MICHIGAN DEPARTMENT OF NATURAL RESOURCES & ENVIRONMENT
WATER BUREAU
MARCH 2010

STAFF REPORT

BIOLOGICAL SURVEY OF THE LOWER MUSKEGON RIVER WATERSHED MUSKEGON AND NEWAYGO COUNTIES, MICHIGAN JULY-SEPTEMBER 2006

INTRODUCTION

Staff of the Surface Water Assessment Section (SWAS) conducted qualitative biological and habitat surveys in the Muskegon River watershed from July-September 2006. Due to the large study area and the high number of survey stations, the results of these surveys are divided into three reports: (1) Lower Muskegon River; (2) Middle Muskegon River; and (3) Upper Muskegon River watersheds (Figure 1). The Lower Muskegon River watershed (this report) is comprised of the mainstem Muskegon River and all tributaries from Muskegon Lake upstream to Croton Dam. The Middle Muskegon River watershed (Wesener, 2010b) is comprised of the mainstem Muskegon River and all tributaries from Croton Dam upstream to M-115. State highway M-115 was chosen as an upstream boundary for this portion of the watershed since it is the approximate boundary between the Southern Michigan Northern Indiana Till Plains (SMNITP) and Northern Lakes and Forests (NLF) ecoregions (Omernik and Gallant, 1988). Finally, the Upper Muskegon River watershed (Wesener, 2010c) is comprised of the mainstem Muskegon River and all tributaries upstream of M-115.

The Lower Muskegon River watershed was surveyed from July-September 2006. This survey was designed to qualitatively characterize the biotic integrity of macroinvertebrate communities with respect to existing habitat conditions at selected sites throughout the Muskegon River watershed. Surveys were performed according to the SWAS rapid bioassesment protocol, Procedure 51 (MDEQ, 1990), at 17 stations in wadeable segments of the mainstem Muskegon River and its tributaries.

Two site selection methods were used to assess the Muskegon River watershed in 2006: (1) stratified random; and (2) targeted. A probabilistic monitoring approach, using stratified random site selection to address statewide and regional questions about water quality, was used to select 9 stations throughout the lower watershed (MDEQ, 2006 draft). In addition to probabilistic monitoring, 8 sites within the lower watershed were selected for targeted monitoring to fulfill specific monitoring requests, assess known or potential areas of concern, collect information and assess attainment of water quality standards (WQS) from areas where historic survey information was lacking, or to collect information related to National Pollutant Discharge Elimination System (NPDES) permits.

Table 1 lists all sites visited and the type of work done at each site. Survey and site visit locations are presented in Figure 2. Macroinvertebrate community ratings and habitat evaluations are given in Tables 2a and 2b, and Table 3, respectively.

OBJECTIVES

The specific objectives of this survey were to:

- Assess the current status/condition of individual waters and determine attainment of Michigan WQS.
- Support water quality-based effluent limit development for NPDES permits.
- Identify potential nonpoint source (NPS) pollution problems.
- Evaluate general water quality trends in the watershed.
- Satisfy monitoring requests submitted by external and internal customers.

WATERSHED DESCRIPTION

The Muskegon River is located in the north-central part of the Lower Peninsula and incorporates over 2,350 square miles of land. The river is 212 miles long, with a 575-foot drop in elevation between the source from Higgins Lake and Houghton Lake to the mouth at Lake Michigan. Most of the watershed is contained within eight counties: Roscommon, Missaukee, Clare, Osceola, Mecosta, Montcalm, Newaygo, and Muskegon. Approximately 94 tributaries flow directly into the main stem of the Muskegon River and primary tributaries include the West Branch of the Muskegon River, Clam River, Middle Branch River, Hersey River, Little Muskegon River, Bigelow Creek, Brooks Creek, and Cedar Creek (O'Neal, 1997). The watershed is included in the SMNITP and NLF ecoregions (Omernik and Gallant, 1988).

Biological and habitat surveys were conducted at 66 stations throughout the watershed. Fish were collected at one site and several additional sites were visited to make general observations. In addition to 9 stations on the mainstem Muskegon River, over 30 different tributaries were assessed in 2006.

The lower Muskegon River, from Croton Dam to the mouth at Lake Michigan, is the subject of this report. This portion of the Muskegon River covers all of Muskegon County and part of Newaygo County. There are approximately 17 registered dams in this portion of the watershed and many water bodies are classified as designated trout streams. These include the Muskegon River and all tributaries from T10N, R16W, Section 18 to T12N, R11W, Section 18 (MDNR, 2004).

For a more detailed description of the watershed, including its recent and geologic history, hydrology, land use patterns, and biological communities, please refer to the Michigan Department of Natural Resources (MDNR), Fisheries Division, Fisheries Special Report 19, "Muskegon River Watershed Assessment" (O'Neal, 1997).

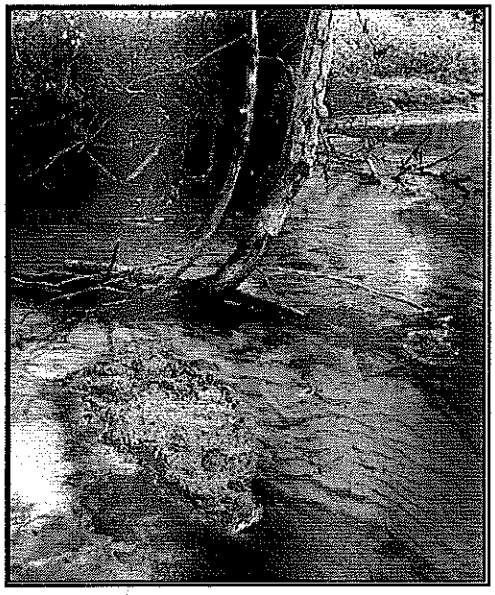
HISTORICAL SAMPLING EFFORTS

Recent Michigan Department of Environmental Quality (MDEQ) surveys of the lower Muskegon River watershed were conducted in 1996 and 2001.

Bigelow Creek, which enters the Muskegon River in Newaygo, was assessed in 1996 to document the effects of in-stream habitat improvement structures (Walker, 1998). Qualitative fish, macroinvertebrate, and habitat surveys were conducted at three stations. These surveys, in addition to water chemistry monitoring, indicated that Bigelow Creek was meeting WQS.

Sand Creek, which originates near Grant, Michigan, in Newaygo County, was also surveyed in 1996 by staff of the MDEQ. Two stations assessed were found to be meeting WQS with an acceptable macroinvertebrate community and fair habitat conditions (Cooper, 1998).

In 2001, qualitative fish, macroinvertebrate, and habitat surveys were performed throughout the Muskegon River watershed. A total of 8 stations were visited in the lower portion of the watershed (Schmitt, 2005a). Macroinvertebrate communities were rated excellent at 2 stations and acceptable at 3 stations. No stations were found to be poor. Total number of taxa for the 5 stations ranged from 18 to 26. Habitat ratings at the 8 stations ranged from fair (moderately impaired) to good (slightly impaired), and cumulative habitat scores ranged from 62 to 101. Results of macroinvertebrate community, habitat assessment, and water chemistry sampling indicated that WQS were being met; however, historical logging, increased agriculture, and urbanization were identified as possible stressors to the biological communities and habitat quality throughout the Muskegon River watershed (Schmitt, 2005a; Schmitt, 2005b; and Schmitt, 2005c).



SAMPLING RESULTS

Macroinvertebrate Community Assessment

The qualitative macroinvertebrate community data is rated based on the total score of 9 metrics rating from poor (-9 to -5), acceptable (-4 to +4), and excellent (+5 to +9). Macroinvertebrate communities rated acceptable at 16 stations in the lower portion of the watershed and excellent at 1 station. Total number of taxa for all stations ranged from 13 to 28 (Table 2a). Overall macroinvertebrate community scores for these sites ranged from -4 to +5 (Table 2b).

Habitat Assessment

Habitat evaluation is important in determining the nature and degree of abiotic constraints on the biological potential of the stream. This evaluation is accomplished through characterizing the stream based on selected physical measurements and descriptive watershed features. The habitat metrics measure a wide range of physical characteristics, which are important to the optimum development and stability of biological communities, and are used to develop habitat survey categories.

Habitat evaluations are made on in-stream habitat first, followed by channel morphology, bank structural features, and riparian vegetation. The habitat assessment process involves rating the sum total of 10 metrics as excellent (>154 total points), good (105-154), marginal (56-104), or poor (<56) based on the criteria included on the Habitat Assessment Field Data Sheets (MDEQ, 1990).

Overall stream habitat scores, which consider in-stream habitat as well as the adjacent stream banks and riparian habitat at the 17 sites in the lower Muskegon River watershed ranged from 89 (marginal) to 165 (excellent) (Table 3). Glide/pool metrics were used to evaluate habitat at 16 of the sites and riffle/run metrics were used at the remaining site. Overall, stream habitat at 1 of the sites was rated as excellent, 13 sites were rated as good, and 3 were rated as marginal. The sites where habitat scores were better tended to have higher riparian and bank structure scores. Also notable is that the marginal sites tended to score much lower than good sites on the flashiness, sediment deposition, and pool variability metrics (Table 3).

Habitat conditions throughout the watershed are highly influenced by past land use. Virgin timber was logged from the entire watershed and, while there is extensive secondary timber growth, urban development and agriculture are substantial in some areas. Removal of riparian vegetation has reduced important wood habitat in the channel, reducing available habitat and habitat complexity. Many tributaries have been dredged and straightened and most of the moderate and high gradient reaches have been impounded (O'Neal, 1997).

O'Neal (1997) reported that large scale aquatic habitat problems, including destabilized hydrologic conditions, water temperature changes, increased sediment erosion, and decreased in-stream habitat occur throughout the watershed and will likely become more severe as urban and agricultural development continues.

Stratified Random Sample Results

Although all probabilistic sites scored acceptable, it is estimated that the true proportion of stream miles in the entire Muskegon River watershed supporting the "other indigenous aquatic life designated use" component of Rule 323.1100(1)(e) of Michigan's WQS is between 94 percent (the lower 95 percent confidence limit) and 100 percent. This estimate is based on the results of sampling 50 randomly chosen sites in the Muskegon River watershed.

DISCUSSION

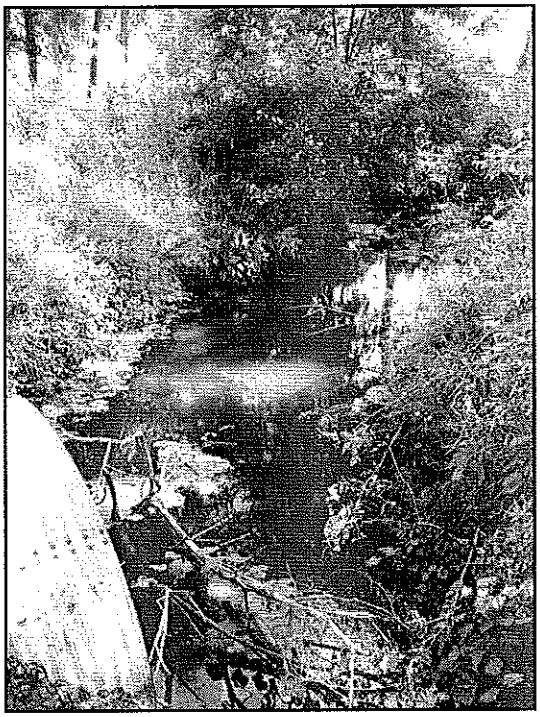
NPS Summary

A number of external requests for monitoring were submitted to assess the impacts of sediment traps (Stations 6-9), road stream crossing improvements and habitat concerns (Stations 3 and 15), and elevated nutrients (Stations 10-11 and 18). These stations were visited to address the monitoring requests and are discussed in more detail below.

Bear Creek

Bear Creek at River Road (Station 3) was assessed in response to a request from MDEQ district staff for baseline information. The macroinvertebrate community was rated acceptable (+2) and habitat rated marginal (moderately impaired). The in-stream habitat revealed evidence of a flashy hydrologic regime (e.g., point bars, aggraded, mid-channel sand islands, eroding banks, and pools were generally absent). Riparian habitat was also lacking due to vegetation being mowed all the way to the stream's edge. The macroinvertebrate habitat is limited to some large woody debris, sand, and pockets of fine particulate organic matter.

Cedar Creek



Cedar Creek was assessed at 2 locations (Stations 6-9) to evaluate the effects of sediment traps maintained by the United States Forest Service. At Crocker Road, the macroinvertebrate community scored 3 points higher below the sediment trap (Station 6) than above it (Station 7). This may suggest some positive influence from the sediment trap. In-stream habitat and stream flow differed between stations with the upstream station being dominated by gravel, cobble, and hardpan clay substrate. This station was a high gradient area while below the sediment trap flow was slower and substrate was mostly sand with macroinvertebrate habitat limited to large woody debris.

Cedar Creek (Stations 10 and 11) was previously found to have elevated ammonia compared to reference sites in the ecoregions. Procedure 51 was performed at 2 sites to determine if the macroinvertebrate community was meeting WQS. Water chemistry samples were not included in this assessment. Cedar Creek at Crystal Lake Road (Station 10) was found to have an acceptable macroinvertebrate community (+3) despite having sparse in-stream habitat. Pools were essentially absent, bank scour was estimated to be >20 inches above the stream, and loose, moving sand bedload was measured at one point to be 85 centimeters deep. There were no hard substrates except for sparse, large woody debris. Cedar Creek at Holton Road (Station 11) was found to have an acceptable macroinvertebrate community (-3) but was tending towards poor. Free-floating macrophytes (e.g., Lemna sp.) and attached and free-floating algae (e.g., Cladophora sp. and Spirogyra sp.) were prevalent at this station. A failed bank stabilization structure was present on the bend below M-120 as were large amounts of concrete riprap. The banks were severely scoured (>20 inches) and in-stream habitats, like large woody debris and concrete riprap, were covered with fine silt.

Minnie Creek

Minnie Creek at 96th Avenue (Station 15) was visited to determine its WQS attainment status. In 2001, this site was placed on the Section 303(d) list (LeSage and Smith, 2008) as a 4c (Impairment is not caused by a pollutant) due to habitat modification. The macroinvertebrate community was not assessed at that time. Evidence of past channelization was evident but did not appear to be recent. The riparian zone was dense with grasses and alders dominating. There was very little in-stream habitat due to a uniform, sandy bottom and low water levels. The macroinvertebrate community was acceptable (+1) and habitat rated marginal (moderately impaired) in 2006. Surprisingly, a young-of-the-year brown trout (*Salmo trutta*) was collected as part of the macroinvertebrate survey suggesting that trout may be naturally reproducing in Minnie Creek.

Penoyer Creek

Penoyer Creek (Station 18) was visited at the site of the Chain of Lakes Wastewater Treatment

Plant to assess the impacts of landfill leachate and to investigate bacterial or fungal slimes. It was determined upon arrival at the site that it would be a poor candidate for an upstream/downstream Procedure 51 study due to 2 large ponds that were considered to be affecting stream flow, temperature, and ultimately community composition. The site visit revealed no evidence of slimes or plaques above or below this location.

CONCLUSION

Results of the macroinvertebrate community and habitat assessments indicate that Michigan's WQS are being met in the lower Muskegon River watershed. However, there is considerable potential for protection and enhancement of biological communities in the watershed. Poor historic and current land use practices in the watershed have, and will continue to cause habitat degradation in the form of bank erosion, stream morphology changes (widening, aggradation of sediments, loss of habitat diversity, etc.), and increased embededness, and will reduce indigenous aquatic life metric scores. All biological communities would benefit from stabilization of stream discharge, maintaining natural water temperatures, protection and rehabilitation of in-stream habitats, riparian zones, and dam removal or mitigation of various dam issues (O'Neal, 1997).

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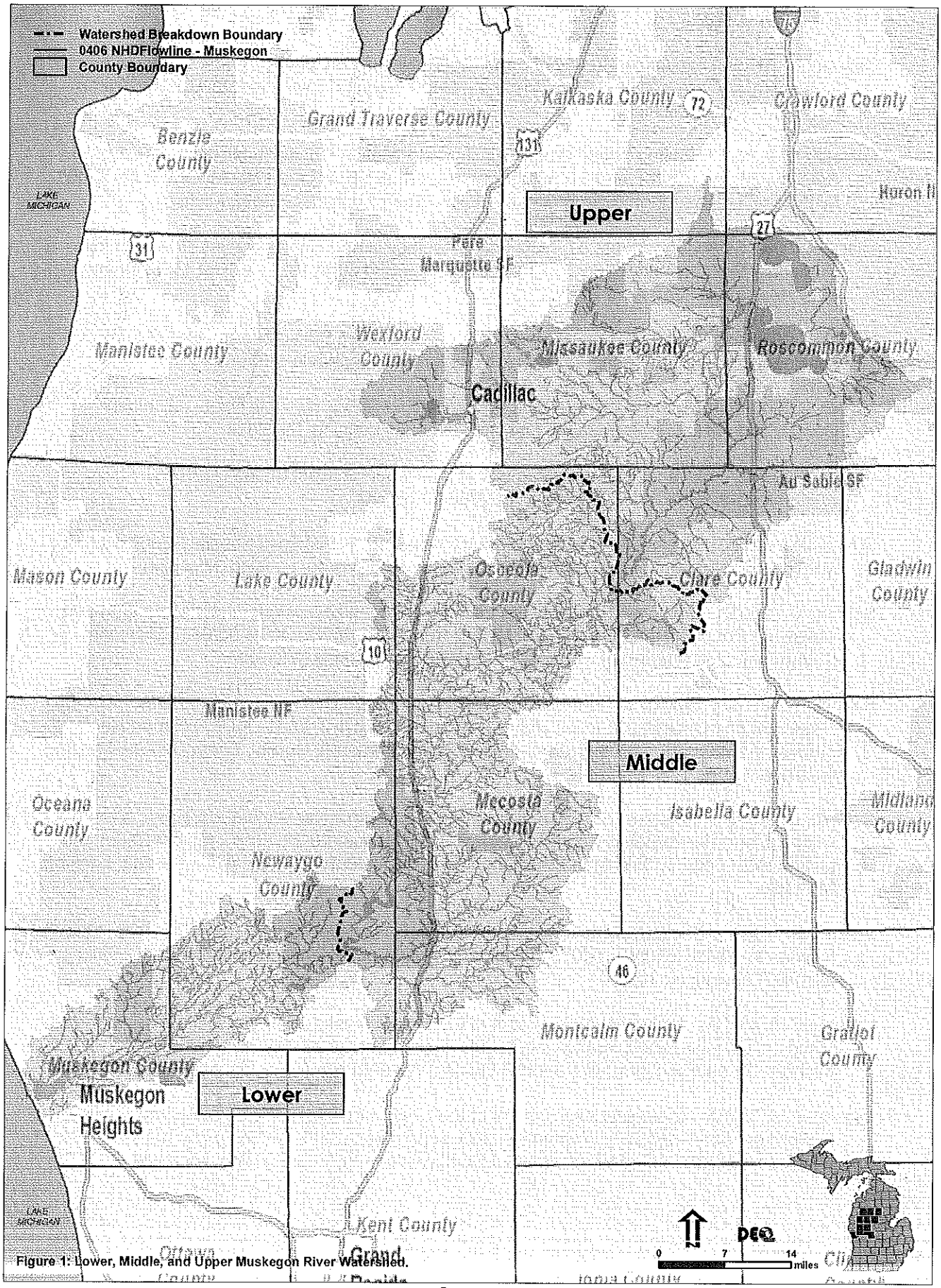

Figure 1: Lower, Middle, and Upper Muskegon River Watershed.

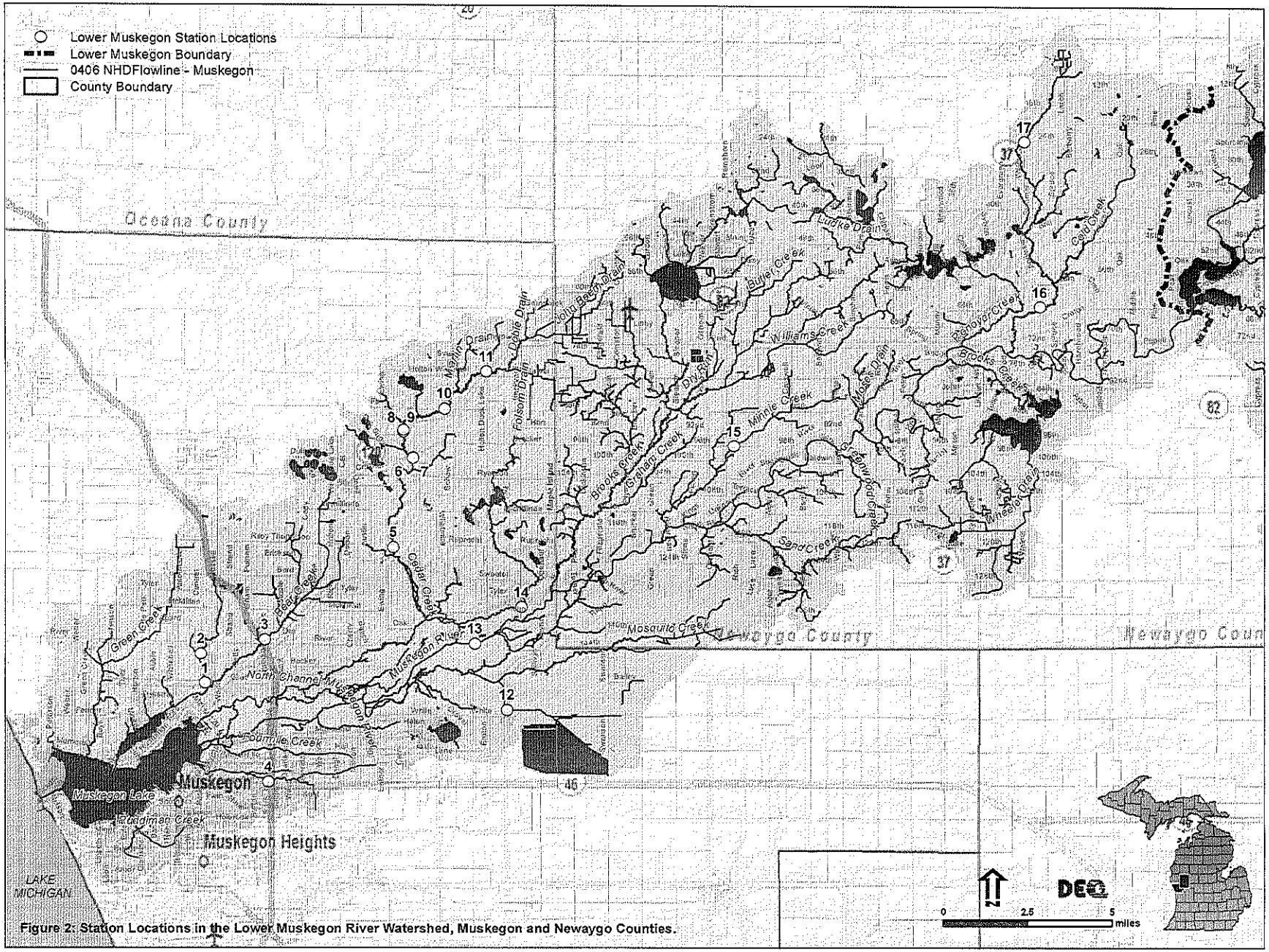

Figure 2: Station Locations in the Lower Muskegon River Watershed, Muskegon and Newaygo Counties.

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Table 1. Lower Muskegon River watershed station locations and Procedure 51 macroinvertebrate and habitat scores and ratings.

Station	Waterbody Name	Location	County	Latitude	Longitude	P51 Bugs	Bug Score	Bug Rating	P51 Habitat	Habitat Score	Habitat Rating
1	Little Bear Creek	Giles Rd	Muskegon	43.2780	-86.2444	X	0	Acceptable	X	110	Good
2	Little Bear Creek	d/s River Rd (RR bridge)	Muskegon	43.2907	-86.2469	X	-4	Acceptable	X	136	Good
3	***Bear Creek***	***River Rd.***	***Muskegon***	***43.2969***	***-86.2095***	***X***	***2***	***Acceptable***	***X***	***89***	***Marginal***
4	Ryerson Creek	Home St	Muskegon	43.2357	-86.2071	X	-1	Acceptable	X	116	Good
5	Cedar Creek	u/s two-track off Sweeter Rd	Muskegon	43.3366	-86.1343	X	-1	Acceptable	X	132	Good
6	***Cedar Creek***	***Crocker Rd. (d/s sediment trap)***	***Muskegon***	***43.3749***	***-86.1226***	***X***	***3***	***Acceptable***	***X***	***152***	***Good***
7	***Cedar Creek***	***Crocker Rd. (u/s sediment trap)***	***Muskegon***	***43.3746***	***-86.1228***	***X***	***0***	***Acceptable***	***X***	***144***	***Good***
8	***Cedar Creek***	***M120 (d/s sediment trap)***	***Muskegon***	***43.3863***	***-86.1285***	***X***	***-3***	***Acceptable***	***X***	***109***	***Good***
9	***Cedar Creek***	***M120 (u/s sediment trap)***	***Muskegon***	***43.3869***	***-86.1285***	***X***	***0***	***Acceptable***	***X***	***118***	***Good***
10	***Cedar Creek***	***Crystal Lake Rd.***	***Muskegon***	***43.3960***	***-86.1043***	***X***	***3***	***Acceptable***	***X***	***106***	***Good***
11	***Cedar Creek***	***Holton Rd.***	***Muskegon***	***43.4117***	***-86.0795***	***X***	***-3***	***Acceptable***	***X***	***105***	***Good***
12	Power Line Rd Drain	Maple Island Rd	Muskegon	43.2668	-86.0674	X	-3	Acceptable	X	91	Marginal
13	Muskegon River	d/s Hilton Duck Lake Rd	Muskegon	43.2952	-86.0862	X	5	Excellent	X	116	Good
14	Little Cedar Creek	Brickyard Rd	Muskegon	43.3110	-86.0588	X	-2	Acceptable	X	133	Good
15	***Minnie Creek***	***96th Avenue***	***Muskegon***	***43.3801***	***-85.9342***	***X***	***1***	***Acceptable***	***X***	***91***	***Marginal***
16	Bigelow Creek	off 2-track S of 58th Ave	Newaygo	43.4394	-85.7535	X	4	Acceptable	X	165	Excellent
17	Bigelow Creek	Walnut Ave	Newaygo	43.5108	-85.7624	X	3	Acceptable	X	116	Good

Bold/Italic = Targeted Sites

Table 2A. Qualitative macroinvertebrate sampling results for

TAXA	Little Bear Creek Giles Road 7/17/2006 **STATION 1**	Little Bear Creek upstream River Road 7/17/2006 **STATION 2**	Bear Creek River Road 8/30/2006 **STATION 3**	Ryerson Creek Homes Road 8/28/2006 **STATION 4**
PLATYHELMINTHES (flatworms)				
Turbellaria	1			4
ANNELIDA (segmented worms)				
Hirudinea (leeches)				1
Oligochaeta (worms)		4	10	4
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	192	142	74	150
Decapoda (crayfish)		1	1	
Isopoda (sowbugs)	36	50		3
Arachnoidea				
Hydracarina	1	1		
Insecta				
Ephemeroptera (mayflies)				
Baetidae	23	7	1	57
Heptageniidae	3		7	
Odonata				
Anisoptera (dragonflies)				
Aeshnidae	1		8	
Gomphidae			3	
Zygoptera (damselflies)				
Calopterygidae	2		8	
Plecoptera (stoneflies)				
Nemouridae	1			
Hemiptera (true bugs)				
Gerridae	1	1		3
Veliidae			3	2
Megaloptera				
Corydalidae (dobson flies)			4	
Sialidae (alder flies)			1	
Trichoptera (caddisflies)				
Brachycentridae	2		60	
Hydropsychidae	32	2	8	
Lepidostomatidae		7		
Limnephilidae	1	2	1	
Coleoptera (beetles)				
Dytiscidae (total)	3	1		1
Dryopidae			1	
Elmidae			2	
Diptera (flies)				
Athericidae		1		
Ceratopogonidae			1	
Chironomidae	8	24	29	15
Empididae			1	
Simuliidae	3	5	3	
Tabanidae		1	2	
Tipulidae			1	1
MOLLUSCA				
Gastropoda (snails)				
Lymnaeidae		1		
Physidae		3	2	3
Planorbidae				1
Pelecypoda (bivalves)				
Sphaeriidae (clams)	3	1	2	
TOTAL INDIVIDUALS	313	254	233	245

Table 2B. Macroinvertebrate metric evaluation of

METRIC	Little Bear Creek Giles Road 7/17/2006 STATION 1 Value	Score	Little Bear Creek upstream River Road 7/17/2006 STATION 2 Value	Score	Bear Creek River Road 8/30/2006 STATION 3 Value	Score	Ryerson Creek Homes Road 8/28/2006 STATION 4 Value	Score
TOTAL NUMBER OF TAXA	17	0	18	0	24	0	13	0
NUMBER OF MAYFLY TAXA	2	0	1	-1	2	0	1	-1
NUMBER OF CADDISFLY TAXA	3	0	3	0	3	0	0	-1
NUMBER OF STONEFLY TAXA	1	1	0	-1	0	-1	0	-1
PERCENT MAYFLY COMP.	8.31	0	2.76	-1	3.43	0	23.27	1
PERCENT CADDISFLY COMP.	11.18	0	4.33	0	29.61	1	0.00	-1
PERCENT DOMINANT TAXON	61.34	-1	55.91	-1	31.76	0	61.22	-1
PERCENT ISOPOD, SNAIL, LEECH	11.50	-1	21.26	-1	0.86	1	3.27	1
PERCENT SURF. AIR BREATHERS	1.28	1	0.79	1	1.29	1	2.45	1
TOTAL SCORE		0		-4		2		-2
MACROINV. COMMUNITY RATING		ACCEPT.		ACCEPT.		ACCEPT.		ACCEPT.

Table 2A. Qualitative macroinvertebrate sampling results for

TAXA	Cedar Creek Sweeter Rd 7/17/2006 STATION 5	Cedar Creek Crocker Rd. d/s sandtrap 9/25/2006 STATION 6	Cedar Creek Crocker Rd 8/29/2006 STATION 7	Cedar Creek M-120 below sand 8/29/2006 STATION 8
PLATYHELMINTHES (flatworms)				
Turbellaria		1		
ANNELIDA (segmented worms)				
Hirudinea (leeches)	1			
Oligochaeta (worms)	4	20	1	87
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	110	118	70	45
Decapoda (crayfish)	1			
Isopoda (sowbugs)	7			
Arachnoidea				
Hydracarina		2		1
Insecta				
Ephemeroptera (mayflies)				
Baetidae	13	52	5	14
Ephemerellidae		22	1	
Ephemeridae	4			
Heptageniidae	1	10	1	
Odonata				
Anisoptera (dragonflies)				
Cordulegastridae		1		
Hemiptera (true bugs)				
Belostomatidae			1	
Corixidae	7	5		
Gerridae				1
Nepidae				1
Notonectidae				1
Veliidae				1
Trichoptera (caddisflies)				
Brachycentridae	36	44	140	5
Glossosomatidae			20	
Hydropsychidae	8	29	2	3
Limnephilidae	1	13	10	2
Philopotamidae		4		
Polycentropodidae		3		
Uenoidae			2	
Coleoptera (beetles)				
Gyrinidae (adults)				1
Hydrophilidae (total)	1			
Dryopidae		2	1	
Elmidae		1		
Diptera (flies)				
Athericidae		3		
Ceratopogonidae		1		
Chironomidae	51	11	3	15
Dixidae				2
Empididae	1			
Simuliidae	36	2		
Tabanidae		4		
Tipulidae		1		
MOLLUSCA				
Gastropoda (snails)				
Ancylidae (limpets)		1		
Physidae	5	22	13	92
Planorbidae				1
Pelecypoda (bivalves)				
Sphaeriidae (clams)		6	1	1
TOTAL INDIVIDUALS	287	378	271	273

Table 2B. Macroinvertebrate metric evaluation of

METRIC	Cedar Creek Sweeter Rd 7/17/2006 STATION 5 Value	Score	Cedar Creek Crocker Rd. d/s sandtrap 9/25/2006 STATION 6 Value	Score	Cedar Creek Crocker Rd 8/29/2006 STATION 7 Value	Score	Cedar Creek M-120 below sand trap 8/29/2006 STATION 8 Value	Score
TOTAL NUMBER OF TAXA	17	0	25	1	15	0	17	0
NUMBER OF MAYFLY TAXA	3	0	3	0	3	0	1	-1
NUMBER OF CADDISFLY TAXA	3	0	5	1	5	1	3	0
NUMBER OF STONEFLY TAXA	0	-1	0	-1	0	-1	0	-1
PERCENT MAYFLY COMP.	6.27	0	22.22	1	2.58	-1	5.13	0
PERCENT CADDISFLY COMP.	15.68	0	24.60	0	64.21	1	3.66	-1
PERCENT DOMINANT TAXON	38.33	-1	31.22	0	51.66	-1	33.70	0
PERCENT ISOPOD, SNAIL, LEECH	4.53	0	6.08	0	4.80	0	34.07	-1
PERCENT SURF. AIR BREATHERS	2.79	1	1.32	1	0.37	1	1.83	1
TOTAL SCORE		-1		3		0		-3
MACROINV. COMMUNITY RATING		ACCEPT.		ACCEPT.		ACCEPT.		ACCEPT.

Table 2A. Qualitative macroinvertebrate sampling results for

TAXA	Cedar Creek M-120 above sand trap 8/29/2006 **STATION 9**	Cedar Creek Crystal Lake Rd 8/29/2006 **STATION 10**	Cedar Creek Holton Road 8/29/2006 **STATION 11**	Powerline Drain Maple Island Road 8/29/2006 **STATION 12**
PORIFERA (sponges)	1			
PLATYHELMINTHES (flatworms)				
Turbellaria	1			
ANNELIDA (segmented worms)				
Hirudinea (leeches)				3
Oligochaeta (worms)	66	1	23	3
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	50	53	21	30
Isopoda (sowbugs)			2	164
Arachnoidea				
Hydracarina	1	1		
Insecta				
Ephemeroptera (mayflies)				
Baetidae	69	22	1	1
Caenidae				6
Ephemeridae			1	
Heptageniidae		2	1	
Odonata				
Anisoptera (dragonflies)				
Aeshnidae			1	1
Zygoptera (damselflies)				
Calopterygidae		2	1	
Coenagrionidae			1	5
Plecoptera (stoneflies)				
Perlidae		2		
Pteronarcyidae		2		
Hemiptera (true bugs)				
Corixidae			3	1
Gerridae			4	
Notonectidae			1	
Veliidae	1	1	2	8
Megaloptera				
Corydalidae (dobson flies)		1		
Sialidae (alder flies)			2	
Trichoptera (caddisflies)				
Brachycentridae	45	146	2	
Hydropsychidae	12	14		
Hydroptilidae			2	18
Leptoceridae				1
Limnephilidae	6	5	6	
Coleoptera (beetles)				
Dytiscidae (total)		1		
Gyrinidae (adults)	2	1		
Haliplidae (adults)				1
Hydrophilidae (total)		1		3
Dryopidae	1	2		
Elmidae		1	14	
Diptera (flies)				
Chironomidae	24	6	149	2
Culicidae			1	1
Dixidae				2
Simuliidae	7			
Tabanidae		7	2	
Tipulidae	1	1		
MOLLUSCA				
Gastropoda (snails)				
Physidae	26	11	19	13
Planorbidae				25
Pelecypoda (bivalves)				
Pisidiidae	1			
Sphaeriidae (clams)	1		1	2
TOTAL INDIVIDUALS	315	283	260	290

Table 2B. Macroinvertebrate metric evaluation of

METRIC	Cedar Creek M-120 above sand trap 8/29/2006 STATION 9 Value	Score	Cedar Creek Crystal Lake Rd 8/29/2006 STATION 10 Value	Score	Cedar Creek Holton Road 8/29/2006 STATION 11 Value	Score	Powerline Drain Maple Island Road 8/29/2006 STATION 12 Value	Score
TOTAL NUMBER OF TAXA	18	0	22	0	23	0	20	0
NUMBER OF MAYFLY TAXA	1	-1	2	0	3	0	2	0
NUMBER OF CADDISFLY TAXA	3	0	3	0	3	0	2	0
NUMBER OF STONEFLY TAXA	0	-1	2	1	0	-1	0	-1
PERCENT MAYFLY COMP.	21.90	1	8.48	0	1.15	-1	2.41	-1
PERCENT CADDISFLY COMP.	20.00	0	58.30	1	3.85	-1	6.55	0
PERCENT DOMINANT TAXON	21.90	0	51.59	-1	57.31	-1	56.55	-1
PERCENT ISOPOD, SNAIL, LEECH	8.25	0	3.89	1	8.08	0	70.69	-1
PERCENT SURF. AIR BREATHERS	0.95	1	1.41	1	4.23	1	4.83	1
TOTAL SCORE		0		3		-3		-3
MACROINV. COMMUNITY RATING		**ACCEPT.**		**ACCEPT.**		**ACCEPT.**		**ACCEPT.**

Table 2A. Qualitative macroinvertebrate sampling results for

TAXA	Muskegon River Hilton Duck Lake Road 9/11/2006 STATION 13	Little Cedar Creek Brickyard Road 8/29/2006 STATION 14	Minnie Creek 96th Avenue 8/28/2006 STATION 15	Bigelow Creek 58th St 8/30/2006 STATION 16
PORIFERA (sponges)	1			1
ANNELIDA (segmented worms)				
Hirudinea (leeches)		1	2	
Oligochaeta (worms)	7	1		5
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	14	81	77	25
Decapoda (crayfish)				1
Isopoda (sowbugs)	3	94		
Arachnoidea				
Hydracarina		5		3
Insecta				
Ephemeroptera (mayflies)				
Baetiscidae				5
Baetidae	113	4	1	12
Caenidae	3	1		3
Ephemeridae	3	1		11
Heptageniidae	2	1	15	13
Isonychiidae	1			
Leptophlebiidae			1	
Tricorythidae	3			
Odonata				
Anisoptera (dragonflies)				
Aeshnidae	1	1	5	
Gomphidae	5	1	2	2
Zygoptera (damselflies)				
Calopterygidae	1	8	30	1
Coenagrionidae	1	1		
Plecoptera (stoneflies)				
Perlidae	1			
Hemiptera (true bugs)				
Belostomatidae	1	1		
Corixidae	1	14		2
Gerridae	1	1	2	1
Notonectidae	1	1		
Veliidae		1	7	1
Megaloptera				
Corydalidae (dobson flies)			1	
Sialidae (alder flies)		1		
Trichoptera (caddisflies)				
Brachycentridae	23	1	3	92
Glossosomatidae				1
Helicopsychidae				4
Hydropsychidae	2	1		14
Hydroptilidae			2	
Leptoceridae		4	1	2
Limnephilidae			3	5
Coleoptera (beetles)				
Dytiscidae (total)	1			
Gyrinidae (adults)	3			
Haliplidae (adults)	1			
Hydrophilidae (total)		1	3	1
Elmidae	4		14	16
Diptera (flies)				
Athericidae			8	
Ceratopogonidae	2		1	
Chironomidae	62	6	23	13
Culicidae		2		
Dixidae		17		2
Simuliidae	3	1	10	4
Syrphidae		1		
Tabanidae		1	5	3
MOLLUSCA				
Gastropoda (snails)				
Ancylidae (limpets)	2	3		14
Hydrobiidae		2		2
Physidae	2	1	8	2
Planorbidae		1	1	1
Pleuroceridae				3
Viviparidae		1		
Pelecypoda (bivalves)				
Sphaeriidae (clams)		4	13	7
TOTAL INDIVIDUALS	268	266	238	272

Table 2B. Macroinvertebrate metric evaluation of

METRIC	Muskegon River Hilton Duck Lake Road 9/11/2006 STATION 13		Little Cedar Creek Brickyard Road 8/29/2006 STATION 14		Minnie Creek 96th Avenue 8/28/2006 STATION 15		Bigelow Creek 58th St 8/30/2006 STATION 16	
	Value	Score	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	30	1	35	1	25	1	33	1
NUMBER OF MAYFLY TAXA	6	1	4	1	3	1	5	1
NUMBER OF CADDISFLY TAXA	2	0	3	0	4	0	6	1
NUMBER OF STONEFLY TAXA	1	1	0	-1	0	-1	0	-1
PERCENT MAYFLY COMP.	46.64	1	2.63	-1	7.14	0	16.18	0
PERCENT CADDISFLY COMP.	9.33	0	2.26	-1	3.78	-1	43.38	1
PERCENT DOMINANT TAXON	42.16	-1	35.34	0	32.35	0	33.82	0
PERCENT ISOPOD, SNAIL, LEECH	2.61	1	38.72	-1	4.62	0	8.09	0
PERCENT SURF. AIR BREATHERS	3.36	1	8.27	0	5.04	1	1.84	1
TOTAL SCORE		5		-2		1		4
MACROINV. COMMUNITY RATING		**EXCELLENT**		**ACCEPT.**		**ACCEPT.**		**ACCEPT.**

Table 2A. Qualitative macroinvertebrate sampling results for Bigelow Creek Walnut Ave 8/30/2006

TAXA	STATION 17
ANNELIDA (segmented worms)	
Oligochaeta (worms)	6
ARTHROPODA	
Crustacea	
Amphipoda (scuds)	57
Decapoda (crayfish)	3
Insecta	
Ephemeroptera (mayflies)	
Baetidae	3
Ephemeridae	1
Heptageniidae	3
Odonata	
Anisoptera (dragonflies)	
Aeshnidae	8
Gomphidae	1
Zygoptera (damselflies)	
Calopterygidae	35
Hemiptera (true bugs)	
Pleidae	1
Veliidae	2
Megaloptera	
Sialidae (alder flies)	2
Trichoptera (caddisflies)	
Brachycentridae	66
Glossosomatidae	1
Hydropsychidae	12
Hydroptilidae	2
Limnephilidae	6
Molannidae	1
Coleoptera (beetles)	
Hydrophilidae (total)	1
Elmidae	1
Diptera (flies)	
Ceratopogonidae	1
Chironomidae	25
Simuliidae	1
Tabanidae	5
MOLLUSCA	
Gastropoda (snails)	
Ancylidae (limpets)	1
Hydrobiidae	1
Physidae	7
Pelecypoda (bivalves)	
Sphaeriidae (clams)	1
TOTAL INDIVIDUALS	254

Table 2B. Macroinvertebrate metric evaluation of

Bigelow Creek
Walnut Ave
8/30/2006
STATION 17

METRIC	Value	Score
TOTAL NUMBER OF TAXA	28	1
NUMBER OF MAYFLY TAXA	3	0
NUMBER OF CADDISFLY TAXA	6	1
NUMBER OF STONEFLY TAXA	0	-1
PERCENT MAYFLY COMP.	2.76	-1
PERCENT CADDISFLY COMP.	34.65	1
PERCENT DOMINANT TAXON	25.98	0
PERCENT ISOPOD, SNAIL, LEECH	3.54	1
PERCENT SURF. AIR BREATHERS	1.57	1
TOTAL SCORE		3
MACROINV. COMMUNITY RATING		**ACCEPT.**

Table 3. Habitat evaluation for	Little Bear Creek		Little Bear Creek		Bear Creek		Ryerson Creek		Cedar Creek	
	Giles Road		upstream River Road		River Road		Homes Road		Sweeter Rd	
	GLIDE/POOL		GLIDE/POOL		GLIDE/POOL		GLIDE/POOL		GLIDE/POOL	
	STATION 1		**STATION 2**		**STATION 3**		**STATION 4**		**STATION 5**	
HABITAT METRIC										
Substrate and Instream Cover										
Epifaunal Substrate/ Avail Cover (20)	4		7		5		6		4	
Embeddedness (20)*										
Velocity/Depth Regime (20)*										
Pool Substrate Characterization (20)**	6		7		8		9		6	
Pool Variability (20)**	4		8		3		7		11	
Channel Morphology										
Sediment Deposition (20)	4		6		3		5		6	
Flow Status - Maint. Flow Volume (10)	9		10		10		9		10	
Flow Status - Flashiness (10)	4		9		1		5		10	
Channel Alteration (20)	18		19		18		16		18	
Frequency of Riffles/Bends (20)*										
Channel Sinuosity (20)**	7		14		11		13		7	
Riparian and Bank Structure										
Bank Stability (L) (10)	9		10		2		9		10	
Bank Stability (R) (10)	9		10		2		8		10	
Vegetative Protection (L) (10)	9		10		9		9		10	
Vegetative Protection (R) (10)	9		10		4		8		10	
Riparian Veg. Zone Width (L) (10)	9		8		10		8		10	
Riparian Veg. Zone Width (R) (10)	9		8		3		4		10	
TOTAL SCORE (200):	110		136		89		116		132	
HABITAT RATING:	**GOOD**		**GOOD**		**MARGINAL**		**GOOD**		**GOOD**	
	(SLIGHTLY		(SLIGHTLY		(MODERATELY		(SLIGHTLY		(SLIGHTLY	
	IMPAIRED)		IMPAIRED)		IMPAIRED)		IMPAIRED)		IMPAIRED)	
	Note: Individual metrics may better describe conditions directly affecting the biological community while the Habitat Rating describes the general riverine environment at the site(s).									
Date:	7/17/2006		7/17/2006		8/30/2006		8/28/2006		7/17/2006	
Weather:	Sunny				Partly Cloudy		Cloudy		Sunny	
Air Temperature:	85	Deg. F.	85	Deg. F.	65	Deg. F.		Deg. F.	90	Deg. F.
Water Temperature:	65	Deg. F.	64	Deg. F.	61	Deg. F.	60	Deg. F.	72	Deg. F.
Ave. Stream Width:	14	Feet	11.3	Feet	12.5	Feet	12	Feet	34	Feet
Ave. Stream Depth:	0.75	Feet	1	Feet	0.33	Feet	0.6	Feet	1.3	Feet
Surface Velocity:	1.25	Ft./Sec.	0.94	Ft./Sec.	0.41	Ft./Sec.	0.5	Ft./Sec.	1.25	Ft./Sec.
Estimated Flow:	13.125	CFS	10.622	CFS	1.69125	CFS	3.6	CFS	55.25	CFS
Stream Modifications:	None		None		None		None		None	
Nuisance Plants (Y/N):	N		N		N		N		N	
Report Number:										
STORET No.:	610325		610324		610661		610664		610519	
Stream Name:	Little Bear Creek		Little Bear Creek		Bear Creek		Ryerson Creek		Cedar Creek	
Road Crossing/Location:	Giles Road		upstream River Road		River Road		Homes Road		Sweeter Rd	
County Code:	61		61		61		61		61	
TRS:	10N16W06		11N16W32		11N16W34		10N16W21		11N15W20	
Latitude (dd):	43.278089		43.29586		43.29688		43.23528		43.3333103	
Longitude (dd):	-86.244424		-86.244282		-86.20952		-86.2064		-86.1338385	
Ecoregion:	SMNITP		SMNITP		SMNITP		SMNITP		SMNITP	
Stream Type:	Coldwater		Coldwater		Warmwater		Warmwater		Coldwater	
USGS Basin Code:	4060102		4060102		4060102		4060102		4060102	
* Applies only to Riffle/Run stream Surveys										
** Applies only to Glide/Pool stream Surveys										

Table 3 cont'd. Habitat evaluation for	Cedar Creek		Cedar Creek		Cedar Creek		Cedar Creek		Cedar Creek	
	Crocker Rd. d/s sandtrap		Crocker Rd		M-120 below sand trap		M-120 above sand trap		Crystal Lake Rd	
	GLIDE/POOL		GLIDE/POOL		GLIDE/POOL		GLIDE/POOL		GLIDE/POOL	
	STATION 6		**STATION 7**		**STATION 8**		**STATION 9**		**STATION 10**	
HABITAT METRIC										
Substrate and Instream Cover										
Epifaunal Substrate/ Avail Cover (20)	8		11		5		6		5	
Embeddedness (20)*										
Velocity/Depth Regime (20)*										
Pool Substrate Characterization (20)**	8		10		11		10		8	
Pool Variability (20)**	18		16		7		5		5	
Channel Morphology										
Sediment Deposition (20)	8		10		5		4		3	
Flow Status - Maint. Flow Volume (10)	10		10		10		10		10	
Flow Status - Flashiness (10)	7		3		3		3		2	
Channel Alteration (20)	20		18		16		20		18	
Frequency of Riffles/Bends (20)*										
Channel Sinuosity (20)**	20		16		6		14		11	
Riparian and Bank Structure										
Bank Stability (L) (10)	5		6		2		5		3	
Bank Stability (R) (10)	8		6		6		5		3	
Vegetative Protection (L) (10)	10		9		9		9		9	
Vegetative Protection (R) (10)	10		9		9		9		9	
Riparian Veg. Zone Width (L) (10)	10		10		10		8		10	
Riparian Veg. Zone Width (R) (10)	10		10		10		10		10	
TOTAL SCORE (200):	152		144		109		118		106	
HABITAT RATING:	**GOOD**		**GOOD**		**GOOD**		**GOOD**		**GOOD**	
	(SLIGHTLY		(SLIGHTLY		(SLIGHTLY		(SLIGHTLY		(SLIGHTLY	
	IMPAIRED)		IMPAIRED)		IMPAIRED)		IMPAIRED)		IMPAIRED)	
	Note: Individual metrics may better describe conditions directly affecting the biological community while the Habitat Rating									
	describes the general riverine environment at the site(s).									
Date:	9/25/2006		8/29/2006		8/29/2006		8/29/2006		8/29/2006	
Weather:	Sunny		Sunny		Sunny		Sunny		Sunny	
Air Temperature:	50	Deg. F.	75	Deg. F.	75	Deg. F.	75	Deg. F.	75	Deg. F.
Water Temperature:	49	Deg. F.	62	Deg. F.	60	Deg. F.	62	Deg. F.	60	Deg. F.
Ave. Stream Width:	15	Feet	18	Feet	24	Feet	33	Feet	15	Feet
Ave. Stream Depth:	2	Feet	1	Feet	1	Feet	0.88	Feet	0.54	Feet
Surface Velocity:	1	Ft./Sec.	1	Ft./Sec.	0.5	Ft./Sec.	0.4	Ft./Sec.	0.5	Ft./Sec.
Estimated Flow:	30	CFS	18	CFS	12	CFS	11.616	CFS	4.05	CFS
Stream Modifications:	Habitat Improvement		Bank Stabilization		None		Habitat Improvement		None	
Nuisance Plants (Y/N):	N		N		N		N		N	
Report Number:										
STORET No.:	610511		610489		610659		610658		610520	
Stream Name:	Cedar Creek		Cedar Creek		Cedar Creek		Cedar Creek		Cedar Creek	
Road Crossing/Location:	Crocker Rd. d/s sandtrap		Crocker Rd		M-120 below sand trap		M-120 above sand trap		Crystal Lake Rd	
County Code:	61		61		61		61		61	
TRS:	11N15W5		11N15W5		12N15W32		12N15W32		12N15W28	
Latitude (dd):	43.37572		43.37607		43.38626		43.38685		43.3963904	
Longitude (dd):	-86.12346		-86.12401		-86.12852		-86.12848		-86.1041196	
Ecoregion:	SMNITP		SMNITP		SMNITP		SMNITP		SMNITP	
Stream Type:	Coldwater		Coldwater		Coldwater		Coldwater		Coldwater	
USGS Basin Code:	4060102		4060102		4060102		4060102		4060102	
* Applies only to Riffle/Run stream Surveys										
** Applies only to Glide/Pool stream Surveys										

Table 3 cont'd. Habitat evaluation for	Cedar Creek		Powerline Drain		Muskegon River		Little Cedar Creek		Minnie Creek	
	Holton Road		Maple Island Road		downstream Hilton Duck Lake Road		Brickyard Road		96th Avenue	
	GLIDE/POOL		GLIDE/POOL		RIFFLE/RUN		GLIDE/POOL		GLIDE/POOL	
	STATION 11		STATION 12		STATION 13		STATION 14		STATION 15	
HABITAT METRIC										
Substrate and Instream Cover										
Epifaunal Substrate/ Avail Cover (20)	5		10		3		5		5	
Embeddedness (20)*					6					
Velocity/Depth Regime (20)*					6					
Pool Substrate Characterization (20)**	6		11				6		8	
Pool Variability (20)**	13		0				2		2	
Channel Morphology										
Sediment Deposition (20)	11		18		1		18		3	
Flow Status - Maint. Flow Volume (10)	10		10		10		10		8	
Flow Status - Flashiness (10)	2		8		8		10		3	
Channel Alteration (20)	15		5		19		19		13	
Frequency of Riffles/Bends (20)*					9					
Channel Sinuosity (20)**	10		0				14		7	
Riparian and Bank Structure										
Bank Stability (L) (10)	5		9		10		10		6	
Bank Stability (R) (10)	6		9		8		10		5	
Vegetative Protection (L) (10)	7		3		8		8		8	
Vegetative Protection (R) (10)	7		3		8		8		7	
Riparian Veg. Zone Width (L) (10)	4		2		10		4		8	
Riparian Veg. Zone Width (R) (10)	4		3		10		9		8	
TOTAL SCORE (200):	105		91		116		133		91	
HABITAT RATING:	GOOD		MARGINAL		GOOD		GOOD		MARGINAL	
	(SLIGHTLY		(MODERATELY		(SLIGHTLY		(SLIGHTLY		(MODERATELY	
	IMPAIRED)		IMPAIRED)		IMPAIRED)		IMPAIRED)		IMPAIRED)	
	Note: Individual metrics may better describe conditions directly affecting the biological community while the Habitat Rating									
	describes the general riverine environment at the site(s).									
Date:	8/29/2006		8/29/2006		9/11/2006		8/29/2006		8/28/2006	
Weather:	Sunny		Cloudy		Cloudy		Sunny		Cloudy	
Air Temperature:	70	Deg. F.	65	Deg. F.	55	Deg. F.	70	Deg. F.	70	Deg. F.
Water Temperature:	60	Deg. F.	62	Deg. F.	67	Deg. F.	63	Deg. F.	65	Deg. F.
Ave. Stream Width:	15	Feet	50	Feet	350	Feet	25	Feet	7.5	Feet
Ave. Stream Depth:	1.75	Feet	3	Feet	3	Feet	1.5	Feet	0.3	Feet
Surface Velocity:	0.25	Ft./Sec.	0.5	Ft./Sec.	2.5	Ft./Sec.	1	Ft./Sec.	0.41	Ft./Sec.
Estimated Flow:	6.5625	CFS	75	CFS	2625	CFS	37.5	CFS	0.9225	CFS
Stream Modifications:	nk Stabilization		Dredged		None		None		Dredged	
Nuisance Plants (Y/N):	N		N		N		N		N	
Report Number:										
STORET No.:	610660		610665		610662		610663		620278	
Stream Name:	Cedar Creek		Powerline Drain		Muskegon River		Little Cedar Creek		Minnie Creek	
Road Crossing/Location:	Holton Road		Maple Island Road		downstream Hilton Duck Lake Road		Brickyard Road		96th Avenue	
County Code:	61		61		61		61		62	
TRS:	12N15W23		10N15W11		11N15W34		11N09W22		11N14W01	
Latitude (dd):	43.41172		43.26662		43.29776		43.3111		43.38011	
Longitude (dd):	-86.07953		-86.06705		-86.07954		-86.0591		-85.93424	
Ecoregion:	SMNITP		SMNITP		SMNITP		SMNITP		SMNITP	
Stream Type:	Coldwater		Coldwater		Coldwater		Coldwater		Warmwater	
USGS Basin Code:	4060102		4060102		4060102		4060102		4060102	
* Applies only to Riffle/Run stream Surveys										
** Applies only to Glide/Pool stream Surveys										

Table 3 cont'd. Habitat evaluation for	Bigelow Creek 58th St GLIDE/POOL STATION 16		Bigelow Creek Walnut Ave GLIDE/POOL STATION 17	
HABITAT METRIC				
Substrate and Instream Cover				
Epifaunal Substrate/ Avail Cover (20)	14		4	
Embeddedness (20)*				
Velocity/Depth Regime (20)*				
Pool Substrate Characterization (20)**	15		7	
Pool Variability (20)**	15		5	
Channel Morphology				
Sediment Deposition (20)	8		2	
Flow Status - Maint. Flow Volume (10)	10		10	
Flow Status - Flashiness (10)	8		5	
Channel Alteration (20)	19		18	
Frequency of Riffles/Bends (20)*				
Channel Sinuosity (20)**	18		12	
Riparian and Bank Structure				
Bank Stability (L) (10)	10		9	
Bank Stability (R) (10)	8		9	
Vegetative Protection (L) (10)	10		9	
Vegetative Protection (R) (10)	10		9	
Riparian Veg. Zone Width (L) (10)	10		7	
Riparian Veg. Zone Width (R) (10)	10		10	
TOTAL SCORE (200):	165		116	
HABITAT RATING:	**EXCELLENT** (NON-IMPAIRED)		**GOOD** (SLIGHTLY IMPAIRED)	
	Note: Individual metrics may better describe conditions directly affecting the biological community while the Habitat Rating describes the general riverine environment at the site(s).			
Date:	8/30/2006		8/30/2006	
Weather:	Sunny		Sunny	
Air Temperature:	72	Deg. F.	75	Deg. F.
Water Temperature:	64	Deg. F.	64	Deg. F.
Ave. Stream Width:	30	Feet	10	Feet
Ave. Stream Depth:	0.9	Feet	0.5	Feet
Surface Velocity:	1	Ft./Sec.	0.5	Ft./Sec.
Estimated Flow:	27	CFS	2.5	CFS
Stream Modifications:	Habitat Improvement		Habitat Improvement	
Nuisance Plants (Y/N):	N		N	
Report Number:				
STORET No.:	620214		620213	
Stream Name:	Bigelow Creek		Bigelow Creek	
Road Crossing/Location:	58th St		Walnut Ave	
County Code:	62		62	
TRS:	13N12W09		13N12W16	
Latitude (dd):	43.4494		43.4983	
Longitude (dd):	-85.745		-85.7627	
Ecoregion:	SMNITP		SMNITP	
Stream Type:	Warmwater		Warmwater	
USGS Basin Code:	4060102		4060102	
* Applies only to Riffle/Run stream Surveys				
** Applies only to Glide/Pool stream Surveys				