Mu3	157.4
Ch2	12.1	Mu4	186.7
Ch3	48.2	Mu5	51.0
Ch4	58.3	Se1	1.2
Fr1	3.3	Wa1	148.4
Lm1	14.9	Wa2	88.6
Lm2	44.5	Wa3	29.7

3. The flow duration curves for each monitoring site were transformed to load duration curves by applying water quality criteria values for *E. coli*. This TMDL is based upon the premise that all discharges (point and nonpoint) must meet the WQS, which by definition means that the water body will meet the WQS and its designated use. For each impaired segment, two load duration curves were constructed to represent the two maximum Michigan WQS for *E. coli*.

   Load duration curves for the total body contact and partial body contact daily maximum standards were constructed by multiplying daily flow by the daily WQS and a standard unit conversion factor to compute daily *E. coli* load using Equation 2 (EPA 2007b).

   Equation 2: Daily Load Calculation

$$Q_{(cfs)} * WQS_{(CFU/100mL)} * 24{,}466{,}000_{(mL/cfs-day)} = CFU/day$$

4. The daily geometric mean values for each of the 18 monitoring weeks were converted to a daily load using Equation 2 and plotted on the LDCs to provide information on the frequency, magnitude, and timing of load exceedances (see Figure 8). The *E. coli* loads represented by each of the seven BST samples were also plotted in the same way. Loads that fall above the curve indicate exceedances of the daily maximum WQS (total body contact, in the example in Figure 8), and those below the curve indicate compliance with the WQS. In this way it can be shown which locations contribute loads above or below the water quality standard line.

5. Interpretation of the load duration curves and monitoring data was aided by dividing each plot into five flow duration intervals following EPA guidance (EPA 2007b), displayed in Table 11.

Table 11: Flow duration intervals

Zone	Flow Duration Interval
High Flow	0-10%
Moist Conditions	10-40%
Mid-Range Flows	40-60%
Dry Conditions	60-90%
Low Flows	90-100%

These plots show the flow conditions in which the water quality standards exceedances occur. Those exceedances at the right side of the graph occur during low flow conditions and may indicate constant sources such as failing on-site sewage disposal systems (OSDS), livestock with stream access, or illicit connections to storm sewers or surface waters. Exceedances on the left side of the graph occur during higher flow events and indicate a source which increases during wet weather, such as contaminated storm water runoff.

6. The final step is to determine where reductions need to occur. Load duration curves reveal whether impairments are occurring during high flows, low flows, or both flow conditions, and this provides useful insight about potential sources. For example, if target loads are exceeded during storm events, implementation efforts can target those Best Management Practices (BMPs) that will most effectively reduce storm water runoff. This allows for a more efficient implementation effort. In addition to the *E. coli* data collected in 2010, bacterial source tracking analyses were also conducted on seven samples to provide information on the relative contribution of human versus other sources of bacteria. This information supplements the load duration curves to identify pollutant contributions from different sources and inform the distribution of LAs and WLAs. The estimated reduction needed is calculated by comparing the 90th percentile of the *E. coli* loads for the monitoring data in each flow duration interval with the load representing the WQS at the midpoint of the interval (Figure 8).

4.1.1. Stream Flow Estimation

The Pine River was evaluated as a flow surrogate for the ungaged watersheds based on several parameters:

a. Area: The drainage area for the Pine River gage is 184 square miles, which is comparable in size to the Munuscong and Waishkey River watersheds (see Table 10). The drainage area for the monitored subwatersheds varies widely and the lack of nearby gaged watersheds prohibits a more comprehensive area-ratio calculation. The small, more developed water bodies near Sault Ste. Marie likely experience "flashier" conditions than what the LDC predicts; limitations will be described in section 4.1.2.

b. Land cover: The Pine River is primarily comprised of forests and wetlands (Table 12), the percentages of which are within 10% of the Munuscong, Little Munuscong, and Waishkey River watersheds. Overall, all of the watersheds are generally rural with a minimal amount of heavy development (see Table 2).

Table 12: 2006 land cover in the Pine River Watershed

Land Cover Category	Pine River	
	Acres*	% of Drainage Basin **
Open Water	319	0.27%
High & Medium Development	111	0.09%
Low Development & Open Space	1,024	0.87%
Cropland	4,339	3.68%
Pasture	7,184	6.10%
Grassland	11,582	9.83%
Forests	42,634	36.20%
Wetlands	50,420	42.82%
Bare	146	0.12%
TOTAL * **	**117,760**	**100%**

*All land cover values are rounded to the nearest acre.
** Percent land cover is based on the acreage prior to rounding
*** Due to rounding error, the total percentage may not add up to 100.00%

c. Regional precipitation: A visual inspection of precipitation patterns during the 2010 monitoring season indicates that weather patterns are generally similar across the region. A rain event will generally be seen in all parts of the study area, although the timing and rainfall totals differ slightly. While there are some differences in precipitation, a comparison of records during the monitoring period in Sault Ste. Marie, Pickford, and Detour (Table 13) indicate that the totals are within 15% of each other and not significantly different enough to raise concern. The Pine River gage is 11 miles west of Pickford and is likely to experience similar precipitation patterns to the rest of the TMDL study area.

Table 13: Precipitation comparison for the monitoring period (June 1 – October 7, 2010)

	Sault Ste. Marie	Pickford	Detour
Rain Total (in)	19.06	21.39	18.08
Daily Average (in)	0.15	0.14	0.16
Standard Deviation	0.31	0.40	0.37
Coefficient of Variance	2.13	2.90	2.24

d. Flow: The distribution of flow in the Pine River during the monitoring period was widely varied with monitoring dates in all of the five flow categories, which means that a range of flows are represented during the monitoring duration. The flow duration curve for the Pine River is shown in Figure 10 with the monitoring dates plotted.

4.1.2. Limitations

The Area-Ratio method assumes that flow characteristics are the same in all of the watersheds. Although the reference gage on the Pine River is close to each of the TMDL watersheds, regional variability in precipitation likely leads to some error in estimating streamflow at the ungaged sites. For the Area-Ratio method, it is desirable that the drainage areas of the gaged and ungaged sites are similar (i.e. a ratio of 0.5 to 1.5; Archfield and Vogel, 2010). This is not possible for all of the TMDL watersheds, which have drainage areas ranging from 0.7 to 186.7 mi^2, compared to 184 mi^2 for the Pine River gage. It is likely that the small watersheds will be flashier than the Pine River, responding more quickly to rain events.

4.2. Linkage between Point and Nonpoint Sources and Water Quality

Establishing links between potential bacteria sources and *E. coli* concentrations measured in the TMDL watersheds is complicated by the large number of potential sources and the variability of bacteria monitoring results. Although the sparseness of available data make it difficult to draw site-specific conclusions, the load duration curves, field observations, and land cover data can identify general patterns and trends that provide perspective on significant *E. coli* sources in these watersheds (Table 14) (adapted from EPA 2007b).

Table 14: Potential relative importance of sources for different flow conditions

Bacteria Source	Flow Duration Interval				
	High Flow	Moist Conditions	Mid-Range Flow	Dry Conditions	Low Flow
WWTF				M	H
Illicit connections to storm sewers and surface waters				M	H
WWSLs and OSDS			H	M	
Sanitary sewer leaks			H	M	
Urban stormwater (nonpoint & point source)		H	H	H	
Sanitary sewer and OSDS overflows	H	H	H		
Rural stormwater	H	H	M		
Streambed sediment remobilization	H	M			
Explanation: H = High; M = Medium					

As described in Section 1.2, a watershed approach has been used to develop TMDLs for the 33 impaired water body segments listed in Table 1. This approach evaluates *E. coli* sources in each HUC-12 watershed that includes impaired segments. Within the HUC-12 watersheds, *E. coli* sources, land cover, and watershed characteristics are quite similar. The resulting *E. coli* loading and WQS exceedances shown in the load duration curves therefore have similar flow regime and magnitude characteristics, even though they represent data collected at different sites in the same watershed. Due to this consistency, representativeness, and hydrologic connection of the tributaries, the Load Allocations and Wasteload Allocations calculated for each of the eight tributary watersheds described in Section 1.2 apply to each impaired segment in the watershed. The following similarities in the plots are discussed further in the next sections.

- Ashmun Creek Figures 14 - 16 show two of the three sites with exceedances in the mid to low flow regimes
- Mission Creek Figures 18 and 19 show exceedances under a wide range of conditions from moist to low flow
- Waishkey River Figures 25 - 27 all show no exceedances of the PBC standards and few exceedances above the TBC standards
- Charlotte River Figures 30 - 33 show exceedances across all flow regimes in three of four locations, and high levels of exceedance under high flow
- Little Munuscong River Figures 36 - 37 show one exceedance in the moist conditions and a few under dry conditions
- Munuscong River Figures 40 - 44 show exceedance in high to dry flow regimes

4.2.1. Seymour Creek Watershed

The Seymour Creek Watershed is near the western edge of Sault Ste. Marie. Land in the watershed is 48% forest and 28% wetlands (Table 2 and Figure 11). Based on the 2010 U.S. Census, there is an estimated population of 1573 persons occupying 658 housing units in the Seymour Creek watershed (Figure 3 and Table 7). Developed areas - primarily low density - occupy 17% of the watershed and include a part of the Tanglewood Marsh golf course. Approximately the northern half of the watershed, including most of the developed area, is served by sanitary sewers draining to the City of Sault Ste. Marie Wastewater Treatment Plant (WWTP). The WWTP outfall discharges to the St. Marys River and is outside of the Seymour Creek Watershed. Aerial photographs (Microsoft, 2011) indicate that eight OSDS are present in the southern half of the watershed. One site (Se1) near the mouth of the creek was monitored in 2010, and this site had frequent exceedances of the WQS. The area around Se1 is highly developed, with a vegetative buffer of less than 50 feet. Wooded riparian buffers are visible on the aerial orthophotograph (Microsoft, 2011) throughout most of the watershed, with the exception of the golf course.

Nonpoint Sources

Potential nonpoint sources of *E. coli* include: illicit connections to storm sewers and surface waters; improper garbage disposal (litter); urban and golf course runoff carrying pet and/or wildlife feces (e.g. geese, other waterfowl, and mammals); failing, improperly designed or overflowing OSDS; and wildlife.

Point Sources

The only NPDES permitted facility in the Seymour Creek Watershed is the sanitary sewer collection system for the City of Sault Ste. Marie WWTP. The outfall for the WWTP is outside the Seymour Creek Watershed. Leaking sanitary sewers from the City of Sault Ste. Marie WWTP collection system and sanitary sewer overflows are potential point sources in the watershed, however no SSO have been reported. Older sanitary sewer collection systems may have infiltration issues and result in leakage of raw sewage. It is unknown if the City of Sault Ste. Marie WWTP collection system is leaking; therefore it is listed as a potential source.

Linkage Analysis

The load duration curve for Se1 is shown in Figure 12. Both the total and partial body contact daily maximum water quality standards were exceeded during a range conditions from low flows through moist conditions. This monitoring site had the 4th highest frequency of WQS exceedance of all of the TMDL watershed sites monitored in 2010, with the maximum daily geometric mean *E. coli* concentration of 3,444 CFU/100 mL. The BST analysis indicated a high proportion of bacteria from human sources. Low flow WQS exceedances may therefore be due to illicit discharges to storm sewers or surface waters and/or leaking sanitary sewer collection system. Exceedances during dry, mid-range and moist conditions are more likely related to urban wildlife and pet waste in runoff from developed areas and/or the golf course.

Comparison of *E. coli* monitoring data and daily precipitation (Figure 13) indicates that the highest concentrations occurred during the driest weather in July 2010. This is consistent with low flow sources such as illicit discharges, failing or poorly designed OSDS, leaking sanitary sewers, or wildlife congregating in the stream (e.g. geese). Lower concentrations (but still above the total body contact WQS of 100 CFU / 100 mL) are common during periods with frequent rains, consistent with wet weather sources of bacteria (stormwater).

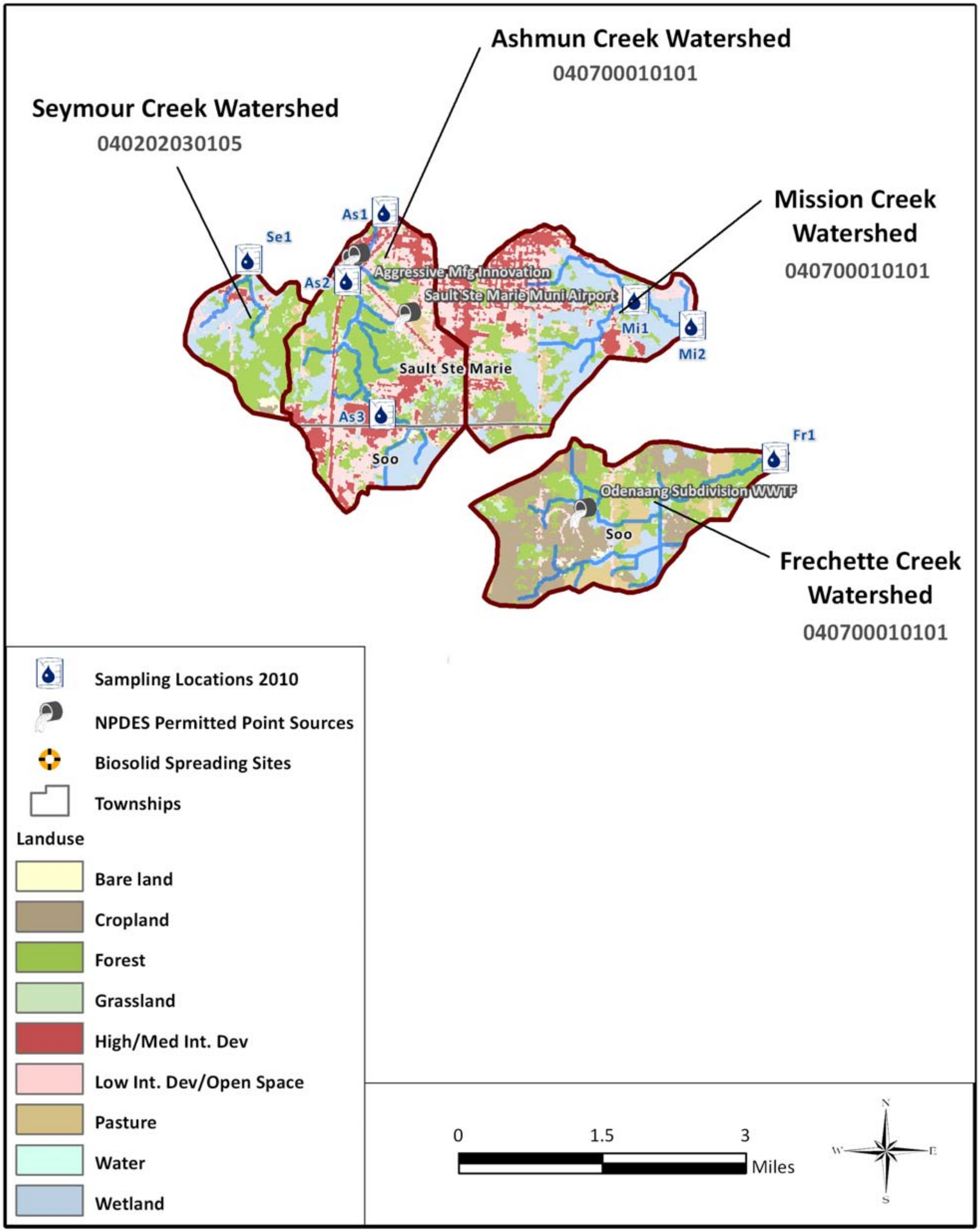

Figure 11: Characteristics of the Seymour, Ashmun, Mission and Frechette Creeks Watersheds.

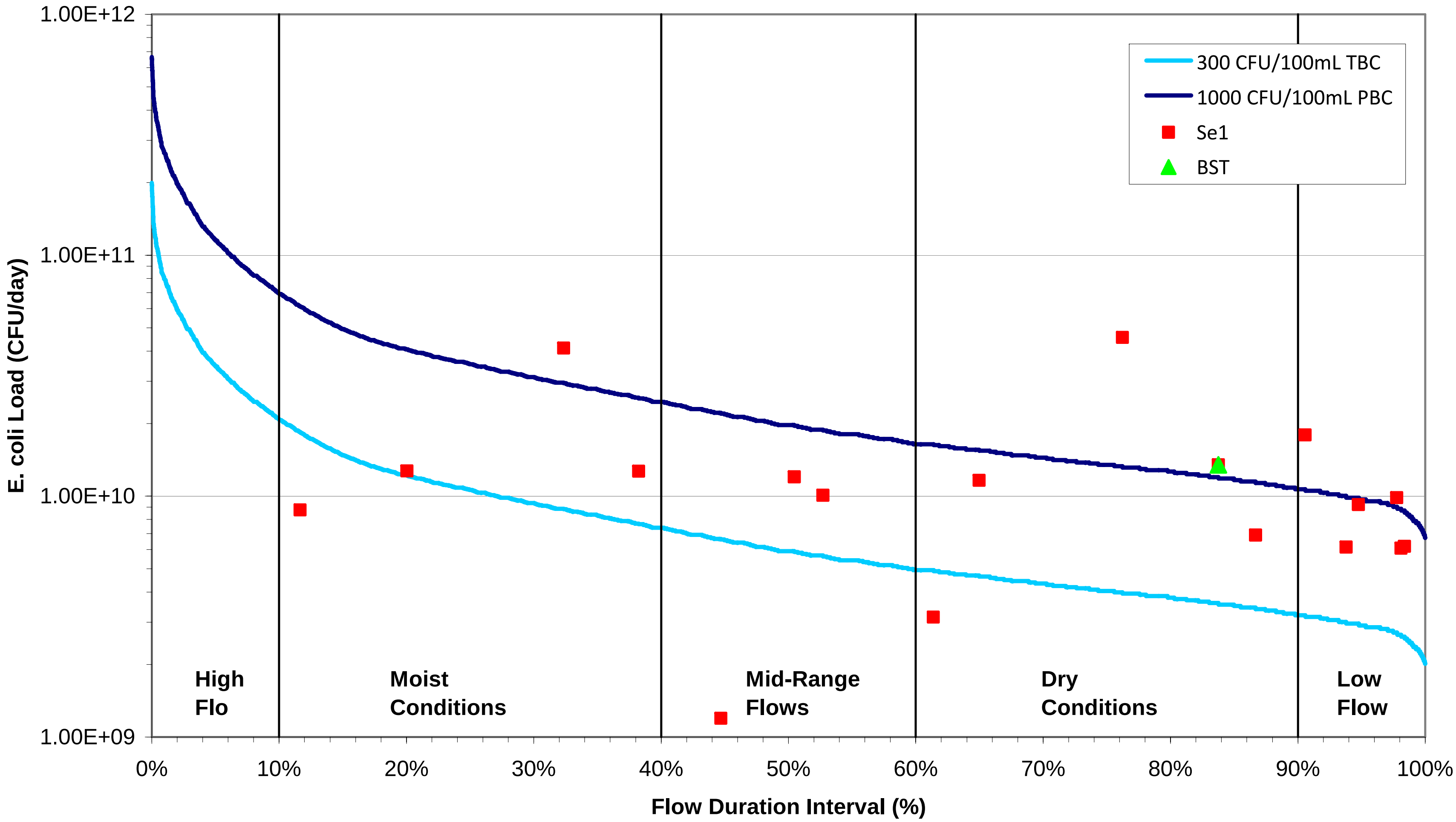

Figure 12: Load duration curve for Seymour Creek Watershed monitoring site Se1
Note: red squares indicate 2010 weekly *E. coli* data. Green triangle indicates *E. coli* result for BST sample.

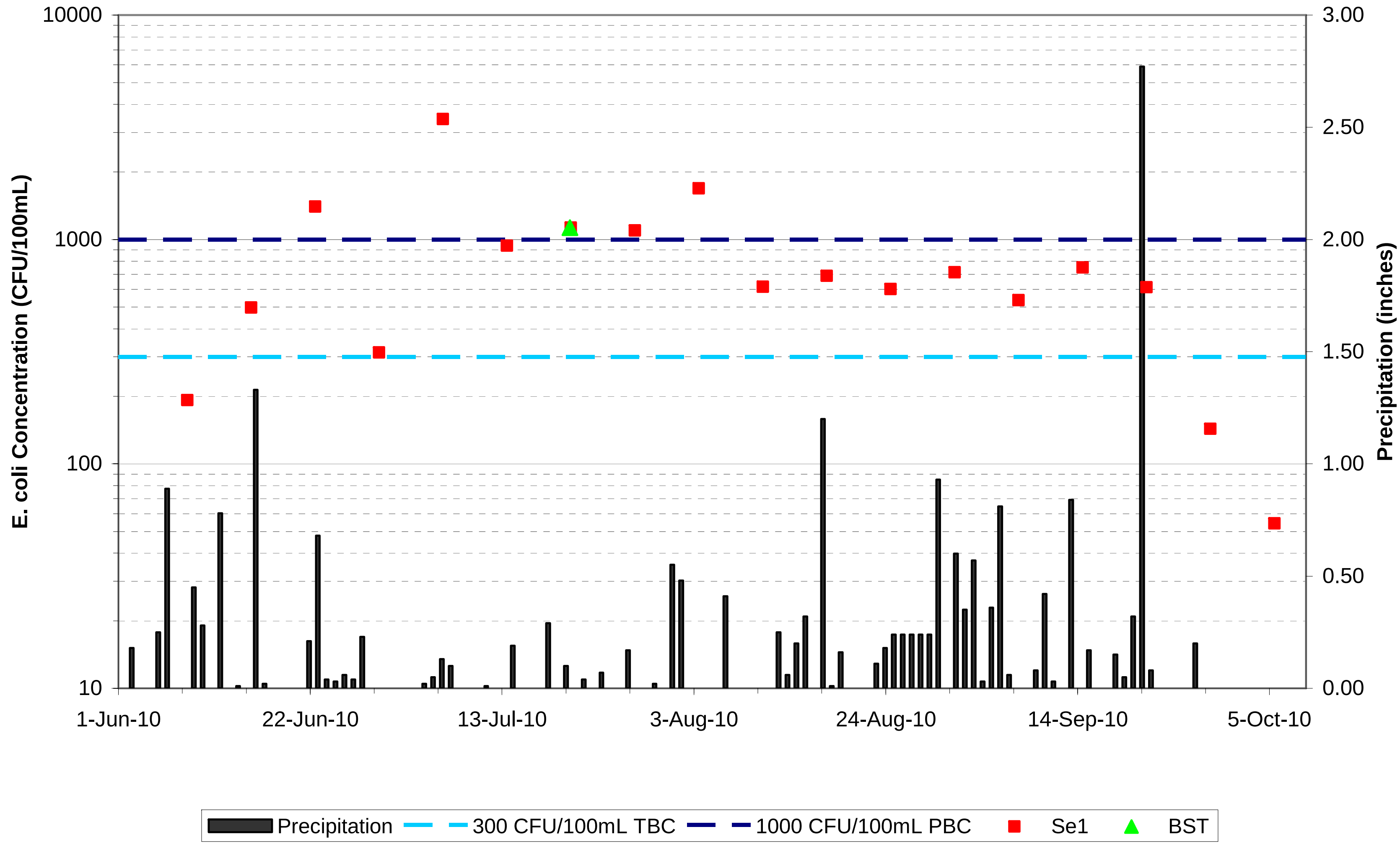

Figure 13: ***E. coli*** **concentrations and precipitation in the 24-hours preceding sample collection for the Seymour Creek watershed.**

4.2.2. Ashmun Creek Watershed

The Ashmun Creek Watershed is 49% developed land (Table 2 and Figure 11), with 77% of the watershed within the City of Sault Ste. Marie, and 23% of the watershed in Soo Township. Based on the 2010 U.S. Census, there is an estimated population of 4289 persons occupying 1787 housing units in the Ashmun Creek watershed (Figure 3 and Table 7). Virtually the entire watershed is served by the City of Sault Ste. Marie's WWTP, although the WWTP outfall discharges to the St. Marys River and is outside the Ashmun Creek Watershed. Aerial photographs (Microsoft, 2011) indicate that two OSDS are present near the southeast and western boundaries of the watershed. Forests cover 30% of the watershed and are concentrated in the central portion of the watershed. *E. coli* samples were collected in 2010 from three locations in the Ashmun Creek Watershed (Figure 11). Samples exceeded the total and partial body contact daily maximum WQS during most weeks, including high and low flow events. A low proportion of human bacteria were detected in a BST sample collected at As1 on August 19, 2010. Fewer WQS occurred at site As2, perhaps indicating some dilution of *E. coli* in the more heavily forested central part of the watershed.

Nonpoint Sources

Potential nonpoint sources of *E. coli* include: illicit connections to storm sewers and surface water; urban runoff carrying pet and wildlife feces (e.g. birds, raccoons and rodents); improper garbage disposal (litter); failing, improperly designed or overflowing OSDS; and wildlife feces in runoff from forested areas.

Point Sources

There are 3 industrial stormwater NPDES permitted point source dischargers in the watershed, all upstream of monitoring site As1 and downstream of sites As2 and As3 (Table 15 and Figure 11). Leaking sanitary sewers and sanitary sewer overflows in the City of Sault Ste. Marie WWTP collection system are also potential point sources, however no SSO have been reported.

Table 15: NPDES permitted point source dischargers in the Ashmun Creek Watershed.

Regulated Entity	Permit No.	Permit Type	Receiving Water	AUID
Sault Ste Marie Muni Airport	MIS110006	Storm Water from Industrial Activities	Ashmun Creek	040700010101-02
Hoover Precision Products	MIS110015	Storm Water from Industrial Activities	Ashmun Creek	040700010101-02
Aggressive Mfg Innovation	MIS111667	Storm Water from Industrial Activities	Ashmun Creek	040700010101-02

Linkage Analysis

The load duration curve for As1, the monitoring site farthest downstream in the Ashmun Creek Watershed, is shown in Figure 14. As1 is a few hundred yards upstream of Whitefish Bay in a densely wooded area with mulched hiking and All Terrain Vehicle (ATV) trails. However, most of the reach from As1 upstream to As2 lacks riparian buffers. This site receives runoff from some of the most densely developed areas of Sault Ste. Marie, including both industrial and residential areas.

WQS were exceeded in most of the 18 monitoring weeks, during conditions ranging from low flows to moist conditions. The majority of exceedances at site As1 and As2 occurred during low flows indicating a constant source such as illicit connections or leaking sanitary sewers. Site As1 had the 3rd highest frequency of WQS exceedances of the locations in the TMDL watersheds monitored in 2010, with a maximum *E. coli* daily geometric mean of 6,288 CFU/100 mL.

The load duration curve for As2**,** the middle site on Ashmun Creek, is shown in Figure 15. This site is located immediately upstream of the I-75 crossing, approximately 1 mile upstream of As1. The riparian area near this site has dense grass and tree cover. Fewer exceedances of the WQS occurred at As2 than either the upstream or downstream sites, and with the number of WQS exceedances at As2 ranking 17th out of the 21 sites in the TMDL watersheds monitored in 2010. The maximum daily geometric mean *E. coli* concentration at this site was 1251 CFU/100 mL. This may reflect the larger proportion of forest in the watershed and the presence of wooded buffers upstream of As2 compared with As1 and As3.

The load duration curve for As3, the monitoring site farthest upstream in the watershed, is shown in Figure 16. The area immediately around As3 is a steep, heavily mowed road-crossing embankment, and 2006-era land cover in the vicinity of As3 is highly developed (NOAA, 2006). A buffer of infrequently mowed, tall grass approximately 20-feet wide is present between the creek and the road and parking lots. Parking lots, roadways, and industrial complexes are nearby, and much of the developed area upstream of As3 lacks a riparian buffer. The load duration curve indicates that exceedances of the *E. coli* standard are most common for flows during dry conditions and mid-range flows, with the two highest daily *E. coli* loads occurring during or the day after precipitation events. This pattern is consistent with contaminated urban stormwater released during small, frequent runoff events. The WQS exceedance frequency at this site ranked 13th out of the 21 sites in the TMDL watersheds monitored in 2010, with a maximum daily geometric mean *E. coli* concentration at this site was 14,097 CFU/100 mL. There are no NPDES permitted point source dischargers upstream of site As1.

Comparison of *E. coli* monitoring data and daily precipitation (Figure 17) indicates that concentrations above the total and partial body contact daily maximum WQS occur during dry periods (resulting from low flow sources, such as illicit discharges or leaking sanitary sewers) and wet periods (sources such as urban stormwater contaminated with wildlife and pet waste).

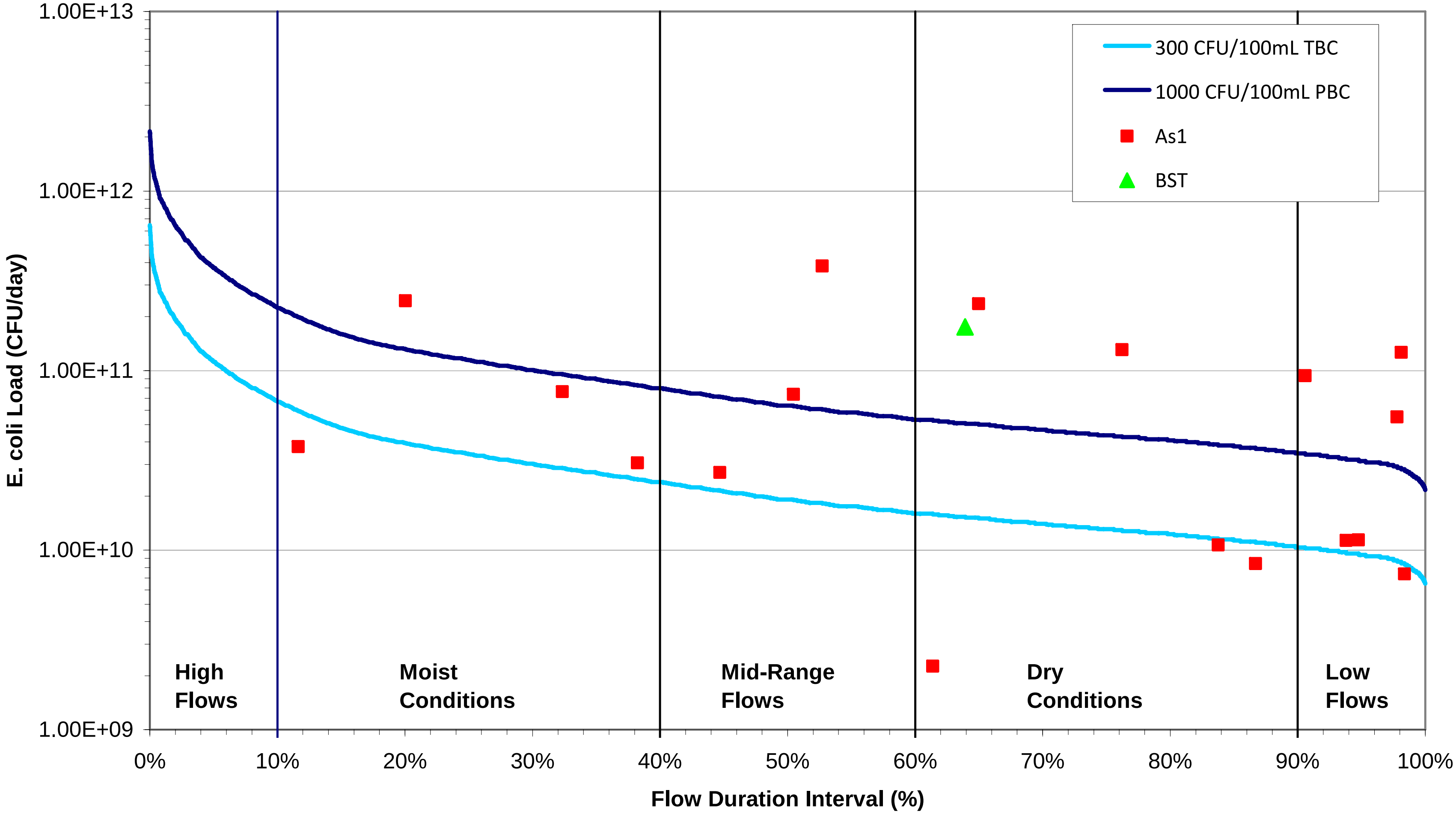

Figure 14: Load duration curve for Ashmun Creek Watershed monitoring site As1

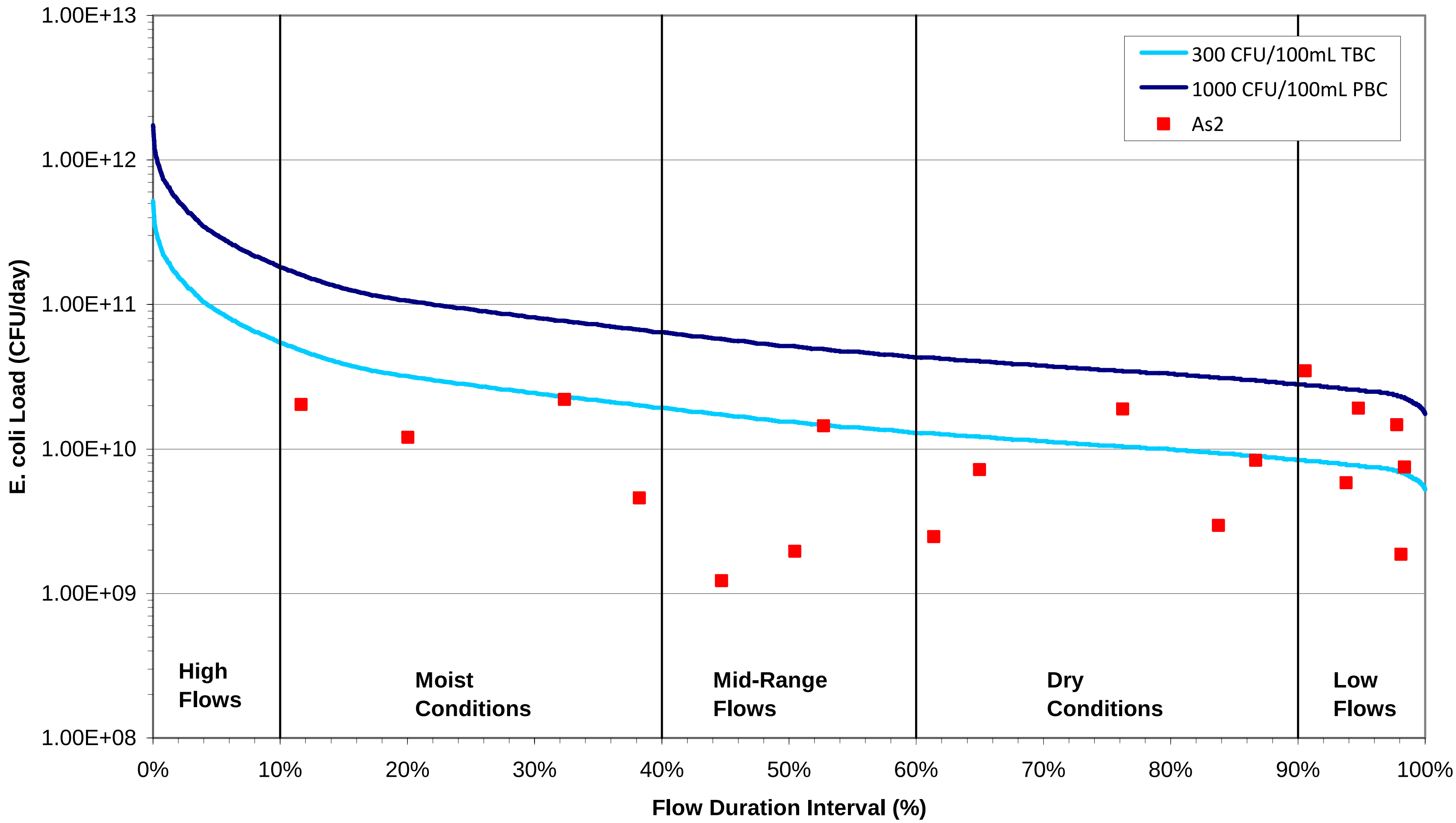

Figure 15: Load duration curve for Ashmun Creek Watershed monitoring site As2

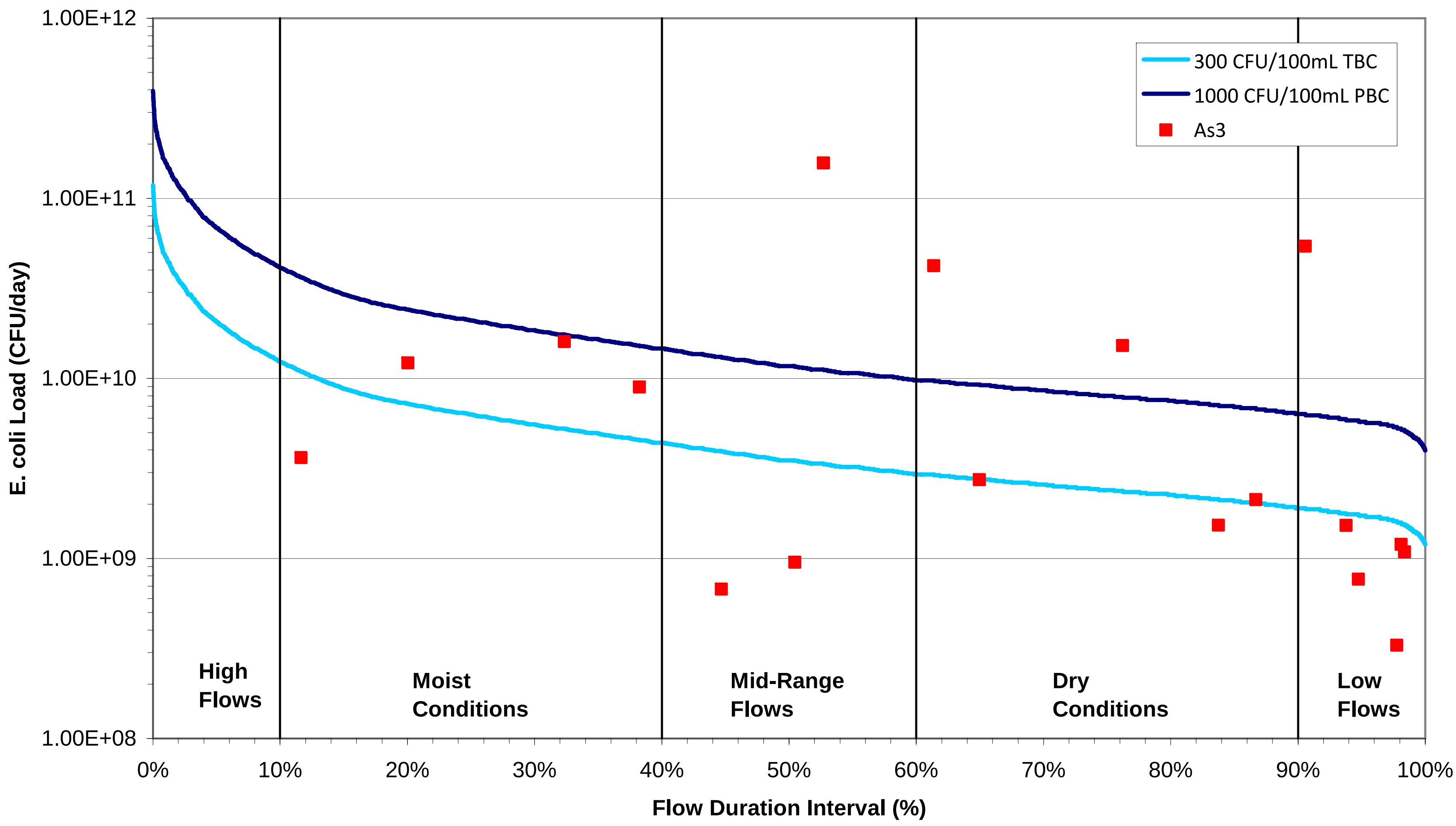

Figure 16: Load duration curve for Ashmun Creek Watershed monitoring site As3

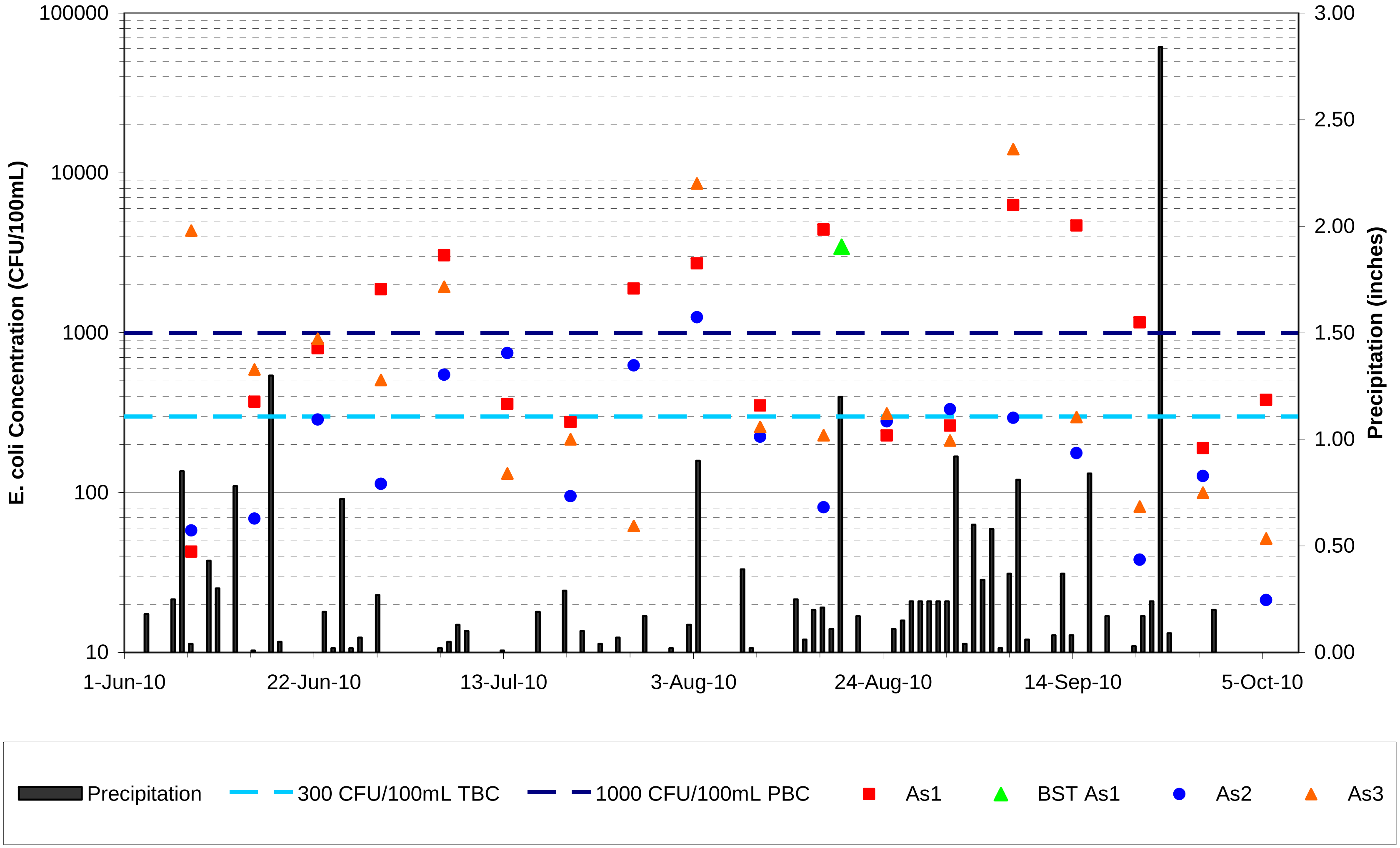

Figure 17: *E. coli* concentrations and precipitation in the 24-hours preceding sample collection for the Ashmun Creek Watershed.

4.2.3. Mission Creek Watershed

Most of the Mission Creek Watershed (96%) is located in the southeastern part of the City of Sault Ste. Marie, and 4% of the watershed is located in Soo Township. Its most common land covers are developed areas, wetlands, and forests (Table 2 and Figure 11). Based on the 2010 U.S. Census, there is an estimated population of 5375 persons occupying 2514 housing units in the Mission Creek watershed (Figure 3 and Table 7). All developed areas in the watershed are served by the City of Sault Ste. Marie WWTP, although the WWTP outfall is directly to the St. Marys River and outside the Mission Creek Watershed. During the 2010 monitoring season, the *E. coli* WQS were frequently exceeded at both monitoring sites in the watershed (Mi1 and Mi2). BST detected no human bacteria at Mi1 on August 19, 2010, and a low proportion of human bacteria at Mi2 on October 7, 2010. The Sault Ste Marie county club and golf course is located between the 2 monitoring sites. Mi2 is located approximately 100 feet upstream of a channel to the St Marys River, and water was observed to be flowing upstream in all or part of the stream cross section from the St. Marys River during 13 of the 18 sample collection events. This likely impacted the monitoring results, and dates with reverse flow are indicated in Appendix A. The reach of Mission Creek between Mi1 and Mi2 is heavily forested; however a tributary that joins Mission Creek just upstream of its mouth at the St. Marys River drains from the Sault Ste. Marie Country Club and generally lacks riparian buffers, indicating that waterfowl congregating on the golf course are a potentially significant source. Upstream of Mi1, wooded buffers are common, but there are several developed areas without buffers.

Nonpoint Sources

Potential nonpoint sources of *E. coli* include: illicit connections to storm sewers and surface water; urban runoff carrying feces from pets and congregating urban wildlife (e.g. waterfowl on the golf course, raccoons and rodents); failing or improperly designed OSDS; and rural runoff carrying wildlife feces.

Point Sources

The only NPDES permitted facility in the Mission Creek Watershed is the sanitary sewer collection system for the City of Sault Ste. Marie WWTP. The outfall for the WWTP is located on the St. Marys River and is outside the Mission Creek Watershed. Leaking sanitary sewers from the City of Sault Ste. Marie WWTP collection system and sanitary sewer overflows are potential point sources in the watershed, however no SSOs have been reported. Older sanitary sewer collection systems may have infiltration issues and result in leakage of raw sewage. It is unknown if the City of Sault Ste. Marie WWTP collection system is leaking; therefore it is listed as a potential source.

Linkage Analysis

The load duration curves for Mi1 and Mi2 (Figure 18 and Figure 19) indicate exceedances of WQS in conditions ranging from low flows to moist conditions. This suggests a dry weather, such as illicit connections to storm sewers or surface waters, waterfowl congregating in the stream, and/or leaking sanitary sewers, as well as a wet weather source, such as urban runoff containing bacteria from urban wildlife and/or pets.

Comparison of *E. coli* monitoring data and daily precipitation (Figure 20) indicates that concentrations above the total and partial body contact daily maximum WQS are common during both dry periods and periods with frequent precipitation. This is consistent with low flow sources, such as illicit discharges or leaking sanitary sewers, and runoff driven sources such as urban stormwater contaminated with wildlife and pet waste. Sites Mi1 and Mi2 had the 5th and 9th most frequent WQS exceedances of the 21 sites in the TMDL watersheds monitored in 2010. The maximum *E. coli* daily geometric mean concentrations were 16,536 CFU/100 mL at Mi1 and 4,744 CFU/100 mL at Mi2.

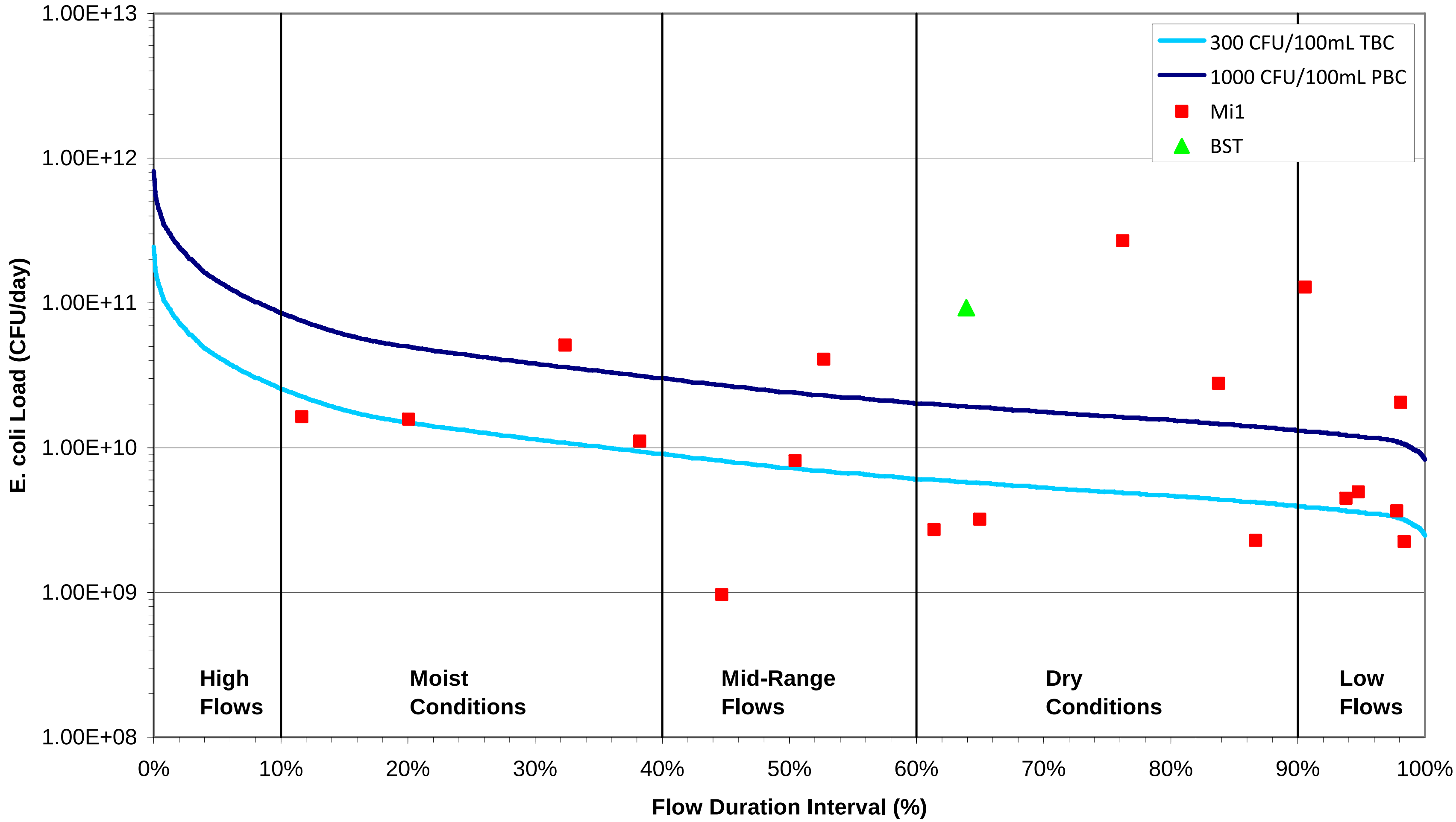

Figure 18: Load duration curve for Mission Creek Watershed monitoring site Mi1

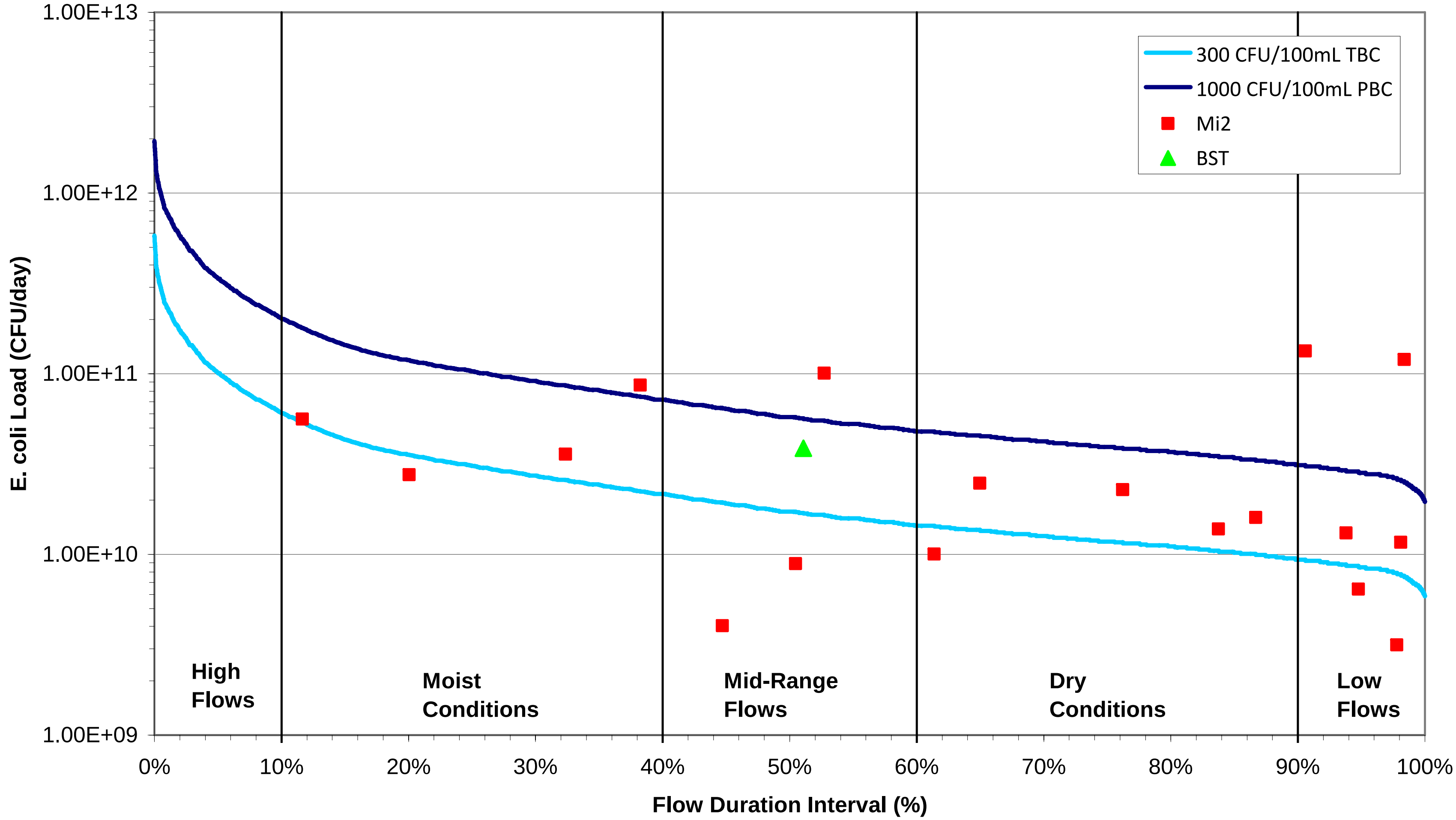

Figure 19: Load duration curve for Mission Creek Watershed monitoring site Mi2

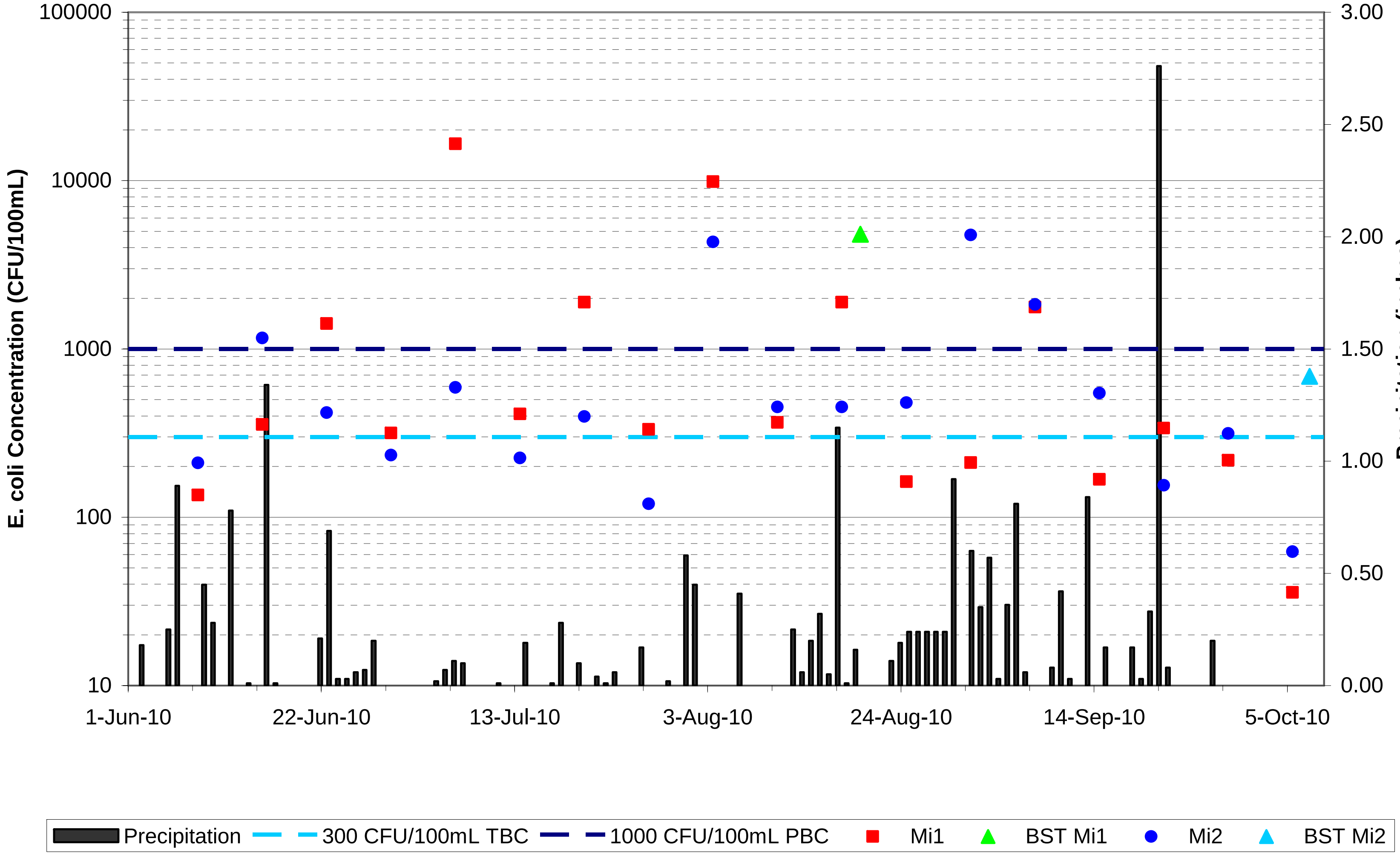

Figure 20: ***E. coli*** **concentrations and precipitation in the 24-hours preceding sample collection for the Mission Creek watershed.**

4.2.4. Frechette Creek Watershed

The Frechette Creek Watershed is located approximately 4 miles southeast of Sault Ste. Marie. It includes only 5% developed land, and these areas are served by OSDS. Based on the 2010 U.S. Census, there is an estimated population of 967 persons occupying 373 housing units in the Frechette Creek watershed (Figure 3 and Table 7). The most common land covers (Table 2 and Figure 11) are cropland (35%), forest (30%), and pasture (15%). One 2010 monitoring site, Fr1, is located in the watershed, approximately 600 feet upstream the St Marys River. Reverse flow from the river was observed during 3 of the 18 sample collection events (indicated in Appendix A). Much of Frechette Creek has a wooded riparian buffer, however large portions of the headwaters have very thin or no buffers in agricultural and developed areas. The BST sample collected on July 20, 2010 had a moderate proportion of human bacteria (Table 8), indicating illicit connections or failing OSDS.

Nonpoint Sources

Potential nonpoint sources of *E. coli* include: failing, poorly designed or overflowing OSDS and illicit connections (human influence indicated by BST results); runoff from livestock in pasture areas, and runoff from pets and wildlife.

Point Sources

One NPDES permitted point source discharger, the Odenaang Subdivision WWTF, is located in the Frechette Creek Watershed (Table 16 and Figure 11). The Odenaang Subdivision WWTF is operated by the Sault Tribe of Chippewa Indians, and therefore is authorized to discharge (in accordance with its effluent limitation of 126 CFU/100 mL for the 30-day geometric mean for *E. coli* and monitoring requirements contained in their NPDES permit) by the EPA; therefore, it is the EPAs responsibility to ensure that NPDES permit compliance and effluent limitations are sufficient to ensure that Michigans WQS are met when tribal waters enter waters of the state of Michigan. EPA records indicate that the facility is in compliance with the permit.

Table 16: NPDES permitted point source dischargers in the Frechette Creek Watershed.

Regulated Entity	Permit No.	Permit Type	Receiving Water	AUID
Odenaang Subdivision WWTF	MI-0057087-2[1]	Wastewater Treatment Facility	Frechette Creek	040700010101-05

[1] Permit issued by EPA.

Linkage Analysis

The load duration curve for Fr1 (Figure 21) indicates that both the total and partial body contact daily maximum WQS were exceeded in a range of flow durations, from low flows to moist conditions. This suggests both a dry weather source, such as OSDS, and a wet weather source, such as agricultural runoff.

The highest 3 *E. coli* concentrations in the Frechette watershed occurred during both wet (mid-June and mid-August) and dry (early July) periods (Figure 22). The lowest concentrations occurred during relatively wet weather from late August through early October, although it is possible that this trend may be due, at least in part, to declining water temperature in the fall. These observations also indicate both wet and dry weather sources. Monitoring site Fr1 had the 8th most frequent WQS exceedances of the 21 sites in the TMDL watersheds monitored in 2010, with a maximum daily geometric mean *E. coli* concentration of 3,472 CFU/100 mL.

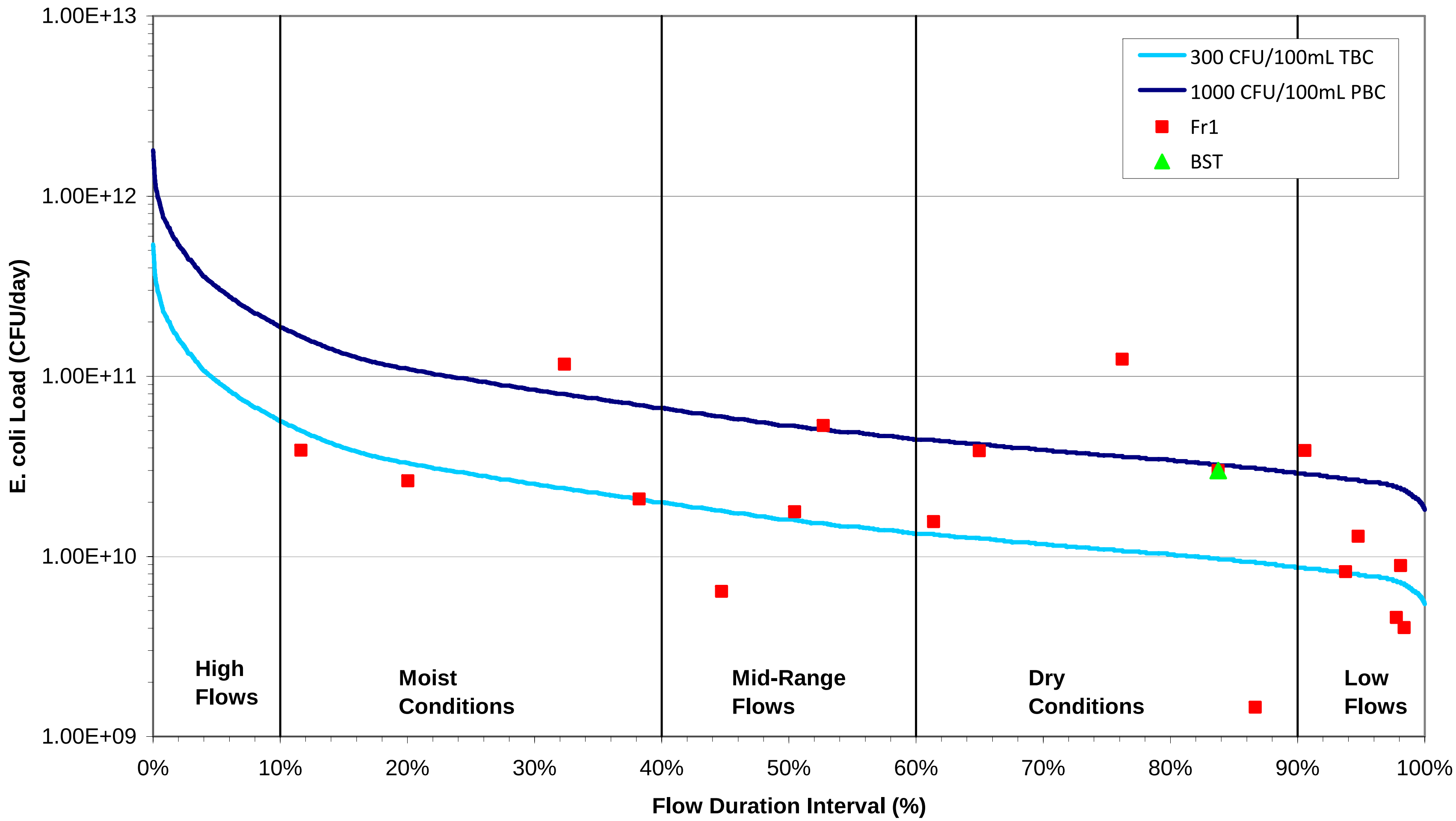

Figure 21: Load duration curve for Frechette Creek Watershed monitoring site Fr1

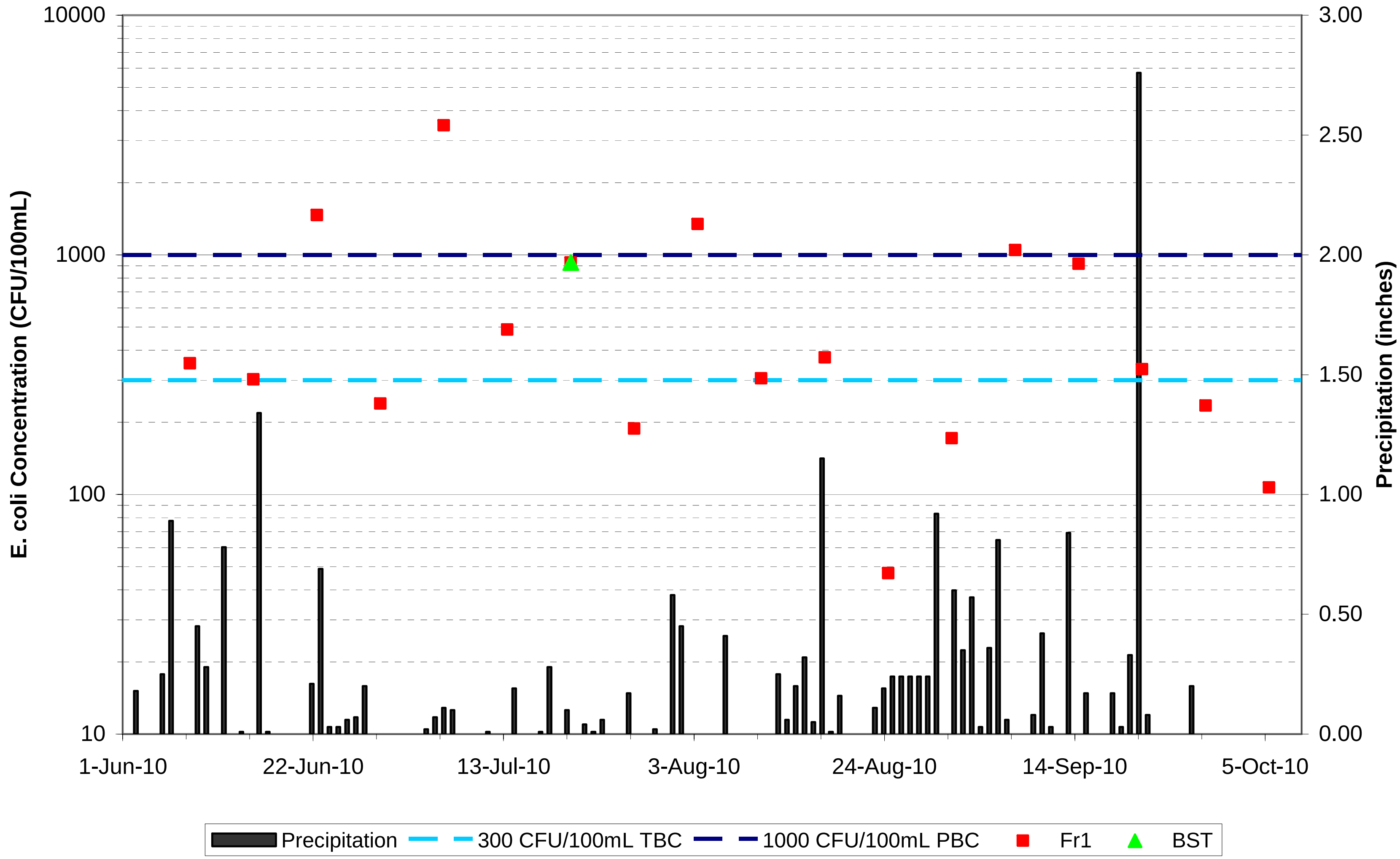

Figure 22: ***E. coli*** **concentrations and precipitation in the 24-hours preceding sample collection for the Frechette Creek watershed.**

4.2.5. Waishkey River Watershed

The Waishkey River Watershed is located southwest of the City of Sault Ste. Marie. More than 70% of the watershed is covered by forest and wetlands, 17% of the area is cropland or pasture, and less than 3% is developed land (Table 2 and Figure 23). Based on the 2010 U.S. Census, there is an estimated population of 7,111 persons occupying 2,614 housing units in the Waishkey River Watershed (Figure 3 and Table 7). These households are served by OSDS. *E. coli* samples were collected in 2010 at three sites in the watershed. The total body contact daily maximum WQS was exceeded once at the site farthest downstream (Wa1), four times at Wa2 on Hickler Creek, and three times at Wa3 on the East Branch of the Waishkey River. The partial body contact WQS was not exceeded by any of the 2010 samples in the Waishkey River. No BST samples were collected in the Waishkey watershed.

Nonpoint Sources

Potential nonpoint sources of *E. coli* include failing, poorly designed or overflowing OSDS, illicit connections to surface water, runoff from active livestock pasture and the land-application of manure, manure stockpiling, livestock with direct access to streams or wetlands, wildlife and pets. Some OSDS in the Waishkey River Watershed have been observed to be closer to streams than the 200-foot setback required by the Superior Environmental Health Code for lagoon systems, creating a higher potential risk of bacteria contamination of streams.

Point Sources

NPDES permitted point source dischargers in the Waishkey River Watershed include the Dafter Sanitary Landfill, the Continental Teves-Brimley Wastewater Stabilization Lagoon (WWSL), and the Kinross Township Waste Water Treatment Facility (Figure 23 and Table 17). All three are located upstream of Wa2. The Kinross Township Wastewater Treatment Facility (WWTF) serves development in the vicinity of the former Kincheloe Air Force Base. Although the discharge point for the Kinross WWTF is located in the Waishkey Creek Watershed, virtually all of the area served by the facility is located in the Munuscong River Watershed. The plant uses clarifiers, trickling filters and sedimentation tanks before chlorination for primary, secondary, and tertiary wastewater treatment. Effluent discharges to Hutton Creek, a tributary of the Waishkey River. Two reported SSOs for the Kinross WWTF discharged dilute and partially treated sewage in 2005 and 2006. The first event was due to a sewer pipe blockage and occurred in the adjacent Munuscong River Watershed. The SSO in 2006 occurred at a secondary filter at the WWTF when a discharge valve was inadvertently left closed after repair work, and 1200 gallons of partially treated sewage were discharge to soil near the filter. Biosolids are treated to reduce pathogens and land-applied to agricultural land within Superior and Pickford Townships in the Waishkey watershed. Biosolids are the residuals settled out of municipal and commercial sanitary sewage during the treatment process, and are also known as sewage sludge.

The sanitary sewer collection system for the Superior Township WWSL serves a developed area in the Waishkey River Watershed near monitoring site Wa1. However, the WWSL discharges to Little Waishkey Creek and is outside of the TMDL watershed.

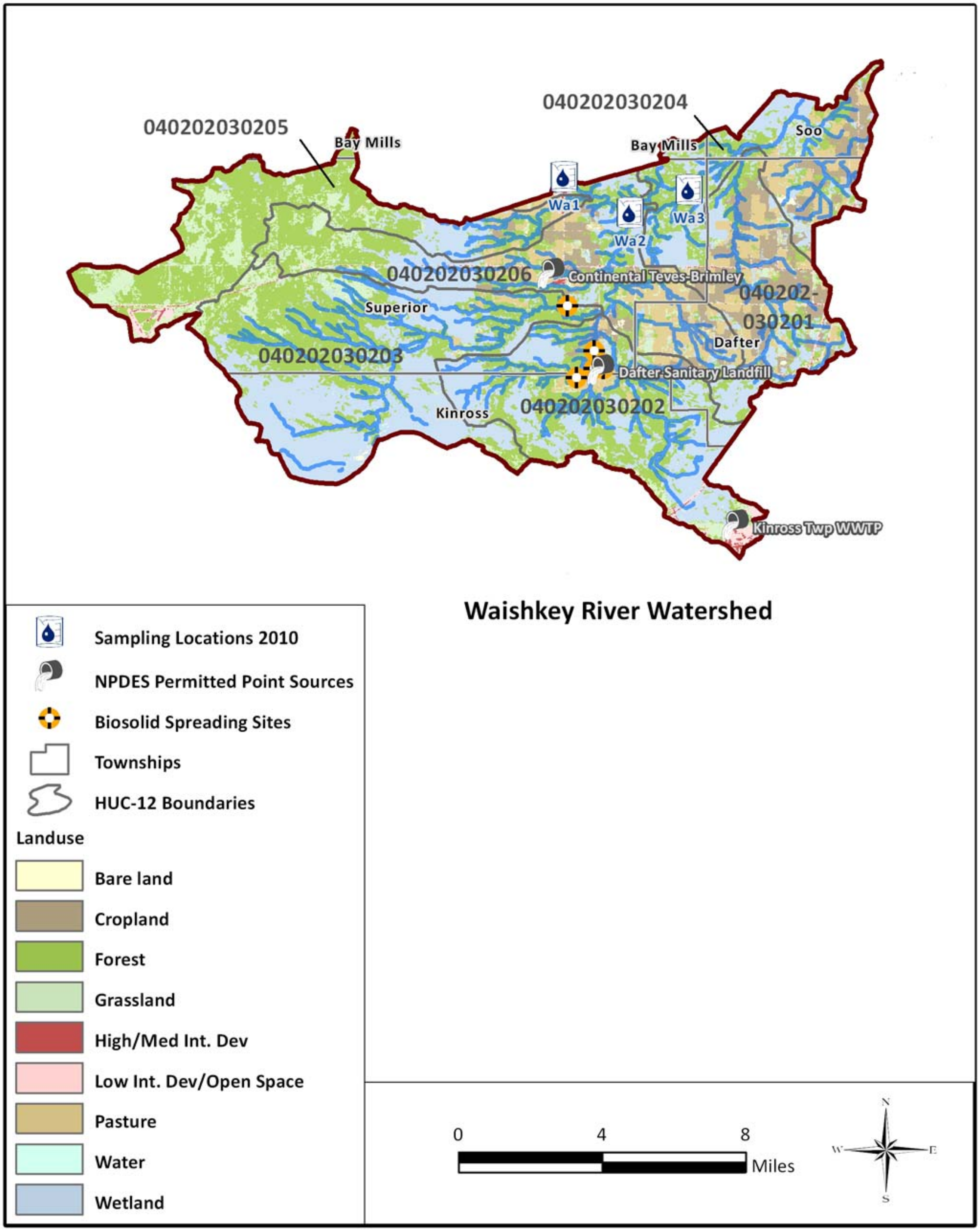

Figure 23: Characteristics of the Waishkey River Watershed.

Table 17: NPDES permitted point source dischargers in the Waishkey River Watershed.

Regulated Entity	Permit No.	Permit Type	Receiving Water	AUID
Dafter Sanitary Landfill	MIS110005	Storm Water from Industrial Activities	Waishkey River	040202030202-01
Continental Teves-Brimley	MIG580201	Wastewater Stabilization Lagoons	Hickler Creek and Waishkey River	040202030206-01
Kinross Twp WWTF	MI0057776	Wastewater Treatment Facility	A wetland contiguous with Hutton Creek	040202030202-02

Linkage Analysis

Comparison of *E. coli* concentrations with daily precipitation (Figure 24) indicates that the highest concentrations occurred in September 2010, which was the wettest part of the monitoring period. This suggests a runoff related bacteria source.

Subwatersheds upstream of Wa3 include the South Branch of the East Branch of the Waishkey River Watershed (HUC 040202030201) and much of the East Branch of the Waishkey River Watershed (HUC 040202030204) (Figure 23). The South Branch watershed has significant agricultural activity, with 33% cropland and 19% pasture. The East Branch watershed has less agriculture (15% cropland and 15% pasture) and more wetlands and forest (32% and 33%, respectively). Wooded buffers are common on the main stem of the East Branch, however many headwater reaches of its tributaries lack buffers. A large portion of the South Branch of the East Branch downstream of M-28 also lacks buffers.

Exceedances of the total body contact daily maximum WQS occurred at Wa3 during dry to moist conditions, with no exceedances during low flows (Figure 25). This suggests that bacteria are being transported from the upstream area during runoff events, with pastures being the most probable source. The WQS exceedances at site Wa3 ranked 19th out of the 21 sites in the TMDL watersheds monitored during 2010, with a maximum daily geometric mean *E. coli* concentration of 923 CFU/100 mL.

Three subwatersheds are upstream of monitoring site Wa2: the South Branch of the Waishkey River (HUC 040202030202), the West Branch of the Waishkey River (HUC 040202030203), and most of Hickler Creek (HUC 040202030206). The South and West Branches have predominantly natural land cover, with combined wetland and forest cover of 82% and 92%, respectively. The Hickler Creek Watershed has more agricultural land cover, with 12% cropland and 19% pasture. Vegetative buffers are very common along the South and West Branches, but large portions of Hickler Creek in agricultural areas lack buffers. All three NPDES permitted point source dischargers are located upstream of Wa2, and the Kinross Township WWTP is permitted (via its NPDES permit) to spread biosolids at five locations upstream of Wa2 (Figure 23).

Wa2 experienced total body contact daily maximum WQS exceedances in dry to moist conditions (Figure 26). This site ranked 18th out of the 21 sites monitored during 2010 in terms of WQS exceedance frequency, with a maximum daily geometric mean *E. coli* concentration of 517 CFU/100 mL. The three highest daily loads occurred approximately two days after rainfalls of 0.27 to 0.75 inches. This suggests a time lag between runoff events and delivery of bacteria downstream, which is consistent with the large watershed area and forest cover which has a slower response to rainfall. The most probable bacteria source is runoff affected by unregulated livestock pastures, manure stockpiling, and land application of livestock waste. The land-application of biosolids is a potential source, although the contribution would be minor given that the land area available for application is relatively small, the waste receives treatment to reduce pathogens, and the land-application is closely regulated by the MDEQ.

Wa1 is located 1,000-feet upstream of Whitefish Bay, and this site experienced reverse flows from St. Marys River in 6 of the 18 monitoring weeks (indicated in Appendix A). On those dates, bacteria concentrations may have been affected by water from Lake Superior. The area upstream of Wa1 includes the watersheds upstream of sites Wa2 and Wa3, plus the Orrs Creek Watershed (HUC 040202030205) and small parts of the South Branch of the East Branch and Hickler Creek – Waishkey River Watersheds. Orrs Creek has 93% natural land cover (forest, wetland and grassland) with little development or agriculture. Wooded buffers are present along most of Orrs Creek. In addition to the biosolids spreading locations discussed above, the Kinross Township WWTP has a permit to spread biosolids at one additional location upstream of Wa1 (Figure 23).

Monitoring site Wa1 had the lowest WQS exceedance frequency of the 21 sites in the TMDL watersheds monitored in 2010. The only exceedance of the total body contact daily maximum WQS at Wa1 occurred during dry conditions (Figure 27), with a maximum daily geometric mean *E. coli* concentration of 427 CFU/100 mL. The distribution of *E. coli* loads at different flow durations is similar to Wa2 and Wa3, and bacteria sources are likely to be similar.

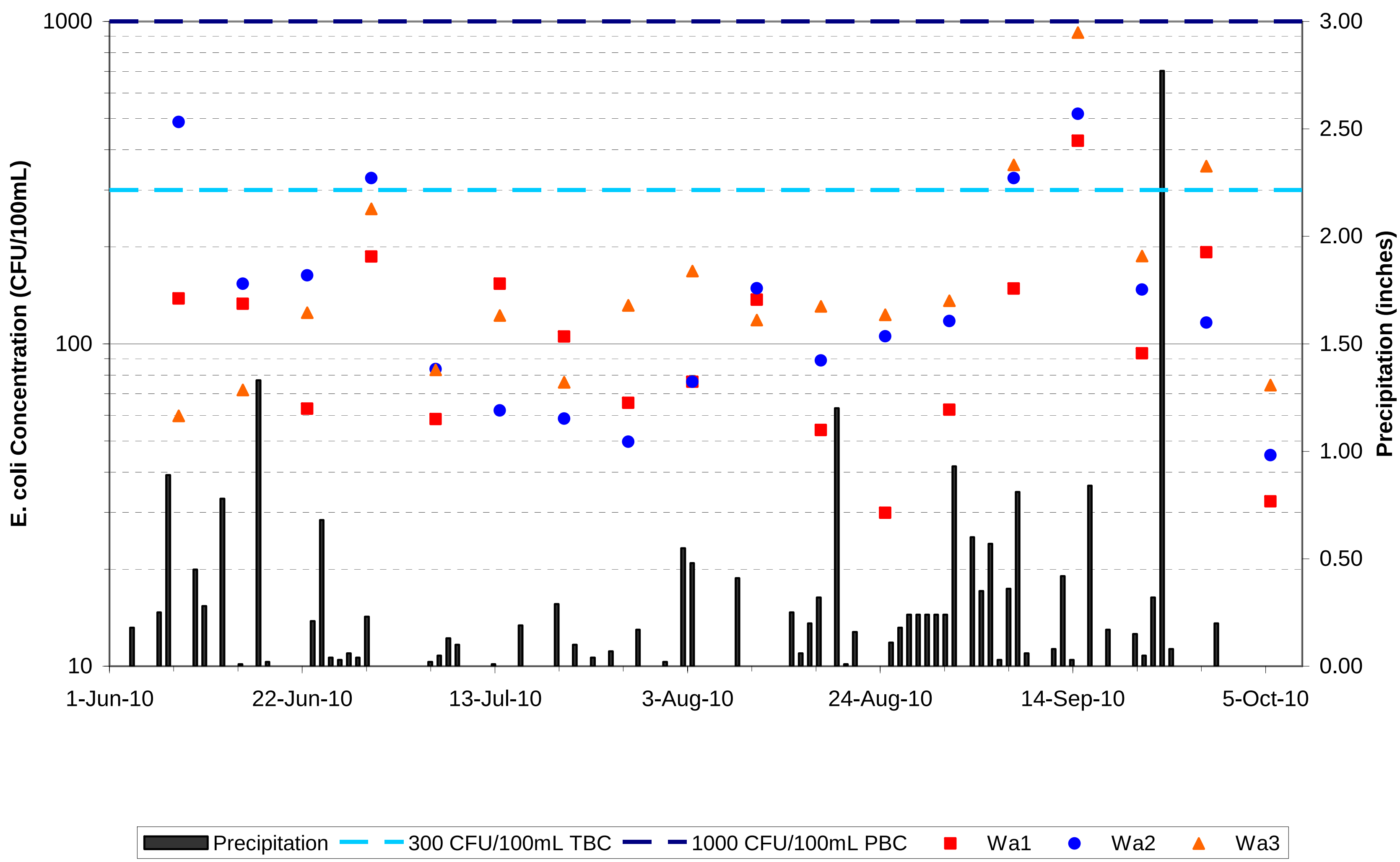

Figure 24: ***E. coli*** **concentrations and precipitation in the 24-hours preceding sample collection for the Waishkey River Watershed.**

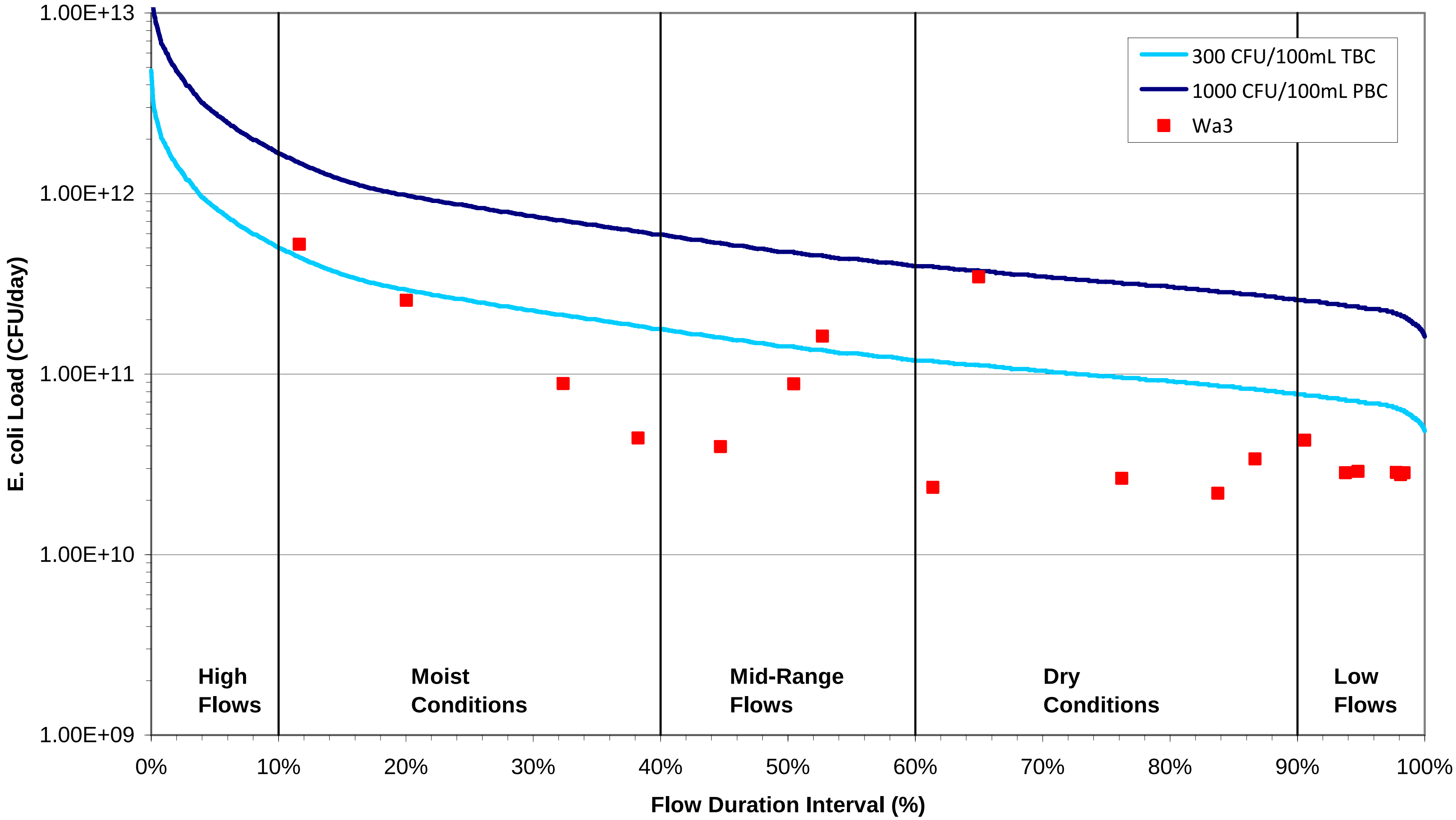

Figure 25: Load duration curve for Waishkey River Watershed monitoring site Wa3

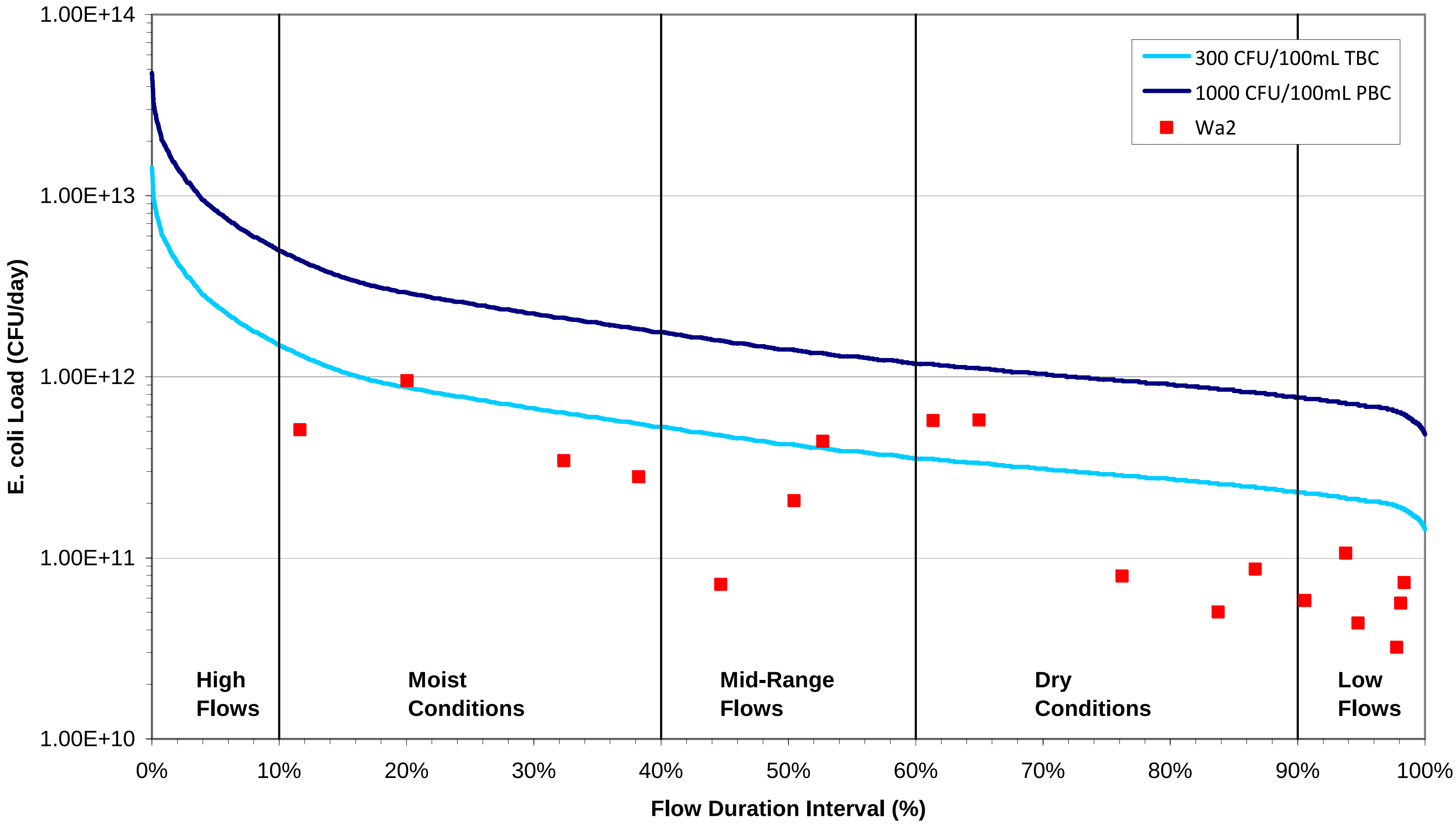

Figure 26: Load duration curve for Waishkey River Watershed monitoring site Wa2

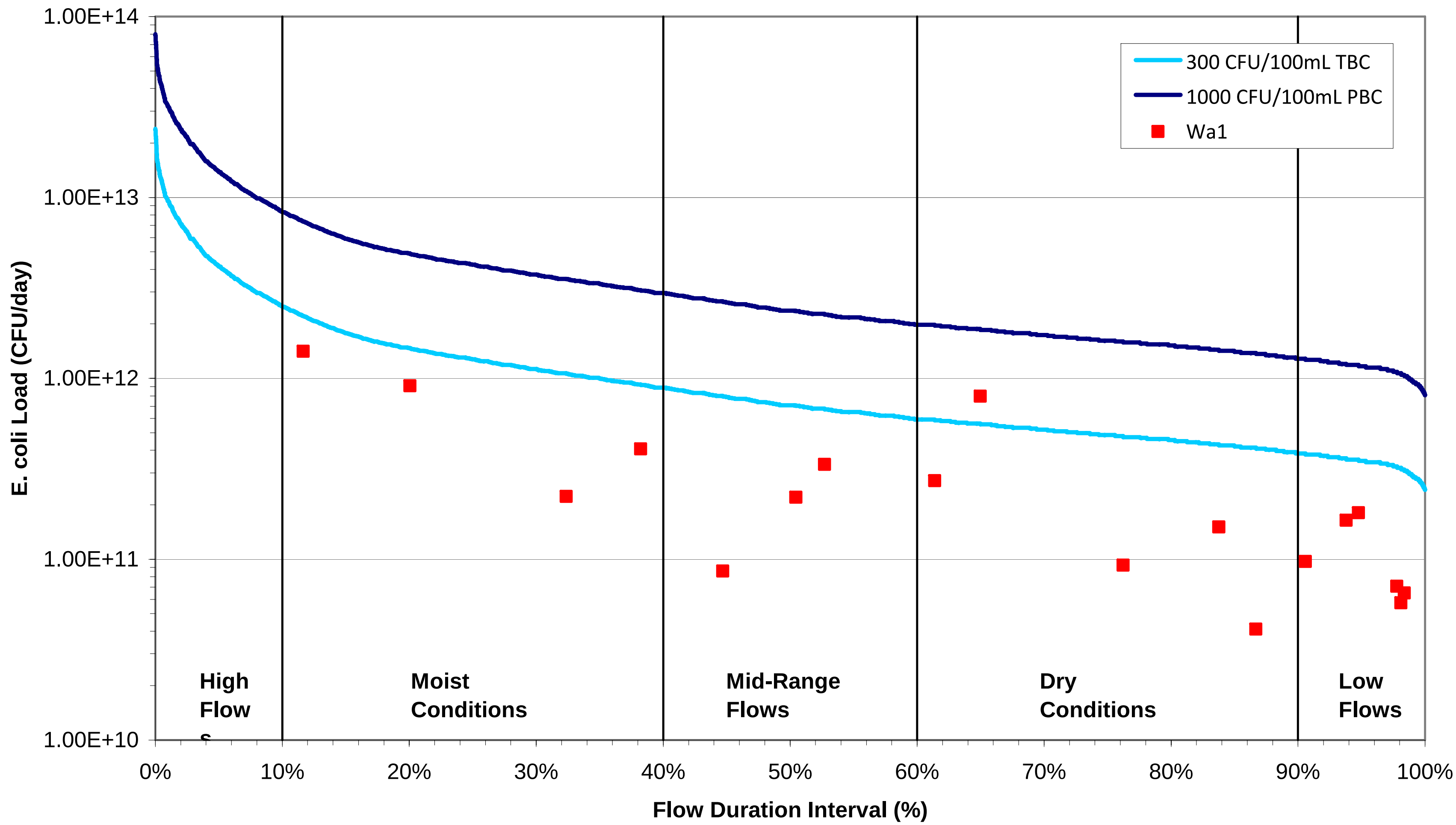

Figure 27: Load duration curve for Waishkey River Watershed monitoring site Wa1

4.2.6. Charlotte River Watershed

The Charlotte River Watershed is located south of Sault Ste Marie in a predominantly rural area. Cropland and pastures cover 24% and 18% of the watershed, respectively (Table 2 and Figure 28). More than half of the watershed (52%) is covered by forest or wetland. Developed land constitutes only 4% of the watershed. Based on the 2010 U.S. Census, there is an estimated population of 3451 persons occupying 1562 housing units in the Charlotte River watershed (Figure 3 and Table 7). All of these households are served by OSDS. The 2010 monitoring included four locations in the watershed (Figure 4), and the WQS were exceeded for a range conditions from dry to wet weather. The site farthest downstream, Ch4, had fewer exceedances than the three upstream sites.

Nonpoint Sources

Potential nonpoint sources of *E. coli* include failing or poorly designed OSDS, illicit connections to surface water, runoff from active livestock pasture and the land-application of manure, manure stockpiling, livestock with direct access to streams or wetlands, wildlife and pets.

Point Sources

There are two NPDES permitted point source dischargers in the Charlotte River Watershed (Table 18 and Figure 28) however, neither of these permitted WWSL are active. The Bruce School lagoons are upstream of monitoring sites Ch3 and Ch4. Observation of the school property indicates that the school is closed and that the lagoons remain full of water. The Cleve Reid Mobile Home Park has been issued a permit for a WWSL system, but the mobile home park and lagoons have not yet been constructed. The Cleve Reid Mobile Home Park property is located upstream of sites Ch2, Ch3 and Ch4.

Table 18: NPDES permitted point source dischargers in the Charlotte River Watershed.

Regulated Entity	Permit No.	Permit Type	Receiving Water	AUID
Bruce School	MIG580209	Wastewater Stabilization Lagoons	Spring Creek	040700010103-01
Cleve Reid MHP	MIG580255	Wastewater Stabilization Lagoons	Charlotte River	040700010102-01

Linkage Analysis

Comparison of *E. coli* concentrations with daily precipitation (Figure 29) indicates a general pattern that the highest concentrations typically occurred on or shortly after days with rainfall events (e.g mid-June, August and early September), and that many of the lowest concentrations occurred during dry periods, such as July (Appendix A). Note that even in drier weather, the total body contract daily maximum WQS was frequently exceeded at sites Ch1, Ch2 and Ch3. The *E. coli* concentration on any particular sampling date was typically the lowest at the site farthest downstream, Ch4, where WQS were rarely exceeded. This observation could be due to bacterial mortality or dilution due to reversed flows from the St. Marys River. Both wet and dry weather sources are an issue in this watershed.

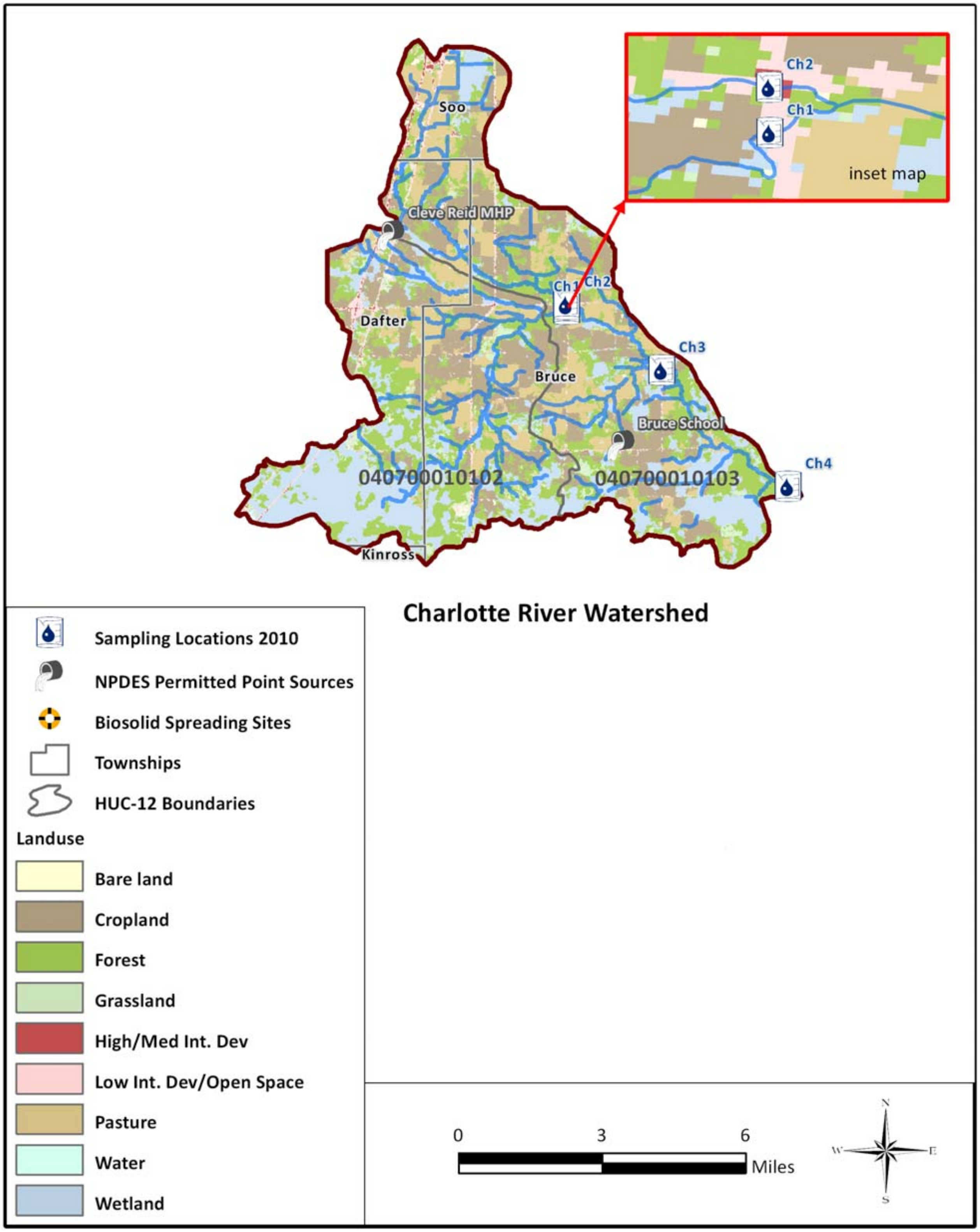

Figure 28: Characteristics of the Charlotte River Watershed.

Monitoring site Ch1 is located at the outlet of the Charlotte River Headwaters subwatershed (040700010102). That Subwatershed has 22% cropland and 13% pasture, with these agricultural areas concentrated in the downstream half of the watershed. Aerial photograph review indicates that many reaches of the Charlotte River and its tributaries lack wooded buffers, especially in the downstream, agricultural portion of this Subwatershed.

The load duration curve for Ch1 (Figure 30) shows a bimodal distribution of exceedances of the total and partial body contact daily maximum WQS, with the highest concentration occurring during moist conditions to high flows, and during low flows to dry conditions. Based on watershed land cover, the wet weather source is likely to be related to livestock contaminating runoff, and the dry weather source is likely to be OSDS, illicit connections or livestock with direct access to streams and wetlands. This site had the 7th most frequent WQS exceedances of the 21 sites in the TMDL watersheds monitored in 2010, with a maximum daily geometric mean *E. coli* concentration of 10,979 CFU/100 mL.

Sites Ch2 and Ch3 are both within the Charlotte River Subwatershed (040700010103). Site Ch3 is downstream of both Ch1 and Ch2. Land cover in the Charlotte River Subwatershed has more pasture and less wetlands than the Charlotte River Headwaters Watershed (22% vs. 13%, and 19% vs. 31%, respectively). Wooded buffers are common along the main stem of the Charlotte River upstream of Ch2 and Ch3, but not on tributaries that drain agricultural areas.

The load duration curves for monitoring sites Ch2 and Ch 3 (Figure 31 and Figure 32) show the same bimodal pattern as Ch1. Sites Ch2 and Ch3 had fewer WQS exceedances than Ch1, ranking 11th and 12th, respectively, out of the 21 sites in the TMDL watersheds monitored in 2010. The maximum daily geometric mean *E. coli* concentrations at Ch2 and Ch3 were 10,136 CFU/100 mL and 10,358 CFU/100 mL, respectively. Based on the large areas of pasture and the low prevalence of riparian buffers, the most probable wet weather source of bacteria is livestock. During lower flows, the probable bacteria sources are failing and poorly designed OSDS, illicit connections, and livestock with direct stream or wetland access. OSDS and illicit connections are implicated by the presence of a moderate proportion of human bacteria in a BST sample collected at site Ch2 on August 19, 2010 during dry conditions (Table 8).

Monitoring site Ch4 (Figure 33) is near the outlet of the Charlotte River Subwatershed, less than ¼ mile upstream of Lake Nicolet in the St Marys River. Reverse flow from the river was observed during 3 of the 18 sample collection events (indicated in Appendix A). The incremental drainage area between Ch3 and Ch4 has more extensive forest than the watershed upstream of Ch3, and wide wooded buffers are very common. *E. coli* concentrations at Ch4 in 2010 were typically lower than the upstream sites, with only two exceedances of the total body contact WQS. This site ranked 20th out of the 21 monitoring sites in terms of WQS exceedance frequency, with a maximum daily geometric mean *E. coli* concentration of 1,375 CFU/100 mL. The lower concentrations may be related to the more extensive wooded buffer between Ch3 and Ch4, although backflow from the St. Marys River may have diluted bacteria on the three sampling dates when this was observed.

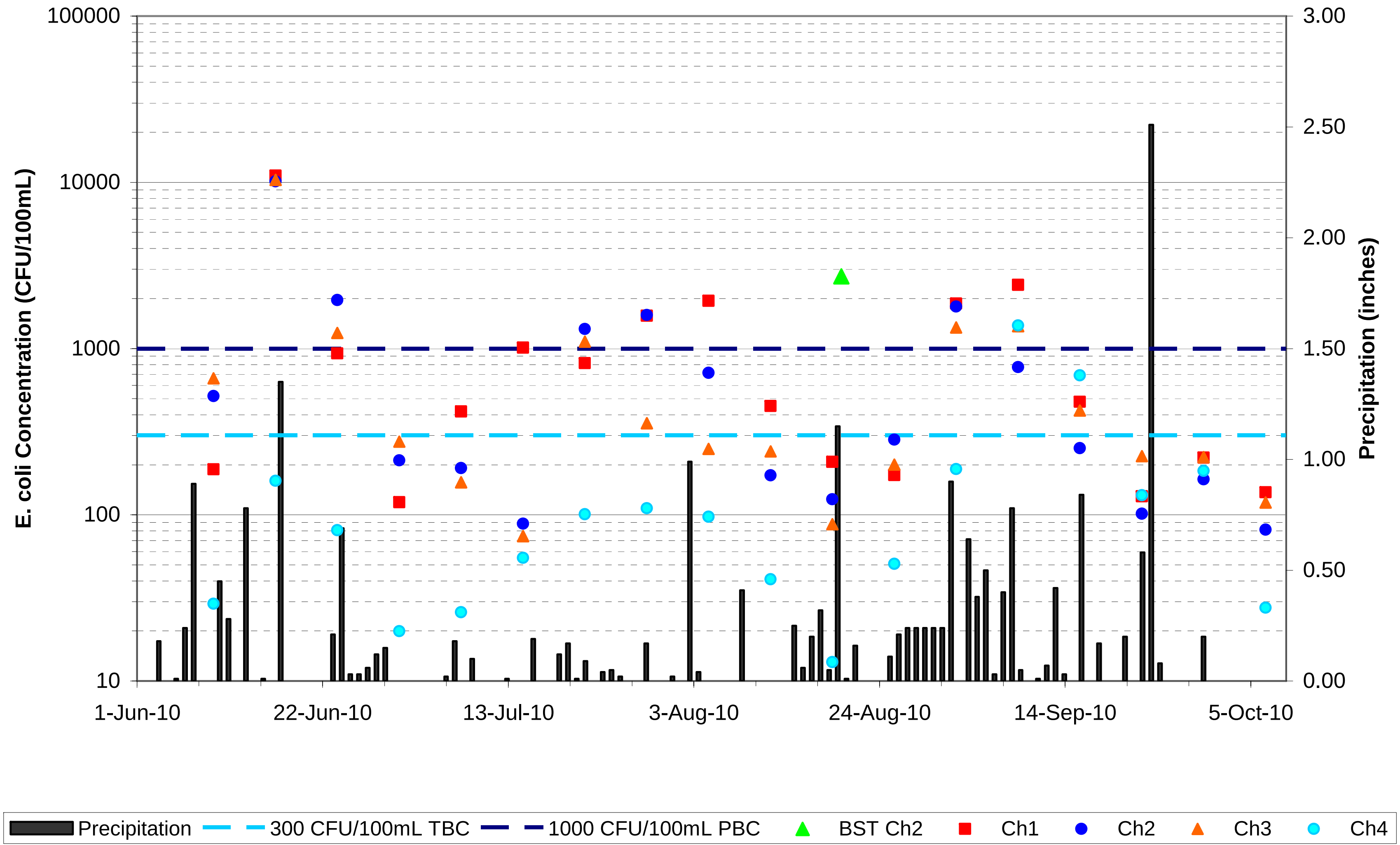

Figure 29: ***E. coli*** **concentrations and precipitation in the 24-hours preceding sample collection for the Charlotte River Watershed.**

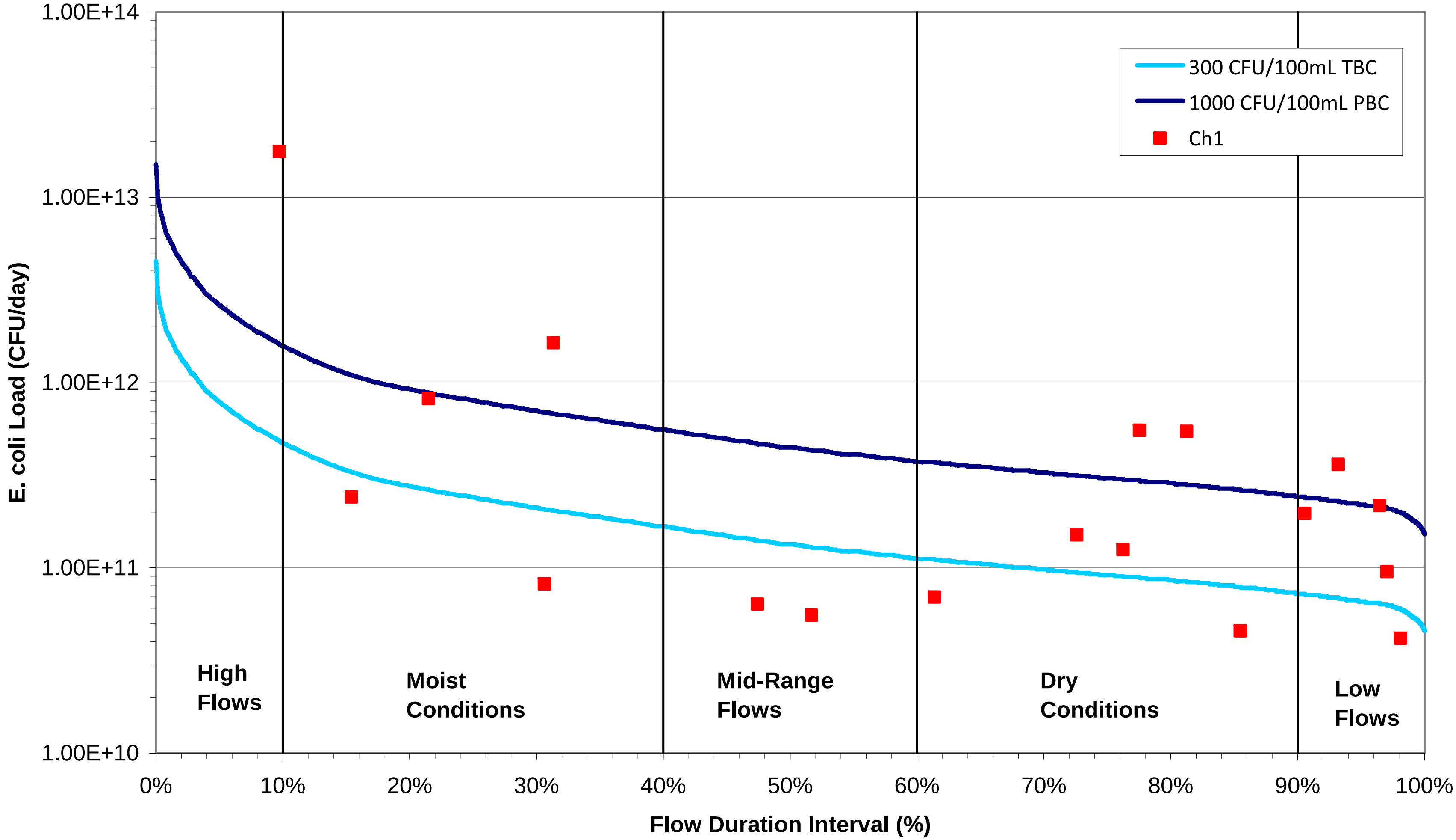

Figure 30: Load duration curve for Charlotte River Watershed monitoring site Ch1

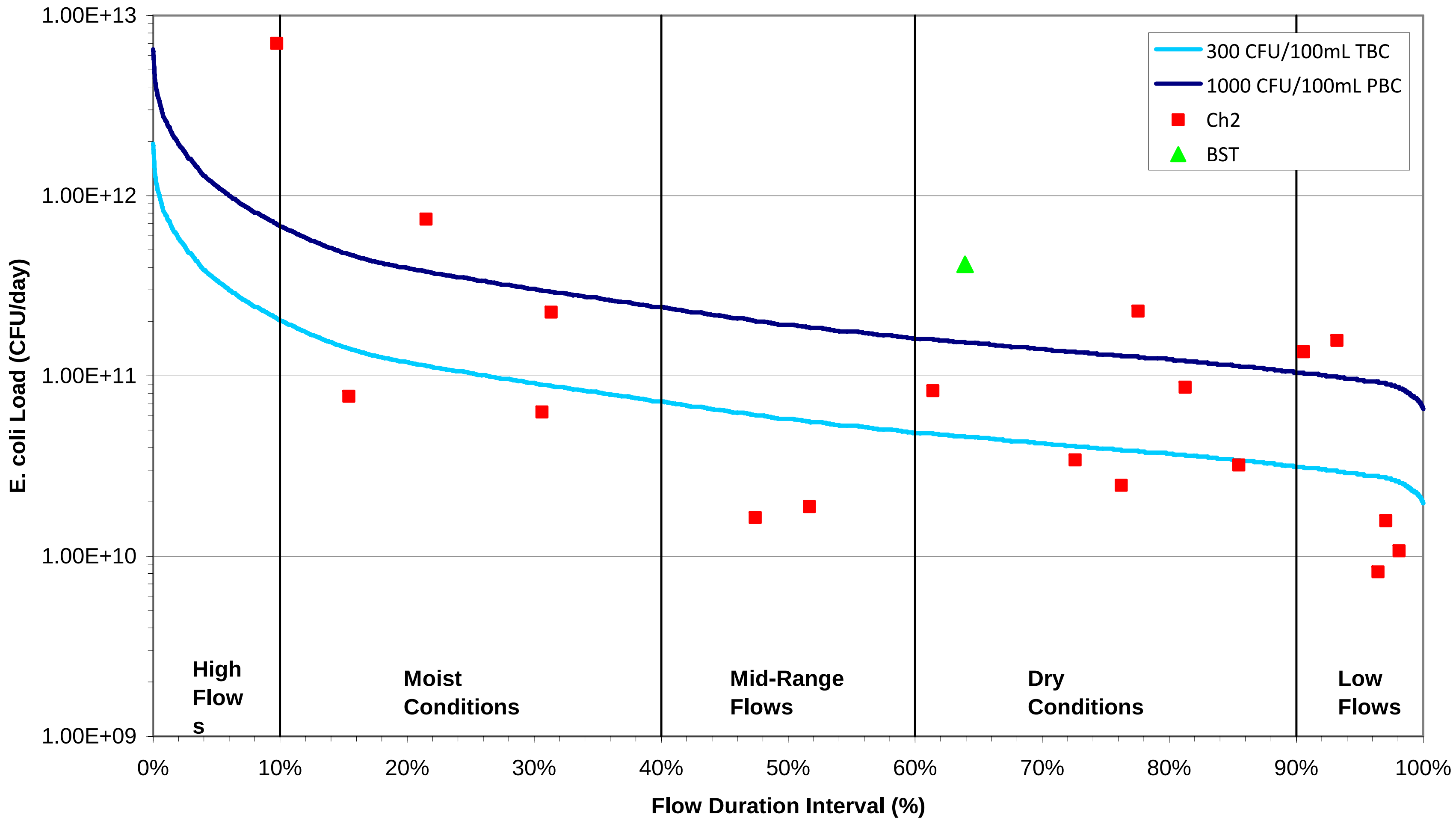

Figure 31: Load duration curve for Charlotte River Watershed monitoring site Ch2.

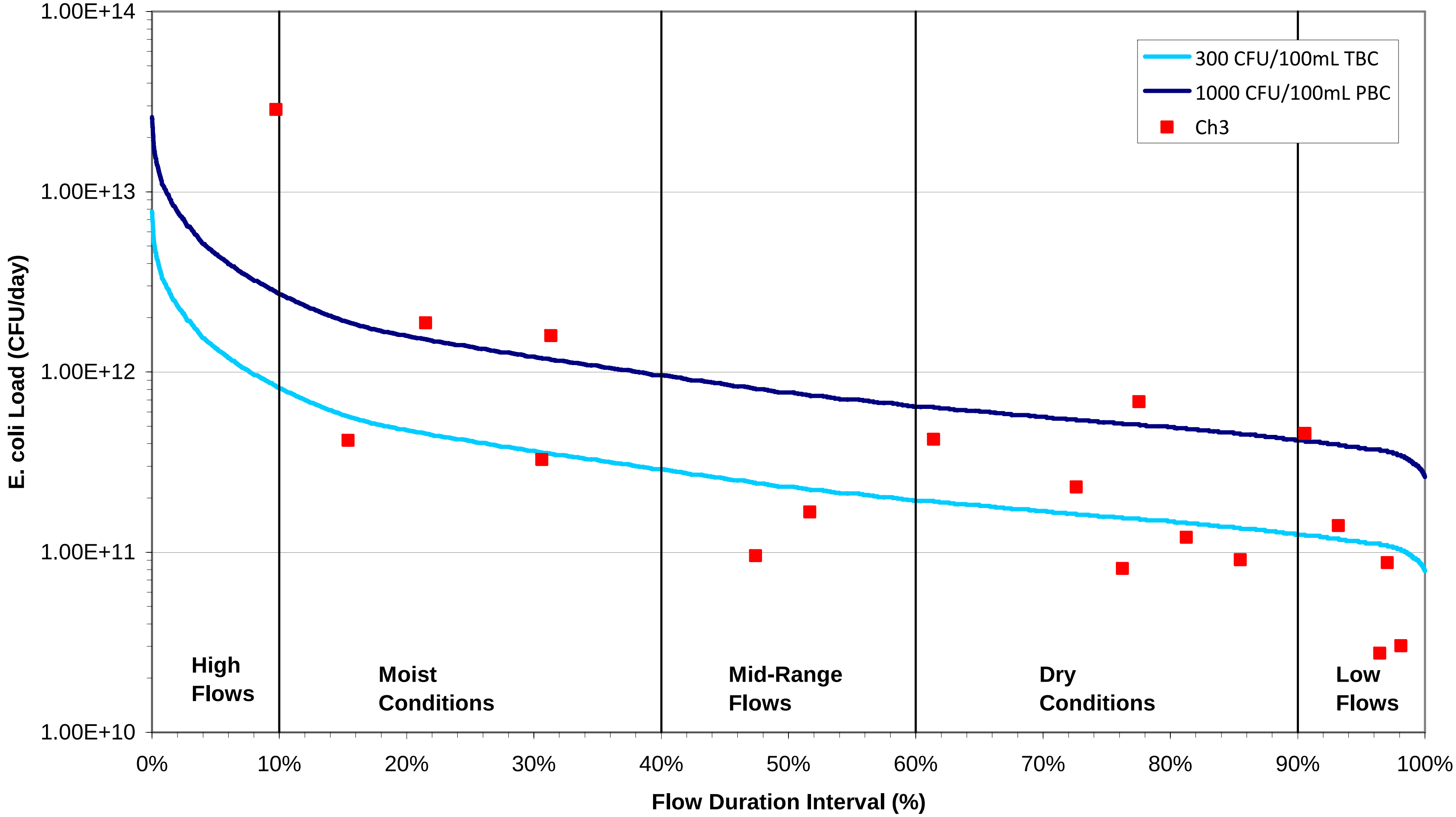

Figure 32: Load duration curve for Charlotte River Watershed monitoring site Ch3.

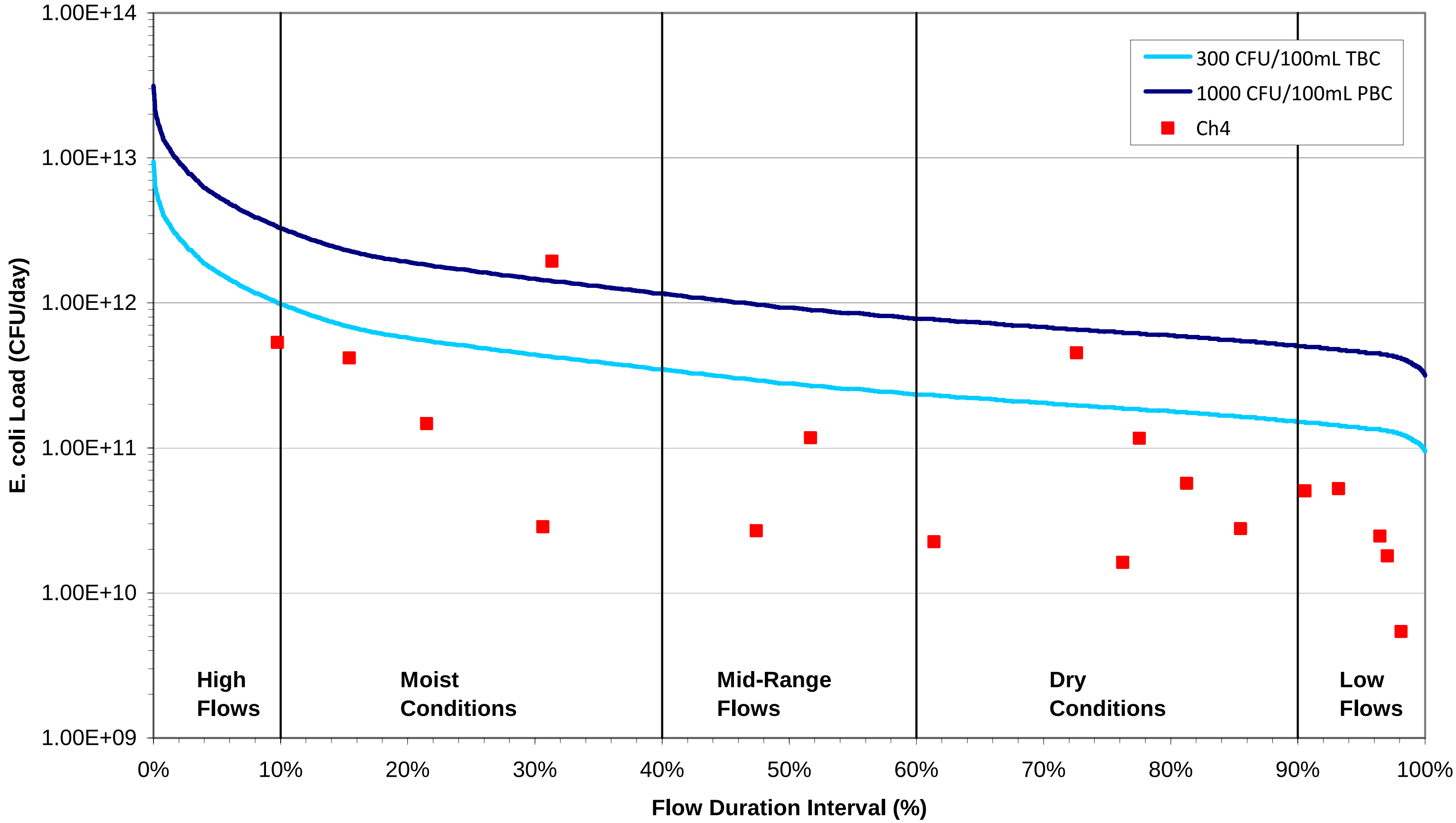

Figure 33: Load duration curve for Charlotte River Watershed monitoring site Ch4.

4.2.7. Little Munuscong River Watershed

The Little Munuscong River Watershed, located approximately 17 miles south of Sault Ste. Marie, is dominated by wetlands and forest (approximately 84% of the watershed). Approximately 10% of land cover in the watershed is pasture and cropland (Table 2 and Figure 34), and only 2% of the watershed is developed. Based on the 2010 U.S. Census, there is an estimated population of 2666 persons occupying 1022 housing units in the Little Munuscong River watershed (Figure 3 and Table 7). These households use primarily OSDS lagoons, with the possible exception of some housing units near the Kinross WWTF.

Nonpoint Sources

Potential nonpoint sources of *E. coli* include failing, poorly designed or overflowing OSDS, illicit connections to surface water, runoff from active livestock pasture and the land-application of manure, manure stockpiling, livestock with direct access to streams or wetlands, wildlife and pets. Some OSDS in the Little Munuscong River Watershed have been observed closer to streams than the 200-foot setback required by the Superior Environmental Health Code for lagoon systems, creating a higher potential risk of bacteria contamination of streams.

Point Sources

There are no NPDES permitted point source dischargers in the Little Munuscong Watershed.

Linkage Analysis

Comparison of *E. coli* concentrations with daily precipitation (Figure 35) shows that the highest concentrations in 2010 occurred both during rainfall events and during dry periods. It therefore appears that there are multiple bacteria sources that affect wet and dry weather.

The Little Munuscong watershed includes two HUC-12 watersheds: the Little Munuscong River Headwaters (040700010104) and the Little Munuscong River (040700010105). Monitoring site Lm1 is in the central part of the Little Munuscong River Headwaters Subwatershed, and monitoring site Lm2 is near the outlet of the Little Munuscong River Subwatershed. Land cover is similar in these subwatersheds, however there is more cropland and pasture, and less forest in the downstream subwatershed (Table 2). Pastures occupy approximately 5% of the combined watersheds. Wooded buffers are common, but the northern headwaters of the Little Munuscong River watershed (HUC 040700010105) have substantial areas of pasture that lack wooded buffers.

The load duration curves for Lm1 and Lm2 both show that exceedances of the total and partial body contact daily maximum WQS occurred most frequently during the lowest and highest flows (Figure 36 and Figure 37). This indicates multiple sources of *E. coli*. Both sites are located very near OSDS lagoons, which may be worth inspecting to determine if they meet the Superior Environmental Health Code and are functioning properly. Higher flow bacteria loads may be driven by runoff carrying waste from livestock, wildlife and/or pets, and overflowing OSDS lagoons. Horses were observed upstream of Lm1, and homes with dogs were observed near Lm2. Sites Lm1 and Lm2 had the 16th and 14th most frequent daily maximum WQS exceedances, respectively, out of the 21 sites in the TMDL watersheds monitored during 2010. The maximum daily geometric mean *E. coli* concentrations recorded in 2010 were 3,040 CFU/100 mL at Lm1 and 4,567 CFU/100 mL at Lm2.

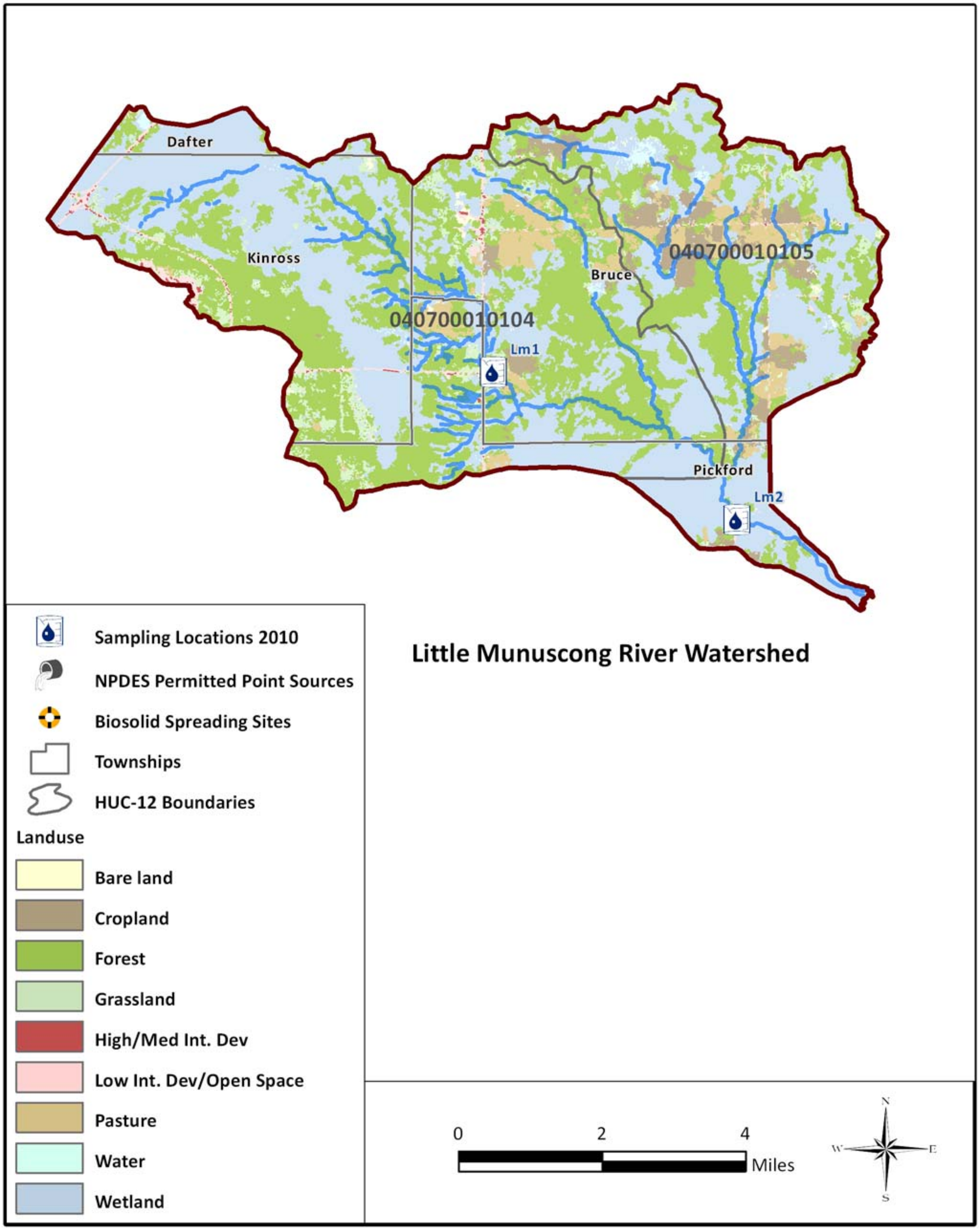

Figure 34: Characteristics of the Little Munuscong River Watershed.

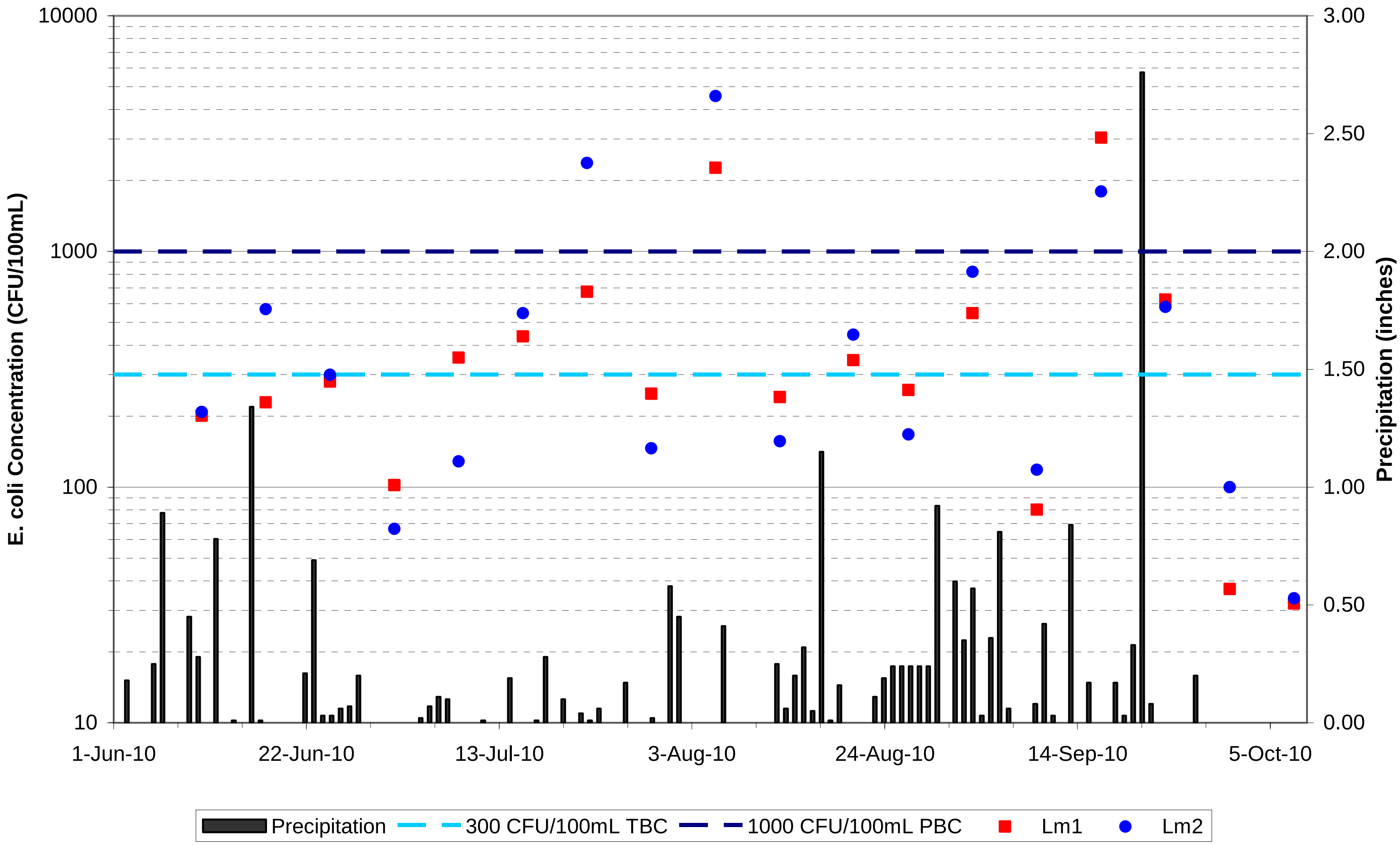

Figure 35: ***E. coli*** **concentrations and precipitation in the 24-hours preceding sample collection for the Little Munuscong Watershed.**

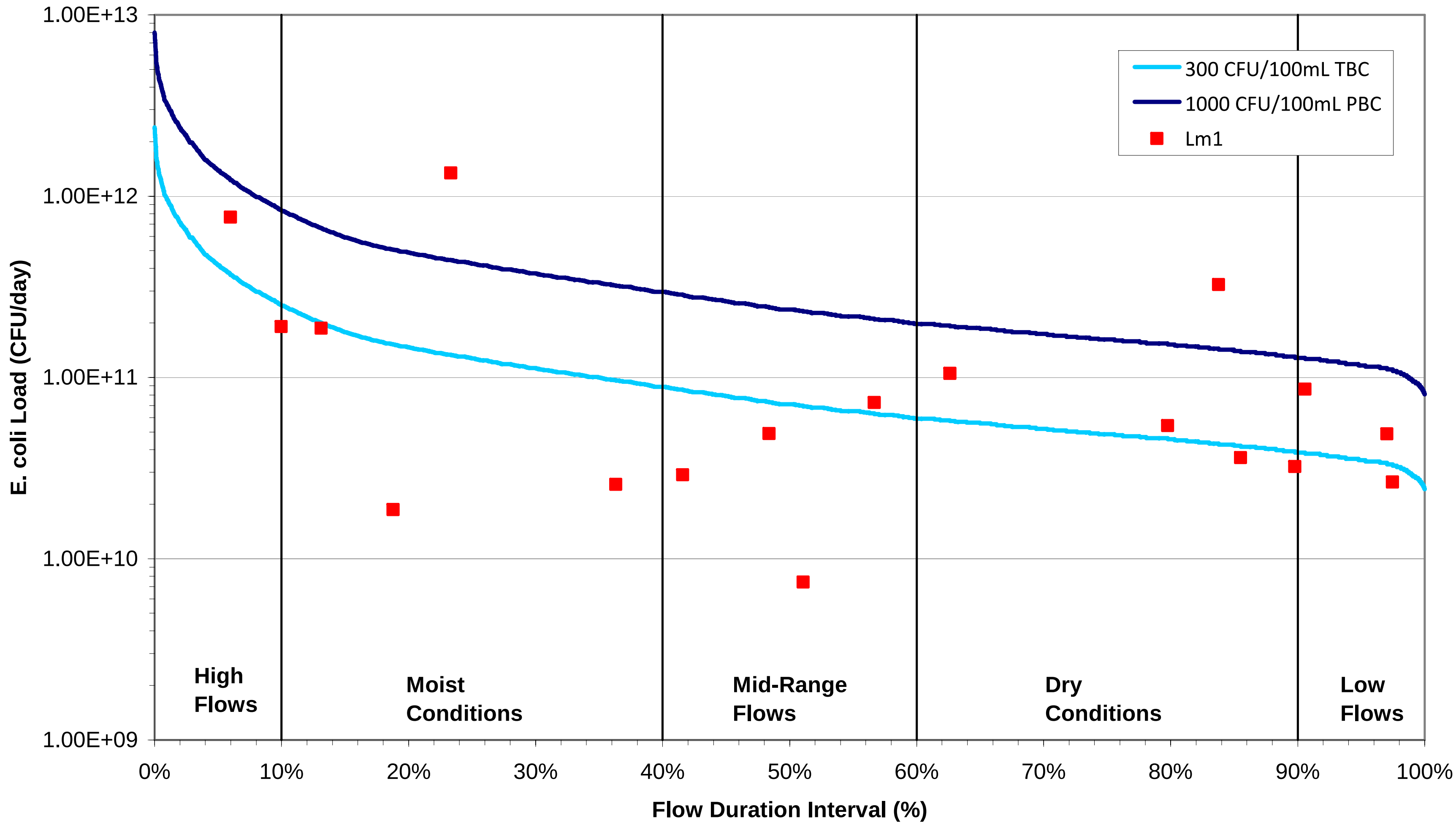

Figure 36: Load duration curve for Little Munuscong River Watershed monitoring site Lm1.

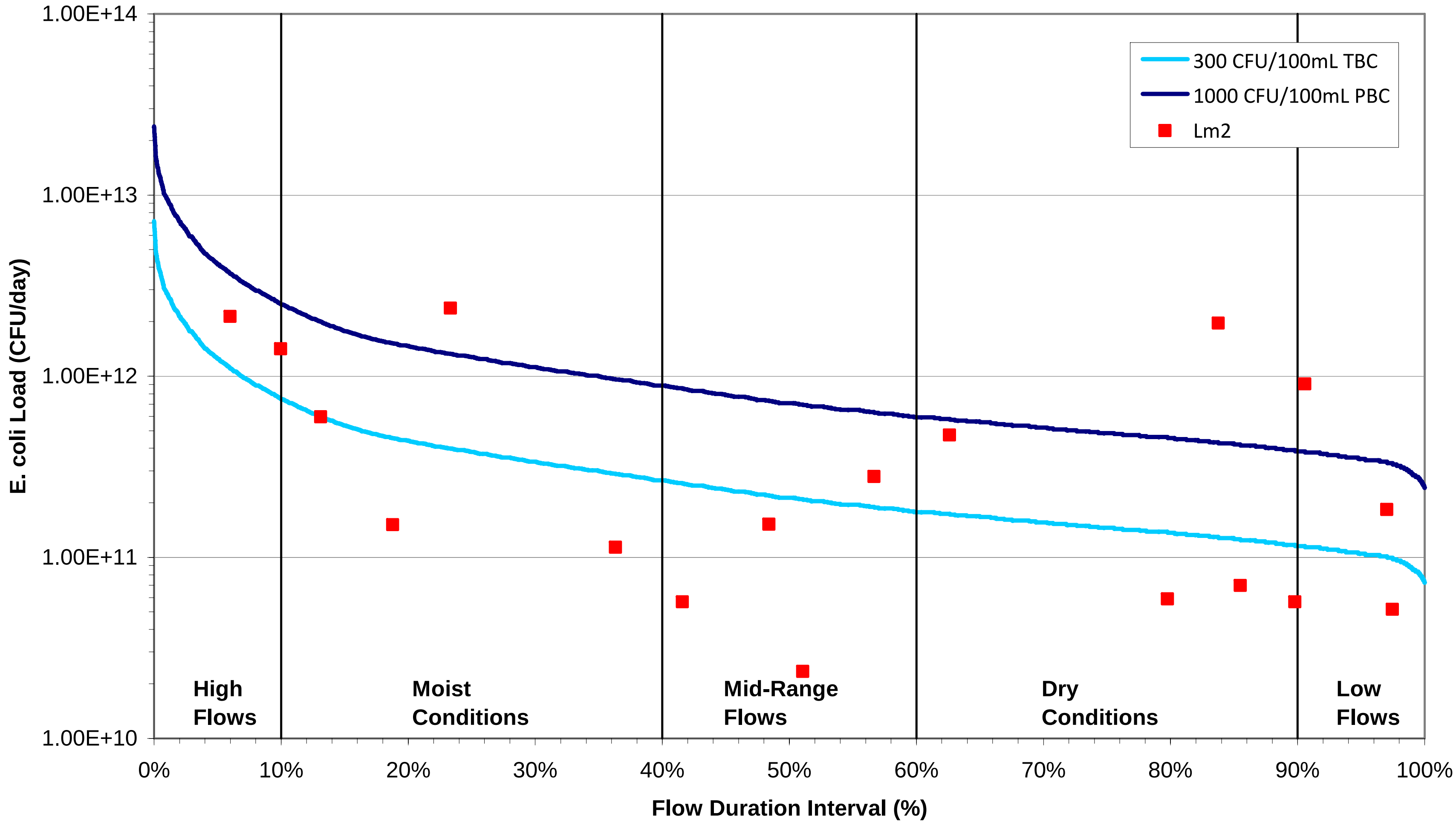

Figure 37: Load duration curve for Little Munuscong River Watershed monitoring site Lm2.

4.2.8. Munuscong River Watershed

The Munuscong River Watershed is located approximately 25 miles south of Sault Ste. Marie. It occupies an area of nearly 120,000 acres and includes seven subwatersheds (Table 2 and Figure 38). The watershed is sparsely developed (4%), although it does include concentrated development at Pickford Township. Based on the 2010 U.S. Census, there is an estimated population of 11,068 persons occupying 3565 housing units in the Munuscong River watershed (Figure 3 and Table 7). Of this population, an estimated 250 households are served by the Pickford WWSL, and an estimated 1000 households are served by the Kinross WWTF. Thus, the estimated number of OSDS in the watershed is 2300. Forest and wetlands occupy 65% of the watershed, and pasture covers 19% of the watershed. *E. coli* samples were collected in 2010 from five locations, which all frequently exceeded the total and partial body contact daily maximum WQS. There are 10 permitted biosolids land-applications sites originating from three waste water facilities (Figure 38).: Kinross WWTP (MI0057776), St. Ignace WWTP (MI0020699), and Drummond Island Resort (MIG570215)

Nonpoint Sources

Potential nonpoint sources of *E. coli* include failing, poorly designed or overflowing OSDS, illicit connections to surface water, runoff from active livestock pasture and the land-application of manure, manure stockpiling, livestock with direct access to streams or wetlands, wildlife, land-application of biosolids, and pets.

Point Sources

Two NPDES permitted point source dischargers are located in the watershed (Table 19 and Figure 38): one WWSL and one industrial stormwater discharge. The Pickford WWSLis downstream of site Mu2 and approximately 2 mi upstream of site Mu3. Note that the outfall of the Kinross WWTF, which serves part of the Munuscong River watershed population, is located in the Waishkey River watershed. Two reported SSOs for the Kinross WWTF occurred in 2005 and 2006. The 2005 event discharged 100 gallons of diluted raw sewage to a street in the Munuscong River Watershed due to a sewer pipe blockage. The 2006 event occurred at a secondary filter at the WWTF located in the Waishkey River Watershed. Two SSOs have been reported for the Pickford WWSL. The 2007 event was caused by a sanitary sewer break and discharged 1500 gallons of raw sewage to a ravine near a private residence. The 2008 event was caused by snowmelt that overwhelmed the system capacity and discharge 1200 gallons of diluted raw sewage to the Munuscong River.

Table 19: NPDES permitted point source dischargers in the Munuscong River Watershed.

Regulated Entity	Permit No.	Permit Type	Receiving Water	AUID
Mast Fab Co-Superior Fab Div	MIS110025	Storm Water from Industrial Activities	Kincheloe AFB storm sewer system	040700010207-01
Pickford UA WWSL	MIG580206	Wastewater Stabilization Lagoons	Munuscong River	040700010204-01

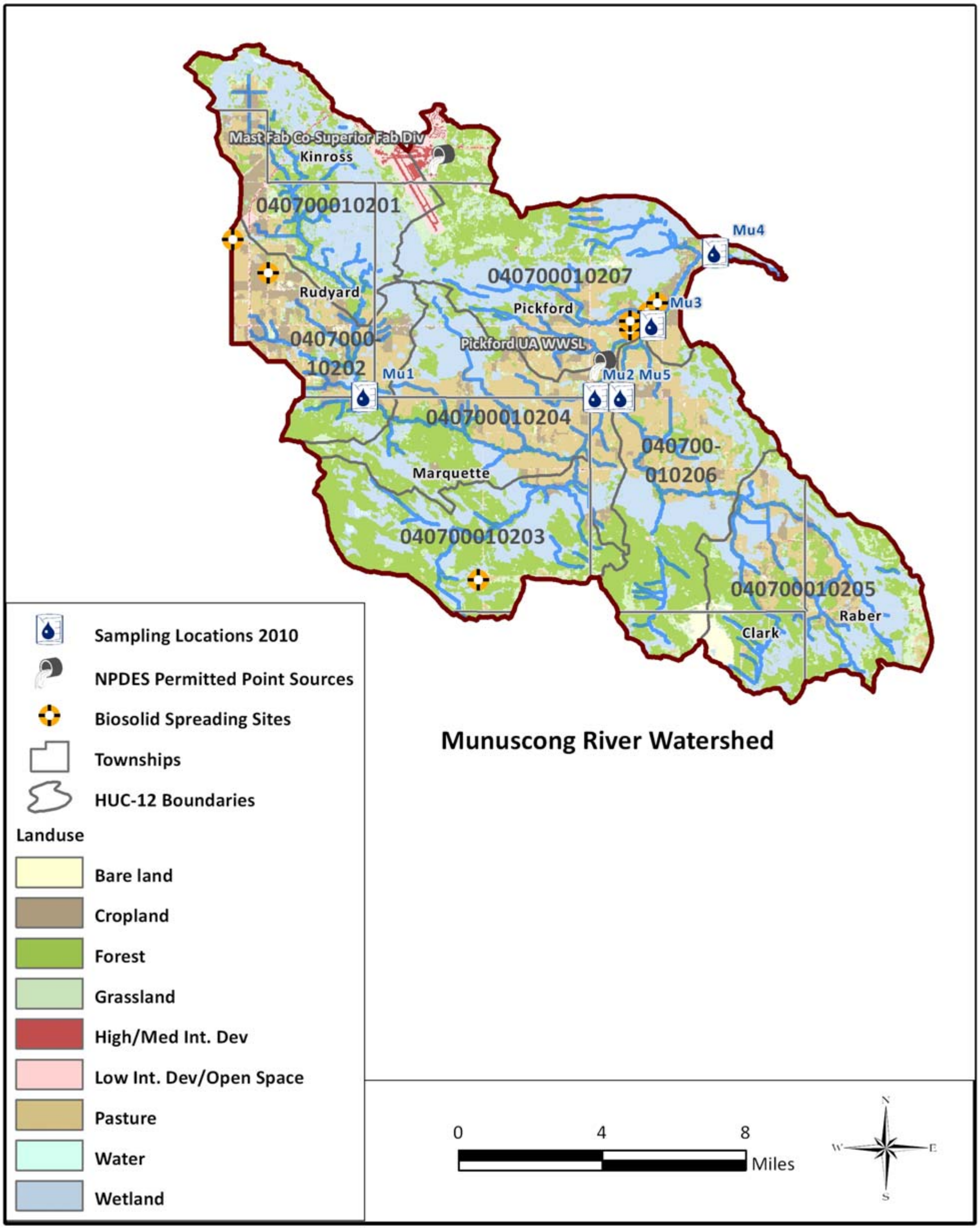

Figure 38: Characteristics of the Munuscong River Watershed.

Linkage Analysis

Comparison of *E. coli* concentrations with daily precipitation (Figure 39) shows that the highest concentrations in 2010 occurred the day of or the day after rains of 1 inch or more, but that *E. coli* concentrations were typically well above the total body contact WQS during both wet and dry conditions. This indicates multiple bacteria sources.

Monitoring site Mu1 is downstream of the Headwaters of the Munuscong River watershed (040700010201) and most of the Upper Munuscong River watershed (040700010202) (Figure 38). The latter watershed includes two biosolids spreading sites for the St. Ignace WWTP. Compared to the entire Munuscong River Watershed, the Headwaters watershed has more development (8%) and less pasture (9%). The Upper Munuscong Watershed has little development (3%) but significant areas of cropland (21%) and pasture (33%). Wooded buffers are widespread in the Headwaters Watershed and less common in the heavily pastured Upper Munuscong Watershed (040700010202).

The load duration curve for Mu1 (Figure 40) indicates that the WQS are exceeded frequently for all but the lowest flows. This site had the 10th most frequent WQS exceedances of the 21 sites in the TMDL watersheds monitored in 2010, with a maximum daily geometric mean *E. coli* concentration of 18,396 CFU/100 mL. The probable source of bacteria in wet weather runoff is livestock related, although pets, wildlife and biosolids land-application are other possible contributor. The highest *E. coli* concentrations at site Mu1 were recorded during higher flow conditions, indicating a significant wet weather source in the headwaters and upper Munuscong areas.

Monitoring site Mu2 is located in Pickford Township downstream of Mu1. In addition to the areas upstream of Mu1, the Taylor Creek and Middle Munuscong River subwatersheds (HUC 040700010203 and 040700010204, respectively) drain to Mu2. Three permitted biosolids spreading sites are located in the Taylor Creek Watershed near its southern divide; facilities producing these biosolids are the Kinross Township WWTP and the Drummond Island Resort. The Taylor Creek Watershed has very little development (1%), cropland (1%) or pasture (4%). In contrast, 35% of the Middle Munuscong River Watershed is pasture. Wooded buffers are common in the Taylor Creek Watershed and rare in the Middle Munuscong Watershed (040700010204).

The load duration curve for Mu2 (Figure 41) is very similar to that for Mu1, however WQS were more frequent at Mu2, which ranked 6th out of the 21 sites in terms of WQS exceedance frequency. Additionally, exceedances of the daily maximum TBC water quality standard were much more common at low flows at site Mu2, indicating a constant source of *E. coli* contamination (such as livestock with direct stream access, illicit connections or failing OSDS). The maximum daily geometric mean *E. coli* concentration of 7,592 CFU/100 mL. Livestock, especially in the Middle Munuscong Watershed, and on-site waste water systems are the probable bacteria sources. It is possible that runoff from biosolids spreading sites also contributes to the bacteria load during wet weather. OSDS with lagoons are common in the watershed, and the failure of these systems is a probable source of bacteria during low flow and dry conditions.

Monitoring site Mu5 is located less than 1 mile east of Pickford on the East Branch of the Munuscong River. Two subwatersheds are upstream of Mu5: the Hannah Creek Watershed (HUC 040700010205) and the East Branch of the Munuscong River Watershed (HUC 040700010206), and these watersheds have significant pasture areas (14% and 27%, respectively). Significant portions of these pasture areas lack wooded buffers, especially in the East Branch subwatershed. Only 1% of these watersheds is developed, however numerous private OSDS are present near the creek less than 0.5 mile upstream of the monitoring location.

Monitoring site Mu5 had exceedances of both the total and partial body contact WQS in the full range of flow duration intervals (Figure 42). This site had the most frequent WQS exceedances of all of the 2010 monitoring sites, with a maximum daily geometric mean *E. coli* concentration of 14,930 CFU/100 mL. The large areas of pasture without riparian buffers upstream of Mu5 suggests that the probable wet weather source is livestock related. Overflowing OSDS during heavy rains is also a potential wet weather bacteria source. Failing or poorly designed OSDS and illicit connections are the most likely source of bacteria at lower flows, and this is substantiated by the high proportion of human bacteria in the BST sample collected on September 30, 2010.

Monitoring sites Mu3 and Mu4 are located downstream of the three monitoring sites discussed above and are both in the Lower Munuscong River subwatershed (040700010207). A small upstream portion of this subwatershed drains to Mu3, and Mu4 is located near the watershed outlet and receives drainage from nearly the entire subwatershed. The Lower Munuscong River subwatershed has slightly more development (6%) than other portions of the Munuscong River Watershed, and it has 14% pasture. Many reaches in this watershed lack wooded buffers, especially in the southern half of the watershed. There are 5 permitted biosolids spreading sites in areas of the watershed that drain to each monitoring site: four for the Kinross WWTP and one for the Drummond Island Resort. The Munuscong Golf Club drains to Mu4, and many golf courses attract geese and other wildlife.

The load duration curve for Mu3 (Figure 43) is similar to those for the monitoring sites discussed above and supports the same conclusion that livestock and private on-site waste water systems are the most probable bacteria sources. Site Mu3 had more frequent WQS exceedances than any site except Mu5, with a maximum daily geometric mean *E. coli* concentration of 10,255 CFU/100 mL. Monitoring site Mu4 had fewer WQS exceedances, ranking 15th out of the 21 sites, with most exceedances occurring during mid-range to high flows (Figure 44). This indicates that OSDS may have less impact on this monitoring site than at the four upstream sites, although they remain a potential source. Wet-weather sources, such as run-off from livestock appear to be the major contributor of contamination to Mu4. The maximum daily geometric mean *E. coli* concentration at Mu4 in 2010 was 3,576 CFU/100 mL

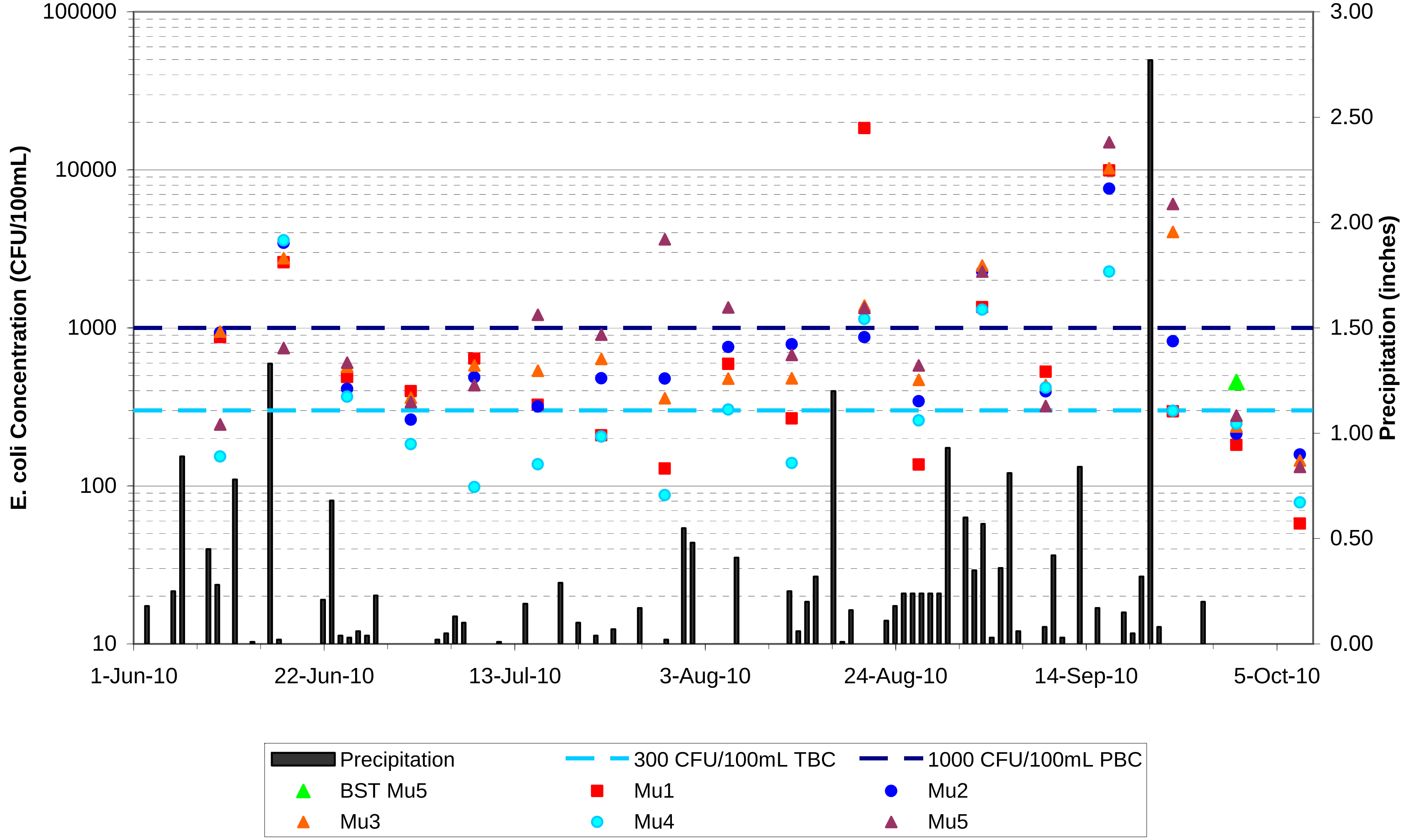

Figure 39: ***E. coli*** **concentrations and precipitation in the 24-hours preceding sample collection for the Munuscong River Watershed.**

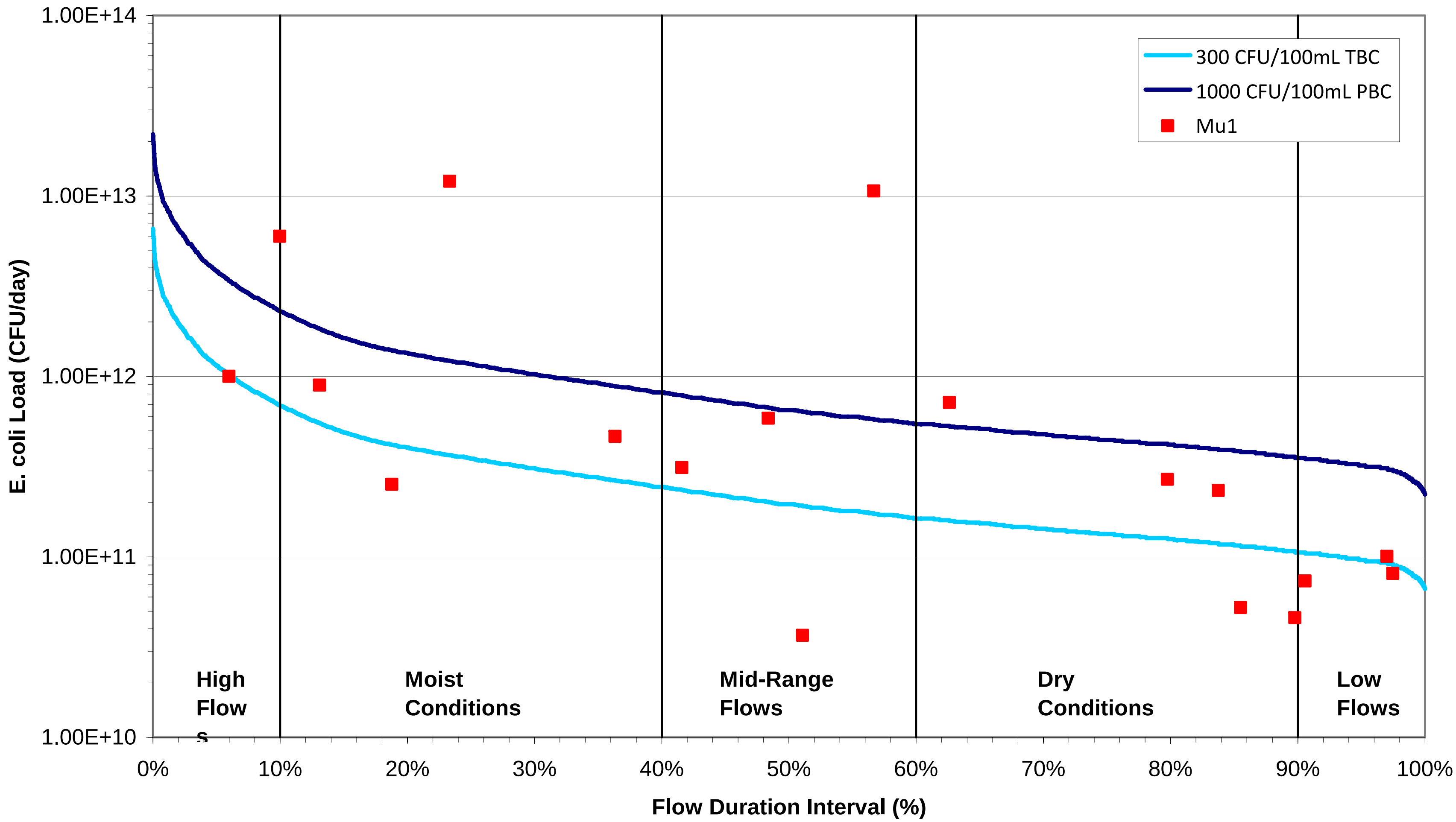

Figure 40: Load duration curve for Munuscong River Watershed monitoring site Mu1.

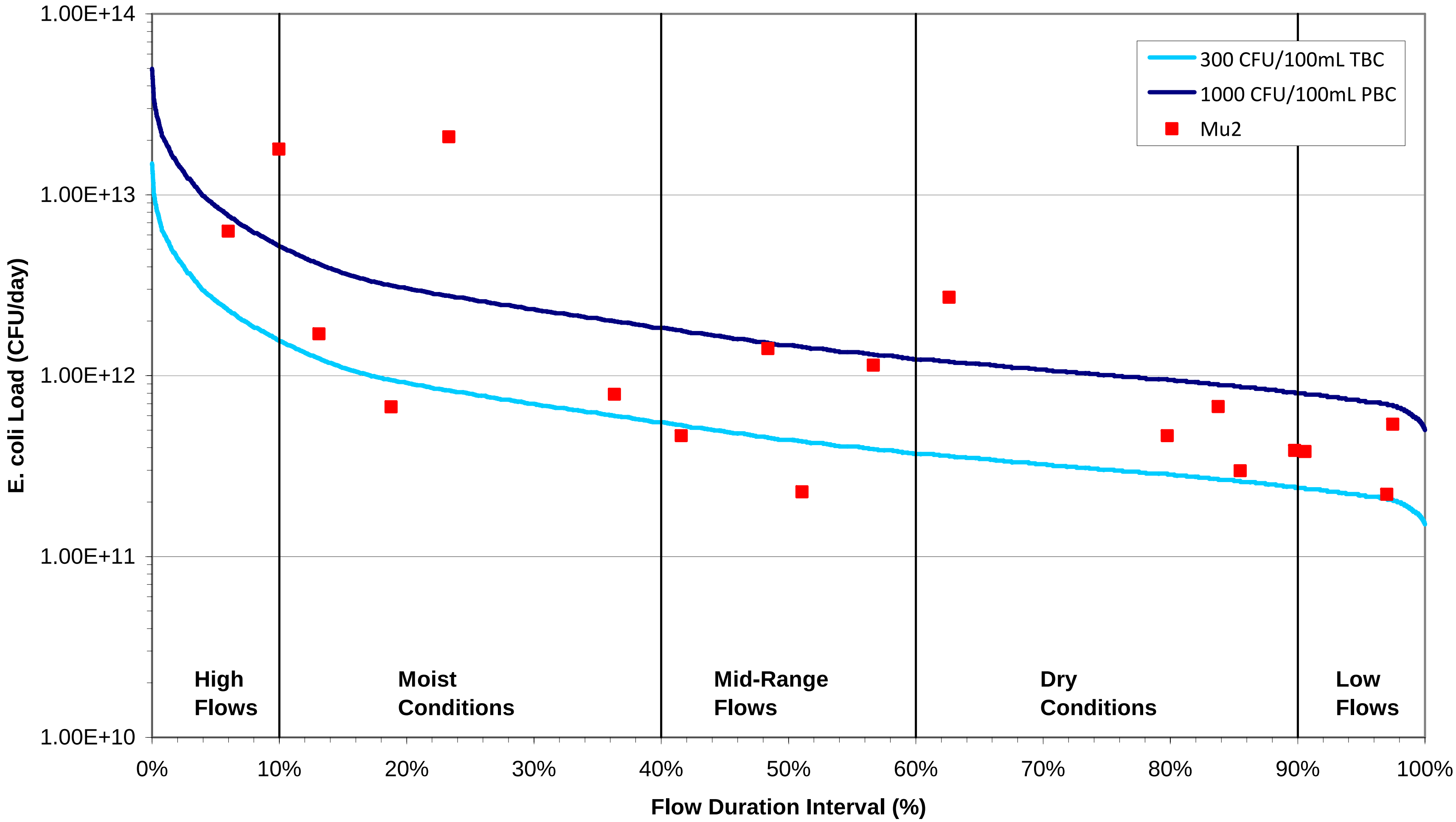

Figure 41: Load duration curve for Munuscong River Watershed monitoring site Mu2.

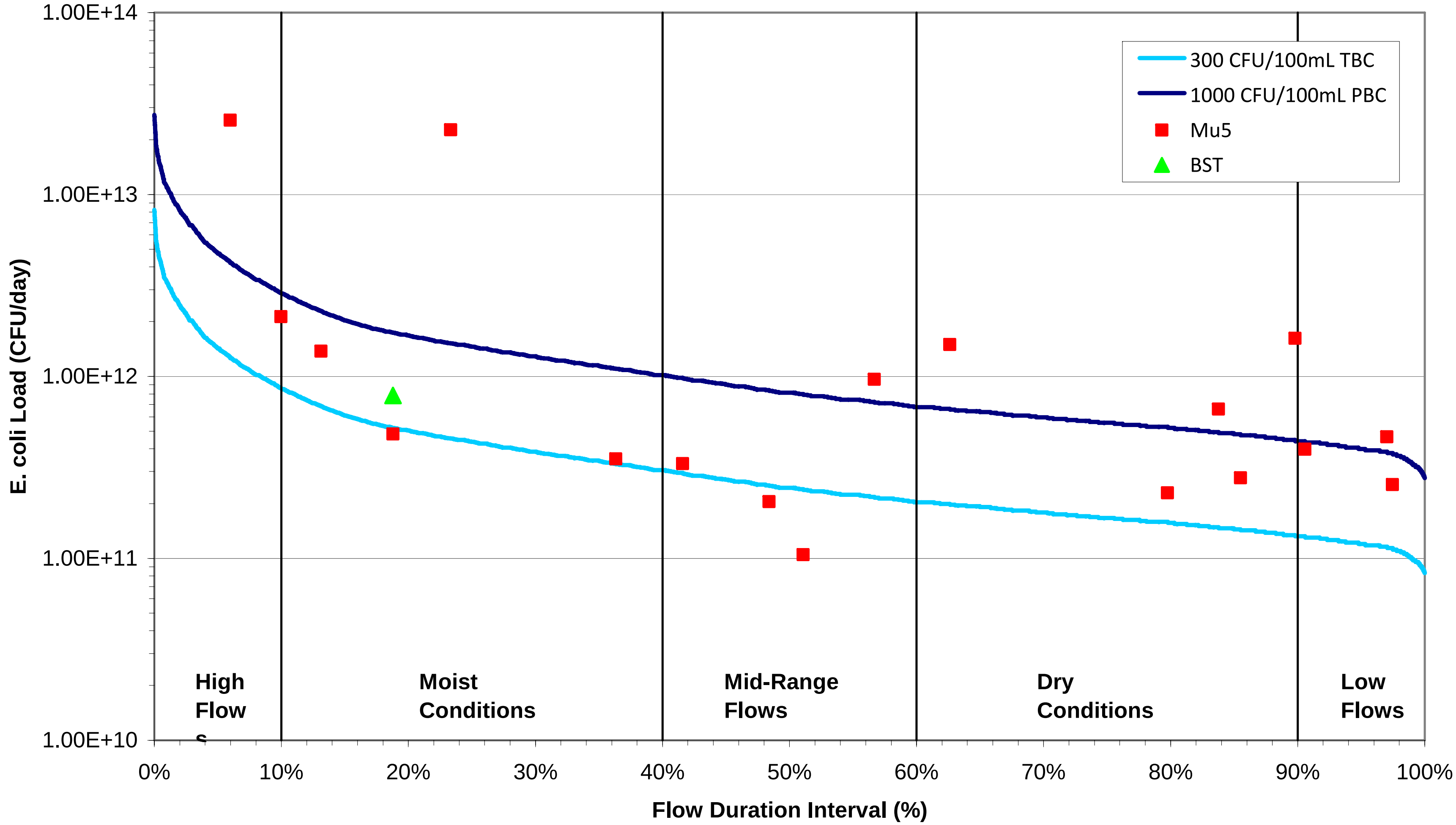

Figure 42: Load duration curve for Munuscong River Watershed monitoring site Mu5.

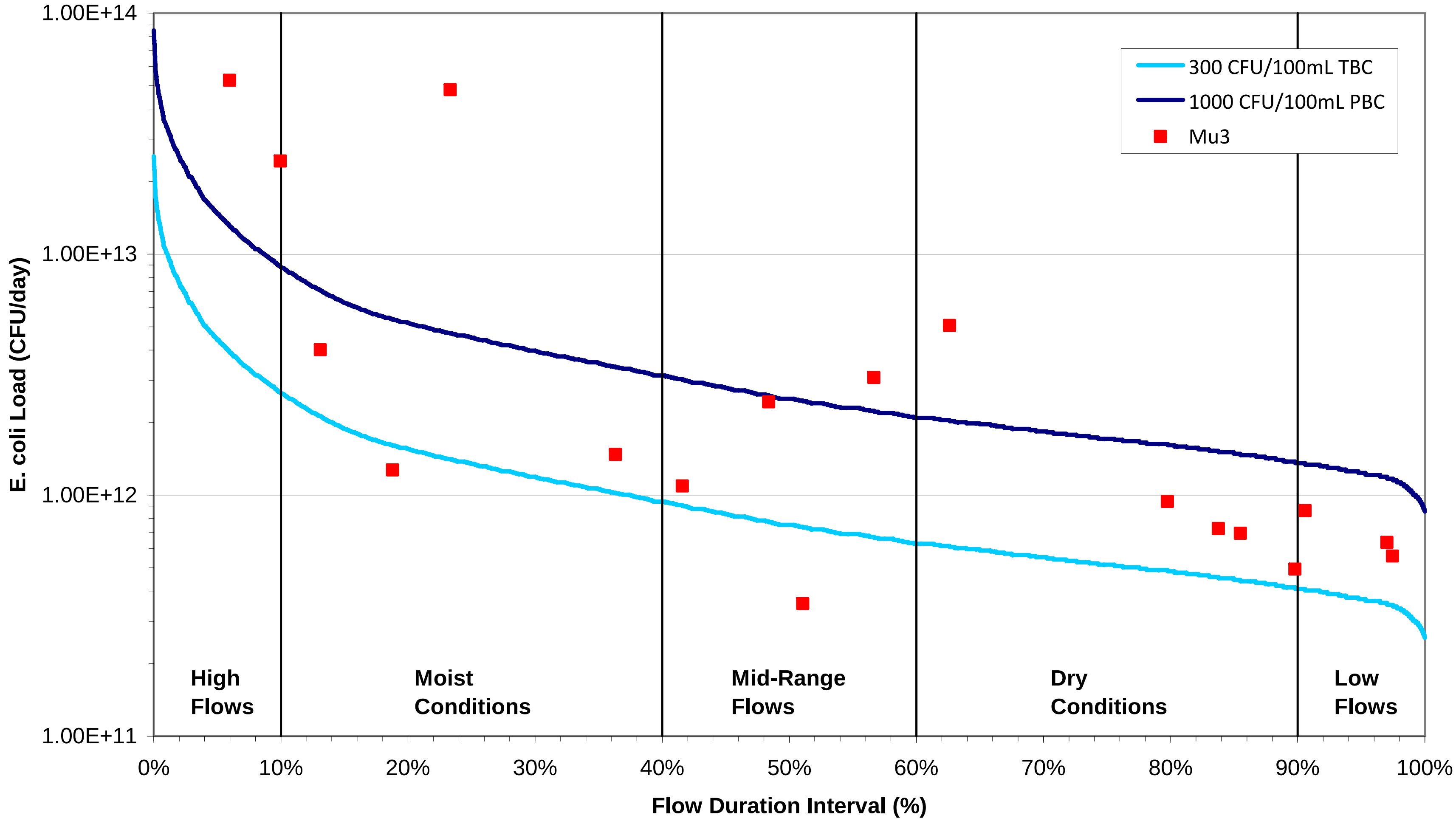

Figure 43: Load duration curve for Munuscong River Watershed monitoring site Mu3.

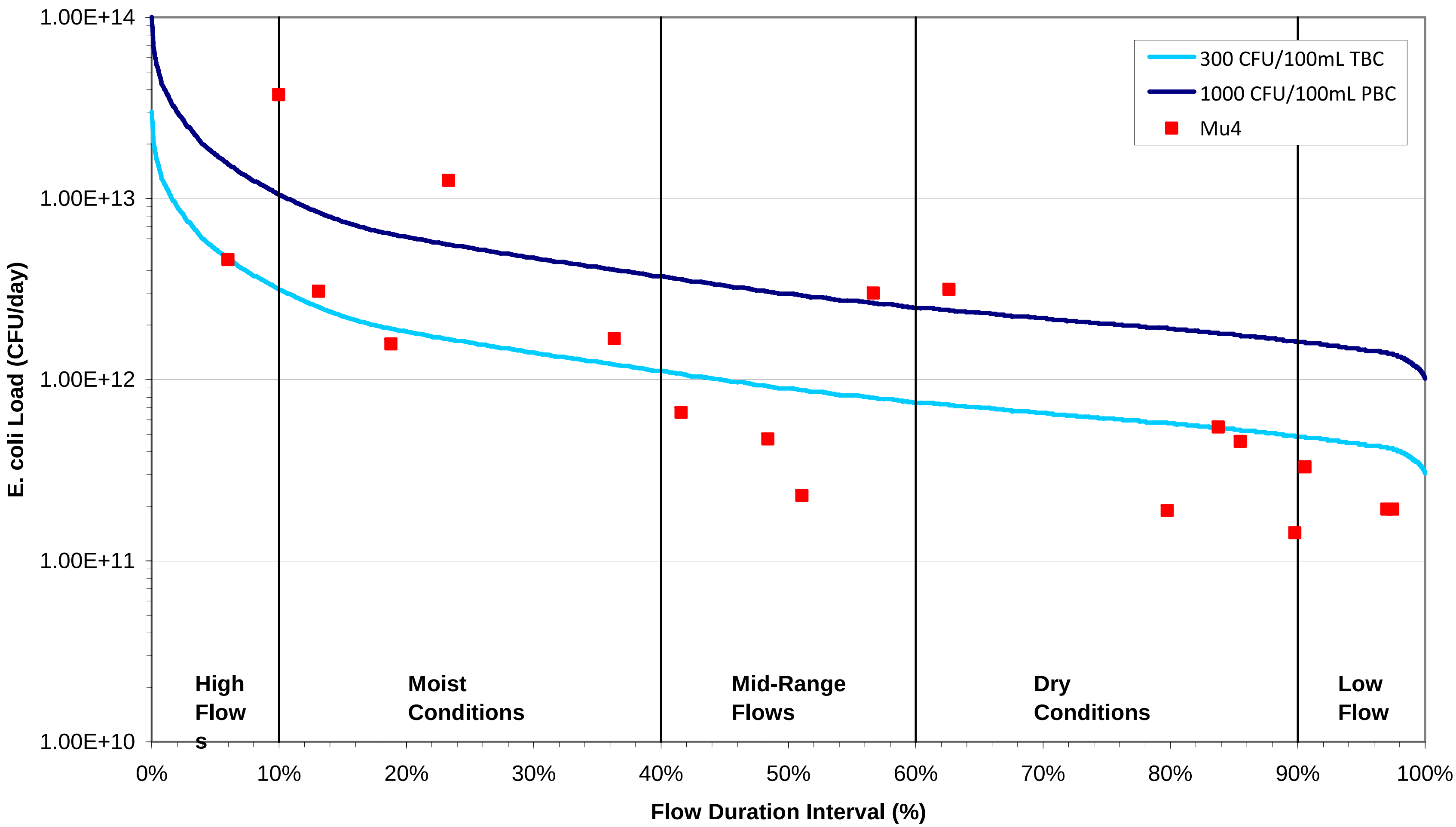

Figure 44: Load duration curve for Munuscong River Watershed monitoring site Mu4.

4.2.9. Summary of Potential Sources

The most probable sources of *E. coli* in the TMDL watersheds identified in the linkage analysis in the preceding sections are summarized in Table 20. Note, however, that all of the potential sources described in Section 4.2 may contribute *E. coli* to the watersheds. Key observations of the linkage analysis include the following:

- Wet weather runoff carrying livestock waste from pastures is a probable bacteria source in many watersheds, especially where fencing or vegetated buffers are lacking.
- OSDS appear to be a significant source of bacteria in drier conditions, particularly in the Frechette Creek, Charlotte River, Little Munuscong River, and Munuscong River Watersheds. Although the population density is low, many of these systems are located near creeks, and soils in much of the area are not suited for standard OSDS adsorption systems which would direct wastewater into the ground for further treatment. Illicit connections of private waste water plumbing directly to surface water is one possible route for bacteria, and one apparent illicit connection was observed during a watershed tour.
- Urban stormwater carrying bacteria from pets, urban wildlife (including waterfowl) is a probable source of bacteria in urban watersheds during frequent, small runoff events that flush pollutants from impervious surfaces and from storm sewers.
- Probable dry and wet weather bacteria sources in urban areas are illicit connections of sanitary sewers to storm sewers and there is the potential for leaking sanitary sewer pipes. During wet weather, stormwater may flush accumulated sanitary wastewater from illicit connections from storm sewers into surface water.
- NPDES discharges are considered a potential source of *E. coli* to surface waters; however, provisions and limitations contained within the permits are designed to achieve the WQS in the receiving water. If a permittee is in compliance with their permit, the contribution of E. coli to surface water is unlikely to cause an exceedance of the TBC or PBC WQS.

Table 20: Most significant probable *E. coli* sources by watershed.

Watershed Name	HUC-12 subwatershed	Livestock	Urban wildlife and/or pets	OSDS	Sanitary Sewer Leaks	Illicit Connections	NPDES Permitted Waste Water Systems
Seymour Creek	40202030105		✓		✓	✓	
Ashmun Creek	40700010101		✓		✓	✓	
Mission Creek	40700010101		✓		✓	✓	
Frechette Creek	40700010101	✓		✓		✓	✓
Charlotte River Headwaters	40700010102	✓		✓		✓	
Charlotte River	40700010103	✓		✓		✓	✓
Headwaters Little Mununuscong River	40700010104	✓		✓		✓	
Little Mununuscong River	40700010105	✓		✓		✓	
Headwaters Munuscong River	40700010201	✓		✓		✓	
Upper Munuscong River	40700010202	✓		✓		✓	
Taylor Creek	40700010203	✓		✓		✓	
Middle Munuscong River	40700010204	✓		✓		✓	✓
Hannah Creek	40700010205	✓		✓		✓	
East Br. Munuscong River	40700010206	✓		✓		✓	
Lower Munuscong River	40700010207	✓	✓	✓		✓	✓
South Branch of East Br. of Waishkey River	40202030201	✓					
South Branch of Waishkey River	40202030202	✓					✓
West Branch of Waishkey River	40202030203	✓					
East Branch of Waishkey River	40202030204	✓					
Orrs Creek	40202030205	✓					
Hickler Creek - Waishkey River	40202030206	✓					

Note: Illicit connections, failing OSDS, and pet and wildlife waste are potential sources in all watersheds.

5.0 DETERMINATION OF LOAD CAPACITY

5.1. Loading Capacity

The TMDL (or loading capacity) represents the maximum amount of pollutant that a water body is capable of assimilating while continuing to meet existing water quality standards. The objective of a TMDL is to allocate loads among pollutant sources so that appropriate control measures can be implemented and water quality standards achieved. Wasteload allocations (WLAs) are assigned to point source discharges regulated by NPDES permits and unregulated nonpoint source loads are assigned load allocations (LAs). A TMDL is expressed as the sum of all individual WLAs for point source loads, LAs for nonpoint source loads, and an appropriate margin of safety (MOS), which takes into account uncertainty (Equation 3).

Equation 3: Calculation of the TMDL

$$TMDL = \sum WLA + \sum LA + MOS$$

Typically, TMDLs are expressed on a mass loading basis (e.g., pounds per day). However, EPA's Water Quality Planning and Management Regulation (40 CFR Part 130) allows for TMDLs to be expressed in terms of organism counts (or resulting concentration) if appropriate. Mass is not an appropriate measure for indicator bacteria TMDLs. Therefore, the TMDLs documented in this report are expressed in terms of concentration and are set equal to the concentration-based water quality standards; therefore the TMDL is equal to the TBC water quality standard of 130 *E. coli* per 100 mL as a 30-day geometric mean, 300 *E. coli* per 100 mL as a daily maximum during the recreation season, and PBC water quality standard of 1,000 *E. coli* per 100 mL as a daily maximum year-round. Table 21 provides a summary of the daily *E. coli* baseline, loading capacity, and reduction goal for each of the TMDL watersheds. Baseline values represent the highest daily geometric mean observed at the most downstream monitoring station during the 2010 monitoring program. This follows the standard EPA proceedure of using the 90^{th} percentile of the monitoring data in each flow duration interval to represent baseline conditions, as described in Section 4.1. The estimated reduction goals are provided for informational purposes only. Given that this is a concentration-based TMDL, attainment with the TMDLs requires attainment with the water quality standards. For informational purposes, Appendix B summarizes load-based calculations using Equation 3.

5.2. Critical Conditions

TMDLs must take into account critical environmental conditions to ensure that water quality is protected during times when it is most vulnerable. The presence of *E. coli* in water bodies is a result of a mixture of continuous and wet-weather driven sources. The existence of multiple sources of *E. coli* to a water body results in a variety of critical conditions (e.g., high flow is the critical condition for stormwater-related sources and low flow is the critical condition for dry weather sources such as illicit connections). Therefore, no single critical condition is applicable for this TMDL. Critical conditions are implicit in these TMDLs because all flow conditions have been considered in their development, and expressing the TMDL as a concentration equal to the WQS ensures that the WQS will be met under all critical flow and loading conditions.

Table 21: Daily *E. coli* baseline, loading capacity, and reduction goal for each TMDL watershed.

Watershed	Daily E. coli (CFU / 100 mL)				% Reduction
	Baseline[1]	Loading Capacity[2]		Reduction[3]	
Ashmun Creek (As1)	6,288	(May 1 – Oct 31)	300	5,988	95%
		(Nov 1 – Apr 30)	1,000	5,288	84%
Charlotte River (Ch4)	1,375	(May 1 – Oct 31)	300	1,075	78%
		(Nov 1 – Apr 30)	1,000	375	27%
Mission Creek (Mi2)	4,744	(May 1 – Oct 31)	300	4,444	94%
		(Nov 1 – Apr 30)	1,000	3,744	79%
Little Munuscong River (Lm2)	4,567	(May 1 – Oct 31)	300	4,267	93%
		(Nov 1 – Apr 30)	1,000	3,567	78%
Munuscong River (Mu4)	3,576	(May 1 – Oct 31)	300	3,276	92%
		(Nov 1 – Apr 30)	1,000	2,576	72%
Frechette Creek (Fr1)	3,472	(May 1 – Oct 31)	300	3,172	91%
		(Nov 1 – Apr 30)	1,000	2,472	71%
Seymour Creek (Se1)	3,444	(May 1 – Oct 31)	300	3,144	91%
		(Nov 1 – Apr 30)	1,000	2,472	71%
Waishkey River (Wa1)	427	(May 1 – Oct 31)	300	127	30%
		(Nov 1 – Apr 30)	1,000	0	0%

[1] Highest daily geometric mean observed at the most downstream monitoring station during the 2010 monitoring program.

[2] Daily loading capacities set equal to the TBC WQS (a daily maximum of 300 *E. coli* per 100 mL from May 1 to October 31) and the PBC WQS (daily maximum of 1,000 *E. coli* per 100 mL year-round).

[3] Estimated reduction goals provided for informational purposes only. Attainment with the TMDLs requires attainment with the water quality standards.

6.0 POLLUTANT LOAD ALLOCATIONS

6.1. Load Allocation

The load allocation for nonpoint sources of *E. coli* in each of the watersheds is summarized in Table 22.

The load allocation for *E. coli* in nonpoint sources of stormwater runoff in each of the watersheds is set equal to the concentration-based water quality standards, as follows: 130 *E. coli* per 100 mL as a 30-day geometric mean and a daily maximum of 300 *E. coli* per 100 mL from May 1 to October 31; and a daily maximum of 1,000 *E. coli* per 100 mL November 1 to April 30. The relative responsibility for achieving the reductions of *E. coli* necessary to meet water quality standards is approximated based on the amount of land under the jurisdiction of the local unit of government in each of the watersheds. Eleven municipalities have land area within the TMDL source area (Table 23).

Discharge of untreated sanitary sewage to receiving waters is prohibited; therefore, the load allocation for failing or poorly designed OSDS in each of the watersheds is zero (0), and the reduction goal is 100% (i.e., complete elimination).

Illicit discharges to storm sewers or surface water are also prohibited; therefore the load allocation for illicit discharges to storm drains in each of the watersheds is zero (0), and the reduction goal is 100% (i.e., complete elimination).

Table 22: Load allocation for nonpoint sources of *E. coli*.

Watershed	Load Allocation
Nonpoint sources of stormwater runoff from all land covers	130 *E. coli* per 100 mL as a 30-day geometric mean and a daily maximum of 300 *E. coli* per 100 mL from May 1 to October 31; and a daily maximum of 1,000 *E. coli* per 100 mL November 1 to April 30.
Failing or leaking OSDS	0 *E. coli* per 100 mL
Illicit discharges to storm drains in non MS4 areas	0 *E. coli* per 100 mL

Table 23: Distribution of land for each municipality.

Watershed	Municipality	Square Miles	% of Watershed / Relative Responsibility
Ashmun Creek	City of Sault Ste Marie	3.1	77%
	Soo Township	0.9	23%
Charlotte River	Bruce Township	36.3	62%
	Dafter Township	17.5	30%
	Kinross Township	0.1	0%
	Soo Township	4.5	8%
Mission Creek	City of Sault Ste Marie	3.5	96%
	Soo Township	0.1	4%
Little Munuscong River	Bruce Township	24.5	54%
	Dafter Township	1.3	3%
	Kinross Township	12.6	27%
	Pickford Township	7.5	16%
Munuscong River	Clark Township	8.4	4%
	Kinross Township	15.7	8%
	Marquette Township	40.5	22%
	Pickford Township	85.5	46%
	Raber Township	13.7	7%
	Rudyard Township	23.8	13%
Frechette Creek	Soo Township	3.4	100%
Seymour Creek	City of Sault Ste Marie	1.2	100%
Waishkey River	Bay Mills Township	0.9	1%
	Dafter Township	29.2	20%
	Kinross Township	34.7	23%
	Soo Township	6.8	5%
	Superior Township	76.8	52%

6.2. Wasteload Allocation

The wasteload allocation for NPDES permitted point source discharges in each of the watersheds is summarized in Tables 24 and 25.

The wasteload allocation for all regulated surface water dischargers (Figure 45) is set equal to the concentration-based water quality standards, as follows: 130 *E. coli* per 100 mL as a 30-day geometric mean and a daily maximum of 300 *E. coli* per 100 mL from May 1 to October 31; and a daily maximum of 1,000 *E. coli* per 100 mL November 1 to April 30. There are two municipal wastewater treatment facilities with individual National Pollutant Discharge Elimination System (NPDES) permits (Kinross Township Wastewater Treatment Facility, MI0057776; and Odenaang Subdivision Wastewater Treatment Plant, MI-0057087-2); one statewide individual municipal Separate Stormwater Sewer Systems (MS4) permit for the Michigan Department of Transportation (MDOT; MI0057364); and ten certificates of coverage issued under general NPDES permits, including five permits for wastewater stabilization lagoons (MIG580201, MIG580206, MIG580209, MIG580255, and

MIG580371) and five permits for storm water from industrial activities (MIS110005, MIS110006, MIS110015, MIS110025, and MIS111667). Note that the Odenaang Subdivision WWTF is operated by the Sault Tribe of Chippewa Indians, and therefore is authorized to discharge (in accordance with effluent limitations and monitoring) by the EPA; therefore, it is the EPA's responsibility to ensure that NPDES permit compliance and effluent limitations are sufficient to ensure that Michigan's WQS are met when tribal waters enter waters of the state of Michigan.

Illicit discharges of sanitary wastewater to surface waters and storm drains are prohibited; therefore the load allocation for illicit discharges to surface waters and storm drains in each of the watersheds is zero (0), and the reduction goal is 100% (i.e., complete elimination).

Table 24: Wasteload allocation for regulated surface water discharges.

Source	Wasteload Allocation
Regulated surface water discharge, including stormwater runoff and wastewater treatment facility discharge	130 *E. coli* per 100 mL as a 30-day geometric mean and a daily maximum of 300 *E. coli* per 100 mL from May 1 to October 31; and a daily maximum of 1,000 *E. coli* per 100 mL November 1 to April 30.
Illicit discharges to surface waters and storm drains	0 *E. coli* per 100 mL
Leaking sanitary sewer lines	0 *E. coli* per 100 mL
Sanitary sewer overflows	0 *E. coli* per 100 mL

Table 25: Wasteload allocation for regulated surface water discharges.

Watershed	Regulated Entity	Permit Type	Wasteload Allocation
Ashmun Creek	Sault Ste Marie Muni Airport (Permit no. MIS110006)	Storm Water from Industrial Activities	130 *E. coli* per 100 mL as a 30-day geometric mean and a daily maximum of 300 *E. coli* per 100 mL from May 1 to October 31; and a daily maximum of 1,000 *E. coli* per 100 mL November 1 to April 30.
	Hoover Precision Products (Permit no. MIS110015)	Storm Water from Industrial Activities	
	Aggressive Mfg Innovation (Permit no. MIS111667)	Storm Water from Industrial Activities	
Waishkey River	Dafter Sanitary Landfill (Permit no. MIS110005)	Storm Water from Industrial Activities	
	Continental Teves-Brimley (Permit no. MIG580201)	Wastewater Stabilization Lagoons	
	Kinross Twp WWTF (Permit no. MI0057776)	Wastewater Treatment Facility	
Charlotte River	Bruce School (Permit no. MIG580209)	Wastewater Stabilization Lagoons	
	Cleve Reid MHP (Permit no. MIG580255)	Wastewater Stabilization Lagoons	
Frechette Creek	Odenaang Subdivision WWTF (Permit no. MI-0057087-2[1])	Wastewater Treatment Facility	
Statewide	Michigan Department of Transportation (Permit no. MI0057364)	MS4	

[1] Permit issued by EPA.

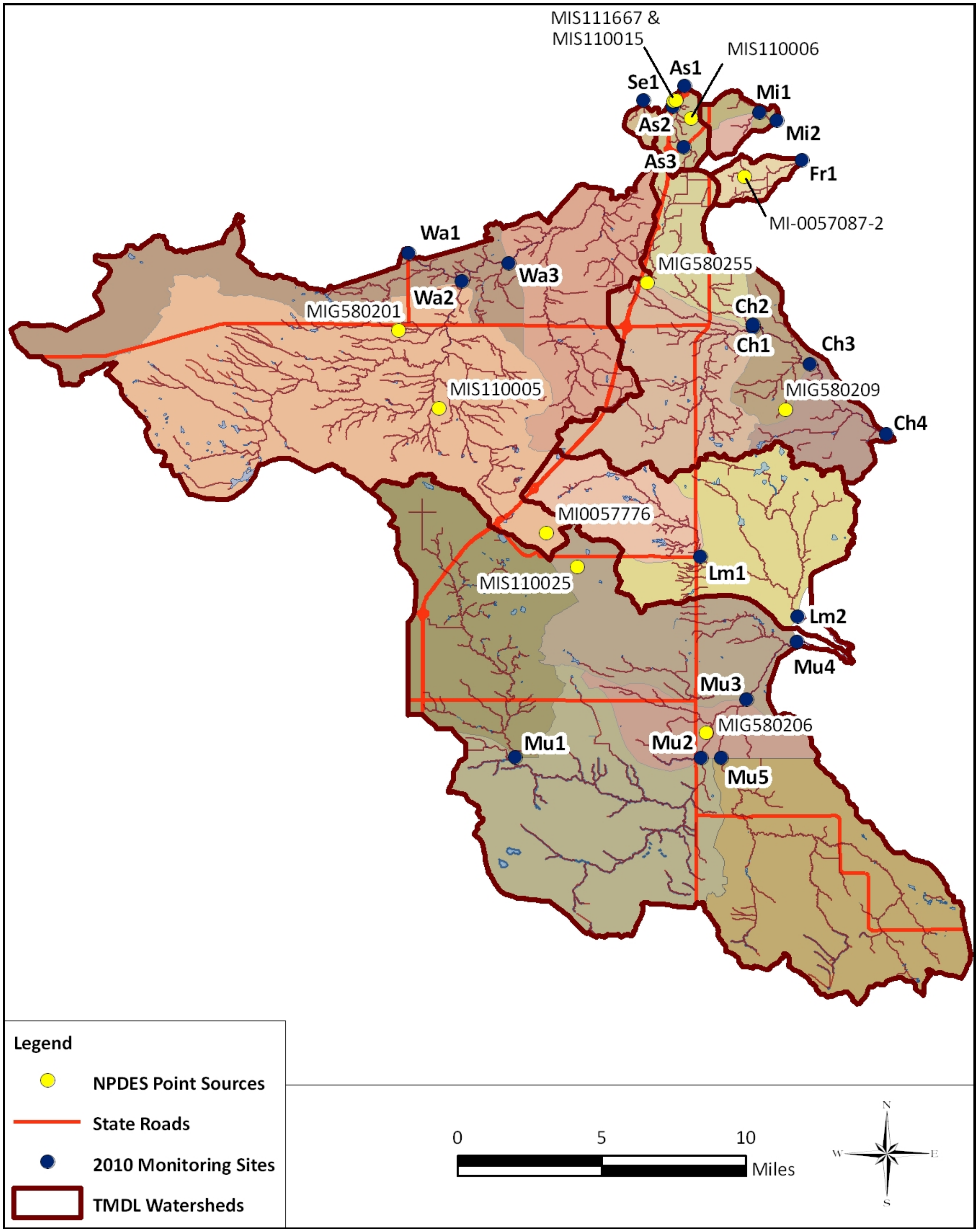

Figure 45: Locations of NPDES regulated point discharges.

6.3. Margin of Safety

The purpose of the margin of safety (MOS) is to account for uncertainty or lack of knowledge concerning the relationship between pollutant loading and water quality, including the pollutant decay rate. The margin of safety can be implicit (i.e., incorporated into the TMDL analysis through conservative assumptions) or explicit (i.e., expressed in the TMDL as a portion of the loadings) or a combination of both. No rate of pollutant decay was used for the TMDLs, providing an implicit margin of safety. Pathogen organisms ordinarily have a limited capability of survival outside of their hosts, and therefore, a rate of pollutant decay could be included. However, applying a rate of pollutant decay may result in an allocation that is greater than the water quality standards, thus no rate of decay is applied to provide greater protection of water quality. Setting the load allocations and wasteload allocations equal to the TBC (130 *E. coli* per 100 mL as a 30-day geometric mean and a daily maximum of 300 *E. coli* per 100 mL from May 1 to October 31) and the PBC (a daily maximum of 1,000 *E. coli* per 100 mL November 1 to April 30) is a more conservative approach than developing an explicit margin of safety. It also accounts for the uncertainty in the relationship between pollutant loading and water quality, based on available data and the assumption to not use a rate of pollutant decay. Finally, requiring the water quality standards to be met under all flow conditions also adds to the assurance that an explicit margin of safety is unnecessary.

6.4. Seasonal Variation

TMDLs must take into account seasonal variation in environmental conditions to ensure that water quality is protected year-round. The water quality standards for *E. coli* are expressed in terms of seasons (e.g., TBC from May 1 through October 31 and PBC year-round). Setting the TMDLs equal to the water quality standards ensures that the water quality standards will be met year-round. Given that this is a concentration-based TMDL, water quality standards must be met regardless of flow conditions in the applicable season.

7.0 REASONABLE ASSURANCE AND IMPLEMENTATION PLAN

The previous sections provide detailed discussion on the watershed conditions and potential *E. coli* sources. Measures must be taken to reduce *E. coli* levels from both point and nonpoint sources in each of the eight watersheds in which the impaired water bodies are located. This section will discuss existing programs, planned programs and recommended actions to reduce or to eliminate *E. coli* sources and improve water quality in the impaired streams and rivers.

7.1.1. Permitted Wastewater Facilities

Discharges from the WWSL are regulated directly by the MDEQ under General Permit MIG589000, or the USEPA (MI-0057087-2 for the Odenaang subdivision on tribal land). All WWSL and WWTF are required to meet their respective NPDES permit limits. Michigan regulates discharges containing treated or untreated human waste (i.e., sanitary wastewater) using fecal coliform as the indicator. Sanitary wastewater discharges are required to meet the effluent limitation of 200 fecal coliform per 100 mL as a monthly geometric mean and 400 fecal coliform per 100 mL as a 7-day geometric mean. Michigan's WQS for *E. coli* are based upon criteria in the USEPA's 1986 criteria document (USEPA, 1986). Specifically, the USEPA criterion of 126 *E. coli* per 100 mL is the basis for Michigan's TBC WQS of 130 *E. coli* per 100 mL. This criterion is intended to provide a level of protection of producing no more than 8 illnesses per 1,000 swimmers and approximates the degree of protection provided by the fecal coliform indicator of 200 fecal coliform per 100 mL bacteria standard recommended by the USEPA prior to the adoption of the 1986 criteria. The sanitary discharges are expected to be in compliance with the ambient PBC and TBC *E. coli* WQS if their NPDES permit limits for fecal coliform are met. All WWSL discharges under general permit MIG589000 must monitor their effluent for fecal coliform and receive MDEQ approval prior to beginning a discharge. During discharge, monitoring for fecal coliform occurs the first day and every other day after the first day of discharge. Discharge is prohibited between during periods of significant ice cover, January 1 and February 28/29, and from June 1 through September 30th.

NPDES individual permits, COCs, and general permits are reissued every five years on a rotating schedule, and the requirements within the permits may also change at reissuance. Pursuant to R 323.1207(1)(b)(ii) of the Part 8 rules, and 40 CFR, Part 130.7, NPDES permits issued or reissued after the approval of this TMDL are required to be consistent with the goals of this TMDL.

It is the responsibility of MDEQ staff to inspect and audit NPDES permitted facilities once every five years on a rotating basis. At the time of these audits, MDEQ staff review permits, permittee actions, submittals, and records to ensure that each permittee is fulfilling the requirements of their permit. Consistency of the permit with the TMDL, and any potential deficiencies of the facility will be reviewed and addressed as part of the audit and permit reissuance processes.

7.1.2. NPDES Permitted Stormwater

Michigan's general industrial storm water permit (MIS110000) specifies that facilities need to obtain a certified operator who will have supervision and control over the control structures at the facility, eliminate any unauthorized non-storm water discharges, and develop and implement the Storm Water Pollution Prevention Plan for the facility. The permittee shall determine whether its facility discharges storm water to a water body for which the MDEQ has established a TMDL. If so, the permittee shall assess whether the TMDL requirements for the facility's discharge are being met through the existing Storm Water Pollution Prevention Plan controls or whether additional control measures are necessary. The permitee's assessment of whether the TMDL requirements are being met shall focus on the effectiveness, adequacy, and implementation of the permittee's Storm Water Pollution Prevention Plan controls. The applicable TMDLs will be identified in the COC issued under this permit.

The Michigan Department of Transportation has a statewide NPDES Individual Storm Water Permit (MI0057364) to cover storm water discharges from its MS4. This statewide permit requires the permittee to reduce the discharge of pollutants to the maximum extent practicable and employ Best Management Practices to comply with TMDL requirements.

NPDES individual permits, COCs, and general permits are reissued every five years on a rotating schedule, and the requirements within the permits may also change at reissuance. Pursuant to R 323.1207(1)(b)(ii) of the Part 8 rules, and 40 CFR, Part 130.7, NPDES permits issued or reissued after the approval of this TMDL are required to be consistent with the goals of this TMDL.

It is the responsibility of MDEQ staff to inspect and audit NPDES permitted facilities once every five years on a rotating basis. At the time of these audits, MDEQ staff review permits, permittee actions, submittals, and records to ensure that each permittee is fulfilling the requirements of their permit. Consistency of the permit with the TMDL, and any potential deficiencies of the facility will be reviewed and addressed as part of the audit and permit reissuance processes.

7.2. Stakeholder involvement and watershed planning

Reasonable assurance activities are programs that are in place or planned to assist in meeting the TMDL allocations and water quality standards. To have a successful implementation plan, it is critical that all stakeholders are identified and have some level of ownership in the actions needed to meet the TMDL requirements. For this TMDL, likely stakeholders include:

- Michigan DEQ
- Municipal Government Officials
- Bay Mills Indian CommunitySault Ste. Marie Tribe of Chippewa Indians
- Chippewa County Health Department (CCHD)
- Munuscong River Watershed Association
- East/Chippewa Mackinac Conservation District
- Natural Resources Conservation Service
- Lake Superior State University
- Concerned Citizens
- USEPA

There is only one approved watershed management plan (WMP) within the TMDL area. The Sault Area WMP was completed by the Chippewa/East Mackinac Conservation District in 2007 and provides a comprehensive discussion of the water quality issues associated with waters that discharge to the St. Marys in the vicinity of Sault Ste. Marie, including Ashmun Creek, Frechette

Creek, Mission Creek, Seymour Creek and Shunk Creek. The Sault Area WMP assessed other pollutants in addition to *E. coli* such as nutrients, suspended sediment, hazardous or toxic materials, and changes in hydrology. The Sault Area WMP includes discussion on known impairments from pathogens, such as *E. coli,* in the waters described above. There are implementation recommendations for specific BMPs at specific locations.

In 2011, MDEQ prepared a report titled "Munuscong River Watershed Hydrologic Study". This report compared changes in hydrology between pre-European settlement and present. There is a detailed description of land use, estimates of runoff, and changes in stream morphology. The report identified critical stream reaches that were most unstable, providing a disproportionate share of pollutants based on hydrologic criteria.

The hydrologic study report was prepared to support the Chippewa/East Mackinac Conservation District and Munuscong River Watershed Association develop a WMP for the Munuscong and Little Munuscong Rivers. The intent of the project is to investigate nonpoint source pollutants, included *E. coli*, in the watersheds and identify methods and practices to improve water quality. This effort is supported through the participation of public and private stakeholders and funded by Section 319 Nonpoint Source Grants through the MDEQ.

The existing Sault Area WMP and future Munuscong River WMP (when approved) will greatly assist stakeholders in implementing practices to improve water quality for point and non-point pollutants, including *E. coli*. These plans will address the elements required by USEPA for eligibility for funding water quality improvement projects through the Section 319 Nonpoint Source Grants to States and Territories.

For remaining watersheds in the TMDL the development of watershed management plans to help identify management practices and actions that can improve water quality for *E. coli* and other pollutants. Grant eligible watershed plans must include the nine key elements listed below.

1. Identify causes of impairment and pollutant sources that need to be controlled to achieve needed load reductions. Sources that need to be controlled should be identified at the significant subcategory level along with estimates of the extent to which they are present in the watershed.
2. Estimate the load reduction expected from management measures.
3. Describe of nonpoint source management measures that will need to be implemented to achieve load reductions and a description of the critical areas in which those measures will be need to implement this plan.
4. Estimate of the amounts of technical and financial assistance needed, associated costs, and sources/authorities that will be relied on to implement this plan.
5. Have an information/education component used to enhance the public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing nonpoint source management measures that will be implemented.
6. Provide a schedule for implementing the nonpoint source management measures identified in this plan that is reasonable expeditious.
7. Describe interim measureable milestones for determining whether nonpoint source management measures or other actions are being implemented.

8. Have a set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress being made toward attainting water quality standards.
9. Include a monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established above.

This implementation plan and TMDL report provides a framework to develop a watershed management plan that address these nine elements However additional work will need to be completed by stakeholders to provide more detailed information on specific actions and initiatives to reduce *E. coli* in impaired waters.

The St. Marys River between Whitefish Bay and the Detour straight has been designated as an Area of Concern (AOC). The U.S.-Canada Great Lakes Water Quality Agreement (Annex 2 of the 1987 Protocol) defines AOCs as "geographic areas that fail to meet the general or specific objectives of the agreement where such failure has caused or is likely to cause impairment of beneficial use of the area's ability to support aquatic life." Of particular interest to this TMDL is that one of the impairments to beneficial use is periodic beach closings due to high bacteria levels. This TMDL and the Implementation Plan will improve water quality at the affected beaches by reduce *E. coli* loading in the watersheds draining to the St. Marys River.

7.3. Implementation Plan

The previous monitoring work and the information included in this TMDL report provide a baseline watershed characterization. As implementation actions are undertaken, additional information is expected to become available, including additional monitoring results, Geographic Information System (GIS) data, and hydrologic studies. Throughout implementation and additional data gathering, it is imperative that the stakeholders work together to ensure that the data are shared and leveraged to best take advantage of the funding/resources and address issues any group will likely encounter.

This implementation identifies multiple approaches for reducing *E. coli* levels from point and nonpoint sources. As with any plan, to be successful there must be an iterative process that is periodically checked, modified, and documented to confirm that the pollutant reduction goals are being met and there is a consequent improvement in water quality. The goal of this implementation plan is to provide local stakeholders with a framework to restore impaired waters and enhance the value of their land and water resources.

A key next step will be to conduct a detailed inspection of the individual TMDL subwatersheds to inventory the potential sources of *E. coli* identified in this report. Examples of this include watershed surveys for livestock operations, tillage practices, and examination of OSDS via areal imagery. MDEQ, the Chippewa County Health Department, and the East Chippewa Mackinac Conservation District are likely organizations to collaborate and lead this effort. The detailed inspection will provide the specific number and locations of each type of bacteria source that need to be addressed through implementation actions. Based on this information, a list of specific projects can be developed, along with implementation costs and a schedule.

Table 26 summarizes the *E. coli* sources that are likely to be most significant and priority implementation actions for each HUC-12 watershed. Each of the implementation actions identified in Table 26 is described in Section 7.3 (Implementation Actions). Local stakeholders have already begun to implement some of these actions, as noted in Table 26.

Table 26: Implementation Action Summary by subwatershed (12-digit HUC).

Watershed Name & HUC-12 No.	Associated Sample ID(s)	Priority (Based on WQS Exceedance Rank)	Likely Sources Based on Source Assessment	Implementation Actions	Implementation in Progress
Ashmun Creek 40700010101	As1 As2 As3	3 17 13	Urban wildlife and/or pets	Regulatory Controls Information & Education Urban Riparian Buffers	NPDES permitted facilities Served by sanitary sewer (City of Sault Ste. Marie) Monitoring by Lake Superior State University Sault Area WMP Pet Ordinance
			Sanitary Sewer Leaks	Inspections	
			Illicit Connections	Inspections	
Frechette Creek 40700010101	Fr1	8	Livestock	Grazing Practices Feedlot BMPs Wetland Restoration Rural Riparian Buffers	NPDES permitted facility OSDS leak testing by CCHD Portion of area served by sanitary sewer (Odenaang) NPDES permitted facility
			On-Site Systems	Regulatory Controls	
			Illicit Connections	Inspections	
			Permitted Waste Water Facilities	Facility Operations & Management	
Mission Creek 40700010101	Mi1 Mi2	5 9	Urban wildlife and/or pets	Regulatory Controls Information & Education Urban Riparian Buffers	Served by sanitary sewer (City of Sault Ste. Marie) Sault Area WMP Pet Ordinance Conservation programs
			Sanitary Sewer Leaks	Inspections	
			Illicit Connections	Inspections	
Seymour Creek 40202030105	Se1	4	Urban wildlife and/or pets	Regulatory Controls Information & Education Urban Riparian Buffers	Served by sanitary sewer (City of Sault Ste. Marie) Sault Area WMP Pet Ordinance
			Sanitary Sewer Leaks	Inspections	
			Illicit Connections	Inspections	

Watershed Name & HUC-12 No.	Associated Sample ID(s)	Priority (Based on WQS Exceedance Rank)	Likely Sources Based on Source Assessment	Implementation Actions	Implementation in Progress
Charlotte River Headwaters 40700010102	Ch1	7	Livestock	Grazing Practices Feedlot BMPs Rural Riparian Buffers Wetland Restoration	NPDES permitted facilities Superior Environmental Health Code Conservation programs
			On-site systems	Regulatory Controls	
			Illicit Connections	Inspections	
Charlotte River 40700010103	Ch2 Ch3 Ch4	11 12 20	Livestock	Grazing Practices Feedlot BMPs Rural Riparian Buffers Wetland Restoration	Superior Environmental Health Code Conservation programs
			On-site systems	Regulatory Controls	
			Illicit Connections	Inspections	
Headwaters Little Mununuscong River 40700010104	Lm1	16	Livestock	Grazing Practices Feedlot BMPs Rural Riparian Buffers Wetland Restoration	Superior Environmental Health Code Conservation programs
			On-site systems	Regulatory Controls	
			Illicit Connections	Inspections	
Little Mununuscong River 40700010105	Lm2	14	Livestock	Grazing Practices Feedlot BMPs Wetland Restoration	Superior Environmental Health Code Conservation programs
			On-site systems	Regulatory Controls	
			Illicit Connections	Inspections	
Headwaters Munuscong River 40700010201	Mu1	10	Livestock	Grazing Practices Feedlot BMPs Wetland Restoration	Superior Environmental Health Code Munuscong River Watershed Association Conservation programs
			On-site systems	Regulatory Controls	
			Illicit Connections	Inspections	

Watershed Name & HUC-12 No.	Associated Sample ID(s)	Priority (Based on WQS Exceedance Rank)	Likely Sources Based on Source Assessment	Implementation Actions	Implementation in Progress
Upper Munuscong River 40700010202	Mu1	10	Livestock	Grazing Practices Feedlot BMPs Rural Riparian Buffers Wetland Restoration	Superior Environmental Health Code Munuscong River Watershed Association Conservation programs
			On-site systems	Regulatory Controls	
			Illicit Connections	Inspections	
Taylor Creek 40700010203	Mu2	6	Livestock	Grazing Practices Feedlot BMPs Wetland Restoration	Superior Environmental Health Code Munuscong River Watershed Association Conservation programs
			On-site systems	Regulatory Controls	
			Illicit Connections	Inspections	
Middle Munuscong River 40700010204	Mu2 Mu3	6 2	Livestock	Grazing Practices Feedlot BMPs Rural Riparian Buffers Wetland Restoration	NPDES permitted facility Portion of area served by sanitary sewer (Pickford) Superior Environmental Health Code Munuscong River Watershed Association Conservation programs
			On-site systems	Regulatory Controls	
			Illicit Connections	Inspections	
Hannah Creek 40700010205	Mu5	1	Livestock	Grazing Practices Feedlot BMPs Wetland Restoration	Superior Environmental Health Code Munuscong River Watershed Association Conservation programs
			On-site systems	Regulatory Controls	
			Illicit Connections	Inspections	
East Br. Munuscong River 40700010206	Mu3 Mu5	2 1	Livestock	Grazing Practices Feedlot BMPs Rural Riparian Buffers Wetland Restoration	Superior Environmental Health Code Munuscong River Watershed Association Conservation programs
			On-site systems	Regulatory Controls	
			Illicit Connections	Inspections	

Watershed Name & HUC-12 No.	Associated Sample ID(s)	Priority (Based on WQS Exceedance Rank)	Likely Sources Based on Source Assessment	Implementation Actions	Implementation in Progress
Lower Munuscong River 40700010207	Mu4	15	Livestock	Grazing Practices Feedlot BMPs Wetland Restoration	NPDES permitted facility Served by sanitary sewer (Kinross) Permitted biosolids spreading Superior Environmental Health Code Munuscong River Watershed Association Conservation programs
			On-site systems	Regulatory Controls	
			Illicit Connections	Inspections	
			Permitted Waste Water Facilities	Facility Operations & Management	
South Branch of East Br. of Waishkey River 40202030201	Wa3	19	Livestock	Grazing Practices Feedlot BMPs Wetland Restoration	Superior Environmental Health Code Conservation programs
			On-site systems	Regulatory Controls	
			Illicit Connections	Inspections	
South Branch of Waishkey River 40202030202	Wa2	18	Livestock	Grazing Practices Feedlot BMPs Wetland Restoration	NPDES permitted facilities Permitted biosolids spreading Superior Environmental Health Code Conservation programs
			On-site systems	Regulatory Controls	
			Illicit Connections	Inspections	
			Permitted Waste Water Facilities	Facility Operations & Management	
West Branch of Waishkey River 40202030203	Wa2	18	Livestock	Grazing Practices Feedlot BMPs Wetland Restoration	Permitted biosolids spreading Superior Environmental Health Code Conservation programs
			On-site systems	Regulatory Controls	
			Illicit Connections	Inspections	
East Branch of Waishkey River 40202030204	Wa3	19	Livestock	Grazing Practices Feedlot BMPs Wetland Restoration	Superior Environmental Health Code Conservation programs
			On-site systems	Regulatory Controls	
			Illicit Connections	Inspections	

Watershed Name & HUC-12 No.	Associated Sample ID(s)	Priority (Based on WQS Exceedance Rank)	Likely Sources Based on Source Assessment	Implementation Actions	Implementation in Progress
Orrs Creek 40202030205	Wa1	21	Livestock	Grazing Practices Feedlot BMPs Wetland Restoration	Superior Environmental Health Code Conservation programs
			On-site systems	Regulatory Controls	
			Illicit Connections	Inspections	
Hickler Creek - Waishkey River 40202030206	Wa2	18	Livestock	Grazing Practices Feedlot BMPs Rural Riparian Buffers Wetland Restoration	NPDES permitted facility Superior Environmental Health Code Conservation programs
			On-site systems	Regulatory Controls	
			Illicit Connections	Inspections	

7.4. Implementation Actions

As shown in Table 26, specific methods for addressing *E. coli* sources have been identified. It is critical that additional watershed reconnaissance and investigation is completed to identify and inventory specific *E. coli* source areas, as well as identify areas where BMPs could be installed. Where provided, estimated costs for specific practices were obtained from the Natural Resources Conservation Service Michigan Electronic Field Office Technical Guide, Section I, Statewide Conservation Practice Typical Installation Cost Information, December 2010. A comprehensive description of implementation costs was not completed for this implementation plan since a detailed survey of sources at each watershed has not yet been completed. After the detailed watershed survey is completed, nine key elements can be fully described and included in a WMP. The following sections describe the implementation methods for reducing the potential for *E. coli* discharge to impaired waters.

7.4.1. Livestock

The Michigan Agriculture Environmental Assurance Program (MAEAP) is a voluntary program established by Michigan law (1994 PA 451, MCL 324.3109d) to minimize the environmental risk of farms, and to promote adherence to Right to Farm Generally Accepted Agricultural Management Practices, also known as GAAMP. In order for a farm to earn MAEAP verification, it must demonstrate that it is meeting the requirements geared toward reducing contamination of ground and surface water, as well as the air. Livestock*a*Syst is the portion of the MAEAP verification process that holds the most promise for protecting waters of the state from contamination by *E. coli* and other pathogens, and requirements for verification include: steps to promote the separation of contaminated stormwater from clean stormwater at the farm site, the completion of a CNMP similar to that required by NPDES permitted CAFOs, runoff control at feedlots and the identification of environmentally sensitive areas, the prevention of manure reaching tile lines and runoff from manure land-application area controlled through incorporation of manure or other conservation practices.

Grazing Practices

During the 2010 monitoring project, livestock were observed at several locations with either direct access to streams and rivers or pastured directly adjacent to the water bodies. Observations during the 2010 monitoring project and subsequent reconnaissance showed that riparian buffers were typically not present in pasture lands and grazed areas. Several mitigation options include:

Fencing for the exclusion of livestock in streams and other waterways. This consists of installing fencing to isolate portions of the pasture where livestock have direct access to the stream. Keeping animals away from open water will prevent defecation in the stream, which can lead to bacterial pollution. One drawback is that this may require the farmer to find alternative water sources for livestock. Communications with representatives from the Chippewa County Natural Resources Conservation Service (NRCS) revealed that landowners have been seeking assistance, both technical and financial, from NRCS for fencing projects. We recommend this ongoing work be supported and continued. The estimated cost for installation of fencing is approximately $1.32 per foot

[Conservation Practice Standard (CPS) 382]. Funding and technical assistance is available from NRCS for installation through various conservation programs.

We recommend fencing projects to reduce livestock access to waterways be implemented in the grazed portions of the following areas; headwaters of Frechette Creek (407000410101), Charlotte River Headwaters (40700010102), Charlotte River (40700010103), Headwaters Little Munuscong River (40700010104), Little Munuscong River (40700010105), Headwaters Munuscong River (40700010201), Upper Munuscong River (40700010202),Taylor Creek (40700010203), Middle Munuscong River (40700010204), Hannah Creek (40700010205), East Br. Munuscong River (40700010206),Lower Munuscong River (40700010207), South Branch of East Branch of Waishkey River (40202030201), South Branch of Waishkey River (40202030202), West Branch of Waishkey River (40202030203), East Branch of Waishkey River (40202030204), Orrs Creek (40202030205), and Hickler Creek-Waishkey River (40702030206).

Rural Riparian Buffers

Riparian buffers are an area of predominantly trees and/or shrubs located adjacent to and up-gradient from watercourses or water bodies, typically 50-200 feet wide. The installation of riparian buffers downslope of fields where manure land-application occurs, active pastures, or feedlots can reduce the amount of *E. coli* entering surface water. Additional benefits of riparian buffers include, creating shade to lower or maintain water temperatures to improve habitat for aquatic organisms, reducing excess amounts of sediment, organic material, nutrients and pesticides in surface runoff and reduce excess nutrients and other chemicals in shallow ground water flow and restoring riparian plant communities. Establishing forested riparian buffers typically costs $434.50 per acre (NRCS, 1998). Funding and technical assistance is available from NRCS for installation through various conservation programs.

It is recommended that projects to create riparian vegetated buffers be implemented in the agricultural portions of the following areas; headwaters of Frechette Creek (407000410101), Charlotte River Headwaters (40700010102), Charlotte River (40700010103), Headwaters Little Munuscong River (40700010104), Upper Munuscong River (40700010202), Middle Munuscong River (40700010204), East Br. Munuscong River (40700010206),and Hickler Creek-Waishkey River (40202030206).

Feedlot Best Management Practices

Feedlots that drain to surface waters are another source of *E. coli* delivery to surface waters. Runoff from rain events or snowmelt can transport pathogens. Several methods for managing feedlot runoff are described below.

- Clean water can be diverted to direct runoff and rain water away from open lots or other areas where manure may accumulate. By preventing excess water from entering the feedlot or manure stockpile area, diversions can reduce the potential transport of pathogens. Some examples of clean water diversions are:
    - Gutters: Gutters and downspouts divert roof runoff water from feedlot facilities to a location away from the feedlot. One can also install rock channels at the base of

feedlot buildings instead of a gutter to direct roof runoff. Installation of large gutters is $13.05 per linear foot (CPS 558).

  - Berms & Ditches: Earthen berms and ditches can be used to divert up-slope runoff and rain water from buildings away from open lots or other areas where manure may accumulate. Preventing this excess water from entering the lot or manure stockpile area will reduce pollution potential and keep these areas drier. Drier facilities can improve animal health, which in turn lowers pathogen levels in manure. Berms can also be installed in locations to direct the runoff to a collection area (catch basin, vegetative filter, constructed wetland) where solids in the runoff can settle out. Construction of berms and ditches for diverting water is $3.75 per linear foot (CPS 362).
  - Grassed Waterways: A grassed waterway is a natural or constructed channel that has been graded or shaped to form a bowl-shaped channel. Runoff water can be directed to move across the grassed channel away from the lot. The grass cover also acts as a filter to absorb some of the bacteria and nutrients in the runoff water. The estimated cost for installing new grassed waterways is $4,010.00 per acre (CPS 412).

- Another option for managing feedlot runoff is installing a detention basin. A detention basin retains runoff and reduces runoff flow rate to allow for the settling out of solids. The liquids are drained off to a holding pond, lagoon, constructed wetland or vegetative treatment area. The solids remain in the catch basin for drying and later removal and spreading. These basins are usually designed to contain all manure and runoff for up to a full year. Two possible drawbacks to installing a runoff control structure, such as a detention basin, are cost and lack of space to install the structure. Also, some detention basins can have odor problems. The estimated cost for installing detention basis is highly dependent on size and the quantity of fill soil imported, if necessary. Estimated costs for a large basin (>500 cy) is $6,076.00 (CPS 350)
- Vegetative filter strips can also be placed around the open feedlot as a field border. This allows for a reduction in runoff water entering the feedlot and a reduction in runoff water leaving the feedlot as well as removal of suspended sediment and solids. The vegetative treatment area can be designed either for overland flow or slow-rate infiltration. It is important to divert all outside surface water so that only lot runoff and direct precipitation enter the infiltration area. The estimated cost for installing vegetated filter strips is $206.00 per acre (CPS 393).

State and federal cost-share is available to assist operators with the financial and technical assistance needed to make feedlot improvements. The Environmental Quality Incentive Program (EQIP) assists feedlots that have a high risk for runoff problems. This cost-share funding typically goes to high-cost fixes, such as manure storage basins.

We recommend that projects to improve feedlot management practices be implemented in the agricultural portions of the following areas; headwaters of Frechette Creek (407000410101), Charlotte River Headwaters (40700010102), Charlotte River (40700010103), Headwaters Little Munuscong River (40700010104), Little Munuscong River (40700010105), Headwaters Munuscong River (40700010201), Upper Munuscong River (40700010202),Taylor Creek (40700010203), Middle Munuscong River (40700010204), Hannah Creek (40700010205), East Br. Munuscong River

(40700010206),Lower Munuscong River (40700010207), South Branch of East Branch of Waishkey River (40202030201), South Branch of Waishkey River (40202030202), West Branch of Waishkey River (40202030203), East Branch of Waishkey River (40202030204), Orrs Creek (40202030205), and Hickler Creek-Waishkey River (40702030206).

Wetland Restoration

Wetland restoration has the potential to decrease *E. coli* concentrations in contaminated runoff by increasing the filtration provided by sediment and vegetation (Knox et al., 2008). Wetlands have been shown to have the capability to retain contaminated water long enough to cause increased bacterial mortality, and create conditions which increase mortality (such as high levels of sunlight) (Knox et al., 2008). Riparian wetlands (located between uplands and lakes/streams) with high amounts of emergent vegetation (such as wet meadows and emergent marsh) have the most potential to decrease *E. coli* in runoff, and also would not attract large amounts of waterfowl. The MDEQ endorses the use of its Landscape Level Wetland Functional Assessment (LLWFA) tool as a means to prioritize areas for wetland restoration and protection. Michigan's LLWFA methodology identifies historically lost wetlands, determines the functions they once provided, and helps to prioritize wetlands for restoration to obtain the most significant water quality improvements. Removal of *E. coli* by wetlands is a function that has not been considered in the LLWFA in the past; however, the MDEQ is interested in incorporating this important function of wetlands into the LLWFA. It is important to note the TBC and PBC WQS apply in wetlands (both natural and created) that are designated as surface waters of the state. Watersheds with WMPs, either approved or in progress, are priority for LLWFA completion, and the LLWFA recommendations for wetland restoration for *E. coli* removal can be added to existing LLWFA datasets upon request to the DEQ. Funding and technical assistance is available from NRCS for installation through various conservation programs.

We recommend finding opportunities to identify landowners interested in restoring wetlands in the following areas; headwaters of Frechette Creek (407000410101), Charlotte River Headwaters (40700010102), Charlotte River (40700010103), Headwaters Little Munuscong River (40700010104), Little Munuscong River (40700010105), Headwaters Munuscong River (40700010201), Upper Munuscong River (40700010202),Taylor Creek (40700010203), Middle Munuscong River (40700010204), Hannah Creek (40700010205), East Br. Munuscong River (40700010206),Lower Munuscong River (40700010207), South Branch of East Branch of Waishkey River (40202030201), South Branch of Waishkey River (40202030202), West Branch of Waishkey River (40202030203), East Branch of Waishkey River (40202030204), Orrs Creek (40202030205), and Hickler Creek-Waishkey River (40702030206).

7.4.2. Urban Wildlife and Pets

Bacterial Source Tracking samples in Ashmun and Mission Creeks showed high *E. coli* counts, but did not have correspondingly high human bacteriodes counts. Given the developed nature of the land cover, one likely *E. coli* source is urban wildlife, such as skunks, raccoons, geese, and pets. Scat and fecal deposits contain pathogens that can be discharged to waterways. Methods to address pet waste are described below.

Regulatory Controls

The City of Sault Ste. Marie has a pet ordinance (Part II Chapter 7 Article 2) that describes requirements for handling of pet wastes. The pertinent section is quoted below:

Sec. 7-34. - Sanitation.

> *(a)Yards and exercise runs shall be kept free of dog and cat feces, uneaten food, and shall be maintained in a sanitary condition so as not to be a nuisance because of odor or attraction for flies or vermin.*
>
> *(b)No owner or possessor of a dog or cat shall cause, suffer, or allow it to defecate upon any public or private property without the permission of the owner of such property unless the person owner or possessor shall immediately remove all feces by a sanitary method. The owner or possessor shall possess a container of sufficient size to collect and remove such feces, and shall exhibit such container if requested by any animal control officer. The collected feces shall be disposed of only upon the property of the owner or possessor of the animal.*

Pet waste ordinances are not in place in other areas of the TMDL watersheds (Table 27). Where ordinance are in place now or in the future, animal control officers should continue or begin to monitor and control pets. It is also recommended that an inventory of dog parks or pet 'runs' near waterbodies be completed, with an evaluation of whether the addition of vegetated riparian buffers would benefit water quality at each identified site.

Table 27: Status of Pet Waste Ordinances within TMDL Watershed Local Government Units.

Municipality	Pet Waste Ordinance?
City of Sault Ste Marie	Yes
Bay Mills Township	No
Soo Township	No
Superior Township	No
Bruce Township	No
Dafter Township	No
Kinross Township	No
Pickford Township	No
Rudyard Township	No
Raber Township	No
Marquette Township	No
Clark Township	No

Information & Education

For regulatory controls to be successful, pet owners must be aware of the ordinances and have the tools and information necessary for compliance, and must also be reminded that ordinances will be enforced. Through county and local municipal government agencies as well as watershed groups, outreach efforts should focus educating pet owners about waste cleanup/reduction, monitoring and controlling pets and/or securing them indoors. An informational kiosk or sign, along with supplies for cleaning up feces, should be located in popular dog-walking areas or parks.

Urban Riparian Buffers

Creating shoreline buffers in urban ares, using native or other taller dense vegetation, diminishes short green grass cover, which geese prefer for foraging because it provides an unobstructed view. The goal is to displace foraging geese by creating an environment unfavorable to geese. Shoreline buffers can be incorporated into municipal landscaping plans for public lands and adopted on private lands through zoning code or voluntary cooperation of land owners. Additionally, watershed groups can lead efforts to educate riparian landowners about the use and benefits of shoreline buffers to improve water quality. Establishing native shoreline buffers typically costs $434.50 per acre (CPS 390), and can be viewed as a neighborhood beautification project if using attractive flowering plants.

It is recommended that projects to create riparian vegetated buffers be implemented in the following areas to help filter *E. coli* from urban runoff and discourage congregating waterfowl: Sault Ste. Marie Country Club on Mission Creek, Tanglewood Marsh Golf Course on Seymour Creek, and the reach between monitoring sites As1 and As2 on Ashmun Creek. In addition, the riparian buffer in the cemetery near the mouth of Frechette Creek would be more effective if its width (approximately 10 feet at present) is increased. Projects establishing vegetated riparian buffers require a high degree of cooperation between agencies and land owners.

7.4.3. OSDS - Regulatory Controls

Failing OSDS provide a persistent source of *E. coli* to waterways. The Michigan 2009 Statewide Failed Sewage System Evaluation Summary Report (MDNRE, 2010) showed that system age was the single largest reason for failure of on-site systems. Michigan is the only state in the United States with no unified statewide sanitary code and with decentralized regulatory authority over OSDS (Sacks and Falardeau, 2004). Instead, Michigan regulatory code (Section 2435 of the Public Health Code, 1978 PA 368, as amended) gives local district health departments the authority to "adopt regulations to properly safeguard the public health and to prevent the spread of diseases and sources of contamination." The state of Michigan does issue design criteria for OSDS that are utilized by more than two homes and discharge 1,000-10,000 gallons per day (Michigan Department of Public Health, 1994). For systems that discharge less than 1,000 gallons per day, the system must be approved by the local health department in accordance with local sanitary code (R 323.2210 of the Part 22 rules). Local health departments must be accredited by the state in a process that involves evaluation of the local departments every three years. Additionally, adopted sanitary codes must meet minimum measures proscribed by the state of Michigan. The Superior Environmental Health Code does not require regular inspections or reporting of the condition of OSDS. For traditional OSDS, failures can be quite obvious (i.e. clogging of drain field) but on-site systems can appear to be working yet provide a pathway for *E. coli* to groundwater or waterways.

In 2011, the CCHD tracked failures of OSDS and reported 30 homeowners had contacted their office about failed systems. Although this countywide data includes areas outside the geographic limits of this TMDL, the geologic setting is useful for identifying patterns of locations or reasons for failure. Figure 46 shows the distribution of reported failures in 2011. A large portion of the failures were reported at seasonal waterfront residences along the St. Marys River. Given the intermittent use of these systems, problems are not unexpected. In tracking the failures, CCHD also noted the reason, or multiple reasons, for failure. A breakdown of the reasons for failure is shown on Figure 47.

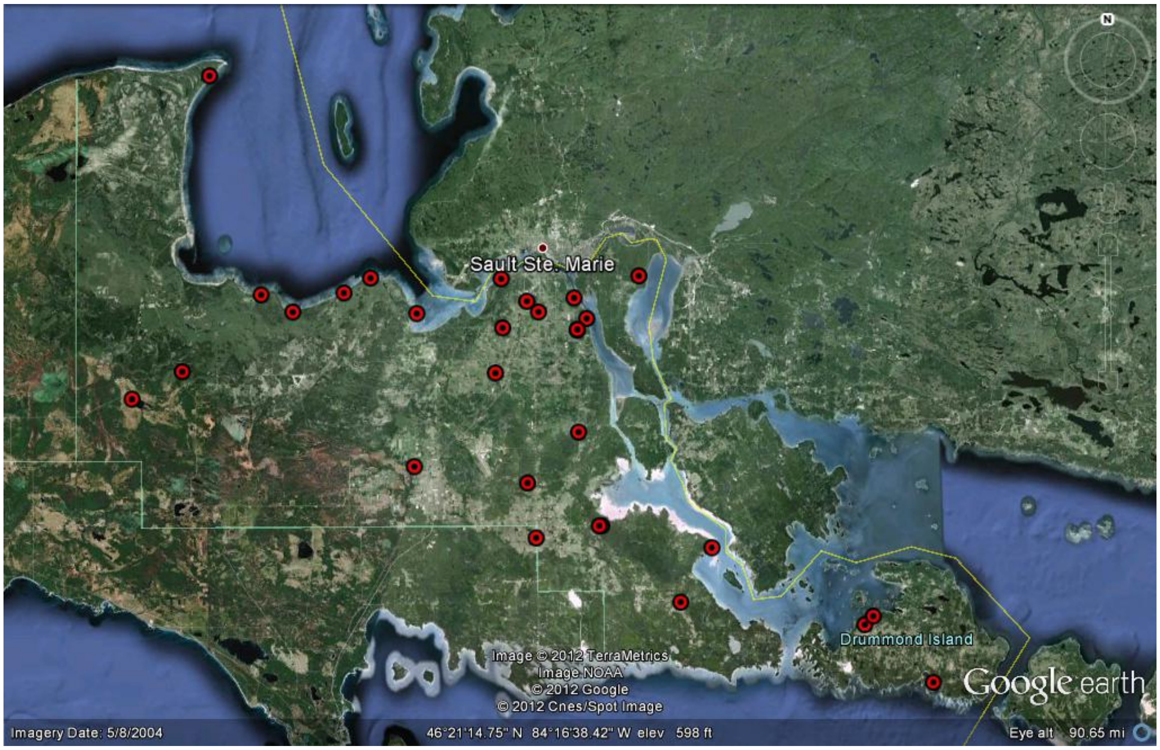

Figure 46: Chippewa County OSDS Failures in 2011
(Map source: Chippewa County Health Department)

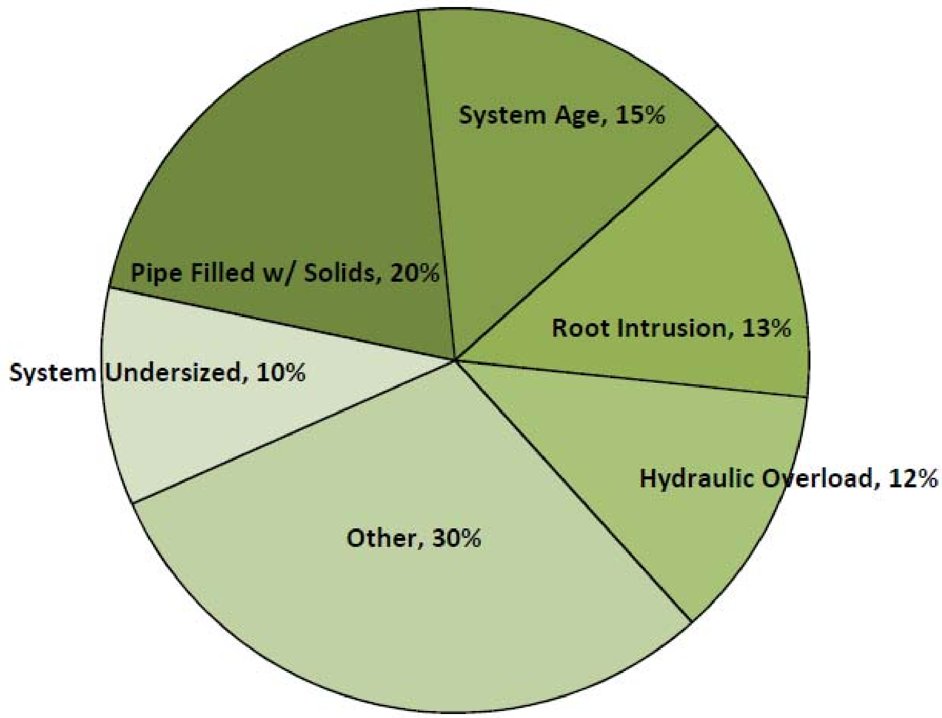

Figure 47: Reasons for OSDS Failure – Chippewa County 2011
(Data source: Chippewa County Health Department)

Several activities are recommended to reduce the potential for *E. coli* contamination of surface water by failing or improperly designed OSDS, including:

- Modifying the Superior Environmental Health Code to require time-of-sale inspections at the time of property transfer, and reporting of existing septic systems;
- Conducting an audit of lagoon and conventional type OSDS to confirm that they are meeting the code requirements; and
- Utilizing GIS to map lagoon and conventional type OSDS systems and analyze for conformance with required surface water setbacks.

7.4.4. Sanitary Sewer Leaks - Inspections

Sanitary sewer leaks can create a significant source for human sewage to reach waterways or conduits that discharge to waterways. The leaks can be created by many factors. Age of infrastructure, damage from tree roots, improper maintenance, or sewer main blockages have the potential to cause sewage leaks. In areas where leaks are detected, the sewer pipes and manholes can be replaced or relined to eliminate leaks.

Sanitary sewer leaks can be detected by numerous inspection techniques, including camera inspection, smoke or dye testing, acoustic methods, electrical and electromagnetic methods, laser profiling, and flow metering (EPA, 2009). It may be beneficial to evaluate sanitary sewer collection systems (identified in this TMDL) for the age, condition, and proximity of the system to surface water.

7.4.5. Illicit Connections - Inspections

Illicit connections are broadly defined as wastewater/sewage handling systems that are not constructed in accordance with existing codes or regulations. This can apply to on-site systems, as well as property served by municipal sanitary sewer facilities. Another type of illicit connection is cross connections of sanitary discharges to storm sewer pipes and infrastructure. These types of illicit connections provide a source of *E. coli* during dry and wet weather conditions. The Superior Environmental Health Code prohibits the discharge of sewage to surface waters or the ground surface, and is enforced by the county health officer. Unpermitted discharges of pollutants to waters of the state (illicit connections), whether direct or indirect, are illegal in the state of Michigan. Section 3109(1) of Part 31 states that a person shall not directly or indirectly discharge into the waters of the state a substance that is or may become injurious to public health, safety, or welfare, or to domestic, commercial, industrial, agricultural, recreational, or other uses that may be made of such waters. Section 3109(2) further specifically prohibits the discharge of raw sewage of human origin, directly or indirectly, into any waters of the state. The municipality in which that discharge originates is responsible for the violation, unless the discharge is regulated by an NPDES permit issued to another party.

To locate areas where illicit connections to storm sewers may be present, we recommend dry-weather screening (checking manholes and outfalls for flow during dry weather, when stormwater discharges are not expected). If dry-weather flow is observed, a sample is collected to test for the presence of *E. coli*. Comparing the location of positive *E. coli* results can help to isolate the source of the illicit discharge. To locate areas where direct connections of sanitary waste to surface waters ('straight pipes' from plumbing or OSDS tanks), we recommend walking the length of surface waters. Sampling of *E. coli* along the length of the stream, or maps of human population and geocoded addresses may be used to narrow down priority areas for this effort, since it is labor and cost intensive. We recommend that this effort be initially concentrated in areas upstream of where human biomarkers were indicated by the BST in this study (such as sites Fr1, Se1, Mu5 and Ch2), and where *E. coli* has been shown to be highest during low flow and dry weather.

In areas where illicit connections are suspected, it is suggested that the plumbing or wastewater collection system be inspected to verify that it is complete and working as designed. The inspections can be achieved by:

- Conducting a visual inspection and dye testing of properties with suspected illicit discharges.
- Camera inspections of sewer laterals and pipes may be more useful if dye testing is not feasible or ineffective in determining the location of illicit discharges.

It is recommended that responsible parties document results in a database and map observations in a Geographic Information System (GIS).

7.5. Implementation Schedule

A recommended schedule for the initiatives described in this implementation plan is shown in Table 28. Specific activities will be identified as further assessment work is completed in individual watersheds and prioritized for implementation as funding and resources become available.

Table 28: Recommended implementation schedule.

Activity	2012	2013	2014	2015	2016	2017
319 Non-point Source Grant Application	X	X	X	X	X	X
Detailed Watershed Assessments	X	X	X			
Develop Watershed Plans		X	X	X	X	
Public Outreach and Education	X	X	X	X	X	X
Installation of Structural BMPs				X	X	X
OSDS Inspections				X	X	X
Monitoring And Evaluation				X	X	X

7.6. Monitoring for Effectiveness

E. coli load reduction rates for management practices are not well established and are the focus of ongoing research. Research in California suggests that improvements in pasture management, including fencing to keep cattle away from streams and vegetated buffer strips, can reduce total *E. coli* load from pastures by more than 90% over the long term, although the benefit for large storms may be minimal (Tate et al., 2006). Upgrading failing or poorly designed OSDS should also be very effective, since properly designed and constructed systems effectively minimize *E. coli* release to the environment. Cleaning up after pets can effectively eliminate this source of *E. coli*; the impact of efforts to educate pet owners to clean up pet waste will depend on their effectiveness in changing the behavior of pet owners.

Future monitoring of the effectiveness of implementation actions will be conducted by the MDEQ as part of the five-year rotating basin monitoring, as resources allow, once actions have occurred to address sources of *E. coli*, as described in this document. When the results of these actions indicate that the water body may have improved to meet WQS, sampling will be conducted at the appropriate frequency to determine if the 30-day geometric mean value of 130 *E. coli* per 100 mL and daily maximum values of 300 *E. coli* per 100 mL and 1,000 *E. coli* per 100 mL are being met. Any future data collected by the MDEQ will be accessible to the public via the Beach Guard database, at https://www.egle.state.mi.us/beach/.

It is recommended that this ongoing monitoring be conducted at the same sites as the 2010 monitoring project, except for Mi2 and Fr1 where frequent backflow from the St. Marys River occurs. These sites should be relocated far enough upstream to minimize backflow impacts. Additional sites should also be sampled in the TMDL watersheds to provide greater detail on implementation effectiveness.

In addition to future monitoring by MDEQ, stakeholders are encouraged to submit proposals for funding of additional monitoring through the Clean Michigan Initiative. This objective of this monitoring could be to more precisely identify bacteria source types and locations to support implementation plan activities.

Flow monitoring in conjunction with bacteria sampling would provide an improved understanding of links between watershed hydrology and bacteria concentrations, and therefore more precise identification of bacteria sources. Options for stream flow monitoring include the following: manual flow measurements each time samples are collected or installation of a continuously recording water level recorder.

8.0 PUBLIC PARTICIPATION

The public participation component of these TMDLs was undertaken to gather information from local stakeholders to improve the TMDL and to keep the public informed about this process. All public meetings for the project were conducted at the Lake Superior State University campus in the City of Sault Ste. Marie, Michigan. The monitoring project in 2010 included a public kickoff meeting on May 3, 2010 and a public meeting to present the final monitoring results on December 8, 2010. A public kickoff meeting for the TMDL development was held on March 20, 2012. MDEQ and EPA received written comments on the final draft TMDL report and implementation plan during the public comment period from July 15 – August 15, 2012. The final TMDL and implementation plan were presented at a public meeting on July 31, 2012, with 21 stakeholders attending.

9.0 REFERENCES

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APPENDIX A

Monitoring results for 2010 *E. coli* study

Table A1: St. Marys River Monitoring Project for TMDL Development

E. coli Monitoring Results Summary

All results reported as CFU/100 mL

< 1.0	Results below the reporting limit
300.0	Light grey shaded cell shows exceedance of total body contact daily maximum WQS (300 CFU/100 mL)
*1,000.0 **	Light grey shaded cell with asterisk shows exceedance of partial body contact daily maximum WQS (1,000 CFU/100 mL)
130.0	Dark grey shaded cell shows exceedance of total body contact 30-day geomean WQS (130 cfu/100 mL)
75.0	Underlined values indicate some or all flow at site observed to be in the upstream direction.

SAMPLE LOCATION	NAME	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15	Week 16	Week 17	Week 18
As1	As1A	46.5	387.3	727.0	2,419.6	2,954.0	344.8	275.5	1,413.6	3,089.0	410.6	5,633.0	235.9	214.3	6,382.0	5,756.0	1,203.3	161.6	360.9
	As1B	44.1	360.9	816.4	1,732.9	2,419.6	344.8	307.6	2,419.6	1,989.0	272.3	4,165.0	201.4	218.7	6,437.0	4,257.0	920.8	214.2	461.1
	As1C	37.9	365.4	866.4	1,553.1	3,986.0	387.3	248.9	1,986.3	3,267.0	387.3	3,692.0	248.1	387.3	6,053.0	4,195.0	1,413.6	198.9	328.2
	Daily Geomean	42.7	371.0	801.2	1,867.4 *	3,054.2 *	358.4	276.3	1,894.0 *	2,717.7 *	351.2	4,424.6 *	227.6	262.8	6,288.4 *	4,684.4 *	1,161.4 *	190.2	379.4
	30-Day Geomean	--	--	--	--	591.4	905.2	853.4	1,013.6	1,092.6	708.9	1,171.8	1,127.3	759.4	898.1	1,507.9	1,154.0	1,113.3	1,198.1
As2	As2A	53.6	64.4	344.8	90.9	435.2	980.4	135.4	686.7	1,203.3	198.9	66.3	206.4	325.5	387.3	261.3	36.9	124.6	16.1
	As2B	59.8	74.9	261.3	122.3	613.1	517.2	75.4	547.5	1,046.2	290.9	85.7	191.8	365.4	224.7	135.4	35.0	162.4	26.2
	As2C	60.5	67.7	261.3	131.4	613.1	816.4	83.6	648.8	1,553.1	193.5	93.3	547.5	307.6	290.9	156.5	42.8	101.7	22.8
	Daily Geomean	57.9	68.8	286.6	113.4	546.9	745.3	94.9	624.8	1,250.5 *	223.7	81.0	278.8	332.0	293.6	176.9	38.1	127.2	21.3
	30-Day Geomean	--	--	--	--	147.9	246.6	262.9	307.3	496.6	415.3	266.4	330.5	291.3	218.0	208.0	178.9	152.9	88.3
As3	As3A	3,544.0	290.9	686.7	387.3	2,419.6	142.1	209.8	56.5	N/A	325.5	261.3	214.3	155.3	13,169.0	217.8	98.8	88.4	54.8
	As3B	3,931.0	866.4	1,299.7	579.4	1,732.9	172.2	248.1	63.7	8,126.0	201.4	214.3	365.4	198.9	14,209.0	461.1	75.4	90.6	51.2
	As3C	5,940.0	816.4	866.4	579.4	1,732.9	93.3	193.5	65.7	9,075.0	261.3	214.2	387.3	307.6	14,972.0	260.3	73.8	124.6	48.7
	Daily Geomean	4,357.7 *	590.4	917.8	506.6	1,936.8 *	131.6	216.0	61.8	8,587.4 *	257.8	228.9	311.8	211.8	14,097.2 *	296.8	81.9	99.9	51.5
	30-Day Geomean	--	--	--	--	1,183.0	587.5	480.5	280.1	493.4	329.6	368.2	396.2	506.9	559.7	575.7	468.8	373.4	281.4
Ca1	Ca1A	2.0	2.0	1,119.9	14.6	4.1	4.1	6.3	40.2	5.2	3.1	7.4	1.0	12.2	9.5	< 1.0	2.0	26.5	4.1
	Ca1B	< 1.0	1.0	17.5	9.5	5.2	4.1	2.0	13.5	3.0	5.2	2.0	9.8	1.0	3.1	33.6	2.0	32.3	1.0
	Ca1C	2.0	7.3	71.2	12.2	7.4	1.0	2.0	6.2	4.1	3.1	3.1	11.0	5.2	5.2	1.0	2.0	24.3	1.0
	Daily Geomean	1.6	2.5	111.7	11.9	5.4	2.6	2.9	15.0	4.0	3.6	3.6	4.8	4.0	5.3	3.2	2.0	27.5	1.6
	30-Day Geomean	--	--	--	--	7.8	8.5	8.9	5.9	4.8	4.4	4.7	5.2	4.0	4.2	4.1	3.7	5.2	4.3
Ca2	Ca2A	7.4	10.8	185.0	5.2	6.3	< 1.0	5.2	21.8	7.4	3.0	3.1	2.0	7.5	5.2	1.0	4.1	29.2	< 1.0
	Ca2B	4.1	2.0	10.8	17.3	3.1	6.3	6.3	12.1	3.1	5.2	3.1	6.3	7.4	12.0	< 1.0	< 1.0	27.9	4.1
	Ca2C	5.2	2.0	387.3	14.8	5.2	3.0	5.2	17.5	6.3	2.0	5.2	3.1	3.1	10.8	< 1.0	1.0	34.6	1.0
	Daily Geomean	5.4	3.5	91.8	11.0	4.6	2.7	5.6	16.7	5.2	3.2	3.7	3.4	5.5	8.7	1.0	1.6	30.4	1.6
	30-Day Geomean	--	--	--	--	9.8	8.5	9.3	6.6	5.7	5.3	5.6	5.1	4.1	4.5	3.6	3.0	4.7	3.7
Ch1	Ch1A	186.0	11,264.0	648.8	104.6	387.3	1,119.9	727.0	1,299.7	2,590.0	344.8	224.7	214.3	2,419.6	2,419.6	387.3	155.3	228.2	127.4
	Ch1B	206.4	11,582.0	1,046.2	127.4	517.2	1,203.3	816.4	1,732.9	1,413.6	488.4	178.9	125.9	1,732.9	2,419.6	461.1	108.6	206.4	139.6
	Ch1C	172.3	10,144.0	1,203.3	125.9	365.4	770.1	920.8	1,732.9	1,986.3	547.5	224.7	193.5	1,553.1	2,419.6	613.1	127.4	228.2	143.9
	Daily Geomean	187.7	10,979.0 *	934.8	118.8	418.3	1,012.4 *	817.6	1,574.4 *	1,937.4 *	451.8	208.2	173.5	1,867.4 *	2,419.6 *	478.4	129.0	220.7	136.8
	30-Day Geomean	--	--	--	--	625.5	876.2	521.2	578.5	1,011.0	1,026.7	748.3	548.8	567.9	593.7	600.5	545.7	572.6	339.5
Ch2	Ch2A	206.4	10,918.0	2,419.6	201.4	290.9	78.9	1,299.7	1,553.1	435.2	160.7	110.6	325.5	979.0	980.4	307.6	101.4	167.0	81.6
	Ch2B	387.3	8,782.0	1,986.3	201.4	235.9	81.3	1,119.9	1,986.3	344.8	193.5	130.9	238.2	2,419.6	816.4	224.7	104.3	198.9	118.7
	Ch2C	1,732.9	10,860.0	1,553.1	235.9	101.7	107.6	1,553.1	1,299.7	2,419.6	166.4	131.4	290.9	2,419.6	579.4	231.0	98.8	131.4	55.6
	Daily Geomean	517.4	10,135.7 *	1,954.3 *	212.3	191.1	88.4	1,312.4 *	1,588.6 *	713.4	173.0	123.9	282.6	1,789.6 *	774.1	251.8	101.5	163.4	81.4
	30-Day Geomean	--	--	--	--	839.0	589.2	391.5	375.6	478.6	469.2	502.0	369.2	378.1	384.4	414.3	398.1	356.8	192.3
Ch3	Ch3A	547.5	10,807.0	1,413.6	248.9	140.1	68.3	920.8	298.7	248.9	214.3	93.4	228.2	1,413.6	1,119.9	435.2	307.6	190.4	157.6
	Ch3B	816.4	10,712.0	1,203.3	307.6	111.2	93.2	1,203.3	344.8	290.9	261.3	98.5	172.3	1,203.3	1,732.9	378.4	261.3	201.4	107.6
	Ch3C	648.8	9,599.0	1,119.9	272.3	248.1	64.4	1,203.3	435.2	214.3	248.1	73.3	204.6	1,413.6	1,299.7	461.1	143.0	285.1	98.7
	Daily Geomean	661.9	10,357.8 *	1,239.6 *	275.2	157.0	74.3	1,100.7 *	355.2	249.4	240.4	87.7	200.4	1,339.7 *	1,361.2 *	423.5	225.7	221.9	118.7
	30-Day Geomean	--	--	--	--	818.4	528.4	337.5	262.8	257.7	280.6	290.1	206.4	269.1	377.8	423.2	511.2	521.8	321.4
Ch4	Ch4A	32.3	166.4	69.7	18.9	28.8	35.5	71.2	81.6	65.7	39.9	35.5	46.4	151.5	1,413.6	980.4	178.5	218.7	31.3
	Ch4B	19.9	167.0	66.3	11.0	19.9	60.2	96.0	105.0	98.8	21.8	6.3	39.9	143.9	1,413.6	461.1	111.2	104.3	21.8
	Ch4C	38.8	148.3	113.7	38.4	30.5	78.5	150.0	152.9	142.1	78.9	9.8	70.3	307.6	1,299.7	727.0	113.7	272.3	30.9
	Daily Geomean	29.2	160.3	80.7	20.0	26.0	55.1	100.8	109.4	97.3	40.9	13.0	50.6	188.6	1,374.6 *	690.1	131.2	183.8	27.6
	30-Day Geomean	--	--	--	--	45.5	51.7	47.1	50.1	68.8	75.3	56.4	49.2	54.8	93.1	163.7	260.0	336.5	229.2
Fr1	Fr1A	307.6	290.9	1,553.1	275.5	4,103.0	365.4	980.4	167.4	1,299.7	365.4	344.8	18.1	146.7	979.0	1,203.3	290.9	248.9	115.3
	Fr1B	488.4	344.8	1,299.7	218.7	3,498.0	613.1	1,119.9	238.2	1,553.1	248.9	488.4	83.6	152.9	1,119.9	613.1	387.3	261.3	123.6
	Fr1C	290.9	275.5	1,553.1	228.2	2,917.0	517.2	727.0	167.0	1,203.3	313.0	307.6	68.3	224.7	1,046.2	1,046.2	328.2	198.9	86.0
	Daily Geomean	352.3	302.3	1,463.6 *	239.6	3,472.3 *	487.5	927.6	188.1	1,344.2 *	305.3	372.8	46.9	171.4	1,046.8 *	917.3	333.2	234.7	107.0
	30-Day Geomean	--	--	--	--	664.6	709.2	887.5	588.8	831.4	511.2	484.5	266.8	261.8	249.1	310.4	303.5	418.7	381.1

Table A1: St. Marys River Monitoring Project for TMDL Development

E. coli Monitoring Results Summary

All results reported as CFU/100 mL

< 1.0	Results below the reporting limit
300.0	Light grey shaded cell shows exceedance of total body contact daily maximum WQS (300 CFU/100 mL)
*1,000.0 **	Light grey shaded cell with asterisk shows exceedance of partial body contact daily maximum WQS (1,000 CFU/100 mL)
130.0	Dark grey shaded cell shows exceedance of total body contact 30-day geomean WQS (130 cfu/100 mL)
75.0	Underlined values indicate some or all flow at site observed to be in the upstream direction.

SAMPLE LOCATION	NAME	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15	Week 16	Week 17	Week 18
Lm1	Lm1A	191.8	325.5	275.5	111.2	248.9	261.3	866.4	290.9	2,419.6	201.4	488.4	307.6	307.6	75.4	3,410.0	686.7	31.5	25.9
	Lm1B	325.5	161.6	275.5	77.6	387.3	579.4	579.4	307.6	2,419.6	238.2	290.9	235.9	307.6	75.4	2,954.0	547.5	36.9	41.0
	Lm1C	129.6	228.2	290.9	122.3	461.1	547.5	613.1	172.2	1,986.3	290.9	290.9	238.2	1,732.9	90.9	2,790.0	648.8	43.5	30.9
	Daily Geomean	***200.8***	***229.0***	***280.6***	***101.8***	***354.2***	***436.0***	***675.2***	***248.8***	***2,265.5 ****	***240.8***	***345.8***	***258.6***	***547.3***	***80.2***	***3,040.3 ****	***624.8***	***37.0***	***32.0***
	30-Day Geomean	--	--	--	--	215.5	251.7	312.5	305.1	567.4	525.2	501.4	413.8	484.5	248.4	412.5	464.3	314.6	178.3
Lm2	Lm2A	187.2	461.1	344.8	39.9	118.7	410.6	2,281.0	122.3	4,798.0	124.6	461.1	151.5	920.8	131.4	2,419.6	980.4	90.6	28.8
	Lm2B	186.0	579.4	298.7	83.3	129.6	770.1	2,419.6	178.9	3,877.0	178.0	461.1	186.0	920.8	108.1	1,986.3	435.2	101.7	40.8
	Lm2C	260.3	686.7	260.3	88.4	137.6	517.2	2,419.6	142.1	5,121.0	172.5	410.6	166.4	648.8	116.9	1,203.3	461.1	108.6	32.7
	Daily Geomean	***208.5***	***568.2***	***299.3***	***66.5***	***128.4***	***546.9***	***2,372.5 ****	***145.9***	***4,567.1 ****	***156.4***	***443.6***	***167.4***	***819.4***	***118.4***	***1,795.0 ****	***581.6***	***100.0***	***33.7***
	30-Day Geomean	--	--	--	--	197.8	239.8	319.2	276.5	644.3	670.2	642.7	378.2	534.1	257.2	419.1	442.4	399.1	210.9
Mi1	Mi1A	151.5	344.8	1,986.3	235.9	19,349.0	547.5	1,986.3	290.9	10,144.0	344.8	1,986.3	172.2	166.4	1,986.3	224.7	290.9	307.6	38.9
	Mi1B	129.1	298.7	920.8	461.1	17,260.0	410.6	1,732.9	365.4	8,823.0	387.3	1,986.3	155.3	365.4	1,986.3	127.4	325.5	248.9	38.4
	Mi1C	127.4	435.2	1,553.1	290.9	13,540.0	307.6	1,986.3	344.8	10,712.0	365.4	1,732.9	161.6	155.3	1,413.6	166.4	410.6	135.4	30.5
	Daily Geomean	***135.6***	***355.2***	***1,416.3 ****	***316.3***	***16,536.3 ****	***410.4***	***1,898.0 ****	***332.2***	***9,860.5 ****	***365.4***	***1,898.0 ****	***162.9***	***211.3***	***1,773.4 ****	***168.3***	***338.8***	***218.0***	***35.7***
	30-Day Geomean	--	--	--	--	813.7	1,015.5	1,419.9	1,062.4	2,113.7	986.1	1,339.5	819.7	748.8	531.3	455.0	322.3	341.7	239.5
Mi2	Mi2A	142.1	3,129.0	344.8	261.3	648.8	178.5	261.3	143.0	6,382.0	579.4	435.2	517.2	4,284.0	1,413.6	435.2	139.6	261.3	75.4
	Mi2B	344.8	648.8	387.3	214.3	648.8	275.5	488.4	107.6	2,419.6	488.4	488.4	488.4	4,500.0	1,810.0	547.5	172.3	410.6	54.8
	Mi2C	190.4	770.1	547.5	228.2	488.4	231.0	488.4	112.6	5,208.0	325.5	435.2	435.2	5,539.0	2,419.6	686.7	155.3	290.9	59.1
	Daily Geomean	***210.5***	***1,160.6 ****	***418.2***	***233.8***	***590.2***	***224.8***	***396.5***	***120.1***	***4,316.4 ****	***451.7***	***452.2***	***479.0***	***4,744.2 ****	***1,836.2 ****	***546.9***	***155.1***	***314.8***	***62.5***
	30-Day Geomean	--	--	--	--	426.4	432.0	348.5	271.6	486.6	461.2	530.4	550.9	1,149.1	968.6	1,006.4	812.5	747.1	314.3
Mu1	Mu1A	816.4	2,419.6	547.5	344.8	517.2	307.6	248.1	122.3	579.4	307.6	23,822.0	119.8	920.8	488.4	9,599.0	290.9	193.5	49.6
	Mu1B	629.4	2,419.6	387.3	298.7	866.4	387.3	161.6	172.3	613.1	248.9	15,152.0	131.4	1,553.1	547.5	10,807.0	307.6	155.3	68.3
	Mu1C	1,299.7	3,013.0	547.5	613.1	579.4	290.9	228.2	101.4	579.4	248.9	17,247.0	160.7	1,732.9	547.5	9,338.0	290.9	198.9	56.5
	Daily Geomean	***874.1***	***2,603.1 ****	***487.8***	***398.2***	***638.0***	***326.0***	***209.2***	***128.8***	***590.5***	***267.1***	***18,395.9 ****	***136.3***	***1,353.3 ****	***527.1***	***9,894.5 ****	***296.4***	***181.5***	***57.6***
	30-Day Geomean	--	--	--	--	776.3	637.4	384.9	294.9	319.1	268.1	600.6	551.3	882.4	862.6	1,776.4	778.0	823.9	438.2
Mu2	Mu2A	1,203.3	2,686.0	365.4	328.2	290.9	313.0	435.2	410.6	727.0	816.4	980.4	240.0	2,419.6	435.2	N/A	1,046.2	209.8	185.0
	Mu2B	980.4	3,089.0	461.1	285.1	547.5	313.0	461.1	410.6	727.0	686.7	648.8	488.4	1,986.3	517.2	7,976.0	613.1	178.5	135.4
	Mu2C	686.7	4,959.0	410.6	193.5	727.0	325.5	547.5	648.8	816.4	866.4	1,046.2	344.8	2,419.6	275.5	7,227.0	866.4	261.3	157.6
	Daily Geomean	***932.2***	***3,452.3 ****	***410.5***	***262.6***	***487.4***	***317.1***	***478.9***	***478.2***	***755.7***	***786.1***	***873.1***	***343.2***	***2,265.5 ****	***395.8***	***7,592.3 ****	***822.2***	***213.9***	***158.0***
	30-Day Geomean	--	--	--	--	700.8	564.9	380.5	392.3	484.7	533.3	653.1	610.9	833.9	732.7	1,153.3	1,139.5	1,036.7	608.6
Mu3	Mu3A	980.4	2,433.0	613.1	547.5	686.7	547.5	727.0	325.5	365.4	410.6	1,553.1	488.4	2,419.6	410.6	6,995.0	3,267.0	191.8	166.4
	Mu3B	770.1	2,954.0	613.1	365.4	579.4	727.0	648.8	461.1	613.1	547.5	1,203.3	579.4	3,129.0	387.3	9,594.0	5,461.0	307.6	127.4
	Mu3C	1,119.9	2,917.0	488.4	235.9	488.4	387.3	547.5	307.6	488.4	488.4	1,413.6	365.4	2,011.0	517.2	16,071.0	3,692.0	228.2	142.1
	Daily Geomean	***945.6***	***2,757.4 ****	***568.4***	***361.4***	***579.2***	***536.2***	***636.8***	***358.8***	***478.3***	***478.8***	***1,382.4 ****	***469.4***	***2,478.5 ****	***434.9***	***10,255.2 ****	***4,038.6 ****	***237.9***	***144.4***
	30-Day Geomean	--	--	--	--	791.3	706.4	526.9	480.6	508.3	489.3	591.4	556.4	818.9	803.5	1,483.0	1,837.6	1,604.1	908.5
Mu4	Mu4A	178.0	4,882.0	387.3	186.0	111.9	135.4	125.0	71.7	517.2	191.8	866.4	228.2	1,203.3	517.2	2,419.6	344.8	248.1	95.9
	Mu4B	145.5	1,890.0	488.4	166.4	83.6	145.0	201.4	83.3	290.9	131.4	1,413.6	209.8	1,299.7	387.3	1,989.0	235.9	209.8	88.0
	Mu4C	139.6	4,954.0	261.3	201.4	101.7	130.9	344.8	111.9	186.0	107.1	1,203.3	365.4	1,413.6	365.4	2,419.6	325.5	290.9	57.6
	Daily Geomean	***153.5***	***3,575.5 ****	***367.0***	***184.0***	***98.4***	***137.0***	***205.5***	***87.4***	***303.6***	***139.2***	***1,138.0 ****	***259.6***	***1,302.7 ****	***418.3***	***2266.6 ****	***298.1***	***247.4***	***78.6***
	30-Day Geomean	--	--	--	--	325.3	318.0	179.6	134.8	149.0	159.8	244.0	255.6	438.8	467.8	817.4	625.3	619.3	353.2
Mu5	Mu5A	153.9	866.4	686.7	435.2	488.4	1,299.7	980.4	4,519.0	866.4	816.4	1,299.7	410.6	1,986.3	410.6	15,648.0	5,448.0	6.0	135.4
	Mu5B	195.6	920.8	648.8	231.0	488.4	1,046.2	1,046.2	2,011.0	1,986.3	816.4	1,413.6	727.0	2,419.6	290.9	12,740.0	6,266.0	198.9	146.7
	Mu5C	488.4	517.2	488.4	387.3	344.8	1,299.7	727.0	5,291.0	1,413.6	461.1	1,299.7	648.8	2,419.6	275.5	16,695.0	6,568.0	248.9	115.3
	Daily Geomean	***245.0***	***744.5***	***601.5***	***338.9***	***434.9***	***1,209.0 ****	***906.8***	***3,636.3 ****	***1,344.9 ****	***674.8***	***1,336.6 ****	***578.6***	***2,265.5 ****	***320.5***	***14,930.4 ****	***6,075.1 ****	***66.7***	***131.8***
	30-Day Geomean	--	--	--	--	438.3	603.1	627.4	899.1	1,184.5	1,293.3	1,319.5	1,206.1	1,097.2	823.6	1,529.9	2,071.0	1,344.5	761.2
Se1	Se1A	161.6	686.7	1,732.9	307.6	648.8	488.4	770.1	1,046.2	1,413.6	547.5	727.0	613.1	866.4	770.1	1,119.9	686.7	131.4	45.7
	Se1B	185.0	387.3	1,413.6	307.6	2,419.6	980.4	1,553.1	1,203.3	1,413.6	980.4	866.4	579.4	648.8	410.6	648.8	517.2	129.6	62.0
	Se1C	238.2	461.1	1,119.9	325.5	26,025.0	1,732.9	1,203.3	1,046.2	2,419.6	435.2	517.2	613.1	648.8	488.4	579.4	648.8	172.5	56.3
	Daily Geomean	***192.4***	***496.8***	***1,399.9 ****	***313.5***	***3,444.2 ****	***939.7***	***1,129.0 ****	***1,096.2 ****	***1,691.0 ****	***615.9***	***688.1***	***601.7***	***714.5***	***536.5***	***749.5***	***613.1***	***143.2***	***54.2***
	30-Day Geomean	--	--	--	--	679.1	932.6	1,099.0	1,046.6	1,466.1	1,039.1	976.3	860.8	790.2	628.1	653.2	638.3	479.0	286.0

Table A1: St. Marys River Monitoring Project for TMDL Development

E. coli Monitoring Results Summary

All results reported as CFU/100 mL

< 1.0	Results below the reporting limit
300.0	Light grey shaded cell shows exceedance of total body contact daily maximum WQS (300 CFU/100 mL)
1,000.0 *	Light grey shaded cell with asterisk shows exceedance of partial body contact daily maximum WQS (1,000 CFU/100 mL)
130.0	Dark grey shaded cell shows exceedance of total body contact 30-day geomean WQS (130 cfu/100 mL)
75.0	Underlined values indicate some or all flow at site observed to be in the upstream direction.

SAMPLE LOCATION	NAME	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15	Week 16	Week 17	Week 18
Wa1	Wa1A	104.6	118.7	71.2	248.1	50.4	185.0	93.2	68.9	68.3	142.1	69.7	34.1	49.6	150.0	344.8	118.7	209.8	25.6
	Wa1B	101.7	118.7	66.3	135.4	53.8	105.0	102.5	52.9	48.7	142.1	52.1	23.3	65.7	214.2	488.4	79.8	190.4	38.3
	Wa1C	248.1	167.0	52.9	193.5	73.3	186.0	122.3	77.6	133.4	127.4	43.5	33.6	74.9	101.4	461.1	86.0	178.2	35.0
	Daily Geomean	***138.2***	***133.0***	***63.0***	***186.6***	***58.4***	***153.4***	***105.3***	***65.6***	***76.3***	***137.0***	***54.0***	***29.9***	***62.5***	***148.3***	***426.6***	***93.4***	***192.4***	***32.5***
	30-Day Geomean	--	--	--	--	**104.7**	**107.0**	**102.1**	**102.9**	**86.1**	**102.1**	**82.9**	**64.4**	**63.8**	**72.8**	**91.4**	**102.0**	**148.0**	**129.8**
Wa2	Wa2A	461.1	124.6	190.4	275.5	90.6	36.9	53.8	43.2	88.4	143.9	88.6	90.8	101.7	410.6	461.1	151.5	133.3	48.7
	Wa2B	613.1	214.3	165.8	290.9	111.9	77.6	48.8	51.2	78.0	137.6	70.6	151.5	86.2	307.6	517.2	148.3	123.6	48.0
	Wa2C	410.6	135.4	137.4	435.2	57.3	83.6	76.7	55.4	64.4	165.8	111.9	85.5	186.0	275.5	579.4	142.1	95.9	39.3
	Daily Geomean	***487.8***	***153.5***	***163.0***	***326.7***	***83.5***	***62.1***	***58.6***	***49.7***	***76.3***	***148.6***	***88.8***	***105.5***	***117.7***	***326.5***	***517.0***	***147.3***	***116.5***	***45.1***
	30-Day Geomean	--	--	--	--	**201.6**	**133.5**	**110.1**	**86.8**	**64.9**	**72.8**	**78.2**	**88.0**	**104.6**	**139.9**	**179.5**	**198.6**	**202.5**	**167.2**
Wa3	Wa3A	88.6	61.3	131.4	235.9	90.6	104.6	66.3	101.4	222.4	206.4	133.4	142.1	201.4	435.2	920.8	104.6	686.7	98.8
	Wa3B	53.8	67.0	114.5	248.9	85.5	135.4	103.9	125.9	155.3	108.1	131.4	110.6	105.4	344.8	1,046.2	86.0	238.2	78.0
	Wa3C	44.8	90.8	129.6	307.6	73.8	129.6	63.7	178.9	137.6	74.4	127.4	118.7	118.7	307.6	816.4	727.0	275.5	53.7
	Daily Geomean	***59.8***	***71.9***	***124.9***	***262.4***	***83.0***	***122.4***	***76.0***	***131.7***	***168.1***	***118.4***	***130.7***	***123.1***	***136.1***	***358.7***	***923.1***	***187.0***	***355.9***	***74.5***
	30-Day Geomean	--	--	--	--	**103.2**	**119.1**	**120.4**	**121.7**	**111.3**	**119.5**	**121.1**	**133.4**	**134.2**	**156.2**	**235.5**	**253.0**	**312.9**	**277.4**

APPENDIX B

E. coli load and waste load summary

Loading Capacity

This concentration-based TMDL is based on the Michigan water quality standards, expressed as *E. coli* concentrations in fecal coliform units per 100 mL. This appendix provides additional information through calculation of daily *E. coli* loads to characterize the TMDL waterbodies' loading capacity and load allocations (LA) and waste load allocations (WLA) for nonpoint and point sources, respectively. A load-based TMDL is expressed as the sum of all individual WLAs, LAs and a margin of safety (MOS), as shown in Equation B-1.

Equation B-1: Calculation of load-based TMDL

$$TMDL = \sum WLA + \sum LA + MOS$$

Baseline E. coli loads, loading capacity and reduction goals for the TMDL watersheds are summarized in Table B-1 through Table B-8. The baseline is based on the 90th percentile load observed at the most downstream monitoring station during the 2010 monitoring program. The highest single observed load is used as an estimate of the 90th percentile, since the total number of samples for each flow duration interval is less than 10. Load duration curves including monitoring data for these sites are shown in Figures B-1 through B-8.

Table B-1: Daily *E. coli* baseline, loading capacity, and reduction goal for the Seymour Creek Watershed.

Flow Interval	Season	Daily *E. coli* (cfu / day)			% Reduction
		Baseline[1]	Loading Capacity[2]	Reduction[3]	
High flows	May 1 – Oct 31	ND	3.47 E +10	ND	ND
	Nov 1 – Apr 30	ND	1.16 E +11	ND	ND
Moist conditions	May 1 – Oct 31	4.12 E +10	1.06 E +10	3.06 E +10	74%
	Nov 1 – Apr 30	4.12 E +10	3.53 E +10	5.85 E +9	14%
Mid-range flows	May 1 – Oct 31	1.20 E +10	5.91 E +9	6.11 E +09	51%
	Nov 1 – Apr 30	1.20 E +10	1.97 E +10	0	0%
Dry conditions	May 1 – Oct 31	4.56 E +10	4.04 E +9	4.15 E +10	91%
	Nov 1 – Apr 30	4.56 E +10	1.35 E +10	3.21 E +10	70%
Low flows	May 1 – Oct 31	1.80 E +10	2.91 E +9	1.51 E+10	84%
	Nov 1 – Apr 30	1.80 E +10	9.69 E +9	8.27 E+9	46%

[1] 90th percentile load observed at monitoring station Se1 during the 2010 monitoring program.

[2] Calculated for monitoring station Se1 using the load duration curve in Figure B-1.

[3] Estimated reduction goals provided for informational purposes only.

[4] ND signifies no observed data available.

Table B-2: Daily *E. coli* baseline, loading capacity, and reduction goal for the Ashmun Watershed.

Flow Interval	Season	Daily *E. coli* (cfu / day)			% Reduction
		Baseline[1]	Loading Capacity[2]	Reduction[3]	
High flows	May 1 – Oct 31	ND[3]	1.12 E +11	ND[3]	ND[3]
	Nov 1 – Apr 30	ND[3]	3.75 E +11	ND[3]	ND[3]
Moist conditions	May 1 – Oct 31	2.45 E +11	3.43 E +10	2.11 E +11	86%
	Nov 1 – Apr 30	2.45 E +11	1.14 E +11	1.31 E +11	53%
Mid-range flows	May 1 – Oct 31	3.82 E +11	1.91 E +10	3.63 E +11	95%
	Nov 1 – Apr 30	3.82 E +11	6.38 E +10	3.19 E +11	83%
Dry conditions	May 1 – Oct 31	2.35 E +11	1.31 E +10	2.22 E +11	94%
	Nov 1 – Apr 30	2.35 E +11	4.36 E +10	1.92 E +11	81%
Low flows	May 1 – Oct 31	1.26 E +11	9.41 E +9	1.17 E +11	93%
	Nov 1 – Apr 30	1.26 E +11	3.14 E +10	9.50 E +10	75%

[1] 90th percentile load observed at the most downstream monitoring station (As1) during the 2010 monitoring program.

[2] Calculated for monitoring station As1 using the load duration curve in Figure B-2.

[3] Estimated reduction goals provided for informational purposes only.

[4] ND signifies no observed data available.

Table B-3: Daily *E. coli* baseline, loading capacity, and reduction goal for the Mission Creek Watershed.

Flow Interval	Season	Daily *E. coli* (cfu / day)			% Reduction
		Baseline[1]	Loading Capacity[2]	Reduction[3]	
High flows	May 1 – Oct 31	ND	1.01 E +11	ND	ND
	Nov 1 – Apr 30	ND	3.38 E +11	ND	ND
Moist conditions	May 1 – Oct 31	8.63 E +10	3.09 E +10	5.54 E +10	64%
	Nov 1 – Apr 30	8.63 E +10	1.03 E +11	0	0%
Mid-range flows	May 1 – Oct 31	1.01 E +11	1.73 E +11	8.34 E +10	83%
	Nov 1 – Apr 30	1.01 E +11	5.75 E +10	4.31 E +10	43%
Dry conditions	May 1 – Oct 31	2.48 E +10	1.18 E +10	1.30 E +10	52%
	Nov 1 – Apr 30	2.48 E +10	3.93 E +10	0	0%
Low flows	May 1 – Oct 31	1.34 E +11	8.48 E +9	1.25 E +11	94%
	Nov 1 – Apr 30	1.34 E +11	2.83 E +10	1.05 E +11	79%

[1] 90th percentile load observed at the most downstream monitoring station (Mi2) during the 2010 monitoring program.

[2] Calculated for monitoring station Mi2 using the load duration curve in Figure B-3.

[3] Estimated reduction goals provided for informational purposes only.

[4] ND signifies no observed data available.

Table B-4: Daily *E. coli* baseline, loading capacity, and reduction goal for the Frechette Creek Watershed.

Flow Interval	Season	Daily *E. coli* (cfu / day)			% Reduction
		Baseline[1]	Loading Capacity[2]	Reduction[3]	
High flows	May 1 – Oct 31	ND	9.40 E +10	ND	ND
	Nov 1 – Apr 30	ND	3.13 E +11	ND	ND
Moist conditions	May 1 – Oct 31	1.16 E +11	2.87 E +10	8.78 E +10	75%
	Nov 1 – Apr 30	1.16 E +11	9.56 E +10	2.09 E +10	18%
Mid-range flows	May 1 – Oct 31	5.32 E +10	1.60 E +10	3.72 E +10	70%
	Nov 1 – Apr 30	5.32 E +10	5.33 E +10	0	0%
Dry conditions	May 1 – Oct 31	1.24 E +11	1.09 E +10	1.13 E +11	91%
	Nov 1 – Apr 30	1.24 E +11	3.64 E +10	8.79 E +10	71%
Low flows	May 1 – Oct 31	3.86 E +10	7.87 E +9	3.08 E+10	80%
	Nov 1 – Apr 30	3.86 E +10	2.62 E +10	1.24 E+10	32%

[1] 90th percentile load observed at monitoring station Fr1 during the 2010 monitoring program.

[2] Calculated for monitoring station Fr1 using the load duration curve in Figure B-4.

[3] Estimated reduction goals provided for informational purposes only.

[4] ND signifies no observed data available.

Table B-5: Daily *E. coli* baseline, loading capacity, and reduction goal for the Waishkey River Watershed.

Flow Interval	Season	Daily *E. coli* (cfu / day)			% Reduction
		Baseline[1]	Loading Capacity[2]	Reduction[3]	
High flows	May 1 – Oct 31	ND[3]	4.17 E +12	ND[3]	ND[3]
	Nov 1 – Apr 30	ND[3]	1.39 E +13	ND[3]	ND[3]
Moist conditions	May 1 – Oct 31	1.41 E +12	1.27 E +12	1.39 E +11	10%
	Nov 1 – Apr 30	1.41 E +12	4.24 E +12	0	0%
Mid-range flows	May 1 – Oct 31	3.35 E +11	7.10 E +11	0	0%
	Nov 1 – Apr 30	3.35 E +11	2.37 E +12	0	0%
Dry conditions	May 1 – Oct 31	7.95 E +11	4.85 E +11	3.10 E +11	39%
	Nov 1 – Apr 30	7.95 E +11	1.62 E +12	0	0%
Low flows	May 1 – Oct 31	1.81 E +11	3.49 E +11	0	0%
	Nov 1 – Apr 30	1.81 E +11	1.16 E +12	0	0%

[1] 90th percentile load observed at the most downstream monitoring station (Wa1) during the 2010 monitoring program.

[2] Calculated for monitoring station Wa1 using the load duration curve in Figure B-5.

[3] Estimated reduction goals provided for informational purposes only.

[4] ND signifies no observed data available.

Table B-6: Daily *E. coli* baseline, loading capacity, and reduction goal for the Charlotte River Watershed.

Flow Interval	Season	Daily *E. coli* (cfu / day)			% Reduction
		Baseline[1]	Loading Capacity[2]	Reduction[3]	
High flows	May 1 – Oct 31	5.35 E +11	1.64 E +12	0	0%
	Nov 1 – Apr 30	5.35 E +11	5.46 E +12	0	0%
Moist conditions	May 1 – Oct 31	1.94 E +12	5.00 E +11	1.44 E +12	74%
	Nov 1 – Apr 30	1.94 E +12	1.67 E +12	2.73 E +11	14%
Mid-range flows	May 1 – Oct 31	1.17 E +11	2.79 E +11	0	0%
	Nov 1 – Apr 30	1.17 E +11	9.30 E +11	0	0%
Dry conditions	May 1 – Oct 31	4.52 E +11	1.91 E +11	2.61 E +11	58%
	Nov 1 – Apr 30	4.52 E +11	6.35 E +11	0	0%
Low flows	May 1 – Oct 31	5.23 E +10	1.37 E +11	0	0%
	Nov 1 – Apr 30	5.23 E +10	4.57 E +11	0	0%

[1] 90th percentile load observed at the most downstream monitoring station (Ch4) during the 2010 monitoring program.

[2] Calculated for monitoring station Ch4 using the load duration curve in Figure B-6.

[3] Estimated reduction goals provided for informational purposes only.

[4] ND signifies no observed data available.

Table B-7: Daily *E. coli* baseline, loading capacity, and reduction goal for the Little Munuscong River watershed.

Flow Interval	Season	Daily *E. coli* (cfu / day)			% Reduction
		Baseline[1]	Loading Capacity[2]	Reduction[3]	
High flows	May 1 – Oct 31	2.14 E +12	1.25 E +12	8.87 E +11	41%
	Nov 1 – Apr 30	2.14 E +12	4.17 E +12	0	0%
Moist conditions	May 1 – Oct 31	2.38 E +12	3.81 E +11	1.99 E +12	84%
	Nov 1 – Apr 30	2.38 E +12	1.27 E +12	1.10 E +12	46%
Mid-range flows	May 1 – Oct 31	2.79 E +11	2.13 E +11	6.63 E +10	24%
	Nov 1 – Apr 30	2.79 E +11	7.10 E +11	0	0%
Dry conditions	May 1 – Oct 31	1.96 E +12	1.46 E +11	1.82 E +12	93%
	Nov 1 – Apr 30	1.96 E +12	4.85 E +11	1.48 E +12	75%
Low flows	May 1 – Oct 31	9.07 E +11	1.05 E +11	8.02 E +11	88%
	Nov 1 – Apr 30	9.07 E +11	3.49 E +11	5.58 E +11	62%

[1] 90th percentile load observed at the most downstream monitoring station (Lm2) during the 2010 monitoring program.

[2] Calculated for monitoring station Lm2 using the load duration curve in Figure B-7.

[3] Estimated reduction goals provided for informational purposes only.

[4] ND signifies no observed data available.

Table B-8: Daily E. coli baseline, loading capacity, and reduction goal for the Munuscong River watershed.

Flow Interval	Season	Daily *E. coli* (cfu / day)			% Reduction
		Baseline[1]	Loading Capacity[2]	Reduction[3]	
High flows	May 1 – Oct 31	3.74 E +12	5.25 E +12	3.22 E +13	86%
	Nov 1 – Apr 30	3.74 E +12	1.75 E +13	1.99 E +13	53%
Moist conditions	May 1 – Oct 31	1.26 E +13	1.60 E +12	1.10 E +13	87%
	Nov 1 – Apr 30	1.26 E +13	5.34 E +12	7.25 E +12	58%
Mid-range flows	May 1 – Oct 31	3.01 E +12	8.94 E +11	2.11 E +12	70%
	Nov 1 – Apr 30	3.01 E +12	2.98 E +12	2.75 E +10	1%
Dry conditions	May 1 – Oct 31	3.15 E +12	6.11 E +11	2.54 E +12	81%
	Nov 1 – Apr 30	3.15 E +12	2.04 E +12	1.12 E +12	35%
Low flows	May 1 – Oct 31	3.30 E +11	4.39 E +11	0	0%
	Nov 1 – Apr 30	3.30 E +11	1.46 E +12	0	0%

[1] 90th percentile load observed at the most downstream monitoring station (Mu4) during the 2010 monitoring program.

[2] Calculated for monitoring station Mu4 using the load duration curve in Figure B-8.

[3] Estimated reduction goals provided for informational purposes only.

[4] ND signifies no observed data available.

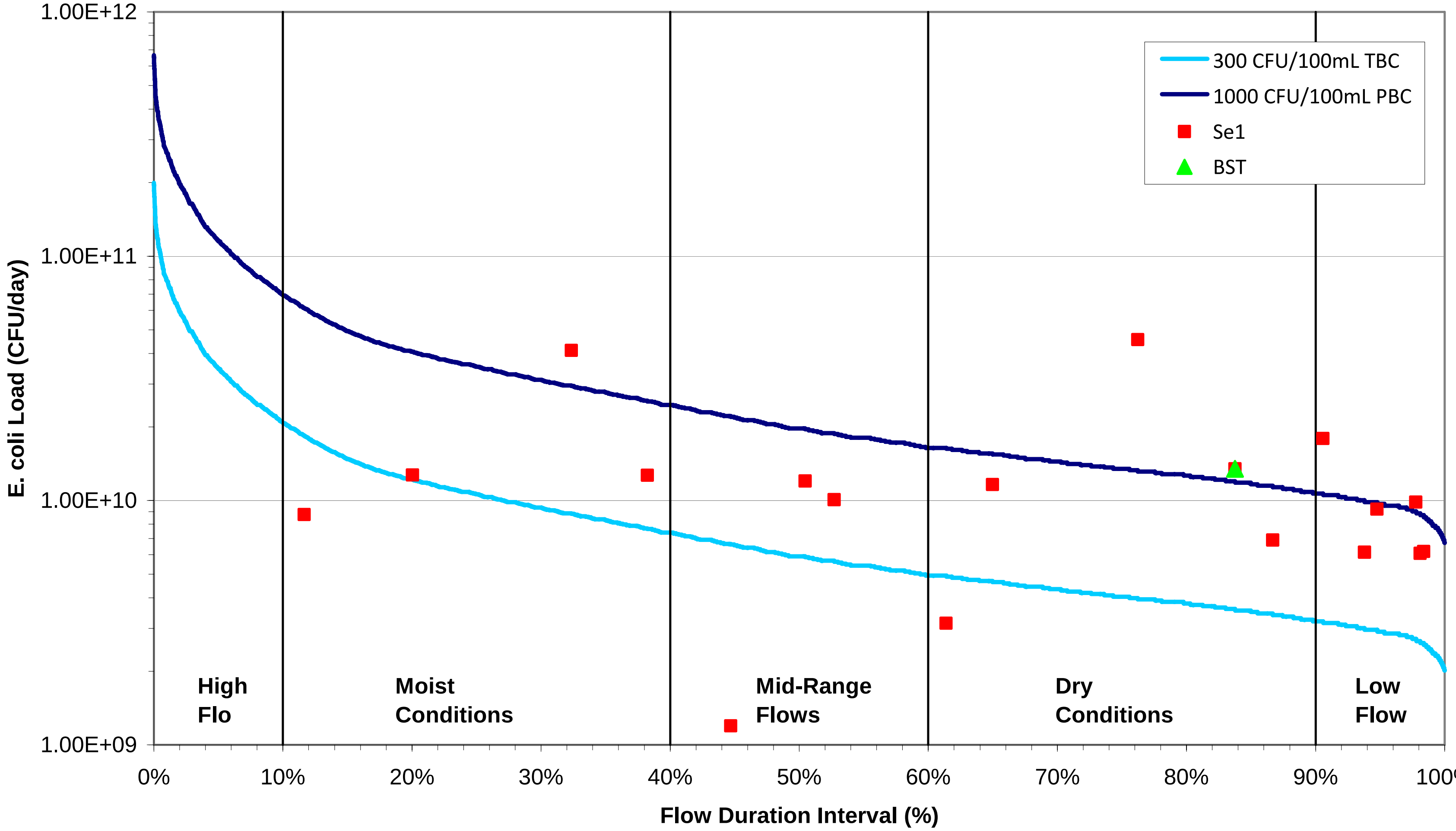

Figure B-1: Load duration curve for Seymour Creek Watershed monitoring site Se1

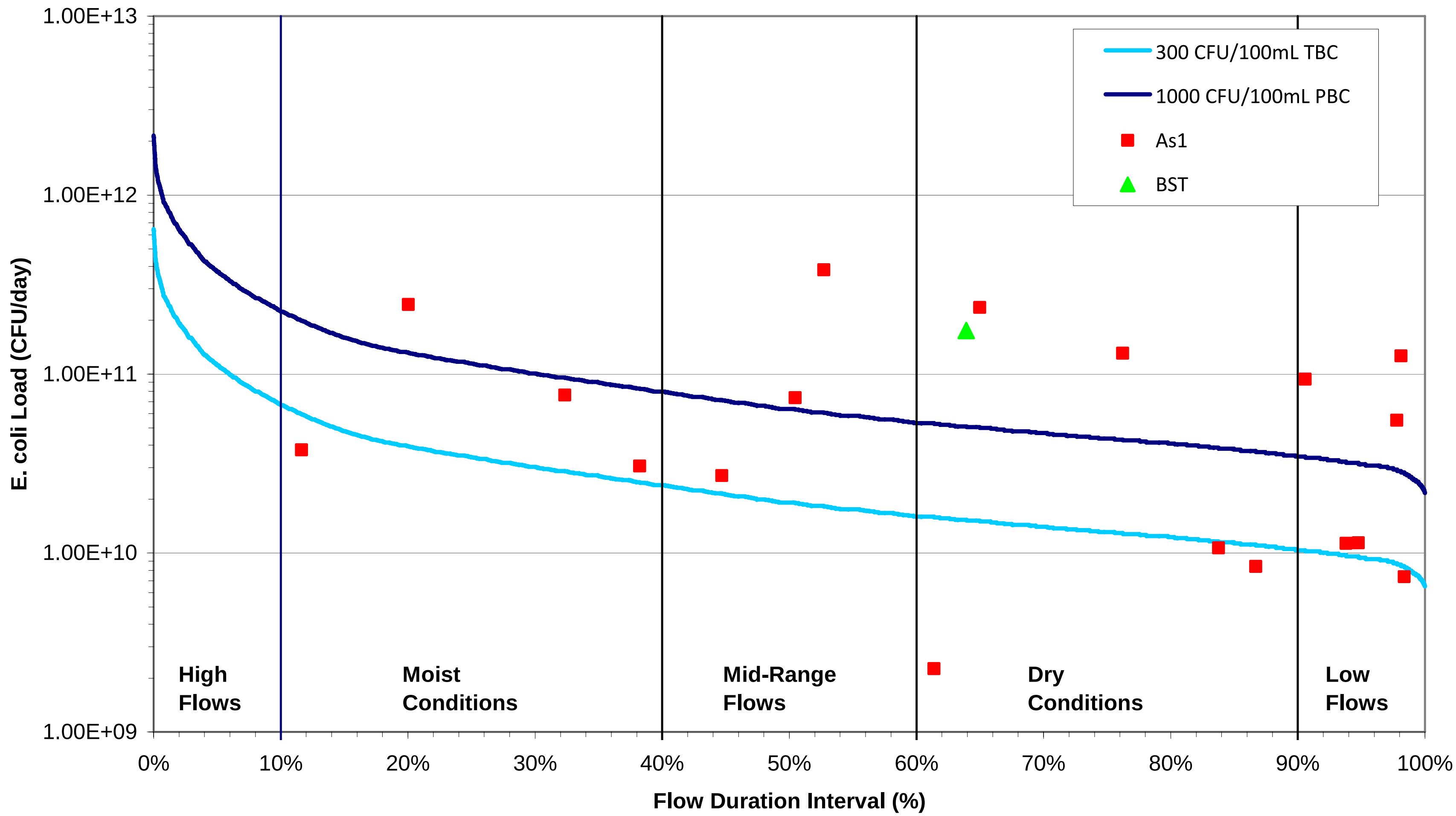

Figure B-2: Load duration curve for Ashmun Creek Watershed monitoring site As1

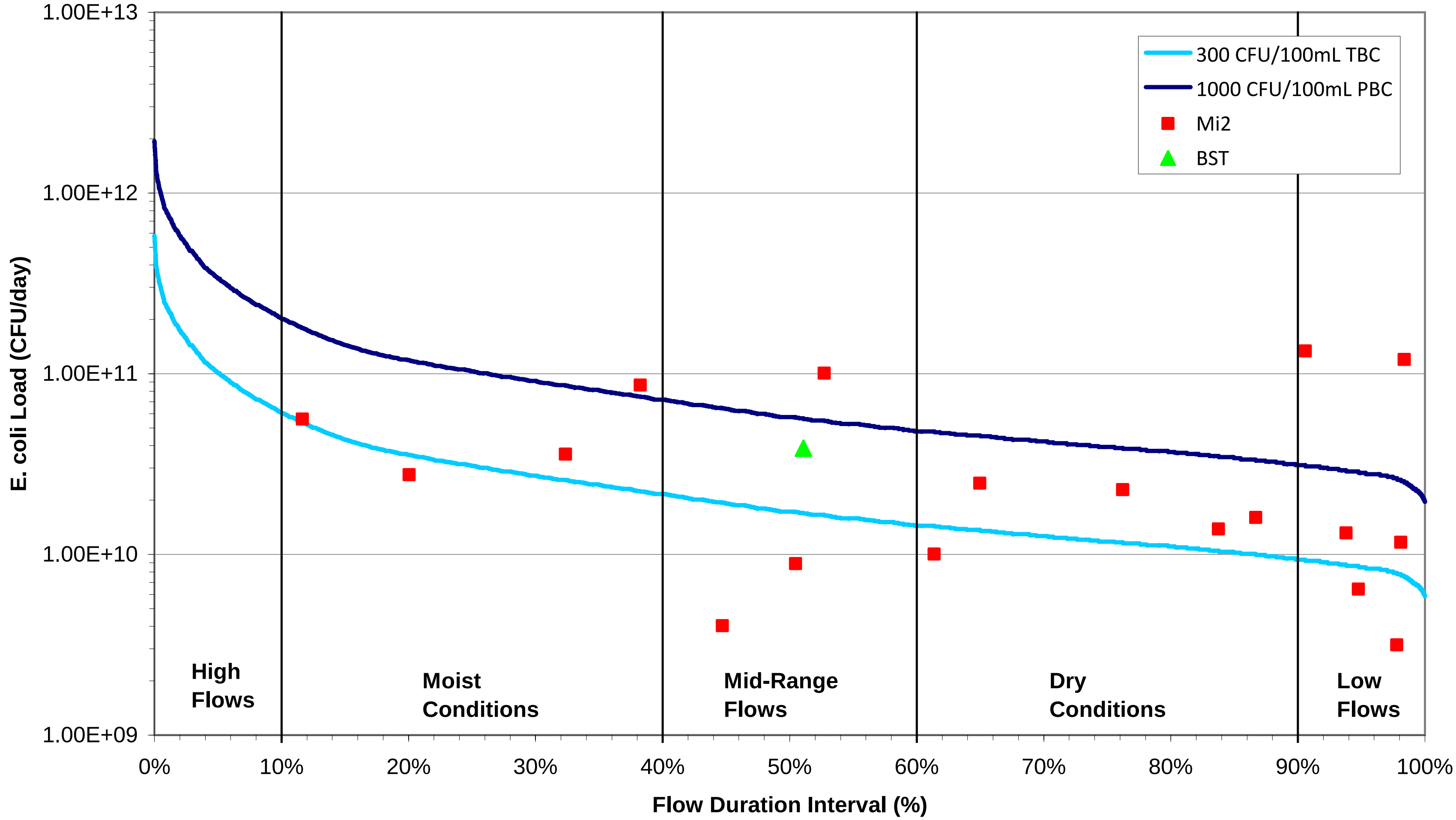

Figure B-3: Load duration curve for Mission Creek Watershed monitoring site Mi2

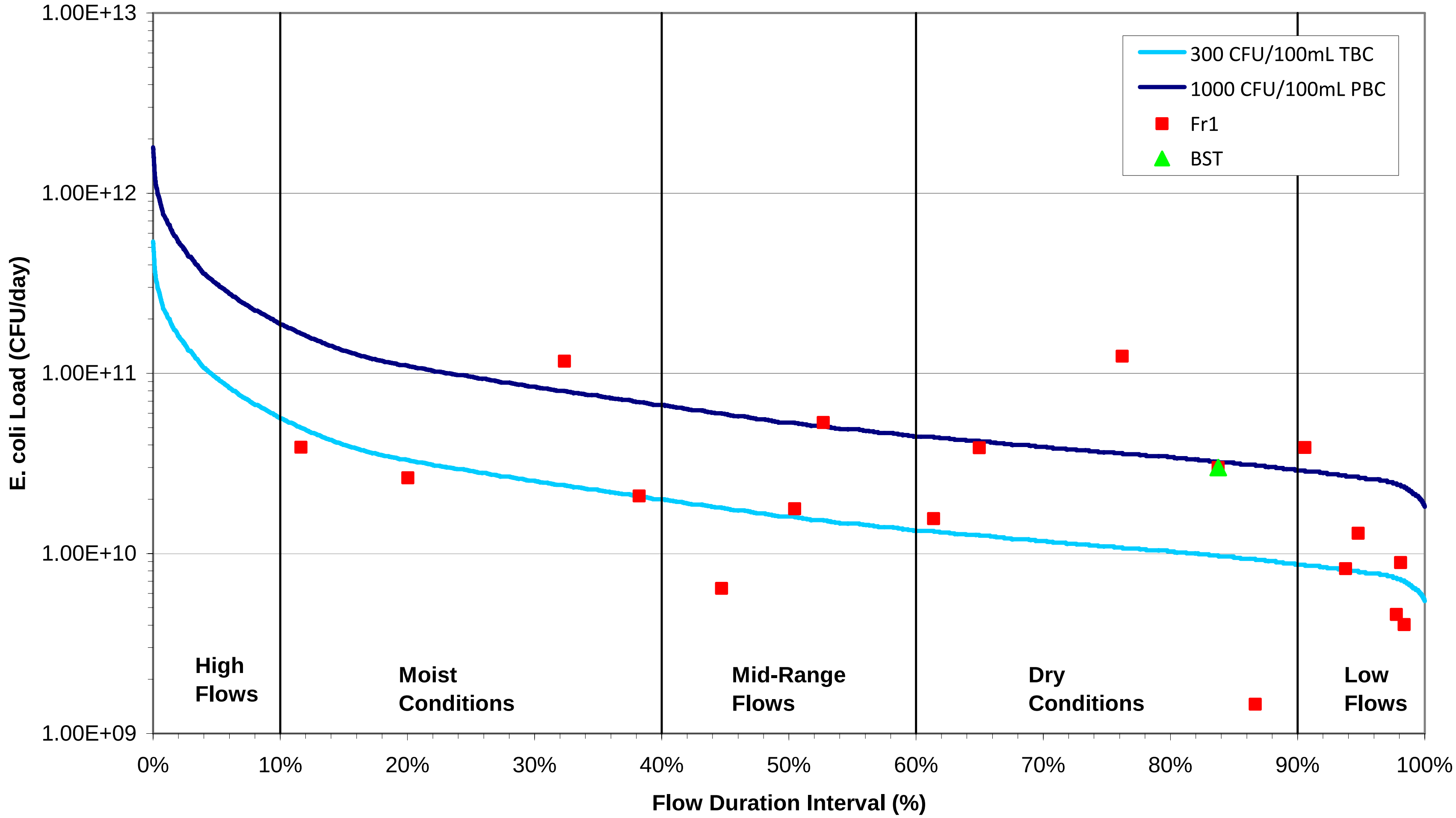

Figure B-4: Load duration curve for Frechette Creek Watershed monitoring site Fr1

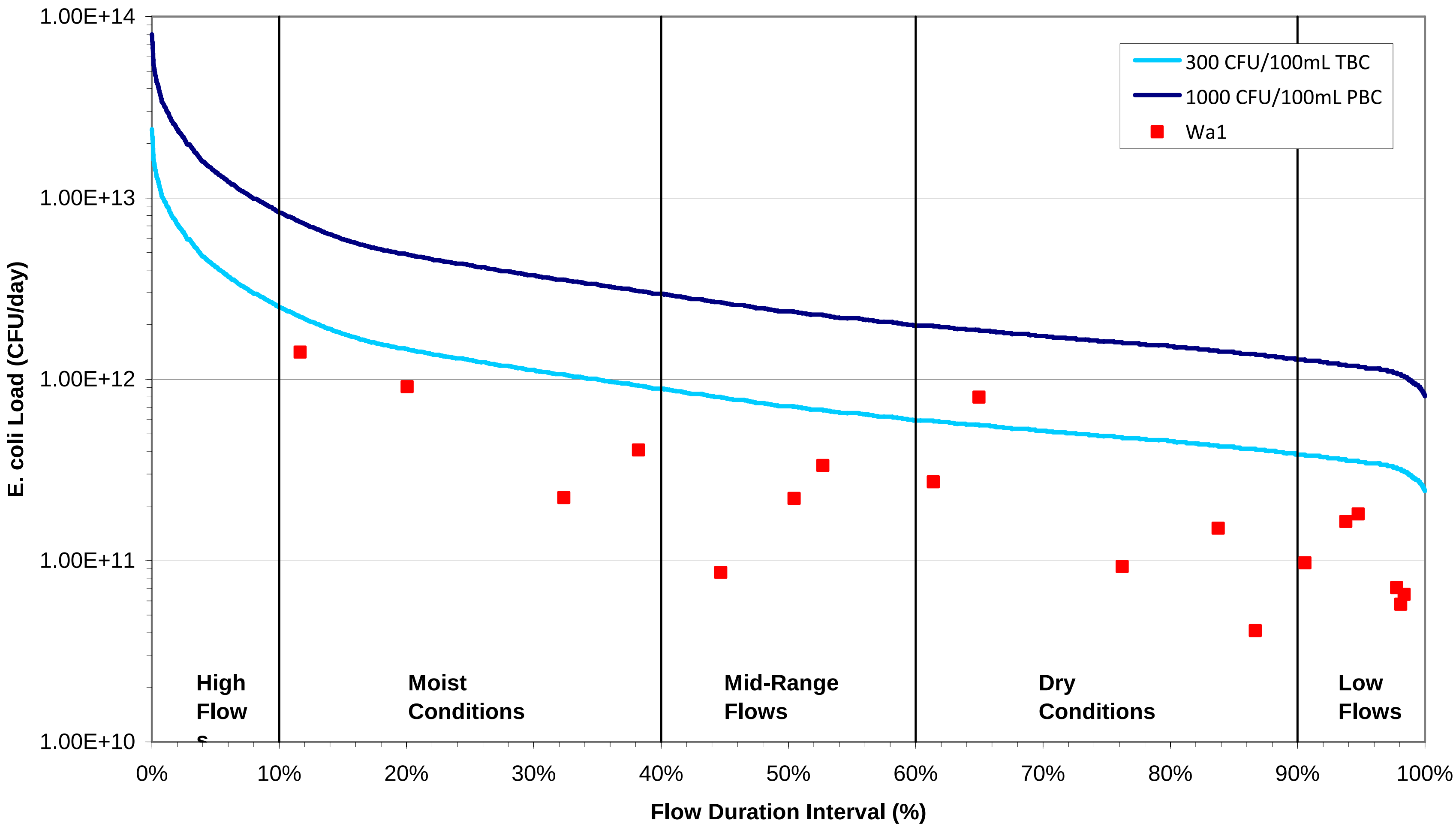

Figure B-5: Load duration curve for Waishkey River Watershed monitoring site Wa1

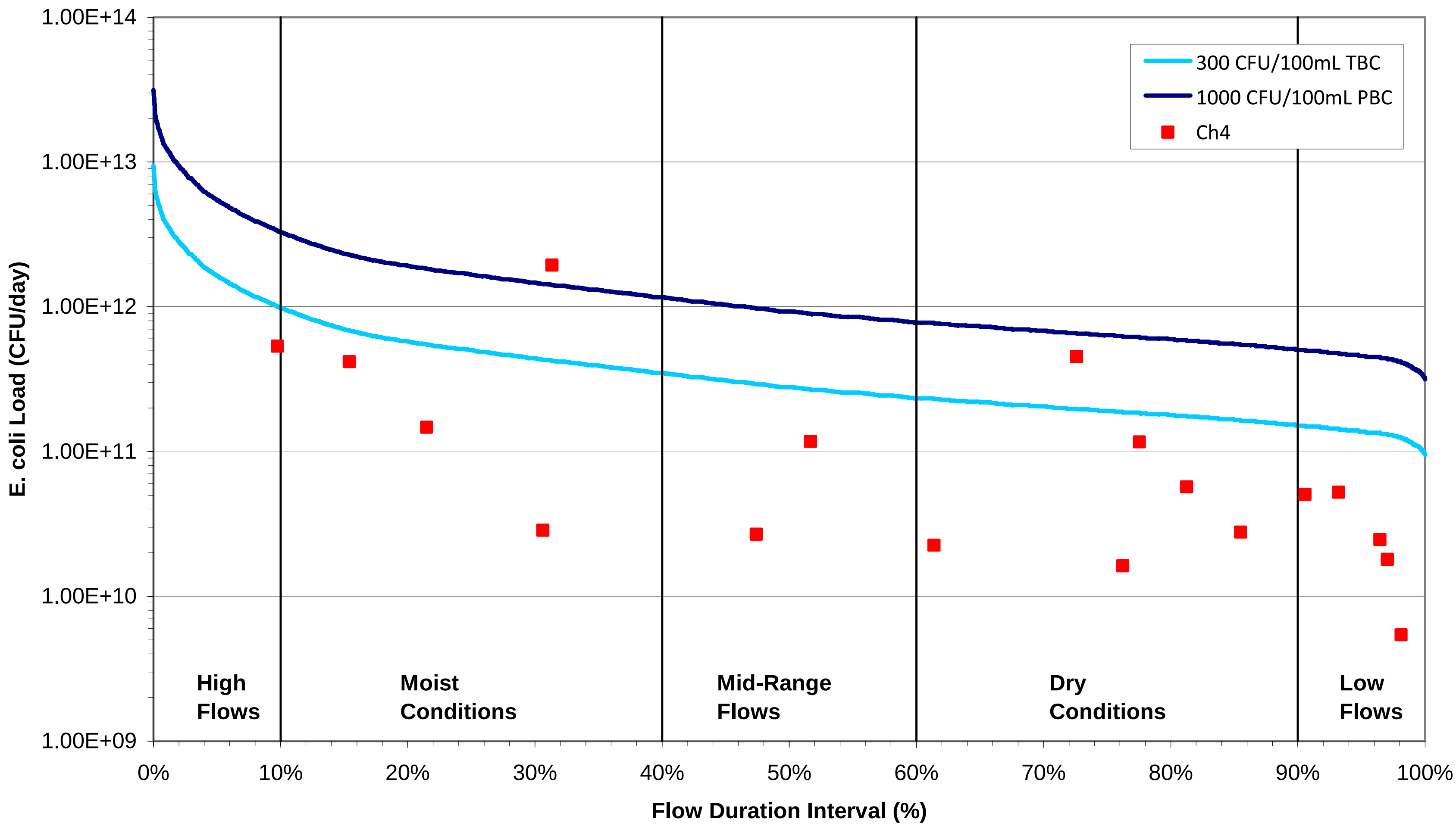

Figure B-6: Load duration curve for Charlotte River Watershed monitoring site Ch4

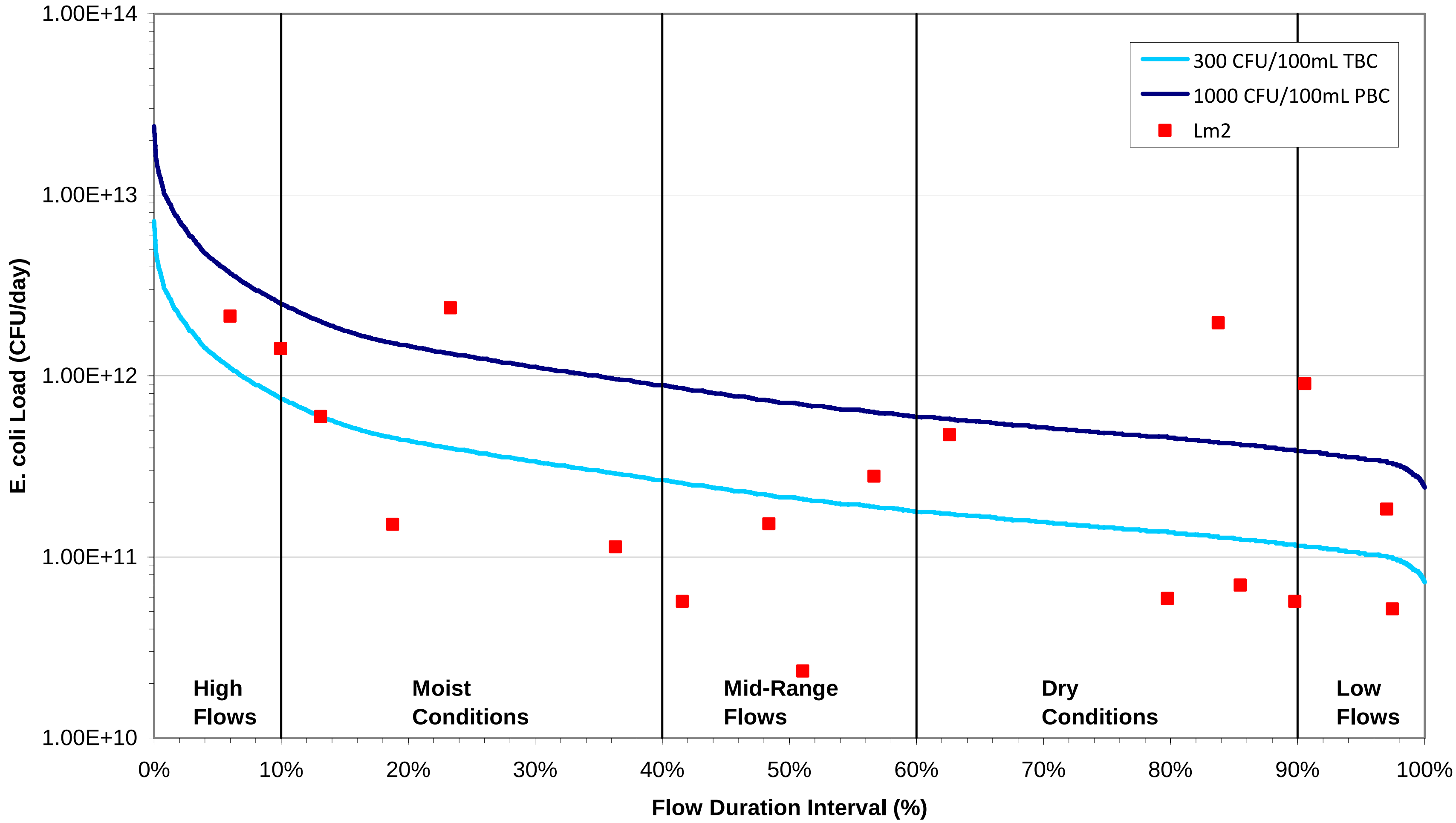

Figure B-7: Load duration curve for Little Munuscong River Watershed monitoring site Lm2

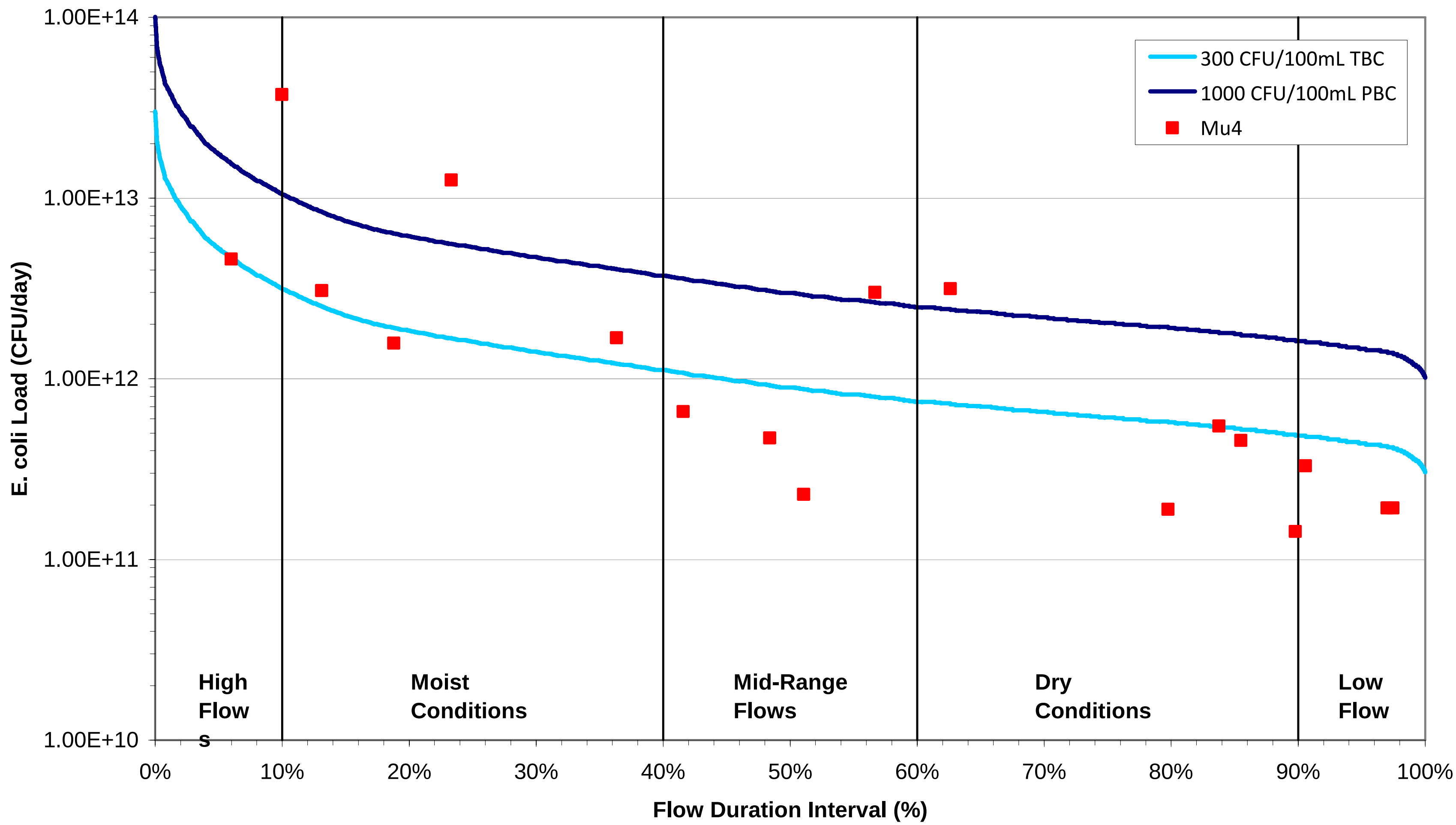

Figure B-8: Load duration curve for Munuscong River Watershed monitoring site Mu4

Point Source Wasteload Calculations

The waste load allocations for NPDES regulated point source dischargers, calculated for informational purposes, are summarized in Table B-9 through Table B-16. Waste loads were calculated as described below.

The Waishkey and Frechette Creek Watersheds receive discharges from the Kinross WWTF and the Odenaang Subdivision WWTF, respectively. Wasteload allocations for these facilities were calculated by converting each facility's maximum daily flow in millions of gallons per day to flow in cubic feet per second. It is assumed that facilities are in compliance with the WQS (130 *E. coli* per 100 mL as a 30-day geometric mean and a daily maximum of 300 *E. coli* per 100 mL from May 1 to October 31; and a daily maximum of 1,000 *E. coli* per 100 mL November 1 to April 30), as no evidence is known to the contrary. Each facility's maximum daily flow was multiplied by the WQS coliform concentration and the appropriate TMDL conversion factor from Table B3 of the EPA document, "An Approach for Using Load Duration Curves in the Development of TMDLs" (2007), to give the coliform concentration in its wastewater in cfu/day.

The Waishkey River Watershed receives a discharge from a WWSL: the Continental Tives-Brimley WWSL. The maximum permitted discharge of this facility was estimated by multiplying two parameters: the maximum lagoon drawdown due to pumping of 1 foot per day, as specified in the general discharge permit for WWSLs in Michigan, and the estimated area of the facility's largest lagoon, determined from aerial imagery (Microsoft Bing, 2011). Because such facilities typically maintain multiple lagoons, but only pump one at a time, using the area of the largest lagoon yields the most conservative estimate. Although the wasteload calculated using this method has not been consistently comparable with loads based on reported maximum daily flows where these flows are available (order of magnitude difference), these WWSL flows are small relative to flows throughout the watersheds. Consequently, the variability in these small flows should not significantly impact the conclusions of this modeling effort. A discharge permit exists for the Cleve Reid Mobile Home Park, but the park has not yet been constructed, so the permitted waste load was not counted towards the target load for the Ashmun Creek Watershed.

Both the Waishkey and Ashmun Creek receive dischargers from storm sewer structures. Three storm sewer systems, serving the Sault Sainte Marie Municipal Airport, Hoover Precision Products, and Aggressive Manufacturing Innovation, discharge in the Ashmun Creek Watershed, and the Dafter Landfill discharges stormwater in the Waishkey Watershed. Wasteloads allocations for storm sewer systems were estimated by multiplying the fraction of the watershed served by each system and the remaining target load after subtracting WWTF and WWSL wasteload allocations. The area served by the storm sewer systems was estimated by measuring the area of all impervious surfaces and grassed areas that are completely surrounded by impervious surfaces on these properties as shown on Microsoft Bing (2011) aerial photos streamed into ArcGIS Desktop v10 as a basemap. All measurements were completed within the State Plane Coordinate System (Zone 2111 – Michigan North).

Nonpoint Source Load Calculations

Load calculations, for information purposes, for nonpoint sources of *E. coli* in each of the watersheds are also summarized in Table B-9 through Table B-16. Nonpoint source load allocations were calculated as the percent of each watershed not served by storm sewer systems multiplied by the target load remaining after subtracting WWTP and WWSL wasteloads.

Table B-9: Daily *E. coli* load allocations and loading capacities for the Seymour Creek Watershed.

Flow Interval	Season	Load Allocation (cfu / day)	Loading Capacity (cfu / day)
High flows	May 1 – Oct 31	3.47 E +10	3.47 E +10
	Nov 1 – Apr 30	1.16 E +11	1.16 E +11
Moist conditions	May 1 – Oct 31	1.06 E +10	1.06 E +10
	Nov 1 – Apr 30	3.53 E +10	3.53 E +10
Mid-range flows	May 1 – Oct 31	5.91 E +9	5.91 E +9
	Nov 1 – Apr 30	1.97 E +10	1.97 E +10
Dry conditions	May 1 – Oct 31	4.04 E +9	4.04 E +9
	Nov 1 – Apr 30	1.35 E +10	1.35 E +10
Low flows	May 1 – Oct 31	2.91 E +9	2.91 E +9
	Nov 1 – Apr 30	9.69 E +9	9.69 E +9

Table B-10: Daily *E. coli* wasteload allocations, load allocations, and loading capacities for the Ashmun Creek Watershed.

Flow Interval	Season	Wasteload Allocations (cfu / day)			Load Allocation (cfu / day)	Loading Capacity (cfu / day)
		Sault Ste Marie Muni Airport	Hoover Precision Products	Aggressive Mfg Innovation		
High flows	May 1 – Oct 31	1.77 E +9	1.18 E +8	2.32 E +8	1.10 E +11	1.12 E +11
	Nov 1 – Apr 30	5.90 E +9	3.92 E +8	7.73 E +8	3.68 E +11	3.75 E +11
Moist conditions	May 1 – Oct 31	5.40 E +8	3.59 E +7	7.07 E +7	3.36 E +10	3.43 E +10
	Nov 1 – Apr 30	1.80 E +9	1.20 E +8	2.36 E +8	1.12 E +11	1.14 E +11
Mid-range flows	May 1 – Oct 31	3.01 E +8	2.00 E +7	3.95 E +7	1.88 E +10	1.91 E +10
	Nov 1 – Apr 30	1.00 E +9	6.68 E +7	1.32 E +8	6.26 E +10	6.38 E +10
Dry conditions	May 1 – Oct 31	2.06 E +8	1.37 E +7	2.70 E +7	1.28 E +10	1.31 E +10
	Nov 1 – Apr 30	6.86 E +8	4.56 E +7	8.99 E +7	4.28 E +10	4.36 E +10
Low flows	May 1 – Oct 31	1.48 E +8	9.85 E +6	1.94 E +7	9.23 E +9	9.41 E +9
	Nov 1 – Apr 30	4.94 E +8	3.28 E +7	6.47 E +7	3.08 +10	3.14 E +10

Table B-11: Daily *E. coli* load allocations and loading capacities for the Mission Creek Watershed.

Flow Interval	Season	Load Allocation (cfu / day)	Loading Capacity (cfu / day)
High flows	May 1 – Oct 31	1.01 E +11	1.01 E +11
	Nov 1 – Apr 30	3.38 E +11	3.38 E +11
Moist conditions	May 1 – Oct 31	3.09 E +10	3.09 E +10
	Nov 1 – Apr 30	1.03 E +11	1.03 E +11
Mid-range flows	May 1 – Oct 31	1.73 E +10	1.73 E +10
	Nov 1 – Apr 30	5.75 E +10	5.75 E +10
Dry conditions	May 1 – Oct 31	1.18 E +10	1.18 E +10
	Nov 1 – Apr 30	3.93 E +10	3.93 E +10
Low flows	May 1 – Oct 31	8.48 E +9	8.48 E +9
	Nov 1 – Apr 30	2.83 E +10	2.83 E +10

Table B-12: Daily *E. coli* wasteload allocations, load allocations, and loading capacities for the Frechette Creek Watershed.

Flow Interval	Season	Wasteload Goal (cfu / day) Odenaang Subdivision WWTF[1]	State Loading Capacity (cfu / day)	Loading Capacity (cfu / day)
High flows	May 1 – Oct 31	4.66 E +9	8.93 E +10	9.40 E +10
	Nov 1 – Apr 30	1.55 E +10	2.98 E +11	3.13 E +11
Moist conditions	May 1 – Oct 31	4.66 E +9	2.40 E +10	2.87 E +10
	Nov 1 – Apr 30	1.55 E +10	8.00 E +10	9.56 E +10
Mid-range flows	May 1 – Oct 31	4.66 E +9	1.13 E +10	1.60 E +10
	Nov 1 – Apr 30	1.55 E +10	3.78 E +10	5.33 E +10
Dry conditions	May 1 – Oct 31	4.66 E +9	6.28 E +9	1.09 E+10
	Nov 1 – Apr 30	1.55 E +10	2.09 E +10	3.64 E +10
Low flows	May 1 – Oct 31	4.66 E +9	3.21 E +9	7.87 E +9
	Nov 1 – Apr 30	1.55 E +10	1.07 E +10	2.62 E +10

[1]Facility is owned/operated by tribe, with permit issued by EPA. Load shown for this facility is a suggested as a voluntary goal but is not included in the TMDL. The allocation to be approved by EPA for this TMDL is the State Loading Capacity.

Table B-13: Daily E. coli wasteload allocations, load allocations, and loading capacities for the Waishkey watershed.

Flow Interval	Season	Wasteload Allocations (cfu / day)			Load Allocation (cfu / day)	Loading Capacity (cfu / day)
		Kinross WWTP	Continental WWSL	Dafter Stormwater		
High flows	May 1 – Oct 31	1.71 E +10	9.25 E +8	4.38 E +8	4.15 E +12	4.17 E +12
	Nov 1 – Apr 30	5.71 E +10	3.08 E +9	1.46 E +9	1.38 E +13	1.39 E +13
Moist conditions	May 1 – Oct 31	1.71 E +10	9.25 E +8	1.32 E +8	1.25 E +12	1.27 E +12
	Nov 1 – Apr 30	5.71 E +10	3.08 E +9	4.40 E +8	4.18 E +12	4.24 E +12
Mid-range flows	May 1 – Oct 31	1.71 E +10	9.25 E +8	7.29 E +7	6.92 E +11	7.10 E +12
	Nov 1 – Apr 30	5.71 E +10	3.08 E +9	2.43 E +8	2.31 E +12	2.37 E +12
Dry conditions	May 1 – Oct 31	1.71 E +10	9.25 E +8	4.92 E +7	4.67 E +11	4.85 E +11
	Nov 1 – Apr 30	5.71 E +10	3.08 E +9	1.64 E +8	1.56 E +12	1.62 E +12
Low flows	May 1 – Oct 31	1.71 E +10	9.25 E +8	3.49 E +7	3.31 E +11	3.49 E +11
	Nov 1 – Apr 30	5.71 E +10	3.08 E +9	1.16 E +8	1.10 E +12	1.16 E +12

Table B-14: Daily E. coli load allocations and loading capacities for the Charlotte Creek Watershed.

Flow Interval	Season	Load Allocation (cfu / day)	Loading Capacity (cfu / day)
High flows	May 1 – Oct 31	1.64 E +12	1.64 E +12
	Nov 1 – Apr 30	5.46 E +12	5.46 E +12
Moist conditions	May 1 – Oct 31	5.00 E +11	5.00 E +11
	Nov 1 – Apr 30	1.67 E +12	1.67 E +12
Mid-range flows	May 1 – Oct 31	2.79 E +11	2.79 E +11
	Nov 1 – Apr 30	9.30 E +11	9.30 E +11
Dry conditions	May 1 – Oct 31	1.91 E +11	1.91 E +11
	Nov 1 – Apr 30	6.35 E +11	6.35 E +11
Low flows	May 1 – Oct 31	1.37 E +11	1.37 E +11
	Nov 1 – Apr 30	4.57 E +11	4.57 E +11

Table B-15: Daily *E. coli* load allocations and loading capacities for the Little Munuscong Watershed.

Flow Interval	Season	Load Allocation (cfu / day)	Loading Capacity (cfu / day)
High flows	May 1 – Oct 31	1.25 E +12	1.25 E +12
	Nov 1 – Apr 30	4.17 E +12	4.17 E +12
Moist conditions	May 1 – Oct 31	3.81 E +11	3.81 E +11
	Nov 1 – Apr 30	1.27 E +12	1.27 E +12
Mid-range flows	May 1 – Oct 31	2.13 E +11	2.13 E +11
	Nov 1 – Apr 30	7.10 E +11	7.10 E +11
Dry conditions	May 1 – Oct 31	1.46 E +11	1.46 E +11
	Nov 1 – Apr 30	4.85 E +11	4.85 E +11
Low flows	May 1 – Oct 31	1.05 E +11	1.05 E +11
	Nov 1 – Apr 30	3.49 E +11	3.49 E +11

Table B-16: Daily *E. coli* load allocations and loading capacities for the Munuscong River Watershed.

Flow Interval	Season	Load Allocation (cfu / day)	Loading Capacity (cfu / day)
High flows	May 1 – Oct 31	5.25 E +12	5.25 E +12
	Nov 1 – Apr 30	1.75 E +13	1.75 E +13
Moist conditions	May 1 – Oct 31	1.60 E +12	1.60 E +12
	Nov 1 – Apr 30	5.34 E +12	5.34 E +12
Mid-range flows	May 1 – Oct 31	8.94 E +11	8.94 E +11
	Nov 1 – Apr 30	2.98 E +12	2.98 E +12
Dry conditions	May 1 – Oct 31	6.11 E +11	6.11 E +11
	Nov 1 – Apr 30	2.04 E +12	2.04 E +12
Low flows	May 1 – Oct 31	4.39 E +11	4.39 E +11
	Nov 1 – Apr 30	1.46 E +12	1.46 E +12