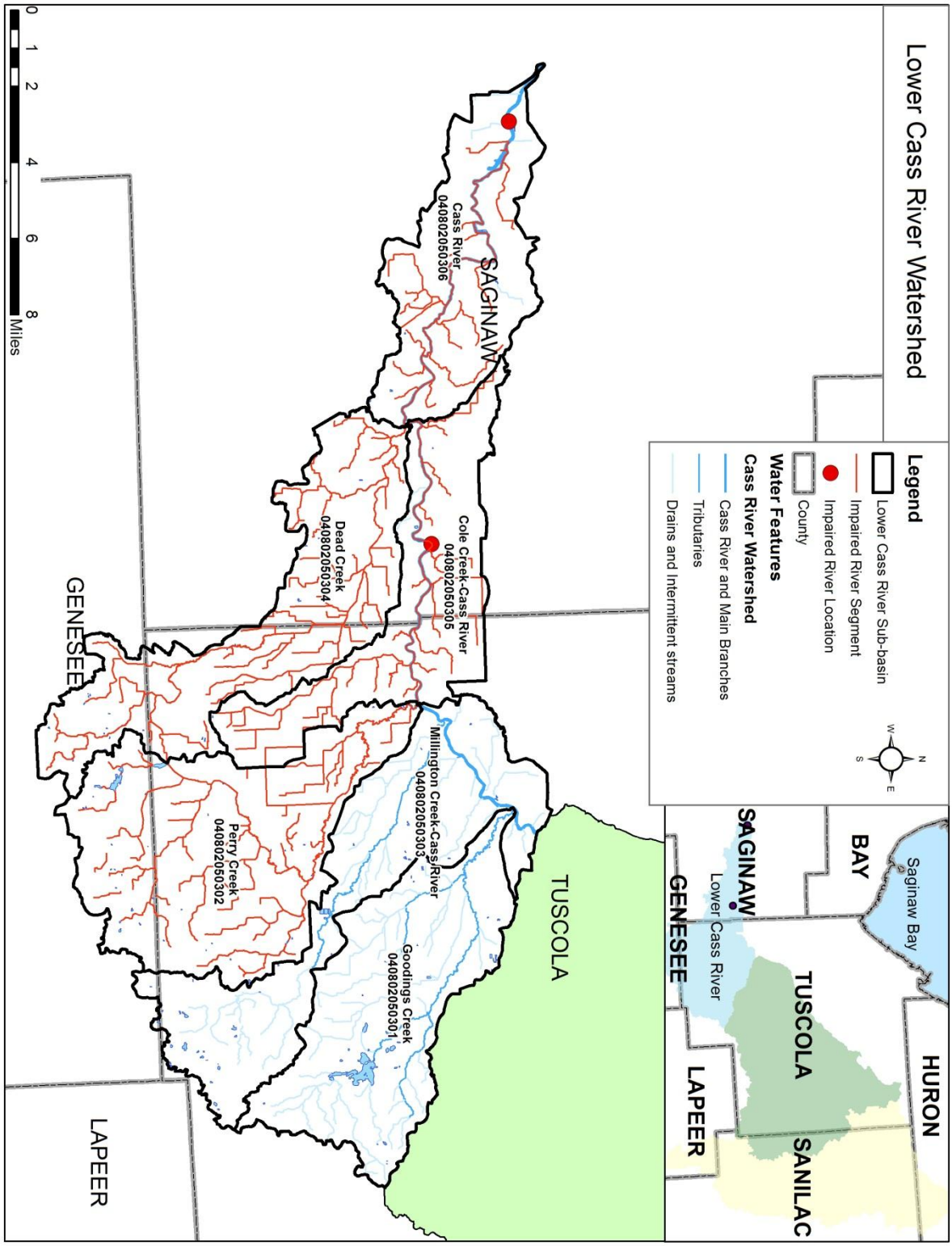
Chapter 9: Lower Cass River

Findings of inventory, critical areas and recommendations for BMP's

Figure 9.1 Lower Cass River Subwatersheds



9.1 Lower Cass River Summary

The Lower Cass River includes areas of Vassar and downstream to the confluence with the Saginaw River in James Township, Saginaw County and includes the tributaries of Goodings Creek, Perry Creek, Millington Creek, Dead Creek and Cole Creek. The Lower Cass River sub-basin occupies 20.4% of the total watershed totaling 118,516 acres. The Lower Cass River is further divided into six sub-watersheds that are described in Table 9.1.

Table 9.1: Watershed Sub-watersheds

Sub- watersheds	Acres	Sq. Miles	% of Total Watershed
Lower Cass River	118,516		20.4
01-Goodings Creek	19,761	30.9	3.4
02-Perry Creek	25,471	39.8	4.4
03-Millington Creek	20,455	32	3.5
04-Dead Creek	21,462	33.5	3.7
05-Cole Creek	15,899	24.8	2.7
06-Cass River	15,468	24.2	2.7

The Lower Cass River is part of two ecoregions: the Southern Michigan/Northern Indiana Drift Plains whose soils and landforms make for an agricultural industry that typically produces feed grain, soybeans, and livestock and the Huron/Erie Lake Plains ecoregion dominated by broad, flat lands that are characteristically fertile. Originally this ecoregion's soil had very poor drainage, but there are now several man-made drains. The characteristically fertile soils of this ecoregion have led to high farming activity that mainly produces corn, soybeans, and livestock.

The Lower Cass River most accurately reflects the average land use of the entire watershed. This sub-basin's agricultural land use is about 54.4 percent and its natural land use is about 37.8 percent. Subwatersheds with the greatest agricultural land cover are the Cole Creek (66%), Perry Creek (65%), Dead Creek (57%) and Millington Creek (53%). Goodings Creek has the highest percentage of natural land cover at 55% in the Lower Cass River.

9.2 Lower Cass River causes and sources of impairments and threats (EPA Element A)

Water body use designations (EPA, A.1)

Designated Uses

A stream or site in the watershed is listed as impaired if it is failing to meet one or several designated uses as defined by the State of Michigan. Designated uses for the Lower Cass River and its tributaries include:

- **Agriculture** – Irrigation water for crops or water for livestock

- **Wildlife and Other Indigenous Aquatic Life** –Aquatic life and wildlife can thrive and reproduce. (Comment: Minimum Flows and levels should be maintained in order to sustain environmental conditions and wildlife throughout the year. (Water balance)

- **Total and Partial Body Contact** – Recreational (swimming, fishing, boating) all waters protected for recreation shall not exceed specific levels of E.coli from May to October.

- **Warm Water Fishery** – Water supports warm water fish species including reproduction and sustainability,

Table 9.2 compiles information from the impaired waterbodies list provided by MDEQ and information gathered during the 2011 inventory. Sub-watersheds were inventoried via in-stream surveys and/or windshield surveys. Chapter 3 describes the methodology used for each of the inventory methods. Goodings Creek are the Cass River sub-watersheds listed as attaining all designated use by MDEQ. Goodings Creek was not inventoried based on the high percentage of undeveloped land use (wetlands, forests, etc). The Cass River sub-watershed was inventoried in 2008 for streambank erosion.

Impaired sub-watersheds were priority for in-stream inventory to identify sources of pollution. Four sub-watersheds in the Lower Cass River: Perry Creek, Millington Creek, Dead Creek, and Cole Creek are listed as impaired by the MDEQ and were inventoried via in-stream surveys by the Tuscola Conservation District during the 2011 field season.

Two initial criteria were looked at to determine which sub-watersheds should be inventoried for agricultural NPS pollution sources and causes, a known impairment and the percentage of agricultural land use. Each sub-watershed was then assigned a priority between one and three, with priority one sub-watersheds having both impaired waterways and agricultural land use at 75% or greater. This rationale resulted in two sub-watersheds being inventoried using the windshield survey: Dead Creek and Cole Creek.

Table 9.2 Impaired, partially impaired, and/or threatened uses (EPA A.3)

Lower Cass River Sub-basin	Impaired Uses per MDEQ in-stream surveys	Potentially Impacted (Suspected)	Notes
2012 Integrated Report (IR)			
10-HUC: 0408020503	Fish Consumption		PCB in Water Column, Mercury in Fish Tissue; 2013 TMDL
Perry Creek			
AUID: 040802050302-01	Total Body Contact Recreation		E. coli, 2013 TMDL (2015 TMDL per 2014 IR)
Millington Creek			
AUID: 040802050303-01	Other Indigenous Aquatic Life and Wildlife		Mercury in water column, 2013 TMDL (2015 TMDL per 2014 IR)
			Total Body Contact (TBC) and Partial Body Contact (PBC) listed as impaired per 2014 IR
AUID: 040802050303-01	Warmwater Fishery		Mercury in water column, 2013 TMDL (2014 TMDL per 2014 IR)
	Other Indigenous Aquatic Life and Wildlife		Mercury in water column, 2013 TMDL (2014 TMDL per 2014 IR)
			2014 IR cites Insufficient Information for TBC and PBC
Dead Creek			
AUID: 040802050304-01	Total and Partial Body Contact Recreation		E. coli, 2015 TMDL
	Fish Consumption		Dioxin (including 2, 3, 7, 8-TCDD), 2023 TMDL; PCB in fish tissue
AUID: 040802050304-02	Other Indigenous Aquatic Life and Wildlife (2012 IR)		Other anthropogenic substrate alterations, Other flow regime alterations; removed in 2014 IR
	Total and Partial body contact (2014 IR)		Listed in the 2014 IR
	Fish Consumption		Dioxin (including 2, 3, 7, 8-TCDD), 2023 TMDL
Cole Creek – Cass River (headwaters)			
AUID: 040802050305-01	Total Body Contact Recreation		E. coli, 2013 TMDL (2015 TMDL per 2014 IR)
AUID: 040802050305-02	Total Body Contact Recreation		E. coli, 2017 TMDL (2015 TMDL per 2014 IR)
AUID:	Total Body Contact		E. coli, 2013 TMDL (2015 TMDL per

Lower Cass River Sub-basin	Impaired Uses per MDEQ in-stream surveys	Potentially Impacted (Suspected)	Notes
040802050305-03	Recreation		2014 IR)
	Fish Consumption		Dioxin (including 2, 3, 7, 8-TCDD), 2023 TMDL; PCB in fish tissue
AUID: 040802050305-04	Total and Partial Body Contact Recreation		E. coli, 2013 TMDL (2015 TMDL per 2014 IR)
	Fish Consumption		Dioxin (including 2, 3, 7, 8-TCDD), 2023 TMDL; PCB in fish tissue
AUID: 040802050305-05	Total Body Contact Recreation		E. coli, 2013 TMDL; 2014 IR cites TBC and PBC as impaired
Cass River (mouth)			
AUID: 040802050306-01	Total Body Contact Recreation		E. coli, 2013 TMDL (2015 TMDL per 2014 IR)
	Other Indigenous Aquatic Life and Wildlife		Mercury and PCB in water column, 2014 TMDL for Mercury
	Fish Consumption		Dioxin (including 2, 3, 7, 8-TCDD), 2023 TMDL
		Warmwater Fishery	Extensive streambank erosion per 2011 Inventory
AUID: 040802050306-02	Total Body Contact Recreation		E. coli, 2013 TMDL (2015 TMDL per 2014 IR)
AUID: 040802050306-03	Other Indigenous Aquatic Life and Wildlife		Mercury and PCB in water column, 2014 TMDL for Mercury; removed in 2014 IR
	Fish Consumption		Dioxin (including 2, 3, 7, 8-TCDD), 2023 TMDL

Water quality criteria (EPA, A.2)
The water quality criteria used to evaluate the environmental health of water bodies in the Lower Cass River are defined below.

Bacteria – Partial and Total Body Contact (Taken from the 2013 TMDL for *E. coli*, developed by MDEQ for Portions of the Cass River and Tributaries, including Millington, Cole, Perry, and Dead Creeks)

For Partial Body Contact, all the waters of the State shall have not more than 1000 E. coli bacteria per 100 milliliters of water. For Total Body Contact, the waters of the State shall have not more than 130 E. coli bacteria per 100 milliliters of water, as a 30-day average and 300 E. coli per 100 ml water at any time. Each sampling event shall consist of three or more samples taken at representative locations within a defined sampling area. At no time shall the waters of

the state protected for total body contact recreation contain more than a maximum of 300 E. coli per 100 ml. Compliance shall be based on the geometric mean of three or more samples taken during the same sampling event at representative locations within a defined sampling area.

In addition, sanitary wastewater discharges have an additional target: Discharges containing treated or untreated human sewage shall not contain more than 200 fecal coliform bacteria per 100 ml, based on the geometric mean of all of five or more samples taken over a 30-day period, nor more than 400 fecal coliform bacteria per 100 ml, based on the geometric mean of all of three or more samples taken during any period of discharge not to exceed seven days. Other indicators of adequate disinfection may be utilized where approved by the department.

Sediment

Total Suspended Solids (TSS) - Rule 50 of the Michigan Water Quality Standards (Part 4 of Act 451) states that waters of the state shall not have any of the following unnatural physical properties in quantities which are or may become injurious to any designated use: turbidity, color, oil films, floating solids, foam, settleable solids, suspended solids, and deposits. This kind of rule, which does not establish a numeric level, is known as a "narrative standard." Most people consider water with a TSS concentration less than 20 mg/l to be clear. Water with TSS levels between 40 and 80 mg/l tends to appear cloudy, while water with concentrations over 150 mg/l usually appears dirty. The nature of the particles that comprise the suspended solids may cause these numbers to vary.

Table 9.3 Specific causes and sources of impairments and/or threats (EPA, A.4)

The statuses of designated uses presented in Table 9.2 are correlated with the causes and sources of impairments for each sub-watershed in Table 7.3.

Sub-watershed name	Use Description	Cause name	Source(s)
Perry Creek	Partial Body Contact Total Body Contact	E. coli	1. Illicit discharges, 2. Wildlife and pet waste, 3. Agriculture, 4. Contaminated runoff, 5. Failing sewage treatment systems
Millington Creek	Partial Body Contact Recreation Total Body Contact Recreation	E. coli	1. Illicit discharges, 2. Wildlife and pet waste, 3. Agriculture, 4. Contaminated runoff, 5. Failing sewage treatment systems
Dead Creek	Other Indigenous Aquatic Life and Wildlife	Other anthropogenic substrate alterations Other flow regime alterations	1. Channelization
Dead Creek	Partial Body Contact Recreation Total Body Contact Recreation	E. coli	1. Illicit discharges, 2. Wildlife and pet waste, 3. Agriculture, 4. Contaminated runoff, 5. Failing sewage treatment systems
Cole Creek – Cass River (headwaters)	Partial Body Contact Recreation Total Body Contact Recreation	E. coli	1. Illicit discharges, 2. Wildlife and pet waste, 3. Agriculture, 4. Contaminated runoff, 5. Failing sewage treatment systems
Cass River	Total Body Contact Recreation THREAT: Warm water fishery THREAT: Other Indigenous Aquatic Life and Wildlife	E. coli Sediment (suspected)	1. Agriculture 2. Wildlife and pet waste 3. Streambank erosion (known)

Causes of impairment (or threats) quantified (EPA, A.5)

The causes of threats to water quality and known impairments are quantified by E. Coli, tiling and ditching, and streambank erosion. Causes were quantified through data presented in the

2013 TMDL for the Cass River and Tributaries, GIS analysis of surface water, and analysis of the 2008 streambank erosion inventory.

E. Coli

Water quality testing was performed in 2010 and 2012 as a part of the 2013 Draft TMDL for E. coli in portions of the Cass River and Tributaries, including Millington, Cole, Perry, and Dead Creeks. This information is included in Table 1 (2010) and Table 3 (2012) of the 2013 TMDL draft and summarized below in Table 9.4.

Table 9.4 Summary of sampling site locations, site geometric means, and water quality exceedances for sites sampled in 2010 and 2012.

Note that site geometric means are the geometric means of all sample results for each site, and are calculated to facilitate comparisons among sites and are not intended to be compared to the water quality standards to determine exceedances.

Sampling Year	Site ID	Site Description	Site Geometric Means	Number of total body contact exceedances	Number of partial body contact exceedances
2010	1	Cass River @ Bray Rd	105	0	0
2010	2	Cass River @ Main St	55	1	0
2010	3	Cass River @ Dixie Hwy	132	1	0
2010	4	Cass River @ Fort Rd	85	1	0
2010	5	Cass River @ M-13	58	0	0
2010	6	Zehnder/Dead Cr @ Curtis Road	463	14	2
2010	7	Cole Cr @ Ormes Rd	470	11	2
2010	8	Perry Cr @ Ormes Rd	340	9	0
2010	9	Millington Cr @ Loren Rd	376	11	1
2010	10	Unnamed Tributary @ Van Cleve (Tuscola Rd)	1,017	9	7
2012	C1	Cole Cr @ Bray Rd (north)	253	1	1
2012	C2	Calkins Dr @ Bray Rd (south)	1,981	5	4
2012	S1	Smith Dr @ Murphy Lake Rd	2,344	5	5
2012	D1	Dead Cr @ Lewis Rd	480	5	0
2012	P1	Burns Dr @ Birch Run Rd	253	2	0
2012	P2	Perry Cr @ Vassar Rd	254	5	1
2012	P3	Pedlow Dr/Perry Cr @ Irish Rd	544	5	1
2012	M1	Millington Cr @ Millington Rd	920	5	2
2012	M2	Millington Cr @ Murphy Lake Rd	399	3	1

Tiling and Ditching

Dead Creek is an agricultural watershed (nearly 60% of land cover), with approximately 50 miles of agricultural drains that have been channelized.

Streambank Erosion

The 2008 streambank inventory identified 46 sites within the Cass River subwatershed totaling 8,205 feet in length and contributing an estimated 11,920 tons of sediment annually. A total of 23 sites were identified in Cole Creek totaling 1,565 feet in length and contributing and estimated 4,392 tons of sediment annually.

Locations of Impairments (EPA, A.6-8)

Figure 9.2 shows the known locations of impairment sources from the 2011 in-stream and windshield inventories and the 2008 streambank inventory. Additional potential sources were identified in the 2013 Draft TMDL for the Lower Cass River detailing potential sites for livestock access and impairment in the Perry Creek and Millington Creek subwatersheds.

Priority livestock sites were those identified during the 2011 windshield surveys. High priority sites are those where known surface water impairments were observed and pollutant loading estimates could be calculated. Medium priority sites are those where surface water quality impairments are suspected and pollutant loading estimates can be calculated. Low priority sites are those where surface water quality impairments are suspected but pollutant loading estimates could not be calculated due to lack of adequate site details.

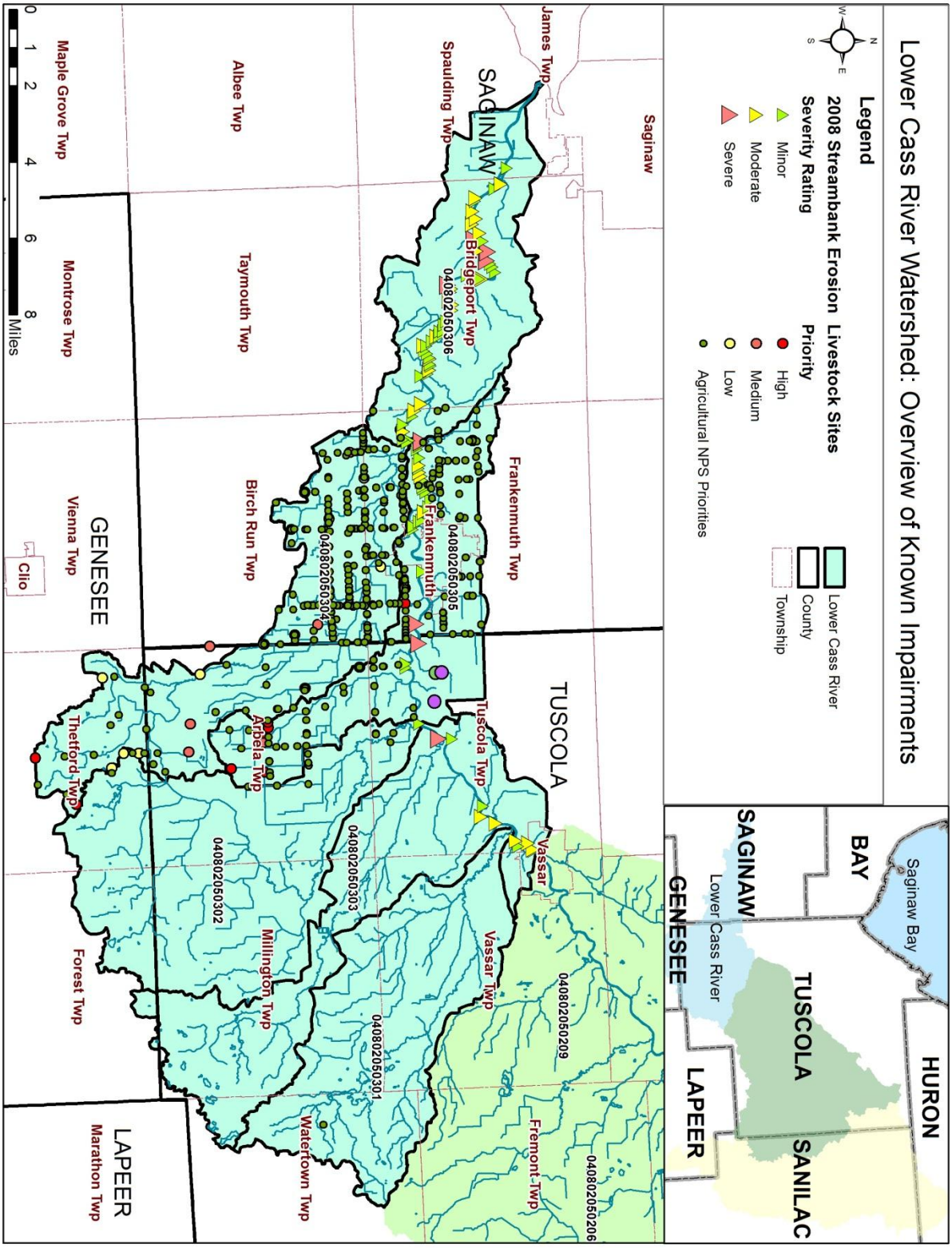
The 2011 In-stream survey results are those sites identified while conservation district staff were wading stretches of impaired waterways. Impairment locations were delineated by sources. Sources identified in the Upper Cass River include gully erosion, livestock access, stream crossing (eroding), streambank erosion, tile outlets, urban nps (urban nonpoint source or stormwater runoff), and ag nps (agricultural nonpoint source or field runoff).

Ag NPS priorities were those identified during the 2011 in-stream survey when conservation district staff identified priority areas to reduce field runoff. These locations are important to target for BMP's because a known impairment was observed. Ag NPS priority sites include field runoff, manure spreading, or inadequate buffer strips.

During the windshield survey, agricultural sites were classified by the practices that were installed on each site. Fields that were listed as having conventional tillage and 25% or less field residue are highlighted to aide in targeting of outreach programs for conservation tillage, grassed buffers, and cover crops.

Table 9.5 further summarizes information shown in Figure 9.2 by subwatershed and recommended management measures.

Figure 9.2 All Impairment Locations, Lower Cass River



9.3 Implementation Priorities and Schedule

The inventories conducted in 2008 and 2011 were reviewed and prioritized by a technical committee for the Lower Cass River watershed. Representatives present at the meeting included the Cass River Greenway Committee, Saginaw Conservation District, Environmental Science consultant, Spicer Group, and UM-Flint. These priorities have been combined with those set forth in the draft 2013 TMDL authored by the MDEQ. A summary of the priorities is shown in Table 9.5.

Further discussion on how sites were prioritized is included in Chapter 7 regarding the Upper Cass River. The same methods were employed in prioritizing sites for the Lower Cass River.

Table 9.5 Lower Cass River Implementation Priorities

Priority	Sub-shed	Problem or Management Measure	Technical Assistance Type	Quantity	Schedule	Site Specific Table and Maps
1	Cole Creek	Restrict livestock access, Manure Management	Landowner outreach and assistance for fencing, crossings, stacking facilities, MAEAP certification, etc.	966 animals; 15 sites	2014-2016	Table 9.5 Figure 9.3
1	Dead Creek	Restrict livestock access, Manure Management		1,265 animals; 10 sites		Table 9.6 Figure 9.4
1	Perry Creek	95 potential sites for livestock exclusion		95 sites		*Table 12 of 2013 TMDL
1	Millington Creek	30 potential sites for livestock exclusion		30 sites		*Table 12 of 2013 TMDL
2	Cole Creek	Streambank erosion	Landowner outreach, engineering and construction	1,565 linear feet; 23 sites	2016-2018	Table 9.9 Figure 9.5
2	Cass River	Streambank erosion		8,205 linear feet; 46 sites		Table 9.10 Figure 9.6
3	Cass River	Wetland restoration (over 90% wetland loss)	Landowner outreach, engineering and construction	**See LLFWA	2018-2020	Figure 9.7
4	Dead Creek	Conservation tillage and cover crops, vegetated buffers	Landowner outreach and assistance	8,600 Acres; 230 sites	2020-2023	Table 9.11 Figure 9.8
4	Cole Creek	Conservation tillage and cover crops, vegetated buffers		5,675 acres; 126 sites		Table 9.13 Figure 9.9

*2013 TMDL, Total Maximum Daily Load for *E. coli* in Portions of the Cass River and Tributaries, including Millington, Cole, Perry, and Dead Creeks; Genesee, Saginaw, and Tuscola Counties. Michigan Department of Environmental Quality, Water Resources Division. Draft April 2013. http://www.michigan.gov/documents/deq/wrd-assesment-TMDL-CassRiver_DRAFT_420027_7.pdf
**LLFWA, The Landscape Level Functional Wetland Assessment is available through the Michigan Department of Environmental Quality, Wetland Restoration and Watershed Planning, http://www.michigan.gov/deq/0,4561,7-135-3313_3687-10419--,00.html

9.4 Priority Source Loadings

Sources of pollutant loadings are discussed by priority: livestock access, streambank erosion, wetland restoration and cropland runoff.

Priority 1: Livestock Access

Inventory

Livestock access was chosen as the top priority for the Lower Cass River watershed due to findings during the 2011 field inventory and testing information presented in the draft 2013 TMDL. Impacts from livestock are believed to be contributing *E. coli* to surface waters and are impairing the designated uses of partial body and total body contact recreation. Sites were identified in Cole Creek and Dead Creek in the 2011 field inventory and suspected sites were identified in the draft 2013 TMDL in Millington Creek and Perry Creek.

A total of 15 sites were identified in Cole Creek that potentially impact water quality. These 15 sites have a total of 966 animals that are being raised for agricultural purposes. Sites have been prioritized based upon if a known impairment is observed and proximity to surface water, table 9.6 provides a breakdown of these sites; all sites in Cole Creek are shown in Figure 9.3.

A total of 10 livestock impairment sites were identified in the Dead Creek subwatershed, with a total of 1,265 animals being raised for agricultural purposes. Sites have been prioritized based upon if a known impairment is observed and proximity to surface water, table 9.7 provides a breakdown of these sites; all sites are mapped in Figure 9.4.

Millington Creek was identified as a priority in the draft 2013 TMDL, a full listing of sites is available in Table 12 of the draft TMDL. Perry Creek was also identified as a priority in the draft 2013 TMDL and the suspected sites are included in Table 12 of the draft TMDL.

Load Estimate Methodology

The Pollutant controlled calculation and documentation for Section 319 Watersheds Training Manual, June, 1999 section on Feedlot Pollution Reduction was utilized. The steps outlined in this document were developed into an Excel spreadsheet calculator. The calculation requires the determination of the average rainfall (R) per day by selecting the state and county in which the feedlot is located. The variable R is then calculated, in this case it is approximately R= 0.2848, as the watershed locations are within the same rainfall isopleths. The spreadsheet was set up so there were input areas for Slaughter Beef (feeder cattle); Dairy Cattle, Horses, Feeder Pigs (it was assumed that all pigs were feeders in the watershed), and sheep. So for Table 9.6 Cole Creek Impairments from Livestock Access, the pollutant loading calculator is set up to determine the Annual average mass load of pollutants in runoff using the following formula; the Mass load x Rain days per year x Correction Factor for number of rain days assuming the cows are "feeders" that yields approximately 57 lbs-P per year, and 308 lbs-N per year which could make its way to the watershed drainage system. Additionally, almost 387 lbs-BOD (biological oxygen demand) could be introduced into the surface water system annually from these feeder cattle and sheep on this site. A copy of the calculator is available for viewing in APPENDIX C, it is set up to show the above mentioned calculation.

Table 9.6 Cole Creek sites with potential impacts from livestock

Map Label	Lat. (UTM-X)	Long. (UTM-Y)	# animals	Acres	Type	Priority 1=High 2 = Med. 3= Low	Estimated Annual "P" Load (lbs/yr)[1]	Estimated "N" Load (lbs/yr)[1]	Estimated BOD Load (lbs/yr)[1]	Reduction Target %
17	(4795444)	(283171)	40	NR	20 cattle; 20 sheep	1	57.0	308.0	387.0	100
19	(4790372)	(285553)	25	NR	25 sheep	1	4.0	47.0	34.0	100
42	(4790516)	(284384)	200	NR	200 sheep	1	32.0	378.0	270.0	100
43	43.27888	-83.75502	2	15	2 horses	1	2.0	23.0	38.0	100
4	43.27909	-83.70019	20	30	20 horses	2	0.0	4.0	7.0	100
5	43.28789	-83.70533	200	NR	200 cattle	2	540.0	2,699.0	3,599.0	100
6	43.30198	-83.79434	350	10	350 cattle	2	118.0	589.0	785.0	100
20	43.19204	-83.62073	33	20	15 cattle; 3 horses; 15 pigs	2	47.0	249.0	354.0	100
18	43.19434	-83.61529	18	40	10 cattle; 3 horses; 5 pigs	3	31.0	173.0	246.0	0
21	43.28447	-83.77433	2	12	horses	3	2.0	23.0	38.0	0
23	43.26737	-83.69579	50	50	cattle	2	135.0	675.0	900.0	0
24	43.31254	-83.7347	5	5	cattle	3	13.0	67.0	90.0	0
71	43.19619	-83.68073	11	NR	3 horse 8 pigs	3	1.0	5.0	9.0	0
76	43.29329	-83.76105	6	55	cattle	3	19.0	119.0	135.0	0
78	43.30715	-83.78113	4	30	horse	3	5.0	46.0	77.0	0

Figure 9.3 Livestock Impairments, Cole Creek

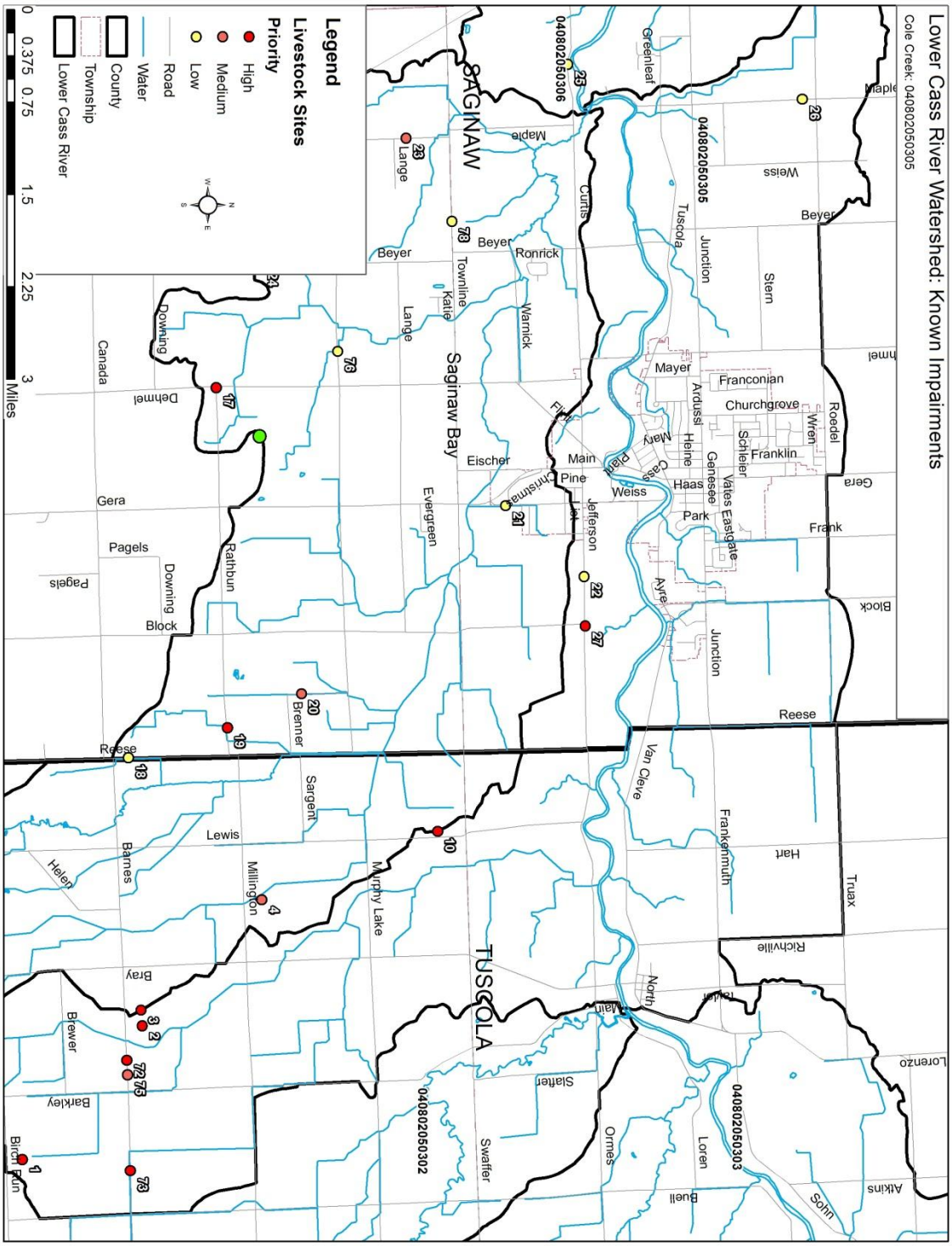
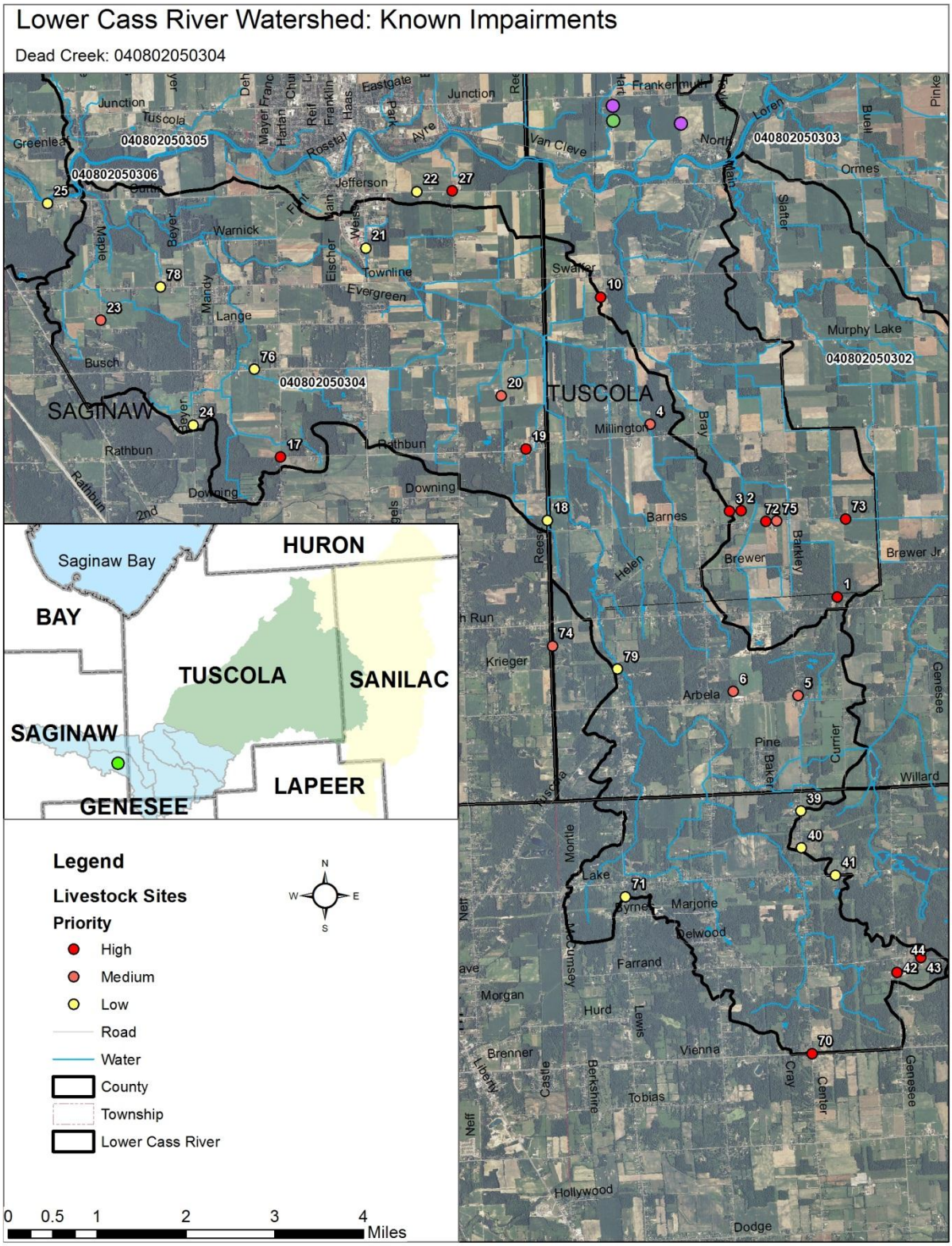


Table 9.7 Dead Creek sites with potential impacts from livestock

Map Label	Lat. (UTM-X)	Long. (UTM-Y)	# animals	Acres	Type	Priority 1=High 2 = Med. 3= Low	Estimated Annual "P" Load (lbs/yr)[1]	Estimated "N" Load (lbs/yr)[1]	Estimated BOD Load (lbs/yr)[1]	Reduction Target %
1	(4792116)	(286374)	5	NR	pigs	1	1.0	4.0	9.0	100
2	(4793782)	(284722)	250	NR	150 cattle 100 sheep	1	421.0	2,213.0	2,834.0	100
3	(4793781)	(284516)	204	NR	200 cattle 4 pigs	1	541.0	2,703.0	3,606.0	100
10	(4797794)	(282417)	50	NR	sheep	1	8.0	94.0	67.0	100
27	43.32149	-83.715	353	20	200 cows; 3 horse 150 sheep	1	568.0	3,017.0	3,859.0	100
72	(4793766)	(28511)	120	NR	100 cattle 20 sheep	1	273.0	1,387.0	1,827.0	100
73	(4793737)	(286625)	16	NR	10 cattle 6 sheep	1	28.0	146.0	188.0	100
75	(4793805)	(253473)	204	NR	200 cattle 4 pigs	2	541.0	2,703.0	3,606.0	100
22	43.32154	-83.723	40	20	cattle	3	108.0	540.0	720.0	0
26	43.34876	-83.7989	23	70	3 horse 20 sheep	3	7.0	72.0	84.0	0

Figure 9.4 Livestock Sites, Dead Creek



Priority 2: Streambank Erosion

Inventory

Streambank erosion was chosen as high priority due to the findings of the 2008 streambank inventory and the support and interest from the Cass River Greenway committee in coordinating streambank restoration projects along the Lower Cass River that further promote the Cass River as a recreation destination and enhance habitat for aquatic life. Numerous streambank erosion sites were identified in Cole Creek and the Cass River subwatersheds in 2008.

A total of 23 streambank erosion sites were identified along the Cass River in the Cole Creek subwatershed totaling 1,565 linear feet. Nutrient and sediment loading estimates for each site are shown in table 9.8; Figure 9.5 shows where streambank erosion sites are located within the Cole Creek subwatershed.

A total of 46 streambank erosion sites were identified along the Cass River totaling 8,205 linear feet. Nutrient and sediment loading estimates for each site are shown in table 9.9; each site is mapped for the Cass River subwatershed in Figure 9.6.

Loading Estimate Methodology

The loading reduction target for all streambank erosion sites is 100% assuming that the bank is stabilized to mitigate future erosion from occurring. Using the *Pollutants Controlled Calculation and Documentation for Section 319 Watersheds Training Manual* (June, 1999), we are able to provide information on the nutrient aspect of sediment loading in a watershed in Tables 9.9, 9.10. Using the data gathered by field survey crews, the sediment loading could be estimated from the length, width and depth of the visible erosion. This would be developed, first into a volume, then a mass. From the mass and general type of soils, we used a ratio of 1.1 pounds of phosphorus per ton of sediment to obtain the pounds of phosphorus loading.

This erosion volume estimate has to be converted to Tons, therefore, using the geotechnical reference manual *GeoTechnical Engineering-Principles and Practices, 1999 by D.P.Coduto* the soils in this area are well represented by a factor of 110 lbs/ft3, when this is divided by 2000 lbs/Ton the conversion factor of 0.055 Tons/ft3 is obtained.

Table 9.8 Cole Creek Streambank Erosion Sites

Site ID	Depth (ft)	Height (ft)	Length (ft)	Slope	Condition of Toe (bank) Impacts Potential Causes Additional Comments	Rating Chart	Sediment Load (tons/yr)	P Load (lbs/yr)	N Load (lbs/yr)	Load Reduction %
15	1	20	100	1:1	Bank Eroding, Toe Unstable, Undercutting, wake from boats	Minor	125	137.5	275	0
725	2	10	35	1:1	Bank Eroding, Toe Unstable, high water, visible due to about 1 foot water level drop	Minor	43.8	48.1	96.3	0
726	1.5	8	10	3:1	Bank Eroding, Toe Stable, Foot Traffic	Minor	7.50	8.3	16.5	0
728	2	15	25	2:1	Bank Eroding, Toe Unstable, Foot Traffic, aquatic vegetation not growing; roots exposed	Minor	46.9	51.6	103.1	0
729	1.5	15	100	1:1	Bank Eroding, Agric Runoff, River Bend, high water carving out roots, toe beginning to stabilize; human activity above bank	Minor	140.6	154.7	309.4	0
731	2	8	15	1:1	Undercutting, high water, toe beginning to stabilize; roots exposed	Minor	15.0	16.5	33.0	0
732	2	10	20	1:1	Bank Eroding, Toe Stable, run-off	Minor	25.0	27.5	55.0	0
733	1.5	10	50	1:1	Bank Eroding, Toe Unstable, Trampled, Undercutting, Foot Traffic, high water 2 sites in 1; carved out bank by humans	Minor	46.9	51.6	103.1	0
734	1.5	8	10	2:1	Bank Eroding, Toe Unstable, high water, roots exposed	Minor	7.5	8.3	16.5	0
759	1.5	10-15	80	2:1	Bank Eroding, Toe Stable, high water, roots exposed; trees leaning in; dead tree debris in water; bank is re-vegetating	Minor	93.8	103.1	206.3	0
760	1.5	15	10	2:1	Bank Eroding, Foot Traffic, Sediment Dropped, toe beginning to stabilize	Minor	14.0	15.5	30.9	0
763	1	8	60	2:1	Bank Eroding, Toe Unstable, Sediment Dropped, high waters, toe beginning to grow vegetation; residence above bank	Minor	30.0	33.0	66.0	0

Site ID	Depth (ft)	Height (ft)	Length (ft)	Slope	Condition of Toe (bank) Impacts Potential Causes Additional Comments	Rating Chart	Sediment Load (tons/yr)	P Load (lbs/yr)	N Load (lbs/yr)	Load Reduction %
765	1.5	15	60	2:1	Bank Eroding, Foot Traffic, toe beginning to stabilize; residence above bank; roots exposed	Minor	84.4	92.8	185.6	0
766	1	8-10	110	2:1	Bank Eroding, Toe Stable, Foot Traffic, Seepage, high water, roots exposed	Minor	61.9	68.1	136.1	0
767	<1	8	40	1:1	Bank Eroding, Toe Unstable, Undercutting, River Bend	Minor	20.0	22.0	44.0	0
768	1.5	10	30	2:1	Bank Eroding, Toe Unstable, River Bend, roots exposed; trees leaning into river; bank beginning to re-vegetate in some areas; right bank - 15 ft	Minor	28.1	30.9	61.9	0
727	1.5	12	50	1:1	Bank Eroding, Undercutting, highwater, Toe stabilizing	Moderate	56.3	61.9	123.8	100
761	1.5	15	120	1:1	Bank Eroding, Sediment Dropped, toe somewhat stable; large cement blocks on top of bank (dumping); roots exposed; left bank - too 10 ft	Moderate	168.8	185.6	371.3	100
762	2	12	60	2:1	Bank Eroding, Toe Unstable, high water, unknown human impact above bank; trees falling in	Moderate	90.0	99.0	198.0	100
764	2	12	400-500	1:1	Bank Eroding, Toe Unstable, Foot Traffic, Sediment Dropped, Seepage, high water, run-off; residence above bank - mowed to bank	Moderate	675.0	742.5	1,485.0	100
13	1.5	40	80	1:1	Bank Eroding, Toe Unstable, River Bend, sediment fall was undercutting; deer	Severe	300.0	330.0	660.0	100
14	2	40	250-300	1:1	Bank Eroding, Toe Unstable	Severe	1,375.0	1,512.5	3,025.0	100
769	1.5	20	500	1:1	Bank Eroding, Toe Unstable, Undercutting, River Bend, high water; run-off from road above bank huge cement block above bank; toe re-vegetating in patchy area; left bank - 35 ft	Severe	937.5	1,031.3	2,062.5	100

Figure 9.5 Cole Creek Streambank Erosion Sites

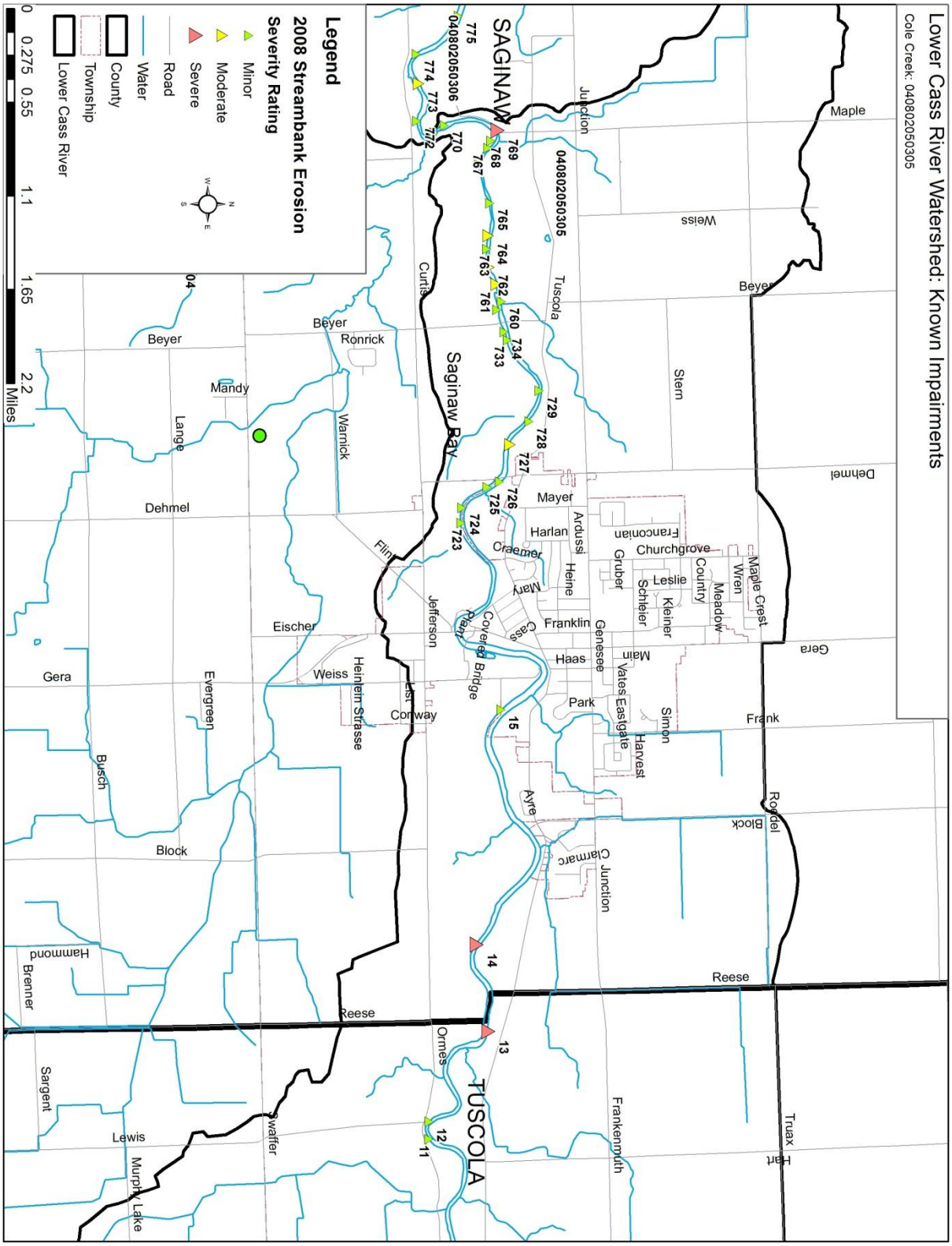


Table 9.9 Cass River Streambank Erosion Sites

Site ID	Average Depth (ft)	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes, Additional Comments	Rating Chart	Sediment load (tons/yr)	Est P Load (lbs/yr)	Est N Load (lbs/yr)	Load Reduction %
772	1.5	8	40	2:1	Bank Eroding, Toe Unstable, Undercutting, River Bend, Sediment Dropped, high water	Minor	30.0	33.0	66.0	0
774	1	18	30	2:1	Bank Eroding, Toe Stable, River Bend, Seepage, road up above; high water before rapid; roots exposed; immersive aquatic vegetation is patchy	Minor	33.8	37.1	74.3	0
775	1.5	8	230	1:1	Bank Eroding, Toe Unstable, high water land may be mowed; roots exposed; trees leaning in	Minor	172.5	189.8	379.5	0
779	1.5	8	300	2:1	Undercutting, Agric Runoff, Illicit disch, River Bend, Seepage, high water, roots exposed	Minor	225.00	247.5	495.0	0
793	3.5	10	350	1:1	Bank Eroding, River Bend, Sediment dropped, high water, toe stabilizing	Minor	765.6	842.2	1,684.4	0
795	2	8	10	2:1	Undercutting, high water, no toe; tree at bank's edge; large cottonwood; could create obstruction when it falls in	Minor	10.0	11.0	22.0	0
796	35	10	145	2:1	Bank Eroding, Toe Unstable, Trampled, Undercutting, Foot Traffic, high water, patchy toe stabilization; roots exposed	Minor	317.2	348.9	697.8	0
798	2	10	150	1:1	Bank Eroding, Undercutting, outside of river bend; high water, roots exposed; toe stabilizing; trees leaning in	Minor	187.5	206.3	412.5	0
799	1.5	12	20	2:1	Bank Eroding, Toe Stable, high water	Minor	22.5	24.8	49.5	0
800	3	8	45	1:1	Undercutting, high water, toe stabilizing in	Minor	67.5	74.3	148.5	0

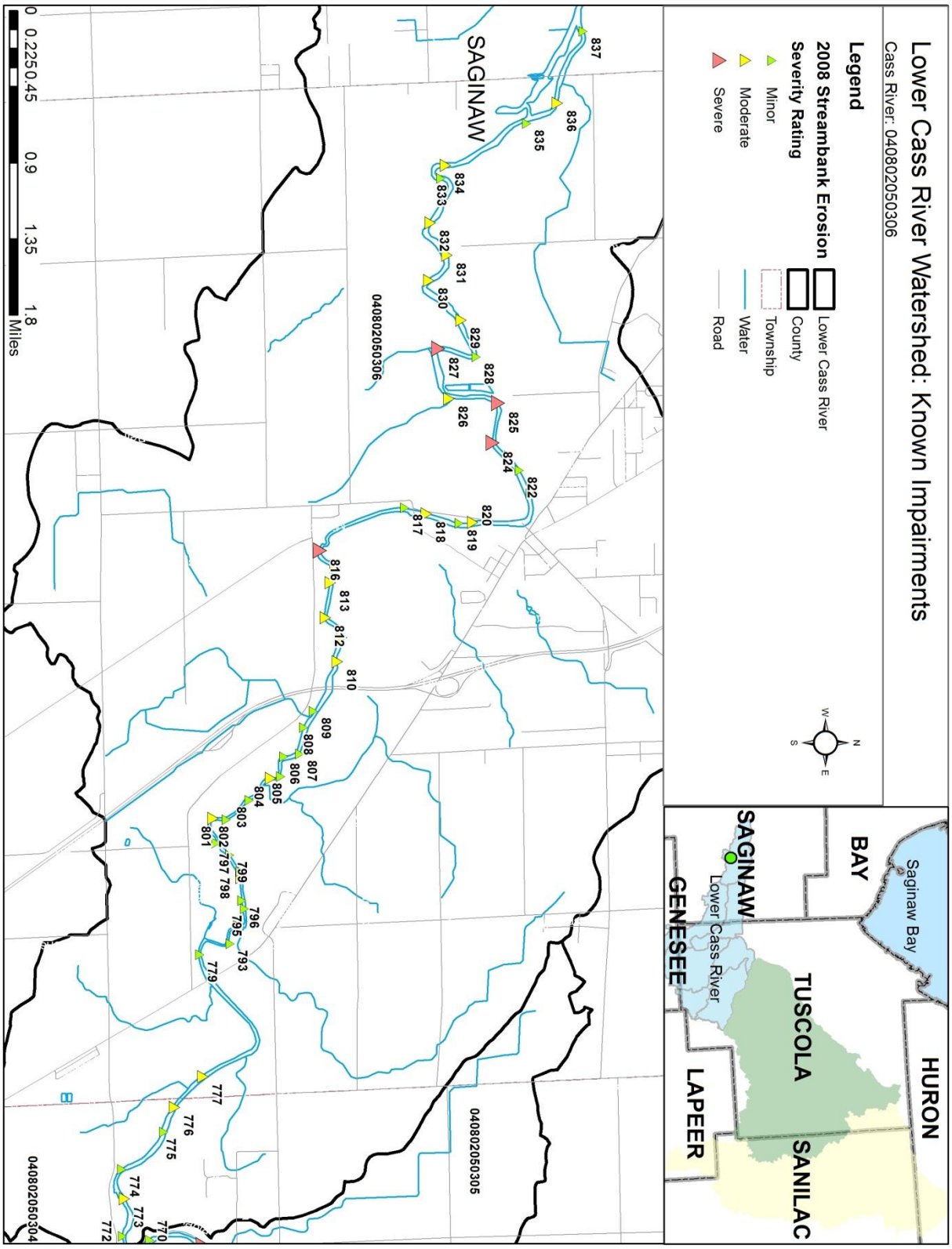
Site ID	Average Depth (ft)	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes, Additional Comments	Rating Chart	Sediment load (tons/yr)	Est P Load (lbs/yr)	Est N Load (lbs/yr)	Load Reduction %
					one area; roots exposed					
802	2	7	280	2:1	Bank Eroding, Undercutting, River Bend, high water, toe stabilizing; trees falling in	Minor	245.0	269.5	539.0	0
803	2	7-8	120	2:1	Bank Eroding, Toe Unstable, high water, toe stabilizing in some areas; roots exposed	Minor	112.5	123.8	247.5	0
805	4	8	70	1:1	Toe Unstable, river bend - cut bank, roots exposed	Minor	140.0	154.0	308.0	0
806	3	10	150	2:1	Bank Eroding, high water; river bend outside	Minor	281.3	309.4	618.8	0
807	2	8-10	200	1:1	Bank Eroding, River Bend, high water, toe stabilizing; roots exposed	Minor	225.0	247.5	495.0	0
808	2	7	100	1:1	Bank Eroding, Toe Unstable, Undercutting, Sediment Dropped, high water, toe stabilizing in one area; roots exposed	Minor	87.5	96.3	192.5	0
809	3	10	160	1:1	Bank Eroding, Toe Unstable, Undercutting, high water, tree roots exposed	Minor	300.0	330.0	660.0	0
817	3	15-20	65	1:1	Bank Eroding, Toe Unstable, R.R. tracks above bank	Minor	213.3	234.6	469.2	0
819	2	6-7	30	2:1	Toe Unstable, Undercutting, high water, tree roots exposed	Minor	24.4	26.8	53.6	0
821	2.5	8-10	150	1:1	Tiles, Sediment Dropped, toe stabilizing; runoff; mowed to edge above bank; several drains (tiles) in bank	Minor	210.9	232.0	464.1	0
822	2.5	6	120	1:1	Bank Eroding, Sediment Dropped, high water toe stabilizing	Minor	112.5	123.8	247.5	0

Site ID	Average Depth (ft)	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes, Additional Comments	Rating Chart	Sediment load (tons/yr)	Est P Load (lbs/yr)	Est N Load (lbs/yr)	Load Reduction %
823	4.5-5	6	120	1:1	Bank Eroding, Undercutting, Sediment Dropped, high water, toe stabilizing in some areas; roots exposed; log jams may be creating diverted movement of water	Minor	213.8	235.1	470.3	0
828	3	10	130	2:1	Bank Eroding, Agric Runoff, Tiles, River Bend, Sediment Dropped, high water, several spots of agricultural run-off; sharp river bend; storm run-off; trees leaning in; tiled above; stabilized with large cement chunk in one area	Minor	243.8	268.1	536.3	0
833	1.5	5	230	2:1	Bank Eroding, River Bend, Sediment Dropped, high water, patchy toe stabilization; storm run-off	Minor	107.8	118.6	237.2	0
776	2-5	10-12	50	1:1	Bank Eroding, Toe Unstable, Trampled from Foot Traffic, Sediment Dropped, high water; pool formed by dead, fallen trees	Moderate	98.4	108.3	216.6	100
777	<1	8	55	1:1	Bank Eroding, Toe Stable, high water, roots exposed; large bed of L. Tail growing in front	Moderate	27.5	30.3	60.5	100
794	3	12	100	1:1	Bank Eroding, Toe Unstable, River Bend, Sediment Dropped, high water, roots exposed; river meanders	Moderate	225.0	247.5	495.0	100
797	3	7	100	1:1	Bank Eroding, Toe Unstable, Undercutting, River Bend, high water, roots exposed; trees leaning in	Moderate	131.3	144.4	288.8	100
801	4	5-7	250	2:1	Bank Eroding, Toe Unstable, Undercutting, Sediment Dropped, high water; river bend outside – cutbank, roots exposed	Moderate	375.0	412.5	825.0	100

Site ID	Average Depth (ft)	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes, Additional Comments	Rating Chart	Sediment load (tons/yr)	Est P Load (lbs/yr)	Est N Load (lbs/yr)	Load Reduction %
804	3	8	120	1:1	Bank Eroding, Toe Unstable, Undercutting , high water; river bend - cut bank, roots exposed	Moderate	180.0	198.0	396.0	100
810	2	7	90	1:1	Bank Eroding, Toe Unstable, high water; river bend due to sediment and partial log jam SNWR property	Moderate	78.8	86.6	173.3	100
811	2	8	250	2:1	Bank Eroding, Toe Unstable, Undercutting, many log jams affecting water flow; beginning of river bend, roots exposed; trees leaning in; right bank - 30 ft	Moderate	250.0	275.0	550.0	100
812	4	15	350	1:1	Bank Eroding, Toe Unstable, Buffer Absent, River Bend, high water; mowed to edge run-off; mowed to edge; residence; trees leaning in	Moderate	1,312.5	1,443.8	2,887.5	100
813	3	8	100	1:1	Bank Eroding, Toe Unstable, Undercutting, Sediment Dropped, high water trees leaning in; left bank - 65 ft	Moderate	150.0	165.0	330.0	100
815	4.5	8-10	160	2:1	Bank Eroding, Toe Unstable, high water; river bend - cut bank, roots exposed	Moderate	405.0	445.5	891.0	100
818	1.5	8	200	1:1	Bank Eroding, Undercutting, Seepage, high water, toe stabilizing	Moderate	150.0	165.0	330.0	100
820	3	7	40	1:1	Bank Eroding, Toe Unstable, Sediment Dropped, high water, roots exposed; tree leaning in	Moderate	52.5	57.8	115.5	100

Site ID	Average Depth (ft)	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes, Additional Comments	Rating Chart	Sediment load (tons/yr)	Est P Load (lbs/yr)	Est N Load (lbs/yr)	Load Reduction %
826	2	6	1000	1:1	Bank Eroding, Toe Unstable, River Bend, high water, roots exposed; trees leaning in; drain/creek comes out here	Moderate	750.0	825.0	1,650.0	100
829	2.5-3	8-10	160	1:1	Bank Eroding, Toe Unstable, Agric Runoff, River Bend, Obstruction, high water; toe stabilizing in areas; possible seepage; log jam deflecting water; cleared area above bank; powerlines visible	Moderate	247.5	272.3	544.5	100
830	3	12	60	1:1	Bank Eroding, Toe Unstable, River Bend, high water	Moderate	135.0	148.5	297.0	100
831	2.5	12	80	1:1	Bank Eroding, Toe Unstable, Agric Runoff, River Bend, Sediment Dropped, high water	Moderate	150.0	165.0	330.0	100
832	4.5	3-5	230	1:1	Bank Eroding, Toe Unstable, Undercutting, River Bend, high water, trees leaning in	Moderate	258.8	284.6	569.3	100
816	3	35	65	1:1	Bank Eroding, Toe Unstable, River Bend, Sediment Dropped, high water, upper and lower bank eroding	Severe	426.6	469.2	938.4	100
824	3	6	200	1:1	Bank Eroding, Toe Unstable, Undercutting, River Bend, Sediment Dropped, high water, roots exposed	Severe	225.0	247.5	495.0	100
825	3.5	6	1000	1:1	Toe Unstable, Undercutting, River Bend, high water, patchy toe stabilization	Severe	1,312.5	1,443.8	2,887.5	100
827	4.5	7	300	1:1	Bank Eroding, Toe Unstable, Undercutting, River Bend, Sediment Dropped, Seepage, high water roots exposed	Severe	590.6	649.7	1,299.4	100

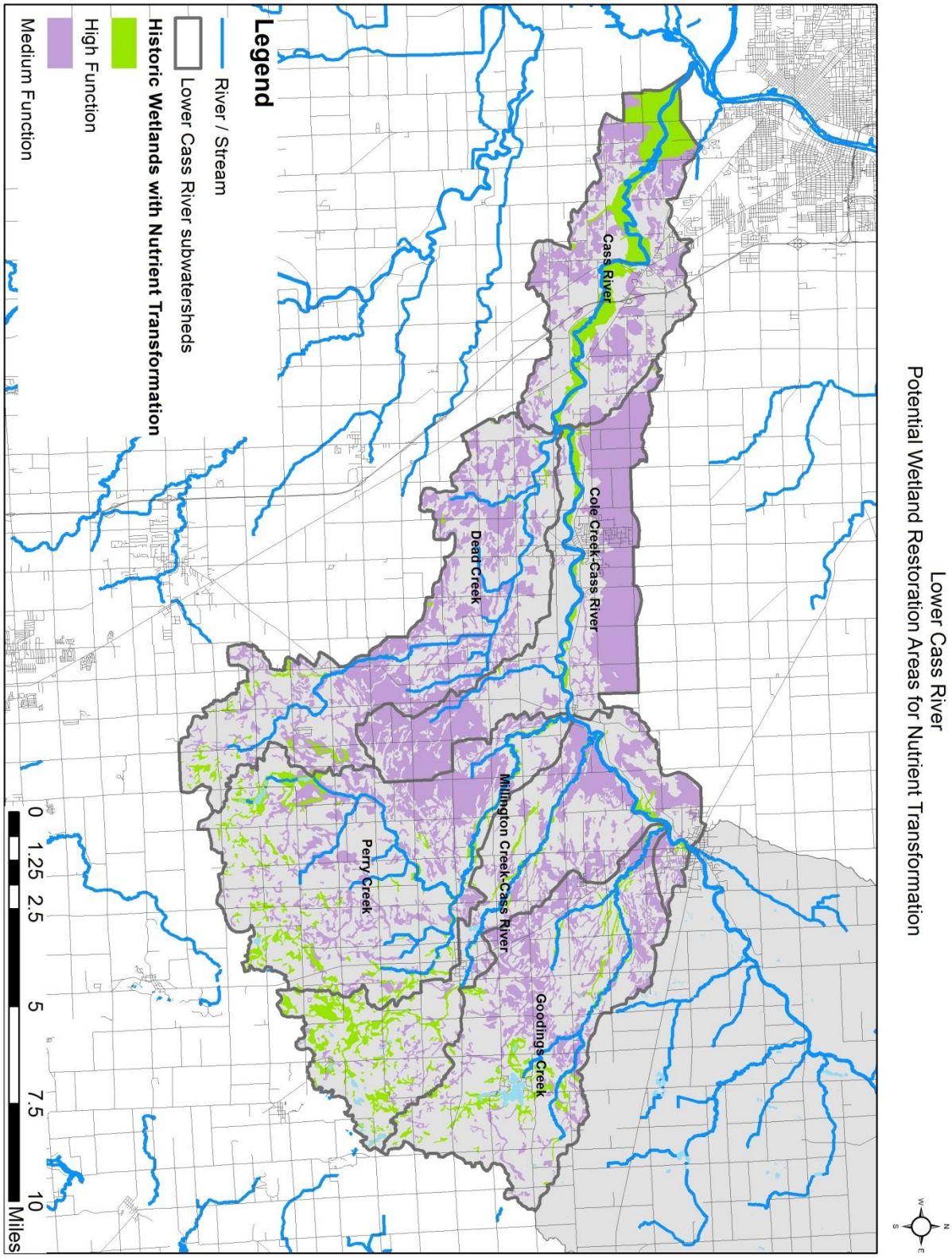
Figure 9.6 Cass River Streambank Erosion Sites



Priority 3: Wetland Restoration

Wetland restoration in the Lower Cass River was identified as a priority in the Landscape Level Wetland Functionality Assessment performed by the MDEQ and as a priority in the draft 2013 TMDL for nutrient reduction. Over 90% of wetlands have been removed in the Lower Cass River; the LLWFA tool can be used to identify potential sites for restoration. The LLFWA was used to create Figure 9.7 that shows areas where wetlands were historically present and had the function of transferring nutrients. The map of historic wetlands is only a representation of potential restoration areas. Field verification is necessary to determine that current land use permits the practice of wetland restoration.

Figure 9.7 Historic Wetland Sites with Nutrient Transformation Function



Priority 4: Cropland Runoff

Inventory

Sites were identified during the 2011 field inventory in the Dead Creek and Cole Creek subwatersheds that employed conventional tilling methods and had minimal field residue, below is a summary by HUC-12 Code (Table 9.10).

Table 9.10 Summary of sites identified for Agricultural Best Management Practices

HUC Name	HUC-12 CODE	Total HUC-12 Acres	Known Sites	Total Acreage of known sites	Supporting Tables and Maps
Dead Creek	402050304	21,462	230	8,600	Figure 9.8 Figure 9.9 Table 9. 12 Table 9.13 Table 9.14
Cole Creek	402050305	15,899	126	5,675	Figure 9.10 Figure 9.11 Table 9. 15 Table 9.16 Table 9.17

Loading Estimate Methodology

The STEPL model was used to calculate the total contribution of nitrogen load in pounds per year, phosphorous load in pounds per year, biological oxygen demand in pounds per year, and sediment in tons per year for known acreage of problem sites.

The HIT Model was used to calculate a subwatershed cost-benefit comparison for three practices based on the assumption of the worst 5% and/or 10% total agricultural area be put into mulch-till, no-till and 30-feet grass buffers.

Summary Tables and Map

A series of tables and figures follows for each of the subwatersheds that were inventoried during the 2011 windshield survey.

Dead Creek

A total of 230 sites totaling 8,600 acres were identified in the Dead Creek subwatershed that have attributes that can contribute to agricultural nonpoint source runoff, these attributes include conventional tillage and less than 25% crop residue on the field. These sites are described in Table 9.11 and mapped in Figures 9.8 and 9.9. Table 9.12 provides pollutant loads estimates and Table 9.13 provides an estimation of pollutant reduction and a cost benefit analysis.

Cole Creek

A total of 126 sites totaling 5,675 acres were identified in the Cole Creek subwatershed that have attributes that can contribute to agricultural nonpoint source runoff, these attributes include conventional tillage and less than 25% crop residue on the field. These sites are described in Table 9.14 and mapped in Figures 9.10 and 9.11. Table 9.15 provides pollutant loads estimates and Table 9.16 provides an estimation of pollutant reduction and a cost benefit analysis.

Table 9.11 Dead Creek Priority Sources of Agricultural NPS

Label	Township	Lat	Long	Field Size Acres	Field Orientation	Slope of land	Residue Type	Percent Residue
315	Birch Run	43.307110	-83.799030	14	N/S	Flat		0-25%
316	Birch Run	43.307140	-83.800920	20	N/S	Flat	Corn	0-25%
317	Birch Run	43.307080	-83.802150	5	N/S	Flat		0-25%
318	Birch Run	43.307080	-83.804250	5	N/S	Flat		0-25%
319	Birch Run	43.301290	-83.794320	10	E/W	Flat	Corn	0-25%
320	Frankenmuth	43.307090	-83.763640	0	N/S	Flat		0-25%
321	Frankenmuth	43.321700	-83.773490	120	N/S	Flat	Corn	0-25%
322	Frankenmuth	43.320710	-83.771390	20	N/S	Flat	Sugar Beet	0-25%
323	Frankenmuth	43.321720	-83.767300	55	N/S	Flat	Bean	0-25%
324	Frankenmuth	43.321810	-83.759230	100	E/W	Flat	Bean	0-25%
325	Frankenmuth	43.321710	-83.791650	40	N/S	Mod	Bean	0-25%
326	Frankenmuth	43.321760	-83.763300	100	N/S	Flat	Corn	0-25%
327	Frankenmuth	43.321810	-83.759230	100	E/W	Flat	Bean	0-25%
328	Frankenmuth	43.321810	-83.759230	100	E/W	Flat	Bean	0-25%
329	Frankenmuth	43.321760	-83.763300	100	N/S	Flat	Corn	0-25%
330	Frankenmuth	43.321710	-83.791650	40	N/S	Mod	Bean	0-25%
331	Frankenmuth	43.321810	-83.759230	100	E/W	Flat	Bean	0-25%
332	Frankenmuth	43.321720	-83.767300	55	N/S	Flat	Bean	0-25%
333	Frankenmuth	43.321710	-83.771390	40	N/S	Mod	Bean	0-25%
334	Frankenmuth	43.321700	-83.773490	120	N/S	Flat	Corn	0-25%
335	Thetford	43.190550	-83.640510	40	E/W	Flat	Corn	0-25%
336	Thetford	43.190830	-83.620670	30	E/W	Flat	Bean	0-25%
337	Thetford	43.179938	-83.626170	100	N/S	Mod	Bean	0-25%
338	Thetford	43.201610	-83.640910	50		Mod	Corn	0-25%
339	Thetford	43.221620	-83.675020	100	N/S	Flat		0-25%

Label	Township	Lat	Long	Field Size Acres	Field Orientation	Slope of land	Residue Type	Percent Residue
340	Thetford	43.210180	-83.681120	30	N/S	Flat	Wheat	0-25%
341	Thetford	43.208190	-83.656020	20	E/W	Mod	Corn	0-25%
342	Thetford	43.211550	-83.661210	120	E/W	Mod	Bean	0-25%
343	Thetford	43.221880	-83.653520	80	N/S	Flat	Bean	0-25%
344	Thetford	43.220840	-83.641070	80	E/W	Hilly	Bean	0-25%
345	Arbela	4792873.0	283946.00	30		Flat	Bean	0 - 25%
346	Arbela	4794265.0	283963.00	80		Flat	Corn	0 - 25%
347	Arbela	4795428.0	283115.00	80		Flat	Corn	0 - 25%
348	Arbela	4793786.0	284428.00	60		Flat	Wheat	0 - 25%
349	Arbela	4794212.0	283961.00	20		Flat	Bean	0 - 25%
350	Arbela	4793826.0	282182.00	30		Flat	Corn	0 - 25%
351	Arbela	4793811.0	282925.00	30		Flat	Corn	0 - 25%
352	Arbela	4795444.0	283171.00	80		Flat	Bean	0 - 25%
353	Arbela	4795426.0	283257.00	80		Flat	Corn	0 - 25%
354	Arbela	4794903.0	283962.00	80		Flat	Corn	0 - 25%
355	Arbela	4791602.0	283947.00	30		Flat	Corn	0 - 25%
356	Arbela	4792194.0	281986.00	30		Flat	Bean	0 - 25%
357	Arbela	4788898.0	282947.00	30		Flat	Bean	0 - 25%
358	Arbela	4794265.0	283963.00	60		Flat	Corn	0 - 25%
359	Arbela	4789048.0	285527.00	20		Flat	Corn	0 - 25%
360	Arbela	4788847.0	285984.00	80		Flat	Corn	0 - 25%
361	Arbela	4789324.0	286344.00	80		Flat	Corn	0 - 25%
362	Birch Run	43.278940	-83.747990	40	E-W	Flat	0	0 - 25%
363	Birch Run	43.293220	-83.745670	20	N-S	Flat	Corn	0 - 25%
364	Birch Run	43.290540	-83.754670	80	N-S	Flat	0	0 - 25%
365	Birch Run	43.284350	-83.754830	40	E-W	Flat	Corn	0 - 25%

Label	Township	Lat	Long	Field Size Acres	Field Orientation	Slope of land	Residue Type	Percent Residue
366	Birch Run	43.278880	-83.755020	15	N-S	Flat	0	0 - 25%
367	Birch Run	43.293070	-83.738810	40	N-S	Flat	Corn	0 - 25%
368	Birch Run	43.278870	-83.713310	10	E-W	Flat	0	0 - 25%
369	Birch Run	43.279210	-83.697380	40	N-S	Flat	0	0 - 25%
370	Birch Run	43.279210	-83.697380	40	N-S	Flat	0	0 - 25%
371	Birch Run	43.273590	-83.695670	20	N-S	Flat	Corn	0 - 25%
372	Birch Run	43.267370	-83.695790	50	E-W	Flat	0	0 - 25%
373	Birch Run	43.295120	-83.707650	100	N-S	Flat	0	0 - 25%
374	Birch Run	43.293690	-83.698410	100	N-S	Flat	0	0 - 25%
375	Birch Run	43.285000	-83.754920	40	E-W	Flat	Corn	0 - 25%
376	Birch Run	43.280130	-83.755160	80	E-W	Mod	Corn	0 - 25%
377	Birch Run	43.285000	-83.754920	40	E-W	Flat	Corn	0 - 25%
378	Birch Run	43.293280	-83.757990	160	N-S	Flat	Corn	0 - 25%
379	Birch Run	43.293180	-83.762030	10	N-S	Flat	Corn	0 - 25%
380	Birch Run	43.293140	-83.764650	40	N-S	Flat	0	0 - 25%
381	Birch Run	43.293310	-83.770500	40	N-S	Flat	0	0 - 25%
382	Birch Run	43.301550	-83.714060	40	E-W	Flat	Corn	0 - 25%
383	Birch Run	43.273280	-83.713390	20	N-S	Flat	0	0 - 25%
384	Birch Run	43.293310	-83.711390	40	N-S	Flat	0	0 - 25%
385	Birch Run	43.293470	-83.704730	100	N-S	Flat	Corn	0 - 25%
386	Birch Run	43.297000	-83.695570	80	N-S	Flat	0	0 - 25%
387	Birch Run	43.303360	-83.695420	20	E-W	Flat	0	0 - 25%
388	Birch Run	43.306860	-83.698270	60	N-S	Flat	0	0 - 25%
389	Birch Run	43.306900	-83.702130	40	N-S	Flat	Corn	0 - 25%
390	Birch Run	43.299970	-83.735410	40	E-W	Flat	0	0 - 25%
391	Birch Run	43.293110	-83.708720	40	N-S	Flat	0	0 - 25%

Label	Township	Lat	Long	Field Size Acres	Field Orientation	Slope of land	Residue Type	Percent Residue
392	Birch Run	43.293860	-83.715310	80	E-W	Flat	0	0 - 25%
393	Birch Run	43.296000	-83.715080	10	E-W	Flat	Corn	0 - 25%
394	Birch Run	43.299230	-83.714890	10	E-W	Flat	Corn	0 - 25%
395	Birch Run	43.303050	-83.714720	40	N-S	Flat	0	0 - 25%
396	Birch Run	43.306890	-83.718290	30	E-W	Flat	0	0 - 25%
397	Birch Run	43.306740	-83.726450	80	E-W	Flat	0	0 - 25%
398	Birch Run	43.293070	-83.738830	40	N-S	Flat	Corn	0 - 25%
399	Birch Run	43.293390	-83.753260	20	N-S	Flat	0	0 - 25%
400	Birch Run	43.302220	-83.754630	80	E-W	Flat	0	0 - 25%
401	Birch Run	43.307290	-83.740080	80	N-S	Flat	Corn	0 - 25%
402	Birch Run	43.302310	-83.735410	40	N-S	Flat	0	0 - 25%
403	Birch Run	43.278860	-83.721340	30	N-S	Flat	0	0 - 25%
404	Birch Run	43.283040	-83.715340	40	E-W	Flat	Corn	0 - 25%
405	Birch Run	43.285260	-83.715400	50	E-W	Flat	Corn	0 - 25%
406	Birch Run	43.286530	-83.715410	40	E-W	Flat	0	0 - 25%
407	Birch Run	43.290230	-83.715350	20	N-S	Flat	Corn	0 - 25%
408	Birch Run	43.293190	-83.715460	40	N-S	Flat	0	0 - 25%
409	Birch Run	43.293040	-83.732650	80	E-W	Flat	0	0 - 25%
410	Birch Run	43.293070	-83.728410	40	N-S	Flat	Corn	0 - 25%
411	Birch Run	43.293120	-83.723340	40	N-S	Flat	0	0 - 25%
412	Birch Run	43.293160	-83.719810	40	N-S	Flat	0	0 - 25%
413	Birch Run	43.291150	-83.715310	30	E-W	Flat	Corn	0 - 25%
414	Birch Run	43.290850	-83.715350	30	E-W	Flat	0	0 - 25%
415	Birch Run	43.288470	-83.715460	0	E-W	Flat	0	0 - 25%
416	Birch Run	43.284350	-83.715570	40	E-W	Flat	Corn	0 - 25%
417	Birch Run	43.279090	-83.700190	30	N-S	Flat	0	0 - 25%

Label	Township	Lat	Long	Field Size Acres	Field Orientation	Slope of land	Residue Type	Percent Residue
418	Birch Run	43.286340	-83.702100	80	E-W	Flat	0	0 - 25%
419	Birch Run	43.286490	-83.697390	80	E-W	Flat	Corn	0 - 25%
420	Birch Run	43.291530	-83.754630	81	E-W	Flat	0	0 - 25%
421	Birch Run	43.301310	-83.754590	40	E-W	Flat	Corn	0 - 25%
422	Birch Run	43.303060	-83.754580	30	E-W	Flat	0	0 - 25%
423	Birch Run	43.303790	-83.754570	40	E-W	Flat	0	0 - 25%
424	Birch Run	43.307080	-83.756420	40	N-S	Flat	0	0 - 25%
425	Birch Run	43.307130	-83.762990	20	N-S	Flat	Corn	0 - 25%
426	Birch Run	43.273370	-83.769240	20	N-S	Flat	0	0 - 25%
427	Frankenmuth	43.319420	-83.729870	12	N-S	Flat	-99	0 - 25%
428	Frankenmuth	43.317540	-83.715250	25	N-S	Flat	Corn	0 - 25%
429	Birch Run	43.306890	-83.717830	30	E-W	Flat	0	0 - 25%
430	Frankenmuth	43.306870	-83.721370	37	N-S	Flat	0	0 - 25%
431	Frankenmuth	43.306990	-83.723590	40	N-S	Flat	-99	0 - 25%
432	Frankenmuth	43.308920	-83.740430	30	E-W	Flat	-99	0 - 25%
433	Frankenmuth	43.314330	-83.740340	12	N-S	Flat	Corn	0 - 25%
434	Frankenmuth	43.311800	-83.736460	2	N-S	Flat	-99	0 - 25%
435	Frankenmuth	43.318500	-83.736600	25	N-S	Flat	-99	0 - 25%
436	Frankenmuth	43.308960	-83.754550	24	E-W	Flat	0	0 - 25%
437	Frankenmuth	43.307340	-83.744850	15	N-S	Flat	0	0 - 25%
438	Frankenmuth	43.306960	-83.743650	10	N-S	Flat	Corn	-99
439	Frankenmuth	43.309830	-83.740560	25	N-S	Flat	0	0 - 25%
440	Frankenmuth	43.313160	-83.740550	7	E-W	Flat	Corn	0 - 25%
441	Frankenmuth	43.314370	-83.754360	30	E-W	Flat	0	0 - 25%
442	Frankenmuth	43.317830	-83.754590	50	N-S	Mod	Corn	0 - 25%
443	Birch Run	43.284840	-83.774310	3	E-W	Flat	-99	0 - 25%

Label	Township	Lat	Long	Field Size Acres	Field Orientation	Slope of land	Residue Type	Percent Residue
444	Birch Run	43.293290	-83.770370	25	N-S	Mod	-99	0 - 25%
445	Birch Run	43.290550	-83.754690	150	N-S	Flat	-99	0 - 25%
446	Birch Run	43.301290	-83.794320	10	E-W	Flat	Corn	0 - 25%
447	Birch Run	43.305080	-83.794350	20	N-S	Flat	-99	0 - 25%
448	Birch Run	43.291680	-83.794230	9	N-S	Flat	-99	0 - 25%
449	Birch Run	43.293370	-83.790800	7	N-S	Flat	-99	0 - 25%
450	Birch Run	43.293400	-83.781850	30	E-W	Flat	-99	0 - 25%
451	Birch Run	43.293390	-83.781000	20	N-S	Flat	0	0 - 25%
452	Birch Run	43.288440	-83.774380	70	E-W	Flat	Corn	0 - 25%
453	Birch Run	43.284470	-83.774330	12	none - site is a pasture	Flat	-99	0 - 25%
454	Frankenmuth	43.315620	-83.715180	15	E-W	Mod	Corn	0 - 25%
455	Birch Run	43.307080	-83.784450	40	N-S	Flat	0	0 - 25%
456	Frankenmuth	43.306800	-83.696720	38	N-S	Flat	-99	0 - 25%
457	Birch Run	43.306890	-83.697750	30	E-W	Flat	0	0 - 25%
458	Birch Run	43.306900	-83.701510	40	N-S	Flat	Corn	0 - 25%
459	Birch Run	43.306890	-83.704280	30	E-W	Flat	0	0 - 25%
460	Frankenmuth	43.306930	-83.709630	35	E-W	Flat	-99	-99
461	Frankenmuth	43.309060	-83.715070	20		Flat	-99	-99
462	Frankenmuth	43.311590	-83.715130	35	E-W	Flat	-99	-99
463	Birch Run	43.303730	-83.794300	70	N-S	Flat	Corn	0 - 25%
464	Birch Run	43.300540	-83.792870	10	N-S	Flat	-99	0 - 25%
465	Birch Run	43.297230	-83.794230	3	none--grass covered field	Flat	-99	0 - 25%
466	Birch Run	43.305130	-83.774370	55	E-W	Flat	-99	0 - 25%
467	Birch Run	43.306660	-83.774410	3	E-W	Flat	-99	0 - 25%
468	Birch Run	43.293290	-83.761050	25	N-S	Mod	-99	0 - 25%

Label	Township	Lat	Long	Field Size Acres	Field Orientation	Slope of land	Residue Type	Percent Residue
469	Birch Run	43.293140	-83.764340	40	N-S	Flat	0	0 - 25%
470	Birch Run	43.293250	-83.767450	17	N-S	Flat	-99	0 - 25%
471	Birch Run	43.300590	-83.773070	10	N-S	Flat	Corn	0 - 25%
472	Birch Run	43.300580	-83.769840	5	N-S	Flat	-99	0 - 25%
473	Birch Run	43.300610	-83.763180	20	N-S	Flat	-99	0 - 25%
474	Birch Run	43.293330	-83.758220	10	N-S	Flat	-99	0 - 25%
475	Birch Run	43.307050	-83.759720	10	N-S	Flat	-99	0 - 25%
476	Frankenmuth	43.307090	-83.756730	10	N-S	Flat	-99	0 - 25%
477	Frankenmuth	43.314460	-83.767780	14	N-S	Flat	-99	76% +
478	Frankenmuth	43.313630	-83.754620	8	N-S	Flat	Corn	0 - 25%
479	Frankenmuth	43.314210	-83.762660	40	N-S	Flat	-99	0 - 25%
480	Frankenmuth	43.313770	-83.754630	6	N-S	Flat	Corn	0 - 25%
481	Frankenmuth	43.314440	-83.768880	10	N-S	Flat	-99	0 - 25%
482	Frankenmuth	43.307150	-83.774990	0		Flat	Corn	0 - 25%
483	Frankenmuth	43.307160	-83.770770	60	N-S	Flat	-99	0 - 25%
484	Frankenmuth	43.321610	-83.769790	10	E-W	Flat	-99	0 - 25%
485	Frankenmuth	43.321510	-83.766370	14	E-W	Flat	-99	0 - 25%
486	Frankenmuth	43.318120	-83.754680	70	N-S	Flat	-99	0 - 25%
487	Birch Run	43.307130	-83.786380	20	N-S	Flat	Corn	0 - 25%
488	Frankenmuth	43.307150	-83.781130	0		Flat	Corn	0 - 25%
489	Frankenmuth	43.316550	-83.775860	7	E-W	Flat	Corn	0 - 25%
490	Frankenmuth	43.311750	-83.775780	15	E-W	Flat	Corn	0 - 25%
491	Frankenmuth	43.317210	-83.775820	1	E-W	Flat	-99	-99
492	Frankenmuth	43.309060	-83.795550	20		Flat	-99	-99
493	Frankenmuth	43.321670	-83.790310	40	N-S	Mod	Corn	0 - 25%
494	Frankenmuth	43.321670	-83.785390	40	N-S	Mod	Corn	0 - 25%

Label	Township	Lat	Long	Field Size Acres	Field Orientation	Slope of land	Residue Type	Percent Residue
495	Frankenmuth	43.321630	-83.781010	20	N-S	Mod	-99	-99
496	Frankenmuth	43.321670	-83.777040	40	N-S	Mod	Corn	0 - 25%
497	Frankenmuth	43.307220	-83.800250	30	N-S	Flat	-99	0 - 25%
498	Frankenmuth	43.307140	-83.797050	20	N-S	Mod	-99	0 - 25%
499	Frankenmuth	43.307190	-83.802260	15	none	-99	-99	0 - 25%
500	Frankenmuth	43.315720	-83.795750	7	N-S	Flat	-99	0 - 25%
501	Frankenmuth	43.311200	-83.795610	70	N-S	Flat	Corn	0 - 25%
502	Birch Run	43.305610	-83.695410	40	E-W	Mod	-99	0 - 25%
503	Birch Run	43.303030	-83.695430	8	E-W	Flat	-99	0 - 25%
504	Birch Run	43.298850	-83.695470	8	E-W	Mod	-99	0 - 25%
505	Birch Run	43.293700	-83.698100	40	E-W	Flat	-99	0 - 25%
506	Birch Run	43.293560	-83.700870	20	N-S	Mod	-99	0 - 25%
507	Birch Run	43.293470	-83.703600	100	N-S	Flat	Corn	0 - 25%
508	Birch Run	43.293380	-83.707080	45	E-W	Flat	Corn	0 - 25%
509	Birch Run	43.293270	-83.711570	10	N-S	Flat	Corn	0 - 25%
510	Birch Run	43.293220	-83.713690	20	N-S	Flat	Corn	0 - 25%
511	Birch Run	43.300930	-83.714740	30	N-S	Flat	Corn	0 - 25%
512	Birch Run	43.309390	-83.714520	30	unknown-dense soy bean plants	Flat	-99	0 - 25%
513	Birch Run	43.306900	-83.710170	40	N-S	Flat	Corn	0 - 25%
514	Birch Run	43.306840	-83.703070	15	E-W	Flat	-99	0 - 25%
515	Birch Run	43.306240	-83.714460	17	E-W	Flat	-99	0 - 25%
516	Birch Run	43.305130	-83.714580	55	E-W	Flat	-99	0 - 25%
517	Birch Run	43.303130	-83.714650	12	N-S	Flat	Corn	0 - 25%
518	Birch Run	43.300380	-83.716810	9	N-S	Flat	-99	0 - 25%
519	Birch Run	43.300380	-83.717900	9	N-S	Flat	-99	0 - 25%

Label	Township	Lat	Long	Field Size Acres	Field Orientation	Slope of land	Residue Type	Percent Residue
520	Birch Run	43.300360	-83.719230	12	N-S	Flat	Corn	0 - 25%
521	Birch Run	43.300350	-83.721850	5	N-S	Flat	-99	0 - 25%
522	Birch Run	43.300320	-83.724580	30	E-W	Flat	-99	-99
523	Birch Run	43.300240	-83.730810	10	N-S	Flat	-99	-99
524	Birch Run	43.300200	-83.733660	10	E-W	Flat	-99	0 - 25%
525	Birch Run	43.306900	-83.733040	40	N-S	Flat	Corn	0 - 25%
526	Birch Run	43.299670	-83.714850	10	E-W	Flat	Corn	0 - 25%
527	Birch Run	43.296390	-83.715030	12	E-W	Flat	-99	0 - 25%
528	Birch Run	43.295600	-83.715100	10	E-W	Flat	Corn	0 - 25%
529	Birch Run	43.294020	-83.715230	15	E-W	Flat	-99	0 - 25%
530	Birch Run	43.293140	-83.722560	40	N-S	Flat	0	0 - 25%
531	Birch Run	43.300250	-83.727600	12	E-W	Flat	-99	0 - 25%
532	Birch Run	43.300320	-83.722490	30	E-W	Flat	-99	-99
533	Birch Run	43.300330	-83.741330	23	N-S	Flat	Corn	0 - 25%
534	Birch Run	43.305180	-83.754570	95	E-W	Flat	Corn	0 - 25%
535	Birch Run	43.300560	-83.752510	15	E-W	Flat	-99	0 - 25%
536	Birch Run	43.293120	-83.738360	40	N-S	Flat	0	0 - 25%
537	Birch Run	43.293450	-83.753570	8	N-S	Flat	Corn	0 - 25%
538	Birch Run	43.305600	-83.754650	15	N-S	Flat	-99	0 - 25%
539	Birch Run	43.301770	-83.754650	18	E-W	Flat	-99	0 - 25%
540	Birch Run	43.301450	-83.754660	19	E-W	Flat	-99	0 - 25%
541	Birch Run	43.300620	-83.766050	25	N-S	Flat	Corn	0 - 25%
542	Birch Run	43.307070	-83.762340	15	N-S	Flat	-99	0 - 25%
543	Birch Run	43.307050	-83.759720	10	N-S	Flat	-99	0 - 25%
544	Birch Run	43.306090	-83.794330	25	E-W	Flat	Corn	0 - 25%

Figure 9.8 Dead Creek, Priority Sources of Agricultural NPS in Tuscola County

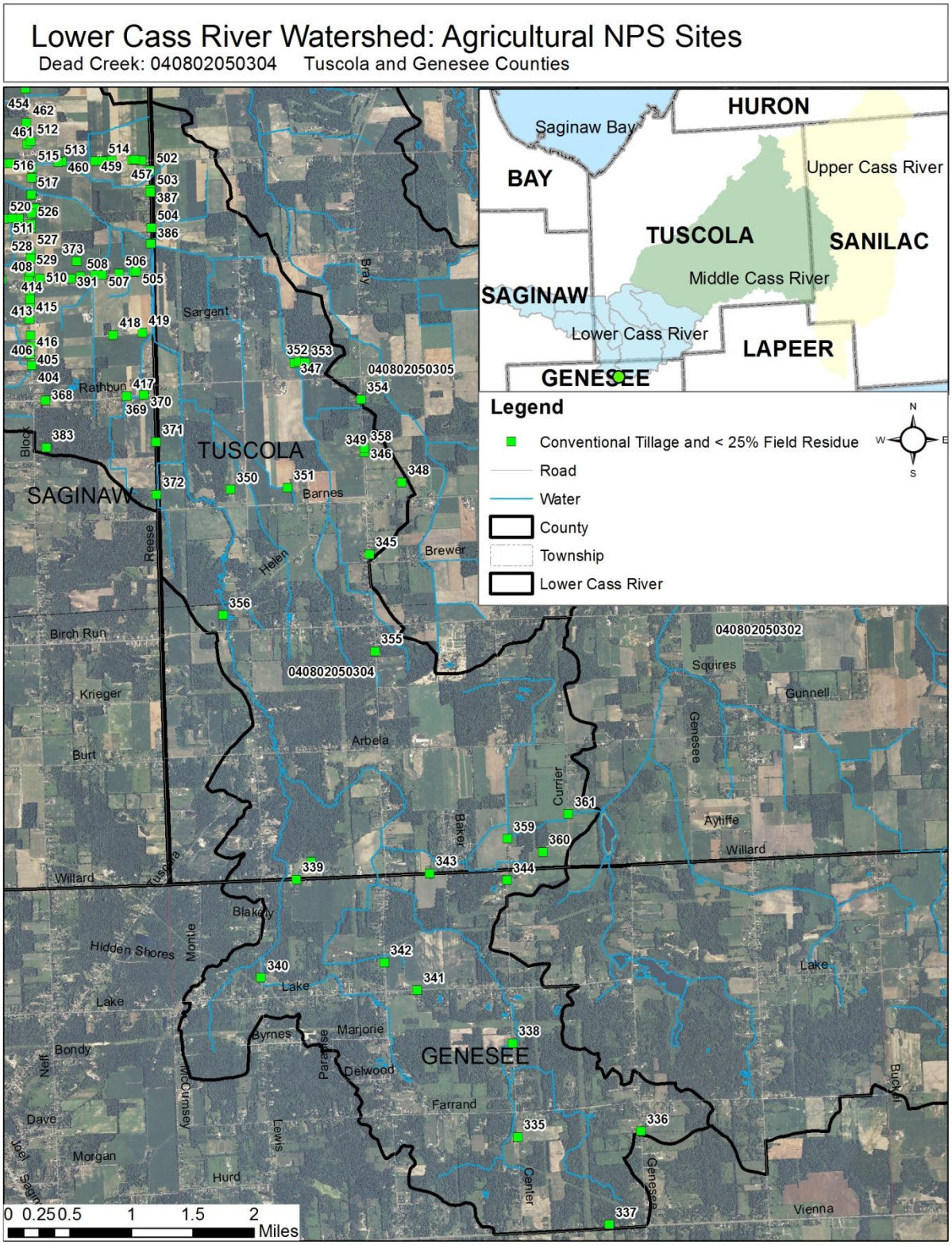
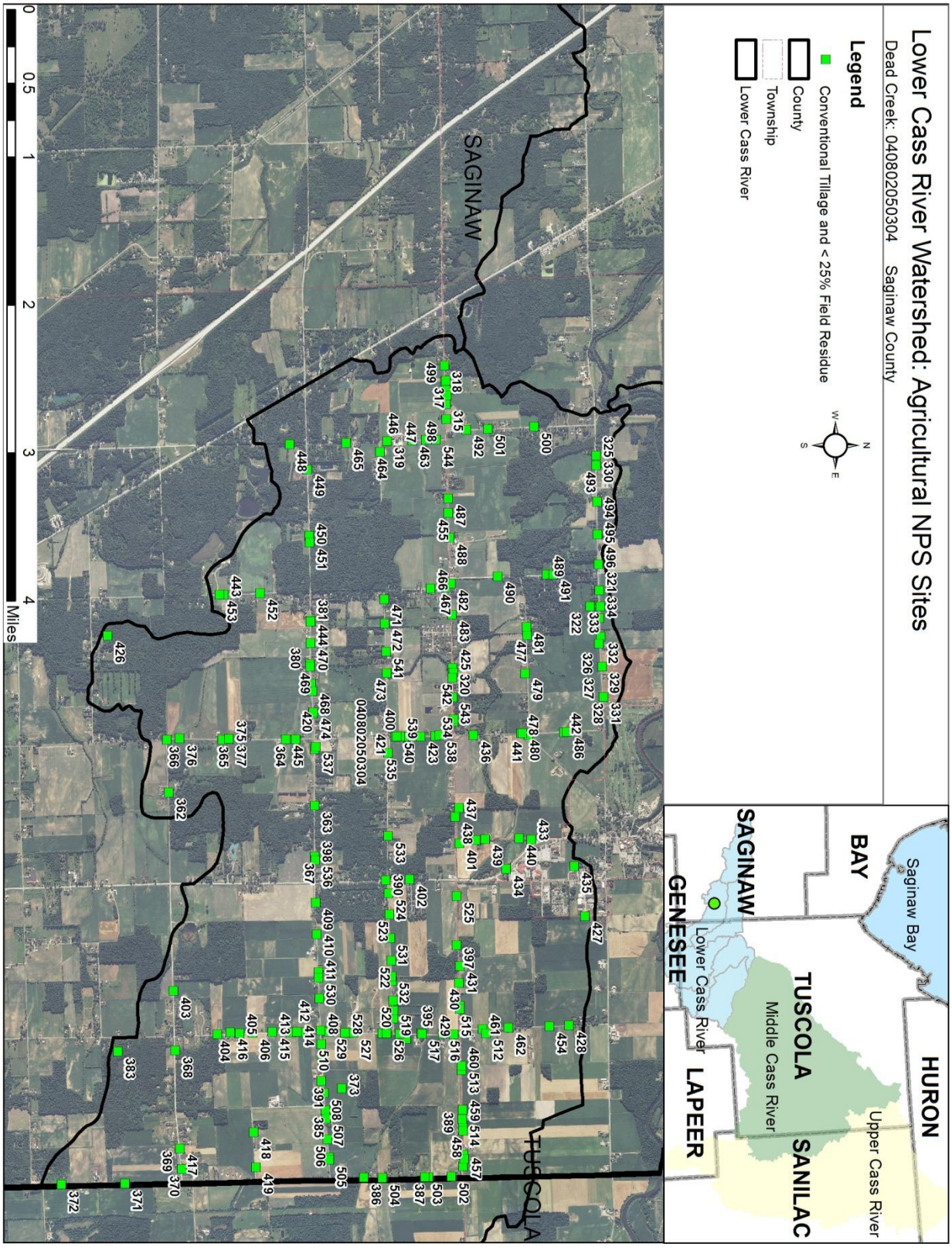


Figure 9.9 Dead Creek, Priority Sites of Agricultural NPS in Saginaw County



Pollutant loading reductions were estimated for nitrogen (N), phosphorus (P), biological oxygen demand (BOD), and sediment for each site utilizing the STEPL Model, results are shown below in Table 9.12.

Table 9.12 Dead Creek, Pollutant loads and reductions, STEPL Model

Acres of Cropland	N Load (no BMP) (lb/yr)	P Load (no BMP) (lb/yr)	BOD Load (no BMP) (lb/yr)	Sediment Load (no BMP) (t/yr)
8,600 acres of known sites	54,827.1	6,935.1	64,614.4	1,386.7
	N Load (with BMP) (lb/yr)	**P Load (with BMP) (lb/yr)**	**BOD Load (with BMP) (lb/yr)**	**Sediment Load (with BMP) (t/yr)**
	32,976.7	3,051.2	57,186.0	226.0
	% N Reduction	**% P Reduction**	**% BOD Reduction**	**% Sed Reduction**
	39.9	56.0	11.5	83.7

Table 9.13 shows results from the HIT Model, developed by the Institute for Water Research at Michigan State University. The greatest sediment reduction can occur when no-till practices are placed on 10% of the most erosive areas in the Dead Creek subwatershed. The greatest return on investment is shown in the column titled 'BMP cost benefit' showing that no-till on the most erosive 5% of land will reduce sediment at a cost of $41 per ton as compared to $69 per ton for no-till on the most erosive 10% of land. Load reduction targets for sediment in the Dead Creek are aimed at reaching no-till on 5% of the subwatersheds area.

Table 9.13 Estimated Reductions in Pollutants for Dead Creek

Practice	Sediment Reduction (tons/yr)	BMP cost benefit ($/ton reduction)	Phosphorous Reduction (lbs/yr) / $/lb-P
mulch till on sediment for worst 5% (1,073 acres)	187	$115	159 / $135
mulch till on sediment for worst 10% (2,146 acres)	155	$69	132 / $81
No Till on sediment for worst 5% (1,073 acres)	362	$41	308 / $49
No Till on sediment for worst 10% (2,146 acres)	437	$69	371 / $81
sediment for 30ft grass buffer	394	$80	335 / $94

Table 9.14 Cole Creek Priority Sources of Agricultural NPS

Label	Township	UTM Y-coord	UTM X-coord	Field Size Acres	Field Orientation	Slope	Residue Type	Percent Residue
561	Arbela	4792144	284725	70	NR	Flat	Corn	0 - 25%
562	Arbela	4795412	284128	10	NR	Flat	Wheat	0 - 25%
563	Arbela	4795402	284514	100	NR	Flat	Corn	26 - 50%
564	Arbela	4795394	285051	60	NR	Flat	Bean	0 - 25%
565	Arbela	4796223	283992	0	NR	Flat	Wheat	-99
566	Arbela	4792604	285546	120	NR	Flat	Wheat	0 - 25%
567	Arbela	4792969	284791	60	NR	Flat	Wheat	0 - 25%
568	Arbela	4792144	284725	30	NR	Flat	Corn	0 - 25%
569	Arbela	4795349	285599	40	NR	Flat	Bean	0 - 25%
570	Arbela	4793762	285404	10	NR	Flat	Bean	0 - 25%
571	Arbela	4793774	285122	50	NR	Flat	Bean	0 - 25%
572	Arbela	4795351	285597	70	NR	Flat	Bean	0 - 25%
573	Arbela	4794961	285592	150	NR	Flat	Corn	0 - 25%
574	Arbela	4794437	285582	70	NR	Flat	Corn	0 - 25%
575	Arbela	4794075	285562	40	NR	Flat	Bean	0 - 25%
576	Arbela	4793755	286146	40	NR	Flat	Wheat	0 - 25%
577	Arbela	4793752	286165	80	NR	Flat	Bean	0 - 25%
578	Arbela	4793737	286625	5	NR	Flat	Corn	0 - 25%
579	Arbela	4793746	286779	40	NR	Flat	Corn	0 - 25%
580	Arbela	4797048	283459	60	NR	Flat	Bean	0 - 25%
581	Arbela	4797058	283197	80	NR	Flat	Bean	0 - 25%
582	Arbela	4795397	285118	80	NR	Flat	Wheat	0 - 25%
583	Tuscola	4797794	282417	10	NR	Mod	-99	76% +
584	Tuscola	4799425	282419	10	NR	Flat	Bean	0 - 25%
585	Tuscola	4799425	282419	10	NR	Flat	Bean	0 - 25%

Label	Township	UTM Y-coord	UTM X-coord	Field Size Acres	Field Orientation	Slope	Residue Type	Percent Residue
586	Tuscola	4798816	282443	30	NR	Flat	Corn	0 - 25%
587	Tuscola	4798784	282443	10	NR	Flat	Bean	0 - 25%
588	Tuscola	4799944	284656	10	NR	Flat	Bean	0 - 25%
589	Tuscola	4799956	284258	20	NR	Flat	Corn	0 - 25%
590	Tuscola	4799956	284258	20	NR	Flat	Corn	0 - 25%
591	Tuscola	4799196	281431	40	NR	Flat	Corn	26 - 50%
592	Tuscola	4798395	282145	60	NR	Flat	Bean	0 - 25%
593	Tuscola	4798383	282492	20	NR	Flat	Bean	0 - 25%
594	Tuscola	4798362	283245	10	NR	Flat	Bean	0 - 25%
595	Tuscola	4798359	283245	10	NR	Flat	Corn	0 - 25%
596	Tuscola	4798334	284337	40	NR	Flat	Bean	0 - 25%
597	Frankenmuth	-83.732940	43.321560	70	N/S	Flat	Bean	0-25%
598	Frankenmuth	-83.718890	43.321440	120	E/W	Mod	Wheat	0-25%
599	Frankenmuth	-83.727300	43.321560	70	N/S	Flat	Bean	0-25%
600	Frankenmuth	-83.721760	43.330280	40	E/W	Mod	Bean	0-25%
601	Frankenmuth	-83.758650	43.342630	70	N/S	Flat	Corn	0-25%
602	Frankenmuth	-83.758670	43.344910	70	E/W	Flat	Sugar Beat	0-25%
603	Frankenmuth	-83.798370	43.350350	20	E/W	Flat	Wheat	0-25%
604	Frankenmuth	-83.788740	43.345750	40	N/S	Flat	Corn	0-25%
605	Frankenmuth	-83.788760	43.345750	40	N/S	Flat	Corn	0-25%
606	Frankenmuth	-83.788700	43.342300	80	N/S	Flat	Bean	0-25%
607	Frankenmuth	-83.788650	43.339220	40	N/S	Flat	Corn	0-25%
608	Frankenmuth	-83.788620	43.336990	20	E/W	Flat	Wheat	0-25%
609	Frankenmuth	-83.798720	43.343930	30	N/S	Flat	Bean	0-25%
610	Frankenmuth	-83.785020	43.350320	60	E/W	Flat	Bean	0-25%
611	Frankenmuth	-83.778750	43.347130	20	E/W	Flat	Bean	0-25%
612	Frankenmuth	-83.778750	43.347130	20	E/W	Flat	Bean	0-25%

Label	Township	UTM Y-coord	UTM X-coord	Field Size Acres	Field Orientation	Slope	Residue Type	Percent Residue
613	Frankenmuth	-83.778730	43.346100	40	E/W	Flat	Bean	0-25%
614	Frankenmuth	-83.778730	43.346100	40	E/W	Flat	Bean	0-25%
615	Frankenmuth	-83.778670	43.343010	5	E/W	Flat	Bean	0-25%
616	Frankenmuth	-83.778670	43.343010	5	E/W	Flat	Bean	0-25%
617	Frankenmuth	-83.778670	43.343010	5	E/W	Flat	Bean	0-25%
618	Frankenmuth	-83.781830	43.335790	80	N/S	Mod	Corn	0-25%
619	Frankenmuth	-83.776090	43.335710	40	N/S	Flat	Corn	0-25%
620	Frankenmuth	-83.773310	43.335730	40	N/S	NR	Wheat	0-25%
621	Frankenmuth	-83.773320	43.335730	40	N/S	NR	Wheat	0-25%
622	Frankenmuth	-83.765450	43.335770	100	N/S	Flat	Bean	0-25%
623	Frankenmuth	-83.761180	43.335800	60	N/S	Flat	Sugar Beat	0-25%
624	Frankenmuth	-83.759650	43.343210	20	E/W	Flat	Corn	0-25%
625	Frankenmuth	-83.771310	43.343150	20	N/S	Flat	Corn	0-25%
626	Frankenmuth	-83.758590	43.349880	70	E/W	Flat	Bean	0-25%
627	Frankenmuth	-83.782650	43.350680	40	N/S	Flat	Bean	0-25%
628	Frankenmuth	-83.793430	43.350520	60		Flat	Corn	0-25%
629	Frankenmuth	-83.785620	43.350430	40	N/S	Flat	Bean	0-25%
630	Frankenmuth	-83.790230	43.349890	60	N/S	Flat	Bean	0-25%
631	Frankenmuth	-83.799680	43.355360	60	N/S	Flat	Bean	0-25%
632	Frankenmuth	-83.806960	43.350480	40	E/W	Flat	Wheat	0-25%
633	Frankenmuth	-83.814620	43.350420	70		Flat	Bean	0-25%
634	Frankenmuth	-83.798890	43.348760	70	E/W	Flat	Bean	0-25%
635	Frankenmuth	-83.798850	43.347420	30	E/W	Flat	Corn	0-25%
636	Frankenmuth	-83.801120	43.335760	10	N/S	Hilly	Corn	51-75%
637	Frankenmuth	-83.728240	43.343160	20	E/W	Flat	Wheat	0-25%
638	Frankenmuth	-83.718120	43.338110	60	N/S	Mod	Corn	0-25%
639	Frankenmuth	-83.718260	43.346000	20	N/S	Flat	Bean	0-25%

Label	Township	UTM Y-coord	UTM X-coord	Field Size Acres	Field Orientation	Slope	Residue Type	Percent Residue
640	Frankenmuth	-83.728240	43.346460	20	E/W	Flat	Bean	0-25%
641	Frankenmuth	-83.728280	43.349990	80	E/W	Flat	Corn	0-25%
642	Frankenmuth	-83.729510	43.341360	50	E/W	Flat	Wheat	0-25%
643	Frankenmuth	-83.728220	43.339390	20	E/W	Flat	Bean	0-25%
644	Frankenmuth	-83.735900	43.350300	20	E/W	NR	Bean	0-25%
645	Frankenmuth	-83.728250	43.342090	20	E/W	Flat	Bean	0-25%
646	Frankenmuth	-83.738100	43.345010	40	E/W	Flat	Bean	0-25%
647	Frankenmuth	-83.735700	43.350310	20	E/W	Flat	Sugar Beat	0-25%
648	Frankenmuth	-83.798520	43.329820	60	N/S	Mod	Corn	0-25%
649	Frankenmuth	-83.799710	43.335800	60	N/S	Flat	Sugar Beat	0-25%
650	Frankenmuth	-83.718110	43.336550	80	N/S	Flat	Corn	0-25%
651	Frankenmuth	-83.718170	43.345220	40	E/W	Flat	Bean	0-25%
652	Frankenmuth	-83.718180	43.347170	40	N/S	Flat	Corn	0-25%
653	Frankenmuth	-83.703050	43.350210	20	E/W	Flat	Corn	0-25%
654	Frankenmuth	-83.698300	43.345910	30	E/W	Flat	Bean	0-25%
655	Frankenmuth	-83.698290	43.343880	30	E/W	Flat	Corn	0-25%
656	Frankenmuth	-83.698300	43.339140	35	E/W	Flat	Wheat	0-25%
657	Frankenmuth	-83.703880	43.335770	100	N/S	Flat	Bean	0-25%
658	Frankenmuth	-83.704810	43.335750	30	N/S	Flat	Bean	0-25%
659	Frankenmuth	-83.704810	43.335750	30	N/S	Flat	Bean	0-25%
660	Frankenmuth	-83.706890	43.335800	60	N/S	Flat	Sugar Beat	0-25%
661	Frankenmuth	-83.709510	43.335790	80	N/S	Mod	Corn	0-25%
662	Frankenmuth	-83.709860	43.335660	10	NR	Mod	Bean	0-25%
663	Frankenmuth	-83.709680	43.335710	40	N/S	Flat	Corn	0-25%
664	Frankenmuth	-83.701860	43.335690	40	N/S	Mod	Corn	0-25%
665	Frankenmuth	-83.698380	43.330740	40	N/S	Mod	Corn	0-25%
666	Frankenmuth	-83.708250	43.330180	70	E/W	Mod	Bean	0-25%

Label	Township	UTM Y-coord	UTM X-coord	Field Size Acres	Field Orientation	Slope	Residue Type	Percent Residue
667	Frankenmuth	-83.696560	43.321330	70	N/S	Mod	Corn	0-25%
668	Frankenmuth	-83.706700	43.321410	5	E/W	Flat	Bean	0-25%
669	Frankenmuth	-83.711270	43.321470	70	E/W	Flat	Corn	0-25%
670	Frankenmuth	-83.779800	43.333050	80	E/W	Flat	Wheat	0-25%
671	Frankenmuth	-83.782450	43.333300	20	N/S	Flat	Wheat	0-25%
672	Frankenmuth	-83.795370	43.332040	60	N/S	Mod	Corn	0-25%
673	Frankenmuth	-83.788980	43.335810	80	N/S	Flat	Bean	0-25%
674	Frankenmuth	-83.788980	43.335810	80	N/S	Flat	Bean	0-25%
675	Frankenmuth	-83.785830	43.335810	80	N/S	Flat	Bean	0-25%
676	Frankenmuth	-83.784380	43.335810	80	N/S	Flat	Bean	0-25%
677	Frankenmuth	-83.776470	43.331240	10	N/S	Mod	Bean	0-25%
678	Frankenmuth	-83.776450	43.331940	15	N/S	Hilly	Corn	0-25%
679	Frankenmuth	-83.769520	43.332720	10	E/W	Flat	Bean	0-25%
680	Frankenmuth	-83.774630	43.332490	10	N/S	Mod	Bean	0-25%
681	Frankenmuth	-83.772240	43.335840	80	N/S	Mod	Bean	0-25%
682	Frankenmuth	-83.761090	43.335900	70	E/W	Mod	Corn	0-25%
683	Frankenmuth	-83.776120	43.327790	10	NR	Hilly	-99.000000	0-25%
684	Frankenmuth	-83.775910	43.323020	80	N/S	Flat	Wheat	0-25%
685	Frankenmuth	-83.775910	43.323020	80	N/S	Flat	Wheat	0-25%
686	Frankenmuth	-83.776120	43.327790	10	NR	Hilly	-99.000000	0-25%

Figure 9.10 Cole Creek Agricultural NPS Sites, Tuscola County

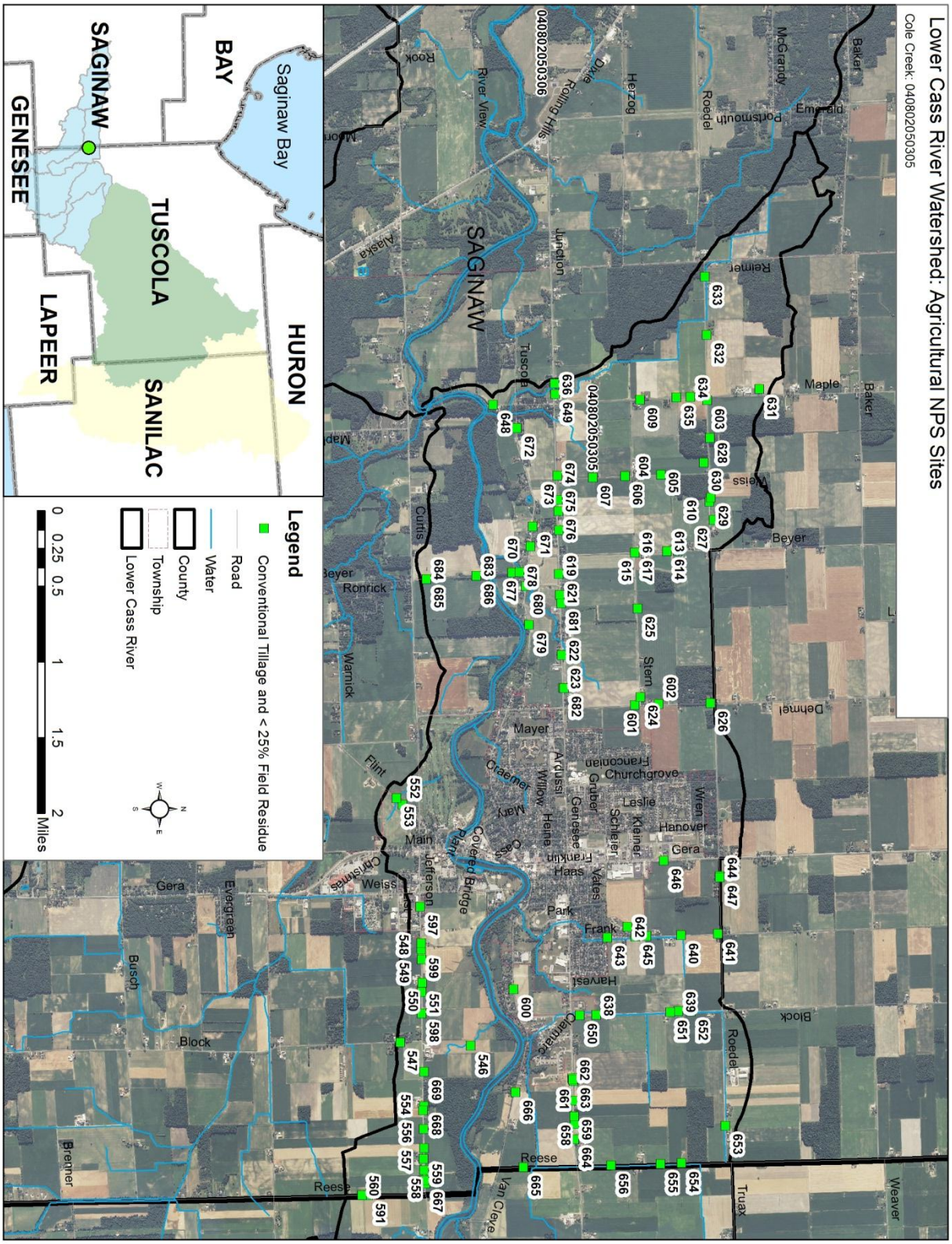
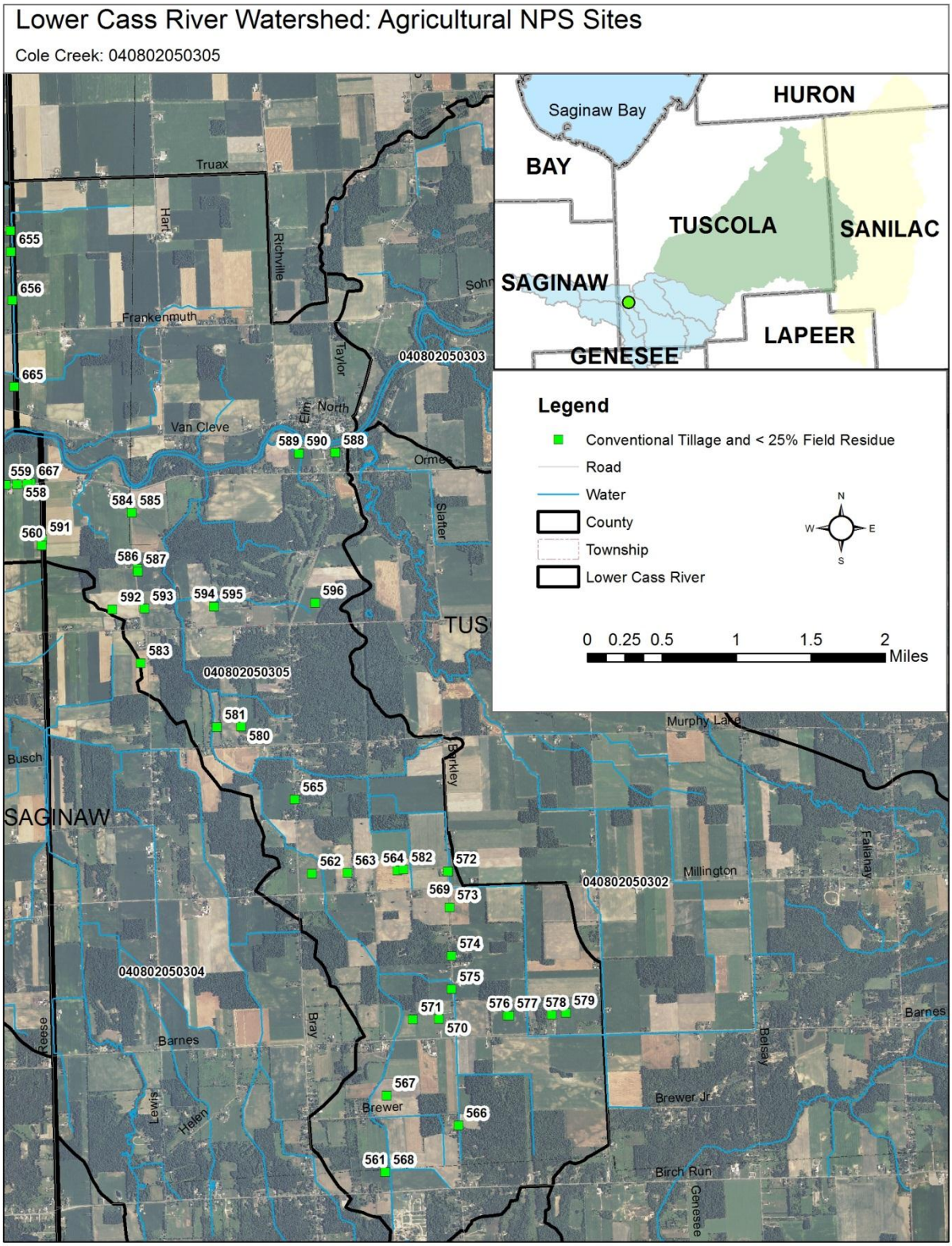


Figure 9.11 Cole Creek Priority Sites for Agricultural BMPs, Saginaw County



Pollutant loading reductions were estimated for nitrogen (N), phosphorus (P), biological oxygen demand (BOD), and sediment at the site level utilizing the STEPL Model, results are shown below in Table 9.15.

Table 9.15 Cole Creek, Pollutant loads and reductions, STEPL Model

Acres of Cropland	N Load (no BMP) (lb/yr)	P Load (no BMP) (lb/yr)	BOD Load (no BMP) (lb/yr)	Sediment Load (no BMP) (t/yr)
5,675 acres of known sites	36,477.1	4,690.9	43,233.1	1,008.0
	N Load (with BMP) (lb/yr)	**P Load (with BMP) (lb/yr)**	**BOD Load (with BMP) (lb/yr)**	**Sediment Load (with BMP) (t/yr)**
	21,809.3	2,032.1	37,833.1	164.3
	% N Reduction	**% P Reduction**	**% BOD Reduction**	**% Sed Reduction**
	40.2	56.7	12.5	83.7

The HIT Model results in Table 9.15 shows that the greatest sediment reduction can occur when no-till practices are placed on 10% of the most erosive areas in the Cole Creek subwatershed. The greatest return on investment is shown in the column titled 'BMP cost benefit' showing that no-till on the most erosive 5% of land will reduce sediment at a cost of $26 per ton as compared to $74 per ton for mulch-till on the most erosive 5% of land. Load reduction targets for sediment in the Cole Creek are aimed at reaching no-till on 5% of the subwatersheds area.

Table 9.16 Estimated Reductions in Pollutants for Cole Creek

Practice	Sediment Reduction (tons/yr)	BMP cost benefit ($/ton reduction)	P-Reduction (lbs/yr) / $/lb-P
Mulch till on sediment for worst 5% (795 acres)	214	$74	182 / $87
Mulch till on sediment for worst 10% (1,590 acres)	185	$73	157 / $51
No Till on sediment for worst 5% (795 acres)	431	$26	366 / $30
No Till on sediment for worst 10% (1,590 acres)	500	$45	425 / $52
Sediment for 30ft grass buffer	425	$56	361 / $66

9.5 Estimate of the load reductions expected from the proposed management measures (EPA Element B)

E.Coli is the only impairment that has a documented quantity needed to attain designated uses which aligns with Michigan's Water Quality Standards (WQS). Though not calculated specifically for *E.coli*, the known sites where livestock are impacting surface waters have been estimated for sediment and nutrient reductions. Correcting these sites will address *e. coli* inputs to these waterbodies. We will address the high and medium priority sites in the TMDL watersheds to remove 100% of impairments from livestock thus removing sources for e. coli to enter surface water.

In water bodies that are currently meeting designated uses but where significant pollutant sources were identified, percent pollutant reductions to achieve improved water quality are based on the load reductions that would be realized by remediating high and medium priority sites identified. Exceptions where load reductions are expected to be 100% are where there is few impairment sources identified. These source impairments include streambank erosion sites, wetland loss, and cropland runoff and are summarized in Table 9.16.

Load reductions needed to address each impairment and threat (EPA, B.1)

E.Coli is the only impairment that has a documented quantity needed to attain designated uses which aligns with Michigan's Water Quality Standards (WQS). Though not calculated specifically for *E.coli*, the known sites where livestock are impacting surface waters have been estimated for sediment and nutrient reductions. Correcting these sites will address e. coli inputs to these waterbodies.

We will address the high and medium priority sites in the TMDL watersheds (Dead Creek, Cole Creek, Perry Creek and Millington Creek) to remove 100% of impairments from livestock thus removing sources for e. coli to enter surface water. Table 9.17 provides a summary of the expected load reductions for each impairment source.

Table 9.17 Summary Table of Expected Load Reductions

Impairment Source	Loading Estimate for Total Sites	Loading Reductions	Loading Reduction %
Livestock Access	3,502 lbs/yr P, 18,284 lbs/yr N, 23,769 lbs/yr BOD	Dependent on practice – see tables 9.18-9.20	Variable depending on practice installed
Streambank Erosion	Tons Sediment = 4,392 + 11,811 = 16,203; lbs P = 4,832 + 13,069 = 17,901; lbs N = 9,664 + 26,138 = 35,802	Tons sediment = 846 + 7,541 = 8,387; lbs P = 931 + 8,285 = 9,216; lbs N = 1,862 + 16,570 = 18,432	51% sediment; 51% P; 51% N
Wetland Loss	Unknown	See LLFWA	Dependent on acreage feasibility
Cropland Runoff	91,304 lbs/yr N, 11,626 lbs/yr P, 107,847 lbs/yr BOD, 2,394 t/yr Sediment	36,518 lbs/yr N, 6,452 lbs/yr P, 12,828 lbs/yr BOD, 2,004 t/yr Sediment	39.9% N, 56% P, 11.8% BOD, 83.7% Sediment

Method used for determination of these nutrient loadings was the *Pollutant Controlled Calculation and Documentation for Section 319 Watersheds Training Manual, June, 1999.*
Table 9.18 shows reductions in annual loadings if vegetated filter strips are used to protect waterways. Table 9.19 shows reductions in annual loadings if waste management systems are used to on high priority sites. Table 9.20 shows reductions in annual loadings if a waste storage facility is used on high priority sites.

Table 9.18 Reductions from vegetated filter strips.

Location	Phosphorus (lbs/yr)	Nitrogen (lbs/yr)	BOD (lbs/yr)
Tuscola County (High Priority)	1770	ND	ND
Saginaw County (High Priority)	510	ND	ND
Genesee County (High Priority)	540	ND	ND

ND = A reduction constant was Not Determined in the 319 method used for this table

Table 9.19 Reductions from waste management systems

Location	Phosphorus (lbs/yr)	Nitrogen (lbs/yr)	BOD (lbs/yr)
Tuscola County (High Priority)	1,875	8,480	ND
Saginaw County (High Priority)	540	2,665	ND
Genesee County (High Priority)	570	580	ND

ND = A reduction constant was Not Determined in the 319 method used for this table

Table 9.20 Reductions from waste storage facilities

Location	Phosphorus (lbs/yr)	Nitrogen (lbs/yr)	BOD (lbs/yr)
Tuscola County (High Priority)	1,250	6,890	ND
Saginaw County (High Priority)	360	2,165	ND
Genesee County (High Priority)	380	475	ND

ND = A reduction constant was Not Determined in the 319 method used for this table

9.7 Description of the management measures needed to achieve the proposed load reductions (EPA Element C)

Goals for the Lower Cass River Watershed (EPA, C1)

1. Restore the designated uses of total and partial body contact on the Cole Creek and Cass River
2. Restore the designated use of other indigenous aquatic life and wildlife
3. Connect the Shiawassee National Wildlife Refuge (formally or informally) with Michigan's State Game Areas and other private natural areas along the Cass River

Management Measures are Applicable & Feasible (EPA, C2-3)

A suite of management measures are available to reduce pollution and impacts to water quality in the Upper Cass River. Management measures are listed by priority. Chapter 4 details the urban stormwater analysis and appropriate management measures for Vassar, Frankenmuth, and Bridgeport.

Livestock Access: Livestock can be restricted to accessing surface water by installation of fencing along river corridors, and installation of alternate watering facilities.

Streambank Erosion can be addressed through a variety of means. These include installation of vegetative buffers to slow overland runoff and stabilization of the bank itself using natural materials such as logs or brush mattresses to hard armoring options such as gabion baskets or rip rap in extreme erosion cases.

Naturalize drains and reconnect to floodplain where feasible to remediate loss of aquatic life in Dead Creek and Cass River.

Agricultural NPS is a broad category that includes the following causes of impairments: Cropland erosion/runoff, Conventional Tillage, Surface ditching, Manure spreading. These can be addressed through a combination of **Agricultural BMP's:**

- Conservation tillage / Mulch-till
- Grassed Buffers
- Cover cropping

Stormwater management: Vassar, Frankenmuth, and Bridgeport are the urbanized areas in the Lower Cass River that were inventoried as a part of the urban hydrologic assessment, detailed in Chapter 4. There are structural recommendations to keep runoff on-site and managerial recommendations for planning commissions to enact to reduce stormwater runoff.

Recommended Managerial Strategies

Point of sale septic system ordinance: Bacteria pollution is a pervasive problem in Michigan and the Cass River Watershed. Michigan is only one of two states in the union that do not have a statewide ordinance relating to the inspection of septic systems at the time of sale. Several

counties have adopted or are working on developing time of sale ordinances for their communities. A sample ordinance from the Barry-Eaton District Health Department is included in the watershed plan for local health departments to consider for adaptation and adoption.

Low impact development: A recent study performed by the Planning and Zoning Center at Michigan State University, evaluated the use of Low Impact Development in the Cass River Watershed. Full recommendations are included in appendix E. Stormwater management is also considered a component of low impact development and is detailed in Chapter 4.

Critical Locations for Management Measures (EPA C.4)
Critical locations coincide with areas where there is an ample amount of inventory information available and a known impairment.

Critical locations are shown in the inventory section for Dead Creek, Cole Creek, Perry Creek, Millington Creek, and the Cass River. These five subwatersheds are listed as impaired by the Michigan DEQ, inventory data from 2010-11, and HIT Modeling all support targeted restoration in these subwatersheds.

The Lower Cass River strategy was reviewed by stakeholders on May 21, 2013 at the Saginaw County Conservation District. Priority areas for installation of management measures included:

Priority 1: Dead Creek, Cole Creek, Perry Creek, Millington Creek
Livestock fencing, manure stacking facilities, alternative watering facilities

Priority 2: Cole Creek, Cass River
Streambank Stabilization

Priority 3: Cass River
Wetland Restoration

Priority 4: Dead Creek, Cole Creek
Conservation tillage and cover crops

Load reductions linked to management measures (EPA, C5 & C6)

See STEPL Modeling results for reductions in sediment/nutrient reductions through installation of agricultural BMP's. The percent reduction for agricultural BMP's are demonstrated in the HIT Model calculations for mulch-till, no-till and grass buffer strips. We assume practices installed for livestock exclusions, e. coli reduction, gully stabilization, tile outlet erosion, and streambank stabilization have the ability to reduce loading by at or near 100% (e.g. permanent sediment reduction by fencing livestock out of riparian areas).

9.8 **Implementation Schedule and Assistance** (EPA Elements D, F, G, H)

EPA Elements C-H are presented by priority subwatershed and impairment in Tables 9.21 and 9.22. The public information and education section is included in Chapter 6.

Table 9.21 Implementation Priorities and Management

Priority Sub-shed	MGMT Measure	Technical Assistance Type	Technical Cost	*Project Lead and Partners	Quantity	Material / Installation Cost	Total Cost and Potential Funding	Regulatory Agencies
1 Dead Creek	Livestock exclusion	Landowner outreach and assistance for fencing, crossings, stacking facilities, MAEAP certification, etc	estimated need for part-time technician over two years for outreach and technical assistance ($45,000 each year)	*Saginaw Conservation District, MMPA, Farm Bureau, MSUE, MAEAP, USDA-NRCS	1,265 animals	est avg $15,000 per site * 10 sites	195,000.00 319, Farm Bill, USDA-NRCS	FSA, MDA, MDEQ
1 Cole Creek	Livestock exclusion				966 animals	est avg $15,000 per site * 15 sites	225,000.00	
1 Perry Creek	Livestock exclusion				95 sites	est avg $15,000 per site * 95 sites	1,425,000.00	
1 Millin g-ton Creek	Livestock exclusion				30 sites	est avg $15,000 per site * 30 sites	450,000.00	
2 Cole Creek	Streambank stabilization	Landowner outreach, engineering	est at 20,000 for .25 FTE staff position	*Saginaw Conservation District, Saginaw	1,565 linear feet	est $20 per linear ft	51,300.00 CZM, 319, SWIN	Drain Office, MDEQ, Soil

Priority Sub-shed	MGMT Measure	Technical Assistance Type	Technical Cost	*Project Lead and Partners	Quantity	Material / Installation Cost	Total Cost and Potential Funding	Regulatory Agencies
2 Cass River	Streambank stabilization	and construction		Bay RC&D, Cass River Greenway	8,205 linear feet	est $20 per linear ft	164,100.00	Erosion
3 Cass River	Wetland restoration (over 90% wetland loss)	Landowner outreach, engineering and construction	USFWS, MDEQ programs	*Saginaw Conservation District, USFWS	500 acres	est $100 per acre	500,000.00 USFWS, 319, WHIP	MDEQ
4 Dead Creek	Conservation tillage and cover crops, vegetated buffers	Landowner outreach and assistance	Full time technician for Conservation District for 2 years, estimated at 90K	*Saginaw Conservation District, Farm Bureau, Star of the West	8600 Acres	$10-14 per acre = $86,000 - $120,400	210,000.00 319, Farm Bill, USDA-NRCS	FSA, MDA
4 Cole Creek	Conservation tillage and cover crops, vegetated buffers				5,675 acres	$10-14 per acre = $56,750 - $79,450	79,450.00 319, Farm Bill, USDA-NRCS	FSA, MDA
Entire 10-digit HUC	Monitoring Program	Water quality monitoring and analysis	$300 per sample including staff time, each site sampled 5 times	Cass River Greenway Committee	6 subwatershed sites and 5 on main channel	N/A	$16,500 MiCorps, MDEQ, Local match	MDEQ, EPA

The public information and education plan can be found in Chapter 6 (EPA Element E). The education plan is broken to address each of the pollutant sources and causes by target audience, message, and delivery tools.

Table 9.22 Implementation Schedule and Milestones (EPA Element F & G)

Priority	Subwatershed	Management Measure	Implementation Schedule	Interim Measurable Milestones	Evaluation Dates
1	Dead Creek	Livestock access	2014-2016	7 High priority sites - # animals	2017 confirm 7 sites identified in inventory have installed BMPs
1	Cole Creek	Livestock access	2014-2016	4 High priority sites - # animals	2017 confirm 4 sites identified in inventory have installed BMPs
1	Perry Creek	95 potential sites for livestock exclusion (Table 12 of Draft 2013 TMDL)	2014-2016	50 sites within 100' of stream	2017 confirm 50 sites have installed BMPs
1	Millington Creek	30 potential sites for livestock exclusion (Table 12 of Draft 2013 TMDL)	2014-2016	18 sites within 100' of stream	2017 – confirm 18 sites have installed BMPs
2	Cole Creek	Streambank erosion	2018-2020	900 Feet stabilized (severe sites)	2021 – confirm 900 feet of bank stabilized
2	Cass River	Streambank erosion	2018-2020	1,500 feet stabililzed (severe sites)	2021 – confirm 1,500 feet of bank stabilized
3	Cass River	Wetland restoration (over 90% wetland loss)	2017-20-23	500 acres	2023 – confirm acreage of restored wetland

Priority	Subwatershed	Management Measure	Implementation Schedule	Interim Measurable Milestones	Evaluation Dates
4	Dead Creek	Conservation tillage and cover crops, vegetated buffers	2019-2021	860 acres (10% of known acreage)	2022 – confirm acreage of measures installed
4	Cole Creek	Conservation tillage and cover crops, vegetated buffers	2019-2021	600 acres (~ 10% of known acreage)	2022 – confirm acreage of measures installed
n/a	Lower Cass River	Monitoring Program	Short term (1-3 years)	Monitoring program to coincide with implementation of priority areas mentioned above	

The three actions required for each management measure are similar:

1. Submit funding proposal to MDEQ (Year One)
2. Landowner Outreach (Year Two)
3. Site Design and Implementation (Year Two-Year Three)
4. Monitoring, Re-evaluation of WMP Status and Next Steps (Year Three-Year Four)

9.8 Criteria to determine whether or not load reductions are being achieved (EPA Element H)

Criteria for evaluating load reductions are strictly for *E. coli* as mentioned in section A. The planning committee should revisit the plan and TMDL's every two years to evaluate progress on achieving milestones and subsequent load reductions. All known sources of bacterial contamination will be addressed and their success measured by reductions in *e.coli* levels as dictated by state water quality standards. A monitoring request will be made in the TMDL watersheds to MDEQ after these priority impairment sources have been corrected to determine if designated uses have been restored. Numeric criteria are delineated by the state of Michigan Water Quality Standards.

There is currently no water ways listed as impaired due to sediment or phosphorous in the Lower Cass River. Criteria for determining whether load reductions have been achieved for sediment and nutrient loading will be based upon the evaluation of the amount of practices installed and associated pollutant load reduction. A monitoring request will be submitted to the MDEQ for a biological assessment pre-project and post-project implementation to determine if improvements in water quality have been achieved.

9.9 Monitoring component to evaluate the effectiveness of implementation (EPA Element I)

Two major monitoring initiatives continue in the watershed. The first is the five-year basin monitoring program stewarded by the Michigan DEQ and the continuation of the TMDL process. The second is initiated by the Cass River Greenway committee, based in Frankenmuth. Together, monitoring data will in theory measure improvements of Cass River water quality. It is assumed that major restoration projects completed during implementation will have separate monitoring plans and Quality Assurance Project Plans (QAPPs) established as a part of their funding requirements.

Chapter 3 provides an overview of previous monitoring done in the Cass River. From this evaluation data gaps have been identified that should be looked at within the context of a comprehensive monitoring strategy for this watershed. Data gap analysis for the Lower Cass River shows monitoring data for all subwatersheds (Table 3.6, Chapter 3). Continued monitoring is planned for the Lower Cass River per the 2013 TMDL and efforts of the Cass River Greenway committee.

Additional inventory was conducted during the watershed planning phase in these subwatersheds to identify projects that would help achieve water quality restoration goals. Subwatersheds that were assessed by MDEQ with high water quality scores were not

inventoried due to time and budget constraints. Ongoing monitoring efforts in the watershed include: 1) MDEQ's five-year basin monitoring program and the continuation of their TMDL monitoring process, and 2) Monitoring being performed by the Cass River Greenway committee, based in Frankenmuth along the Cass River corridor.

The Cass River Greenway monitoring effort is titled "Cass River Water Quality Monitoring Project", and was funded by State of Michigan Department of Environmental Quality –Water Resources Division-Office of Surface Water Assessment (Project # 2011-0501). The project provides baseline information regarding the main channel of the Cass River. A total of nine sampling sites were included near Cass City, Caro, Vassar, Frankenmuth, and Bridgeport (Table 9.23). Parameters tested at each site include: total phosphorus, total suspended solids, fecal coliform bacteria, nitrates, turbidity, temperature, pH, dissolved oxygen, and biological oxygen demand. A full report of the two-year study is available from Environmental Science Solutions, LLC and online at www.cassriver.org.

Table 9.23 Sampling Sites for Cass River Water Quality Monitoring Project

Site Name	Site ID	Municipality	County	Latitude	Longitude	Watershed
Cemetery Rd.	CC2	Cass City	Tuscola	43.5847	-83.1736	Cass River
Dodge Rd.	CC1	Cass City	Tuscola	43.5698	-83.2321	Cass River
Dayton Rd.	C2	Caro	Tuscola	43.4901	-83.3765	Cass River
Wells Rd.	C1	Caro	Tuscola	43.4503	-83.4401	Cass River
Caine Rd.	V2	Vassar	Tuscola	43.3924	-83.5222	Cass River
Huron Rd.	V1	Vassar	Tuscola	43.3712	-83.5803	Cass River
Bray Rd.	F2	Frankenmuth	Tuscola	43.3244	-83.6572	Cass River
Beyer Rd.	F1	Frankenmuth	Saginaw	43.3287	-83.7584	Cass River
Fort Rd.	B1	Bridgeport	Saginaw	43.3486	-83.8844	Cass River

It is assumed that major restoration projects completed during implementation will have separate monitoring plans and Quality Assurance Project Plans (QAPPs) established as a part of their funding requirements. Potential sites for restoration activities should be identified by at the beginning of any implementation effort to allow for pre-project and post-project

monitoring. Monitoring should also include before and after pictures of implementation projects.

A comprehensive monitoring plan for the Lower Cass River is also recommended to fully evaluate necessary monitoring to fill data gaps, gather background information, and identify other potential water quality impairments or threats. Funding should be sought to develop and implement this Cass River Watershed monitoring plan from the MICorps program or similar funding opportunity. Building off of past monitoring efforts, the following parameters should be monitored at public access sites, and within each subwatershed to determine improvements or declines in water quality:

- E. Coli
- Fecal coliform bacteria
- Total dissolved solids
- Total suspended solids
- pH
- BOD
- Nitrates
- Total Nitrogen
- Total Phosphorus
- Ortho Phosphorus
- Turbidity
- Dissolved oxygen
- Temperature
- Diversity and quantity of macroinvertebrate taxa