MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
WATER RESOURCES DIVISION
JULY 2015

STAFF REPORT

BIOSURVEY OF THE THORNAPPLE RIVER WATERSHED BARRY, EATON, KENT, AND IONIA COUNTIES AUGUST AND SEPTEMBER 2013

SUMMARY OF RESULTS

Within the Thornapple River watershed, macroinvertebrate communities were sampled at 27 sites using the Surface Water Assessment Section (SWAS) Procedure 51 (Michigan Department of Environmental Quality [MDEQ], 1990). Site locations and a summary of all results are located in Table 1. Overall, the macroinvertebrate communities in the Thornapple River were widely variable, ranging in score from -6 (poor) to +7 (excellent) on a scale of -9 to +9. The average macroinvertebrate score for the 27 stream sites was -2 (at the low end of the acceptable range). Sites scored excellent at 4 sites, acceptable at 20 sites, and poor at 3 sites (Tables 2a and 2b). Poor macroinvertebrate communities were found at sites located at Mud Creek at Saddlebag Road, Little Thornapple at M-43, and Little Thornapple at Harwood Road. Habitat was generally categorized as good, based on the average habitat score of 110 for the watershed (Tables 1 and 3). Fish community did not meet the coldwater fish designated use at all 3 sites sampled (Quaker Brook, Duck Creek, and Pratt Lake Creek) (Tables 4a and 4b). In addition to biological surveys, analyses of 2006-era land cover (Table 5), human population (Table 6), and river reach gradient and flow (Table 7) were completed.

BACKGROUND INFORMATION

History and Geography

The Thornapple River (hydrologic unit code (HUC) 04050007) is a tributary to the Lower Grand River, with the confluence just east of Grand Rapids, Michigan (Figure 1). The Thornapple River watershed contains 36 subbasins, which can be seen in Figure 1, and is home to about 104,000 people (Table 6). The highest density of human habitation is near the confluence with the Grand River, in the Grand Rapids metropolitan area.

The entire Thornapple River watershed is within the Southern Michigan Northern Indiana Till Plain ecoregion, which broadly covers the majority of the southern half of the Lower Peninsula of Michigan (Omernik and Gallant, 1988). In terms of the U.S. Geological Survey (USGS) landscape ecosystem types, the Thornapple River watershed is composed of Lansing, Cassopolis Ice-Contact Ridges, and Battle Creek Outwash Plain subsections (Albert, 1995). The eastern portion of the watershed is in the Lansing ecosystem subsection, where soils are rich loams. Presettlement vegetation would have supported beech and maple forests with occasional pockets of forested wetlands, which formerly occupied about 22 percent of the area. Most uplands in the fertile Lansing subsection have been converted to agriculture while most wetlands were deforested and converted to pastureland. Drainage by tiling and ditching was necessary to support agriculture in many areas, and as a result, many stream headwaters that were once sprawling wetlands are now drainage ditches and maintained drains with low

gradient (less than 1 meter elevation drop per kilometer). Topography is gently rolling in the Lansing subsection.

The southwestern portion of the watershed, most in Barry County, is a patchwork of the Cassopolis Ice-Contact Ridges and Battle Creek Outwash Plain subsections. These ecosystems are composed of sand and gravel outwash plains with numerous small lakes and wetlands, broken by steep gradient ice-contact ridges and end-moraines. The steep terrain results in higher gradient streams, such as Glass Creek and Fall Creek, which have an overall gradient of 2.0 to 2.5 meters elevation loss per kilometer. Well drained portions originally supported tall-grass prairies, oak-hickory forests, and oak savannahs such as those being restored and preserved at the Pierce Nature Preserve southwest of Hastings, and the Barry State Game Area, which encompasses 17,000 acres in the Glass Creek vicinity. Farming was not sustainable in this area and efforts were largely abandoned in the 1920s and 1930s, resulting in the reforestation of abandoned fields, but residential areas are expanding. The main channel of the Thornapple River near the confluence of the Grand River occupies a former glacial outwash channel that is about 30 meters lower than the surrounding plains. Because of the deep soils, streams tend to trench deeply and have steep eroding banks in high gradient areas, for example, High Bank Creek.

Past Biological Surveys

The most recent survey of the Thornapple River watershed was conducted in 2008 (Rippke, 2009). Macroinvertebrate communities were found to be poor at 3 sites: the Little Thornapple River (Barry County) at M-43, Little Thornapple River (Eaton County) at Vermontville Highway, and Church Drain at Stewart Road. In 2008, macroinvertebrate communities rated acceptable at the majority of sites, and excellent at 5 sites. A subset of the randomly selected sites are monitored every 5 years to detect statewide and local trends in water quality. These sites are denoted with a “T” after their site number in Table 1.

Hydrology

Water velocity, stream morphology, and flow are influenced by the gradient, or slope, of the stream. Flow conditions of the river at survey sites are a key factor in determining aquatic macroinvertebrate and fish community composition (Figure 4). The gradient, described as meters of elevation change over 1 kilometer of stream length, was calculated within each National Hydrography Dataset reach that contained a survey site (Table 7), using USGS Digital Elevation Models.

Several dams and impoundments remain in place on the main stem Thornapple River including 5 dams (Ada, Cascade, Middleville, LeBarge [Caledonia], and Irving) (Figure 3) that take advantage of natural gradient changes in the river to generate hydroelectric power. The hydrology of the main stem river is dramatically affected by water level manipulation caused by these dams. The Nashville Dam, originally constructed in 1854, created the 80-acre Nashville Mill Pond (impoundment). The dam was removed in 2009 allowing a more natural river system in that area to be restored. According to a 2012 2-week study of continuous dissolved oxygen in the area of the former impoundment, the removal of that dam resulted in an increase in dissolved oxygen in the river, which has the potential to benefit fish communities in that area in addition to restoring fish passage that was once blocked by the dam (Carpenter, 2012).

Historic wetland destruction is a major issue that continues to affect water quality in the Thornapple River. Overall, the Thornapple River watershed has lost about 50 percent of its presettlement extent of wetland area, and some subbasins have lost as much as 82 percent of their original wetland area (Table 5) ((MDEQ, 2007 and U.S. Fish and Wildlife Service [USFWS], 2005). The drainage of wetlands was mainly conducted to allow farming of these productive soils. But these activities resulted in the creation of ditches that require maintenance to continue draining the land. The loss of half of the presettlement wetlands has had a negative impact on aquatic ecosystems, including the loss of flood plain access to fish, loss of groundwater infiltration, increased flashiness (flow variability), and altered hydrology where wetlands were drained by creating drainage channels. The water levels on the main stem Thornapple River, near the city of Hastings, demonstrate this flashiness in response to a heavy rainfall event that occurred on August 22-23, 2013 (Figure 4). The periodic dredging and straightening of these ditches that were formed in places formerly occupied by wetlands also removes niche habitats that are important to fish and macroinvertebrates.

Land Cover

Land cover, or the types of vegetation or anthropogenic uses covering the land, has a bearing on stream hydrology, sediment transport (erosion), and water temperature. For example, agricultural land cover types generally lose more topsoil by sheet and gully erosion than a forested land would, while developed land with its impervious surfaces would generally increase runoff and decrease infiltration during precipitation or snow melt events. The Thornapple River watershed is predominantly agricultural land, with overall 42 percent cultivated land and an additional 18 percent pasture land (National Oceanic and Atmospheric Administration [NOAA], 2011). Overall, developed land is only 5% of the watershed, but is locally more common, such as in the portion of the Thornapple that are near the city of Grand Rapids, where developed land is about 46% of that sub-basin.

METHODS

Sites for this water quality survey were selected via two methods: targeted sampling to address specific areas of interest; and probabilistic sampling, using stratified, random site selection to address statewide and regional questions about water quality. The probabilistic approach was used to select 17 sites in the Thornapple watershed (Figures 1, 2.1, and 2.2) (MDEQ, 2015 [draft]). Random sample selection was stratified based on stream temperature and flow characteristics, placing streams in two temperature categories (cold and warm) and further classifying them into four size categories (small, medium, large, and very large). In addition to probabilistic monitoring, 14 sites were selected for targeted monitoring to fulfill specific monitoring requests, fill gaps in historic surveys, and collect information relevant to NPDES permits.

Procedure 51 describes the methodology for macroinvertebrate, fish, and habitat surveys of wadeable streams. Procedure 51 rates macroinvertebrate communities as poor (-9 to -5), acceptable (-4 to +4), and excellent (+5 to +10), based on the proportions of each taxa found, and the sensitivity of the community assemblage to water quality concerns. Habitat was rated on a scale of poor (<56), marginal (56-104), good (105-154), or excellent (>154), based on in-stream and riparian characteristics and impairments.

The Geographic Information System was used to analyze land cover (NOAA, 2011), stream slope, and flow (U.S. Department of Agriculture-Natural Resources Conservation Service [USDA-NRCS] et al., 2014), wetland loss (USFWS, 2005), and human population (U.S. Census

Bureau, 2010a and 2010b), patterns at the subbasin level. Subbasins are subwatersheds that are approximately equal in size to 12-digit HUCs.

RESULTS

Summary of Poor Fish Communities

According to the 1997 Directors Order, "Designated Trout Streams in the State of Michigan," coldwater designated streams include Quaker Brook, Cedar Creek, the Coldwater River, and tributaries to the Coldwater River (Tyler Creek, Pratt Lake Drain, and Duck Creek) (Department of Natural Resources, 1997). To meet the coldwater fish community designated use, salmonids must be present at 1 percent of the sample, with a minimum of 50 fish in the sample. In addition to a healthy fish population, chemical makeup of the water (including adequate dissolved oxygen) is also considered in determining if coldwater fish could survive in a stream. Dissolved oxygen was not measured in any of the Thornapple River tributaries as part of this study. Quaker Brook, Duck Creek, and Pratt Lake Drain fish community samples contained no salmonids (Tables 4a and 4b). All of these sites are highly impacted by human activity.

Quaker Brook at East Lawrence Road (Site 30) is a small second order stream with a mean September flow of 4.7 cubic feet per second (cfs) and has a fairly high gradient (3.4 meters in elevation per 1 kilometer of stream length). The subbasins for Quaker Brook (12 and 13) are between 34-38 percent cultivated land, 25 percent hay or pasture, less than 5 percent developed land, and between 11-16 percent wetland area. Where the fish community does not meet the coldwater fish designated use according to our fish community survey results (Site 30, east of Lawrence Road), Quaker Brook is a maintained county drain and has been straightened and channelized for drainage purposes by the Barry County Drain Commission (*link broken, removed*). Further up in the Quaker Brook watershed, a more natural stream character has been maintained and the stream is deep, fast flowing, and meanders through a marsh. However, fish would have to pass through the maintained drain section of the brook in order to reach the more natural upstream portion.

Pratt Lake Creek (Site 13T) is a larger second order stream (a mean September flow of 11 cfs), with a lower gradient (1.3 meters in elevation per 1 kilometer of stream length). This subbasin (30) has a much higher percent of cultivated land (56 percent) than Quaker Brook, and a small area of wetland (5 percent).

Duck Creek is a small second order stream (a mean September flow of 8 cfs), with a lower gradient (1.0 meters in elevation per 1 kilometer of stream length). Duck Creek in this area is a designated county drain maintained by the Ionia County Drain Commission, and the subbasin is highly agricultural, with 67 percent cultivated land and an additional 16 percent in pasture or hay.

Summary of Poor Macroinvertebrate Communities

Little Thornapple at Harwood Road (Site 29) was found to have a poor macroinvertebrate community and is located in subbasin 26. Just downstream, in subbasin 27, is another site that had a poor macroinvertebrate community, Little Thornapple River at M-43 (Site 15). Both of these subbasins had very high proportions (60-68 percent) of cultivated land. Only 6-12 percent of these subbasins are forested (upland natural), and only 6-7 percent is wetland. The

Little Thornapple River at M-43 (Site 15) is a low gradient stream (.35 meters elevation drop per kilometer of stream length). While both site locations are second order streams, at M-43 the channel is much larger with an average flow of 21 cfs in September, compared with the average flow of 5 cfs at Harwood Road (Site 29). These subbasins drain to the high quality trout stream (Coldwater River). The entire main stem Little Thornapple River (including the vicinity of M-43) is actively maintained by the Barry County Drain Commission under Michigan's Drain Code (Public Act 40 of 1056, as amended) (Barry County Drain Commission Web site). The Little Thornapple River in the vicinity of the Harwood Road site is actively maintained by the Ionia County Drain Commission and was last cleaned out in 2012 (personal communication with John Bush, Ionia County Drain Commissioner, October 29, 2014).

The macroinvertebrate community in Mud Creek at Saddlebag Road (Site 12) also scored poorly (-6, on a scale of -9 to +9). No mayflies were found at this site, and the community was dominated by amphipods. Mayflies are a group of insects that generally requires somewhat clean and oxygenated water, while amphipoda are extremely tolerant of poor conditions. Another sensitive taxa, caddis flies, were also scarce. This drain (the Colier and Mud Creek Intercounty Drain) is maintained upstream of Saddlebag Road by the Eaton County Drain Commission and downstream of the road crossing by the Barry County Drain Commission (personal communication with Brittany Covault, Drain Project and Assessment Administrator, Eaton County Drain Commissioner's Office, March 2015). The last drain maintenance was conducted in 2013. The creek in this area is a fairly small second order stream with a very low gradient of 1 meter elevation drop per kilometer, and a flow of 13 cfs. This site is in subbasin 15, which is one of the most agricultural subwatersheds in the Thornapple River with a total of 80 percent of the land in cultivation or hay/pasture.

The macroinvertebrate community several miles downstream at Davenport Road (Site 17T) was considerably better (score of 0, on a scale of -9 to +9). Amphipods were still the dominant taxa at this site, but two taxa of mayflies were found (although in very low numbers) and caddis flies were much more common than at Site 12. This site is also a designated county drain (Barry County Drain Commission Web site), but considerable amounts of large woody debris were present at the time of this survey, and some meanders had formed in the stream, providing a diversity of habitats that were not present at Saddlebag Road (Site 12). Mud Creek at Davenport Road is a third order stream with a mean September flow almost double that of the Saddlebag Road site (Table 7).

Church Drain at Stewart Road (Site 3) was found to have an acceptable macroinvertebrate community during this survey, while in a prior survey it had been poor (Rippke, 2009). It is the author's opinion that the condition of the macroinvertebrate community itself has not changed; rather, the change in macroinvertebrate community reflected by the score was likely due to the inclusion of a few taxa that were rare at the site in 2013, and were not captured in 2009. Amphipods were overwhelmingly the dominant taxa in both 2009 and 2013. This site is a small stream (flow of 2.2 cfs) but has a fairly high gradient (1.78 meters per kilometer), which results in ample water movement. The entirety of Church Drain is a designated county drain, maintained when deemed necessary by the Eaton County Drain Commissioner (personal communication with John Perry, Deputy Drain Commissioner, Eaton County Drain Commission, March 2015).

Nonpoint Source Issues

Historic dredging, drain construction and maintenance, and the destruction of about 50 percent of the presettlement wetland area has altered the channel morphology and hydrology (flow

patterns) of the Thornapple River and its tributaries significantly. In many cases, the cross section of the larger rivers became U-shaped, with steep sides and a channel that is relatively deep for their width, with little bottom contour or instream habitat features. Because of the increased depth and diminished area of shallow nearshore edge, these U-shaped channels do not provide areas for aquatic plants to root, and cobble, boulders, and gravel are too deep under the water to provide habitat for aquatic macroinvertebrates. These U-shaped channels often have infrequent or no large woody debris along the edges to serve as fish or macroinvertebrate habitat, because rather than depositing in shallow areas near the bank, it is swept away by the current or removed during drain maintenance activities. Woody debris often continues to float downstream until it forms a debris dam at a culvert. Because of the steep banks and dredge spoils, these incised channels do not flow into their floodplains at high flows. If a river cannot access its floodplain, this will often result in high energy flows eroding and scouring banks and the stream bed. A prime example of the U-shaped channel is Site 5 (Thornapple River at Pinch and Otto Roads). At Site 5 there were no shallow areas in the river, and it was consistently about 3 feet deep and steep-sided, and the bottom substrate was almost entirely a mix of soft silt and sand. Thornapple River at Ionia Road (Site 11) is an extremely deep example (estimated to be greater than 5 feet deep) of a U-shaped channel with almost no available habitat for macroinvertebrates to inhabit except at the very edge, this site also had 20 inches of bare soil above the water level due to bank scour. Site 6 (Thornapple River at Mulliken Road) is another example of a river that has been historically dredged and straightened, but at this site the channel is beginning to naturalize and recover, with accumulations of large woody debris and rootwads from trees providing some habitat. The macroinvertebrate community is in the high acceptable range (+4).

Improperly installed road crossing culverts can also cause issues in fish passage and changes in channel morphology. At Site 10 (Scipio Creek at Highway 66), the culvert was perched above the water level and may impede fish passage. At Site 13T, Pratt Lake Creek passes under Wingeier Avenue through an older double culvert, and one of the culvert pipes is clogged with a grassy sand bar. Emmons Creek at Thornapple Drive (Site 25) had a double culvert with a similar sediment accumulation problem (see photo below).

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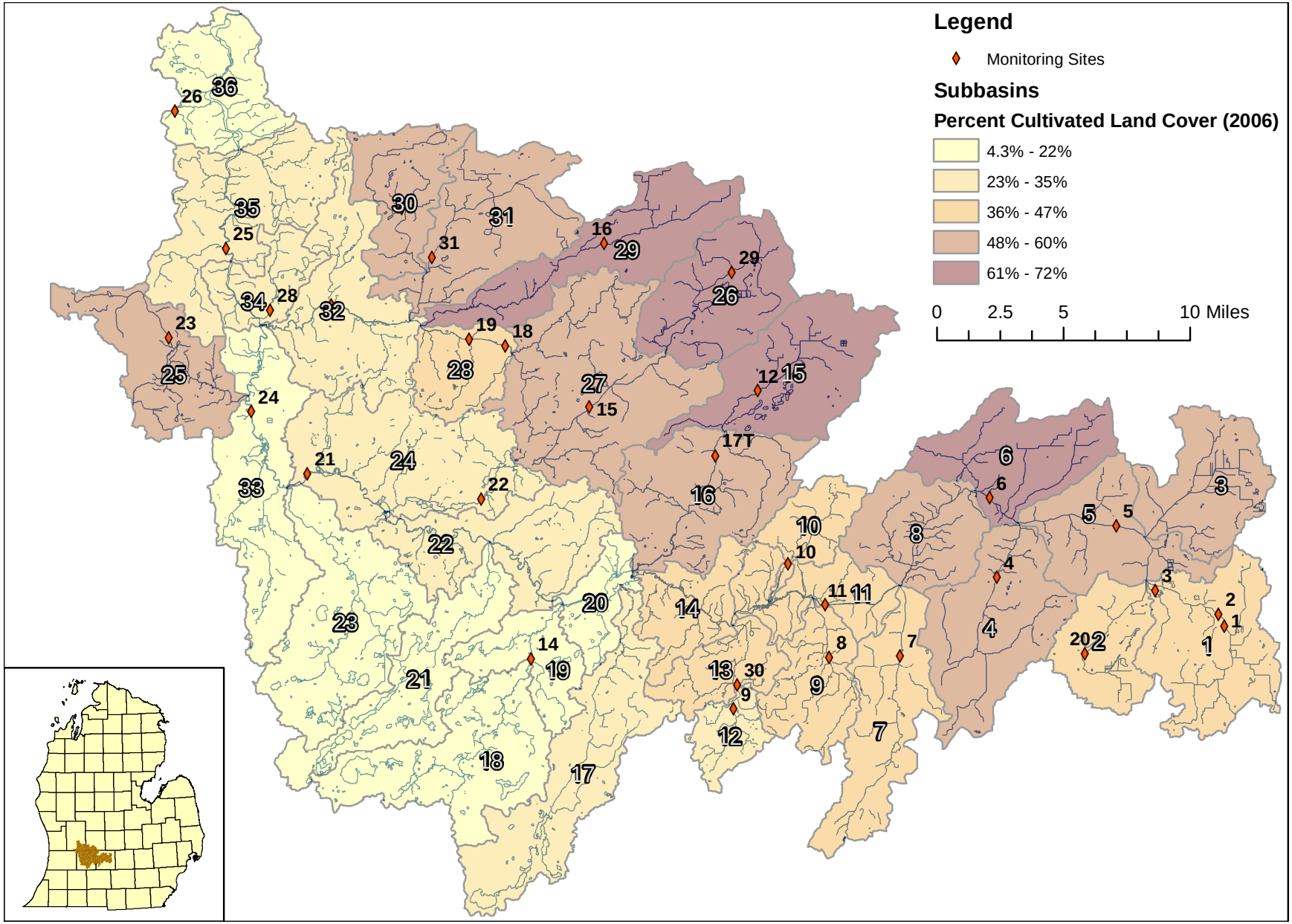

Figure 1. Locations of sites and subbasins in the Thornapple River watershed, and the percent of each subbasin that is cultivated land based on 2006-era landcover data (NOAA, 2011).

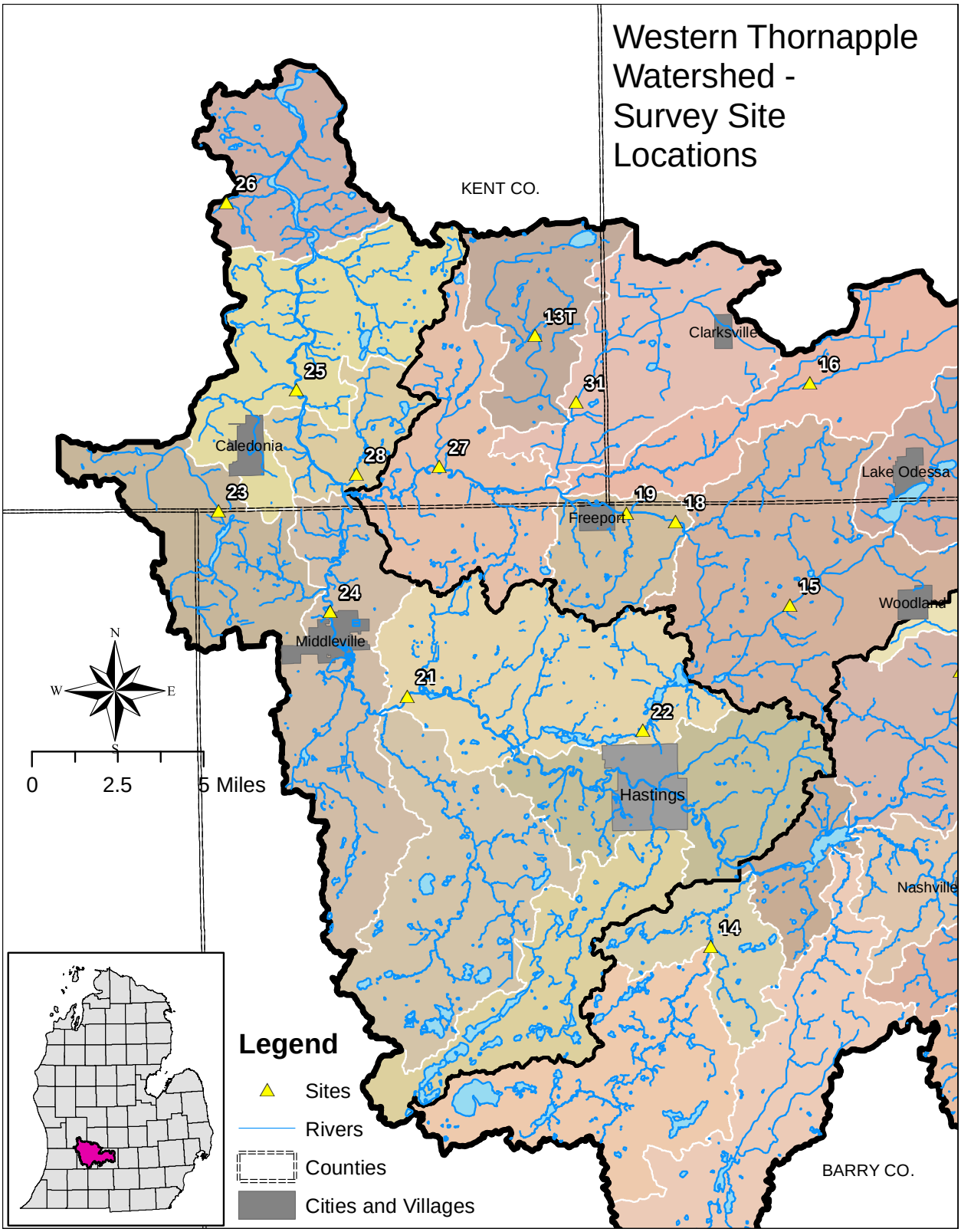

Figure 2.1. Site locations in the western portion of the Thornapple River watershed.

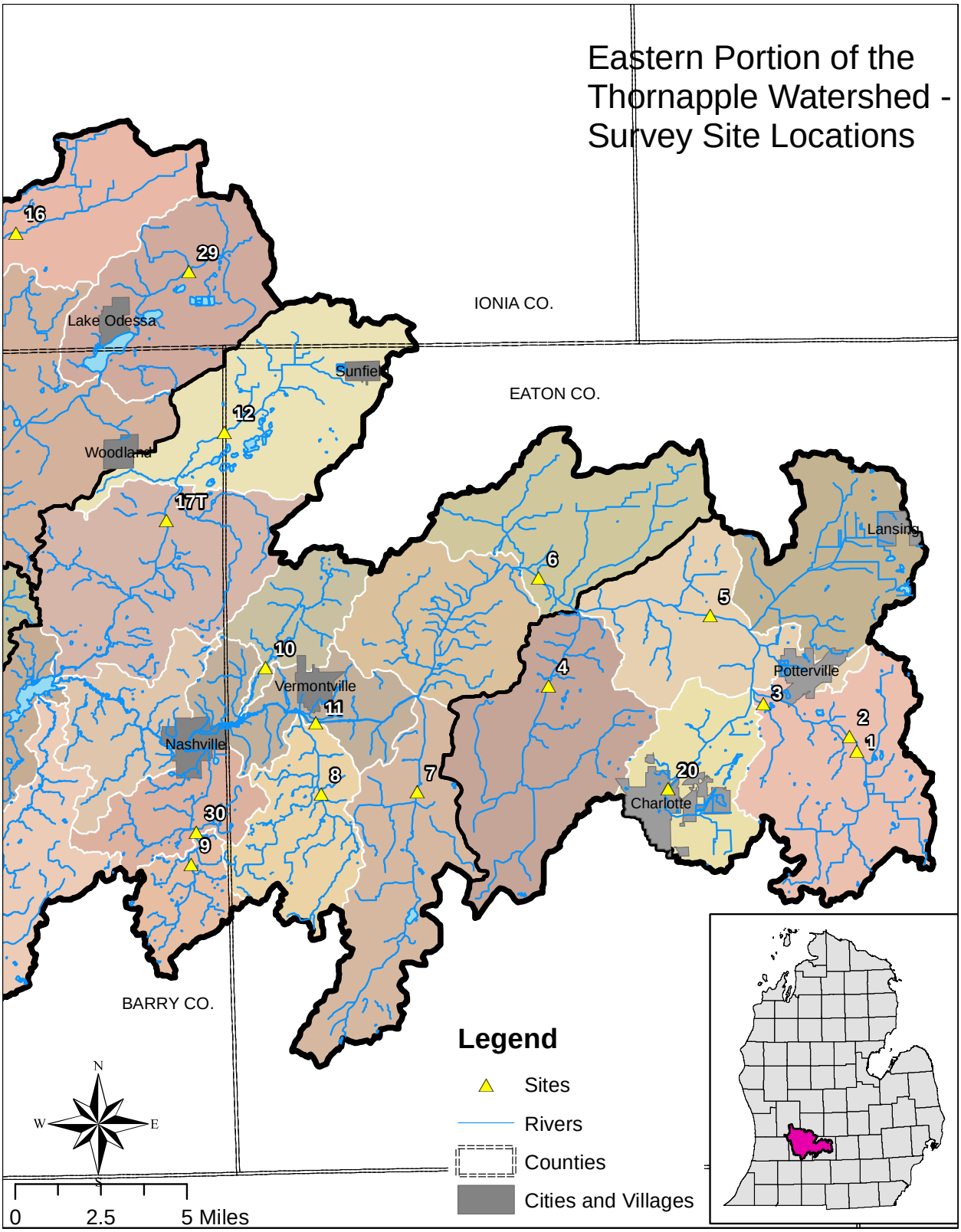

Figure 2.2. Site locations in the eastern portion of the Thornapple River watershed.

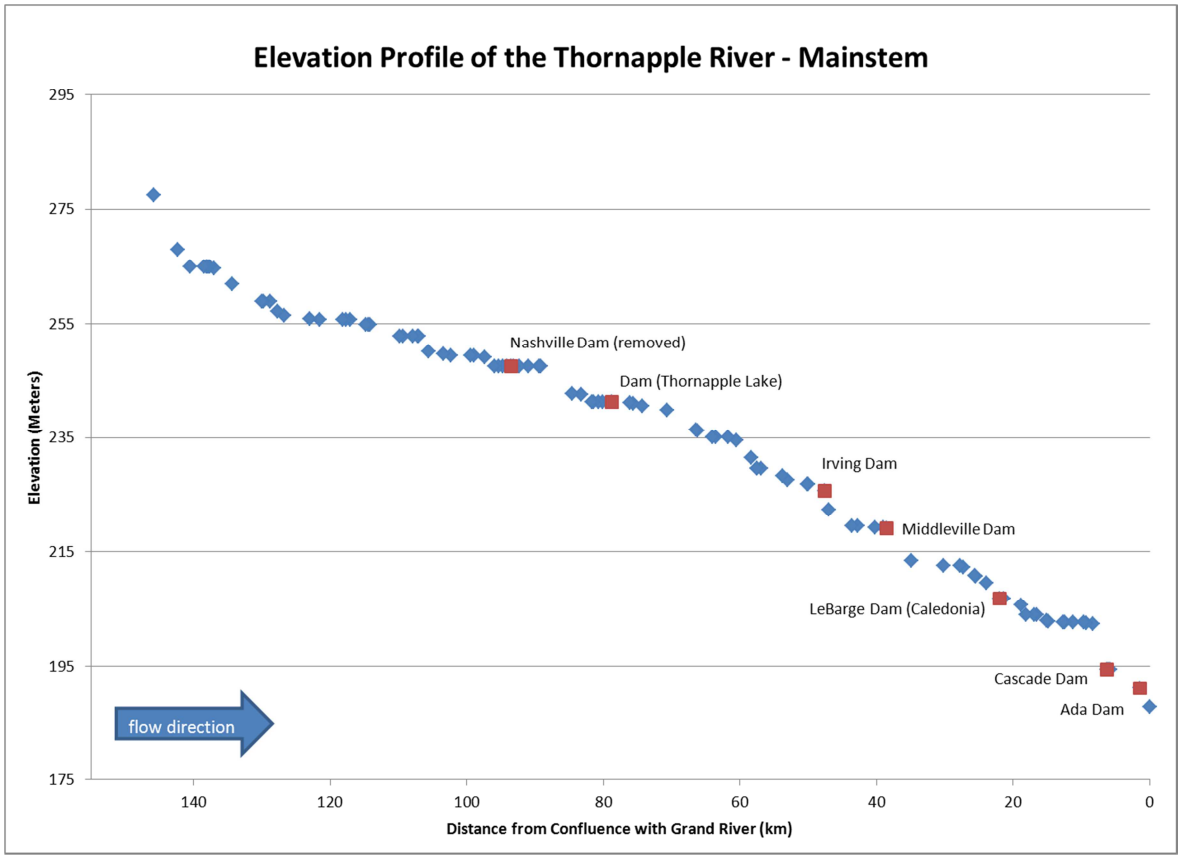

Figure 3. Elevation and gradient change along the main stem Thornapple River, including the placement of notable dams (USDA-NRCS et al., 2014).

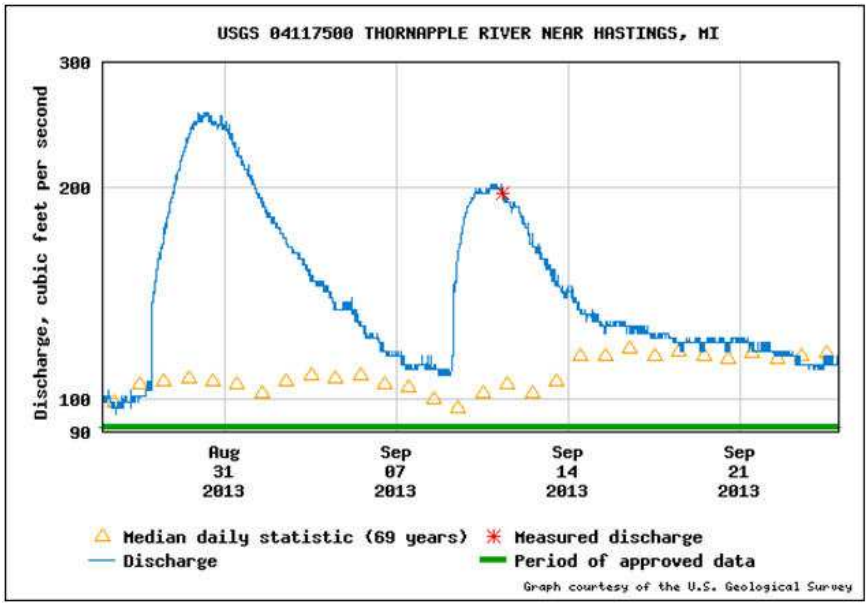

Figure 4. Flow discharge (cfs) of the Thornapple River near Hastings during this study (graph courtesy of the USGS).

Table 1. Summary of sampling site locations and biological survey results within the Thornapple River watershed.

					Bugs		Habitat		Fish	
Site	Longitude	Latitude	Waterbody	Location	Score	Rating	Score	Rating	Score	Rating
1	-84.71504	42.59653	Thornapple River	Kinsel Highway	-2	Accept	88	Marginal	na	na
2	-84.71934	42.60286	Thornapple River	Royston Road	+2	Accept	102	Marginal	na	na
3	-84.76840	42.61713	Church Drain	N Stewart Rd	-3	Accept	107	Good	na	na
4	-84.89094	42.62616	Little Thornapple River	W Vermontville Hwy	-1	Accept	102	Marginal	na	na
5	-84.79781	42.65477	Thornapple River	Pinch and Otto Rd	+1	Accept	89	Marginal	na	na
6	-84.89579	42.67169	Thornapple River	Mulliken Road	+4	Accept	100	Marginal	na	na
7	-84.96700	42.58193	Lacey Creek	Valley Highway	+2	Accept	82	Marginal	na	na
8	-85.02176	42.58152	Hayon Creek	Valley Hwy	-1	Accept	98	Marginal	na	na
9	-85.09665	42.55250	Quaker Brook	Maple Grove Road	-1	Accept	160	Excellent	na	na
10	-85.05276	42.63528	Scipio Creek	Vermontville Highway	0	Accept	151	Good	na	na
11	-85.02455	42.61157	Thornapple River	Ionia Road	-1	Accept	74	Marginal	na	na
12	-85.07476	42.73488	Mud Creek	Saddlebag Road	**-6**	**Poor**	71	Marginal	na	na
13T	-85.35081	42.84138	Pratt Lake Creek	Wingeier Ave (north)	-2	Accept	117	Good	*	**Poor**
14	-85.25321	42.58255	Cedar Creek	Mixer Road	+2	Accept	148	Good	na	na
15	-85.20598	42.72656	Little Thornapple River	M 43	**-5**	**Poor**	103	Marginal	na	na
16	-85.19320	42.82010	Duck Creek	Jackson Road	-2	Accept	109	Good	-3	Accept
17T	-85.10864	42.69792	Mud Creek	Davenport Rd	0	Accept	122	Good	na	na
18	-85.27108	42.76219	Coldwater River	Messer Road	+6	Excellent	107	Good	na	na
19	-85.29917	42.76594	Coldwater River	Off Vedder Rd	+7	Excellent	114	Good	na	na
20	-84.82336	42.58177	Butternut Creek	S of Peck Hwy (cemetary)	-1	Accept	124	Good	na	na
21	-85.42571	42.68937	Thornapple River	Irving Road	+6	Excellent	122	Good	na	na
22	-85.29078	42.67409	Sugar Creek	d/s of M-43 (Broadway)	+2	Accept	142	Good	na	na
23	-85.53317	42.76826	Duncan Creek	108th St SE	0	Accept	92	Marginal	na	na
24	-85.46924	42.72545	Thornapple River	Crane Road	+5	Excellent	114	Good	na	na
25	-85.48809	42.81917	Emmons Creek	Thornapple River Dr SE	-2	Accept	115	Good	na	na
26	-85.52727	42.89838	Unnamed Trib (GFIA)	36th St SE (West)	na	na	na	na	na	na
27	-85.40612	42.78632	Clark and Bunker Drain	100th	na	na	na	na	na	na
28	-85.45379	42.78339	Drain from Campbell and Barber Lakes	100th	na	na	na	na	na	na
29	-85.09413	42.80278	Little Thornapple	Harwood	**-5**	**Poor**	95	Marginal	na	na
30	-85.09360	42.56610	Quaker Brook	E of Lawrence Rd	na	na	100	Marginal	*	**Poor**
31	-85.32747	42.81314	Tyler Creek	u/s of 84th St	0	Accept	121	Good	na	na

* -not scored

na - not surveyed, visual flow evaluation only

Table 2A. Qualitative macroinvertebrate sampling results for sites in the Thornapple River; August-September, 2013.

TAXA	Thornapple River Kinsel Hwy 8/28/2013 STATION 1	Thornapple River Royston Road 8/28/2013 STATION 2	Church Drain Stewart Road 8/28/2013 STATION 3	Little Thornapple River Vermontville Highway 9/10/2013 STATION 4
PORIFERA (sponges)		1		
PLATYHELMINTHES (flatworms)				
Turbellaria	5	1		
ANNELIDA (segmented worms)				
Hirudinea (leeches)	2			
Oligochaeta (worms)	14	9	2	7
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	48	29	266	49
Decapoda (crayfish)	1		1	1
Isopoda (sowbugs)	9	3	2	2
Arachnoidea				
Hydracarina	2	1		2
Insecta				
Ephemeroptera (mayflies)				
Baetidae	5	5	1	
Caenidae	8	14		
Heptageniidae		1		3
Odonata				
Anisoptera (dragonflies)				
Aeshnidae	1			
Zygoptera (damselflies)				
Calopterygidae	5	11		15
Coenagrionidae	27	13		
Hemiptera (true bugs)				
Belostomatidae	1			
Corixidae	6	8	1	6
Gerridae	1	1	2	7
Mesoveliidae				2
Nepidae	1			
Notonectidae	1	1		7
Pleidae	4			
Saldidae	2		6	
Megaloptera				
Sialidae (alder flies)	12	8	5	5
Trichoptera (caddisflies)				
Helicopsychidae		1		
Hydropsychidae	2	7	3	3
Hydroptilidae		4		
Leptoceridae	4	5		1
Limnephilidae				4
Phryganeidae				4
Polycentropodidae				4
Rhyacophilidae				2
Coleoptera (beetles)				
Dytiscidae (total)	1	1	1	
Gyrinidae (adults)			7	
Haliplidae (adults)	6		1	1
Dryopidae	1	4		
Elmidae	8	84		1
Diptera (flies)				
Ceratopogonidae	1		1	
Chironomidae	57	38	8	67
Culicidae	1	1		
Dixidae				2
Ptychopteridae		2		
Tabanidae		1	1	2
Thaumaleidae		4		
MOLLUSCA				
Gastropoda (snails)				
Ancylidae (limpets)				3
Hydrobiidae		2		3
Physidae	6		4	10
Planorbidae	16			
Pelecypoda (bivalves)				
Pisidiidae				2
Sphaeriidae (clams)		1		2
Unionidae (mussels)		1		
TOTAL INDIVIDUALS	258	262	312	217

Table 2B. Macroinvertebrate metric evaluation of sites in the Thornapple River; August-September, 2013.

METRIC	Thornapple River Kinsel Hwy 8/28/2013 STATION 1 Value	Score	Thornapple River Royston Road 8/28/2013 STATION 2 Value	Score	Church Drain Stewart Road 8/28/2013 STATION 3 Value	Score	Little Thornapple River Vermontville Highway 9/10/2013 STATION 4 Value	Score
TOTAL NUMBER OF TAXA	31	1	30	1	17	0	28	1
NUMBER OF MAYFLY TAXA	2	0	3	0	1	0	1	-1
NUMBER OF CADDISFLY TAXA	2	0	4	0	1	-1	6	1
NUMBER OF STONEFLY TAXA	0	-1	0	-1	0	-1	0	-1
PERCENT MAYFLY COMP.	5.04	0	7.63	0	0.32	-1	1.38	-1
PERCENT CADDISFLY COMP.	2.33	-1	6.49	0	0.96	-1	8.29	0
PERCENT DOMINANT TAXON	22.09	0	32.06	0	85.26	-1	30.88	0
PERCENT ISOPOD, SNAIL, LEECH	12.79	-1	1.91	1	1.92	1	8.29	0
PERCENT SURF. AIR BREATHERS	9.30	0	5.34	1	5.77	1	10.60	0
TOTAL SCORE		-2		2		-3		-1
MACROINV. COMMUNITY RATING		ACCEPT.		ACCEPT.		ACCEPT.		ACCEPT.

Table 2A. Qualitative macroinvertebrate sampling results for sites in the Thornapple River; August-September, 2013.

TAXA	Thornapple River Pinch and Otto Road 9/10/2013 STATION 5	Thornapple River Mulliken Road 9/10/2013 STATION 6	Lacey Creek Valley Hwy 9/9/2013 STATION 7	Hayon Creek Valley Hwy 8/28/2013 STATION 8
ANNELIDA (segmented worms)				
Oligochaeta (worms)	5	27	11	14
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	11	5	140	78
Decapoda (crayfish)		3	1	1
Isopoda (sowbugs)	9		1	27
Arachnoidea				
Hydracarina	1	5		
Insecta				
Ephemeroptera (mayflies)				
Baetiscidae		1		
Baetidae		3	2	3
Caenidae	1			1
Heptageniidae	1	8	3	
Leptophlebiidae		33		
Odonata				
Anisoptera (dragonflies)				
Aeshnidae	1	1	2	4
Cordulegastridae				1
Gomphidae	1	3	1	
Libellulidae				1
Zygoptera (damselflies)				
Calopterygidae	15	29	31	15
Coenagrionidae	5	5		1
Hemiptera (true bugs)				
Belostomatidae			1	
Corixidae	1	3	3	32
Gerridae				2
Nepidae	1	1	1	
Pleidae		1		
Saldidae			1	1
Veliidae				1
Megaloptera				
Corydalidae (dobson flies)			1	1
Sialidae (alder flies)	3	1	1	1
Trichoptera (caddisflies)				
Brachycentridae	1			
Hydropsychidae	1	4	55	4
Leptoceridae	8	5		4
Limnephilidae	1	1		
Phryganeidae			1	
Polycentropodidae	13	2		2
Rhyacophilidae	2			
Coleoptera (beetles)				
Dytiscidae (total)				1
Gyrinidae (adults)				1
Scirtidae (adults)				1
Dryopidae		1	1	1
Elmidae	13	17	11	5
Gyrinidae (larvae)				1
Diptera (flies)				
Ceratopogonidae	1	1		
Chironomidae	147	91	23	16
Culicidae		1		1
Dixidae			1	1
Tabanidae	2	1	2	3
Tipulidae		1	1	
MOLLUSCA				
Gastropoda (snails)				
Ancylidae (limpets)		1		
Hydrobiidae	3	4		
Physidae		1		2
Pelecypoda (bivalves)				
Sphaeriidae (clams)	2	2		
TOTAL INDIVIDUALS	249	262	295	227 *

*- Low macroinvertebrate density at this site. Entire sample was counted and less than the required number (300 +/- 60) was ob

'Table 2B. Macroinvertebrate metric evaluation of sites in the Thornapple River; August-September, 2013.

METRIC	Thornapple River Pinch and Otto Road 9/10/2013 STATION 5		Thornapple River Mulliken Road 9/10/2013 STATION 6		Lacey Creek Valley Hwy 9/9/2013 STATION 7		Hayon Creek Valley Hwy 8/28/2013 STATION 8	
	Value	Score	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	25	1	31	1	23	1	30	1
NUMBER OF MAYFLY TAXA	2	1	4	1	2	1	2	0
NUMBER OF CADDISFLY TAXA	6	1	4	1	2	1	3	1
NUMBER OF STONEFLY TAXA	0	-1	0	-1	0	-1	0	-1
PERCENT MAYFLY COMP.	0.80	-1	17.18	0	1.69	-1	1.76	-1
PERCENT CADDISFLY COMP.	10.44	0	4.58	0	18.98	0	4.41	0
PERCENT DOMINANT TAXON	59.04	-1	34.73	0	47.46	-1	34.36	0
PERCENT ISOPOD, SNAIL, LEECH	4.82	0	2.29	1	0.34	1	12.78	-1
PERCENT SURF. AIR BREATHERS	0.80	1	2.29	1	2.03	1	17.62	0
TOTAL SCORE		1		4		2		-1
MACROINV. COMMUNITY RATING		ACCEPT.		ACCEPT.		ACCEPT.		ACCEPT.

Table 2A. Qualitative macroinvertebrate sampling results for sites in the Thornapple River; August-September, 2013.

TAXA	Quaker Brook Maple Grove Road 9/9/2013 STATION 9	Scipio Creek Vermontville Highway 9/4/2013 STATION 10	Thornapple River Ionia Road 9/11/2013 STATION 11	Mud Creek Saddlebag Road 8/27/2013 STATION 12
PLATYHELMINTHES (flatworms)				
Turbellaria		2		18
ANNELIDA (segmented worms)				
Hirudinea (leeches)		1		7
Oligochaeta (worms)	8	5	110	62
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	203	15	9	120
Decapoda (crayfish)	2		2	
Isopoda (sowbugs)		4	2	1
Arachnoidea				
Hydracarina	1			3
Insecta				
Ephemeroptera (mayflies)				
Baetidae	1	7	3	
Heptageniidae	2	1		
Leptophlebiidae			1	
Odonata				
Anisoptera (dragonflies)				
Aeshnidae	1		1	
Gomphidae			1	
Zygoptera (damselflies)				
Calopterygidae	23	25	10	
Coenagrionidae	1	21		10
Hemiptera (true bugs)				
Belostomatidae			1	
Corixidae	1	25	10	1
Gerridae	1	1	5	
Mesoveliidae			1	
Nepidae			3	
Notonectidae		1		
Pleidae	1		3	
Saldidae		1		
Megaloptera				
Sialidae (alder flies)	1		3	
Trichoptera (caddisflies)				
Brachycentridae	1			
Hydropsychidae	8	38		
Hydroptilidae		2		2
Leptoceridae		8	6	
Limnephilidae	1			
Philopotamidae			1	
Phryganeidae	3	2		
Polycentropodidae			4	
Coleoptera (beetles)				
Dytiscidae (total)		1		1
Gyrinidae (adults)	1			
Haliplidae (adults)		1	1	10
Hydrophilidae (total)				8
Dryopidae				3
Elmidae		4	40	13
Diptera (flies)				
Ceratopogonidae	1	1	1	1
Chironomidae	36	94	87	21
Culicidae				1
Simuliidae	1	7		1
Tabanidae	2			
MOLLUSCA				
Gastropoda (snails)				
Ancylidae (limpets)		2		
Hydrobiidae			1	
Physidae			3	3
Planorbidae				3
Viviparidae				1
Pelecypoda (bivalves)				
Sphaeriidae (clams)		3	4	5
TOTAL INDIVIDUALS	300	272	313	295

'Table 2B. Macroinvertebrate metric evaluation of sites in the Thornapple River; August-September, 2013.

	Quaker Brook Maple Grove Road 9/9/2013 STATION 9		Scipio Creek Vermontville Highway 9/4/2013 STATION 10		Thornapple River Ionia Road 9/11/2013 STATION 11		Mud Creek Saddlebag Road 8/27/2013 STATION 12	
METRIC	Value	Score	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	22	0	25	1	26	1	22	0
NUMBER OF MAYFLY TAXA	2	0	2	0	2	0	0	-1
NUMBER OF CADDISFLY TAXA	4	0	4	0	3	0	1	-1
NUMBER OF STONEFLY TAXA	0	-1	0	-1	0	-1	0	-1
PERCENT MAYFLY COMP.	1.00	-1	2.94	-1	1.28	-1	0.00	-1
PERCENT CADDISFLY COMP.	4.33	0	18.38	0	3.51	-1	0.68	-1
PERCENT DOMINANT TAXON	67.67	-1	34.56	0	35.14	0	40.68	-1
PERCENT ISOPOD, SNAIL, LEECH	0.00	1	2.57	1	1.92	1	5.08	0
PERCENT SURF. AIR BREATHERS	1.33	1	11.03	0	7.67	0	7.12	0
TOTAL SCORE		-1		0		-1		-6
MACROINV. COMMUNITY RATING		ACCEPT.		ACCEPT.		ACCEPT.		POOR

Table 2A. Qualitative macroinvertebrate sampling results for sites in the Thornapple River; August-September, 2013.

TAXA	Pratt Lake Creek North of Wingeire Avenue 8/26/2013 STATION 13T	Cedar Creek Mixer Road 8/27/2013 STATION 14	Little Thornapple River M-43 9/4/2013 STATION 15	Duck Creek Jackson Road 9/4/2013 STATION 16
PLATYHELMINTHES (flatworms)				
Turbellaria	3			3
ANNELIDA (segmented worms)				
Hirudinea (leeches)	1			5
Oligochaeta (worms)	3			
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	144	97	209	94
Decapoda (crayfish)	1	1	4	1
Isopoda (sowbugs)	2		1	
Arachnoidea				
Hydracarina	4		2	10
Insecta				
Ephemeroptera (mayflies)				
Baetidae	4	9		15
Heptageniidae		6	3	2
Isonychiidae				6
Leptophlebiidae				6
Tricorythidae				2
Odonata				
Anisoptera (dragonflies)				
Aeshnidae		9		
Gomphidae		9		
Zygoptera (damselflies)				
Calopterygidae		21	6	20
Coenagrionidae	2	2		1
Plecoptera (stoneflies)				
Perlidae		3		
Hemiptera (true bugs)				
Belostomatidae			1	
Corixidae	9	2	20	10
Gerridae	1	1	4	
Mesoveliidae		2		
Nepidae				1
Notonectidae			1	
Saldidae	6	3		
Megaloptera				
Sialidae (alder flies)			1	
Trichoptera (caddisflies)				
Brachycentridae		14		
Hydropsychidae	21	15		
Hydroptilidae				1
Leptoceridae		3		
Coleoptera (beetles)				
Dytiscidae (total)				2
Haliplidae (adults)	1			43
Hydrophilidae (total)				1
Dryopidae	1	1		
Elmidae	4	18	1	4
Gyrinidae (larvae)	2			
Diptera (flies)				
Ceratopogonidae		1		1
Chironomidae	40	15	15	24
Culicidae			1	
Simuliidae	2	9		
Stratiomyidae		1		
Tipulidae	4			
MOLLUSCA				
Gastropoda (snails)				
Physidae	3		3	1
Planorbidae	4		3	
Viviparidae		2	1	
Pelecypoda (bivalves)				
Sphaeriidae (clams)			1	1
TOTAL INDIVIDUALS	262	244	277	254

'Table 2B. Macroinvertebrate metric evaluation of sites in the Thornapple River; August-September, 2013.

METRIC	Pratt Lake Creek North of Wingeire Avenue 8/26/2013 STATION 13T		Cedar Creek Mixer Road 8/27/2013 STATION 14		Little Thornapple River M-43 9/4/2013 STATION 15		Duck Creek Jackson Road 9/4/2013 STATION 16	
	Value	Score	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	22	0	23	0	18	0	23	0
NUMBER OF MAYFLY TAXA	1	0	2	0	1	-1	5	1
NUMBER OF CADDISFLY TAXA	1	-1	3	0	0	-1	1	-1
NUMBER OF STONEFLY TAXA	0	-1	1	1	0	-1	0	-1
PERCENT MAYFLY COMP.	1.53	-1	6.15	0	1.08	-1	12.20	0
PERCENT CADDISFLY COMP.	8.02	0	13.11	0	0.00	-1	0.39	-1
PERCENT DOMINANT TAXON	54.96	-1	39.75	-1	75.45	-1	37.01	0
PERCENT ISOPOD, SNAIL, LEECH	3.82	1	0.82	1	2.89	1	2.36	1
PERCENT SURF. AIR BREATHERS	6.49	1	3.69	1	9.75	0	22.44	-1
TOTAL SCORE		-2		2		-5		-2
MACROINV. COMMUNITY RATING		ACCEPT.		ACCEPT.		POOR		ACCEPT.

Table 2A. Qualitative macroinvertebrate sampling results for sites in the Thornapple River; August-Septer

TAXA	Mud Creek Davenport Road 8/26/2013 TATION 17T	Coldwater River Messer Road 9/4/2013 STATION 18	Coldwater River NRSA MILS-1056 9/18/2013 STATION 19
PLATYHELMINTHES (flatworms)			
Turbellaria		7	4
ANNELIDA (segmented worms)			
Hirudinea (leeches)	1		1
Oligochaeta (worms)	7		2
ARTHROPODA			
Crustacea			
Amphipoda (scuds)	66	70	30
Decapoda (crayfish)	5	5	2
Isopoda (sowbugs)	1	5	3
Arachnoidea			
Hydracarina	2		1
Insecta			
Ephemeroptera (mayflies)			
Baetidae	17	34	31
Heptageniidae	8	29	50
Isonychiidae			
Leptophlebiidae		1	
Tricorythidae			
Odonata			
Anisoptera (dragonflies)			
Aeshnidae	1		1
Zygoptera (damselflies)			
Calopterygidae	19	2	15
Coenagrionidae			
Plecoptera (stoneflies)			
Perlidae		1	1
Hemiptera (true bugs)			
Belostomatidae			1
Corixidae	1	4	1
Gerridae		1	
Mesoveliidae			1
Nepidae			1
Notonectidae	1		
Pleidae		1	
Trichoptera (caddisflies)			
Glossosomatidae		1	1
Helicopsychidae	1	4	4
Hydropsychidae	31	35	51
Hydroptilidae		1	1
Lepidostomatidae		2	
Leptoceridae	2	1	
Limnephilidae			1
Philopotamidae		1	1
Polycentropodidae		1	3
Uenoidae			1
Coleoptera (beetles)			
Dytiscidae (total)			
Haliplidae (adults)			
Hydrophilidae (total)			
Dryopidae			3
Elmidae	4	29	12
Psephenidae (larvae)			1
Diptera (flies)			
Ceratopogonidae		1	
Chironomidae	65	14	23
Empididae			1
Simuliidae	7	30	39
Tabanidae		1	2
Tipulidae	1	1	1
MOLLUSCA			
Gastropoda (snails)			
Ancylidae (limpets)	10		1
Physidae	2		
Pelecypoda (bivalves)			
Sphaeriidae (clams)	1		
TOTAL INDIVIDUALS	253	282	291

'Table 2B. Macroinvertebrate metric evaluation of sites in the Thornapple River; August-September, 2013

METRIC	Mud Creek Davenport Road 8/26/2013 STATION 17T Value	Score	Coldwater River Messer Road 9/4/2013 STATION 18 Value	Score	Coldwater River NRSA MILS-1056 9/18/2013 STATION 19 Value	Score
TOTAL NUMBER OF TAXA	22	0	26	1	33	1
NUMBER OF MAYFLY TAXA	2	0	3	0	2	0
NUMBER OF CADDISFLY TAXA	3	0	8	1	8	1
NUMBER OF STONEFLY TAXA	0	-1	1	1	1	1
PERCENT MAYFLY COMP.	9.88	0	22.70	1	27.84	1
PERCENT CADDISFLY COMP.	13.44	0	16.31	0	21.65	0
PERCENT DOMINANT TAXON	26.09	0	24.82	0	17.53	1
PERCENT ISOPOD, SNAIL, LEECH	5.53	0	1.77	1	1.72	1
PERCENT SURF. AIR BREATHERS	0.79	1	2.13	1	1.37	1
TOTAL SCORE		0		6		7
MACROINV. COMMUNITY RATING		ACCEPT.		EXCELLENT		EXCELLEN

Table 2A. Qualitative macroinvertebrate sampling results for sites in the Thornapple River; August-September, 2013.

TAXA	Butternut Creek Cemetary (Lansing Road) 9/10/2013 STATION 20	Thornapple River Irving Road 8/27/2013 STATION 21	Sugar Creek downstream M43 9/24/2013 STATION 22	Duncan Creek 108th Street 8/26/2013 STATION 23
PLATYHELMINTHES (flatworms)				
Turbellaria	2		14	1
ANNELIDA (segmented worms)				
Hirudinea (leeches)				1
Oligochaeta (worms)	15	3	2	10
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	66	53	81	15
Decapoda (crayfish)	1	4	1	8
Isopoda (sowbugs)	5	4		
Arachnoidea				
Hydracarina		3		2
Insecta				
Ephemeroptera (mayflies)				
Baetidae	14	6	2	5
Caenidae				2
Ephemerellidae		4		
Heptageniidae		21	1	
Isonychiidae		7		
Tricorythidae		5		
Odonata				
Anisoptera (dragonflies)				
Aeshnidae	2	2		
Gomphidae		2		
Macromiidae		3		
Zygoptera (damselflies)				
Calopterygidae	4	8	7	8
Coenagrionidae		15	1	57
Plecoptera (stoneflies)				
Perlidae		1		
Pteronarcyidae		1		
Hemiptera (true bugs)				
Belostomatidae		1		
Gerridae	1	5	2	1
Mesoveliidae			1	
Nepidae		1		
Notonectidae		1	1	2
Pleidae		1		
Saldidae				3
Megaloptera				
Corydalidae (dobson flies)				1
Sialidae (alder flies)		2	3	
Trichoptera (caddisflies)				
Glossosomatidae			1	
Helicopsychidae			1	
Hydropsychidae	75	1	67	2
Hydroptilidae		3		14
Leptoceridae		3	4	1
Limnephilidae		2	1	
Molannidae				1
Philopotamidae		1	11	
Phryganeidae		7	1	
Polycentropodidae			4	
Coleoptera (beetles)				
Dytiscidae (total)			1	
Haliplidae (adults)			1	
Dryopidae		9		
Elmidae	3	27	6	42
Psephenidae (larvae)		1		
Scirtidae (larvae)			1	
Diptera (flies)				
Athericidae		5		
Ceratopogonidae		1		
Chironomidae	26	27	13	58
Culicidae				2
Simuliidae	30		92	2
Stratiomyidae				2
Tabanidae		3	1	1
Tipulidae	11		1	1
MOLLUSCA				
Gastropoda (snails)				
Hydrobiidae			1	
Lymnaeidae		5		
Physidae			1	10
Planorbidae			1	
Pelecypoda (bivalves)				
Sphaeriidae (clams)		7	2	
Unionidae (mussels)				1
TOTAL INDIVIDUALS	255	255	327	253

'Table 2B. Macroinvertebrate metric evaluation of sites in the Thornapple River; August-September, 2013.

METRIC	Butternut Creek Cemetary (Lansing Road) 9/10/2013 STATION 20		Thornapple River Irving Road 8/27/2013 STATION 21		Sugar Creek downstream M43 9/24/2013 STATION 22		Duncan Creek 108th Street 8/26/2013 STATION 23	
	Value	Score	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	14	0	38	1	32	1	27	1
NUMBER OF MAYFLY TAXA	1	0	5	1	2	0	2	0
NUMBER OF CADDISFLY TAXA	1	-1	6	1	8	1	4	0
NUMBER OF STONEFLY TAXA	0	-1	2	1	0	-1	0	-1
PERCENT MAYFLY COMP.	5.49	0	16.86	0	0.92	-1	2.77	-1
PERCENT CADDISFLY COMP.	29.41	1	6.67	0	27.52	0	7.11	0
PERCENT DOMINANT TAXON	29.41	0	20.78	0	28.13	0	22.92	0
PERCENT ISOPOD, SNAIL, LEECH	1.96	1	3.53	1	0.92	1	4.35	0
PERCENT SURF. AIR BREATHERS	0.39	1	3.53	1	1.83	1	3.95	1
TOTAL SCORE		1		6		2		0
MACROINV. COMMUNITY RATING		ACCEPT.		EXCELLENT		ACCEPT.		ACCEPT.

Table 2A. Qualitative macroinvertebrate sampling results for sites in the Thornapple River; August-September, 2013.

TAXA	Thornapple River Crane Road 8/27/2013 STATION 24	Emmons Creek Thornapple River Rd - North of Caledonia 8/25/2013 STATION 25	Little Thornapple River Harwood Road 9/24/2013 STATION 29	Tyler Creek 84th 9/9/2013 STATION 31
PLATYHELMINTHES (flatworms)				
Turbellaria			173	
ANNELIDA (segmented worms)				
Hirudinea (leeches)		1		
Oligochaeta (worms)	3		1	
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	49	207	40	148
Decapoda (crayfish)		2	2	5
Isopoda (sowbugs)	2	22	25	
Arachnoidea				
Hydracarina	4		7	5
Insecta				
Ephemeroptera (mayflies)				
Baetidae	9	30	1	38
Caenidae	1			
Ephemerellidae	2			
Ephemeridae	4			
Heptageniidae	18	3		8
Isonychiidae	3			
Tricorythidae	1			
Odonata				
Anisoptera (dragonflies)				
Aeshnidae	1	1		2
Gomphidae	3			
Libellulidae	1			
Macromiidae	2			
Zygoptera (damselflies)				
Calopterygidae	11	3	4	8
Coenagrionidae	7		5	
Plecoptera (stoneflies)				
Perlidae	1			
Pteronarcyidae	2			
Hemiptera (true bugs)				
Belostomatidae			1	
Corixidae			2	1
Gerridae	5	5		1
Mesoveliidae			5	
Notonectidae		1	1	1
Megaloptera				
Corydalidae (dobson flies)	1			
Sialidae (alder flies)		2		
Trichoptera (caddisflies)				
Hydropsychidae	3	7		113
Leptoceridae	4		2	
Limnephilidae	3			
Philopotamidae	3			
Phryganeidae		2		
Polycentropodidae	1			
Coleoptera (beetles)				
Dytiscidae (total)			1	
Gyrinidae (adults)	1			
Haliplidae (adults)			1	1
Hydrophilidae (total)			1	
Dryopidae	7			
Elmidae	40	6	1	18
Diptera (flies)				
Athericidae	1			
Chironomidae	64	13	24	27
Culicidae	1			
Simuliidae	5	22	1	7
Tabanidae	1		1	
Tipulidae	1	1	1	4
MOLLUSCA				
Gastropoda (snails)				
Ancylidae (limpets)				2
Lymnaeidae	12			
Physidae		1		1
Pelecypoda (bivalves)				
Sphaeriidae (clams)				1
TOTAL INDIVIDUALS	277	329	300	391

'Table 2B. Macroinvertebrate metric evaluation of sites in the Thornapple River; August-September, 2013.

	Thornapple River		Emmons Creek		Little Thornapple River		Tyler Creek	
	Crane Road		Thornapple River Rd - North of Caledonia		Harwood Road		84th	
	8/27/2013		8/25/2013		9/24/2013		9/9/2013	
	STATION 24		STATION 25		STATION 29		STATION 31	
METRIC	Value	Score	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	36	1	18	0	22	0	19	0
NUMBER OF MAYFLY TAXA	7	1	2	0	1	-1	2	0
NUMBER OF CADDISFLY TAXA	5	1	2	0	1	-1	1	-1
NUMBER OF STONEFLY TAXA	2	1	0	-1	0	-1	0	-1
PERCENT MAYFLY COMP.	13.72	0	10.03	0	0.33	-1	11.76	0
PERCENT CADDISFLY COMP.	5.05	0	2.74	-1	0.67	-1	28.90	1
PERCENT DOMINANT TAXON	23.10	0	62.92	-1	57.67	-1	37.85	-1
PERCENT ISOPOD, SNAIL, LEECH	5.05	0	7.29	0	8.33	0	0.77	1
PERCENT SURF. AIR BREATHERS	2.53	1	1.82	1	4.00	1	1.02	1
TOTAL SCORE		5		-2		-5		0
MACROINV. COMMUNITY RATING		EXCELLENT		ACCEPT.		POOR		ACCEPT.

Table 3. Habitat evaluation for sites in the Thornapple watershed; August-September 2013.

HABITAT METRIC	Thornapple River Kinsel Hwy GLIDE/POOL Station 1	Thornapple River Royston Road GLIDE/POOL Station 2	Church Drain Stewart Road GLIDE/POOL Station 3	Little Thornapple River Vermontville Highway GLIDE/POOL Station 4	Thornapple River Pinch and Otto Road GLIDE/POOL Station 5
Substrate and Instream Cover					
Epifaunal Substrate/ Avail Cover (20)	3	10	3	5	5
Embeddedness (20)*					
Velocity/Depth Regime (20)*					
Pool Substrate Characterization (20)**	6	10	6	6	6
Pool Variability (20)**	1	5	2	8	3
Channel Morphology					
Sediment Deposition (20)	13	18	15	4	3
Flow Status - Maint. Flow Volume (10)	10	10	10	10	10
Flow Status - Flashiness (10)	9	7	9	5	6
Channel Alteration (20)	8	8	8	13	13
Frequency of Riffles/Bends (20)*					
Channel Sinuosity (20)**	1	2	6	3	3
Riparian and Bank Structure					
Bank Stability (L) (10)	10	8	10	8	9
Bank Stability (R) (10)	10	8	10	8	9
Vegetative Protection (L) (10)	7	6	9	6	6
Vegetative Protection (R) (10)	8	6	9	6	6
Riparian Veg. Zone Width (L) (10)	0	2	3	10	5
Riparian Veg. Zone Width (R) (10)	2	2	7	10	5
TOTAL SCORE (200):	88	102	107	102	89
HABITAT RATING:	MARGINAL (MODERATELY IMPAIRED)	MARGINAL (MODERATELY IMPAIRED)	GOOD (SLIGHTLY IMPAIRED)	MARGINAL (MODERATELY IMPAIRED)	MARGINAL (MODERATELY 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:	8/28/2013	8/28/2013	8/28/2013	9/10/2013	9/10/2013
Weather:	Cloudy	Cloudy	Cloudy	Sunny	Partly Cloudy
Air Temperature:	78 Deg. F.	75 Deg. F.	70 Deg. F.	87 Deg. F.	84 Deg. F.
Water Temperature:	74 Deg. F.	74 Deg. F.	66 Deg. F.	73 Deg. F.	67 Deg. F.
Ave. Stream Width:	25 Feet	10 Feet	8 Feet	20 Feet	25 Feet
Ave. Stream Depth:	0.8 Feet	1.5 Feet	0.5 Feet	0.75 Feet	3 Feet
Surface Velocity:	0.5 Ft./Sec.	1.3 Ft./Sec.	1 Ft./Sec.	0.4 Ft./Sec.	0.4 Ft./Sec.
Estimated Flow:	10 CFS	19.5 CFS	4 CFS	6 CFS	30 CFS
Stream Modifications:	Dredged	Dredged	Relocated	Dredged	Dredged
Nuisance Plants (Y/N):	N	N	N	N	N
Report Number:					
STORET No.:	230180	230258	230241	230261	230260
Stream Name:	ıornapple River	Thornapple River	Church Drain	Little Thornapple River	Thornapple River
Road Crossing/Location:	Kinsel Hwy	Royston Road	Stewart Road	Vermontville Highway	Pinch and Otto Road
County Code:	23	23	23	23	23
TRS:	02N03W06	03N03W31	03N04W27	03N05W07	03N04W07
Latitude (dd):	42.59653	42.60286	42.6172	42.62616	42.65477
Longitude (dd):	-84.71504	-84.71934	-84.7684	-84.89094	-84.79781
Ecoregion:	SMNITP	SMNITP	SMNITP	SMNITP	SMNITP
Stream Type:	Warmwater	Warmwater	Warmwater	Warmwater	Warmwater
USGS Basin Code:	4050007	4050007	4050007	4050007	4050007

* Applies only to Riffle/Run stream Surveys
** Applies only to Glide/Pool stream Surveys

Table 3. Habitat evaluation for sites in the Thornapple watershed; August-September 2013.

HABITAT METRIC	Thornapple River Mulliken Road GLIDE/POOL Station 6	Lacey Creek Valley Hwy GLIDE/POOL Station 7	Hayon Creek Valley Hwy GLIDE/POOL Station 8	Quaker Brook Maple Grove Road GLIDE/POOL Station 9	Scipio Creek Vermontville Highway GLIDE/POOL Station 10
Substrate and Instream Cover					
Epifaunal Substrate/ Avail Cover (20)	8	5	5	6	14
Embeddedness (20)*					
Velocity/Depth Regime (20)*					
Pool Substrate Characterization (20)**	8	6	8	8	18
Pool Variability (20)**	5	5	10	13	8
Channel Morphology					
Sediment Deposition (20)	6	3	8	10	19
Flow Status - Maint. Flow Volume (10)	10	10	10	9	9
Flow Status - Flashiness (10)	3	2	4	20	9
Channel Alteration (20)	13	14	8	20	15
Frequency of Riffles/Bends (20)*					
Channel Sinuosity (20)**	4	6	8	20	11
Riparian and Bank Structure					
Bank Stability (L) (10)	9	5	6	10	10
Bank Stability (R) (10)	9	6	6	10	10
Vegetative Protection (L) (10)	6	5	6	8	9
Vegetative Protection (R) (10)	6	7	6	8	9
Riparian Veg. Zone Width (L) (10)	10	2	8	10	4
Riparian Veg. Zone Width (R) (10)	3	6	5	8	6
TOTAL SCORE (200):	100	82	98	160	151
HABITAT RATING:	MARGINAL (MODERATELY IMPAIRED)	MARGINAL (MODERATELY IMPAIRED)	MARGINAL (MODERATELY IMPAIRED)	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:	9/10/2013	9/9/2013	8/28/2013	9/9/2013	9/4/2013
Weather:	Sunny	Sunny	Cloudy	Sunny	
Air Temperature:	87 Deg. F.	80 Deg. F.	Deg. F.	Deg. F.	Deg. F.
Water Temperature:	67 Deg. F.	60 Deg. F.	69 Deg. F.	59 Deg. F.	67 Deg. F.
Ave. Stream Width:	35 Feet	15 Feet	10 Feet	7 Feet	12 Feet
Ave. Stream Depth:	2.5 Feet	1 Feet	1.5 Feet	2 Feet	1 Feet
Surface Velocity:	0.6 Ft./Sec.	1.25 Ft./Sec.	0.5 Ft./Sec.	1 Ft./Sec.	0.5 Ft./Sec.
Estimated Flow:	52.5 CFS	18.75 CFS	7.5 CFS	14 CFS	6 CFS
Stream Modifications:	Dredged	Dredged	Dredged	None	None
Nuisance Plants (Y/N):	N	N	N	N	N
Report Number:					
STORET No.:	230255	230181	230211	80284	230257
Stream Name:	hornapple River	Lacey Creek	Hayon Creek	Quaker Brook	Scipio Creek
Road Crossing/Location:	Mulliken Road	Valley Hwy	Valley Hwy	Maple Grove Road	Vermontville Highway
County Code:	23	23	23	08	23
TRS:	03N05W03	02N06W12	02N06W09	02N07W23	03N06W20
Latitude (dd):	42.67169	42.58186	42.58131	42.5525	42.63528
Longitude (dd):	-84.89579	-84.96656	-85.0219	-85.09665	-85.05276
Ecoregion:	SMNITP	SMNITP	SMNITP	SMNITP	SMNITP
Stream Type:	Warmwater	Warmwater	Warmwater	Coldwater	Warmwater
USGS Basin Code:	4050007	4050007	4050007	4050007	4050007

* Applies only to Riffle/Run stream Surveys

** Applies only to Glide/Pool stream Surveys

Table 3. Habitat evaluation for sites in the Thornapple watershed; August-September 2013.

HABITAT METRIC	Thornapple River Ionia Road GLIDE/POOL Station 11	Mud Creek Saddlebag Road GLIDE/POOL Station 12	Pratt Lake Creek North of Wingeire Avenue GLIDE/POOL Station 13T	Cedar Creek Mixer Road GLIDE/POOL Station 14	Little Thornapple River M-43 GLIDE/POOL Station 15
Substrate and Instream Cover					
Epifaunal Substrate/ Avail Cover (20)	3	3	11	8	5
Embeddedness (20)*					
Velocity/Depth Regime (20)*					
Pool Substrate Characterization (20)**	6	8	11	6	6
Pool Variability (20)**	5	3	5	15	6
Channel Morphology					
Sediment Deposition (20)	1	5	8	10	3
Flow Status - Maint. Flow Volume (10)	10	8	10	10	9
Flow Status - Flashiness (10)	1	6	9	9	5
Channel Alteration (20)	11	5	13	19	13
Frequency of Riffles/Bends (20)*					
Channel Sinuosity (20)**	3	1	8	16	7
Riparian and Bank Structure					
Bank Stability (L) (10)	8	10	9	10	5
Bank Stability (R) (10)	9	10	8	10	8
Vegetative Protection (L) (10)	6	5	7	10	8
Vegetative Protection (R) (10)	4	5	7	10	8
Riparian Veg. Zone Width (L) (10)	5	1	6	10	10
Riparian Veg. Zone Width (R) (10)	2	1	5	5	10
TOTAL SCORE (200):	74	71	117	148	103
HABITAT RATING:	MARGINAL (MODERATELY IMPAIRED)	MARGINAL (MODERATELY IMPAIRED)	GOOD (SLIGHTLY IMPAIRED)	GOOD (SLIGHTLY IMPAIRED)	MARGINAL (MODERATELY 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:	9/11/2013	8/27/2013	8/26/2013	8/27/2013	9/4/2013
Weather:	Partly Cloudy	Sunny	Partly Cloudy	Cloudy	
Air Temperature:	83 Deg. F.	90 Deg. F.	75 Deg. F.	Deg. F.	Deg. F.
Water Temperature:	69 Deg. F.	74 Deg. F.	55 Deg. F.	69 Deg. F.	65 Deg. F.
Ave. Stream Width:	45 Feet	12 Feet	9 Feet	10 Feet	30 Feet
Ave. Stream Depth:	5 Feet	0.2 Feet	0.75 Feet	1.75 Feet	0.75 Feet
Surface Velocity:	0.3 Ft./Sec.	0.8 Ft./Sec.	1.5 Ft./Sec.	1.3 Ft./Sec.	0.5 Ft./Sec.
Estimated Flow:	67.5 CFS	1.92 CFS	10.125 CFS	22.75 CFS	11.25 CFS
Stream Modifications:	Dredged	Dredged	Dredged	Canopy Removal	Dredged
Nuisance Plants (Y/N):	N	N	N	N	N
Report Number:					
STORET No.:	230106	230254	410695	80236	80269
Stream Name:	Thornapple River	Mud Creek	Pratt Lake Creek	Cedar Creek	Little Thornapple River
Road Crossing/Location:	Ionia Road	Saddlebag Road	North of Wingeire Avenue	Mixer Road	M-43
County Code:	23	23	41	08	08
TRS:	03N06W33	04N06W18	05N09W11	02N08W04	04N08W13
Latitude (dd):	42.61157	42.73488	42.841	42.58206	42.727
Longitude (dd):	-85.02455	-85.07476	-85.35	-85.25322	-85.206
Ecoregion:	SMNITP	SMNITP	SMNITP	SMNITP	SMNITP
Stream Type:	Warmwater	Warmwater	Coldwater	Coldwater	Warmwater
USGS Basin Code:	4050007	4050007	4050007	4050007	4050007

* Applies only to Riffle/Run stream Surveys

** Applies only to Glide/Pool stream Surveys

Table 3. Habitat evaluation for sites in the Thornapple watershed; August-September 2013.

HABITAT METRIC	Duck Creek Jackson Road RIFFLE/RUN Station 16	Mud Creek Davenport Road RIFFLE/RUN Station 17T	Coldwater River Messer Road RIFFLE/RUN Station 18	Coldwater River NRSA MILS-1056 RIFFLE/RUN Station 19	Butternut Creek Cemetary (Lansing Road) RIFFLE/RUN Station 20
Substrate and Instream Cover					
Epifaunal Substrate/ Avail Cover (20)	11	10	11	11	11
Embeddedness (20)*	16	8	15	11	16
Velocity/Depth Regime (20)*	8	14	8	10	14
Pool Substrate Characterization (20)**					
Pool Variability (20)**					
Channel Morphology					
Sediment Deposition (20)	14	6	10	16	15
Flow Status - Maint. Flow Volume (10)	10	9	9	10	8
Flow Status - Flashiness (10)	7	3	3	3	1
Channel Alteration (20)	5	15	13	11	11
Frequency of Riffles/Bends (20)*	5	10	8	6	16
Channel Sinuosity (20)**					
Riparian and Bank Structure					
Bank Stability (L) (10)	7	6	4	7	6
Bank Stability (R) (10)	10	8	4	7	6
Vegetative Protection (L) (10)	7	10	5	6	6
Vegetative Protection (R) (10)	7	10	6	6	6
Riparian Veg. Zone Width (L) (10)	1	5	3	8	3
Riparian Veg. Zone Width (R) (10)	1	8	8	2	5
TOTAL SCORE (200):	109	122	107	114	124
HABITAT RATING:	GOOD (SLIGHTLY IMPAIRED)	GOOD (SLIGHTLY IMPAIRED)	GOOD (SLIGHTLY IMPAIRED)	GOOD (SLIGHTLY 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:	9/4/2013	8/26/2013	9/4/2013	9/18/2013	9/10/2013
Weather:	Sunny	Cloudy	Sunny	Sunny	Sunny
Air Temperature:	Deg. F.	85 Deg. F.	75 Deg. F.	60 Deg. F.	70 Deg. F.
Water Temperature:	58 Deg. F.	64 Deg. F.	61 Deg. F.	54 Deg. F.	64 Deg. F.
Ave. Stream Width:	8 Feet	15 Feet	37 Feet	45 Feet	10 Feet
Ave. Stream Depth:	0.5 Feet	1 Feet	1 Feet	1.5 Feet	0.5 Feet
Surface Velocity:	0.5 Ft./Sec.	0.8 Ft./Sec.	1.7 Ft./Sec.	0.56 Ft./Sec.	1.6 Ft./Sec.
Estimated Flow:	2 CFS	12 CFS	62.9 CFS	37.8 CFS	8 CFS
Stream Modifications:	Dredged	Canopy Removal		Dredged	Relocated
Nuisance Plants (Y/N):	N	N	N	N	N
Report Number:					
STORET No.:	340230	80275	80286	80291	230265
Stream Name:	Duck Creek	Mud Creek	Coldwater River	Coldwater River	Butternut Creek
Road Crossing/Location:	Jackson Road	Davenport Road	Messer Road	NRSA MILS-1056	emetary (Lansing Road)
County Code:	34	08	08	08	23
TRS:	05N07W18	04N07W35	04N08W04	04N08W06	02N04W07
Latitude (dd):	42.8201	42.6908	42.76219	42.76618	42.581766
Longitude (dd):	-85.1932	-85.109	-85.27108	-85.29825	-84.82336
Ecoregion:	SMNITP	SMNITP	SMNITP	SMNITP	SMNITP
Stream Type:	Coldwater	Warmwater	Coldwater	Coldwater	Warmwater
USGS Basin Code:	4050007	4050007	4050007	4050007	4050007

* Applies only to Riffle/Run stream Surveys
** Applies only to Glide/Pool stream Surveys

Table 3. Habitat evaluation for sites in the Thornapple watershed; August-September 2013.

HABITAT METRIC	Thornapple River Irving Road GLIDE/POOL Station 21	Sugar Creek downstream M43 RIFFLE/RUN Station 22	Duncan Creek 108th Street GLIDE/POOL Station 23	Thornapple River Crane Road GLIDE/POOL Station 24	Emmons Creek napple River Rd - North of Caledonia RIFFLE/RUN Station 25
Substrate and Instream Cover					
Epifaunal Substrate/ Avail Cover (20)	15	15	6	13	10
Embeddedness (20)*		13			10
Velocity/Depth Regime (20)*		13			15
Pool Substrate Characterization (20)**	10		8	10	
Pool Variability (20)**	6		3	6	
Channel Morphology					
Sediment Deposition (20)	18	13	3	18	6
Flow Status - Maint. Flow Volume (10)	10	9	9	10	8
Flow Status - Flashiness (10)	3	9	6	3	1
Channel Alteration (20)	15	13	13	13	19
Frequency of Riffles/Bends (20)*		10			19
Channel Sinuosity (20)**	10		4	13	
Riparian and Bank Structure					
Bank Stability (L) (10)	6	10	9	3	4
Bank Stability (R) (10)	6	10	9	3	4
Vegetative Protection (L) (10)	5	8	8	3	4
Vegetative Protection (R) (10)	5	8	8	8	4
Riparian Veg. Zone Width (L) (10)	4	2	4	1	3
Riparian Veg. Zone Width (R) (10)	9	9	2	10	8
TOTAL SCORE (200):	122	142	92	114	115
HABITAT RATING:	GOOD (SLIGHTLY IMPAIRED)	GOOD (SLIGHTLY IMPAIRED)	MARGINAL (MODERATELY IMPAIRED)	GOOD (SLIGHTLY 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:	8/27/2013		9/24/2013		8/26/2013		8/27/2013		8/25/2013						
Weather:	Cloudy		Sunny		Cloudy		Cloudy		Cloudy						
Air Temperature:	80	Deg. F.	60	Deg. F.	83	Deg. F.	80	Deg. F.	75	Deg. F.	Deg. F.				
Water Temperature:	74	Deg. F.	63	Deg. F.	67	Deg. F.	71	Deg. F.	64	Deg. F.	Deg. F.				
Ave. Stream Width:	40	Feet	8	Feet	7	Feet	45	Feet	10	Feet	Feet				
Ave. Stream Depth:	3	Feet	0.3	Feet	0.5	Feet	2	Feet	0.6	Feet	Feet				
Surface Velocity:	1.25	Ft./Sec.	0.7	Ft./Sec.	0.25	Ft./Sec.	1.25	Ft./Sec.	0.8	Ft./Sec.	Ft./Sec.				
Estimated Flow:	150	CFS	1.68	CFS	0.875	CFS	112.5	CFS	4.8	CFS	CFS				
Stream Modifications:	Dredged		None		Dredged		Dredged		None						
Nuisance Plants (Y/N):	N		N		N		N		N						
Report Number:															
STORET No.:	80285		80292		410648		80283		410651						
Stream Name:	hornapple River		Sugar Creek		Duncan Creek		Thornapple River		Emmons Creek						
Road Crossing/Location:	Irving Road		downstream M43		108th Street		Crane Road		Thornapple River Rd - North of Caledonia						
County Code:	08		08		41		08		41						
TRS:	04N09W31		03N08W06		05N10W31		04N10W15		05N10W16						
Latitude (dd):	42.68937		42.674091		42.76838		42.72545		42.81913						
Longitude (dd):	-85.42571		-85.29078		-85.53326		-85.46924		-85.48804						
Ecoregion:	SMNITP		SMNITP		SMNITP		SMNITP		SMNITP						
Stream Type:	Warmwater		Warmwater		Warmwater		Warmwater		Warmwater						
USGS Basin Code:	4050007		4050007		4050007		4050007		4050007						

* Applies only to Riffle/Run stream Surveys

** Applies only to Glide/Pool stream Surveys

Table 3. Habitat evaluation for sites in the Thornapple watershed; August-September 2013.

HABITAT METRIC	Little Thornapple River Harwood Road RIFFLE/RUN Station 29	Quaker Brook Lawrence Road RIFFLE/RUN Station 30	Tyler Creek 84th RIFFLE/RUN Station 31
Substrate and Instream Cover			
Epifaunal Substrate/ Avail Cover (20)	8	7	13
Embeddedness (20)*	3	5	14
Velocity/Depth Regime (20)*	11	13	13
Pool Substrate Characterization (20)**			
Pool Variability (20)**			
Channel Morphology			
Sediment Deposition (20)	17	10	12
Flow Status - Maint. Flow Volume (10)	10	10	10
Flow Status - Flashiness (10)	6	8	8
Channel Alteration (20)	1	6	14
Frequency of Riffles/Bends (20)*	5	6	14
Channel Sinuosity (20)**			
Riparian and Bank Structure			
Bank Stability (L) (10)	10	10	2
Bank Stability (R) (10)	10	10	6
Vegetative Protection (L) (10)	6	6	2
Vegetative Protection (R) (10)	6	5	7
Riparian Veg. Zone Width (L) (10)	1	3	1
Riparian Veg. Zone Width (R) (10)	1	1	5
TOTAL SCORE (200):	95	100	121
HABITAT RATING:	MARGINAL (MODERATELY IMPAIRED)	MARGINAL (MODERATELY 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:	9/24/2013	9/11/2013	9/9/2013
Weather:	Sunny		Cloudy
Air Temperature:	70 Deg. F.	Deg. F.	70 Deg. F.
Water Temperature:	60 Deg. F.	67 Deg. F.	59 Deg. F.
Ave. Stream Width:	8 Feet	8 Feet	13 Feet
Ave. Stream Depth:	0.3 Feet	1 Feet	0.75 Feet
Surface Velocity:	0.4 Ft./Sec.	0.5 Ft./Sec.	1.7 Ft./Sec.
Estimated Flow:	0.96 CFS	4 CFS	16.575 CFS
Stream Modifications:	Dredged	Dredged	Bank Stabilization
Nuisance Plants (Y/N):	N	N	N
Report Number:			
STORET No.:	80293	80256	410706
Stream Name:	ittle Thornapple River	Quaker Brook	Tyler Creek
Road Crossing/Location:	Harwood Road	Lawrence Road	84th
County Code:	08	08	41
TRS:	xxxxxxxx	02N07W13	05N09W13
Latitude (dd):	42.80277	42.5661	42.81386123
Longitude (dd):	-85.094128	-85.0936	-85.3275353
Ecoregion:	SMNITP	SMNITP	SMNITP
Stream Type:	Warmwater	Coldwater	Coldwater
USGS Basin Code:	4050007	4050007	4050007

* Applies only to Riffle/Run stream Surveys
** Applies only to Glide/Pool stream Surveys

Table 4A. Qualitative fish sampling results for Pratt Lake Creek, Duck Creek, and Quaker Brook.

TAXA	Pratt Lake Creek North of Wingeire Avenue 9/11/2013 STATION 13T	Duck Creek Jackson Road 9/24/2013 STATION 16	Quaker Brook Lawrence Road 9/11/2013 STATION 30
Petromyzontidae (lampreys)			
Ichthyomyzon fossor ammocoete (N. brook)			1
Umbridae (mudminnows)			
Umbra limi (Central mudminnow)	6		5
Cyprinidae (minnows and carps)			
Campostoma anomalum (Central stoneroller)		11	
Nocomis biguttatus (Horneyhead chub)			2
Semotilus atromaculatus (Creek chub)	12	64	28
Luxilus cornutus (Common shiner)		33	2
Notropis dorsalis (Central bigmouth)		33	
Notropis stramineus (Sand shiner)			3
Pimephales notatus (Bluntnose minnow)		13	
Rhinichthys atratulus (Blacknose dace)		116	3
Cottidae (sculpins)			
Cottus bairdii (Mottled sculpin)	4		
Catostomidae (suckers)			
Catostomus commersoni (White sucker)	2	10	12
Gasterosteidae (sticklebacks)			
Culaea inconstans (Brook stickleback)	5	4	
Centrarchidae (sunfish)			
Ambloplites rupestris (Rock bass)			1
Lepomis cyanellus (Green sunfish)	3		2
Lepomis gibbosus (Pumpkinseed sf)	7		
Lepomis macrochirus (Bluegill sf)	46		
Micropterus salmoides (Largemouth bass)	2		
Percidae (perch)			
Etheostoma caeruleum (Rainbow darter)			9
Etheostoma nigrum (Johnny darter)	9	62	6
Percina maculata (Blackside darter)			2
TOTAL INDIVIDUALS	96	346	76

Number of hybrid sunfish	0	0	0
Number of anomalies	0	0	0
Percent anomalies	0.000	0.000	0.000
Percent salmonids	0.000	0.000	0.000
Reach sampled (ft)	900	600	375
Area sampled (sq ft)	8,100	4,800	3,000
Density (# fish/sq ft)	0.012	0.072	0.025
Gear	bps	bps	bps

Table 4B. Fish metric evaluation of Pratt Lake Creek, Duck Creek, and Quaker Brook.

METRIC	Pratt Lake Creek North of Wingeire Avenue 9/11/2013 STATION 13T Value	Score	Duck Creek Jackson Road 9/24/2013 STATION 16 Value	Score	Quaker Brook Lawrence Road 9/11/2013 STATION 30 Value	Score
TOTAL NUMBER OF TAXA	10	1	9	1	13	1
NO. OF DARTER, SCULPIN, MADTOM TAXA	2	0	1	0	3	1
NUMBER OF SUNFISH TAXA	3	1	0	-1	2	1
NUMBER OF SUCKER TAXA	1	0	1	0	1	0
NUMBER OF INTOLERANT TAXA	1	-1	0	-1	3	1
PERCENT TOLERANT	33.33	0	76.59	-1	73.68	-1
PERCENT OMNIVOROUS TAXA	20.83	0	58.67	-1	63.16	-1
PERCENT INSECTIVOROUS TAXA	77.08	1	38.15	0	34.21	0
PERCENT PISCIVOROUS TAXA	2.08	0	0.00	-1	1.32	0
% SIMPLE LITHOPHILIC SPAWNER TAXA	2.08	0	45.95	1	36.84	0

TOTAL SCORE	na	na	na
FISH COMMUNITY RATING	Poor	Poor	Poor
COMMENTS:	Not meeting Coldwater Fish Designated Use because salmonids were not present in the sample, but if scored as a warmwater fish community, it would be acceptable (+2).	Not meeting Coldwater Fish Designated Use because salmonids were not present in the sample, but if scored as a warmwater fish community, it would be acceptable (-3).	Not meeting Coldwater Fish Designated Use because salmonids were not present in the sample, but if scored as a warmwater fish community, it would be acceptable (+2).

Table 5. Color coded land cover percentages indicate the ranking among all subbasins, with red indicating the highest stress on water quality (e.g., high amounts of developed or agricultural land would stress water quality by increasing runoff and adding nonpoint source pollutants; conversely, high amounts of wetland or natural land covers would provide benefits to water quality through stabilized hydrology).

ID	Waterbody	Outlet Description	Total Area	Cultivated Crops		Pasture/Hay		Developed Land		Upland Natural		Wetland		Lost Wetland (as percent of presettlement extent)	
			acres	acres	percent	acres	percent	acres	percent	acres	percent	acres	percent	acres lost	percent
1	Thornapple River	Below Butternut Creek	18,221	8,123	45%	4,163	23%	742	4%	3,245	18%	1,804	10%	3,897	68%
2	Butternut Creek	Mouth	10,012	3,929	39%	1,527	15%	2,052	20%	1,491	15%	837	8%	2,167	70%
3	Thornapple Drain	Mouth	13,673	6,871	50%	2,813	21%	496	4%	2,225	16%	1,114	8%	4,608	83%
4	Little Thornapple River	Mouth	19,550	10,977	56%	4,152	21%	340	2%	2,376	12%	1,661	8%	2,472	57%
5	Thornapple River	Below Little Thornapple River	13,484	7,452	55%	2,529	19%	537	4%	2,001	15%	893	7%	1,845	66%
6	Thornapple River	Below Darken and Boyer Drain	15,467	10,283	66%	2,276	15%	194	1%	1,627	11%	1,073	7%	4,054	78%
7	Lacey Creek	Mouth	15,826	7,283	46%	3,589	23%	164	1%	2,918	18%	1,777	11%	2,193	53%
8	Thornapple River	Below Lacey Creek	12,797	7,730	60%	2,105	16%	132	1%	1,609	13%	1,198	9%	2,129	62%
9	Shanty Creek	Mouth	10,165	4,173	41%	2,865	28%	179	2%	1,759	17%	1,152	11%	1,574	52%
10	Scipio Creek	Mouth	6,239	2,602	42%	892	14%	27	0%	1,558	25%	1,108	18%	457	32%
11	Thornapple River	Mill Pond Dam	9,967	3,986	40%	2,363	24%	356	4%	1,904	19%	1,261	13%	536	33%
12	Quaker Brook	Gage #04117000	4,988	1,713	34%	1,270	25%	72	1%	1,103	22%	741	15%	495	40%
13	Quaker Brook	Mouth	7,205	2,754	38%	1,723	24%	315	4%	1,602	22%	779	11%	946	56%
14	Thornapple River	Above Thornapple Lake	8,882	3,572	40%	1,735	20%	215	2%	1,945	22%	1,379	16%	667	34%
15	Mud Creek	Above Hagar Creek	18,699	13,402	72%	1,526	8%	452	2%	1,592	9%	1,391	7%	4,081	71%
16	Mud Creek	Mouth	19,910	10,960	55%	3,090	16%	221	1%	3,200	16%	2,376	12%	1,641	41%
17	High Bank Creek	Mouth	21,795	7,605	35%	4,925	23%	441	2%	5,224	24%	2,771	13%	1,468	33%
18	Cedar Creek	Above Kellie Creek	21,032	4,366	21%	4,899	23%	365	2%	6,981	33%	3,237	15%	668	18%
19	Cedar Creek	Mouth	8,597	1,851	22%	1,612	19%	133	2%	3,583	42%	1,264	15%	352	22%
20	Thornapple River	Gage #04117500	6,048	1,163	19%	1,379	23%	205	3%	1,863	31%	925	15%	315	29%
21	Fall Creek	Mouth	15,875	2,865	18%	2,882	18%	813	5%	5,942	37%	2,470	16%	467	17%
22	Thornapple River	Above Tributary	18,118	5,156	28%	2,987	16%	3,228	18%	5,009	28%	1,564	9%	982	40%
23	Glass Creek	Mouth	23,520	3,763	16%	3,011	13%	308	1%	11,928	51%	3,626	15%	805	18%
24	Thornapple River	Below Glass Creek	24,798	6,988	28%	4,258	17%	1,046	4%	9,008	36%	2,723	11%	1,505	37%
25	Duncan Creek	Mouth	15,044	7,879	52%	3,877	26%	658	4%	1,457	10%	935	6%	1,362	53%
26	Little Thornapple River	Jordan Lake Dam	16,194	10,981	68%	1,304	8%	1,035	6%	1,028	6%	1,170	7%	3,471	72%
27	Coldwater River	Below Messer Brook	29,540	17,818	60%	5,082	17%	502	2%	3,651	12%	2,348	8%	2,753	53%
28	Coldwater River	Above Duck creek	8,014	3,797	47%	1,800	22%	187	2%	1,594	20%	596	7%	529	40%
29	Duck Creek	Mouth	17,753	11,935	67%	2,761	16%	182	1%	1,962	11%	878	5%	3,970	75%
30	Pratt Lake Creek	Mouth	11,419	6,444	56%	2,147	19%	433	4%	1,233	11%	941	8%	1,461	45%
31	Bear Creek	Mouth	18,928	11,105	59%	4,274	23%	342	2%	2,062	11%	1,031	5%	3,005	61%
32	Coldwater River	Mouth	18,934	5,890	31%	3,630	19%	367	2%	6,717	35%	2,139	11%	1,074	29%
33	Thornapple River	Below Coldwater River	21,019	4,239	20%	2,441	12%	1,297	6%	10,654	51%	2,017	10%	718	29%
34	Thornapple River	Gage #04118000	7,018	1,902	27%	1,389	20%	876	12%	2,022	29%	544	8%	390	33%
35	Thornapple River	Below Tributary	21,445	5,561	26%	3,811	18%	3,996	19%	6,060	28%	1,438	7%	1,594	46%
36	Thornapple River	Mouth	12,800	553	4%	346	3%	5,878	46%	4,534	35%	774	6%	782	52%
	Total		542,976	227,671	42%	97,431	18%	28,785	5%	124,670	23%	53,936	10%	61,433	51%

Table 6. 2010 U.S. Census data for each subwatershed in the Thornapple River watershed. Data is shown in units (persons or housing units), and density within the subwatershed (units per acre).

ID	Waterbody	Outlet Description	Population		Occupied Housing Units	
			People	density (people/ acre)	OHU	density (OHU/acre)
1	Thornapple River	Below Butternut Creek	3,570	0.20	1,447	0.08
2	Butternut Creek	Mouth	5,393	0.54	2,367	0.24
3	Thornapple Drain	Mouth	1,922	0.14	784	0.06
4	Little Thornapple River	Mouth	1,989	0.10	790	0.04
5	Thornapple River	Below Little Thornapple River	2,426	0.18	1,028	0.08
6	Thornapple River	Below Darken and Boyer Drain	985	0.06	406	0.03
7	Lacey Creek	Mouth	1,427	0.09	566	0.04
8	Thornapple River	Below Lacey Creek	761	0.06	287	0.02
9	Shanty Creek	Mouth	817	0.08	319	0.03
10	Scipio Creek	Mouth	270	0.04	119	0.02
11	Thornapple River	Mill Pond Dam	1,925	0.19	802	0.08
12	Quaker Brook	Gage #04117000	400	0.08	148	0.03
13	Quaker Brook	Mouth	1,299	0.18	555	0.08
14	Thornapple River	Above Thornapple Lake	997	0.11	423	0.05
15	Mud Creek	Above Hagar Creek	1,625	0.09	708	0.04
16	Mud Creek	Mouth	949	0.05	395	0.02
17	High Bank Creek	Mouth	2,324	0.11	1,178	0.05
18	Cedar Creek	Above Kellie Creek	2,422	0.12	1,224	0.06
19	Cedar Creek	Mouth	989	0.12	407	0.05
20	Thornapple River	Gage #04117500	1,170	0.19	699	0.12
21	Fall Creek	Mouth	3,878	0.24	1,843	0.12
22	Thornapple River	Above Tributary	7,467	0.41	3,227	0.18
23	Glass Creek	Mouth	2,085	0.09	980	0.04
24	Thornapple River	Below Glass Creek	5,427	0.22	2,282	0.09
25	Duncan Creek	Mouth	3,447	0.23	1,181	0.08
26	Little Thornapple River	Jordan Lake Dam	3,698	0.23	1,732	0.11
27	Coldwater River	Below Messer Brook	2,461	0.08	1,001	0.03
28	Coldwater River	Above Duck creek	1,065	0.13	408	0.05
29	Duck Creek	Mouth	1,087	0.06	411	0.02
30	Pratt Lake Creek	Mouth	991	0.09	359	0.03
31	Bear Creek	Mouth	2,051	0.11	809	0.04
32	Coldwater River	Mouth	2,745	0.15	960	0.05
33	Thornapple River	Below Coldwater River	5,576	0.27	2,336	0.11
34	Thornapple River	Gage #04118000	2,775	0.40	1,048	0.15
35	Thornapple River	Below Tributary	9,887	0.46	3,572	0.17
36	Thornapple River	Mouth	15,545	1.21	5,944	0.46
	Total		103,848	0.19	42,747	0.08

Note: green to red gradient indicates density of human population in subwatershed. Green is low, yellow shades are moderate, while red indicates high density.

Table 7. Descriptions of flow, gradient, surface water velocity, and stream order of sampled reaches (USDA-NRCS et al., 2014).

ID	Waterbody	Survey Location	Stream Order	Reach Slope (Meters/Kilometer)	Calculated September Mean Flow* (cubic feet per second)	SeptemberMean Surface Velocity* (feet per second)
1	Thornapple River	Kinsel Highway	2	1.06	10.18	0.75
2	Thornapple River	Royston Road	2	1.06	10.18	0.75
3	Church Drain	N Stewart Rd	1	1.78	2.21	0.65
4	Little Thornapple River	W Vermontville Hwy	3	0.20	13.91	0.67
5	Thornapple River	Pinch and Otto Rd	3	0.18	35.62	0.74
6	Thornapple River	Mulliken Road	4	0.35	61.14	0.85
7	Lacey Creek	Valley Highway	3	0.64	12.81	0.73
8	Hayon Creek	Valley Hwy	2	3.17	4.18	0.73
9	Quaker Brook	Maple Grove Road	2	2.08	3.40	0.69
10	Scipio Creek	Vermontville Highway	1	0.63	5.82	0.66
11	Thornapple River	Ionia Road	4	0.00	87.08	0.64
12	Mud Creek	Saddlebag Road	2	1.02	13.57	0.76
13T	Pratt Lake Creek	Wingeier Ave (north)	2	1.33	10.69	0.76
14	Cedar Creek	Mixer Road	2	1.03	20.06	0.79
15	Little Thornapple River	M 43	2	0.35	21.68	0.73
16	Duck Creek	Jackson Road	2	1.03	8.71	0.72
17T	Mud Creek	Davenport Rd	3	0.68	21.73	0.78
18	Coldwater River	Messer Road	3	0.82	36.56	0.84
19	Coldwater River	off Vedder Rd	3	3.18	39.01	0.98
20	Butternut Creek	S of Peck Hwy (cemetary)	1	1.13	4.25	0.67
21	Thornapple River	Irving Road	4	0.84	223.12	1.14
22	Sugar Creek	d/s of M-43 (Broadway)	2	3.87	5.46	0.76
23	Duncan Creek	108th St SE	2	1.17	5.75	0.68
24	Thornapple River	Crane Road	4	1.55	249.20	1.24
25	Emmons Creek	Thornapple River Dr SE	2	5.15	5.64	0.78
26	Unnamed Trib (GFIA)	36th St SE (West)	1	8.36	1.62	0.70
27	Clark and Bunker Drain	100th	2	5.31	6.06	0.80
28	Drain from Campbell and Barber Lakes	100th	2	2.29	4.07	0.70
29	Little Thornapple	Harwood	2	1.49	5.19	0.70
30	Quaker Brook	E of Lawrence Rd	2	3.44	4.65	0.76
31	Tyler Creek	84th St	2	1.61	12.98	0.79

*Velocities and flows are the calculated NHD modelled means for the month of September, when the biological surveys took place.