

**MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY
WATER RESOURCES DIVISION
MARCH 2020
STAFF REPORT**

Biological and water chemistry surveys of selected stations in the Betsie, Platte, and Crystal Rivers, and Herring and Bowens Creeks watersheds; Benzie, Leelanau, Grand Traverse, and Manistee Counties, Michigan; June-September 2018

Introduction

Biological and physical habitat conditions of selected water bodies in the Betsie, Platte, and Crystal Rivers, and Herring and Bowens Creeks watersheds; Benzie, Leelanau, Grand Traverse, and Manistee Counties, were assessed by staff of the Michigan Department of Environment, Great Lakes, and Energy (EGLE), Water Resources Division (WRD), Surface Water Assessment Section (SWAS), from June-September 2018. Water bodies include those listed in Table 1. The primary objectives of the assessments were to:

- 1) Assess the current status and condition of individual water bodies and determine if Michigan Water Quality Standards (WQS) are being met.
- 2) Evaluate biological integrity temporal trends.
- 3) Satisfy monitoring requests submitted by internal and external customers.
- 4) Evaluate the effectiveness of the Nonpoint Source (NPS) Program.
- 5) Identify NPS of water quality impairment.

Watershed Information

Platte River Watershed

The Platte River is a coldwater designated stream (Michigan Department of Natural Resources [MDNR], 1997) that originates approximately 30 miles upstream from its confluence with Lake Michigan. There are only three designated warmwater tributaries in the Platte River watershed (Table 1).

The Platte River starts as an outlet of Long Lake in the western portion of Grand Traverse County. A watershed management plan is available for Long Lake (Great Lakes Environmental Center for The Long Lake Watershed Partnership, 2009). A channel connects Long Lake with Lake Dubonnet, which is actually the result of an impoundment of the Platte River. The river continues to flow west downstream of Lake Dubonnet into Benzie County and then north into Lake Ann. It then continues west and south. Just before US-31 crosses the river, the Platte River State of Michigan Fish Hatchery discharges to the Platte River (MDNR, 2019). The watershed has an area of approximately 528 square miles. Stanley Creek, Kinney Creek, Carter Creek, and Collison Creek enter the Platte River upstream of the village of Honor. The North Branch Platte River meets up with the outlet of Little Platte Lake (805 acres) (Little Platte Lake Association, 2019) and then continues south until it meets with the Platte River just upstream of the confluence with Platte Lake. Platte Lake has a very active watershed and lake improvement group and their Web site includes many links to available data (Platte Lake Improvement Association, 2019). The Platte River Watershed Protection Plan is available on the

Benzie County Conservation District Web site (Brown, 2014). Downstream of Platte Lake, the Platte River continues for approximately five miles before emptying into Lake Michigan.

Table 1. Warmwater designated streams in the Platte River watershed adapted from the MDNR (1997).

Stream	Township, Range, Section	County
Unnamed Creek	T26N, R13W, S04	Benzie
Lower Woodcock Lake Outlet	T27N, R13W, S28	Benzie
Harvey Lake Outlet	T27N, R13W, S28	Benzie

Betsie River

The Betsie River is a coldwater designated stream, with the exception of the portion that is upstream from the Grass Lake Flooding Dam (MDNR, 1997). However, an MDNR, Fisheries Division, report (Tonello, 2017) noted that the Betsie River does not have as many cold groundwater inputs as other northern Michigan rivers. The Betsie River begins in the western portion of Grand Traverse County approximately 50 miles upstream of its confluence with Lake Michigan. The uppermost part of the watershed starts with Mason Creek, a tributary to Duck Lake. Duck Lake is connected to Green Lake and the outlet from Green Lake is the Betsie River. As noted, there is a small dam that backs up the Betsie River near the Grass Lake outlet. Downstream of this dam the gradient increases and the Betsie River picks up in velocity as it flows southwest for approximately 15 miles where it then turns west and north near Crystal Mountain in Manistee County. It then flows north and west into Benzie County for approximately 15 miles until it crosses US-31. It then flows west 10 more miles until it reaches Betsie Lake before meeting up with Lake Michigan just south of Crystal Lake. The Betsie River watershed has an area of approximately 335 square miles. The Little Betsie River joins the main branch just upstream of Thompsonville. Carter, Dair, and Rice Creeks are three additional smaller tributaries to the Betsie River. The Betsie River/Crystal Lake Watershed Management Plan was prepared by the Betsie River/Crystal Lake Watershed Management Plan Steering Committee (2016).

The Platte and Betsie River watersheds are located primarily in the Newago Outwash Plain subsection ecosystem, which consists of outwash plains and excessively well drained sandy soils. However, the most downstream portion flows through the Manistee District, which consists of sand dunes, sand lake plain, ground and end moraines, and outwash (Albert, 1995; Version 3 update June 1998). The portion of the Platte River downstream of Platte Lake is within the Sleeping Bear Dunes National Lakeshore (National Park Service, 2019). All stations are in the North Central Hardwood Forests (NCHF) ecoregion (Omernik and Gallant, 2010).

The Herring Creek watershed is in Benzie County south of the Betsie River watershed and the Bowens Creek watershed is located south of the Herring Creek watershed in Manistee County. Both watersheds are designated as coldwater (MDNR, 1997) and are relatively small in area (25 square miles). Both watersheds are in the Manistee sub-district (Albert, 1995; Version 3 update June 1998) and are in the NCHF ecoregion (Omernik and Gallant, 2010). Land use for the Platte and Betsie Rivers watersheds as well as coastal streams such as Herring and Bowens Creeks is presented in Table 2 and Table 3 (National Oceanic and Atmospheric Administration, 2011).

The amount of impervious area in the Platte and Betsie Rivers watersheds is between 2 and 21 percent (Table 3). Impervious surfaces are those areas on the land that cannot effectively

absorb water and pass it through to the groundwater table. Examples include decks, patios, paved gravel roads, crushed stone driveways, parking areas, and sidewalks. Impervious area is closely linked to areas of development. The amount of total wetlands lost since presettlement times in the Platte and Betsie Rivers watersheds (1-4 percent) is relatively low when compared to the entire state (40 percent) (Fizzell, 2014). The highest percent of wetlands lost in the watersheds presented in this report, is 4 percent in the Betsie River watershed downstream of the Crystal Lake outlet (Table 3).

Table 2. Land use summary for the Platte River, Betsie River, and other nearby watersheds in northwest Michigan.

Watershed	Natural	Developed	Cultivated Agriculture	Hay or Pasture	Water	Other
Platte River	76%	7%	8%	1%	8%	0%
Betsie River	74%	9%	6%	1%	10%	0%
Crystal River, Otter, Herring, and Bowens Creeks	67%	8%	10%	3%	9%	3%

Historical Sampling Efforts and Information

The most recent surveys of the Betsie and Platte Rivers watersheds and adjacent smaller coastal watersheds were conducted in 2013 (Lipse, 2016). Aquatic macroinvertebrate community and habitat assessments were conducted at 14 stations. Macroinvertebrate ratings were all acceptable except for one site in Bowens Creek in Manistee County that rated excellent. Habitat ratings ranged from good to excellent. Historic reports from the past two decades are summarized in Table 4.

Unnamed Tributary to Platte Lake Upstream of US-31

In 2003, staff from EGLE SWAS and Cadillac District Office conducted a chemical and biological survey of an unnamed tributary to Platte Lake in response to a water quality complaint of strong odors and a strange orange coloration of the water and substrate in the stream. It was determined that the west branch of this groundwater-fed stream was being impacted by contaminated groundwater that was venting from an illicit fruit waste disposal to a gravel pit located upgradient of the stream (Wesener, 2011). (Walker, 2003) and (Smith, 2003) found elevated conductivity, total phosphorus, metals concentrations, biochemical oxygen demand (BOD), and total organic carbon concentrations. Modeling indicated the dissolved oxygen (DO) concentrations did not meet WQS further downstream in the unnamed tributary.

The illicit waste was partially removed from the pit, but groundwater and soils were already contaminated. Poor macroinvertebrate conditions were found in 2003 and 2008 and degraded habitat conditions consisting of orange bacterial slimes and accumulated organic matter that would not decompose were found in 2003, 2008, 2009, and 2013. Water quality and biological community data are collected annually by the responsible party of the contaminated groundwater venting to the creek.

In 2013, the SWAS collected additional macroinvertebrate community, bacterial slime quantification, habitat, and water samples from both the impacted reach (west branch) and a control reach that had not been impacted by contaminated groundwater (east branch)

(Carpenter, 2013 and 2014; and Lipsey, 2014 and 2016). The macroinvertebrate community was evaluated using both the SWAS Procedure 51 sampling protocol and a more quantitative method (Michigan Department of Environmental Quality [MDEQ], 2014 and Creal et al., 1996). Procedure 51 resulted in an acceptable (-2) rating for the west branch and an acceptable rating (3) for the east branch. Several additional metrics were calculated using a more quantitative data collection procedure, including total taxa, taxa diversity, number *Ephemeroptera*, *Plecoptera*, and *Trichoptera* (EPT) sensitive taxa, and density of EPT taxa. All metrics indicated that the conditions were more favorable for sensitive taxa in the control reach (Lipsey, 2014).

The extent of bacterial slimes observed in 2013 had decreased since 2003; however, much of the impacted stream substrate continued to have the orange biofilm covering it, which limits the number of sensitive taxa that could potentially colonize the substrate. Water quality sampling results conducted by the responsible party, indicated that both the DO and arsenic WQS were not being met in the impacted reach. The responsible party installed a remediation system in 2016 that forces additional air into the groundwater with the hope of accelerating the natural decomposition of waste remaining in the groundwater (Eric Chatterson, WRD staff, Personal Communication).

Methods

The macroinvertebrate or fish community and physical habitat were qualitatively assessed at 18 stations using the SWAS Procedure 51 for wadeable streams. The stations were sampled upstream of road crossings. The macroinvertebrate and fish communities were assessed and scored with metrics that rate water bodies from excellent (+5 to +9 [macroinvertebrates], +5 to +10 [fish]) to poor (-5 to -9 [macroinvertebrates], -5 to -10 [fish]). Scores from +4 to -4 are rated acceptable. Negative scores in the acceptable range are considered tending towards a poor rating, while zero and positive scores in the acceptable range are tending towards an excellent rating. Habitat evaluations are based on 10 metrics, with a maximum total score of 200. A station with a habitat score greater than 154 is characterized as having excellent habitat, 105-154 is good, 56-104 is marginal, and less than 56 is poor. Where available, macroinvertebrate community scores are used to determine attainment of the Other Indigenous Aquatic Life and Wildlife (OIALW) designated use and fish community scores are used to assess attainment of the warmwater fish designated use. Habitat scores and individual metrics are used to help better understand the biological community scores.

Site Selection

Two site-selection methods are used in watershed surveys: (1) stratified random; and (2) targeted. Stratified random sites support the Status and Trend Program, which is designed to statistically assess the biological conditions of macroinvertebrate communities in Michigan's rivers and streams and determine whether changes are occurring over time (Procedure WRD-SWAS-027 [MDEQ, 2015]). Targeted sites are chosen through the "Targeted Monitoring Request" process, which involves stakeholders from across Michigan submitting monitoring requests. All survey types are considered when determining support of the OIALW designated use component of Rule 100 (R 323.1100(e)) of the Part 4 WQS (Part 4 Rules), promulgated under Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended.

Table 3. More detailed land use for 12-digit watersheds in the Platte and Betsie River and nearby northwest Michigan watersheds. A lighter shaded cell indicates a land use characteristic that is relatively more stressful on aquatic ecosystems.

12 digit HUC	Water Body	Total Area	Natural Area		Developed Area		Agriculture		Cultivated Agriculture		Hay or Pasture		Lost Wetlands		Impervious Area	
		square miles	square miles	percent	square miles	percent	square miles	percent	square miles	percent	square miles	percent	square miles	percent	square miles	percent
	Platte River Watershed															
040601040201	Long Lake-Platte River	23	10	44%	2.1	9%	5.5	24%	4.8	21%	0.69	3%	0.01	2%	0.01	3%
040601040202	Bronson Lake-Platte River	27	21	77%	2.4	9%	1.6	6%	1.2	4%	0.42	2%	0.00	1%	0.03	9%
040601040203	Pearl Lake	30	23	77%	1.5	5%	4.3	14%	3.9	13%	0.45	1%	0.00	1%	0.01	2%
040601040204	North Branch Platte River	46	39	85%	2.5	6%	2.9	6%	2.6	6%	0.31	1%	0.00	1%	0.04	8%
040601040205	Collison Creek-Platte River	46	41	88%	2.9	6%	2.4	5%	2.0	4%	0.39	1%	0.01	1%	0.06	12%
040601040206	Platte River	21	13	64%	1.5	7%	1.0	5%	0.8	4%	0.15	1%	0.00	1%	0.01	6%
	Betsie River Watershed															
040601040301	Duck Lake	35	23	66%	3.0	9%	5.4	15%	4.3	13%	1.02	3%	0.01	2%	0.02	6%
040601040302	Green Lake	21	15	68%	2.4	11%	0.6	3%	0.6	3%	0.07	0%	0.00	2%	0.02	9%
040601040303	Little Betsie River	46	42	92%	2.1	5%	1.1	2%	1.0	2%	0.05	0%	0.00	1%	0.01	3%
040601040304	Dair Creek-Betsie River	54	48	88%	4.5	8%	1.7	3%	1.6	3%	0.15	0%	0.01	1%	0.02	4%
040601040305	Crystal Lake Outlet	44	22	49%	4.4	10%	2.5	6%	2.3	5%	0.20	0%	0.01	2%	0.09	21%
040601040306	Rice Creek-Betsie River	27	20	76%	2.1	8%	4.3	16%	3.8	14%	0.54	2%	0.00	2%	0.00	2%
040601040307	Betsie River downstream of Crystal Lake outlet	15	10	67%	2.3	15%	2.3	15%	2.1	14%	0.15	1%	0.01	4%	0.01	4%
	Other Smaller Coastal Lake Michigan Watersheds															
040601040401	Shalda Creek	59	42	72%	4.6	8%	6.8	12%	5.6	10%	1.20	2%	0.01	1%	0.03	5%
040601040402	Crystal Run	46	31	68%	2.5	5%	1.3	3%	1.0	2%	0.23	0%	0.00	1%	0.06	14%
040601040403	Otter Creek	25	17	68%	1.8	7%	0.7	3%	0.6	3%	0.02	0%	0.00	1%	0.01	3%
040601040404	Arcadia Lake	25	17	70%	1.6	6%	5.7	23%	4.2	17%	1.43	6%	0.00	1%	0.03	11%
040601040405	Portage Lake	25	13	53%	2.7	11%	5.5	22%	4.1	17%	1.34	5%	0.01	2%	0.01	2%
040601040406	Herring Creek	40	26	63%	3.3	8%	7.8	19%	6.5	16%	1.32	3%	0.01	2%	0.01	2%

Table 4. Historic biosurvey reports available for the Betsie, Platte, and Crystal Rivers, and Herring Creek watersheds; Benzie, Leelanau, Grand Traverse, and Manistee Counties, Michigan.

Survey Year	Report Citation Report Number	Finding/Comments
2013	(Carpenter, 2013) #MI/DEQ/WRD-13/033	<ul style="list-style-type: none"> • Ammonia, BOD, and DO samples were collected during the critical season to see if the 7 milligrams per liter (mg/l) minimum DO WQS was met in the unnamed tributary to Platte Lake contaminated with venting groundwater. • Results indicated the DO level was not always attaining the 7 mg/l minimum DO WQS. Ammonia was detected but did not exceed WQS. BOD was not detected.
2014	(Carpenter, 2014) #MI/DEQ/WRD-14/031	<ul style="list-style-type: none"> • Water samples collected monthly from June-September 2014 from an unnamed tributary to Platte Lake in Benzie County. • Results indicated that the water from the west branch of the unnamed tributary did not meet the chronic WQS of 10 parts per billion for arsenic. • Unnatural color, bacterial slimes, and odor remain a problem for the west branch.
2013	(Lipsey, 2016) #MI/DEQ/WRD-16/022	<ul style="list-style-type: none"> • Macroinvertebrate community samples collected at 14 stations; ratings were all acceptable except Bowens Creek rated excellent. • Habitat ratings ranged from good to excellent.
2011	(Wesener, 2011) #MI/DEQ/WRD-11/002	<ul style="list-style-type: none"> • Macroinvertebrate community samples collected at 11 stations, ratings were all acceptable except for the unnamed tributary to Platte Lake rating poor, due to impacts of contaminated venting groundwater and Leo Creek due to procedure issues. • Habitat ratings ranged from good to excellent. • Coldwater fisheries designated use assessed in the Crystal River downstream of Fisher Lake; catch included several species of fish including King and Coho salmon but no resident salmonid fish species.
2003	(Zbytowski, J., 2007a) #MI/DEQ/WB-07/107	<ul style="list-style-type: none"> • Macroinvertebrate community and habitat assessments were conducted at five stations in the Betsie River watershed. Macroinvertebrate communities were rated acceptable at all stations and were found to have good to excellent habitat conditions. • Water chemistry samples were collected at nine stations; WQS were met at all stations.
2003	(Zbytowski, J., 2007b) #MI/DEQ/WB-07/108	<ul style="list-style-type: none"> • Macroinvertebrate community and habitat assessments were conducted at one station in the Cold Creek watershed. Macroinvertebrate community was rated acceptable and was found to have good habitat condition. • Water chemistry samples collected at three stations; WQS met at all stations.
2003	(Zbytowski, J., 2007c) #MI/DEQ/WB-07/109	<ul style="list-style-type: none"> • Macroinvertebrate community and habitat assessments were conducted at two stations in the Herring Creek watershed. Macroinvertebrate communities were rated acceptable at both stations (scores 0 and -3) and were found to have excellent and good habitat conditions, respectively. • Water chemistry samples were collected at seven stations; WQS were met at all stations.
2003	(Zbytowski, J., 2007d) #MI/DEQ/WB-07/111	<ul style="list-style-type: none"> • Macroinvertebrate community and habitat assessments were conducted at five stations in the Platte River watershed. Macroinvertebrate communities were rated acceptable at all stations and had good to excellent habitat conditions. • Water chemistry samples were collected at ten stations; WQS were met at all stations.

Survey Year	Report Citation Report Number	Finding/Comments
2003	(Walker, 2003) #MI/DEQ/WB-03/048	<ul style="list-style-type: none"> • Unnamed tributary to Platte Lake, contaminated venting groundwater study. • East branch supported a coldwater fishery (brook trout), acceptable macroinvertebrate community, and water sample results met WQS. • West branch had a poor macroinvertebrate community and degraded in-stream habitat conditions; thus not meeting WQS. • Water quality samples in the west branch indicated altered water quality characteristics.
2003	(Smith, 2003) #MI/DEQ/WB-03/053	<ul style="list-style-type: none"> • Unnamed Tributary to Platte River, contaminated venting groundwater study. • Elevated BOD and total organic carbon. Modeling indicated the DO concentrations did not meet WQS.

Table 5. Summary of the aquatic habitat and macroinvertebrate community evaluations for selected stations in the Betsie, Platte, and Crystal Rivers, and Herring and Bowens Creeks watersheds, June-September 2018.

Station	Stream Name	Road Crossing	STORET	Township	County	Latitude	Longitude	Habitat Rating	Habitat Score	Macroinvertebrate Rating	Macroinvertebrate Score	T_S_Tr	AUID
1	Crystal River	Upstream of Dam at Fisher Road	450240	Glen Arbor	Leelanau	44.89950	-85.95664	Excellent	177	Acceptable	-2	T	040601040402-02
2	East Branch Unnamed Tributary to Platte Lake	US-31	100252	Benzonia	Benzie	44.66214	-86.04966	Excellent	170	Acceptable	-1	T	040601040206-01
3	West Branch Unnamed Tributary to Platte Lake	US-31	100240	Benzonia	Benzie	44.66380	-86.05420	Good	152	Acceptable	-2	T	040601040206-02
4	Unnamed Tributary to Platte Lake	Platte Lake Road	100248	Benzonia	Benzie	44.66783	-86.05007	Excellent	160	Poor	-7	T	040601040206-02
5a	Unnamed Tributary to Little Platte Lake	Saffron Road	100265	Platte	Benzie	44.71140	-86.05064	Good	122	Poor	-5	T	040601040204-NA
5b	Unnamed Tributary to Little Platte Lake	Downstream Saffron Road	100266	Platte	Benzie	44.71140	-86.05064	Good	117	Acceptable	-1	T	040601040204-NA
6	Platte River	Maple City Hwy.	100264	Inland	Benzie	44.68143	-85.92227	Excellent	186	Acceptable	4	S	040601040205-01
7	Platte River	El Dorado Park	100251	Lake	Benzie	44.72649	-86.14364	Excellent	158	Acceptable	-2	T	040601040206-NA
8a	Mason Creek	East Duck Lake Road	280440	Green Lake	Grand Traverse	44.63095	-85.72151	Good	138	Acceptable	-1	T	40601040301-01

Station	Stream Name	Road Crossing	STORET	Township	County	Latitude	Longitude	Habitat Rating	Habitat Score	Macroinvertebrate Rating	Macroinvertebrate Score	T_S_Tr	AUID
8b	Mason Creek	Downstream East Duck Lake Road	280441	Green Lake	Grand Traverse	44.63095	-85.72151	Good	143	Acceptable	-1	T	40601040301-01
9	Little Betsie River	Nessen Road	100242	Colfax	Benzie	44.53319	-85.87830	Excellent	156	Acceptable	-1	T	040601040303-01
10	Little Betsie River	Bentley Road (East Crossing)	100162	Colfax	Benzie	44.53479	-85.91012	Good	141	Acceptable	-1	S	040601040303-01
11	Betsie River	Nostwick Road	100268	Colfax	Benzie	44.57304	-85.88799	Excellent	183	Excellent	5	S	040601040303-01
12	Betsie River	Reynolds Road	100244	Colfax	Benzie	44.57450	-85.87778	Excellent	156	Acceptable	-1	S	040601040303-01
13	Betsie River	Off Old Grade Road	510255	Springdale	Manistee	44.49200	-86.00900	Excellent	190	Excellent	5	Tr	040601040304-01
14	North Branch Cold Creek	Downstream East Street	100269	Benzonia	Benzie	44.63188	-86.09101	Marginal	86	Poor	-6	T	040601040305-02
15	Cold Creek (south branch)	US-31	100227	Benzonia	Benzie	44.63015	-86.09205	Good	134	Poor	-5	T	040601040305-02
17	Bowens Creek	Downstream Gilbert Road	510276	Arcadia	Manistee	44.48539	-86.20198	Good	146	Acceptable	-4	T	040601040404-NA
SV-1	Herring Creek	Downstream Putney Road	100163	Blaine	Benzie	44.54646	-86.15981	NA	NA	NA	NA	T	040601040406-01

S/T/Tr = status, targeted, trend station
NA = Not Applicable

Habitat Scoring

Poor < 56
Marginal 56-104
Good 105-154
Excellent >154

Macroinvertebrate Scoring

Poor < -4
Acceptable -4 to +4
Excellent > +4

Summary of Findings by Monitoring Objective

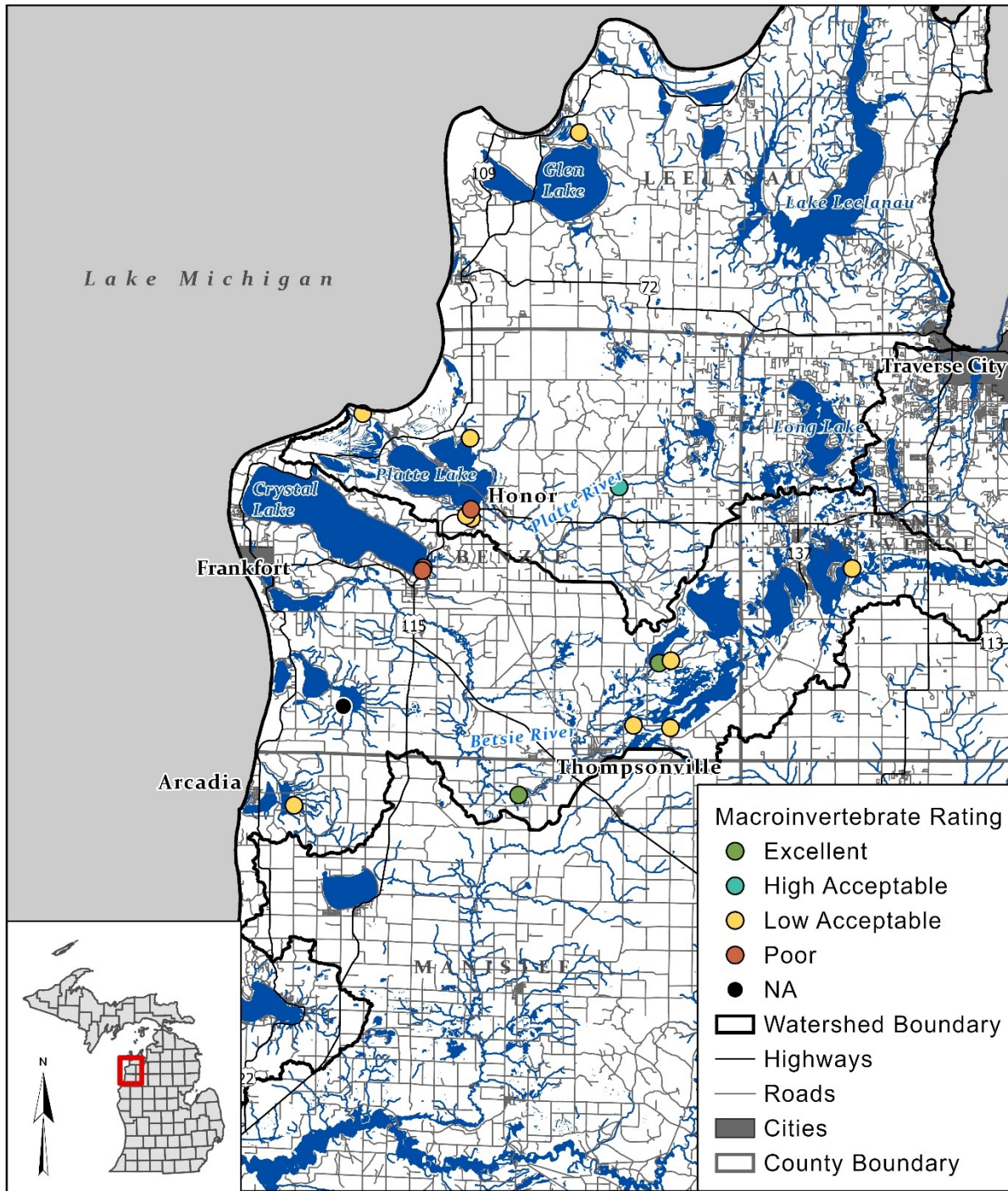
Objective 1: Assess the status and condition of individual waters of the state and determine whether Michigan WQS are being met.

In 2018, 19 sites within the Betsie, Platte, and Crystal Rivers, and Herring and Bowens Creek watersheds were sampled to assess the designated use support status of their associated individual assessment units (Figure 1; Table 5). At all stations, aquatic macroinvertebrate community and habitat assessments were conducted. Fish community assessments were conducted at two stations in Cold Creek, a tributary to Crystal Lake. The OIALW designated use was being met at most stations. Cold Creek is not meeting the OIALW designated use due to macroinvertebrate communities that were rated as poor. The fish community was meeting the coldwater fish community designated use in the south branch but not the north branch of Cold Creek. The metric used to determine attainment of the coldwater fish community is having at least 1% of the fish community be salmonid species.

Crystal River

The Crystal River was sampled upstream of the water control structure at Fisher Road (Station 1). The Crystal River is a relatively small watershed that flows northwest from Glen Lake and Fisher Lake to Lake Michigan. The river is within the Sleeping Bear National Park and the Park Service requested information about the biological community and habitat condition due to the extensive use of the river by kayaks during the warmer months (Figure 2).

The riffle/run habitat was rated excellent (177; Table 7). The riparian area consisted of a mature cedar forest with little understory due to shading. There were extensive riffle areas with clean substrate and large woody debris (LWD) available as epifaunal substrate (Figure 3). The macroinvertebrate community scored acceptable (-2; Table 8 and Table 9). Of the EPT families that are more sensitive to pollution and other environmental stressors, two mayfly, one stonefly, and five caddisfly families were found. The two mayfly families that were found were low in numbers. The dominant taxa found (52%) was black flies (*Simuliidae*).



0 2.5 5 7.5 10 Miles

Betsie and Platte River Watershed Monitoring

Water Resources Division



MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY

Figure 1. Stations sampled in 2017 in the Betsie, Platte, and Crystal Rivers, and Herring and Bowens Creek watersheds; Benzie, Leelanau, Grand Traverse, and Manistee Counties, Michigan.



Figure 2. Signage in the Sleeping Bear Dunes National Park informing kayakers that the risk of impacting stream habitat increases as water levels fall.



Figure 3. Crystal River downstream of water control structure at Fisher Road, Leelanau County, Michigan.

Unnamed Tributary to Platte Lake

In 2018, the east branch of the unnamed tributary was sampled upstream of US-31 (Station 2). The riffle/run habitat was rated as excellent (170; Table 7). The east branch is a small (mean width, 3 feet) coldwater, high gradient stream with substantial flow for the small size. Epifaunal substrate consisted of mostly gravel and sand. There were some undercut banks, aquatic macrophytes, and overhanging grass, woody debris, and cobble. The riffle substrate was clean except for a large amount of sand deposition evident just upstream of US-31 (Figure 4) and at the few bends found in the stream. The stream has few bends, most likely due to historic (>50 years) drain maintenance. The east branch had an impacted riparian area due to agriculture land use. There were few large trees and a large amount of herbaceous vegetation and grasses. The macroinvertebrate community scored acceptable (-1; Table 8 and Table 9).



Figure 4. East branch unnamed tributary to Platte Lake Upstream of US-31. Note the large amount of sedimentation.

The impacted west branch of the unnamed tributary was sampled at one station upstream of US-31 (Station 3). The riffle/run habitat was rated good (152; Table 7). The west branch begins as groundwater seeps along the north facing slopes upstream of this station. The groundwater seep areas are full of watercress and other herbaceous vegetation. The stream is very narrow (1-3 feet on average) and has a steep gradient. The riparian area consists of many large trees and very little herbaceous vegetation due to the amount of shade provided by the mature trees. Almost all stream banks are raw, most likely due to the steep gradient of the stream and lack of understory. Tree roots help to hold the stream banks, but during high flows there is likely in-stream erosion. The stream did not appear flashy. The substrate at this station was a mix of cobble and gravel. There was little LWD, but a lot of small sticks and other woody material. There was no overhanging vegetation, undercut banks, or in-stream macrophytes. The landowner has constructed several small dams with cobble from the stream to make waterfalls and plunge pools. Walking upstream of US-31, the gravel was clean until the stream begins to turn west. At that point, the cobble was covered with the orange tinted biofilm (Figure 5) and there was a fair amount of sediment deposition. The macroinvertebrate community scored

acceptable (-2; Table 8 and Table 9). More information on this creek including a comparison of macroinvertebrate data collected in 2013 and 2018 and more quantitative sampling can be found under Objectives 3 and 4 below and Lipsey (2019).

Water chemistry samples were also collected at locations in the west branch and at Station 2 in the east branch. Water samples were collected on four occasions. The results are presented in Table 6. The arsenic results indicated the human cancer value, chronic WQS of 10 micrograms per liter is still being exceeded in the west branch of the unnamed tributary.

Table 6. Arsenic results for water samples collected from three stations in the unnamed tributary to Platte Lake. Units are micrograms per liter. Latitude and Longitude coordinates are noted after stream name. ND is not detected.

Date	West Branch 1A (Impacted) 44.66270, -86.05448	West Branch 1B (Impacted) 44.66282, -86.05456	East Branch (Reference) 44.66483, -86.05148
5/24/2018	3.40	2.50	ND
6/29/2018	76.00	2.90	ND
7/18/2018	9.10	2.90	ND
9/13/2018	4.20	3.00	ND

Although the macroinvertebrate community in the west branch meets the OIALW designated use, it is not attaining WQS based on the narrative standard, Rule 50 (R 323.1050) of the Part 4 Rules. This narrative addresses the following physical characteristics of a water body: turbidity, color, oil films, floating solids, foams, settleable solids, suspended solids, and deposits. Michigan does not have specific assessment methods or numeric standards for these physical characteristics; therefore, best professional judgement (including visual observation) in conjunction with other assessment types (e.g., biological) is used to determine the OIALW designated use support based on this narrative standard (Goodwin, 2016).



Figure 5. Close-up of groundwater seepage and orange bacterial slimes in the west branch of the unnamed tributary to Platte Lake, Benzie County, Michigan.

A third station on the unnamed tributary to Platte Lake was sampled upstream of Platte Road. This station is downstream of where the west and east branches of the unnamed tributary combine in a wooded wetland area before a defined channel can be found upstream of

Platte Lake Road. A lot of sediment deposition was observed at the site (Figure 6 and Figure 7). The glide/pool habitat was rated as good (150; Table 7).

The macroinvertebrate community scored poor (-7; Table 8 and Table 9). No stonefly taxa, a low density of caddisfly taxa, a high density of *Amphipoda*, and a large percentage of air surface breathers, all contributed to the poor score. The sediment and wetland-like nature of the stream is most likely impacting the Procedure 51 score. More information and a comparison to the 2013 data can be found under Objective 4 and 5 below.



Figure 6. Unnamed tributary to Platte Lake upstream of Platte Road. Note the large amount of silt and sediment deposits.



Figure 7. Unnamed tributary to Platte Lake upstream of Platte Road looking downstream. Note the large amount of silt and sediment deposits.

Unnamed Tributary to Little Platte Lake at Saffron Road

The unnamed tributary to Little Platte Lake was sampled both upstream and downstream of Saffron Road, in anticipation of a planned road crossing replacement. The stream is a very small headwater stream draining wetland areas. At the upstream station (Station 5a), the glide/pool habitat was rated good (122; Table 10). The riparian area consisted of a mature floodplain (Figure 8). Some trees may have been cleared in the past by adjacent landowners. There was no aquatic vegetation, cobble, or gravel available for epifaunal substrate. There were several LWD jams present, but they were covered with silt. The silt was deep along the edges of the stream and where it had piled up behind LWD (Figure 9). The culvert was placed at an odd angle and seemed to be preventing adequate flow and transport of sediment downstream (Figure 10). The macroinvertebrate community scored poor (-5; Table 11 and Table 12). No stonefly taxa were found, and only two mayfly taxa (three individuals) and two caddisfly families (3 individuals) were found. Amphipods made up over 92 percent of the total individuals found.



Figure 8. Unnamed tributary to Little Platte Lake upstream of Saffron Road, Benzie County, Michigan.



Figure 9. Sedimentation in unnamed tributary to Little Platte Lake upstream of Saffron Road, Benzie County, Michigan.



Figure 10. Unnamed tributary to Little Platte Lake. View of misaligned culvert upstream of Saffron Road, Benzie County, Michigan.

At the downstream station (Station 5b), the stream continued to be very shallow with substrate consisting mostly of sand and silt (Figure 11 and Figure 12). The stream appeared a bit flashy (Figure 13). Sandbags were holding the road near the undersized culvert. The habitat at the glide pool station was rated good (117; Table 10). The macroinvertebrate community scored better than the upstream station at the low end of acceptable (-1; Table 11 and Table 12). Once again only two mayfly taxa were found with three individuals, but one stonefly and three caddisfly taxa were also found.



Figure 11. Unnamed tributary to Little Platte Lake downstream of Saffron Road, Benzie County, Michigan.



Figure 12. Sedimentation in Unnamed tributary to Little Platte Lake downstream of Saffron Road, Benzie County, Michigan.



Figure 13. Eroded banks in the unnamed tributary to Little Platte Lake downstream of Saffron Road, Benzie County, Michigan.

Platte River

The Platte River was sampled at two locations. The most upstream station was at Maple City Highway (Station 6). The riffle/run habitat was rated excellent (186; Table 10). The riparian habitat was a wetland area that had trees, shrubs, and herbaceous vegetation. There was a large amount of LWD submerged and available for colonization. The sand was stable and there were a large number of undercut banks and areas of overhanging vegetation. The macroinvertebrate community was rated at the high end of acceptable (4; Table 11 and Table 12). There was a large diversity of EPT taxa; however, there were also many oligochaetes and midge larvae (*Chironomidae*), which can be indicative of an environmental stressor such as sedimentation. In this case, it was likely the patches of silt trapped by wetland vegetation within the stream. There were also several *Physidae* snails found, thereby decreasing the score by another point.

The Platte River was also sampled at the El Dorado Park, Sleeping Bear National Park access point. The glide/pool habitat was rated excellent (158; Table 10). The riparian area on the far side of the river consisted of wetland rushes bordered by mature trees. The park-side riparian area was mature pine trees with very little understory. There was a lot of emergent vegetation on the edges. The epifaunal substrate was mostly sand with a very small amount of gravel and cobble near the kayak launch access point. Undercut banks and rootwads were available. LWD was present but lacking. LWD is very important for sand-dominated streams in northern Michigan. The macroinvertebrate community was rated as acceptable (-2; Table 11 and Table 12). The family diversity was lower than it was at the upstream site. Although EPT taxa were present, the percentage of the total numbers EPT found was lower than expected in a stream of its size located in the NCHF ecoregion. Midges made up 45 percent of the individuals found. A dominance of any one taxa indicate environmental stressors may be impacting the biological community.

Mason Creek

Mason Creek was sampled upstream (Station 8a) and downstream (Station 8b) of Duck Lake Road in anticipation of a planned road crossing replacement. The riffle/run habitat at Station 8a was rated good (138; Table 13). The riparian habitat upstream of the road was a forested wetland floodplain (Figure 14 and Figure 15). There was a lot of shifting sand with one deposit forming an island, but pool diversity was good and there was a lot of LWD for macroinvertebrates to colonize. Small amounts of aquatic macrophytes and gravel were also present, but the gravel was partially embedded and not readily available for colonization. The road crossing consisted of two small culverts, which were greatly undersized for the size of the stream. Upstream the culverts appeared to act as a dam, backing up water during high flow events. Even under the low flow conditions we observed, the culverts were half underwater. The banks were bare in spots as much as three feet above the surface of the water, and sediment deposits were evident. Downstream of the road crossing, the riffle/run habitat was rated as good (143; Table 13). The culverts were perched and a plunge pool that was much wider than the average width of the stream had formed (Figure 16). Further downstream remnants of an old dam were present (Figure 17). Upstream of the dam, gravel and riffle areas were abundant, but downstream of the dam was a deeper pool with a silt bottom (Figure 18). The riparian area has been greatly impacted by landowners and is often mowed to the edge. Duck Lake was visible from this site. The macroinvertebrate community was rated as acceptable both upstream and downstream of the road crossing (-1; Table 14 and Table 15). One additional mayfly family was found upstream, while two additional caddisfly were found downstream. A few more snails and surface air breathers were found downstream, but the numbers of EPT individuals increased downstream. Overall, a large difference in macroinvertebrate communities was not observed. It is anticipated that a lot of sediment will be moving through the system when the road crossing is replaced.



Figure 14. Sediment deposit in Mason Creek upstream of Duck Lake Road, Grand Traverse County, Michigan.



Figure 15. Mason Creek upstream of Duck Lake Road, Grand Traverse County, Michigan.



Figure 16. Mason Creek downstream of Duck Lake Road. Grand Traverse County, Michigan.



Figure 17. Dam remnants in Mason Creek downstream of Duck Lake Road, Grand Traverse County, Michigan.



Figure 18. Mason Creek downstream of Duck Lake Road, looking upstream, Grand Traverse County, Michigan.

Little Betsie River

The Little Betsie River was sampled at two stations. Station 9 was the most upstream station at Nessen Road. This site was visited due to the road crossing being replaced in 2014. It has been sampled in 2008, 2013, and 2018. The riffle/run habitat was rated excellent (156; Table 13). The riparian area was a mature cedar and tag alder community. There was not a lot of herbaceous vegetation due to the density of the trees and shrubs. The substrate consisted of mostly sand with one sand deposit forming an island in the stream. However, there was a lot of LWD available and pool diversity was good. The macroinvertebrate community was rated as acceptable (-1; Table 14 and Table 15). No stonefly taxa were found, which tend to be one of orders of aquatic insects that are most sensitive to environmental stressors; and the percentages of mayflies and caddisflies found were lower than what would be expected in a stream of this size in this ecoregion.

Station 10 was sampled 1.3 miles downstream in the Little Betsie River at Bentley Road. The riffle/run habitat was rated good (141; Table 13). This station is approximately 1.7 miles downstream of Nessen Road. The right side of the stream has a riparian area that is constrained to 10-20 feet in width due to Bentley Road running almost parallel to the stream. Large trees were not abundant. The substrate was primarily sand with some sparse gravel. A large sand deposit was noted at the upstream end of the sampling reach (Figure 19). Some LWD was available for colonization. The water temperature was 5 degrees Fahrenheit (F) warmer than the Nessen Road site. Reasons are not clear, but it is noted here for future reference. The macroinvertebrate community was rated as acceptable (-1; Table 14 and Table 15). No stoneflies were found and only 13 *Baetidae* made up the mayfly community. *Baetidae* can be tolerant of more conditions than many mayfly families. Six *Trichoptera* families were present. *Amphipoda* were dominant at 62 percent.



Figure 19. Little Betsie River upstream of Bentley Road, July 2018, Manistee County, Michigan. Note the shifting sand deposits.

Betsie River

Stations 11, 12, and 13 were sampled in the Betsie River at Nostwick, Reynolds, and off Old Grade Road, respectively. Both Stations 11 and 12 are in the upper portions of the watershed while Station 13 is in the mid portion of the watershed. The riffle/run habitat at Nostwick Road Station 11 was rated excellent (183; Table 16). The transect was started upstream of an old bridge (Figure 20). The riparian area was natural on the right and was a field and yard on the left. There was a lot of gravel and cobble, and a fair amount of LWD and in-stream vegetation. The water temperature was very warm at 79 degrees F. The Betsie River is impounded approximately two miles upstream of this station and likely impacts the river temperature. The macroinvertebrate community also was rated excellent (5; Table 17 and Table 18) with a large number of mayfly and caddisfly taxa but no stonefly. Overall diversity was very high as well at 32 taxa.



Figure 20. Betsie River upstream of Nostwick Road. July 2018, Manistee County, Michigan.

The glide/pool habitat 0.7 miles upstream at Reynolds Road (Station 12) was also rated excellent (156; Table 16). The river was wider and shallower at this station with less LWD and habitat diversity (Figure 21). There was a large amount of algae and more silt and the water temperature continued to be warm (80 degrees F). The macroinvertebrate community was rated acceptable (-1; Table 17 and Table 18). Fewer EPT taxa and less caddisfly density were found than when compared with the downstream Nostwick Road station.



Figure 21. Betsie River upstream of Reynolds Road, Benzie County, Michigan, July 2018.

The riffle/run habitat in the Betsie River off Old Grade Road (Station 13) was rated excellent (190; Table 16). This station has a mix of cobble, sand, and gravel substrate with good pool diversity and some LWD in the stream channel. The riparian was a nice floodplain area on both sides of the stream. Downstream of this station the banks become very steep on the left side. The macroinvertebrate community also was rated excellent (5; Table 17 and Table 18). Twelve EPT sensitive taxa and very few surface air breathers or snails, isopods, or leeches were found. With the Little Betsie River and groundwater inputs between Reynolds Road and this station, the water temperature was much cooler at 60 degrees F. The diversity of stoneflies and numbers of mayflies and caddisflies were a bit lower than expected, and the *Chironomidae* dominance was slightly higher than expected in a high-quality stream in this ecoregion.

Cold Creek

The north and south branches of Cold Creek were sampled at Stations 14 and 15. The north branch was sampled downstream of East Street (Figure 22). The glide/pool habitat scored marginal (86; Table 19). The water temperature was measured at 70 degrees F. The macroinvertebrate community was rated as poor (-6; Table 20 and Table 21). The coldwater fish community was meeting the coldwater fish designated use with 4% of salmonids being present (Table 22). However, the Central Mudminnow, a very tolerant species, made up almost half of all the individuals found. Additional details can be found in the Objectives 3 and 4 section below.



Figure 22. Cold Creek downstream of East Street. Note the lack of overhanging vegetation and lack of riparian cover to shade stream. Beulah, Michigan, July 2018.

The south branch was sampled at US-31. The channel was straight and uniform downstream of US-31 and likely historically channelized upstream of the road. The water temperature was much colder in this branch at 55 degrees F. The riffle/run habitat scored good (134; Table 19). The substrate was all sand but was somewhat firm. This branch lacked the high amount of silt that the north branch contained. Upstream of US-31 LWD and overhanging vegetation was more common and there was some channel diversity and pools available (Figure 23). The macroinvertebrate community was rated poor (-5; Table 20 and Table 21). The coldwater fish community was meeting the coldwater fish designated use with 62% of the individuals being salmonids (Table 22). Additional details can be found in the Objectives 3 and 4 section below.

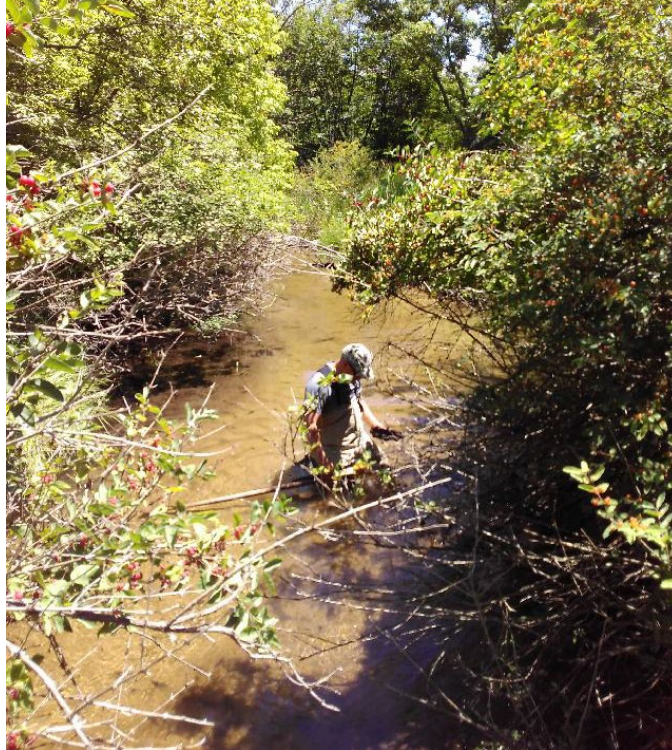


Figure 23. Cold Creek upstream of US-31. Note the overhanging vegetation and sandy substrate. Manistee County, Michigan, July 2018.

Bowens Creek

Bowens Creek was sampled downstream of Gilbert Road at Station 16. The glide/pool habitat scored good (146; Table 19). The riparian area was primarily wetland vegetation, with swamp milkweed, cedars, cattails, and willows (Figure 24). The temperature was very cold at 59 degrees F. The substrate was primarily shifting sand and silt, sinking up to two feet in places. There was no gravel or cobble, but some LWD was present and there were deep pools with lots of aquatic vegetation (*Elodea*) for substrate and cover. The macroinvertebrate community was rated at the low end of acceptable (-4; Table 20 and Table 21). There was only one mayfly taxa and the number of individuals was very low. There was one stonefly and four caddisfly taxa but again the numbers were low. The dominant taxa were midges at almost 60%. More discussion can be found in the Objectives 3 and 4 section below.



Figure 24. Bowens Creek downstream of Gilbert Road, Manistee County, Michigan, August 2018.

Objective 2: Evaluate biological integrity temporal trends.

Station 13 on the Betsie River at Old Grade Road was randomly selected as a trend station to determine statewide trends in biological attainment. This information cannot be summarized statistically until 2021, when enough data has been collected statewide to determine trends. Station 13 has been sampled every five years since 2008.

Looking over past habitat scores since 2008 (Table 23) it can be concluded that, in general, the habitat ratings at Station 13 have remained excellent and have varied only minimally. The macroinvertebrate community has scored acceptable (Table 24 and Table 25) and has varied from a low score of 1 in 2008 to a high score of 5 in 2018. Looking closer at the individual metrics, stonefly taxa found has varied from 0 in 2008, 2 in 2013, and 1 in 2018. Mayfly taxa has not varied but the percentage of Baetidae mayflies found in 2008 was markedly lower to that found in 2013 and 2018. Finally, the number of snails found has decreased over time. These changes in metrics do not indicate there has been a negative or positive change in water quality.

Objectives 3 and 4: Satisfy monitoring requests submitted by internal and external customers; and Identify NPS of water quality impairment.

PLATTE AND CRYSTAL RIVER WATERSHEDS

Platte and Crystal Rivers

The National Park Service requested repeated macroinvertebrate and habitat sampling that was also conducted in 2013 in the Platte River at Eldorado Park, and in the Crystal River downstream of Glen Lake, both within the Sleeping Bear Dunes National Lakeshore. The request is in response to concerns of impacts due to recreational use of both rivers for canoeing, kayaking, and tubing. It is estimated that an additional 400,000 people visited the park in 2017 compared to 2013. Although changes in macroinvertebrate community condition may not be detected with Procedure 51 scores alone, the monitoring will help the park establish a baseline condition of aquatic biodiversity and physical habitat quality that the resources program manager will use when trying to secure federal funding to establish a comprehensive, annual monitoring program as well as assist the park in knowing and documenting any potential resource degradation in a designated Outstanding State Resource Water. Members of a court-appointed committee (which includes EGLE staff) that manages the water level between Glen Lake and the Crystal River via a dam upstream of the sampling site also support this request.

Limited conclusions can be made when comparing the 2013 and 2018 data. The habitat data are collected primarily using guidance from Procedure 51 and best professional judgement, and it is a qualitative, not quantitative, method of habitat assessment. The macroinvertebrate community procedure is slightly more quantitative but is still based on a visual field-based count and identification only to family. SWAS staff observed the following:

Platte River at El Dorado Park

The habitat evaluation was based on glide/pool habitat metrics in 2018 but riffle/run metrics in 2013 (Table 26). This may be due to the slightly increased water depth observed in 2018. The habitat scores are fairly similar (178 in 2013 and 158 in 2018) with both years scoring excellent. There was a slight decrease in total score from 2013 to 2018, but it is impossible to determine if it is a significant change. The macroinvertebrate community was acceptable both years, but the score did decrease slightly from 2013 (1 to -2). One less mayfly family, a decrease in the percentage of caddisfly found, and a slight increase in the number of midge larvae found were observed (Table 27 and Table 28).

Crystal River

In 2013 the Crystal River was sampled downstream of Crystal View/County Road 675, which is in critical need of replacement. Currently, the three culverts do not allow sufficient flow resulting in sediment deposition and a very wide channel with a uniform stream bottom lacking pool habitat diversity upstream of the culverts (Figure 25 and Figure 26). This road crossing would be a great candidate for a road crossing replacement project.

To avoid the negative impact the culverts were having on the river at that location, in 2018, the Crystal River was sampled just upstream of the impact of the culverts but downstream of the water control structure near Fisher Road. When comparing the habitat data at the two locations, there was more sedimentation at the site impacted by the culverts and less epifaunal substrate (Table 26). The macroinvertebrate community scores between the two sites for the two years were nearly identical (-2 vs -1; Table 27 and Table 28). Looking closer at the metrics, the

Crystal View Road station in 2013 had fewer caddisfly taxa and numbers and a larger percentage of isopods, snails, and leeches, and a slightly larger percentage of air surface breathers when compared with the more downstream station near Fisher Road in 2018.



Figure 25. Road Crossing at County Road 675, Crystal River, Leelanau County, Michigan, July 2018.



Figure 26. Sand deposition and widening pool upstream of County Road 675, caused by water not flowing properly through the culvert. Crystal River, Leelanau County, Michigan, July 2018.

Unnamed Tributary (Brozofsky Creek) to Platte Lake

EGLE, WRD, groundwater permitting staff requested that surface water sampling be repeated in the unnamed tributary to Platte Lake, due to ongoing enforcement of measures to remediate the contaminated groundwater that is venting to the stream as described above under Objective 1. The responsible party conducts annual macroinvertebrate community, habitat, and water chemistry sampling and is currently operating an air-sparge system that injects oxygen into the groundwater with the hopes of accelerating the oxidation and thus preventing arsenic, iron, and other cations from being stripped from soil particles in the groundwater table (WRD, personal communication). In addition to the results reported here, there are additional quantitative biological sampling results and a comparison of 2013 with 2018 data, available in a separate report (Lipse, 2019). In 2018, both the impacted reach and control reach had acceptable macroinvertebrate communities (Table 11 and Table 12). Fish have not been sampled in either reach, but brook trout have been observed in the past in the control reach. The rock dams constructed in the impacted reach likely limit the upstream movement of fish. The DO WQS attainment status was not addressed in this study.

Although the macroinvertebrate community scored acceptable in the west branch of the unnamed tributary in 2018 and the amount of bacterial slimes has decreased since 2003 and even since 2013, the orange biofilm is still apparent, is not typical of small streams in the Platte River watershed, and is not found in the control reach that has been chosen as a comparison to background conditions. This combined with the exceedance of the arsenic WQS (Table 6) indicates the west branch of the unnamed tributary to Platte Lake is still not meeting Michigan WQS and has not returned to background conditions.

Further downstream the east branch of the unnamed tributary is known as Brozofsky Creek. A trout farm restoration project occurred in 2014 just upstream of Platte Lake Road, including a culvert replacement at the road crossing. In 2013 the macroinvertebrate score upstream of Platte Lake Road was -3, which is very low for the Platte River watershed. In 2018, we repeated the macroinvertebrate and habitat sampling at Station 4 to determine if the culvert and/or trout farm restoration had a positive effect on habitat availability and macroinvertebrate community health.

The glide/pool habitat was rated as good (150; Table 29). The stream gradient is very low and stream velocity is quite slow with a lot of sediment deposition (muck). The muck was not marked as sediment deposition because it was thought that although there was a lot of muck, it was not due to deposition, but to it being a natural characteristic due to the wetland nature of the stream downstream of US-31. A main channel was not often discernable because of the braided nature of the stream. Epifaunal substrate available for colonization included large amount of aquatic vegetation (watercress), undercut banks, and LWD. The stream channel has been altered downstream of the station as it flows along the side of the Platte Lake Road for a distance before crossing under it. The replacement of the culvert did not improve the flow of the stream as it is still inhibited by the road.

The macroinvertebrate community scored poor (-7; Table 30 and Table 31), which is a significant decrease from the 2013 acceptable score (-2). This lower score was due to a decrease in the number of taxa found. This included four fewer caddisfly taxa, which decreased the overall score. There continues to be a lack of stonefly taxa, a low density of caddisfly taxa, a high density of *Amphipoda*, and a slightly higher number of air surface breathers, which was not surprising due to the wetland-like nature of the stream. The sediment observed at this station may be a result of the restoration measures recently completed upstream. The sediment may

not have had enough time to move downstream out of the area. The sediment and wetland-like nature of the stream are most likely impacting the Procedure 51 score. In 2014 the undersized culvert at the road crossing was also replaced with a larger culvert. However, it is unclear if the culvert was also realigned to better align with the direction of natural stream flow. The stream emerges from the cedar forest and then flows east along the road for several yards until it can cross under the road at the culvert.

Unnamed Tributary to Little Platte Lake

The Conservation Resource Alliance is seeking funds to replace the undersized culvert at Saffron Road (Conservation Resource Alliance, personal communication). The road fill embankments are vertical, and the left approach is steep, causing runoff to enter directly into the stream. This is the only crossing on this stream since it flows through undeveloped land and the Medenbrook Nature Preserve before entering Little Platte Lake. A larger bottomless arch culvert and road approach work are tentatively planned for this site. Monitoring information may help justify funding of the replacement of this structure or provide information necessary for future grant projects or to measure success of those projects. In addition to macroinvertebrate community and habitat surveys, NPS unit staff may also be conducting channel dimension, pattern, and profile information. DO measurements were planned if the stream looked impounded. There was a pool upstream of the culvert; however, the stream was very small and shallow overall so DO readings were deemed not necessary or useful.

As noted in Objective 1, the macroinvertebrate community in the unnamed tributary to Little Platte Lake scored poor (-5; Table 11 and Table 12) upstream of Saffron Road and acceptable (-1; Table 11 and Table 12) downstream of the road. At both the upstream and downstream station the habitat scored good. However, upstream of the road, the culvert was observed at an odd angle and seemed to be preventing adequate flow and transport of sediment downstream (Figure 10). The stream continued to be very shallow downstream of the station with substrate consisting mostly of sand and silt (Figure 11 and Figure 12). The stream downstream of the station appeared a bit flashy (Figure 13). Sandbags were holding the road near the undersized culvert.

BETSIE RIVER WATERSHED

Mason Creek at East Duck Lake Road

The Conservation Resource Alliance and partners were scheduled to replace the undersized culvert at this crossing in 2019. Fish data are available for this stream from the MDNR (Conservation Resource Alliance, personal communication), but EGLE did not have any macroinvertebrate data to share and assist with pre-construction data collection. The habitat was rated good at both stations, and individual scores did not vary much with the exception of riparian zone width, sedimentation, and embeddedness being slightly worse upstream (Table 13). The macroinvertebrate community scores were the same (-1) upstream and downstream.

On May 30, 2019, NPS staff conducted a geomorphology survey of Mason Creek at East Duck Lake Road. Data collected included a longitudinal profile of approximately 430 feet and 5 cross sections. The longitudinal profile indicated about a 4.5-foot drop in elevation due to the perched culvert. The survey was conducted prior to replacement of the culvert, which took place in July 2019. The geomorphology data will be documented in a separate report. This data combined with the habitat and macroinvertebrate community data will be used as

pre-restoration data for a potential success story. Post-restoration data will need to be taken once conditions recover from construction activity.

Little Betsie River at Nessen Road

A narrow box structure was removed and replaced with single lane timber bridge and paved approaches in 2014 at this crossing. Habitat and macroinvertebrate community sampling was conducted in 2008, 2013, and 2018. Habitat ratings dropped from 2008 to 2013 and then rose in 2018, ranging from good to excellent ratings (Table 32). Sediment deposition and epifaunal substrate metrics have had the most change, worsening from 2008 to 2013 and then recovering in 2018. Macroinvertebrate community scores have remained acceptable and relatively unchanged (Table 33 and Table 34). The diversity of EPT taxa has really varied over the past ten years. In 2008 there was a larger diversity of taxa (31 compared with 21); however, the score has always been in the middle of the acceptable range. In 2018, three additional mayfly taxa were found when compared to 2013 and they were three different taxa than those found in 2008. The percentage of mayflies has decreased since 2008 and 2013, but the percentages of caddisfly are up. One stonefly taxa was found in 2013 and not 2018, but only two individuals were found in 2013; therefore, they may have been present but not detected in 2018. Sampling in 2013 and 2018 indicated a macroinvertebrate rating of acceptable with a score of 0 and very little epifaunal substrate due to sedimentation. A score of 0 in the Betsie River watershed is unusually low.

Cold Creek Tributaries (Village of Beulah)

The last and only biosurvey conducted in this watershed was in 2003 downstream of where the north and south branches join. It was rated at the low end of acceptable (-4). A local watershed group is seeking funding for Best Management Practices (BMP) to address sediment, *E. coli*, and nutrient impacts caused by storm water in Cold Creek. In 2018, fish, macroinvertebrate, and habitat data were collected that may later be used as pre-data for BMP implementation.

The first station sampled was the north branch of Cold Creek downstream of East Street. Monitoring could not be conducted upstream because there was not much distance available for sampling prior to the US-31 road crossing. The glide/pool habitat scored marginal (86; Table 19). The creek is a straight channel that runs along a mowed field that is adjacent to US-31. The substrate was a silt and sand mix (Figure 27). The muck was at least 2 feet deep in areas. Aquatic vegetation, sparse rootwads, and undercut banks was the only colonizable substrate available. The water temperature was very warm for a coldwater stream at 70 degrees F. The macroinvertebrate community was rated as poor (-6; Table 20 and Table 21). A low diversity of taxa, a lack of EPT taxa, and the dominance of isopods are all indicators of poor habitat and/or water quality conditions. Sedimentation likely contributes as a cause of nonattainment of the OIALW designated use. It was not clear if the channel is maintained as a county drain. The coldwater fish community was meeting the coldwater fish designated use with four percent of salmonids being present (Table 22). However, the Central Mudminnow, a very tolerant species, made up almost half of all the individuals found.



Figure 27. Silt covering vegetation in Cold Creek downstream of East Street, Benzie County, Michigan, July 2018.

The south branch was sampled at US-31. The channel was straight and uniform downstream of US-31 and historically channelized upstream of the road. The water temperature was much colder in this branch at 55 degrees F. The riffle/run habitat scored good (134; Table 19). The substrate was all sand but was somewhat firm and there was some channel diversity and pools upstream of US-31. There was a large amount of LWD and some overhanging vegetation and watercress for macroinvertebrate colonization. The riffles were made up primarily of LWD. The macroinvertebrate community was rated poor (-5; Table 20 and Table 21). Twenty-two taxa were found, with seven EPT taxa, including one stonefly family. However, the percentages of EPT taxa found was low and midges made up 44 percent of the individuals found with abundant isopods. Although the macroinvertebrate community was somewhat better when compared to the north branch, it still scored poor.

Due to the obvious impacts that silt seems to be having on biotic communities in the north branch of Cold Creek, and the observation of silt funneling out into Crystal Lake during rain events (Figure 28), Cold Creek will likely be listed as not attaining the OIALW designated use in 2020. It is less clear in the south branch what may be causing the poor macroinvertebrate community. It most likely is also related to siltation and possibly storm water draining to the watershed due to the proximity of the stream to roads and other urbanized areas.

E. coli samples were collected for 5 weeks in both the north, south, and middle branches of Cold Creek. The daily total body contact WQS was exceeded for most of the sampling dates. Details of this sampling can be found in the [2018 *E. coli* monitoring report](#) (Rippke, 2019a). Cold Creek was already on the Section 303(d) nonattainment list for exceedance of the total body contact WQS.



Figure 28. Cold Creek confluence with Crystal Lake during a rain event, October 2018, Beulah, Michigan.

ARCADIA LAKE WATERSHED (BOWENS CREEK) AND HERRING CREEK WATERSHED

Bowens Creek

Bowens Creek is a third order stream located in Manistee County near Arcadia, Michigan. The lower section of Bowens Creek watershed is part of a unique and diverse ecosystem defined as Great Lakes coastal wetland. Below St. Pierre Road, Bowens Creek flows approximately 1.2 miles through Arcadia Marsh into Arcadia Lake and eventually into Lake Michigan (Little River Band of Ottawa Indians, 2013). In 2013, the lower portion of Bowens Creek was redirected into its original watercourse by plugging five diversion ditches. The Little River Band of Ottawa Indians did some macroinvertebrate sampling and their report indicates that designated use attainment should be assessed again in the restored channel because they obtained a -5 (poor) Procedure 51 score in 2013 downstream of St. Pierre Road; however, the stream had not yet recovered from restoration activities. They have sampled the stream for fish since the restoration but have not collected additional macroinvertebrate information.

The 2018 sampling plan included determining the OIALW designated use support in the lower reaches of Bowens Creek. One survey was conducted downstream of the restored section and one at St. Pierre Road upstream of the restored section. However, it was not possible to sample downstream of the restored section using Procedure 51 because it is a wetland/lake area and not a wadable stream (Figure 29). At St. Pierre Road, the stream was also too deep for Procedure 51 sampling. Therefore, we sampled Bowens Creek downstream of Gilbert Road (Station 16), which is about .7 miles upstream of St. Pierre Road.



Figure 29. Arcadia Marsh upstream of Northwood Highway, downstream of restored area. Arcadia, Michigan, July 2018.

As noted under Objective 1, the glide/pool habitat scored good (146; Table 19). The riparian area was primarily wetland vegetation, with swamp milkweed, cedars, cattails, and willows. The temperature was very cold at 59 degrees F. The substrate was primarily shifting sand and silt, sinking up to 2 feet in places (Figure 30). This back-up of sediment may be, in part, due to the undersized culverts found at both the St. Pierre Road and Gilbert Road crossings (Figure 31). At Gilbert Road, there was no gravel or cobble, but some LWD was present and there were deep pools with lots of elodea aquatic vegetation for substrate and cover.

The macroinvertebrate community was rated at the low end of acceptable (-4; Table 20 and Table 21). Although this is a one-point positive change from the 2013 score calculated by the Little River Band of Ottawa Indians, it is not enough to be interpreted as an improvement. There was only one mayfly taxa and the number of individuals was also very low. There was one stonefly and four caddisfly taxa but again the numbers were low. The dominant taxa was midges at almost 60 percent.

The Little River Band of Ottawa Indians data from Bowens Creek at St. Pierre Road were not available; however, Bowens Creek was sampled by the SWAS in 2013, 1.75 miles further upstream off Iverson Road. The riffle/run habitat rated good (139; Table 35). Shifting sand dominated the substrate and was as deep as 1.5 feet in places. Leaf packs, undercut banks, and LWD were available for biota. The LWD made the “riffles” in the reach, as the stream was very narrow and shallow. The macroinvertebrate community scored at excellent (6; Table 36 and Table 37). Two families of stonefly were present with one family (*Nemouridae*) being the third most abundant family.



Figure 30. Sediment in Bowens Creek downstream of Gilbert Road, Manistee County, Michigan, July 2018.



Figure 31. Undersized Culvert and widening of stream channel downstream of Gilbert Road, Bowens Creek, Manistee County, Michigan, August 2018.

Herring Creek Watershed

SWAS staff drove through the upper portions of the Herring Creek watershed to observe and record impacts of unrestricted livestock access to tributaries of Herring Creek. Several cattle were observed in 2013 and have been reported by EGLE staff upstream at Putnam Road since 2003. *E. coli* has been sampled with elevated conditions noted by the Benzie County Conservation District. EGLE sampled a tributary to Herring Creek at Gorivan Road, five times in 2018, and all five samples exceeded the total body contact WQS. Details of these sampling results are available in the [2018 *E. coli* monitoring report](#) (Rippke, 2019a).

Overall the stream and riparian habitat conditions along Putney and Gorivan Roads seemed slightly improved since last observed in 2013. Although the vegetation is still actively grazed (Figure 32), the ground was not bare dirt in as many places as was observed in 2013. However, an alternate water source and exclusion of livestock should be considered to remove the potential pathogens and increased sediment entering the stream and downstream water bodies.



Figure 32. Herring Creek upstream of Putney Road. Image shows the livestock water access area.

Conclusions and Future Monitoring Recommendations

In 2018 aquatic macroinvertebrate or fish community and habitat assessments were conducted at a total of 19 stations in the Betsie, Platte, and Crystal Rivers, and Herring and Bowens Creek watersheds. The OIALW designated use was being met at 14 of 18 stations. Four stations had macroinvertebrate communities that scored poor, including the unnamed tributary to Platte Lake upstream of Platte Lake Road, the unnamed tributary to Little Platte Lake upstream of Saffron Road, and both the north and south branches of Cold Creek. Tributaries to Herring Creek were not assessed for the OIALW designated use, but evidence of livestock access was observed, and *E. coli* samples collected indicated that the total body contact WQS was being exceeded (Rippke, 2019a).

Two stations in the Betsie River had macroinvertebrate communities that were rated excellent. The remaining 12 stations had macroinvertebrate communities that were rated acceptable and 11 of these 12 stations had ratings in the low (-1 to -4) acceptable range. This contrasts with most stations scoring high acceptable in 2013 and 2014. One possible reason for this is that in 2018 there was a large number of stations sampled in response to targeted monitoring requests for streams where BMPs were planned or were completed. Therefore, it would be expected that macroinvertebrate community ratings would be low due to habitat stressors that were present at one time at that station and perhaps have not yet fully recovered. Another possible reason is that environmental stressors may be increasing or having a cumulative effect.

Sediment impacts aquatic life by covering up natural substrates needed for survival or spawning, damaging gills needed to breath, and carries other pollutants such as nutrients to the stream. Sedimentation is often caused by runoff and soil erosion from crop lands, storm water runoff from urban areas, and construction in developing areas. Sediment deposits and sedimentation impacts have been observed throughout the Betsie, Platte, and Crystal Rivers, and Herring and Bowens Creek watersheds in the past and continued to be observed in 2018. Efforts to reduce sedimentation through protection, restoration, and conservation practices should continue in these watersheds.

As noted earlier in this report, *E. coli* data collected in Herring and Cold Creeks indicate levels are exceeding the total body contact recreation WQS. Cold Creek is already on the Section 303(d) nonattainment list. When a watershed is put on the nonattainment list due to pathogen exceedances, the [Statewide *E. coli* Total Maximum Daily Load](#) applies (Rippke, 2019b). A Total Maximum Daily Load is a document that describes the process used to set pollutant loads for a water body not meeting WQS. Pollutant load reductions from sources in the watershed are implemented through existing programs such as permits, through voluntary programs, and the work of local stakeholders. More information regarding water bodies that are impaired can be found in [the 2016 Sections 303\(d\), 305\(b\), and 314 Integrated Report](#) (MDEQ, 2016).

Between now and 2023, the following recommendations should be considered as resources allow:

- 1) The culverts at the Crystal River at the Crystal View Road/County Road 675 road crossing are in critical need of replacement. Currently, the three culverts do not allow enough flow resulting in sediment deposition and a very wide channel with a uniform stream bottom that lacks the pool habitat diversity found upstream near Fisher Road.

- 2) The macroinvertebrate community in the unnamed tributary to Platte Lake at Platte Lake Road scored poor and is likely being impacted by the amount of sediment present at that location. This could be the result of restoration measures that took place just upstream of this location in 2014, when abandoned trout farm ponds that were connected to the creek were removed and the area restored to a functioning wetland area (Conservation Resource Alliance, 2019). It may be that sediment had not yet had time to be fully flushed from the stream. In 2014 the undersized culvert at the road crossing was also replaced with a larger culvert. However, it is unclear if the culvert was positioned to better align with the direction of natural stream flow. The stream emerges from the cedar forest and then flows east along the road for several yards until it can cross almost perpendicularly under the road at the culvert. This station should be revisited during the next monitoring cycle to determine if the macroinvertebrate community has improved with time. In the future, if technically and monetarily feasible, a better aligned culvert or free-span bridge may allow for water and sediment to flow more efficiently under the road.
- 3) The macroinvertebrate community in the unnamed tributary to Little Platte Lake upstream of Saffron Road scored poor and may be impacted by the undersized and misaligned culvert. This data may be used to support funding for a road crossing improvement at this location.
- 4) In the future, the west branch of the unnamed tributary to Platte Lake upstream of US-31 should continue to be monitored as the stream continues to recover from the illicit waste groundwater contamination. Although the stream is meeting WQS for the OIALW designated use based on macroinvertebrate community, it is not attaining the Arsenic WQS and it is unknown if the DO WQS is being met. To be sure that conditions have returned to what is natural, a quantitative comparison of the macroinvertebrate community in the west branch and east branch should be considered.
- 5) The Little Betsie River at Nessen Road could be revisited to see if habitat and macroinvertebrate community scores continue to rise. Although the macroinvertebrate community is rated acceptable, a score of 0 is somewhat lower than expected for the Betsie River watershed. A 15-year time period with four separate surveys would be a unique data set.
- 6) The habitat, macroinvertebrate community, and stream profile in Mason Creek at Duck Lake Road could be reevaluated in 2023 to determine if construction of the free-span bridge and replacement of ineffective and undersized culverts and resultant plunge pool results in an improvement in the habitat rating and macroinvertebrate score. It is expected that the sifting sand may begin to mobilize downstream and perhaps other epifaunal substrate like gravel will increase, thereby improving the current macroinvertebrate community.
- 7) The macroinvertebrate community in both the north and south branches of Cold Creek are not meeting the OIALW designated use. Although the coldwater fisheries designated use is being met in both branches, the numbers of salmonids found in the north branch (4 percent) is markedly lower than those found in the south branch (62 percent). Several juvenile Coho salmon were captured. Crystal Lake is unique in that it has the only known "landlocked" population of Coho salmon in the Great Lakes and is naturally reproducing (Tonello, 2016). The MDNR in the same report recommends that Cold Creek should be protected from uncontrolled development and land use practices, and they support

restoring habitat in the watershed. The data reported here supports the conclusion that habitat restoration (improvement of riparian and in-stream habitat, restoration of natural stream patterns, and reduction of sediment and other point source and NPS inputs) in the Cold Creek watershed would be beneficial to the biological communities. The Betsie River/Crystal Lake Watershed Management Plan addresses some possible plans for future work in this watershed (Betsie River/Crystal Lake Watershed Management Plan Steering Committee, 2016).

- 8) Bowens Creek at Gilbert Road should be monitored again in 2023 to determine if the macroinvertebrate community score improves with time, post-restoration. In addition, the undersized culverts at both Gilbert Road and St. Pierre Road should be considered as candidates for future road crossing improvements to allow sediment load movement downstream. Due to the high quality of the stream found further upstream in 2013, we recommend that the stream be considered as a possible priority for protection in this watershed considering the relatively high percentage of agricultural land use (20 percent) and lost wetlands (9 percent) for this area of the state (Lipsey, 2014).
- 9) Herring Creek is being impacted by livestock access to tributaries of the creek near Putney Road. *E. coli* samples indicated WQS are being exceeded. Right-to-Farm staff should be contacted to see if an alternate water source or other BMP could be found to reduce or eliminate sources of sedimentation and *E. coli* to this stream.
- 10) Throughout both the Betsie River and Platte River watersheds, BMPs that reduce sediment and increase habitat diversity and epifaunal substrate should be encouraged. If BMPs noted in either watershed management plan are to be implemented (including road crossing replacements) and it is a priority for NPS staff to show possible success, pre- and post-implementation surveys may be conducted.

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Table 7. Habitat evaluation for the Crystal River upstream of dam at Fisher Road, and three stations in the unnamed tributary to Platte Lake, Leelanau and Benzie Counties, Michigan, June, July, and September 2018.

	Station 1	Station 2	Station 3	Station 4
	Crystal River off Fisher Road upstream of Dam	Unnamed Tributary to Platte Lake - East Branch at US-31	Unnamed Tributary to Platte Lake- West Branch at US-31	Unnamed Tributary to Platte Lake at Platte Lake Road
Date	6/27/18	9/13/18	9/13/18	7/17/18
HABITAT METRICS	RIFFLE/RUN	RIFFLE/RUN	RIFFLE/RUN	GLIDE/POOL
Substrate and Instream Cover				
Epifaunal Substrate/ Available Cover (20)	18	15	14	11
Embeddedness (20)* ¹	16	20	11	na
Velocity/Depth Regime (20)* ¹	17	15	16	na
Pool Substrate Characterization (20)** ²	na	na	na	13
Pool Variability (20)** ²	na	na	na	10
Channel Morphology				
Sediment Deposition (20)	13	17	13	10
Flow Status -Maintenance Flow Volume (10)	9	9	9	10
Flow Status -Flashiness (10)	10	10	8	10
Channel Alteration (20)	19	18	16	13
Frequency of Riffles/Bends (20)* ¹	19	20	20	na
Channel Sinuosity (20)** ²	na	na	na	17
Riparian and Bank Structure				
Bank Stability (L) (10)	10	10	8	10
Bank Stability (R) (10)	10	10	8	10
Vegetative Protection (L) (10)	8	6	6	10
Vegetative Protection (R) (10)	8	7	6	10
Riparian Vegetative Zone Width (L) (10)	10	6	9	8
Riparian Vegetative Zone Width (R) (10)	10	7	8	10
TOTAL SCORE (200):	177	170	152	150
HABITAT RATING:	EXCELLENT	EXCELLENT	GOOD	GOOD
Weather:	partly cloudy	sunny	sunny	partly cloudy
Air Temperature: °F	75	60	70	75
Water Temperature: °F	75	49	53	62
Average Stream Width: Feet	45	3.27	4.27	10
Average Stream Depth: Feet	1.5	0.27	0.22	0.5
Surface Velocity: Feet/Second	2	2	1	1
Estimated Flow: Cubic Feet/Second	95	1	1	2
Stream Modifications:	impounded	none	misaligned	none
Nuisance Plants (Yes/No):	N	N	Y	N
STORET No.:	450240	100188	100240	100248
County Code:	45	10	10	10
Town Range Section:	29N14W24	26N14W07	26N14W07	26N14W07
Latitude (dd):	-85.95664	44.66214	44.6638	44.66783
Longitude (dd):	44.899496	-86.04966	-86.0542	-86.05007
Ecoregion:	NCHF	NCHF	NCHF	NCHF

¹ * Applies only to Riffle/Run stream Surveys
² ** Applies only to Glide/Pool stream Surveys
NA = Not Applicable
L=Left
R=Right

Table 8. Qualitative macroinvertebrate community sampling results for the Crystal River upstream of dam at Fisher Road, and three stations in the unnamed tributary to Platte Lake, Leelanau and Benzie Counties, Michigan, June, July, and September 2018.

	Station 1 Crystal River off Fisher Road upstream of Dam	Station 2 Unnamed Tributary to Platte Lake - East Branch at US-31	Station 3 Unnamed Tributary to Platte Lake-West Branch at US-31	Station 4 Unnamed Tributary to Platte Lake at Platte Lake Road
Taxa	6/27/18	9/13/18	9/13/18	7/17/18
PLATYHELMINTHES (flatworms)				
Turbellaria	1			
NEMATOMORPHA (roundworms)			1	
ANNELIDA (segmented worms)				
Oligochaeta (worms)	3	2	2	2
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	10	210	180	113
Decapoda (crayfish)	3			
Isopoda (sowbugs)	6	5	5	20
Arachnoidea				
Hydracarina		2		
INSECTA				
Ephemeroptera (mayflies)				
Baetidae	2	19	6	9
Heptageniidae	6			
Odonata				
Anisoptera (dragonflies)				
Aeshnidae	1			12
Cordulegastridae			1	2
Gomphidae	1			
Zygoptera (damselflies)				
Calopterygidae				1
Coenagrionidae	1			
Plecoptera (stoneflies)				
Nemouridae		41	64	
Perlidae	11			
Hemiptera (true bugs)				
Gerridae	5		1	4
Mesoveliidae			1	3
Trichoptera (caddisflies)				
Hydropsychidae	46	1	4	3
Lepidostomatidae	1	1	1	4
Leptoceridae	3			
Limnephilidae	1			16
Philopotamidae				1
Polycentropodidae	1			
Rhyacophilidae		4	1	
Uenoidae		2	1	
Coleoptera (beetles)				
Dytiscidae (total)			1	
Hydrophilidae (total)		2	1	
Dryopidae		1		
Elmidae	5	1	2	
Gyrinidae (larvae)	2			

Taxa	Station 1 Crystal River off Fisher Road upstream of Dam	Station 2 Unnamed Tributary to Platte Lake - East Branch at US-31	Station 3 Unnamed Tributary to Platte Lake-West Branch at US-31	Station 4 Unnamed Tributary to Platte Lake at Platte Lake Road
	6/27/18	9/13/18	9/13/18	7/17/18
Diptera (flies)				
Ceratopogonidae	1			1
Chironomidae	50	13	3	37
Dixidae			1	1
Simuliidae	181	11	9	21
Tipulidae	1	1	2	
MOLLUSCA				
Gastropoda (snails)				
Ancylidae (limpets)			1	1
Hydrobiidae	3			
Physidae	1	1		3
Planorbidae		3	4	1
Pelecypoda (bivalves)				
Dreissenidae	1			
Pisidiidae				2
Total Individuals	347	320	292	257

Table 9. Macroinvertebrate metric evaluation for the Crystal River upstream of dam at Fisher Road, and three stations in the unnamed tributary to Platte Lake, Leelanau and Benzie Counties, Michigan, June, July, and September 2018.

METRIC	Station 1 Crystal River off Fisher Road upstream of Dam		Station 2 Unnamed Tributary to Platte Lake - East Branch at US-31		Station 3 Unnamed Tributary to Platte Lake- West Branch at US-31		Station 4 Unnamed Tributary to Platte Lake at Platte Lake Road	
	6/27/18		9/13/18		9/13/18		7/17/18	
	Value	Score	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	26	1	18	1	23	1	21	0
NUMBER OF MAYFLY TAXA	2	0	1	0	1	0	1	-1
NUMBER OF CADDISFLY TAXA	5	0	4	1	4	1	4	0
NUMBER OF STONEFLY TAXA	1	0	1	0	1	0	0	-1
PERCENT MAYFLY COMPOSITION	2.31	-1	5.94	-1	2.05	-1	3.5	-1
PERCENT CADDISFLY COMPOSITION	14.99	0	2.50	-1	2.40	-1	9.34	-1
PERCENT DOMINANT TAXON	52.16	-1	65.63	-1	61.64	-1	43.97	-1
PERCENT ISOPOD, SNAIL, LEECH	2.88	-1	2.81	-1	3.42	-1	9.73	-1
PERCENT SURFACE AIR BREATHERS	1.44	0	0.63	1	1.37	0	2.72	-1
TOTAL SCORE		-2		-1		-2		-7
MACROINVERTEBRATE COMMUNITY RATING	ACCEPTABLE		ACCEPTABLE		ACCEPTABLE		POOR	

Table 10. Habitat evaluations for an unnamed tributary to Little Platte Lake, and the Platte River at two locations in Benzie County, Michigan, June, July, and August 2018.

	Station 5a Unnamed Tributary to Little Platte Lake upstream of Saffron Road	Station 5b Unnamed Tributary to Little Platte Lake downstream of Saffron Road	Station 6 Platte River at Maple City Highway	Station 7 Platte River at El Dorado Park
Date	8/2/18	8/2/18	7/19/18	6/28/18
HABITAT METRICS	GLIDE/POOL	RIFFLE/RUN	RIFFLE/RUN	GLIDE/POOL
Substrate and Instream Cover				
Epifaunal Substrate/ Available Cover (20)	5	8	18	12
Embeddedness (20)* ¹	NA	8	15	NA
Velocity/Depth Regime (20)* ¹	NA	10	20	NA
Pool Substrate Characterization (20)** ²	7	NA	NA	10
Pool Variability (20)** ²	3	NA	NA	13
Channel Morphology				
Sediment Deposition (20)	3	5	15	11
Flow Status -Maintenance Flow Volume (10)	6	8	10	10
Flow Status -Flashiness (10)	6	6	10	10
Channel Alteration (20)	19	19	20	18
Frequency of Riffles/Bends (20)* ¹	NA	14	18	
Channel Sinuosity (20)** ²	15	NA	NA	19
Riparian and Bank Structure				
Bank Stability (L) (10)	10	5	10	10
Bank Stability (R) (10)	10	5	10	10
Vegetative Protection (L) (10)	9	8	10	8
Vegetative Protection (R) (10)	9	8	10	8
Riparian Vegetative Zone Width (L) (10)	10	8	10	10
Riparian Vegetative Zone Width (R) (10)	10	5	10	9
TOTAL SCORE (200):	122	117	186	158
HABITAT RATING:	GOOD	GOOD	EXCELLENT	EXCELLENT
Weather:	cloudy	sunny	partly cloudy	sunny
Air Temperature: °F	67	77	68	70
Water Temperature: °F	51	62	66	70
Average Stream Width: Feet	9	6	40	80
Average Stream Depth: Feet	2	0.25	1	2.5
Surface Velocity: Feet/Second	1	0	2	1
Estimated Flow: Cubic Feet/Second	1	1	69	191
Stream Modifications:	none	none	none	none
Nuisance Plants (Yes/No):	N	N	N	N
STORET No.:	100265	100266	100264	100251
County Code:	10	10	10	10
Town Range Section:	27N14W30	27N14W30	26N13W6	27N15W20
Latitude (dd):	44.7114	44.7114	44.68143	44.72649
Longitude (dd):	-86.05064	-86.05064	-85.92227	-86.14364
Ecoregion:	NCHF	NCHF	NCHF	NCHF

Table 11. Qualitative macroinvertebrate community sampling results for an unnamed tributary to Little Platte Lake, and the Platte River at two locations in Benzie County, Michigan, June, July, and August 2018.

Taxa	Station 5a Unnamed Tributary to Little Platte Lake upstream of Saffron Road	Station 5b Unnamed Tributary to Little Platte Lake downstream of Saffron Road	Station 6 Platte River at Maple City Highway	Station 7 Platte River at El Dorado Park
	8/2/18	8/2/18	7/19/18	6/28/18
ANNELIDA (segmented worms)				
Hirudinea (leeches)		1		1
Oligochaeta (worms)		2	48	4
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	256	215	17	34
Isopoda (sowbugs)	6	2	1	
Decapoda			1	9
Arachnoidea				
Hydracarina			3	32
INSECTA				
Ephemeroptera (mayflies)				
Baetidae	1	2	25	2
Caenidae				5
Ephemerellidae			13	
Heptageniidae			15	1
Isonychiidae			3	
Leptophlebiidae	2	1	1	
Tricorythidae			7	11
Odonata				
Anisoptera (dragonflies)				
Aeshnidae			1	4
Gomphidae			1	5
Zygoptera (damselflies)				
Calopterygidae			2	1
Coenagrionidae			2	8
Plecoptera (stoneflies)				
Perlidae		1	1	3
Hemiptera (true bugs)				
Corixidae				1
Gerridae			1	
Mesoveliidae		1	1	
Notonectidae		1		
Megaloptera				
Corydalidae (dobson flies)			5	
Sialidae (alder flies)		1		
Trichoptera (caddisflies)				
Brachycentridae			2	
Glossosomatidae			1	
Helicopsychidae			14	
Hydropsychidae			43	
Hydroptilidae		1		
Leptoceridae			3	6
Lepidostomatidae		1	1	1
Limnephilidae	2	26		
Molannidae	1			

Taxa	Station 5a Unnamed Tributary to Little Platte Lake upstream of Saffron Road	Station 5b Unnamed Tributary to Little Platte Lake downstream of Saffron Road	Station 6 Platte River at Maple City Highway	Station 7 Platte River at El Dorado Park
	8/2/18	8/2/18	7/19/18	6/28/18
Philopotamidae			3	
Polycentropodidae				3
Lepidoptera (moths)				
Pyrilidae			1	
Coleoptera (beetles)				
Gyrinidae (adults)				
Hydrophilidae (total)		2		
Elmidae			16	6
Diptera (flies)				
Athericidae			1	
Ceratopogonidae	1	1		
Chironomidae	6	7	61	123
Simuliidae			15	
Tipulidae	1	5	3	
MOLLUSCA				
Gastropoda (snails)				
Ancylidae (limpets)			3	
Bithyniidae			4	
Hydrobiidae				2
Physidae	1	1	18	2
Pelecypoda (bivalves)				
Dreissenidae			7	1
Pisidiidae				3
Unionidae (mussels)				1
Total Individuals	277	271	344	269

Table 12. Macroinvertebrate metric evaluation for an unnamed tributary to Little Platte Lake, and the Platte River at two locations in Benzie County, Michigan, June, July, and August 2018.

METRIC	Station 5a Unnamed Tributary to Little Platte Lake upstream of Saffron Road		Station 5b Unnamed Tributary to Little Platte Lake downstream of Saffron Road		Station 6 Platte River at Maple City Highway		Station 7 Platte River at El Dorado Park	
	8/2/18		8/2/18		6/28/19		6/28/19	
	Value	Score	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	10	-1	18	1	36	1	25	1
NUMBER OF MAYFLY TAXA	2	0	2	0	6	1	4	0
NUMBER OF CADDISFLY TAXA	2	0	3	0	7	1	3	0
NUMBER OF STONEFLY TAXA	0	-1	1	0	1	0	1	0
PERCENT MAYFLY COMPOSITION	1.08	-1	1.11	-1	18.6	0	7.06	-1
PERCENT CADDISFLY COMPOSITION	1.08	-1	10.33	0	19.48	0	3.72	-1
PERCENT DOMINANT TAXON	92.42	-1	79.34	-1	17.73	1	45.72	-1
PERCENT ISOPOD, SNAIL, LEECH	2.53	-1	1.48	0	7.56	-1	5.20	-1
PERCENT SURFACE AIR BREATHERS	0.00	1	1.48	0	0.58	1	0.37	1
TOTAL SCORE		-5		-1		4		-2
MACROINVERTEBRATE COMMUNITY RATING	POOR		ACCEPTABLE		ACCEPTABLE		ACCEPTABLE	

Table 13. Habitat evaluations for stations in Mason Creek and the Little Betsie River, Grand Traverse and Benzie Counties, Michigan, July and August 2018.

	Station 8a Mason Creek upstream East Duck Lake Road	Station 8b Mason Creek downstream East Duck Lake Road	Station 9 Little Betsie River at Nessen Road	Station 10 Little Betsie River at Bentley Road
	Date 8/2/18	8/2/18	7/17/18	7/17/18
HABITAT METRICS	RIFFLE/RUN	RIFFLE/RUN	RIFFLE/RUN	RIFFLE/RUN
Substrate and Instream Cover				
Epifaunal Substrate/ Available Cover (20)	10	15	8	8
Embeddedness (20)* ¹	7	16	11	8
Velocity/Depth Regime (20)* ¹	18	13	13	13
Pool Substrate Characterization (20)** ²	NA	NA	NA	NA
Pool Variability (20)** ²	NA	NA	NA	NA
Channel Morphology				
Sediment Deposition (20)	12	16	6	6
Flow Status -Maintenance Flow Volume (10)	10	10	10	10
Flow Status -Flashiness (10)	6	10	10	10
Channel Alteration (20)	18	10	19	18
Frequency of Riffles/Bends (20)* ¹	8	13	19	17
Channel Sinuosity (20)** ²	NA	NA	NA	NA
Riparian and Bank Structure				
Bank Stability (L) (10)	7	9	10	10
Bank Stability (R) (10)	6	8	10	10
Vegetative Protection (L) (10)	8	6	10	9
Vegetative Protection (R) (10)	8	5	10	8
Riparian Vegetative Zone Width (L) (10)	10	7	10	10
Riparian Vegetative Zone Width (R) (10)	10	5	10	4
TOTAL SCORE (200):	138	143	156	141
HABITAT RATING:	GOOD	GOOD	EXCELLENT	GOOD
Weather:	Partly cloudy	cloudy	Partly cloudy	Partly cloudy
Air Temperature: °F	75	70	70	73
Water Temperature: °F	59	56	58	63
Average Stream Width: Feet	12	11	20	22
Average Stream Depth: Feet	1	1	1	0.5
Surface Velocity: Feet/Second	0	1	1	1
Estimated Flow: Cubic Feet/Second	4	7	20	12
Stream Modifications:	none	Canopy removal, bank stabilization	none	none
Nuisance Plants (Yes/No):	N	N	N	N
STORET No.:	280440	280441	100242	100162
County Code:	28	28	10	10
Town Range Section:	26N12W23	26N12W23	25N13W27	25N13W29
Latitude (dd):	44.63095	44.63095	44.5331	44.535
Longitude (dd):	-85.72151	-85.72151	-85.8782	-85.90861
Ecoregion:	NCHF	NCHF	NCHF	NCHF

Table 14. Qualitative macroinvertebrate community sampling results for Mason Creek and the Little Betsie River, Grand Traverse and Benzie Counties, Michigan, July and August 2018.

Taxa	Station 8a Mason Creek upstream East Duck Lake Road	Station 8b Mason Creek downstream East Duck Lake Road	Station 9 Little Betsie River at Nessen Road	Station 10 Little Betsie River at Bentley Road
	8/2/18	8/2/18	7/17/18	7/17/18
ANNELIDA (segmented worms)				
Oligochaeta (worms)	3	4		1
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	172	123	112	165
Decapoda (crayfish)	1	1		
Arachnoidea				
Hydracarina		1	1	2
INSECTA				
Ephemeroptera (mayflies)				
Baetidae	3	25	55	13
Ephemeridae	1		1	
Heptageniidae	4	8	1	
Leptophlebiidae	1	1		
Odonata				
Anisoptera (dragonflies)				
Aeshnidae	2	4		1
Cordulegastridae	1	1		1
Zygoptera (damselflies)				
Calopterygidae	6	14		2
Plecoptera (stoneflies)				
Perlidae	4	5		
Hemiptera (true bugs)				
Corixidae		1		
Gerridae	1	3	1	1
Notonectidae	1	1		
Megaloptera				
Corydalidae (dobson flies)	6	4	1	1
Sialidae (alder flies)	1		1	1
Trichoptera (caddisflies)				
Brachycentridae	5	11	1	11
Glossosomatidae	1			
Helicopsychidae	1	4		
Hydropsychidae	10	16	10	16
Hydroptilidae		2	1	
Lepidostomatidae			16	1
Leptoceridae		1		
Limnephilidae	1	3	6	1
Molannidae				
Philopotamidae	6	6		2
Polycentropodidae				2
Uenoidae		1		
Coleoptera (beetles)				
Gyrinidae		2		
Haliplidae (adults)			1	
Hydrophilidae (total)	1		2	1
Elmidae	6	6		5
Diptera (flies)				

Taxa	Station 8a Mason Creek upstream East Duck Lake Road	Station 8b Mason Creek downstream East Duck Lake Road	Station 9 Little Betsie River at Nessen Road	Station 10 Little Betsie River at Bentley Road
	8/2/18	8/2/18	7/17/18	7/17/18
Ceratopogonidae	1	1		
Chironomidae	14	22	60	24
Simuliidae	4	5	27	4
abanidae	1	1		1
Tipulidae			1	1
MOLLUSCA				
Gastropoda (snails)				
Lymnaeidae			1	
Physidae	5	8	4	4
Viviparidae		1		
Pelecypoda (bivalves)				
Pisidiidae			6	3
Total Individuals	263	286	309	264

Table 15. Macroinvertebrate metric evaluation for Mason Creek and the Little Betsie River, Grand Traverse and Benzie Counties, Michigan, July and August 2018.

METRIC	Station 8a Mason Creek upstream East Duck Lake Road		Station 8b Mason Creek downstream East Duck Lake Road		Station 9 Little Betsie River at Nessen Road		Station 10 Little Betsie River at Bentley Road	
	8/2/18		8/2/18		7/17/18		7/17/18	
	Value	Score	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	28	1	31	1	21	0	24	1
NUMBER OF MAYFLY TAXA	4	0	3	0	3	0	1	-1
NUMBER OF CADDISFLY TAXA	6	1	8	1	5	0	6	1
NUMBER OF STONEFLY TAXA	1	0	1	0	0	-1	0	-1
PERCENT MAYFLY COMPOSITION	3.42	-1	11.89	0	18.45	0	4.92	-1
PERCENT CADDISFLY COMPOSTITION	9.13	-1	15.38	0	11.00	0	12.50	0
PERCENT DOMINANT TAXON	65.40	-1	43.01	-1	36.25	0	62.50	-1
PERCENT ISOPOD, SNAIL, LEECH	1.90	0	3.15	-1	1.62	0	1.52	0
PERCENT SURFACE AIR BREATHERS	1.14	0	2.45	-1	1.29	0	0.76	1
TOTAL SCORE		-1		-1		-1		-1
MACROINVERTEBRATE COMMUNITY RATING	ACCEPTABLE		ACCEPTABLE		ACCEPTABLE		ACCEPTABLE	

Table 16. Habitat evaluations for three stations in the Betsie River, Benzie and Manistee Counties, Michigan, July 2018.

Date	Station 11 Betsie River at Nostwick Road	Station 12 Betsie River at Reynolds Road	Station 13 Betsie River off Old Grade Road
	7/17/18	7/17/18	7/18/18
HABITAT METRICS	RIFFLE/RUN	GLIDE/POOL	RIFFLE/RUN
Substrate and Instream Cover			
Epifaunal Substrate/ Available Cover (20)	18	13	19
Embeddedness (20)* ¹	19	NA	15
Velocity/Depth Regime (20)* ¹	19	NA	19
Pool Substrate Characterization (20)** ²	NA	13	NA
Pool Variability (20)** ²	NA	6	NA
Channel Morphology			
Sediment Deposition (20)	16	17	17
Flow Status -Maintenance Flow Volume (10)	9	10	10
Flow Status -Flashiness (10)	9	10	10
Channel Alteration (20)	20	19	20
Frequency of Riffles/Bends (20)* ¹	20	NA	20
Channel Sinuosity (20)** ²	NA	17	NA
Riparian and Bank Structure			
Bank Stability (L) (10)	9	10	10
Bank Stability (R) (10)	10	10	10
Vegetative Protection (L) (10)	8	10	10
Vegetative Protection (R) (10)	10	9	10
Riparian Vegetative Zone Width (L) (10)	6	8	10
Riparian Vegetative Zone Width (R) (10)	10	4	10
TOTAL SCORE (200):	183	156	190
HABITAT RATING:	EXCELLENT	EXCELLENT	EXCELLENT
Weather:	sunny	sunny	sunny
Air Temperature: °F	73	70	65
Water Temperature: °F	79	80	60
Average Stream Width: Feet	37	69.5	40
Average Stream Depth: Feet	1	1	2
Surface Velocity: Feet/Second	2	1	2
Estimated Flow: Cubic Feet/Second	68	58	171
Stream Modifications:	canopy removal	canopy removal	none
Nuisance Plants (Yes/No):	N	N	N
STORET No.:	100268	100244	510255
County Code:	10	10	51
Town Range Section:	25N13W9	25N13W10	24N14W09
Latitude (dd):	44.57304	44.5745	44.49317
Longitude (dd):	-85.88799	-85.8777	-86.00453
Ecoregion:	NCHF	NCHF	NCHF

Table 17. Qualitative macroinvertebrate community sampling results for three stations in the Betsie River, Benzie and Manistee Counties, Michigan, July 2018.

Taxa	Station 11 Betsie River at Nostwick Road	Station 12 Betsie River at Reynolds Road	Station 13 Betsie River off Old Grade Road
	7/17/18	7/17/18	7/18/18
PLATYHELMINTHES (flatworms)			
Turbellaria	4	3	2
ANNELIDA (segmented worms)			
Hirudinea (leeches)			
Oligochaeta (worms)	10	3	29
ARTHROPODA			
Crustacea			
Amphipoda (scuds)	31	70	10
Decapoda (crayfish)	1	1	1
Isopoda (sowbugs)	1	38	1
Arachnoidea			
Hydracarina	5	14	8
Insecta			
Ephemeroptera (mayflies)			
Baetiscidae			
Baetidae	47	9	76
Caenidae	1	1	
Ephemerellidae	2		6
Ephemeridae			
Heptageniidae	44	4	9
Isonychiidae	1		1
Siphonuridae	1		
Tricorythidae	21	79	1
Odonata			
Anisoptera (dragonflies)			
Aeshnidae		4	1
Corduliidae			
Gomphidae	2	4	1
Zygoptera (damselflies)			
Calopterygidae	7		2
Coenagrionidae		1	
Plecoptera (stoneflies)			
Perlidae			1
Hemiptera (true bugs)			
Corixidae		1	
Gerridae	2	2	1
Mesoveliidae		1	
Nepidae		1	
Megaloptera			
Corydalidae (dobson flies)	1		1
Sialidae (alder flies)		4	
Neuroptera (spongilla flies)			
Trichoptera (caddisflies)			
Brachycentridae			1
Helicopsychidae	8	5	
Hydropsychidae	25	5	77
Leptoceridae	3	8	
Limnephilidae	4	1	1

Taxa	Station 11 Betsie River at Nostwick Road	Station 12 Betsie River at Reynolds Road	Station 13 Betsie River off Old Grade Road
	7/17/18	7/17/18	7/18/18
Philopotamidae	5		2
Polycentropodidae		2	1
Uenoidae	4		1
Coleoptera (beetles)			
Gyrinidae (adults)	1		1
Hydrophilidae (total)		1	
Elmidae	26	7	7
Diptera (flies)			
Athericidae			24
Ceratopogonidae	4	1	
Chaoboridae			
Chironomidae	44	79	47
Simuliidae	3		14
Tipulidae	1		1
MOLLUSCA			
Gastropoda (snails)			
Ancylidae (limpets)		1	1
Bithyniidae	2	6	
Hydrobiidae		2	
Lymnaeidae		1	
Physidae	1		1
Planorbidae		1	
Pelecypoda (bivalves)			
Pisidiidae	1	7	1
Unionidae (mussels)		1	
Total Individuals	313	368	331

Table 18. Macroinvertebrate metric evaluation for three stations in the Betsie River, Benzie and Manistee Counties, Michigan, July 2018.

METRIC	Station 11 Betsie River at Nostwick Road		Station 12 Betsie River at Reynolds Road		Station 13 Betsie River off Old Grade Road	
	7/17/18		7/17/18		7/18/18	
	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	32	1	34	1	32	1
NUMBER OF MAYFLY TAXA	7	1	4	0	5	1
NUMBER OF CADDISFLY TAXA	6	1	5	0	6	1
NUMBER OF STONEFLY TAXA	0	-1	0	-1	1	0
PERCENT MAYFLY COMPOSITION	37.38	1	25.27	0	28.10	0
PERCENT CADDISFLY COMPOSITION	15.65	0	5.71	-1	25.08	0
PERCENT DOMINANT TAXON	15.02	1	21.47	1	23.26	0
PERCENT ISOPOD, SNAIL, LEECH	1.28	0	13.32	-1	0.91	1
PERCENT SURFACE AIR BREATHERS	0.96	1	1.63	0	0.60	1
TOTAL SCORE		5		-1		5
MACROINVERTEBRATE COMMUNITY RATING	EXCELLENT		ACCEPTABLE		EXCELLENT	

Table 19. Habitat evaluations for three stations in Cold and Bowens Creeks, Benzie and Manistee Counties, Michigan, June, July, and August 2018.

	Station 14 North Branch Cold Creek downstream East Street	Station 15 South Branch Cold Creek at US-31	Station 16 Bowens Creek downstream Gilbert Road
Date	6/28/18	7/18/18	8/1/18
HABITAT METRICS	GLIDE/POOL	RIFFLE/RUN	GLIDE/POOL
Substrate and Instream Cover			
Epifaunal Substrate/ Available Cover (20)	6	8	9
Embeddedness (20)* ¹	NA	10	NA
Velocity/Depth Regime (20)* ¹	NA	15	NA
Pool Substrate Characterization (20)** ²	11	NA	11
Pool Variability (20)** ²	5	NA	13
Channel Morphology			
Sediment Deposition (20)	5	8	10
Flow Status -Maintenance Flow Volume (10)	9	10	10
Flow Status -Flashiness (10)	5	10	10
Channel Alteration (20)	13	11	18
Frequency of Riffles/Bends (20)* ¹	NA	11	NA
Channel Sinuosity (20)** ²	5	NA	7
Riparian and Bank Structure			
Bank Stability (L) (10)	7	10	10
Bank Stability (R) (10)	6	10	10
Vegetative Protection (L) (10)	3	8	9
Vegetative Protection (R) (10)	6	7	9
Riparian Vegetative Zone Width (L) (10)	2	8	10
Riparian Vegetative Zone Width (R) (10)	3	8	10
TOTAL SCORE (200):	86	134	146
HABITAT RATING:	MARGINAL	GOOD	GOOD
Weather:	sunny	sunny	sunny
Air Temperature: °F	75	74	75
Water Temperature: °F	70	55	59
Average Stream Width: Feet	6	13.5	17
Average Stream Depth: Feet	0.25	0.5	2
Surface Velocity: Feet/Second	1	1	1
Estimated Flow: Cubic Feet/Second	2	7	27
Stream Modifications:	none	canopy removal	none
Nuisance Plants (Y/N):	N	N	N
STORET No.:	100269	100227	510276
County Code:	10	10	51
TRS:	26N15W26	26N15W26	24N16W15
Latitude (dd):	-86.091009	44.63015	44.485415
Longitude (dd):	44.631875	-86.09205	-86.201977
Ecoregion:	NCHF	NCHF	NCHF

Table 20. Qualitative macroinvertebrate community sampling results for three stations in Cold and Bowens Creeks Benzie and Manistee Counties, Michigan, June, July, and August 2018.

	Station 14 North Branch Cold Creek downstream East Street	Station 15 South Branch Cold Creek at US-31	Station 16 Bowens Creek downstream Gilbert Road
Taxa	6/28/18	7/18/18	8/1/18
ANNELIDA (segmented worms)			
Hirudinea (leeches)	1		
Oligochaeta (worms)	1	5	11
ARTHROPODA			
Crustacea			
Amphipoda (scuds)	27	48	33
Decapoda (crayfish)	4		1
Isopoda (sowbugs)	155	64	9
Arachnoidea			
Hydracarina	1	11	5
Insecta			
Ephemeroptera (mayflies)			
Baetidae		2	3
Ephemerellidae		7	
Odonata			
Anisoptera (dragonflies)			
Aeshnidae	1		
Zygoptera (damselflies)			
Coenagrionidae	1		
Plecoptera (stoneflies)			
Nemouridae		5	4
Hemiptera (true bugs)			
Gerridae		1	1
Mesoveliidae	4	2	
Trichoptera (caddisflies)			
Brachycentridae			1
Hydropsychidae		1	1
Lepidostomatidae		6	2
Limnephilidae		1	3
Phryganeidae		1	
Uenoidae	1		
Coleoptera (beetles)			
Dytiscidae (total)		1	
Hydrophilidae (total)		4	1
Diptera (flies)			
Ceratopogonidae	1	3	1
Chironomidae	45	139	160
Dixidae			7
Ephydriidae			1
Ptychopteridae		1	
Simuliidae	1	7	23
Stratiomyidae		1	
Tabanidae			1
Tipulidae			1
MOLLUSCA			
Gastropoda (snails)			
Hydrobiidae	1		

Taxa	Station 14 North Branch Cold Creek downstream East Street	Station 15 South Branch Cold Creek at US-31	Station 16 Bowens Creek downstream Gilbert Road
	6/28/18	7/18/18	8/1/18
Physidae	2	5	1
Pelecypoda (bivalves)			
Pisidiidae	3	4	
Total Individuals	319	249	270

Table 21. Macroinvertebrate metric evaluation for three stations in Cold and Bowens Creeks, Benzie and Manistee Counties, Michigan, June, July, and August 2018.

METRIC	Station 14 North Branch Cold Creek downstream East Street		Station 15 South Branch Cold Creek at US-31		Station 16 Bowens Creek downstream Gilbert Road	
	6/28/18		7/18/18		8/1/18	
	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	16	0	22	0	21	0
NUMBER OF MAYFLY TAXA	0	-1	2	0	1	-1
NUMBER OF CADDISFLY TAXA	1	-1	4	0	4	0
NUMBER OF STONEFLY TAXA	0	-1	1	0	1	0
PERCENT MAYFLY COMPOSITION	0	-1	2.82	-1	1.11	-1
PERCENT CADDISFLY COMPOSTION	0.40	-1	2.82	-1	2.59	-1
PERCENT DOMINANT TAXON	62.25	-1	43.57	-1	59.26	-1
PERCENT ISOPOD, SNAIL, LEECH	63.86	-1	21.63	-1	3.70	-1
PERCENT SURFACE AIR BREATHERS	1.61	0	3.13	-1	0.74	1
TOTAL SCORE		-6		-5		-4
MACROINVERTEBRATE COMMUNITY RATING	POOR		POOR		ACCEPTABLE	

Table 22. Qualitative Fish Sampling for two stations in Cold Creek, Benzie County, Michigan, June and July 2018.

TAXA	Station 14 North Branch Cold Creek downstream of East Street 6/28/18	Station 15 South Branch Cold Creek at US-31 7/18/18
Salmonidae (trouts)		
<i>Oncorhynchus mykiss</i> (Rainbow trout)	0	6
<i>Salvelinus fontinalis</i> (Brook trout)	0	11
<i>Oncorhynchus kisutch</i> (Coho salmon)	4	38
Umbridae (mudminnows)		
<i>Umbra limi</i> (Central mudminnow)	47	3
Cyprinidae (minnows and carps)		
<i>Semotilus atromaculatus</i> (Creek chub)	17	0
<i>Rhinichthys atratulus</i> (Blacknose dace)	21	0
<i>Rhinichthys cataractae</i> (Longnose dace)	4	0
Cottidae (sculpins)		
<i>Cottus cognatus</i> (Slimy sculpin)	1	13
Gasterosteidae (sticklebacks)		
<i>Culaea inconstans</i> (Brook stickleback)	1	0
TOTAL INDIVIDUALS	95	71
Number of anomalies	0	0
Percent anomalies	0	0
Percent salmonids	4.2	77.5
Reach sampled (ft)	600	270
Area sampled (sq. ft)	3600	3645
Density (# fish/sq. ft)	.026	.019
Gear	Backpack shocker	Backpack shocker

Table 23. Habitat evaluation comparison for one station in the Betsie River off Old Grade Road, Benzie County, Michigan, 2008, 2013, 2018.

Date	Betsie River off Old Grade Road	Betsie River off Old Grade Road	Station 13 Betsie River off Old Grade Road
	7/17/08	7/19/13	7/18/18
HABITAT METRICS	GLIDE/POOL	RIFFLE/RUN	RIFFLE/RUN
Substrate and Instream Cover			
Epifaunal Substrate/ Available Cover (20)	16	16	19
Embeddedness (20)* ¹	na	15	15
Velocity/Depth Regime (20)* ¹	na	16	19
Pool Substrate Characterization (20)** ²	15	na	na
Pool Variability (20)** ²	15	na	na
Channel Morphology			
Sediment Deposition (20)	15	15	17
Flow Status -Maintenance Flow Volume (10)	10	9	10
Flow Status -Flashiness (10)	9	9	10
Channel Alteration (20)	20	16	20
Frequency of Riffles/Bends (20)* ¹	na	18	20
Channel Sinuosity (20)** ²	14	na	na
Riparian and Bank Structure			
Bank Stability (L) (10)	10	8	10
Bank Stability (R) (10)	9	6	10
Vegetative Protection (L) (10)	10	8	10
Vegetative Protection (R) (10)	10	9	10
Riparian Vegetative Zone Width (L) (10)	8	8	10
Riparian Vegetative Zone Width (R) (10)	10	8	10
TOTAL SCORE (200):	171	161	190
HABITAT RATING:	EXCELLENT	EXCELLENT	EXCELLENT
Weather:	Cloudy	Partly Cloudy	sunny
Air Temperature: °F	75	80	65
Water Temperature: °F	71	71	60
Average Stream Width: Feet	45	35	40
Average Stream Depth: Feet	2	2.75	2
Surface Velocity: Feet/Second	na	na	2
Estimated Flow: Cubic Feet/Second	na	na	171
Stream Modifications:	None	None	none
Nuisance Plants (Yes/No):	N	N	N
STORET No.:	510255	510255	510255
County Code:	51	51	51
Town Range Section:	24N14W09	24N14W09	24N14W09
Latitude (dd):	44.49317	44.49317	44.49317
Longitude (dd):	-86.00453	-86.00453	-86.00453
Ecoregion:	NCHF	NCHF	NCHF

Table 24. Qualitative macroinvertebrate community sampling result comparison for one station in the Betsie River off Old Grade Road, Benzie County, Michigan, 2008, 2013, 2018.

Taxa	Betsie River off Old Grade Road	Betsie River off Old Grade Road	Station 13 Betsie River off Old Grade Road
	7/17/08	7/19/13	7/18/18
PORIFERA (sponges)	1		
PLATYHELMINTHES (flatworms)			
Turbellaria	3	1	2
ANNELIDA (segmented worms)			
Hirudinea (leeches)		1	
Oligochaeta (worms)	1	36	29
ARTHROPODA			
Crustacea			
Amphipoda (scuds)	5	1	10
Decapoda (crayfish)	3	6	1
Isopoda (sowbugs)		3	1
Arachnoidea			
Hydracarina	4		8
INSECTA			
Ephemeroptera (mayflies)			
Baetidae	2	29	76
Ephemerellidae	7	8	6
Heptageniidae	4	4	9
Isonychiidae	3	1	1
Tricorythidae	2	3	1
Odonata			
Anisoptera (dragonflies)			
Aeshnidae	1		1
Gomphidae	1		1
Zygoptera (damselflies)			
Calopterygidae	5	5	2
Plecoptera (stoneflies)			
Perlidae		1	1
Pteronarcyidae		1	
Hemiptera (true bugs)			
Gerridae	1	1	1
Megaloptera			
Corydalidae			1
Sialidae (alder flies)		1	
Neuroptera (spongilla flies)			
Sisyridae	1		
Trichoptera (caddisflies)			
Brachycentridae	1	3	1
Glossosomatidae	3	1	
Hydropsychidae	75	108	77
Leptoceridae	11	5	
Limnephilidae		1	1
Philopotamidae			2
Polycentropodidae			1
Uenoidae			1
Coleoptera (beetles)			
Gyrinidae (adults)			1
Elmidae	13	22	7

Taxa	Betsie River off Old Grade Road	Betsie River off Old Grade Road	Station 13 Betsie River off Old Grade Road
	7/17/08	7/19/13	7/18/18
Diptera (flies)			
Athericidae	43	33	24
Chironomidae	18	25	47
Simuliidae	20	3	14
Tabanidae		2	
Tipulidae	3	10	1
MOLLUSCA			
Gastropoda (snails)			
Ancylidae (limpets)		1	1
Physidae	3	4	1
Planorbidae	1		
Pelecypoda (bivalves)			
Pisidiidae	8	8	1
Total Individuals	243	328	331

Table 25. Macroinvertebrate metric evaluation comparison for one station in the Betsie River off Old Grade Road, Benzie County, Michigan, 2008, 2013, 2018.

METRIC	Betsie River off Old Grade Road		Betsie River off Old Grade Road		Station 13 Betsie River off Old Grade Road	
	7/17/08		7/19/13		7/18/18	
	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	28	1	30	1	32	1
NUMBER OF MAYFLY TAXA	5	1	5	1	5	1
NUMBER OF CADDISFLY TAXA	4	0	5	0	6	1
NUMBER OF STONEFLY TAXA	0	-1	2	1	1	0
PERCENT MAYFLY COMPOSITION	7.41	-1	13.72	0	28.10	0
PERCENT CADDISFLY COMPOSITION	37.04	0	35.98	0	25.08	0
PERCENT DOMINANT TAXON	30.86	0	32.93	0	23.26	0
PERCENT ISOPOD, SNAIL, LEECH	1.65	0	2.74	-1	0.91	1
PERCENT SURFACE AIR BREATHERS	0.41	1	0.30	1	0.60	1
TOTAL SCORE		1		3		5
MACROINVERTEBRATE COMMUNITY RATING	ACCEPTABLE		ACCEPTABLE		EXCELLENT	

Table 26. Habitat evaluation comparison for one station in the Platte River and two stations in the Crystal River in June 2013, and 2018 Leelanau and Benzie Counties, Michigan.

Date	Station 7 Platte River at El Dorado Park	Platte River at El Dorado Park	Station 1 Crystal River off Fisher Road upstream of Dam	Crystal River downstream of Crystal View Road
	6/28/18	6/20/13	6/27/18	6/21/13
HABITAT METRICS	GLIDE/POOL	RIFFLE/RUN	RIFFLE/RUN	GLIDE/POOL
Substrate and Instream Cover				
Epifaunal Substrate/ Available Cover (20)	12	18	18	13
Embeddedness (20)*1	NA	18	16	na
Velocity/Depth Regime (20)*1	NA	20	17	na
Pool Substrate Characterization (20)**2	10	na	na	16
Pool Variability (20)**2	13	na	na	8
Channel Morphology				
Sediment Deposition (20)	11	13	13	8
Flow Status -Maintenance Flow Volume (10)	10	10	9	9
Flow Status -Flashiness (10)	10	10	10	7
Channel Alteration (20)	18	18	19	15
Frequency of Riffles/Bends (20)*1	na	17	19	na
Channel Sinuosity (20)**2	19	na	na	7
Riparian and Bank Structure				
Bank Stability (L) (10)	10	10	10	8
Bank Stability (R) (10)	10	8	10	6
Vegetative Protection (L) (10)	8	9	8	9
Vegetative Protection (R) (10)	8	8	8	6
Riparian Vegetative Zone Width (L) (10)	10	10	10	10
Riparian Vegetative Zone Width (R) (10)	9	9	10	9
TOTAL SCORE (200):	158	178	177	131
HABITAT RATING:	EXCELLENT	EXCELLENT	EXCELLENT	GOOD
Weather:	sunny	sunny	partly cloudy	partly cloudy
Air Temperature: °F	70	65	75	75
Water Temperature: °F	70	66	75	75
Average Stream Width: Feet	80	46	45	45
Average Stream Depth: Feet	2.5	2	1.5	1.5
Surface Velocity: Feet/Second	1	NA	2	2
Estimated Flow: Cubic Feet/Second	191	NA	95	95
Stream Modifications:	None	None	impounded	impounded
Nuisance Plants (Yes/No):	N	N	N	N
STORET No.:	100251	100251	450240	450240
County Code:	10	10	45	45
Town Range Section:	27N15W20	27N15W20	29N14W24	29N14W24
Latitude (dd):	44.72649	44.72649	-85.95664	-85.95664
Longitude (dd):	-86.14364	-86.14364	44.899496	44.899496
Ecoregion:	NCHF	NCHF	NCHF	NCHF

Table 27. Qualitative macroinvertebrate community sampling result comparison for one station in the Platte River and two stations in the Crystal River in June 2013, and 2018 Leelanau and Benzie Counties, Michigan.

Taxa	Station 7 Platte River at El Dorado Park	Platte River at El Dorado Park	Station 1 Crystal River off Fisher Road upstream of Dam	Crystal River downstream of Crystal View Road
	6/28/18	6/20/13	6/27/18	6/21/13
PLATYHELMINTHES (flatworms)				1
Turbellaria			1	
NEMATOMORPHA (roundworms)				
ANNELIDA (segmented worms)				
Hirudinea (leeches)	1			1
Oligochaeta (worms)	4	3	3	3
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	34	22	10	103
Decapoda (crayfish)	9	1	3	2
Isopoda (sowbugs)		2	6	21
Arachnoidea				
Hydracarina	32	2		1
INSECTA				
Ephemeroptera (mayflies)				
Baetidae	2		2	
Baetiscidae		1		1
Caenidae	5	5	6	5
Ephemerellidae		11		
Ephemeridae		1		
Heptageniidae	1	3		8
Tricorythidae	11			
Odonata				
Anisoptera (dragonflies)				
Aeshnidae	4	1	1	4
Cordulegastridae				
Gomphidae	5	1	1	1
Macromiidae		2		
Zygoptera (damselflies)				
Calopterygidae	1			5
Coenagrionidae	8	1	1	3
Plecoptera (stoneflies)				
Perlidae	3	23	11	4
Hemiptera (true bugs)				
Corixidae	1			
Gerridae				1
Megaloptera				
Corydalidae				1
Trichoptera (caddisflies)				
Hydropsychidae		45	46	
Lepidostomatidae			1	
Leptoceridae	6	1	3	3
Limnephilidae		2	1	1
Lepidostomatidae	1			
Philopotamidae		1		
Polycentropodidae	3		1	1
Coleoptera (beetles)				

Taxa	Station 7 Platte River at El Dorado Park	Platte River at El Dorado Park	Station 1 Crystal River off Fisher Road upstream of Dam	Crystal River downstream of Crystal View Road
	6/28/18	6/20/13	6/27/18	6/21/13
Elmidae	6	5	5	2
Gyrinidae (adults)		1	2	
Hydrophilidae (total)		1		
Diptera (flies)				
Ceratopogonidae		4	1	1
Chironomidae	123	83	50	72
Simuliidae		3	181	
Tipulidae			1	
MOLLUSCA				
Gastropoda (snails)				
Ancylidae (limpets)		1		
Bithyniidae		18		35
Hydrobiidae	2		3	6
Physidae	2	1	1	
Planorbidae				1
Pelecypoda (bivalves)				
Dreissenidae	1	1	1	1
Pisidiidae	3	1		3
Unionidae	1	4		1
Total Individuals	269	251	347	292

Table 28. Macroinvertebrate metric evaluation comparison for one station in the Platte River and two stations in the Crystal River in June 2013, and 2018 Leelanau and Benzie Counties, Michigan.

METRIC	Station 7 Platte River at El Dorado Park		Platte River at El Dorado Park		Station 1 Crystal River off Fisher Road upstream of Dam		Crystal River downstream of Crystal View Road	
	6/28/18		6/20/13		6/27/18		6/21/13	
	Value	Score	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	25	1	31	1	26	1	29	1
NUMBER OF MAYFLY TAXA	4	0	5	1	2	0	3	0
NUMBER OF CADDISFLY TAXA	3	0	4	0	5	0	3	0
NUMBER OF STONEFLY TAXA	1	0	1	0	1	0	1	0
PERCENT MAYFLY COMPOSITION	7.06	-1	8.37	-1	2.31	-1	4.79	-1
PERCENT CADDISFLY COMPOSTITION	3.72	-1	19.52	0	14.99	0	1.71	-1
PERCENT DOMINANT TAXON	45.72	-1	33.07	0	52.16	-1	35.27	0
PERCENT ISOPOD, SNAIL, LEECH	5.20	-1	8.76	-1	2.88	-1	21.92	-1
PERCENT SURFACE AIR BREATHERS	0.37	1	0.80	1	1.44	0	0.34	1
TOTAL SCORE		-2		1		-2		-1
MACROINVERTEBRATE COMMUNITY RATING	ACCEPTABL E		ACCEPTABL E		ACCEPTABL E		ACCEPTABL E	

Table 29. Habitat evaluation comparison for the unnamed tributary to Platte Lake upstream of Platte Lake Road, September 2013 and July 2018, Benzie County, Michigan.

Date	Unnamed Tributary to Platte Lake at Platte Lake Road	Station 4 Unnamed Tributary to Platte Lake at Platte Lake Road
	9/9/2013	7/17/2018
HABITAT METRICS	GLIDE/POOL	GLIDE/POOL
Substrate and Instream Cover		
Epifaunal Substrate/ Available Cover (20)	8	11
Embeddedness (20)* ¹	na	na
Velocity/Depth Regime (20)* ¹	na	na
Pool Substrate Characterization (20)** ²	13	13
Pool Variability (20)** ²	10	10
Channel Morphology		
Sediment Deposition (20)	5	10
Flow Status -Maintenance Flow Volume (10)	10	10
Flow Status -Flashiness (10)	9	10
Channel Alteration (20)	13	13
Frequency of Riffles/Bends (20)* ¹	na	na
Channel Sinuosity (20)** ²	15	17
Riparian and Bank Structure		
Bank Stability (L) (10)	10	10
Bank Stability (R) (10)	10	10
Vegetative Protection (L) (10)	9	10
Vegetative Protection (R) (10)	9	10
Riparian Vegetative Zone Width (L) (10)	5	8
Riparian Vegetative Zone Width (R) (10)	9	10
TOTAL SCORE (200):	135	150
HABITAT RATING:	GOOD	Good
Weather:	partly cloudy	partly cloudy
Air Temperature: °F	78	75
Water Temperature: °F	64	62
Average Stream Width: Feet	9	10
Average Stream Depth: Feet	0.5	0.5
Surface Velocity: Feet/Second	na	1
Estimated Flow: Cubic Feet/Second	na	2
Stream Modifications:	None	none
Nuisance Plants (Yes/No):	N	N
STORET No.:	100248	100248
County Code:	10	10
Town Range Section:	26N14W07	26N14W07
Latitude (dd):	44.66783	44.66783
Longitude (dd):	-86.05007	-86.05007
Ecoregion:	NCHF	NCHF

Table 30. Qualitative macroinvertebrate community sampling result comparison for the unnamed tributary to Platte Lake upstream of Platte Lake Road, September 2013 and July 2018, Benzie County, Michigan.

Taxa	Unnamed Tributary to Platte Lake at Platte Lake Road	Station 4 Unnamed Tributary to Platte Lake at Platte Lake Road
	9/9/2013	7/17/2018
ANNELIDA (segmented worms)		
Hirudinea (leeches)	1	
Oligochaeta (worms)		2
ARTHROPODA		
Crustacea		
Amphipoda (scuds)	8	113
Decapoda (crayfish)	1	
Isopoda (sowbugs)	134	20
Insecta		
Ephemeroptera (mayflies)		
Baetidae		9
Leptophlebiidae	26	
Odonata		
Anisoptera (dragonflies)		
Aeshnidae	4	12
Cordulegastridae		2
Libellulidae	1	
Zygoptera (damselflies)		
Calopterygidae	10	1
Coenagrionidae	2	
Hemiptera (true bugs)		
Gerridae	1	4
Mesoveliidae		3
Notonectidae	1	
Veliidae	1	
Megaloptera		
Sialidae (alder flies)	1	
Trichoptera (caddisflies)		
Hydropsychidae	14	3
Hydroptilidae	1	
Lepidostomatidae	3	4
Limnephilidae	1	16
Molannidae	16	
Philopotamidae	1	1
Phryganeidae	4	
Polycentropodidae	2	
Lepidoptera (moths)		
Pyrilidae	1	
Coleoptera (beetles)		
Haliplidae (adults)	1	
Diptera (flies)		
Ceratopogonidae		1
Chironomidae	12	37
Dixidae		1

Taxa	Unnamed Tributary to Platte Lake at Platte Lake Road	Station 4 Unnamed Tributary to Platte Lake at Platte Lake Road
	9/9/2013	7/17/2018
Simuliidae	1	21
Tipulidae	1	
MOLLUSCA		
Gastropoda (snails)		
Ancylidae (limpets)		1
Physidae	2	3
Planorbidae	2	1
Pelecypoda (bivalves)		
Pisidiidae	4	2
Total Individuals	257	257

Table 31. Macroinvertebrate metric evaluation comparison for the unnamed tributary to Platte Lake upstream of Platte Lake Road, September 2013 and July 2018, Benzie County, Michigan.

METRIC	Unnamed Tributary to Platte Lake at Platte Lake Road		Station 4 Unnamed Tributary to Platte Lake at Platte Lake Road	
	9/9/2013		7/17/2018	
	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	29	1	21	0
NUMBER OF MAYFLY TAXA	1	-1	1	-1
NUMBER OF CADDISFLY TAXA	8	1	4	0
NUMBER OF STONEFLY TAXA	0	-1	0	-1
PERCENT MAYFLY COMPOSITION	10.12	0	3.50	-1
PERCENT CADDISFLY COMPOSITION	16.34	0	9.34	-1
PERCENT DOMINANT TAXON	52.14	-1	43.97	-1
PERCENT ISOPOD, SNAIL, LEECH	54.09	-1	9.73	-1
PERCENT SURFACE AIR BREATHERS	1.56	0	2.72	-1
TOTAL SCORE		-2		-7
MACROINVERTEBRATE COMMUNITY RATING	ACCEPTABLE		POOR	

Table 32. Habitat evaluation comparison for the Little Betsie River at Nessen Road, 2008,2013, and 2018, Benzie County, Michigan.

Date	Station 9 Little Betsie River at Nessen Road	Little Betsie River at Nessen Road	Little Betsie River at Nessen Road
	7/17/18	6/18/13	9/10/08
HABITAT METRICS			
Substrate and Instream Cover			
Epifaunal Substrate/ Available Cover (20)	8	5	15
Embeddedness (20)* ¹	11	na	na
Velocity/Depth Regime (20)* ¹	13	na	na
Pool Substrate Characterization (20)** ²	na	6	10
Pool Variability (20)** ²	na	17	18
Channel Morphology			
Sediment Deposition (20)	6	5	15
Flow Status -Maintenance Flow Volume (10)	10	10	10
Flow Status -Flashiness (10)	10	9	10
Channel Alteration (20)	19	19	20
Frequency of Riffles/Bends (20)* ¹	19	na	na
Channel Sinuosity (20)** ²	na	16	12
Riparian and Bank Structure			
Bank Stability (L) (10)	10	10	10
Bank Stability (R) (10)	10	10	10
Vegetative Protection (L) (10)	10	10	10
Vegetative Protection (R) (10)	10	10	10
Riparian Vegetative Zone Width (L) (10)	10	10	10
Riparian Vegetative Zone Width (R) (10)	10	10	10
TOTAL SCORE (200):	156	147	170
HABITAT RATING:	EXCELLENT	GOOD	EXCELLENT
Weather:	partly cloudy	sunny	sunny
Air Temperature: °F	70	70	50
Water Temperature: °F	58	59	49
Average Stream Width: Feet	20	30	15
Average Stream Depth: Feet	1	0.3	0.5
Surface Velocity: Feet/Second	1	na	na
Estimated Flow: Cubic Feet/Second	20	na	na
Stream Modifications:	None	None	None
Nuisance Plants (Yes/No):	N	N	N
STORET No.:	100242	100242	100242
County Code:	10	10	10
Town Range Section:	25N13W27	25N13W27	25N13W27
Latitude (dd):	44.5331	44.5331	44.5331
Longitude (dd):	-85.8782	-85.8782	-85.8782
Ecoregion:	NCHF	NCHF	NCHF

Table 33. Qualitative macroinvertebrate community sampling result comparison for the Little Betsie River at Nessen Road, 2008,2013, and 2018, Benzie County, Michigan.

Taxa	Station 9 Little Betsie River at Nessen Road	Little Betsie River at Nessen Road	Little Betsie River at Nessen Road
	7/17/18	6/18/13	9/10/08
PLATYHELMINTHES (flatworms)			
Turbellaria	2		
ANNELIDA (segmented worms)			
Oligochaeta (worms)	4	4	
ARTHROPODA			
Crustacea			
Amphipoda (scuds)	29	39	112
Arachnoidea			
Hydracarina	2	3	1
INSECTA			
Ephemeroptera (mayflies)			
Baetidae	24	60	55
Ephemerellidae	2		
Ephemeridae			1
Heptageniidae			1
Isonychiidae	1		
Leptophlebiidae	4		
Odonata			
Anisoptera (dragonflies)			
Aeshnidae		1	
Zygoptera (damselflies)			
Calopterygidae	4	3	
Plecoptera (stoneflies)			
Perlodidae		2	
Hemiptera (true bugs)			
Belostomatidae	1		
Gerridae	2	1	1
Veliidae	2		
Megaloptera			
Corydalidae (dobson flies)	1	2	1
Sialidae (alder flies)	1		1
Trichoptera (caddisflies)			
Brachycentridae	44	41	1
Helicopsychidae	18	1	
Hydropsychidae	15	33	10
Hydroptilidae			1
Lepidostomatidae		12	16
Leptoceridae	1	7	
Limnephilidae	3	3	6
Molannidae	9		
Phryganeidae	1		
Coleoptera (beetles)			
Dytiscidae (total)	1		
Gyrinidae (adults)	1		
Haliplidae (adults)			1
Hydrophilidae (total)	1		2
Diptera (flies)			
Athericidae	2		

Taxa	Station 9 Little Betsie River at Nessen Road		
	7/17/18	6/18/13	9/10/08
Ceratopogonidae		2	
Chironomidae	48	97	60
Dixidae	2		
Ptychopteridae		6	
Simuliidae	8	32	27
Tabanidae	2	1	
Tipulidae			1
MOLLUSCA			
Gastropoda (snails)			
Lymnaeidae			1
Physidae	11	7	4
Pelecypoda (bivalves)			
Pisidiidae	10	26	6
Total Individuals	256	383	309

Table 34. Macroinvertebrate metric evaluation comparison for the Little Betsie River at Nessen Road, 2008,2013, and 2018, Benzie County, Michigan.

METRIC	Station 9 Little Betsie River at Nessen Road		Little Betsie River at Nessen Road		Little Betsie River at Nessen Road	
	7/17/18		6/18/13		9/10/08	
	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	31	1	22	0	21	0
NUMBER OF MAYFLY TAXA	4	0	1	-1	3	0
NUMBER OF CADDISFLY TAXA	7	1	6	1	5	0
NUMBER OF STONEFLY TAXA	0	-1	1	0	0	-1
PERCENT MAYFLY COMPOSITION	12.11	0	15.67	0	18.45	0
PERCENT CADDISFLY COMPOSITION	35.55	0	25.33	0	11.00	0
PERCENT DOMINANT TAXON	18.75	1	25.33	0	36.25	0
PERCENT ISOPOD, SNAIL, LEECH	4.30	-1	1.83	0	1.62	0
PERCENT SURFACE AIR BREATHERS	3.13	-1	1.83	0	1.29	0
TOTAL SCORE		0		0		-1
MACROINVERTEBRATE COMMUNITY RATING	ACCEPTABLE		ACCEPTABLE		ACCEPTABLE	

Table 35. Habitat evaluation comparison for the two stations sampled in Bowens Creek, Manistee County, Michigan 2013 and 2018.

Date	Bowens Creek off Iverson Road	Station 16 Bowens Creek downstream Gilbert Road
	6/19/13	8/1/18
HABITAT METRICS	RIFFLE/RUN	GLIDE/POOL
Substrate and Instream Cover		
Epifaunal Substrate/ Available Cover (20)	8	9
Embeddedness (20)* ¹	2	na
Velocity/Depth Regime (20)* ¹	18	na
Pool Substrate Characterization (20)** ²	na	11
Pool Variability (20)** ²	na	13
Channel Morphology		
Sediment Deposition (20)	4	10
Flow Status -Maintenance Flow Volume (10)	10	10
Flow Status -Flashiness (10)	10	10
Channel Alteration (20)	17	18
Frequency of Riffles/Bends (20)* ¹	16	na
Channel Sinuosity (20)** ²	na	7
Riparian and Bank Structure		
Bank Stability (L) (10)	9	10
Bank Stability (R) (10)	9	10
Vegetative Protection (L) (10)	8	9
Vegetative Protection (R) (10)	8	9
Riparian Vegetative Zone Width (L) (10)	10	10
Riparian Vegetative Zone Width (R) (10)	10	10
TOTAL SCORE (200):	139	146
HABITAT RATING:	GOOD	GOOD
Weather:	Sunny	sunny
Air Temperature: °F	75	75
Water Temperature: °F	53	59
Average Stream Width: Feet	7	17
Average Stream Depth: Feet	1	2
Surface Velocity: Feet/Second	na	1
Estimated Flow: Cubic Feet/Second	na	27
Stream Modifications:	Relocated	none
Nuisance Plants (Yes/No):	N	N
STORET No.:	510268	510276
County Code:	51	51
Town Range Section:	24N16W24	24N16W15
Latitude (dd):	44.46668	44.485415
Longitude (dd):	-86.18077	-86.201977
Ecoregion:	NCHF	NCHF

Table 36. Qualitative macroinvertebrate community sampling result comparison for two stations sampled in Bowens Creek, Manistee County, Michigan 2013 and 2018.

Taxa	Bowens Creek off Iverson Road	Station 16 Bowens Creek downstream Gilbert Road
	6/19/13	8/1/18
ANNELIDA (segmented worms)		
Oligochaeta (worms)	1	11
ARTHROPODA		
Amphipoda (scuds)		
Decapoda (crayfish)	26	33
Isopoda (sowbugs)		1
Amphipoda (scuds)		9
Arachnoidea		
Hydracarina	7	5
INSECTA		
Ephemeroptera (mayflies)		
Baetidae	30	3
Odonata		
Anisoptera (dragonflies)		
Corduliidae	1	
Plecoptera (stoneflies)		
Leuctridae	7	
Nemouridae	47	4
Hemiptera (true bugs)		
Gerridae		1
Trichoptera (caddisflies)		
Brachycentridae		1
Hydropsychidae	14	1
Lepidostomatidae	19	2
Limnephilidae		3
Odontoceridae	1	
Rhyacophilidae	1	
Coleoptera (beetles)		
Dytiscidae (total)	1	
Hydrophilidae (total)	1	1
Elmidae	1	
Diptera (flies)		
Athericidae	7	
Ceratopogonidae	1	1
Chironomidae	57	160
Dixidae	1	7
Ephydriidae		1
Simuliidae	51	23
Tabanidae	2	1
Tipulidae	1	1
MOLLUSCA		
Gastropoda (snails)		
Physidae	1	1
Pelecypoda (bivalves)		
Pisidiidae	1	
Total Individuals	279	270

Table 37. Macroinvertebrate metric evaluation comparison for the two stations sampled in Bowens Creek, Manistee County, Michigan 2013 and 2018.

METRIC	Bowens Creek off Iverson Road		Station 16 Bowens Creek downstream Gilbert Road	
	6/19/13		8/1/18	
	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	23	1	21	0
NUMBER OF MAYFLY TAXA	1	0	1	-1
NUMBER OF CADDISFLY TAXA	4	1	4	0
NUMBER OF STONEFLY TAXA	2	1	1	0
PERCENT MAYFLY COMPOSITION	10.75	0	1.11	-1
PERCENT CADDISFLY COMPOSITION	12.54	0	2.59	-1
PERCENT DOMINANT TAXON	20.43	1	59.26	-1
PERCENT ISOPOD, SNAIL, LEECH	0.36	1	3.70	-1
PERCENT SURFACE AIR BREATHERS	0.72	1	0.74	1
TOTAL SCORE		6		-4
MACROINVERTEBRATE COMMUNITY RATING	EXCELLENT		ACCEPTABLE	