Manitowoc River Watershed
Baseline Survey 2005-2006

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SUMMARY

The Manitowoc River watershed is one of the largest watersheds in the Lakeshore basin and covers approximately 542 square miles draining parts of four counties. Agriculture is the predominant land use within the Manitowoc River Watershed. Within the sub-watersheds, agricultural land use ranges from 56% in the Lower Manitowoc River sub-watershed to a high of 70% in the Branch River sub-watershed.

Water resources in the basin include 62 streams that cover 330 miles. Many headwater streams can experience low or intermittent flows that limit the fish community that inhabits them. Larger streams may have poor water quality because of poor land use in the surrounding watershed. Northern pike and smallmouth bass are the dominant gamefish in basin streams, however the Lower Manitowoc River and the Branch River may experience seasonal runs of trout and salmon from Lake Michigan.

The purpose of the study described in this report was to measure environmental quality in streams located in the Manitowoc River Watershed by using the Hilsenhoff Biotic Index (HBI) for invertebrates and the Index of Biotic Integrity (IBI) for fish. By quantifying the type and number of fish species, macroinvertebrates and plants as well as evaluating the physical habitat of a stream, we can judge the quality of the stream and compare that stream to other streams across the state. These types of studies are also called biological monitoring or bioassessment.

Sampling locations for this study were randomly selected by computer and were divided into four strata: large coldwater streams, large warmwater streams, small coldwater streams and small warmwater streams. Survey locations began at the first upstream riffle above a road crossing and were 100 meters in length for small streams or in large streams 35 times the stream width. Sampling was completed during the summers of 2005 and 2006.

During this survey we captured 5,961 individual fish representing 35 species. The five most abundant species in order were carp, blacknose dace, common shiner, creek chub and central mudminnow. Although carp were the most common overall fish by number, carp were only captured at two locations.

The most common gamefish were smallmouth bass, largemouth bass and northern pike. The majority of smallmouth bass were captured on the Branch River and most of the northern pike were young of year fish captured in headwater locations.

Fish IBI ratings ranged from very poor at seven sites, poor at eight sites, fair at five sites, good at one site and excellent at one site. The IBI scores indicate that across this watershed, fish populations are generally poor. The lack of warm water gamefish was also very noticeable and was likely caused by swings in

dissolved oxygen level, lack of pool habitat or from periodic episodes of low water or flow.

We believe that the data collected shows that: low flow is a problem in some streams, there is a lack of variety in large scale habitat and bottom substrates, that shallow water in runs and riffles along with limited pool depth most likely limits the abundance of warm water gamefish such as smallmouth bass and northern pike in the watershed and that based on HBI and IBI scores, and dissolved oxygen levels it appears that water quality in the Manitowoc River Watershed, excluding the Branch River subwatershed, is generally poor and negatively impacts the biological communities that live there.

INTRODUCTION

The Manitowoc River watershed is one of the largest watersheds in the Lakeshore basin and covers approximately 542 square miles draining parts of four counties (Figure 1). Located in the southern quarter of the basin, the watershed can be divided into four main sub-watersheds, Lower Manitowoc River, North Branch of the Manitowoc River, South Branch of the Manitowoc River and the Branch River (WDNR 2001).

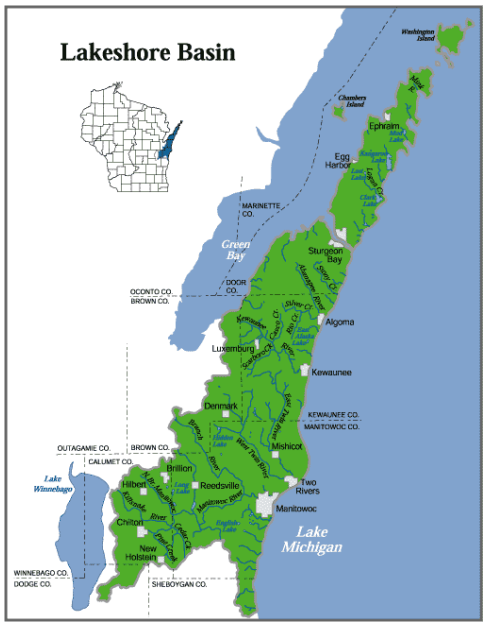


Figure 1. Map of the Lakeshore basin showing the location of the Manitowoc River Watershed.

Water drains from the Niagara Escarpment on the western edge of the watershed eastward toward Lake Michigan. The area reflects past glaciations with eastward dipping bedrock and soils that vary in composition and depth.

Bedrock in the basin is generally dolomite limestone that varies in depth from exposed to greater than 300 feet (DNR 1997). Areas in the Branch River sub-watershed also may have karst features that include sinkholes and fracture zones. Soils are dominated by reddish brown clays in the north and east, loams in the south-east and mineral soils in the central part of the basin. The large amount of clay soil found in this basin can be easily erodable and can negatively affect water quality in the basin.

Within the entire Manitowoc River watershed, agriculture is the predominant land use and is as well within each of the sub-watersheds (Table 1). Of the 346,472 acres in the basin, 215,917 acres (62.3%) are classified as agricultural, with woodlands the next most common land use at 15.8% (Table 1). Within the sub-

watersheds, agricultural land use ranges from 56% in the Lower Manitowoc River sub-watershed to a high of 70% in the Branch River sub-watershed.

Table 1. Land use acreage within the Manitowoc River Watershed by sub-watershed.

Land Use	Lower Manitowoc	North Branch	South Branch	Branch River	Total	Percent
Agriculture	59,211	33,607	74,931	48,168	215,917	62.3
Non-Cropland	12,063	8,117	14,003	2,949	37,132	10.7
Water and Wetlands	1,909	915	2,252	9,861	14,937	4.3
Woodlands	22,310	4,725	21,924	5,683	54,642	15.8
Other (Urban, Roads, etc)	10,846	3,237	7,850	1,911	23,844	6.9
Total	106,339	50,601	120,960	68,572	346,472	100

Water resources in the basin include 62 streams that cover 330 miles. Many headwater streams can experience low or intermittent flows that limit the fish community that inhabits them. Larger streams may have poor water quality because of poor land use in the surrounding watershed. Northern pike and smallmouth bass are the dominant gamefish in basin streams, however the Lower Manitowoc River and the Branch River may experience seasonal runs of trout and salmon from Lake Michigan.

The 13 lakes in the watershed have a total surface acreage of 446 acres. Most are small in size and shallow, although there are several lakes that are deep for their surface acreage. Poor water quality and poor fish communities occur in many basin lakes. Local lakes support bass and bluegill populations although some lakes are stocked with walleye. Most lakes are popular and can be heavily fished or used for other recreational purposes. There are several large wetlands in the basin that are managed to be beneficial for wildlife.

In the only comprehensive fish survey of the basin, Fago (1985) captured more than 18,000 individual fish representing 58 species (Table 2). His catch was dominated by white sucker, central mudminnow and common shiners. Fago also captured greater redhorse, a Wisconsin special concern fish.

Lower Manitowoc River Sub-watershed

The Lower Manitowoc River sub-watershed covers 106,339 acres and is almost (99.4%) entirely in Manitowoc County. Agriculture (55.7%) is the primary land use in this sub-watershed, followed by woodland (Table 3). Within this watershed there are 19 streams that cover 108 miles and two lakes (WDNR 2001).

Of the 88 miles of streams that are classified based on water quality, 58.5 miles are warm water sport fish streams (WWSF), 15.5 miles are warm water forage

fish streams (WWFF), 7 miles of Limited Aquatic Life streams (LAL), 6.5 miles of limited forage fisheries (LFF) and 0.5 miles of coldwater streams (COLD).

Table 2. Species list for the Manitowoc River watershed. An X denotes a species that was captured by either Fago (1985) or during this current survey 2005-2006.

COMMON NAME	SCIENTIFIC NAME	Fago Survey 1974-1983	Current Survey 2005-2006
American brook lamprey	*Lampetra appendix*	X	X
Rainbow trout	*Oncorhynchus mykiss*		X
Central mudminnow	*Umbra limi*	X	X
Northern pike	*Esox lucius*	X	X
Central stoneroller	*Campostoma anomalum*	X	
Largescale stoneroller	*Campostoma oligolepis*	X	X
Goldfish	*Carassius auratus*	X	
Common carp	*Cyprinus carpio*	X	X
Brassy minnow	*Hybognathus hankinsoni*		X
Hornyhead chub	*Nocomis biguttatus*	X	X
Golden shiner	*Notemigonus crysoleucas*	X	X
Emerald shiner	*Notropis atherinoides*	X	
Common shiner	*Luxilus cornutus*	X	X
Rosyface shiner	*Notropis rubellus*	X	X
Sand shiner	*Notropis stramineus*	X	X
Mimic shiner	*Notropis volucellus*	X	
Northern redbelly dace	*Phoxinus eos*	X	X
Southern redbelly dace	*Phoxinus erythrogaster*	X	X
Bluntnose minnow	*Pimephales notatus*	X	X
Fathead minnow	*Pimephales promelas*	X	X
Blacknose dace	*Rhinichthys atratulus*	X	X
Longnose dace	*Rhinichthys cataractae*	X	X
Creek chub	*Semotilus atromaculatus*	X	X
Pearl dace	*Margariscus margarita*	X	X
White sucker	*Catostomus commersoni*	X	X
Northern hog sucker	*Hypentelium nigricans*	X	
Silver redhorse	*Moxostoma anisurum*	X	
Golden redhorse	*Moxostoma erythrurum*	X	
Shorthead redhorse	*Moxostoma macrolepidotum*	X	
Greater redhorse	*Moxostoma valenciennesi*	X	X
Black bullhead	*Ameiurus melas*	X	X
Yellow bullhead	*Ameiurus natalis*	X	X
Brown Bullhead	*Ameiurus nebulosus*	X	X
Channel catfish	*Ictalurus punctatus*	X	X
Stonecat	*Noturus flavus*	X	X
Tadpole madtom	*Noturus gyrinus*	X	
Trout perch	*Percopsis omiscomaycus*	X	
Brook stickleback	*Culaea inconstans*	X	X
Rock bass	*Ambloplites rupestris*	X	X
Green sunfish	*Lepomis cyanellus*	X	X
Pumpkinseed	*Lepomis gibbosus*	X	X
Bluegill	*Lepomis macrochirus*	X	X
Smallmouth bass	*Micropterus dolomieu*	X	X
Largemouth bass	*Micropterus salmoides*	X	X
Iowa darter	*Etheostoma exile*	X	
Fantail darter	*Etheostoma flabellare*	X	
Johnny darter	*Etheostoma nigrum*	X	X
Yellow perch	*Perca flavescens*	X	
Logperch	*Percina caprodes*	X	
Blackside darter	*Percina maculata*	X	X
Mottled sculpin	*Cottus bairdi*	X	X

Table 3. Land use by county in the Lower Manitowoc River Sub-watershed.

Land Use	Calumet County	Manitowoc County	Total Acreage	Percent
Agriculture	416	58,795	59,211	55.7
Non-Cropland	31	12,032	12,063	11.3
Open Water and Wetlands	13	1,896	1,909	1.8
Woodland	67	22,243	22,310	21.0
Other	26	10,820	10,846	10.2
Total	**553**	**105,786**	**106,339**	**100**

Ten streams representing 20 miles have not been classified and have the default listing of WWSF.

The two lakes, Bullhead (67 acres) and Schisel (14 acres), are seepage lakes that are dominated by largemouth bass and bluegill.

Past evaluations of the fish communities and the water resources of this watershed have focused on the mainly on the Manitowoc River. Hogler (2000) reported a diverse community of fish captured in the lower Manitowoc River during spring fyke net surveys conducted in the early 1980's. The captured species were a mix of Lake Michigan and riverine species dominated by bullhead, rainbow trout, white sucker, trout-perch and carp. Surendonk (1996) during May electroshocking in the Manitowoc River above Clarks Mill Dam found a fish community that was dominated by carp, white sucker and bullhead. He also found northern pike pumpkinseed and yellow perch but in much lower abundance than other species.

Schultz (1970) surveyed Mud Creek above Collins Wildlife Area. He found a stream that had low flow and a marginal fish community that was dominated by bullhead, carp and minnows. He also found low numbers of northern pike, and panfish in upstream sections of the river.

There has been several documented fish kills in the Lower Manitowoc River Sub-watershed caused by manure, diel oxygen fluctuations, disease or solvents. A 1982 comprehensive water quality survey found that water quality in this watershed ranged from fair to very poor (Weisensel 1982).

Branch River Sub-watershed

The Branch River sub-watershed covers 68,572 acres and lays in Manitowoc County (61%) and Brown County (39%). Agriculture (70.1%) is the primary land use in this sub-watershed, followed by water and wetlands (Table 4). Within this watershed there are 10 streams that cover 61 miles and two lakes (WDNR 2001).

Table 4. Land use in the Branch River by county.

Land Use	Brown County	Manitowoc County	Total Acreage	Percent
Agriculture	18,786	29,382	48,168	70.1
Non-Cropland	1,150	1,799	2,949	4.3
Open Water and Wetlands	3,846	6,015	9,861	14.4
Woodland	2,216	3,467	5,683	8.3
Other	745	1,166	1,911	2.9
Total	**26,743**	**41,829**	**68,572**	**100**

Of the 44 miles of streams that have been classified, 31.5 miles are WWSF streams, 6.5 miles are coldwater streams and there are 5.5 miles of LFF streams. Seven streams covering 17 miles have not been formally classified and have the default classification of WWSF. In addition, the lower Branch River is classified as an Exceptional Water Resource (EWR).

The two lakes in the watershed, Hemptons and Kellners are small in size. There is no public access at either lake so little is known about their fishery. It is likely they are dominated by panfish and winterkill occasionally.

Many fish surveys have been conducted on the Branch River since 1960. Schultz (1960) and Threinen (1962) each noted low gamefish populations and attributed this to extensive pasturing of cattle in and near the Branch River that had led to erosion that filled in pool habitat. Smallmouth bass and northern pike were the dominant gamefish they captured. In addition to recommending a reduction in non-point source pollution, Schultz recommended selective use of chemicals to remove rough fish from the stream.

In a 1963 survey to document the effect of a habitat manipulation project, Schultz found that the rock bass population increased in number as well as in average size following the channel reconstruction. Little effect was noted for the smallmouth bass population. In a follow-up survey in 1967, Schultz evaluated the fishery following the loss of the rock habitat due to stream straightening caused by a bridge replacement project. He found that the smallmouth bass and rock bass populations had changed little since the previous survey and in addition, he captured several northern pike.

Belonger (1975) surveyed the lower section of the Branch River to assess the fish community. He captured a diverse assemblage of fish that was dominated by rock bass, smallmouth bass, common shiner, longnose dace and white sucker. He also noted abundant filamentous algae growing on the rocks. Peeters (1984) surveyed the same section of river that Belonger surveyed and noted extensive use of the Branch River by Lake Michigan trout and salmon.

While investigating a manure spill that resulted in a fish kill that devastated the lower nine miles of the Branch River, Hogler (1994) found thousands of dead fish and crayfish. Most fish were forage minnows, but a large number of dead smallmouth bass, northern pike, white sucker, and Chinook salmon were also noted.

North Branch of the Manitowoc River Sub-watershed

The North Branch of the Manitowoc River sub-watershed covers 50,601 acres and is located mainly in Calumet County (92%) with the remainder in Manitowoc County (8%). Agriculture (66.4%) is the primary land use in this sub-watershed, followed by non-croplands (Table 5). Within this watershed there are 11 streams that cover 45 miles and five lakes (WDNR 2001).

Table 5. Land use by county in the North Branch of the Manitowoc River Sub-watershed

Land Use	Calumet County	Manitowoc County	Total Acreage	Percent
Agriculture	30,835	2,772	33,607	66.4
Non-Cropland	7,808	310	8,117	16.0
Open Water and Wetlands	775	140	915	1.9
Woodland	4,070	655	4,725	9.3
Other	3,008	229	3,237	6.4
Total	**46,495**	**4,106**	**50,601**	**100**

Thirty-six miles of stream have been classified, with 20 miles classified as WWSF, 9 miles as WWFF and 7 miles as LAL. Four streams covering 9 miles have not been formally classified and have the default classification of WWSF.

The lakes range in size from 10 to 120 acres in size and have had water quality issues that have led to winterkills and other fish kills. A comprehensive survey of Long Lake in 1999 (Hogler 2000) found a fish community dominated by largemouth bass and bluegill and a large number of carp and bullhead.

Fisheries surveys in this sub-watershed have been limited to several on the main stem of the North Branch of the Manitowoc River and Spring Creek. Belonger (1974) surveyed the main North Branch and found a fish community dominated by carp and bullhead with few northern pike, largemouth bass and bluegill. He also noted a lack of stream invertebrates and attributed the poor water quality to a cheese factory.

In several surveys of Spring Creek, Schultz (1971), Belonger (1974) and Meyers (1982b) found a limited fish community dominated by carp, bullhead, white sucker and brook stickleback. Belonger also captured several goldfish in the stream. Very low numbers of gamefish and panfish were captured in any of the surveys. Each investigator noted that the stream had poor water quality, low flow and that many sections had been extensively ditched.

Gansberg (1997) did an extensive survey that focused on the water quality in the sub-watershed. She found that in the main stem North Branch, dissolved oxygen (D.O.) ranged from 5 to 10 ppm, temperature from 12 to 23 C and that phosphorus and ammonia levels were high. Water quality based on the invertebrate community was very poor. She also surveyed Spring Creek, Black Creek and Hilbert Creek and found that D.O. was low while nutrient levels and stream water temperatures were high. Each stream was judged to have poor to very poor water quality.

South Branch of the Manitowoc River Sub-watershed

The South Branch of the Manitowoc River sub-watershed covers 120,960 acres and is located in Calumet County (71.5%), Fond du Lac County (15.3%) and Manitowoc County (13.2%). Agriculture (61.9%) is the primary land use in this sub-watershed, followed by woodland (Table 6). Within this watershed there are 22 streams that cover 126 miles and three lakes (WDNR 2001).

Table 6. Land use by county in the South Branch of the Manitowoc River Sub-watershed

Land Use	Calumet County	Fond du Lac County	Manitowoc County	Total Acreage	Percent
Agriculture	54,823	13,279	6,829	74,931	61.9
Non-Cropland	12,153	472	1,378	14,003	11.6
Open Water and Wetlands	930	1,172	150	2,252	1.9
Woodland	12,648	2,298	6,978	21,924	18.1
Other	5,884	1,276	690	7,850	6.5
Total	**86,438**	**18,497**	**16,025**	**120,960**	

Forty-nine miles of stream have been classified, with 45 miles classified as WWSF, 3 miles as Cold and 1 mile as LAL. Nineteen streams covering 76 miles have not been formally classified and have the default classification of WWSF. Pine Creek, Jordan Creek and the South Branch of the Manitowoc River have been contaminated by PCB's and are currently being remediated. Fish in these streams have high levels of PCB in their flesh and should not be consumed.

Chilton and Hayton Millponds are impounded rivers that are shallow, have poor water quality and poor fisheries. The third lake, Mud Lake, is small and shallow with frequent winterkills.

Meyers (1982a) surveyed the South Branch of the Manitowoc River and found a variety of fish. His catch was dominated by white sucker, common shiner and creek chub. Northern pike, rock bass and carp were also commonly captured.

In a 1978 survey of the Killsnake River, Meyers (1978) found abundant rock bass, bullhead, young of year northern pike and forage minnows. Bottom habitat was cobble and gravel, but Meyers noted that soil and bank erosion had reduced

bank cover and widened the stream. Loss of bank cover and a wide, shallow channel combined with low flow resulted in very warm stream temperatures. Meyers believed that these conditions caused the fishery to be limited. Surendonk (2002) investigated a fish kill in the upper Killsnake and found that the manure spill had impacted the forage fish community of the river.

When Pine Creek was surveyed by Meyers (1977) he found a fish community that was dominated by creek chub and white sucker. He also captured a few small northern pike and sunfish. Meyers noted that electroshocking was difficult because of a soft, silt stream bottom.

Several surveys were conducted on Stony Creek to determine if it was capable of supporting a trout fishery (Dohrman 1946 and Schultz 1961). These studies documented cold stream temperatures and good habitat although Dohrman noted the lack of trees and Schultz noted the high amount of cattle pasturing in and near the stream. Both surveys captured northern pike, white sucker and creek chubs. Both assessed the stream as having a fair potential to support brook trout. Bougie (1997) assessed water quality and the fish community of Stony Brook. She found that the stream had good water quality, good habitat and excellent D.O. The fish she captured included northern pike, largemouth bass and forage minnows. Surendonk (2000) found similar species as Bougie, but also captured recently stocked brown trout.

Study Rationale

The purpose of the study described in this report was to measure environmental quality in streams located in the Manitowoc River Watershed by using the Hilsenhoff Biotic Index (HBI) for invertebrates and the Index of Biotic Integrity (IBI) for fish (Lyons 1992). By quantifying the type and number of fish species, macroinvertebrates and plants as well as evaluating the physical habitat of a stream, we can judge the quality of the stream and compare that stream to other streams across the state. These types of studies are also called biological monitoring or bioassessment.

METHODS

Sampling locations for this study were randomly selected by computer and were divided into four strata: large coldwater streams, large warmwater streams, small coldwater streams and small warmwater streams. Most of the streams within this watershed fell into one of the warmwater categories. If a primary stream site was judged to be a site that could not be surveyed, a secondary site in the same strata was selected. In addition to the randomly selected sites, two sites were chosen on the Lower Manitowoc River to address resource management concerns in the area.

Survey locations began at the first upstream riffle above a road crossing that was at least 10 times the mean stream width (MSW) away from a bridge. The end point of the survey location was determined by assessing MSW. For streams that had a MSW of less than 2.9 meters, the station length was 100 meters, for streams with a MSW of between 2.9 meters and 23 meters; the station length was 35 times the MSW and for streams with a MSW of greater that 23 meters the station was 800 meters in length. Transects within the sampling station were marked starting 1 MSW above the station starting point and then every three MSW thereafter following Wisconsin DNR wadable stream protocol (WDNR 2002). Data was collected at each station following standard procedures for water characteristics and large-scale channel and basin characteristics (Simonson et al. 1994). Variables include stream name, waterbody code, location, air and water temperature, dissolved oxygen, flow, channel size, transect size and spacing, gradient, order, distances between bends, riffles and pools and a generalized stream map. Gradient and sinuosity were determined by plotting starting and ending points using GIS and using measuring tools to determine the value of these variables. All sampling was conducted in 2005 and 2006 during the months of June through September for each survey year.

Discharge

Stream flow and depth were measured at 10 equally spaced locations along a transect at each sample site using a Swoffer current meter. Stream discharge in Cubic Meters per Second (CMS) was calculated by multiplying velocity by depth by the distance between measurement points, and then summing the products along the transect.

Habitat Assessment

Habitat along each of the 12 transects per site were evaluated using standard procedures (Simonson et al. 1994). The host of variables measured included depth and width parameters, bottom characteristics, plant growth, percent shading from vegetation, fish cover, streambank erosion and surrounding land use.

Biological Assessments

Biological assessment work included collecting stream invertebrates and fish. Collected invertebrates were sent to UW-Steven's Point for identification and calculation of the Hilsenhoff Biotic Index (HBI) which relates species diversity, abundance and pollution sensitivity to water quality. Invertebrate samples were collected following standard invertebrate collection procedures.

Fish were sampled using electrofishing gear during the summer. In small streams, a backpack shocker was used to capture fish, while in larger streams, a

stream shocker was used. DC current was used to capture the fish regardless of the gear type.

One upstream pass was made and all fish observed were collected with small nets. Fish were identified and the number of each species tallied. Unidentifiable fish were taken to the office to be identified. One gram of MS-222 per 5 gallons of water was used to anesthetize unidentified fish, which were then transferred into 10% formalin to be preserved for later identification and as a reference for future collections.

The Index of Biotic Integrity (IBI) based on the fish community at each sampling location was calculated. Similar to the HBI, IBI relates community structure to community health and water quality.

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen readings were taken with a YSI meter each visit to the stream to get a snapshot of the current condition of the stream. To get a better sense of stream condition, hobo samplers that measured continuous stream temperatures were also employed at selected stream locations.

RESULTS

Lower Manitowoc River Sub-watershed

Manitowoc River

Highway S

The survey site was located just upstream of County Highway S and was the site of the former Oslo Dam that failed in the 1960's and was completely removed in 1985 (N44.0994, W-087.8230 to N44.1007, W-087.8286). The survey section averaged 15.0 meters in width and was 510 meters in length. The Manitowoc River at this location is a sixth order stream with a gradient of 0.8 meters per kilometer and a sinuosity of 1 to 1.24. The study reach of the river ran through a meadow-shrub-woodland complex (Figure 2).

Figure 2. Looking upstream at the Manitowoc River just above County Highway S. This site was the mill pond of the former Oslo Dam.

Discharge

Water level was judged to be normal for the date of the survey and water clarity was rated turbid. Flow was measured at 0.574 cubic meters per second (CMS).

Habitat

The section of river sampled was mostly run, with one large riffle, several smaller riffles and a large pool at the end of the survey site. Fish cover consisted of mostly boulder in the deeper runs. Several transects had small areas of either large woody debris or undercut banks that provided additional fish habitat. There were 170.7 meters of riffle, 115 meters of pool and 260.1 meters of run in the survey section. Habitat feature length ranged from 17.5 meters to 72.7 meters for riffles, 30.9 meters to 103.4 meters for runs. The average length of a riffle was 42.7 meters, and runs had an average length of 65.0 meters.

The bottom sediments of this site were dominated by gravel or cobble although small patches of boulder were also encountered along several transects (Figure 3).

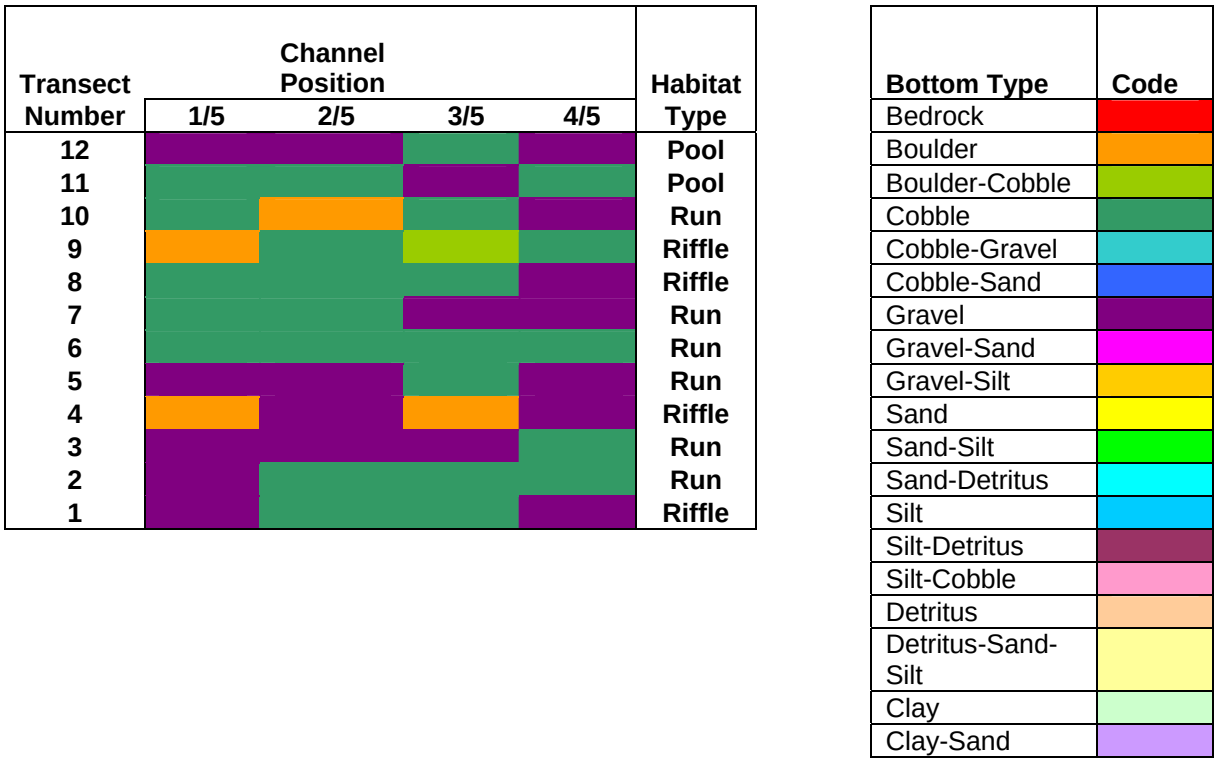


Figure 3. Bottom sediment map and key for the survey site upstream of Highway S on the Manitowoc River. Transect 1 is the furthest downstream sampling location.

Biological Assessments

Invertebrates were collected from a riffle at the downstream end of the station above Highway S. The sample produced a Hilsenhoff Biotic index of 5.708 indicating that water quality was fair. Of the 312 organisms identified, trichopterans dominated the sample (55.8%), followed by dipterans at 34.3%. Ephemeroptera (5.8%), tricladida (2.9%) and oligochates (1.2%) were minor components of the invertebrate sample. A single species of *Cheumatopsyche spp.* was the dominant organism in the sample.

The electroshocking assessment at this site captured 915 individual fish representing seventeen species in the 510 meters of river that was sampled (Table 7). This resulted in an IBI score of 20 and a rating of poor. Common carp and common shiner dominated the catch. Largemouth bass were the dominant gamefish captured although rock bass, pumpkinseed, smallmouth bass, northern pike and channel catfish were also captured. Largemouth bass ranged in length from 50 mm to 80 mm and had an average length of 65 mm. Average lengths for other measured fish were smallmouth bass-68 mm, rock bass-114 mm, pumpkinseed-98 mm and northern pike-225 mm.

During the habitat assessment visit to this site, a fish kill in progress was noted. The species that were observed dead during the assessment included redhorse, white sucker, stoneroller, and several species of shiner and dace. In addition to the dead fish, the water was very turbid. During the fish assessment visit the water was clear and no new dead fish were observed.

Table 7. The species mix and abundance of fish captured during electroshocking on the Manitowoc River at Highway S.

Species	Number
Common Carp	577
Common Shiner	246
Fathead Minnow	18
Largemouth Bass	16
Sand Shiner	14
Stonecat	13
Rock Bass	6
Yellow Bullhead	6
Creek Chub	4
Bluntnose Minnow	3
Pumpkinseed Sunfish	3
Smallmouth Bass	3
Northern Pike	2
Channel Catfish	1
Golden Shiner	1
Johnny Darter	1
Longnose Dace	1
Total	**915**

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen were measured each time we were at this location. During the habitat assessment visit on August 2, 2005, the air temperature was 23.2 C, the water temperature was 24.9 C, and the dissolved oxygen was 44% saturated at 3.61 mg/l. Two days later, the air temperature was 28.3 C, the water temperature was 29.9 C, and the dissolved oxygen was 114.5% saturated at 8.65 mg/l.

Highway W

The survey site was located just upstream of County Highway W (N44.0744, W-087.9774 to N44.0788, W-087.9856). The survey section averaged 41.3 meters in width and was 1080 meters in length. The Manitowoc River at this location has a stream order of six, a gradient of 0.07 meters per kilometer and a sinuosity of 1 to 1.53. The study reach of the river ran through 100% meadow (Figure 4).

Figure 4. Looking upstream from the starting riffle on the Manitowoc River just above Highway W.

Discharge

Water level was judged to be normal for the date of the survey and water clarity was rated turbid. Flow was 0.255 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled was mostly run, with one small riffle at the downstream end of the survey site. Shallow water (<20 cm) did not allow for fish cover to be measured at this location. This site consisted of 45 meters of riffle and 1,035 meters of run.

The bottom sediments of this site were dominated by silt and gravel (Figure 5). Several patches of sand or boulder were also encountered but in much lower frequency.

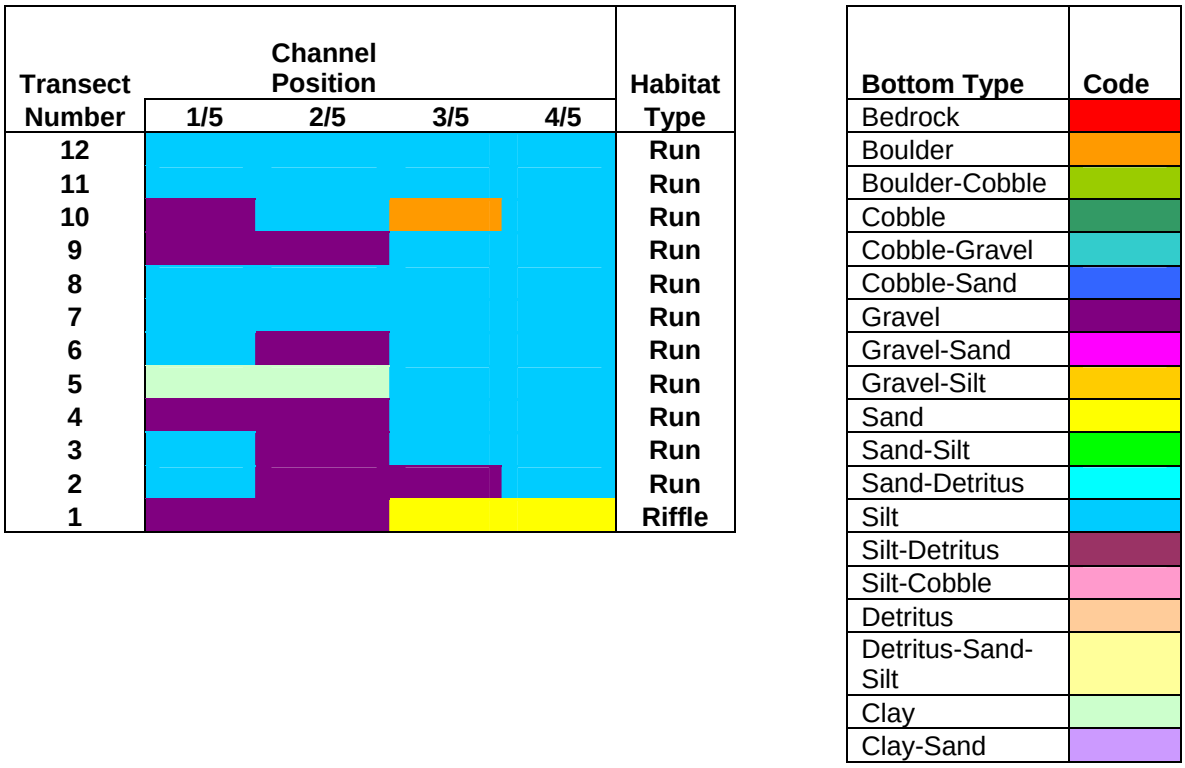


Figure 5. Bottom sediment map and key for the survey site upstream of Highway W on the Manitowoc River. Transect 1 is the furthest downstream sampling location.

Biological Assessments

The electroshocking assessment at this site captured 643 individual fish representing six species in the 1080 meters of river that was sampled (Table 8). This resulted in an IBI score of 0 and a rating of very poor. Common carp dominated the catch with substantially fewer individuals of other species captured. Most of the captured carp were judged to be young of year fish (Figure 6). Largemouth bass and pumpkinseed sunfish were the only gamefish captured during the survey.

Table 8. The species mix and abundance of fish captured during electroshocking on the Manitowoc River upstream Highway W.

Species	Number
Common Carp	579
Fathead Minnow	57
Golden Shiner	3
Pumpkinseed Sunfish	2
Largemouth Bass	1
Northern Redbelly Dace	1
Total	**643**

During the habitat assessment visit to this site we noted numerous dead fish. The species that were observed dead during the assessment included northern pike, common carp and fathead minnow. During the fish assessment visit, no dead fish were observed.

Figure 6. Young of year carp captured at Highway W during electroshocking on the Manitowoc River.

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen were measured at this location during the habitat assessment visit on August 1, 2005. At this time the air temperature was 23.5 C, the water temperature was 29.4 C, and the dissolved oxygen was 210.2% saturated at 16.02 mg/l.

Mud Creek (St. Nazianz)

Hwy 151

The survey site was located just upstream of State Highway 151 (N44.0365, W-087.9386 to N44.4351, W-087.9371). The survey section averaged 5.9 meters in width and was 210 meters in length. Mud Creek at this location is a fourth order stream with a gradient of 0.351 meters per kilometer and a sinuosity of 1 to 1.48. The study reach of the river ran through a meadow-woodland complex (Figure 7).

Figure 7. This upstream view of Mud Creek above Highway 151 is a typical sight for this section of Mud Creek.

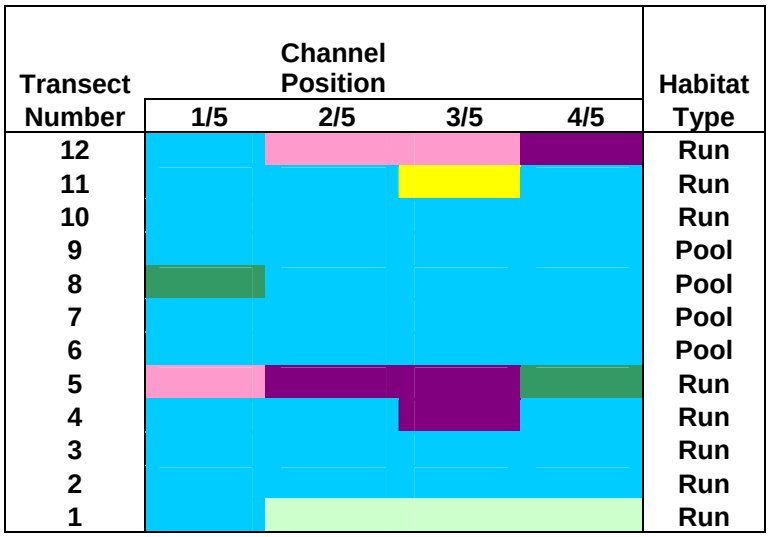
Discharge

Water level was judged to be normal for the date of the survey and water clarity was rated turbid. Flow was measured at 0.0 cubic meters per second (CMS) at this site, but there were visual signs of flow in the creek.

Habitat

The section of river sampled was mostly run, although one large pool was contained in the survey site. This site consisted of 160 meters of run and 51 meters of pool. The average length of the two runs was 80.0 meters. Fish cover was limited to overhanging vegetation found at several locations. Bare soil was common along most transects and bank erosion ranged from 0 to 60%. Sloughing banks and clumps of vegetation floating in the stream were noted at the three upstream transects.

The bottom sediments of this site were dominated by silt (Figure 8). Other bottom types, gravel, cobble or sand were also encountered but in much lower frequency.



Bottom Type	Code
Bedrock	
Boulder	
Boulder-Cobble	
Cobble	
Cobble-Gravel	
Cobble-Sand	
Gravel	
Gravel-Sand	
Gravel-Silt	
Sand	
Sand-Silt	
Sand-Detritus	
Silt	
Silt-Detritus	
Silt-Cobble	
Detritus	
Detritus-Sand-Silt	
Clay	
Clay-Sand	

Figure 8. Bottom sediment map and key for the survey site upstream of Highway 151 on Mud Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessments

The electroshocking assessment at this site captured 146 individual fish representing ten species in the 210 meters of river that was sampled (Table 9). This resulted in an IBI score of 19 and a rating of very poor. White sucker dominated the catch with substantially fewer central mudminnow, johnny darter and largemouth bass captured. Largemouth bass and northern pike were the only gamefish captured during the survey. The twelve bass ranged in length from 25 mm to 45 mm with an average length of 39 mm. It is likely these fish were young of year. The three northern pike ranged in length from 350 mm to 360 mm and had an average length of 357 mm.

Table 9. The species mix and abundance of fish captured during electroshocking on Mud Creek upstream of State Highway 151.

Species	Number
White Sucker	95
Central Mudminnow	12
Johnny Darter	12
Largemouth Bass	12
Brook Stickleback	4
Northern Pike	4
Fathead Minnow	3
Blackside Darter	2
Black Bullhead	1
Creek Chub	1
Total	146

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen were measured at this location during the habitat assessment visit on June 29, 2005 and with a continuous monitor from July through October.

At the time of the habitat assessment the air temperature was 20.3 C, the water temperature was 20.7 C, and the dissolved oxygen was 50.0% saturated at 4.54 mg/l.

A continuous water temperature meter was placed in Mud Creek just downstream of the Hwy 151 bridge. Water temperature ranged from 44 to 80ºF between July 6 and October 18, 2005. The average water temperature during this period was 65ºF.

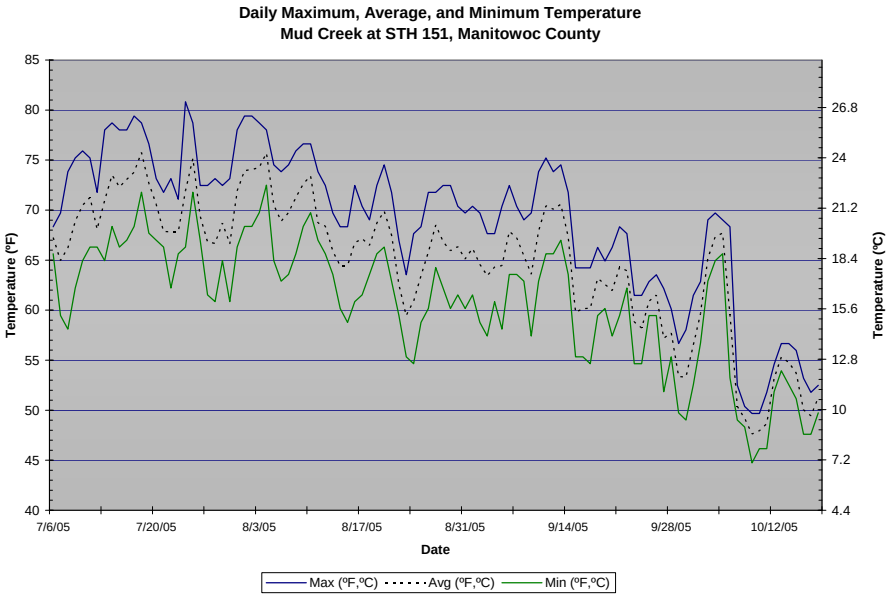


Figure 9. Continuous water temperature readings on Mud Creek from July through October 2005.

Tompkins Road

The survey site was located just upstream of Tompkins Road (N44.0358, W-087.9121 to N44.0361, W-087.9108). The survey section averaged 2.2 meters in width and was 102 meters in length. Mud Creek at this location is a third order stream with a gradient of 1.547 meters per kilometer and a sinuosity of 1 to 1.12. The study reach of the river ran through a meadow-shrub complex with mowed lawn also present (Figure 10).

Figure 10. This upstream view of Mud Creek above Tompkins Road was a typical sight for this section of Mud Creek.

Discharge

Water level was judged to be normal for the date of the survey and water clarity was rated clear. Flow was measured at 0.001 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled had a mixture of habitat features but was dominated by runs. This site consisted of 12.6 meters of riffle, 16.8 meters of pool and 71.9 meters of run. Riffles ranged in length from 2.3 meters to 3.7 meters with an average length of 3.2 meters. Pools ranged in length from 3.4 meters to 13.4 meters and had an average length of 8.4 meters. Runs were longer in length and ranged from 3.4 meters to 39.0 meters in length with an average run length of 14.4 meters. Fish cover was limited to overhanging vegetation and macrophytes found at several locations. Bare soil was common along most transects and bank erosion ranged from 0 to 40%.

The bottom sediments of this site were dominated by gravel (Figure 11). Other bottom types, such as cobble, sand or clay were also encountered but in much lower frequency.

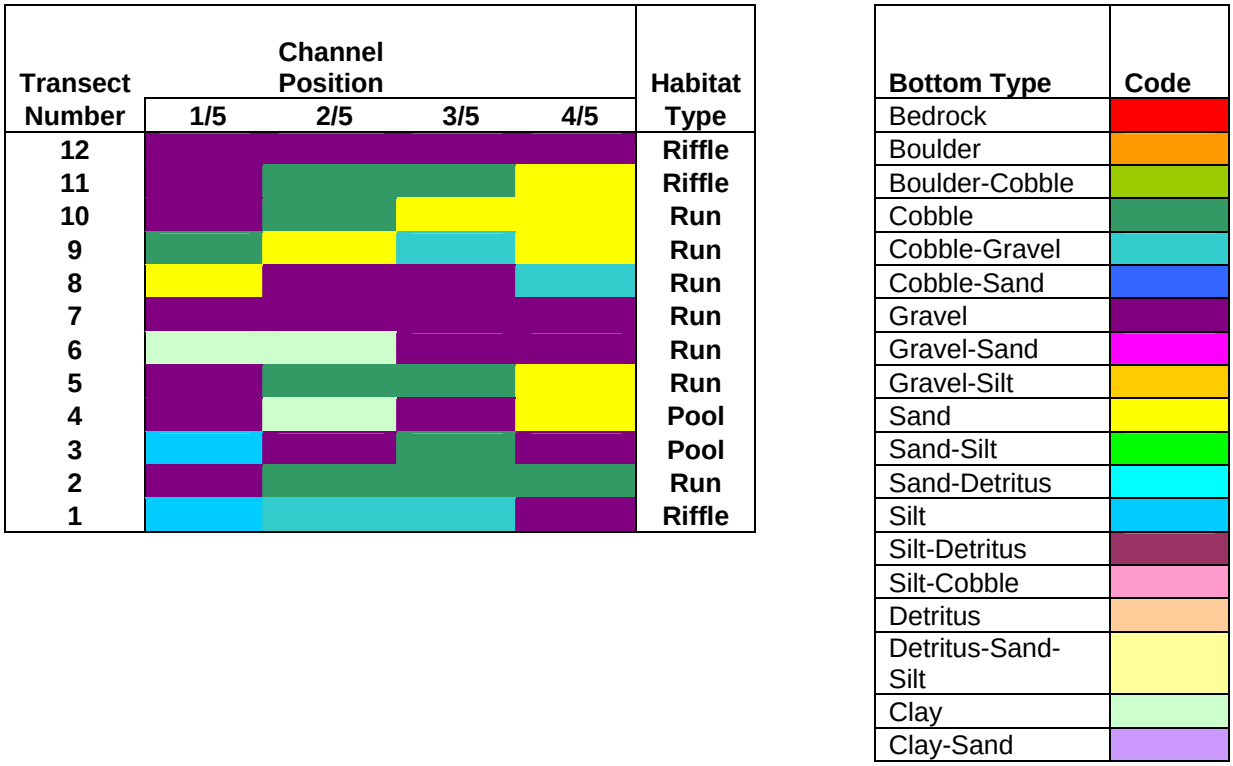


Figure 11. Bottom sediment map and key for the survey site upstream of Tompkins Road on Mud Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessments

The electroshocking assessment at this site captured 178 individual fish representing seven species in the 200 meters of river that was sampled (Table 10). This resulted in an IBI score of 9 and a rating of very poor. Creek chub, central mudminnow and white sucker dominated the catch with substantially fewer fish of other species captured.

Table 10. The species mix and abundance of fish captured during electroshocking on Mud Creek upstream Tompkins Road.

Species	Number
Creek Chub	77
Central Mudminnow	50
White Sucker	35
Fathead Minnow	6
Blackside Darter	5
Johnny Darter	4
Blacknose Dace	1
Total	178

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen were measured at this location during the habitat assessment visit on June 27, 2005.

At the time of the habitat assessment, the air temperature was 24.0 C, the water temperature was 23.2 C, and the dissolved oxygen was 92.2% saturated at 7.87 mg/l.

Unnamed Tributary- Greendale Road

The survey site was located just upstream of Greendale Road (N44.0264, W-087.9425 to N44.0270, W-087.9434). The survey section averaged 1.8 meters in width and was 100 meters in length. The unnamed tributary of Mud Creek at this location is a third order stream with a gradient of 0.351 meters per kilometer and a sinuosity of 1 to 1.06. The study reach of the river ran through a meadow-shrub complex (Figure 12).

Figure 12. This view of the unnamed tributary to Mud Creek above Greendale Road that was surveyed was a typical of this creek section.

Discharge

Water level was judged to be normal for the date of the survey and water clarity was rated turbid. Flow was measured at 0.002 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled was one long run. Fish cover was limited to overhanging vegetation that was noted at several locations. Bare soil was common along most transects and bank erosion ranged from 0 to 60%.

The bottom sediments of this site were dominated by sand, clay or silt (Figure 13). Gravel was the other substrate type encountered but was limited to small areas of the stream bottom.

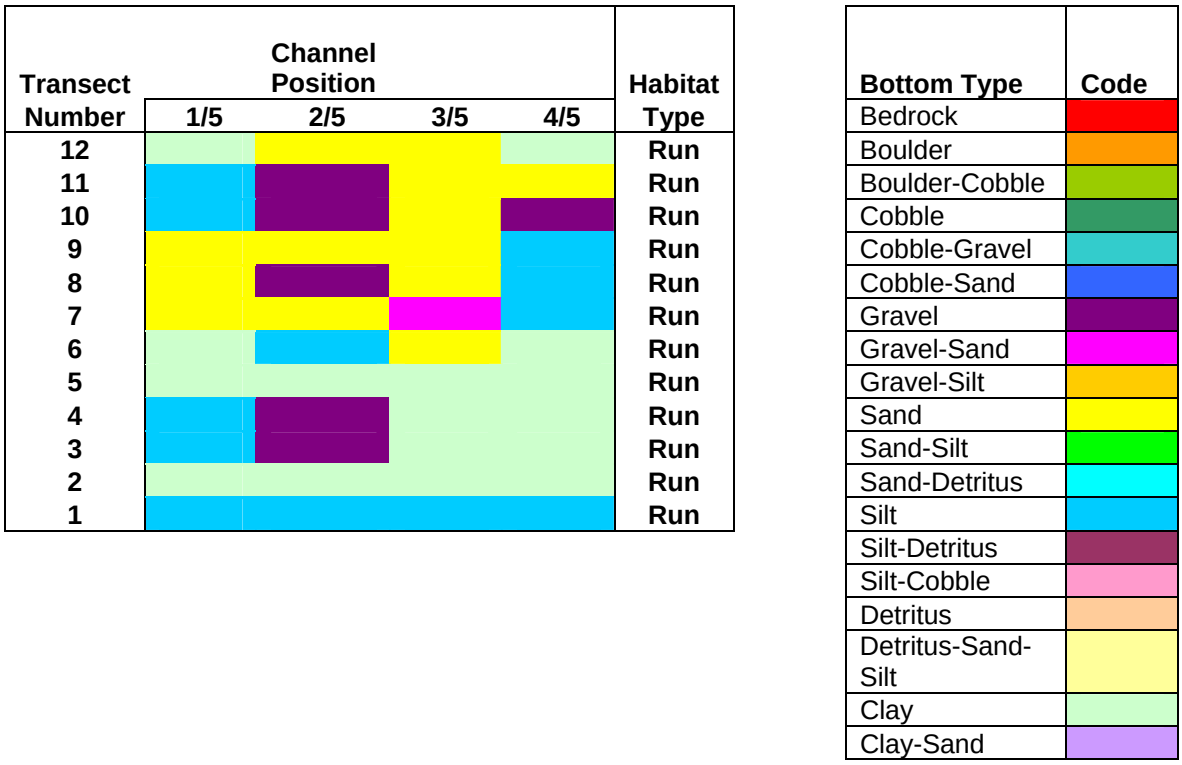


Figure 13. Bottom sediment map and key for the survey site upstream of Greendale Road on an unnamed tributary of Mud Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessments

The electroshocking assessment at this site captured 221 individual fish representing five species in the 100 meters of river that was sampled (Table 11). This resulted in an IBI score of 11 and a rating of very poor, however this result should be viewed cautiously as mean stream width was less than 2.5 meters so IBI scores may not accurately reflect the fish community of the stream. Central mudminnow, white sucker and creek chub dominated the catch with substantially fewer johnny darter and fathead minnow captured.

Table 11. The species mix and abundance of fish captured during electroshocking on an unnamed tributary to Mud Creek upstream of Greendale Road.

Species	Number
Central Mudminnow	103
White Sucker	63
Creek Chub	47
Johnny Darter	5
Fathead Minnow	3
Total	221

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen were measured at this location during the habitat assessment visit on June 27, 2005.

At the time of the habitat assessment, the air temperature was 28.7 C, the water temperature was 24.0 C, and the dissolved oxygen was 81.0% saturated at 6.87 mg/l.

Mud Creek (Reedsville)

Menasha Street

The survey site was located just upstream of Menasha Street in the village of Reedsville (N44.1543, W-087.9540 to N44.1552, W-087.9557). The survey section averaged 4.6 meters in width and was 170 meters in length. Mud Creek at this location is a third order stream with a gradient of 1.645 meters per kilometer and a sinuosity of 1 to 1.31. The study reach of the river ran through an urban setting that was 100% developed (Figure 14).

Figure 14. The urbanized stream corridor of Mud Creek as it flows through Reedsville.

Discharge

Water level was judged to be normal for the date of the survey and water clarity was rated turbid. Flow was measured at 0.002 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled was a mixture of riffles pools and runs although the surveyed section of creek was dominated by pool. Riffles ranged in length from 1.0 meter to 5.8 meters, pools ranged in length from 3.7 meters to 118 meters and the single run was 15.5 meters in length. An average riffle was 3.0 meters in length and the average pool was 34.2 meters in length. Fish cover was limited to aquatic marcophytes and boulder. Bare soil was common along most transects but bank erosion was slight.

The bottom sediments at this site were dominated by silt in downstream sections, sand or gravel in middle sections and cobble in upper sections (Figure 15). Boulder (rip-rap) or clay were also observed but in much lower frequency.

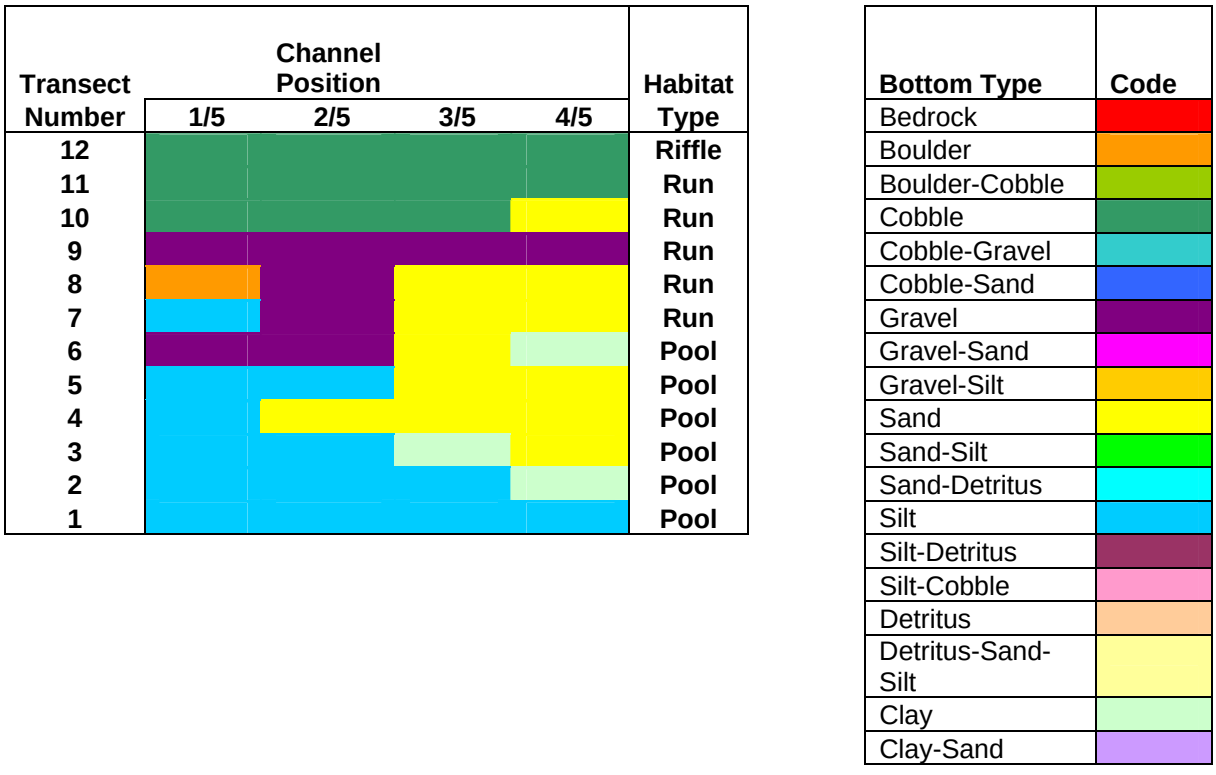


Figure 15. Bottom sediment map and key for the survey site upstream of Menasha Street on Mud Creek in the village of Reedsville. Transect 1 is the furthest downstream sampling location.

Biological Assessments

The electroshocking assessment at this site captured 139 individual fish representing nine species in the 170 meters of river that was sampled (Table 12). This resulted in an IBI score of 20 and a rating of poor. Central mudminnow dominated the catch with substantially fewer northern pike and green sunfish captured.

Table 12. The species mix and abundance of fish captured during electroshocking on Mud Creek upstream Menasha Street in Reedsville.

Species	Number
Central Mudminnow	115
Northern Pike	7
Green Sunfish	5
Creek Chub	3
White Sucker	3
Brown Bullhead	2
Johnny Darter	2
Black Bullhead	1
Bluegill	1
Total	139

The northern pike that were captured ranged in length from 260 mm to 312 mm with an average length of 286 mm. The five green sunfish ranged in length from 70 mm to 120 mm and had an average length of 90 mm.

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen were measured at this location during the habitat assessment visit on June 30, 2005 and with a continuous monitor from July through October.

At the time of the habitat assessment, the air temperature was 19.4 C, the water temperature was 19.4 C, and the dissolved oxygen was 28.1% saturated at 2.60 mg/l.

A continuous temperature monitor was placed in Mud Creek at Goodwin Road, approximately two kilometers downstream of the survey station. The continuous water temperature monitor showed that water temperature ranged from 43F to 85ºF from July 19 to October 18, 2005 (Figure 16). The average water temperature during this time period was 66ºF.

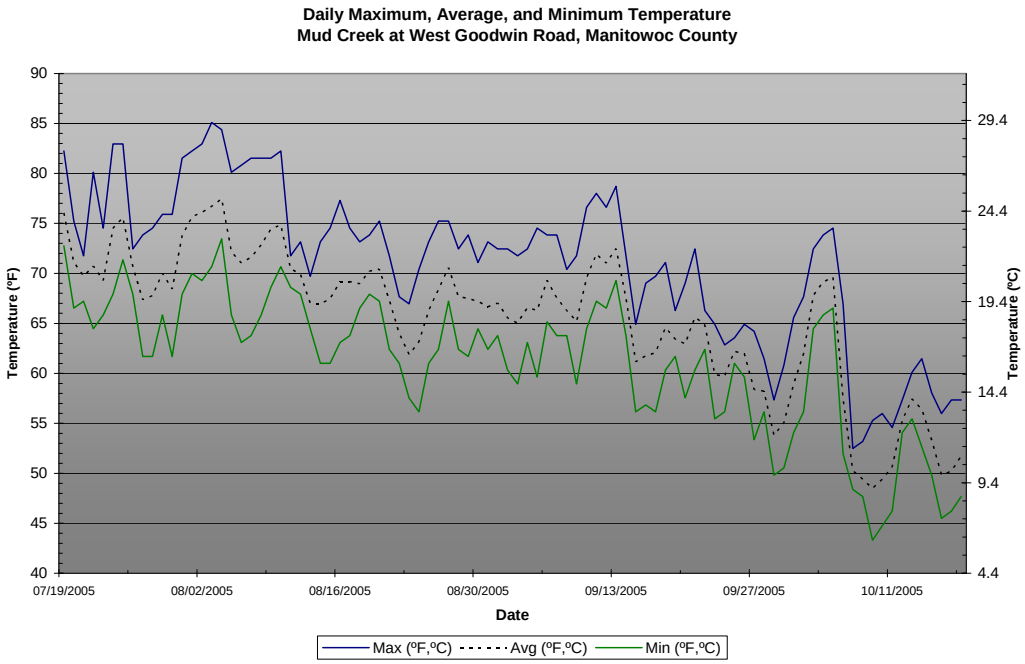


Figure 16. Continuous stream temperature readings above Goodwin Road on Mud Creek, July through October 2005.

County K

The survey site was located just upstream of County K (N44.2258, W-087.9783 to N44.2259, W-087.9795). The survey section averaged 1.96 meters in width and was 100 meters in length. Mud Creek has a stream order of two at this location, a gradient of 0.611 meters per kilometer and a sinuosity of 1 to 1.148. The study reach of the river ran through a meadow-shrub-woodland complex (Figure 17). Upper sections of the stream at this survey site were found in the roadside ditch of County K.

Figure 17. Looking upstream at Mud Creek above County Highway K. The bare soil, duckweed and low water was common throughout the surveyed section of river.

Discharge

Water level was judged to be normal for the date of the survey and water clarity was rated clear. Flow was measured at 0.0 cubic meters per second (CMS) and no visual flow was noted at this site.

Habitat

The section of river sampled was one long run that was 100 meters in length. Water was found in the lower and upper sections of this site, while the middle section was dry. Fish cover was not measured at this location because of shallow water (<200 mm). Bare soil was common along most transects but bank erosion was slight and covered less than 10% of the stream bank.

The bottom sediments at this site were dominated by silt (Figure 18). Clay or silt-cobble substrates were also observed but in much lower frequency.

Transect Number	Channel Position 1/5	2/5	3/5	4/5	Habitat Type
12					Run
11					Run
10					Run
9					Run
8					Run
7					Run
6					Run
5					Run
4					Run
3					Run
2					Run
1					Run

Bottom Type	Code
Bedrock	
Boulder	
Boulder-Cobble	
Cobble	
Cobble-Gravel	
Cobble-Sand	
Gravel	
Gravel-Sand	
Gravel-Silt	
Sand	
Sand-Silt	
Sand-Detritus	
Silt	
Silt-Detritus	
Silt-Cobble	
Detritus	
Detritus-Sand-Silt	
Clay	
Clay-Sand	

Figure 18. Bottom sediment map and key for the survey site upstream of County K on Mud Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessments

Invertebrates were not collected from this location because the stream was dry at the time of sampling.

The electroshocking assessment at this site captured 40 individual fish representing four species in the 100 meters of river that was sampled (Table 13). This resulted in an IBI score of 10 and a rating of very poor, however this result should be viewed cautiously as mean stream width was less than 2.5 meters so IBI scores may not accurately reflect the fish community of the stream. Central mudminnow dominated the catch with substantially fewer northern pike, brook stickleback and black bullhead captured during electroshocking.

Table 13. The species mix and abundance of fish captured during electroshocking on Mud Creek upstream of Highway K.

Species	Number
Central Mudminnow	28
Northern Pike	6
Brook Stickleback	5
Black Bullhead	1
Total	40

The northern pike that were captured ranged in length from 80 mm to 126 mm and had an average length of 95 mm.

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen were measured at this location during the habitat assessment visit on June 30, 2005.

At the time of the habitat assessment, the air temperature was 21.5 C, the water temperature was 23.0 C, and the dissolved oxygen was 33.3% saturated at 3.0 mg/l.

Unnamed Tributary- County Highway W

The survey site was located just upstream of County W (N44.1448, W-087.9636 to N44.1451, W-087.9647). The survey section averaged 1.6 meters in width and was 100 meters in length. The unnamed tributary to Mud Creek at this location has a stream order of three, a gradient of 4.86 meters per kilometer and a sinuosity of 1 to 1.03. The study reach of the river ran through 100% meadow (Figure 19).

Figure 19. Looking upstream through a dense stand of reed canary grass on an unnamed tributary of Mud Creek above County Highway W. The dense reed canary grass was common throughout the survey site.

Discharge

Water level was judged to be normal for the date of the survey and water clarity was rated clear. Flow was measured at 0.0 cubic meters per second (CMS) and no visual flow was noted at this site.

Habitat

The section of river sampled contained a mixture of riffles, runs and pools with 29.0 meters of riffle, 35.6 meters of pool and 35.4 meters of run. The length of habitat features ranged from 1.5 meters to 4.0 meters for riffles, 3.1 meters to 10.9 meters for pools and 3.0 meters to 9.0 meters for runs. Average length for these features were 2.7 meters, 5.9 meters and 5.1 meters for riffles, pools and runs respectively. Fish cover was not measured at this location because of shallow water (<200 mm). Bare soil was common along most transects and bank erosion ranged from 0 to 20%.

The bottom sediments at this site were dominated by gravel (Figure 20). Cobble, silt or clay was also observed but in much lower frequency.

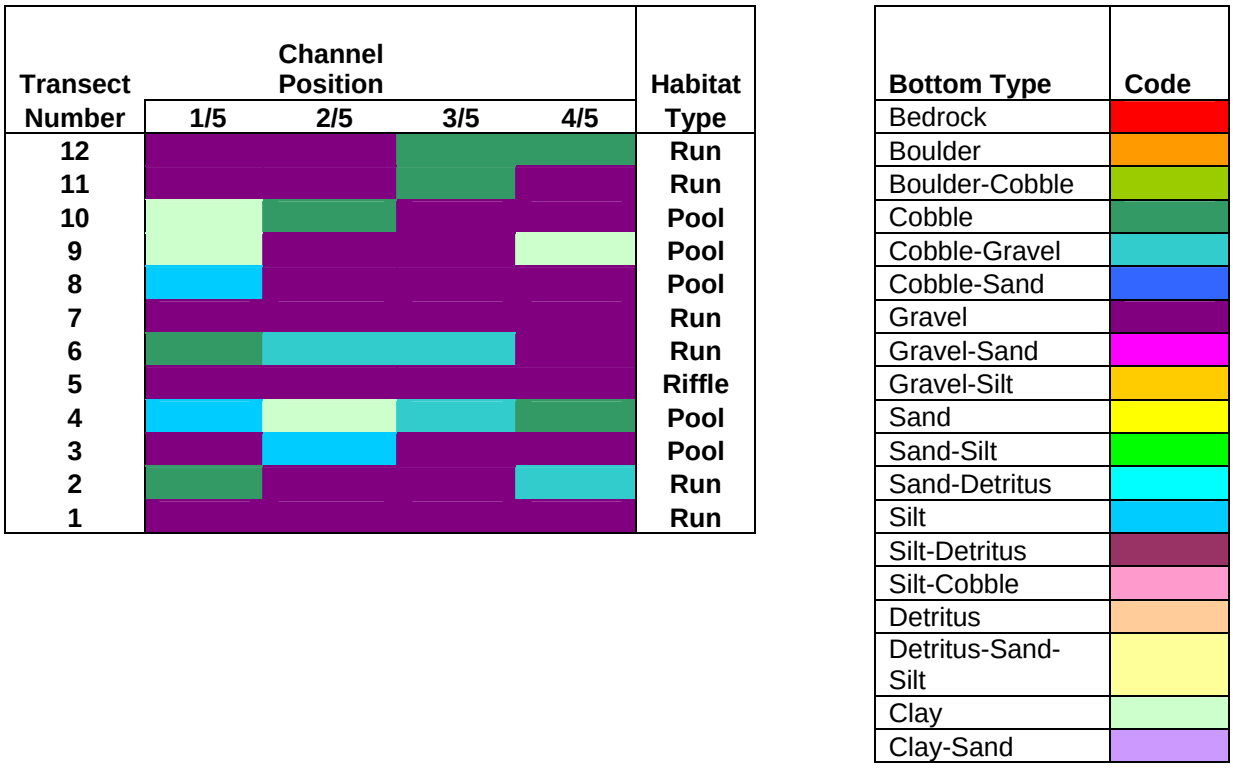


Figure 20. Bottom sediment map and key for the survey site upstream of County W on an unnamed tributary of Mud Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessments

The electroshocking assessment at this site captured 52 individual fish representing five species in the 100 meters of river that was sampled (Table 14). This resulted in an IBI score of 19 and a rating of very poor, however this result should be viewed cautiously as mean stream width was less than 2.5 meters so IBI scores may not accurately reflect the fish community of the stream. Central mudminnow dominated the catch with substantially fewer fish of other species captured during electroshocking.

Table 14. The species mix and abundance of fish captured during electroshocking on an unnamed tributary to Mud Creek upstream of Highway W.

Species	Number
Central Mudminnow	37
Creek Chub	6
Green Sunfish	6
Fathead Minnow	2
Brook Stickleback	1
Total	52

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen were measured at this location during the habitat assessment visit on June 29, 2005.

At the time of the habitat assessment, the air temperature was 21.5 C, the water temperature was 20.4 C, and the dissolved oxygen was 89.1% saturated at 8.11 mg/l.

Branch River Sub-watershed

Branch River

Danmar Road

The survey site was located just upstream of Danmar Road (N44.1640, W-087.7801 to N44.1674, W-087.7822). The survey section averaged 13.0 meters in width and was 442 meters in length. The Branch River at this location has a gradient of 1.583 meters per kilometer, a sinuosity of 1 to 1.43 and is a fourth order stream. The study reach of the river ran through a mainly a meadow-woodland complex, although shrubs, wetland and lawn riparian land uses were also encountered (Figure 21).

Figure 21. An upstream view of the Branch River from Danmar Road.

Discharge

Water level was judged to be normal for the date of the survey and water clarity was rated clear. Flow was 0.147 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled contained a nearly equal mixture of riffle, pool and run although runs were more common than the other habitat features. There were 126 meters of riffle, 122 meters of pool and 195 meters of run in the survey section. Habitat feature length ranged from 5 meters to 32 meters for riffles, 11 meters to 39 meters for pools and 9 meters to 37 meters for runs. The average length of a riffle was 15.8 meters, 24.4 meters for pools and runs had an average length of 15 meters.

The bottom sediments of this site were dominated by gravel or cobble (Figure 22). Several patches of sand or boulder were also encountered but in much lower frequency.

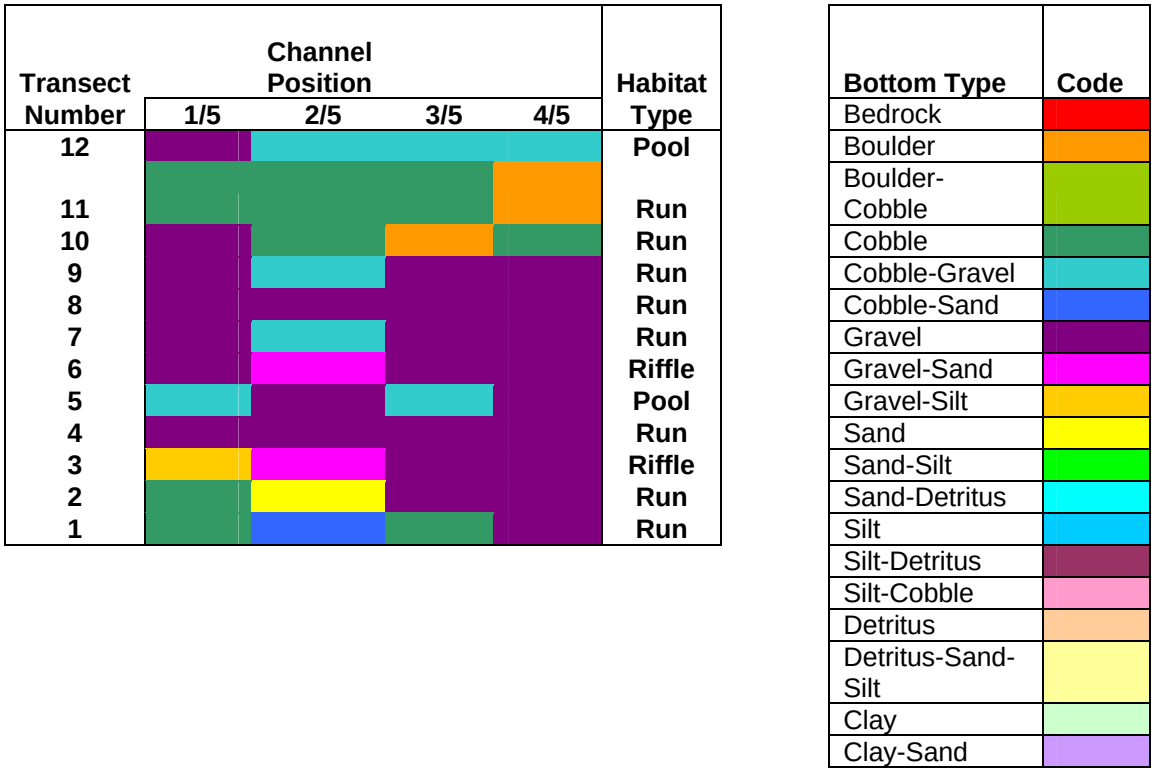


Figure 22. Bottom sediment map and key for the survey site upstream of Danmar Road on the Branch River. Transect 1 is the furthest downstream sampling location.

Biological Assessments

Invertebrates were collected from this site at the first upstream riffle above Danmar Road. The data collected indicated that the Biotic Index for this site was 4.647 which is indicative of good water quality. The sampled invertebrate community was dominated by coleopterans (39.2%) and ephemeropterans (32.4%). Other groups of invertebrates included trichoptera (13.5%), diptera

(10.1%), oligochates (2.7%), and amphipods, nematods and pelecypods each at 0.7%. Elmidae beetles were the most common organism in the sample.

The electroshocking assessment at this site captured 902 individual fish representing fifteen species in the 455 meters of river that was sampled (Table 15). This resulted in an IBI score of 47 and a rating of fair. Common shiner and hornyhead chub dominated the catch with substantially fewer rosyface shiner, johnny darter and fish of other species captured during electroshocking.

The 38 smallmouth bass that were captured ranged in length from 42 mm to 292 mm and had an average length of 134 mm. It appears from the length frequency that several year classes of bass were present in the sample (Figure 23).

Table 15. The species mix and abundance of fish captured during electroshocking on the Branch River upstream of Danmar Road.

Species	Number
Common Shiner	357
Hornyhead Chub	312
Rosyface Shiner	71
Johnny Darter	56
Smallmouth Bass	38
Longnose Dace	31
White Sucker	13
Fathead Minnow	8
Largescale Stoneroller	5
Blacknose Dace	3
Creek Chub	3
Stonecat	2
Blackside Darter	1
Green Sunfish	1
Northern Redbelly Dace	1
Total	**902**

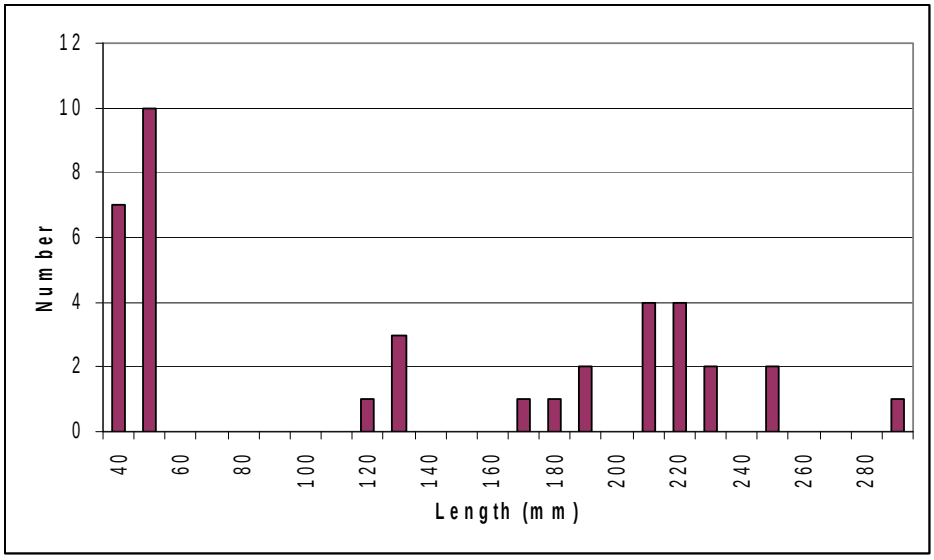


Figure 23. Length frequency of smallmouth bass captured during electroshocking on the Branch River.

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen were measured at this location during the habitat assessment visit on July 7, 2005 and stream temperature was monitored with a continuous monitor from July through October 2005.

At the time of the habitat assessment, the air temperature was 20.5 C, the water temperature was 19.9 C, and the dissolved oxygen was 117.4% saturated at 10.76 mg/l.

A continuous water temperature meter was placed in the Branch River at the bridge on Danmar Road and operated from July 6 to October 18, 2005 (Figure 24). During this period, stream water temperature ranged from 55 to 87ºF with an average temperature of 71ºF.

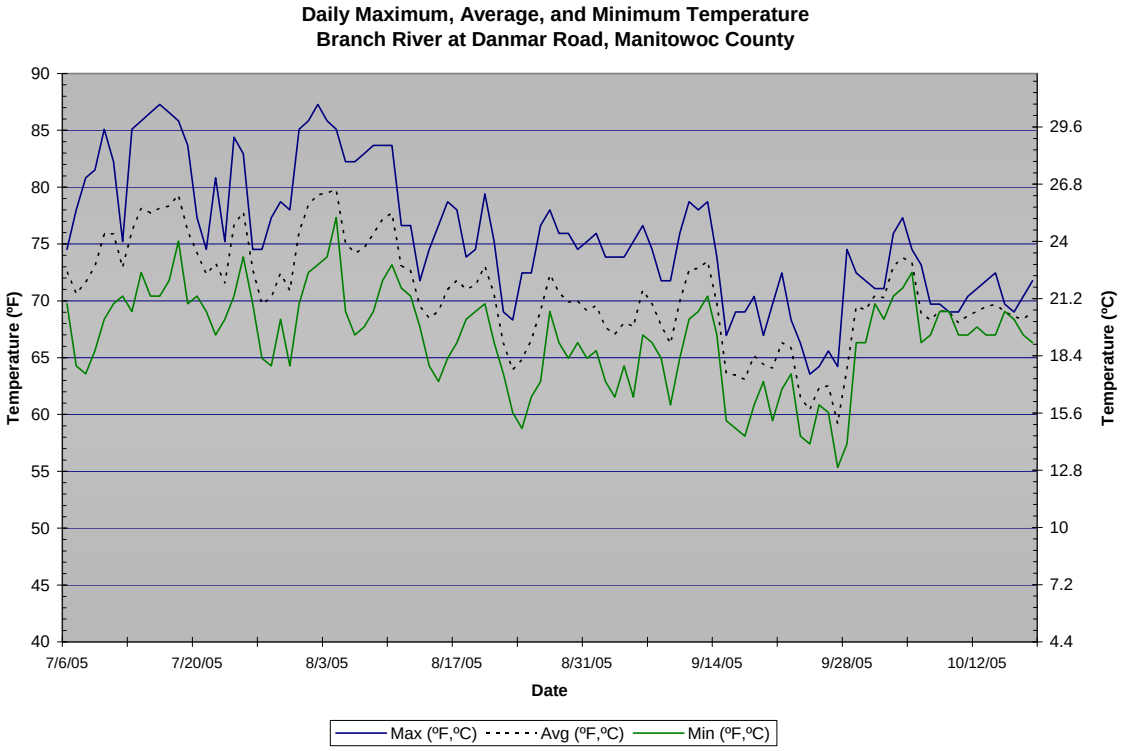


Figure 24. Continuous stream temperature readings of the Branch River at Danmar Road during July through October 2005.

Morrison Road

The survey site was located just upstream of Morrison Road (N44.3206, W-087.9886 to N44.3209, W-087.9894). The survey section averaged 1.6 meters in width and was 100 meters in length although water was found in only the first 68 meters of the survey site. The Branch River at this location is a third order stream with a gradient of 1.28 meters per kilometer and a sinuosity of 1 to 1.02. The study reach of the river ran through a mainly a meadow-woodland complex (Figure 25).

Figure 25. An upstream view of the Branch River from Morrison Road.

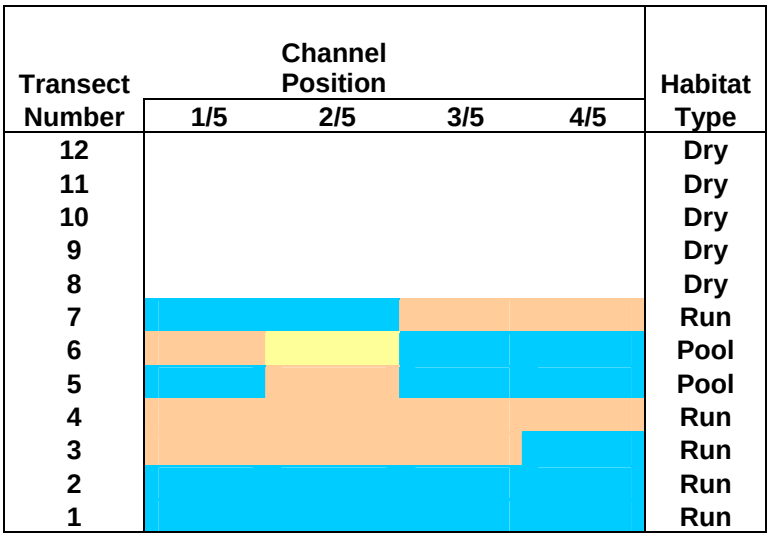
Discharge

Water level was judged to be below normal by at least 0.1 meter for the date of the survey and water clarity was rated clear. Flow was not measurable at this site and no visual signs of flow were noted.

Habitat

The section of river sampled was dominated by runs and contained only a single pool. There were 12.1 meters of pool and 56.3 meters of run in the survey section. Habitat feature length ranged from 3.6 meters to 26.6 meters for runs and the average run was 14.1 meters in length. Bare soil was common throughout the survey site.

The bottom sediments of this site were dominated by clay or silt (Figure 26). Hard substrates were not present at this survey location.



Bottom Type	Code
Bedrock	
Boulder	
Boulder-Cobble	
Cobble	
Cobble-Gravel	
Cobble-Sand	
Gravel	
Gravel-Sand	
Gravel-Silt	
Sand	
Sand-Silt	
Sand-Detritus	
Silt	
Silt-Detritus	
Silt-Cobble	
Detritus	
Detritus-Sand-Silt	
Clay	
Clay-Sand	

Figure 26. Bottom sediment map and key for the survey site upstream of Morrison Road on the Branch River. Transect 1 is the furthest downstream sampling location. The stream was dry from Transect 8 upstream to the end of the survey site.

Biological Assessments

The electroshocking assessment at this site captured 308 individual fish representing three species in the 52 meters of river that was sampled (Table 16). This resulted in an IBI score of 86 and a rating of excellent, however this result should be viewed cautiously as mean stream width was less than 2.5 meters so IBI scores may not accurately reflect the fish community of the stream. Brook stickleback dominated the catch with substantially fewer fathead minnow and white sucker captured during electroshocking.

Table 16. The species mix and abundance of fish captured during electroshocking on the Branch River upstream of Morrison Road.

Species	Number
Brook Stickleback	300
Fathead Minnow	5
White Sucker	3
Total	**308**

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen were measured at this location during the habitat assessment visit on July 12, 2005.

At the time of the habitat assessment, the air temperature was 23.9 C, the water temperature was 13.3 C, and the dissolved oxygen was 79.9% saturated at 8.36 mg/l.

Unnamed Tributary- Grimms Road

The survey site was located on an unnamed tributary to the Branch River just upstream of Grimms Road (N44.2349, W-087.9009 to N44.2350, W-087.9015). The survey section averaged 2.5 meters in width and was 100 meters in length. The unnamed tributary at this location is a second order stream with a gradient of 1.33 meters per kilometer and a sinuosity of 1 to 1.43. The study reach of the river ran through a mainly a shrub-woodland complex although meadow was also encountered in the survey site (Figure 27).

Figure 27. An upstream view of the unnamed tributary to Branch River from Grimms Road showing a typical view of the stream.

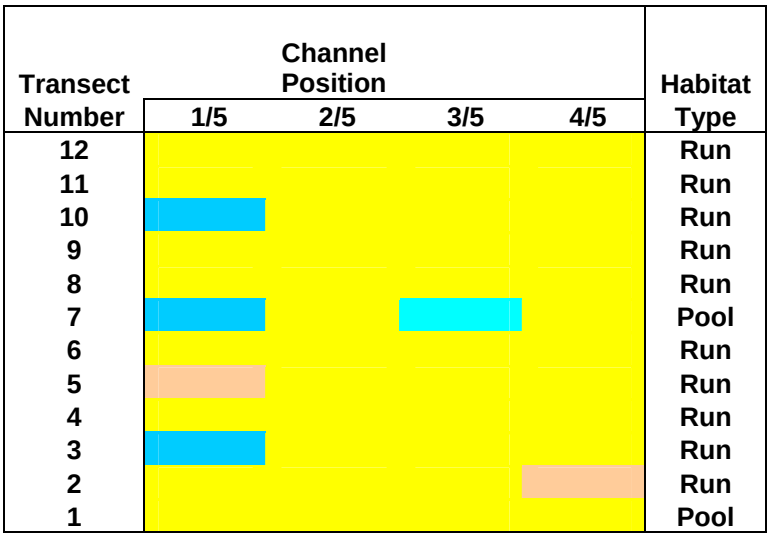
Discharge

Water level was judged to be normal for the date of the survey and water clarity was rated clear. Flow was 0.5 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled contained runs and pools. There were 38.5 meters of pool and 54.2 meters of run in the survey section. Habitat feature length ranged from 12.2 meters to 26.3 meters for pools and from 10.6 meters to 29.6 meters for runs. The average pool length was 19.3 meters and the average run was 18.1 meters in length. Bare soil was common throughout the survey site and erosion of stream banks ranged from 0 to 20%.

The bottom sediments of this site were dominated by sand (Figure 28). Silt and detritus were also encountered but in lower frequency. Hard substrates were not present at this survey location.



Bottom Type	Code
Bedrock	
Boulder	
Boulder-Cobble	
Cobble	
Cobble-Gravel	
Cobble-Sand	
Gravel	
Gravel-Sand	
Gravel-Silt	
Sand	
Sand-Silt	
Sand-Detritus	
Silt	
Silt-Detritus	
Silt-Cobble	
Detritus	
Detritus-Sand-Silt	
Clay	
Clay-Sand	

Figure 28. Bottom sediment map and key for the survey site upstream of Grimms Road on an unnamed tributary to the Branch River. Transect 1 is the furthest downstream sampling location.

Biological Assessments

Invertebrates were not collected at this location because suitable riffle habitat was not present at the time of sampling.

The electroshocking assessment at this site captured 50 individual fish representing seven species in the 100 meters of river that was sampled (Table 17). This resulted in an IBI score of 34 and a rating of fair. Mottled sculpin and johnny darter dominated the catch with substantially fewer fish of other species captured during electroshocking. Northern pike were the only gamefish that we captured during the survey. The pike ranged in length from 92 mm to 104 mm and had an average length of 99 mm.

Table 17. The species mix and abundance of fish captured during electroshocking on an unnamed tributary to the Branch River upstream of Grimms Road.

Species	Number
Mottled Sculpin	20
Johnny Darter	14
Central Mudminnow	6
Northern Pike	3
White Sucker	3
Blackside Darter	2
Creek Chub	2
Total	**50**

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen were measured at this location during the habitat assessment visit on July 6, 2005.

At the time of the habitat assessment, the air temperature was 23.8 C, the water temperature was 18.3 C, and the dissolved oxygen was 112.1% saturated at 10.53 mg/l.

North Branch of the Manitowoc River Sub-watershed

North Branch of the Manitowoc River

Irish Road

The survey site was located just downstream of Irish Road on the Brillion State Wildlife Property (N44.1750, W-088.1485 to N44.1757, W-088.1483). The survey section averaged 3.0 meters in width and was 102 meters in length. The North Branch at this location has a stream order of 4 with a gradient of 0.462 meters per kilometer and a sinuosity of 1 to 1.32. The study reach of the river ran through a mainly a meadow-wetland complex (Figure 29).

Figure 29. An upstream view of the North Branch of the Manitowoc River from the Brillion Wildlife Area showing a typical view of the stream that includes wild rice and reed canary grass.

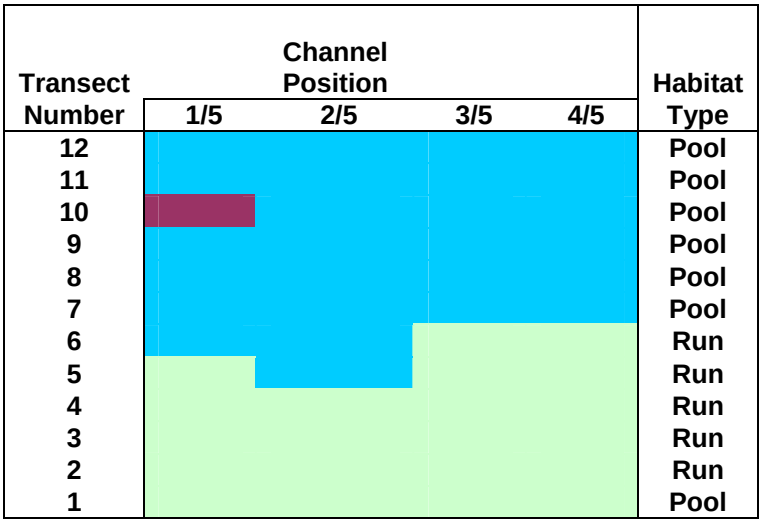
Discharge

Water level was judged to be normal for the date of the survey and water clarity was rated clear. Flow was not measurable although visual signs of flow were noted.

Habitat

The section of river sampled contained one run and a single pool. The first 52.8 meters of the survey site was a run followed by 49.2 meters of pool. Bare soil and erosion were not observed at this location.

The bottom sediments of this site were dominated by clay in the section that was run and by silt in the section that was pool (Figure 30). Additionally, one small patch of gravel was encountered on transect 10.



Bottom Type	Code
Bedrock	
Boulder	
Boulder-Cobble	
Cobble	
Cobble-Gravel	
Cobble-Sand	
Gravel	
Gravel-Sand	
Gravel-Silt	
Sand	
Sand-Silt	
Sand-Detritus	
Silt	
Silt-Detritus	
Silt-Cobble	
Detritus	
Detritus-Sand-Silt	
Clay	
Clay-Sand	

Figure 30. Bottom sediment map and key for the survey site on Brillion Wildlife Area just downstream of Irish Road on the North Branch of the Manitowoc River. Transect 1 is the furthest downstream sampling location.

Biological Assessments

The electroshocking assessment at this site captured 7 individual fish representing three species in the 102 meters of river that was sampled. Captured fish included 3 brook stickleback, 2 fathead minnow and 1 central mudminnow. This resulted in an IBI score of 7 and a rating of very poor.

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen were measured at this location during the habitat assessment visit on July 28, 2005.

At the time of the habitat assessment, the air temperature was 19.6 C, the water temperature was 16.9 C, and the dissolved oxygen was 14.2% saturated at 1.44 mg/l.

Unnamed Tributary (Hilbert Creek)

The survey site was located just upstream of the Hilbert Waste Water Treatment Plant (N44.1439, W-088.1401 to N44.1438, W-088.1409). The survey section averaged 1.4 meters in width and was 100 meters in length. Hilbert Creek at this location has a stream order of 2 with a gradient of 2.127 meters per kilometer and a sinuosity of 1 to 1.27. The study reach of the river ran through 100% meadow (Figure 31).

Figure 31. An upstream view of Hilbert Creek showing a dense growth of reed canary grass.

Discharge

Water level was judged to be normal for the date of the survey and water clarity was rated clear. Flow was not measurable although visual signs of flow were noted.

Habitat

The section of river sampled was one 100 meter run. Bare soil and erosion was uncommon at this location. Abundant overhanging vegetation provided cover for fish at this location.

The bottom sediments of this site were dominated by silt (Figure 32). Cobble, gravel, boulder or clay substrates were also encountered but less frequently than silt or gravel substrates.

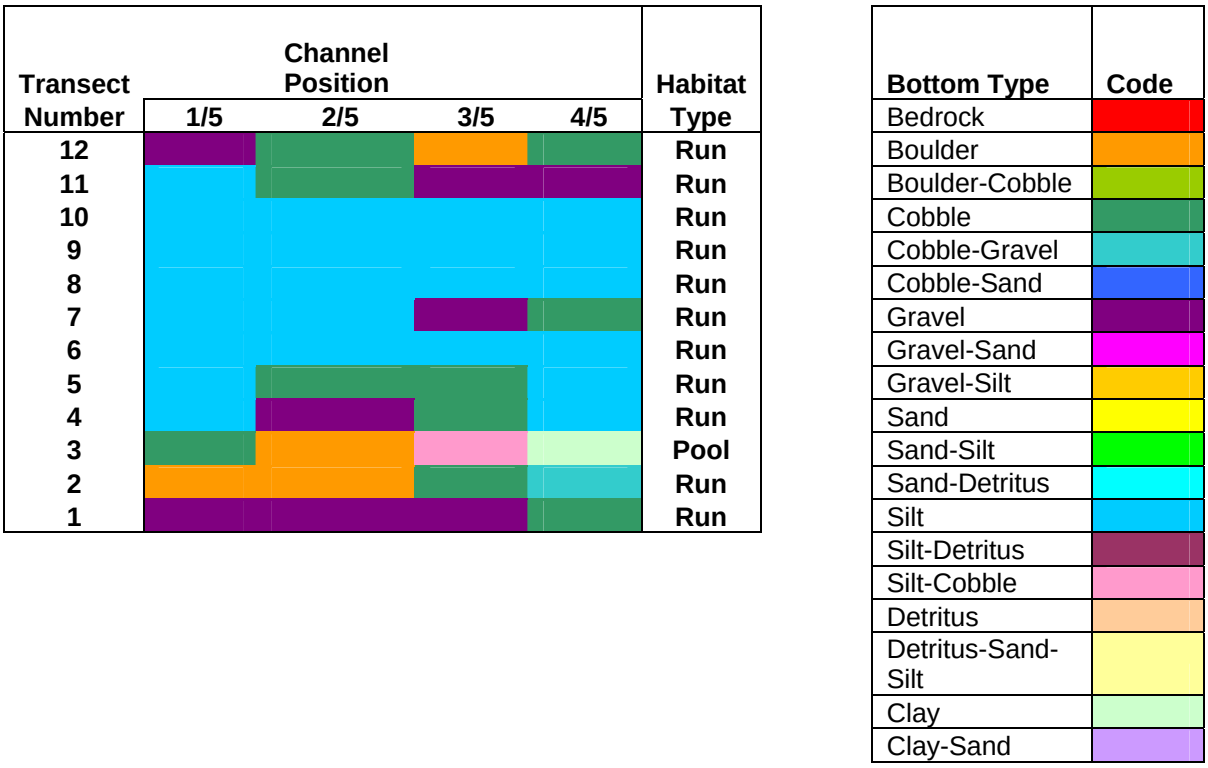


Figure 32. Bottom sediment map and key for the survey site on Hilbert Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessments

The electroshocking assessment at this site captured 50 individual fish representing three species in the 100 meters of river that was sampled (Table 18). This resulted in an IBI score of 23 and a rating of poor, however this result should be viewed cautiously as mean stream width was less than 2.5 meters so IBI scores may not accurately reflect the fish community of the stream. Brook stickleback fathead minnow and central mudminnow were captured during electroshocking.

Table 18. The species mix and abundance of fish captured during electroshocking on Hilbert Creek upstream of the Hilbert WWTP.

Species	Number
Brook Stickleback	20
Fathead Minnow	16
Central Mudminnow	14
Total	**50**

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen were measured at this location during the habitat assessment visit on July 20, 2005.

At the time of the habitat assessment, the air temperature was 20.1 C, the water temperature was 19.4 C, and the dissolved oxygen was 47.7% saturated at 4.35 mg/l.

Spring Creek- Madison Street

The survey site was located just upstream of Madison Street in the city of Brillion (N44.1744, W-088.0607 to N44.1755, W-088.0607). The survey section averaged 3.3 meters in width and was 100 meters in length. Spring Creek at this location has a stream order of 3 with a gradient of 2.171 meters per kilometer and a sinuosity of 1 to 1.24. The study reach of the river ran through a residential neighborhood (Figure 33).

Figure 33. An upstream view of Spring Creek showing residential land use.

Discharge

Water level was judged to be normal for the date of the survey and water clarity was rated turbid and gray in color. Flow was measured at 0.04 CMS at this location.

Habitat

The section of river sampled was dominated by run with lesser amounts of riffle and pool present. The were 24 meters of riffle, 9.3 meters of pool and 66.7

meters of run in the survey section. Riffles ranged from 2.7 meters to 11.0 meters in length, the single pool was 9.3 meters in length and runs ranged from 4.2 meters to 20.8 meters in length. An average riffle was 4.8 meters in length and an average run was 12.5 meters in length. Bare soil was common in the surveyed section of river. Erosion was also noted and ranged from 0% to 20%. A large seawall was noted along one bank at the upstream end of the station. Overhanging vegetation and boulders provided limited cover for fish at this location.

The bottom sediments of this site were dominated by gravel (Figure 34). Cobble, sand or detritus substrates were also encountered but less frequently than gravel substrates.

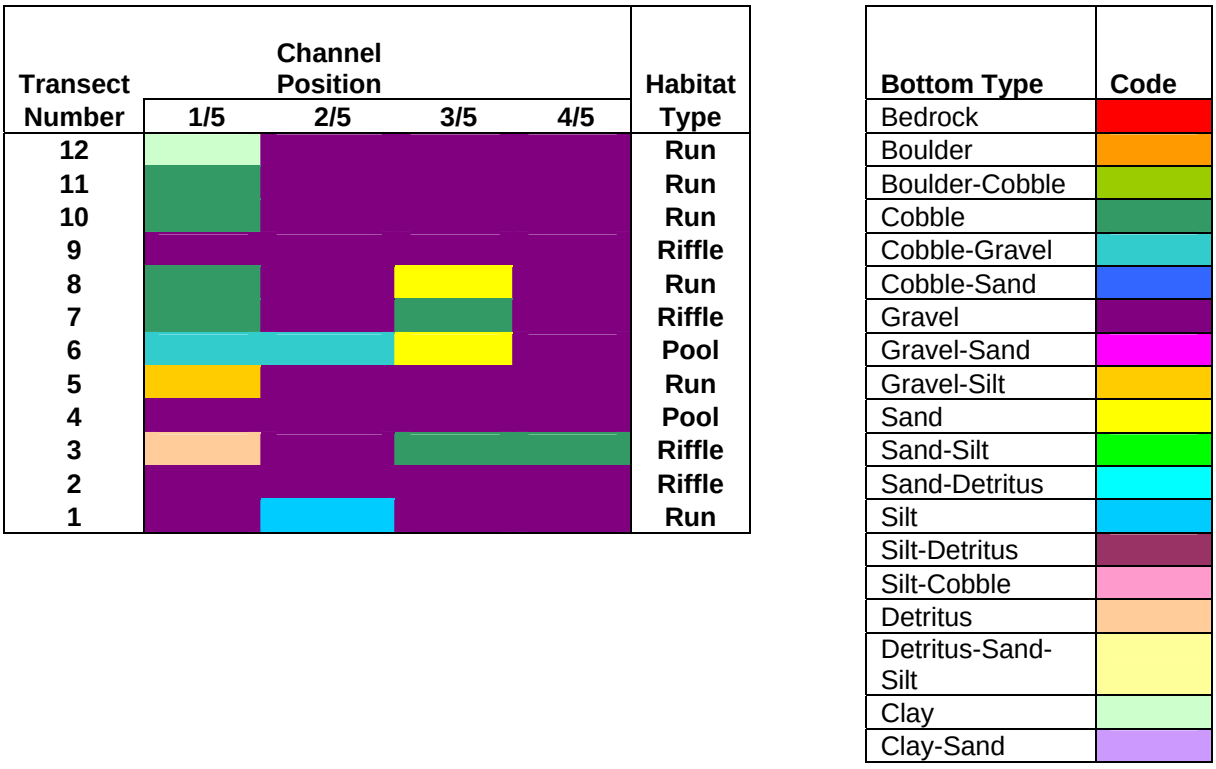


Figure 34. Bottom sediment map and key for the survey site on Spring Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessments

An attempt was made to sample invertebrates at this location, but an insufficient number of invertebrates were collected to submit for evaluation.

The electroshocking assessment at this site captured 127 individual fish representing six species in the 100 meters of river that was sampled (Table 19).

This resulted in an IBI score of 7 and a rating of poor. Creek chub and blacknose dace dominated the catch with substantially fewer individuals of other species captured during electroshocking. The three green sunfish ranged in length from 70 mm to 100 mm and had an average length of 90 mm.

Table 19. The species mix and abundance of fish captured during electroshocking on Spring Creek upstream of Madison Street in the city of Brillion.

Species	Number
Creek Chub	79
Blacknose Dace	38
Brook Stickleback	3
Green Sunfish	3
White Sucker	3
Fathead Minnow	1
Total	**127**

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen were measured at this location during the habitat assessment visit on July 20, 2005.

At the time of the habitat assessment, the air temperature was 19.7 C, the water temperature was 20.7 C, and the dissolved oxygen was 75.6% saturated at 6.70 mg/l.

The following sites were surveyed during the summer of 2006.

South Branch of the Manitowoc River Sub-watershed

South Branch of the Manitowoc River

Irish Road

The survey site was located just upstream of Irish Road in the city of Chilton (N44.0360, W-088.1429 to N44.0353, W-088.1445). The survey section averaged 7 meters in width and was 238 meters in length. The South Branch at this location has a stream order of 3 with a gradient of 3.37 meters per kilometer and a sinuosity of 1 to 1.45. The study reach of the river ran through an urban setting that had land uses which included lawn, meadow, forest and wetland (Figure 35). The stream channel appeared to be natural, although at transect 7 an old dam could have been present.

Figure 35. An upstream view of the South Branch of the Manitowoc River as it flows through Chilton.

Discharge

Water level was judged to be normal for the date of the survey and water clarity was rated clear. Flow was measured at 0.09 CMS at this location.

Habitat

The section of river sampled was dominated by runs and riffles with substantially lesser amounts of pool habitat present. The were 125.5 meters of riffle, 29.8 meters of pool and 136.5 meters of run in the survey section. Riffles ranged from 8.2 meters to 41.2 meters in length, the two pools were 7.0 and 22.8 meters in length and runs ranged from 8.6 meters to 59.6 meters in length. An average riffle was 17.9 meters in length, the average pool was 14.9 meters in length and an average run was 22.8 meters in length. Bare soil and erosion were uncommon in the surveyed section of river and only occurred at three transects. The erosion that was noted ranged from 5% to 10% of the stream bank. Boulders and some woody debris provided cover for fish at this location.

The bottom sediments of this site were dominated by gravel, cobble or boulder (Figure 36). Sand was also encountered at several transects, but less frequently than the rock substrates.

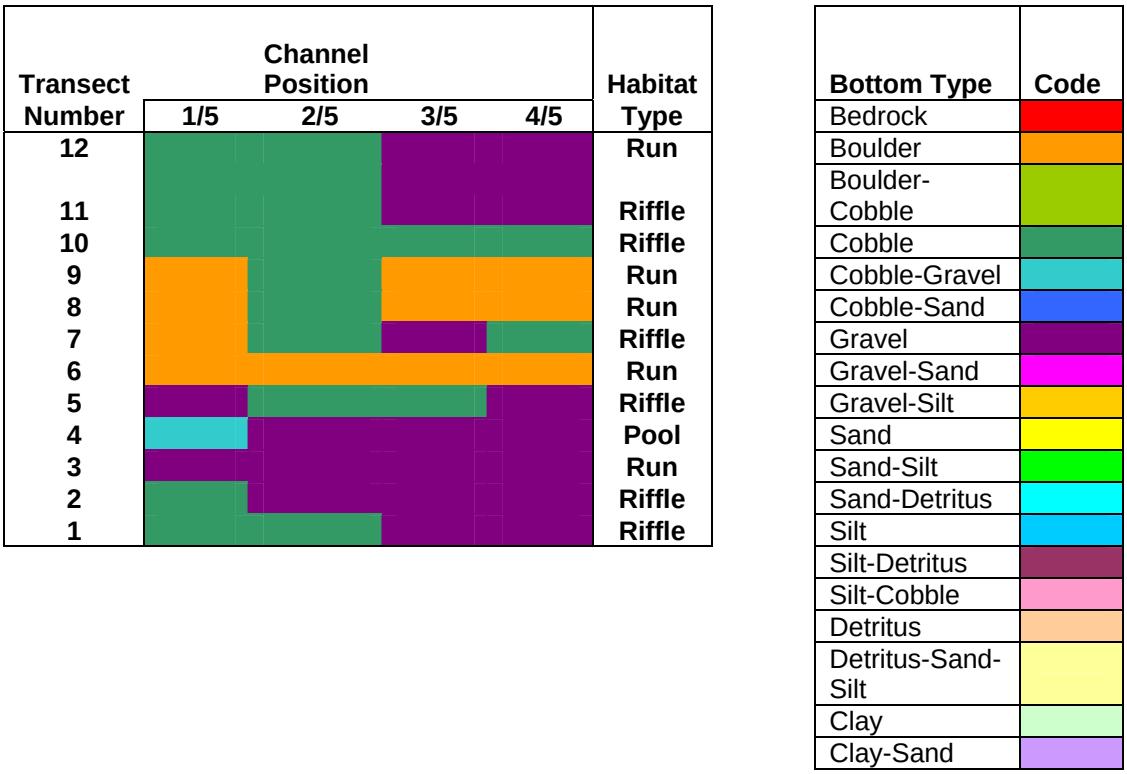


Figure 36. Bottom sediment map and key for the survey site on the South Branch of the Manitowoc River. Transect 1 is the furthest downstream sampling location.

Biological Assessments

The electroshocking assessment at this site captured 389 individual fish representing eleven species in the 238 meters of river that was sampled (Table 20). This resulted in an IBI score of 42 and a rating of fair. Blacknose dace and creek chub dominated the catch with substantially fewer individuals of other species captured during electroshocking. Three panfish species and greater redhorse (a special concern species) were captured during electroshocking.

Table 20. The species mix and abundance of fish captured during electroshocking on the South Branch of the Manitowoc River upstream of Irish Road in the city of Chilton.

Species	Number
Blacknose Dace	165
Creek Chub	133
Common Shiner	41
Rock Bass	17
White Sucker	11
Green Sunfish	8
Johnny Darter	5
Bluntnose Minnow	4
Greater Redhorse	2
Pumpkinseed	2
Brown Bullhead	1
Total	**389**

The seventeen rock bass ranged in length from 85 mm to 195 mm and had an average length of 146 mm. The eight green sunfish ranged in length from 80 mm to 110 mm and had an average length of 92 mm. The lengths of the two pumpkinseed were 85 mm and 90 mm.

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen were measured at this location during the habitat assessment visit on August 7, 2006. A continuous temperature monitor was placed at Lemke Road which is below Hayton Dam or five miles below Irish Road in July 2005 to monitor stream temperature trends.

At the time of the habitat assessment, the air temperature was 22.8 C, the water temperature was 22.1 C, and the dissolved oxygen was 89.8% saturated at 7.80 mg/l.

In 2005, the meter collected data from July 6 through October 12 (Figure 37).

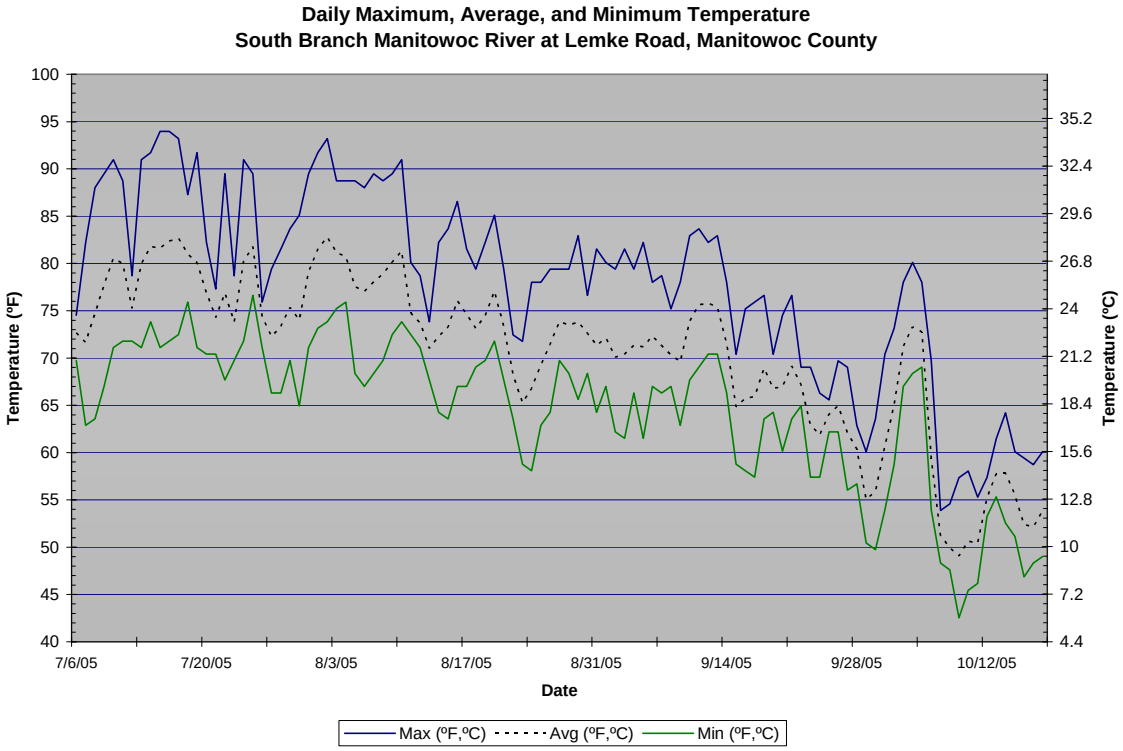


Figure 37. Continuous stream temperature readings of the South Branch of the Manitowoc River at Irish Road during July through October 2005.

During the sample period, stream temperature ranged from a low of 43ºF to a high of 83ºF. The average stream temperature was 70ºF which is normal for a warmwater stream in east central Wisconsin during this time period.

Killsnake River

The survey site was located just upstream of Irish Road (N44.0591, W-088.1434 to N44.0576, W-088.1459). The survey section averaged 9.7 meters in width and was 306 meters in length. The Killsnake River at this location has a stream order of 3, a gradient of 1.48 meters per kilometer and a sinuosity of 1 to 1.85. The study reach of the river ran through a meadow-wetland and a shrub-forest complex (Figure 38).

Figure 38. Looking upstream at the Killsnake River just above Irish Road.

Discharge

Water level was judged to be normal for the date of the survey and water clarity was rated clear. Flow was low at this location and could not be measured, however there were visible signs of water movement.

Habitat

The section of river sampled was dominated by runs. Within the surveyed section of river, there were 41.9 meters of riffle, 93.6 meters of pool and 161.2 meters of run. Riffles ranged from 4.3 meters to 28.7 meters in length, pools ranged from 16.6 meters to 46.0 meters in length and runs ranged from 7.0 meters to 97.0 meters in length. An average riffle was 10.5 meters in length, the average pool was 31.2 meters in length and an average run was 40.3 meters in length. Bare soil and erosion were common in the upstream sections of river that we surveyed. Bare soil in these sections ranged from 0.25 meters to 1.0 meter. Streambank erosion ranged from 5% to 20%. Most of the fish cover was provided by overhanging vegetation or aquatic macrophytes. Limited additional cover was provided by boulders or undercut banks.

The bottom sediments of this site were dominated by cobble or sand (Figure 39). Gravel, boulder or silt substrates were also encountered but less frequently than the cobble-sand substrates.

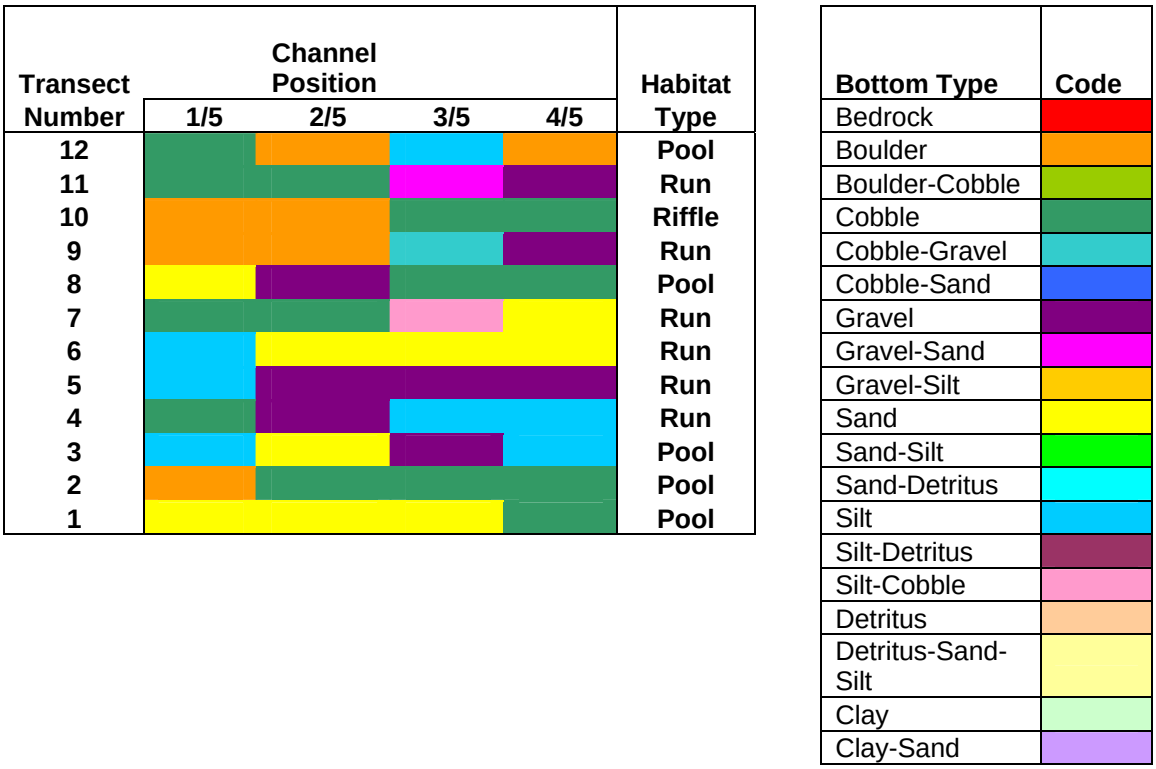


Figure 39. Bottom sediment map and key for the survey site on the Killsnake River. Transect 1 is the furthest downstream sampling location.

Biological Assessments

During electroshocking, we captured 539 individual fish representing fourteen species in the 306 meters of river that was sampled (Table 21). This resulted in an IBI score of 25 and a rating of poor. Creek chub, bluntnose minnow and rock bass dominated the catch with substantially fewer individuals of other species captured during electroshocking.

Table 21. The species mix and abundance of fish captured during electroshocking on the Killsnake River upstream of Irish Road.

Species	Number
Creek Chub	140
Bluntnose Minnow	131
Rock Bass	114
White Sucker	55
Johnny Darter	39
Common Shiner	22
Blacknose Dace	13
Brook Stickleback	8
Bluegill	5
Fathead Minnow	4
Northern Pike	2
Black Bullhead	1
Central Mudminnow	1
Longnose Dace	1
Total	**536**

The 114 rock bass ranged in length from 55 mm to 230 mm and had an average length of 107 mm. It appears from the length frequency multiple year classes of rock bass were captured (Figure 40). The captured northern pike had an average length of 328 mm and the bluegill averaged 73 mm in length.

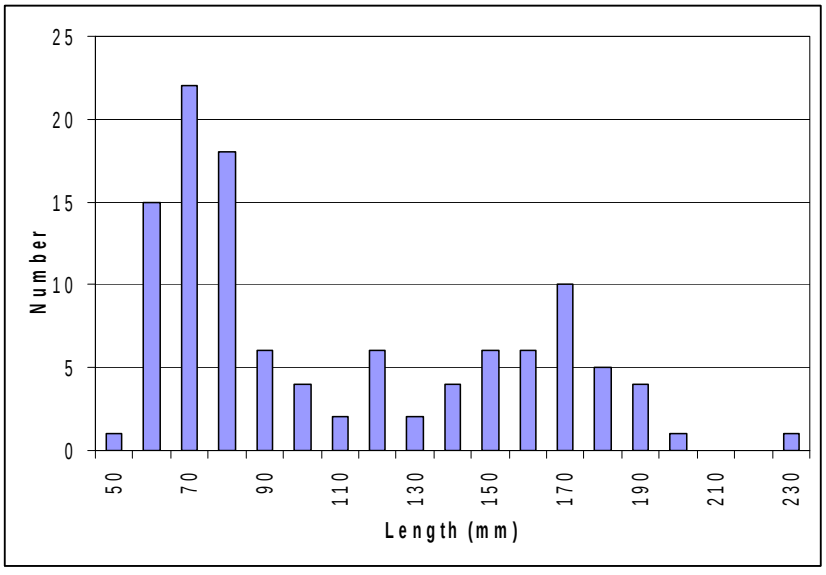


Figure 40. Length frequency of the 114 rock bass captured from the Killsnake River.

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen were measured at this location during the habitat assessment visit on August 7, 2006.

At the time of the habitat assessment, the air temperature was 30.1 C, the water temperature was 23.0 C, and the dissolved oxygen was 113.1% saturated at 9.83 mg/l.

Pine Creek

The survey site was located just upstream of Danes Road (N43.9792, W-088.0687 to N43.9761, W-088.0673). The survey section averaged 3.76 meters in width and was 136 meters in length. Pine Creek at this location has a stream order of 3, a gradient of 9.44 meters per kilometer and a sinuosity of 1 to 1.21. The study reach of the river ran through a meadow- shrub-forest complex (Figure 40).

Figure 41. Looking upstream at a fisheries crew measuring stream width on Pine Creek just above Danes Road.

Discharge

Water level was judged to be normal for the date of the survey and water clarity was rated clear. Flow was measured at 0.05 CMS at this location.

Habitat

The section of river sampled was dominated by riffles. Within the surveyed section of river, there were 95.2 meters of riffle, 28.0 meters of pool and 22.5 meters of run. Riffles ranged from 16.0 meters to 56.0 meters in length, the single pool had a length of 28.0 meters, and runs ranged from 4.0 meters to 18.5 meters in length. An average riffle was 31.7 meters in length and an average run was 11.3 meters in length. Bare soil and erosion were uncommon in the sections of river that we surveyed. When present, bare soil ranged from 0.25 meters to 1.0 meter in length. Erosion of the bare soil ranged from 5% to 20%. In this section of Pine Creek, overhanging vegetation and boulders provided cover for fish.

The bottom sediments of this site were dominated by cobble (Figure 42). Gravel, boulder, sand or silt substrates were also encountered but less frequently than cobble substrates.

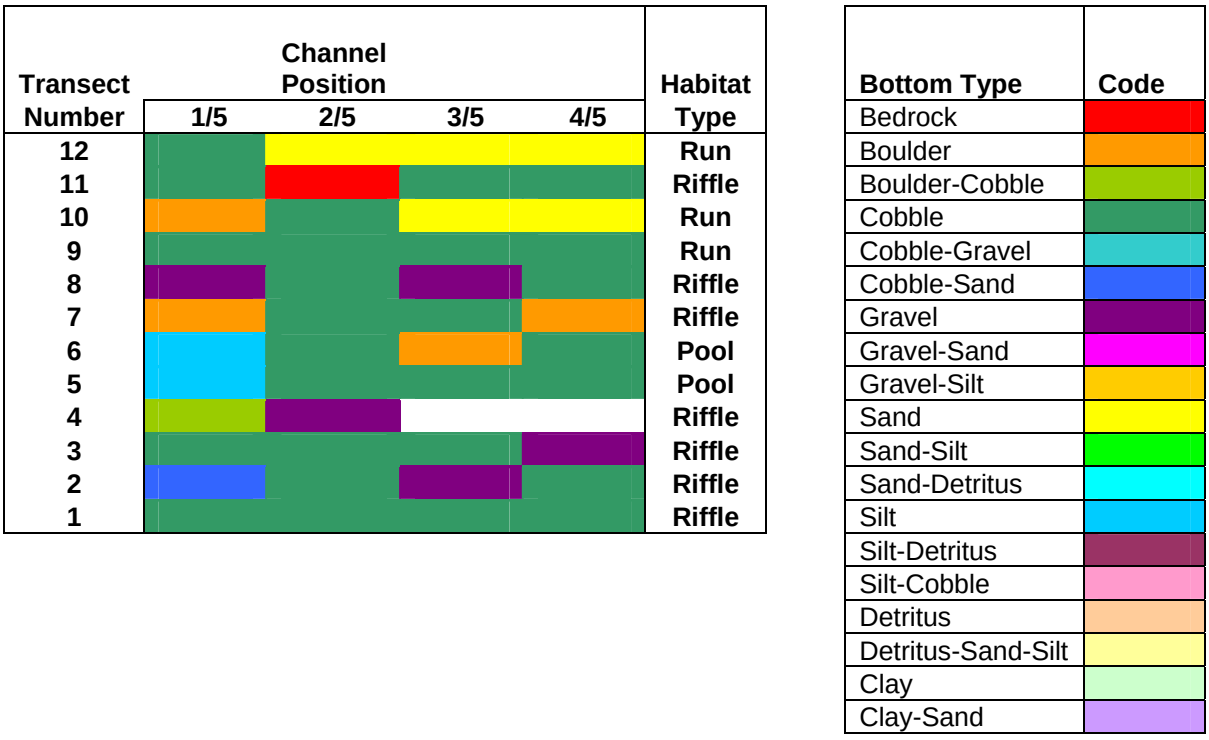


Figure 42. Bottom sediment map and key for the survey site on the Pine Creek. Transect 1 is the furthest downstream sampling location. On transect 4, stations 3/5 and 4/5 were located on a small island therefore the bottom sediments were not identified.

Biological Assessments

At this location we captured 585 individual fish representing ten species in the 306 meters of river that was electroshocked (Table 22). This resulted in an IBI score of 14 and a rating of very poor. Blacknose dace and creek chub dominated the catch with substantially fewer individuals of other species captured during electroshocking.

Table 21. The species mix and abundance of fish captured during electroshocking on Pine Creek upstream of Danes Road.

Species	Number
Blacknose Dace	310
Creek Chub	122
Bluntnose Minnow	31
Green Sunfish	28
Central Mudminnow	27
White Sucker	24
Johnny Darter	10
Brook Stickleback	6
Fathead Minnow	5
Common Shiner	1
Total	**585**

The 28 green sunfish ranged in length from 52 mm to 106 mm and had an average length of 74 mm.

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen were measured at this location during the habitat assessment visit on August 9, 2006.

At the time of the habitat assessment, the air temperature was 25.8 C, the water temperature was 17.9 C, and the dissolved oxygen was 112.8% saturated at 10.68 mg/l.

Unnamed Tributary to Pine Creek

The survey site was located just upstream of Highway 32 (N43.9774, W-088.1128 to N43.9783, W-088.1135). The survey section averaged 2.6 meters in width and was 100 meters in length. The unnamed tributary Pine Creek at this location has a stream order of 2, a gradient of 8.89 meters per kilometer and a sinuosity of 1 to 1.06. The study reach of the river ran through 100% woodland, although steeply sloped agricultural fields were located just outside the riparian buffers (Figure 43).

Figure 43. Looking upstream at a heavily forested tributary to Pine Creek just above Highway 32. The open area in the foreground of the photo is near where the stream crosses underneath Highway 32.

Discharge

Water level was judged to be normal for the date of the survey and water clarity was rated clear. Flow was measured at 0.009 CMS at this location.

Habitat

The section of river sampled was dominated by runs and riffles. Within the surveyed section of river, there were 37.0 meters of riffle, 13.0 meters of pool and 50.0 meters of run. Riffles ranged from 1.0 meters to 25.0 meters in length, pools ranged from 6.0 meters to 7.0 meters in length and runs ranged from 2.0 meters to 22.5 meters in length. An average riffle was 7.4 meters in length, an average pool was 6.5 meters in length and an average run was 9.1 meters in length. Bare soil and erosion were uncommon in the sections of river that we surveyed. When present, bare soil ranged from 0.75 meters to 2.0 meters in length. Erosion of the bare soil ranged from 5% to 60%. In this section of Pine Creek fish cover was limited because of shallow water, but when present, overhanging vegetation or boulders provided cover for fish.

The bottom sediments of this site were dominated by cobble (Figure 44). Gravel, boulder, or clay substrates were also encountered but less frequently than cobble substrates.

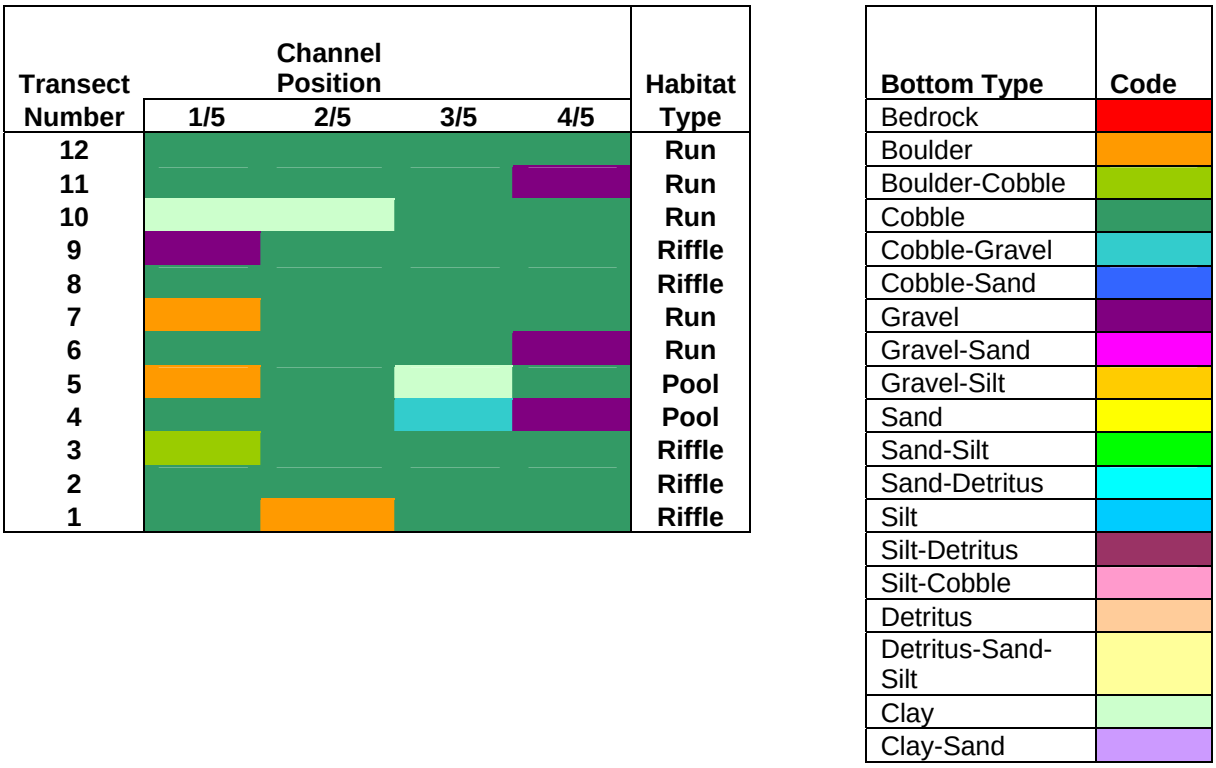


Figure 44. Bottom sediment map and key for the survey site on the unnamed tributary to Pine Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessments

Invertebrates were collected from a riffle just upstream of the start of the survey site. The data collected indicated that the Biotic Index for this site was 6.576 which is indicative of fairly poor water quality. The sampled invertebrate community was dominated by isopods. Nearly 48% of the sample was *Caecidotea intermedia*. Substantially fewer species of other families were captured. Various species of trichopterans and dipterans made up the majority of the remaining invertebrate community.

At this location we captured 120 individual fish representing five species in 100 meters of river that was electroshocked (Table 22). This resulted in an IBI score of 32 and a rating of fair. Brook stickleback and pearl dace dominated the catch with substantially fewer individuals of other species captured during electroshocking.

Table 22. The species mix and abundance of fish captured during electroshocking on an unnamed tributary to Pine Creek upstream of Highway 32.

Species	Number
Brook Stickleback	85
Pearl Dace	31
White Sucker	2
Blacknose Dace	1
Central Mudminnow	1
Total	**120**

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen were measured at this location during the habitat assessment visit on August 3, 2006.

At the time of the habitat assessment, the air temperature was 24.4 C, the water temperature was 19.8 C, and the dissolved oxygen was 84.2% saturated at 7.71 mg/l.

Jordan Creek

The survey site was located upstream of Tecumseh Road (N43.9640, W-088.0764 to N43.9633, W-088.0767). The survey section averaged 3.0 meters in width and was 100 meters in length. At this location Jordan Creek is a second order stream and flows through agricultural and forested lands.

During the single visit to this location, instantaneous temperature and oxygen levels were collected and 100 meters of stream was electroshocked.

Biological Assessments

At this location we captured 238 individual fish representing five species in 100 meters of river that was electroshocked (Table 23). This resulted in an IBI score of 12 and a rating of very poor. Blacknose dace dominated the catch with substantially fewer individuals of other species captured during electroshocking. The single green sunfish was 90 mm in length.

Table 23. The species mix and abundance of fish captured during electroshocking on Jordan Creek upstream of Tecumseh Road.

Species	Number
Blacknose Dace	201
Creek Chub	32
Fathead Minnow	2
Pearl Dace	2
Green Sunfish	1
Total	**238**

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen were measured at this location during the habitat assessment visit on August 15, 2006.

At the time of the habitat assessment, the air temperature was 23.4 C, the water temperature was 20.8 C, and the dissolved oxygen was 83.3% saturated at 7.54 mg/l.

Stony Brook

Quinney Road

The survey site was located just upstream of Quinney Road (N44.0224, W-088.2198 to N44.0232, W-088.2199). The survey section averaged 2.9 meters in width and was 100 meters in length. Stony Brook at this location has a stream order of 1, a gradient of 3.13 meters per kilometer and a sinuosity of 1 to 1.56. The study reach of the river ran through a shrub-woodland complex (Figure 45).

Figure 45. Looking upstream at Stony Brook just upstream of Quinney Road.

Discharge

Water level was judged to be normal for the date of the survey and water clarity was rated clear. Flow was measured at 0.0003 CMS at this location.

Habitat

Runs dominated this section of river. Within the surveyed section of river, there were 8.6 meters of riffle and 91.4 meters of run. The single riffle was 8.6 meters in length and runs ranged from 13.0 meters to 78.4 meters in length. An average run was 45.7 meters in length. Bare soil and erosion were common in the sections of river that we surveyed. When present, bare soil ranged from 0.5 meters to 2.0 meters in length. Erosion of the bare soil ranged from 0% to 100%. In this section of Stony Brook fish cover was limited because of shallow water, but when present, overhanging vegetation and boulders provided cover for fish.

The bottom sediments of this site were dominated by silt (Figure 46). Boulder, cobble or sand were also encountered but less frequently than silt substrates. An error in stream transect spacing resulted in only nine transects being surveyed rather than the standard twelve.

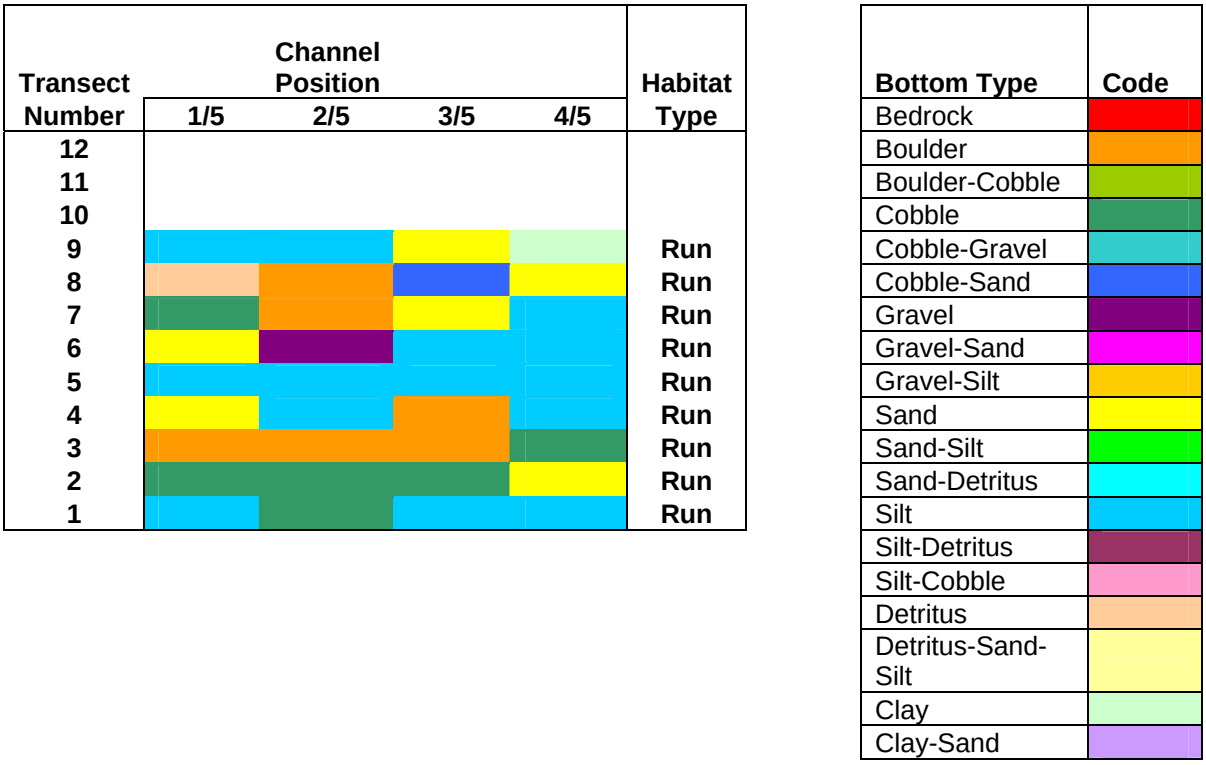


Figure 46. Bottom sediment map and key for the survey site on Stony Brook upstream of Quinney Road. Transect 1 is the furthest downstream sampling location. An error in stream transect spacing resulted in only nine transects being surveyed rather than the standard twelve although the proper stream distance was surveyed.

Biological Assessments

At this location we captured 103 individual fish representing seven species in 100 meters of river that was electroshocked (Table 23). This resulted in an IBI score of 32 and a rating of fair. Johnny darter dominated the catch with substantially fewer individuals of other species captured during electroshocking.

Table 22. The species mix and abundance of fish captured during electroshocking on Stony Brook upstream of Quinney Road.

Species	Number
Johnny Darter	58
White Sucker	13
Blackside Darter	11
Creek Chub	8
Brook Stickleback	6
Central Mudminnow	6
Bluntnose Minnow	1
Total	**103**

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen were measured at this location during the habitat assessment visit on August 10, 2006.

At the time of the habitat assessment, the air temperature was 23.4 C, the water temperature was 17.5 C, and the dissolved oxygen was 98.0% saturated at 9.42 mg/l.

Long Road

The survey site was located just upstream of Long Road (N44.0515, W-088.2458 to N44.0518, W-088.2468). The survey section averaged 1.22 meters in width and was 100 meters in length. Stony Brook at this location has a stream order of 1, a gradient of 1.29 meters per kilometer and a sinuosity of 1 to 1.79. The study reach of the river ran through a meadow-shrub-woodland complex (Figure 47).

Figure 47. Looking upstream at Stony Brook just upstream of Long Road.

Discharge

Water level was judged to be normal for the date of the survey and water clarity was rated clear. Flow was measured at 0.002 CMS at this location.

Habitat

The section of river sampled was a single long run that was 100 meters in length. Bare soil was uncommon in the sections of river that we surveyed. When present, bare soil ranged from 0.25 meters to 1.0 meters in length a long each transect. Erosion of the streambank was not noted in this stream section. In this section of Stony Brook fish cover was limited because of shallow water, but when present, overhanging vegetation and undercut banks provided cover for fish.

The bottom sediments of this site were dominated by silt or detritus (Figure 48). Gravel and sand were also encountered but less frequently than silt or detritus substrates.

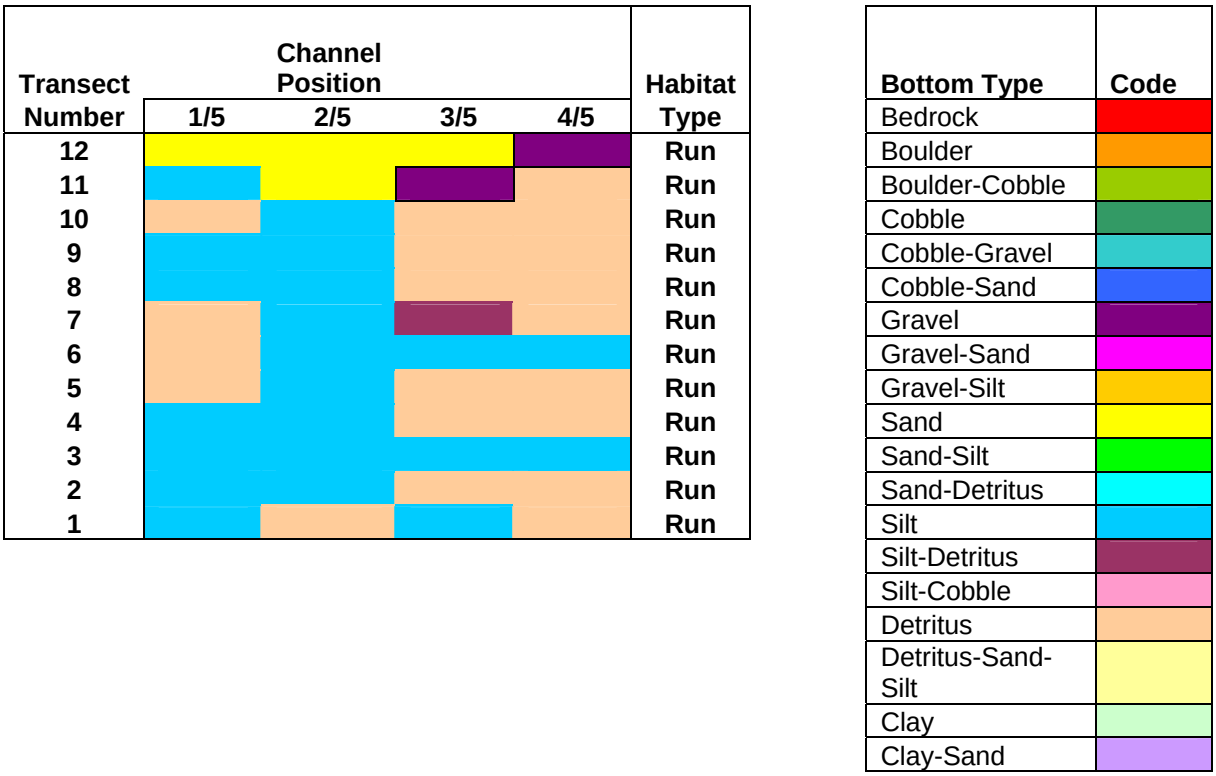


Figure 48. Bottom sediment map and key for the survey site on Stony Brook upstream of Long Road. Transect 1 is the furthest downstream sampling location.

Biological Assessments

Invertebrates were collected from a riffle just downstream of Long Road. The data collected indicated that the Biotic Index for this site was 5.109 which is indicative of good water quality. The sampled invertebrate community was dominated by caddis flies chiefly *Cheumatopysyche spp*.. Substantially fewer coleopteran, dipterans, amphipods and ephemeropterans were captured.

At this location we captured 114 individual fish representing three species in 100 meters of river that was electroshocked (Table 23). This resulted in an IBI score of 44 and a rating of fair. However, because of the small size of this stream IBI scores should be viewed cautiously. Brook stickleback dominated the catch with substantially fewer individuals of other species captured during electroshocking.

Table 22. The species mix and abundance of fish captured during electroshocking on Stony Brook upstream of Long Road.

Species	Number
Brook Stickleback	96
Central Mudminnow	10
Blackside Darter	8
Total	**114**

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen were measured at this location during the habitat assessment visit on August 3, 2006.

At the time of the habitat assessment, the air temperature was 23.3 C, the water temperature was 17.0 C, and the dissolved oxygen was 83.1% saturated at 8.06 mg/l.

Little Manitowoc River Sub-watershed

Little Manitowoc River

The survey site was located just downstream of County Highway B on City of Manitowoc Property (N44.1219, W-087.6547 to N44.1223, W-087.6548). The survey section averaged 3.46 meters in width and was 136 meters in length. The Little Manitowoc River at this location has a gradient of 0.18 meters per kilometer, a sinuosity of 1 to 1.94 and is a third order stream. The study reach of the river ran through a mainly a meadow-shrub complex (Figure 49).

Figure 49. An upstream view of the Little Manitowoc River that shows the meadow-shrub character of the stream.

Discharge

Water level was judged to be normal for the date of the survey and water clarity was rated turbid. Flow was 0.207 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled contained a single long run of 136 meters. The bottom sediments of this site were dominated by sand, clay or gravel (Figure 50). Several patches of cobble or boulder were also encountered but in much lower frequency.

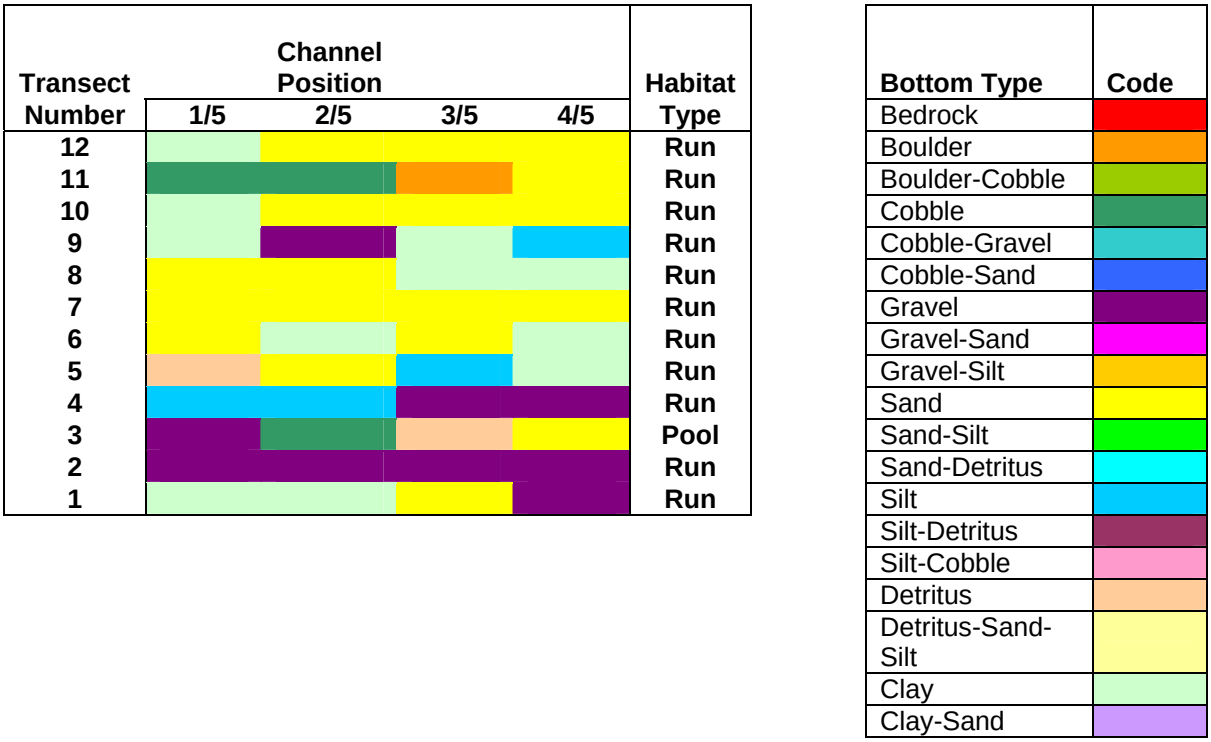


Figure 50. Bottom sediment map and key for the survey site downstream of County Highway B on the Little Manitowoc River. Transect 1 is the furthest downstream sampling location.

Biological Assessments

The electroshocking assessment at this site captured 109 individual fish representing ten species in the 136 meters of river that were sampled (Table 23). This resulted in an IBI score of 25 and a rating of poor. White sucker, johnny darter and mottled sculpin dominated the catch with fewer fish of other species captured during electroshocking.

Table 15. The species mix and abundance of fish captured during electroshocking on the Little Manitowoc River downstream of County Highway B.

Species	Number
White Sucker	53
Johnny Darter	20
Mottled Sculpin	19
Common Shiner	8
Bluntnose Minnow	2
Green Sunfish	2
Rainbow Trout	2
Bluegill	1
Brassy Minnow	1
Fathead Minnow	1
Total	**109**

The two rainbow trout that were captured during shocking were 235 mm and 170 mm in length and were likely stocked in the Manitowoc River during the spring of 2006 as yearlings. The two green sunfish were 60 mm and 70 mm and the lone bluegill was 80 mm in length.

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen were measured at this location during the habitat assessment visit on August 14, 2006.

At the time of the habitat assessment, the air temperature was 22.8 C, the water temperature was 17.9 C, and the dissolved oxygen was 99.3% saturated at 9.48 mg/l.

DISCUSSION

During this two year survey that sampled 22 sites on 17 streams, a variety of physical, chemical and biological characteristics were measured. By measuring a combination of biological, chemical and physical parameters, trends in watershed health can be better understood than if a single individual metric was used.

Chemical monitoring in this study consisted of collection of instantaneous dissolved oxygen and temperature measurements collected at each site or continuous temperature collected at a subset of the sites. Biological samples that were collected as a part of this study included macroinvertebrates for the Hilsenhoff Index (HBI) and fish for the Index of Biotic Integrity (IBI). Habitat assessments were also conducted at each study site. Stream flow was measured and discharge was calculated for each location except at the Jordan Creek site.

A variety of stream sizes were sampled during this survey that ranged in size from the Manitowoc River down to several short unnamed tributaries. Stream gradient for the streams surveyed were generally less than 5 meters per kilometer, although several streams had gradients that were much steeper. Most streams had continuous flow, although several had very low flow and two were dry or partially dry. Because the streams that we sampled were different in stream size, gradient and flow, we noted a variety of large and small scale habitats and biological communities between surveyed streams.

Discharge

Measured flow and the resulting calculated discharge during the study most likely represented low flow or base flow conditions for the streams that were sampled. Flow ranged from 0 (dry) on the Branch River (Morrison Road) and Mud Creek (Reedsville, Hwy K) to 0.574 CMS on the Manitowoc River at Hwy S (Table 16).

Weather conditions during the two years of the study varied greatly. 2005 was a very dry year, while 2006 was very wet during May. Because of this difference in weather, the year that a stream was studied could have influenced the stream flow measurement. But since we had low flow streams in both survey years, we believe that the data collected shows that low flow was a problem in a number of streams such as both Mud Creeks, North Branch of Manitowoc River and Stony Brook. Low flows may cause very warm water temperatures, low dissolved oxygen levels and very shallow water which impacts resident biological communities negatively. Fish communities in these streams were limited to tolerant species that can withstand warm stream temperatures and low dissolved oxygen levels.

Table 16. Manitowoc River Watershed summary table of selected physical and biological data collected during the 2005-2006 survey.

Stream	Location	Dominant Habitat Type	Flow	Bare Soil	Erosion (%)	Dominant Bottom Type	Buffer	HBI	IBI	Temp (C)	DO (mg/l)	Meet Water Class
Branch River	Danmar Road	Run	0.147	No	No	Gravel-Cobble	Yes	Fair	Good	20	10.8	Yes
	Morrison Road	Run	Dry	Yes	0-10	Silt	Yes	--	Excellent	13	8.4	Yes
Unnamed Trib.	Grimms Road	Run	0.005	Yes	0-10	Sand	Yes	--	Fair	18	10.5	Yes
Mud Creek (St. Naz.)	Hwy 151	Run	None	Yes	0-60	Silt	Yes	--	V. Poor	18	4.5	Yes
	Tompkins Road	Run	0.001	Yes	0-40	Gravel-Cobble	Yes	--	V. Poor	23	7.8	Yes
Unnamed Trib.	Greendale Road	Run	0.002	Yes	0-60	Clay-Silt	Yes	--	V. Poor	24	6.9	Yes
Mud Creek (Reeds.)	Menasha Street	Pool	0.002	Yes	0-10	Silt-Sand	No	--	Poor	18	2.6	Yes
	County K	Run	Dry	Yes	0-5	Silt	Yes	--	V. Poor	23	3.0	Yes
Unnamed Trib.	HWY W	Pool-Run	None	Yes	0-20	Gravel	Yes	--	V. Poor	21.5	8.1	Yes
Manitowoc River	HWY W	Run	0.255	Yes	None	Silt	Yes	--	V. Poor	29	16	Yes
	HWY S	Run	0.574	Yes	0-5	Cobble-Gravel	Yes	Fair	Poor	24	3.6	Yes
Spring Creek	Madison Street	Riffle	0.04	Yes	0-20	Gravel	Yes	--	Poor	21	6.7	Yes
N. Branch Manitowoc River	Irish Road	Run	None	None	None	Clay-Silt	Yes	--	Poor	17	1.4	No
Unnamed Trib.	Hilbert WWTP	Run	None	Yes	0-5	Silt-Cobble	Yes	--	Poor	19.4	4.4	No
S. Branch Manitowoc River	Irish Road	Run-Riffle	0.09	Yes	0-10	Gravel-Cobble	Yes	--	Fair	23	7.8	Yes
Killsnake River	Irish Road	Pool	None	Yes	5-20	Cobble-Sand	Yes	--	Poor	23	9.8	Yes
Pine Creek	Danes Road	Riffle	0.05	Yes	5-20	Cobble	Yes	--	Poor	18	11	Yes
Unnamed Trib.	Hwy 32	Run	0.009	Yes	5-60	Cobble	Yes	F. Poor	Fair	19.8	7.7	Yes
Jordan Creek	Tecumseh Road	--	--	--	--	--	Yes	--	V. Poor	21	7.5	Yes
Stony Brook	Quinney Road	Run	0.0003	Yes	0-100	Silt	Yes	--	Fair	17.5	9.4	No
	Long Road	Run	0.002	Yes	None	Silt-Clay	Yes	Good	Fair	17	8.0	No
Little Manitowoc River	Hwy B	Run	0.207	None	None	Silt-Clay	Yes	--	Poor	17.9	9.5	No

Habitat

Three types of habitat were measured during the survey, which included large-scale stream features: runs, pools and riffles; small-scale habitat: bottom type and fish cover; and adjacent land use: buffer type and width.

Throughout the watershed, large-scale habitat varied greatly from stream to stream. Runs were the most common large scale habitat feature within this watershed. Exceptions included Mud Creek (Reedsville) and the Killsnake River where pools were the most common feature and Spring and Pine Creeks where riffles were dominant (Table 16).

Silt, clay, gravel and cobble were the most common sediments observed during the survey. Streams that were either low gradient or streams with high stream bank erosion had bottom sediments that were dominated by silt or clay, or had cobble buried in silt (Table 16). Generally these streams were located in the North Branch of the Manitowoc River or Lower Manitowoc River subwatersheds. Subwatersheds that had higher gradients, such as the South Branch of the Manitowoc River and the Branch River, had bottom sediments that were dominated by gravel or cobble.

Stream corridors were well buffered with 10 meters of forest, meadow or shrubs buffers at most study locations. Most of the streams located in rural areas had buffers much greater than the measured 10 meters, while urban streams such as Mud Creek in Reedsville, Spring Creek in Brillion, and the South Branch of the Manitowoc River in Chilton had buffers that were much narrower, altered (Spring Creek and Mud Creek) and in part consisting of lawn and other landscape.

The lack of variety in large scale habitat and bottom substrate may have negatively impacted invertebrate and fish communities in the watershed which were reflected in the number of poor or very poor IBI scores. Shallow water in runs and riffles along with limited pool depth most likely limits the abundance of warm water gamefish such as smallmouth bass and northern pike in the watershed.

Biological Assessments

Results from the 2005 and 2006 Hilsenhoff Biotic Index samples showed fair water quality at the limited locations that were sampled. The lack of diversity of habitat, low flow and warm water temperatures may be responsible for the scores.

During this survey we captured 5,961 individual fish representing 35 species (Table 2). The five most abundant species in order were carp, blacknose dace, common shiner, creek chub and central mudminnow. Although carp were the most common overall fish by number, carp were only captured at two locations, Highway W and Highway S on the Manitowoc River. The other abundant species were commonly captured at most locations across the watershed.

The most common gamefish were smallmouth bass, largemouth bass and northern pike. The majority of smallmouth bass were captured on the Branch

River and most of the northern pike were young of year fish captured in headwater locations.

Fish IBI ratings ranged from very poor at seven sites, poor at eight sites, fair at five sites, good at one site and excellent at one site (Table 16). The IBI scores indicate that across this watershed, fish populations are poor. The lack of warm water gamefish was also very noticeable and was likely caused by swings in dissolved oxygen level, lack of pool habitat or from periodic episodes of low water or flow.

Water Quality

Temperature and DO measurements along with invertebrate and fish sampling were used to evaluate water quality within the watershed. Several trends in stream temperature and dissolved oxygen levels were observed. First, within this watershed, most streams are warmwater streams. This type of stream tend to have water temperatures that are reflective of ambient air temperatures (Table 16). The exception was the Branch River at Morrison Road where stream temperature was much cooler than the surrounding air temperature and was likely due to groundwater inputs to the stream. Second, dissolved oxygen levels with the watershed appear to be sufficient to support warmwater communities, although several locations had low DO levels that violated the State warmwater standard of 5.0 ppm (Table 16). Additionally several locations, most notably the Branch River at Danmar Road and the Manitowoc River at Highway W appear to undergo large diel swings in DO indicating possible nutrient enrichment.

Four sites of twenty-two that were surveyed do not meet their water quality classification. These locations are the North Branch of the Manitowoc River, two locations on Stony Brook and the Little Manitowoc River. Several others, Mud Creek in Reedsville and the Manitowoc River sites meet their classifications, but have poor water quality and poor fish populations.

Based on HBI and IBI scores, and dissolved oxygen levels it appears that water quality in the Manitowoc River watershed, excluding the Branch River subwatershed, is poor and negatively impacts the biological communities that live in Manitowoc Watershed streams.

CONCLUSIONS

- We believe that the data collected shows that flow is a problem for resident biological communities in some streams.

- The lack of variety in large scale habitat and bottom substrate may have negatively impacted invertebrate and fish communities in the watershed which is reflected by the number of poor or very poor HBI and IBI scores.

Shallow water in runs and riffles along with limited pool depth most likely limits the abundance of warm water gamefish such as smallmouth bass and northern pike in the watershed.

- During this survey we captured 5,961 individual fish representing 35 species. The five most abundant species in order were carp, blacknose dace, common shiner, creek chub and central mudminnow.

- Based on HBI and IBI scores, and dissolved oxygen levels it appears that water quality in the Manitowoc River watershed, excluding the Branch River subwatershed, is poor and negatively impacts the biological communities that live there.

RECOMMENDATIONS

- Actively utilize streambank protection programs (CRP, CREP) to maximize stream bank protection in those streams that exhibit bank erosion.

- Encourage practices to reduce the delivery of sediment and nutrients to basin streams and lakes.

- Encourage the use of land practices that hold and slowly release water into streams to improve stream flows.

- Do additional work utilizing continuous temperature and DO monitors to more fully determine the extent of water quality problems in the watershed.

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