Grant

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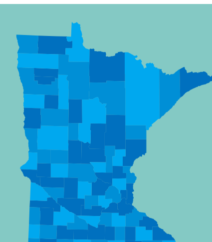
Twelve Mile Creek Nine Key Element Plan

MINNESOTA POLLUTION CONTROL AGENCY



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Executive summary

The Twelve Mile Creek Section 319 Small Watershed Focus Program nine key element (NKE) plan was developed by compiling and synthesizing information from previous studies and planning documents conducted in the watershed. Much of the text and concepts in this NKE plan are derived from the various existing studies and plans in the watershed. Additional information is provided when necessary to address all of the U.S. Environmental Protection Agency's (EPA) nine key elements of a watershed-based plan. Key documents include:

- The North Fork Crow River Watershed Monitoring and Assessment Report, 2011, assessed stream segments in the Twelve Mile Creek Watershed for biology (07010204-563, Unnamed Ditch to Unnamed Ditch, and 07010204-681, Little Waverly Lake to North Fork Crow River) and chemistry (Twelve Mile Creek Watershed outlet at C.R. 107, 2.5 miles N of Waverly), for compliance with water quality standards.
- The North Fork Crow Biotic Stressor Identification Report, 2014, identified Twelve Mile Creek as being a Fish IBI Class 6 - Northern headwaters stream.
- The 12-Mile Creek Dissolved Oxygen Total Maximum Daily Load Report, 2015, includes a total maximum daily load (TMDL) for oxygen demand for Twelve Mile Creek along with watershed information, a summary of water quality data, and implementation strategy.
- The North Fork Crow River Watershed Restoration and Protection Strategy, 2014, addresses the assessed stream segments in the Twelve Mile Creek Watershed, as well as four impaired lakes, and includes a summary of water quality, restoration and protection strategies, and recommended monitoring activities.
- The North Fork Crow River Bacteria, Nutrients, and Turbidity Total Maximum Daily Load Report, 2014, includes total phosphorus TMDLs for four lakes in the Twelve Mile Creek Watershed along with watershed information, a summary of water quality data, and implementation strategy.
- The Ann Lake and Lake Emma Excess Nutrient TMDL Report (2011) includes total phosphorus TMDLs for the two lakes in the Twelve Mile Creek Watershed along with associated information.
- "Aquatic Vegetation of Howard Lake, Wright County, Minnesota, 2008" (Minnesota Department of Natural Resources, 2009) provided a survey and inventory of aquatic vegetation in Howard Lake, including the years the vegetation was first identified in the lake.

The Twelve Mile Creek NKE plan is a living, working document that serves as a guide and starting point for local stakeholders to achieve water quality goals through implementation of nonpoint source pollution control measures. An adaptive management approach is taken to allow for change, reaction, and course correction throughout implementation.

The intent of the Twelve Mile Creek NKE plan is to concisely address the nine elements identified in EPA's *Handbook for Developing Watershed Plans to Restore and Protect our Waters* (EPA 2008) that EPA feels are critical to preparing effective watershed plans to address nonpoint source pollution. EPA emphasizes the use of watershed-based plans containing the nine elements in Section 319 watershed projects in its guidelines for the Clean Water Act Section 319 program and grants (EPA 2013).

The purpose of this plan effort is to build upon the existing foundation of work that has been completed in the Twelve Mile Creek Watershed. The plan builds on the past efforts to inform the details of this plan. Implementing the actions in this plan will achieve the water quality goals for the streams and lakes in the watershed. The goals include meeting the water quality standards for the waterbodies.

This plan incorporates detailed work for specific waterbodies. It builds off of the existing work of the watershed partners described. Considerable cross interactions between various programs makes it difficult to single out any one existing document/plan as the complete picture for the watershed plan that fully meets EPA's nine key elements for every waterbody in the watershed. Instead, each of these plans, studies, and efforts brings more information to the table to inform the actions needed to obtain improved water quality and to ultimate reach water quality standards.

Part of the development of this plan includes synthesizing and compiling the information from these multiple scale planning efforts. Circumstances in the watershed will continue to change. Land use will change, best management practices (BMPs) will be implemented, the climate will continue to change, etc., and the needs of the watershed will change based on these inputs. The milestones and intentional monitoring of progress will guide the changes needed to this plan throughout the implementation process.

Restoration goals

The following restoration goals have been identified for the Twelve Mile Creek watershed:

- **Meet Dissolved Oxygen water quality standards for Twelve Mile Creek** downstream of Little Waverly Lake: attainment of the water quality standard is measured as a daily minimum dissolved oxygen concentration of no less than 5 mg/l.
- **Meet *E. coli* water quality standards for Twelve Mile Creek upstream and downstream of Little Waverly Lake:** attainment of the water quality standard is measured as a monthly geometric mean less than 126 MPN/100 ml.
- **Meet water quality standards for nutrients in Howard Lake:** Howard Lake is impaired for nutrients and fish bioassessments, due largely to watershed drainage and internal loading. Phosphorus must be reduced by 3,488 pounds annually to meet the current standard, which is 40 micrograms per liter TP (deep lake system).
- **Meet water quality standards in Dutch Lake:** Dutch Lake is impaired for nutrients and fish bioassessments, due largely to watershed drainage and internal load. Phosphorus must be reduced by 1,923 pounds annually to meet the current standard of 40 micrograms per liter TP.
- **Meet water quality standards in Little Waverly Lake:** Little Waverly Lake is impaired for nutrients and fish bioassessments, due mostly to influence from internal load. Phosphorus loading must be reduced by 12,867 pounds annually to meet the current shallow lake standard of 60 micrograms per liter.
- **Meet water quality standards in Ann Lake:** Ann Lake is impaired for nutrients and fish bioassessments, due mostly to influence from County Ditch 10. Phosphorus must be reduced by nearly 6,815 pounds annually to meet the shallow lake standard of 60 micrograms per liter.
- **Meet water quality standards for Mary Lake:** Mary Lake is listed as impaired for aquatic life by fish bioassessments.
- **Meet water quality standards in Lake Emma:** Lake Emma is impaired for nutrients, due mostly to influence from Ann Lake. Phosphorus must be reduced by nearly 2,224 pounds annually to meet the shallow lake standard of 60 micrograms per liter.
- **Meet water quality standards in Dog Lake:** Dog Lake is impaired for nutrients.
- **Increase watershed storage and reduce peak flows:** Increase the use of agricultural BMPs, buffers, soil health principles, and water storage to provide lower peak stream flows and restore floodplain connectivity, thus reducing erosion and sediment loading.

Protection goals

- **Maintain or improve water quality in Waverly Lake:** Waverly Lake was impaired for nutrients, due largely to watershed drainage from Carrigan Lake and surrounding agricultural fields, City of Waverly Stormwater, and internal load. It was delisted in 2020. However, continuing to improve water quality in Waverly will aid biological communities as well as ensuring continued beneficial uses of the lake.
- **Maintain or improve water quality in Mary Lake:** Mary Lake is not listed as impaired for nutrients. Continuing improvement of water quality will be the focus by preventing aquatic invasive species from entering the lake and ensuring the beneficial uses of the lake will continue long term.

Water quality condition summary

The Twelve Mile Creek Watershed is a HUC12 watershed that includes nine lakes and two segments of Twelve Mile Creek that have been assessed by the MPCA. Stream segments are identified in MPCA assessments using Waterbody IDs (WIDS) that include the HUC8 code followed by a three-digit number. The HUC 12 is broken into subwatershed for the purposes of this plan. The following section will discuss subwatersheds by lake and stream. Impairments are summarized in Table 1.

Table 1. 303(d) list of the impairments

Water body name	Year added to List	Affected designated use	Pollutant or stressor	TMDL target completion year
Ann	1998 2020 2002	Aquatic Consumption Aquatic Life Aquatic Recreation	Mercury in fish tissue Fish bioassessments Nutrients	2021
Dog	2020	Aquatic Recreation	Nutrients	2021
Dutch	2020 2010	Aquatic Life Aquatic Recreation	Fish bioassessments Nutrients	2021
Emma	2012	Aquatic Recreation	Nutrients	
Howard	1998 2020 2008	Aquatic Consumption Aquatic Life Aquatic Recreation	Mercury in fish tissue Fish bioassessments Nutrients	2021
Little Waverly	2016 2020 2008	Aquatic Consumption Aquatic Life Aquatic Recreation	Mercury in fish tissue Fish bioassessments Nutrients	2021
Mary Mary	2004 2020	Aquatic Consumption Aquatic Life	Mercury in fish tissue Fish bioassessments	2021
Twelve Mile Creek (Dutch Lake to Little Waverly Lake -679)	2020 2020 2020	Aquatic Life Aquatic Life Aquatic Recreation	Benthic macroinvertebrates bioassessments Fish bioassessments *Escherichia coli (E. coli)*	2021 2021 2021
Twelve Mile Creek (Little Waverly Lake to North Fork Crow River -681)	2010 2012	Aquatic Life Aquatic Recreation	Dissolved oxygen *Escherichia coli (E. coli)*	2021
Waverly Waverly	2008 2020	Aquatic Consumption Aquatic Life	Mercury in fish tissue Fish bioassessments (habitat)	2021

Twelve Mile Creek Watershed (HUC12) water quality standards

The streams in the Twelve Mile Creek Watershed are primarily designated as class 2Bg, 3A waters. The water quality standards used in assessing the streams and lakes include the following parameters:

- *E. coli* – not to exceed 126 organisms per 100 milliliters as a geometric mean of not less than five samples representative of conditions within any calendar month, nor shall more than ten percent of all samples taken during any calendar month individually exceed 1,260 organisms per 100 milliliters. The standard applies between April 1 and October 31.
- Dissolved oxygen – daily minimum of 5 mg/L.
- pH – to be between 6.5 and 9.0 pH units.
- Total suspended solids – 10 mg/L (class 2A streams) not to be exceeded more than 10% of the time between April 1 and October 31.
- Stream eutrophication – based on summer average concentrations for the North River Nutrient Region
    - Total phosphorus concentration less than or equal to 50 µg/L and
    - Chlorophyll-a (seston) concentration less than or equal to 7 µg/L or
    - Diel dissolved oxygen flux less than or equal to 4.5 mg/L or
    - Five-day biochemical oxygen demand concentration less than or equal to 3.0 mg/L.
    - If the total phosphorus criterion is exceeded and no other variable is exceeded, the eutrophication standard is met.
- Biological indicators – The basis for assessing the biological community are the narrative water quality standards and assessment factors in Minn. R. 7050.0150. Attainment of these standards is measured through sampling of the aquatic biota and is based on impairment thresholds for IBI that vary by use class. Appendix 5 in the North Fork Crow River Watershed Monitoring and Assessment Report (MPCA 2014) provides the IBI numeric thresholds.
- Lake nutrient standards – summer average total phosphorus concentration less than 40 ug/l

Water quality data summaries

Twelve Mile Creek

Streamflow

Streamflow in Twelve Mile Creek has been monitored by the Minnesota Pollution Control Agency (MPCA) during open water periods for several years between 2002 and 2019 at a site downstream of Little Waverly Lake (18012001). Data is present for different periods of time each year. Mean daily discharge ranged from 0.01 cubic feet per second (cfs) to 336 cfs. The overall average discharge for the period of record was 66 cfs, but the streamflow patterns varied considerably by year. Three years had significant periods of time where flow was less than 1 cfs (Table 2). The variability in flows is seasonal, typically peaking in late spring and in the fall, while exhibiting the lowest flows during the months of June through August. The variability in flow is likely due to precipitation patterns and lake levels in the watershed's lakes, but a specific analysis was not completed. Other factors affecting streamflow include soil types, channel structures such as culverts, bridges, beaver dams, woody debris, and sedimentation; and impervious surfaces in the watershed. The streamflow patterns are likely much different than historically present prior to intensifying agricultural drainage with these changes being considered in managing streamflow alterations.

Table 2. Summary of streamflow data for Twelve Mile Creek near Waverly, 40th St SW

Year	Average daily flow (cfs) for period of record	Percent days with flow < 1 cfs between June 1 and September 30
2002	86	0
2003	34	41
2005	41	No data
2006	17	81
2007	15	91
2009	11	83
2010	43	0
2011	79	0
2017	47	0
2018	48	0
2019	118	0

Stream flow data is present for portions of 2007, 2008, and 2009 at one additional site (CD10, 18012001) in the watershed.

Ditching, tiling, compaction of soils, loss of organic material on farmlands, and loss of native vegetation all have the effect of either reducing the holding capacity of the upland soils, or reducing the time that water remains on the land. In all cases, streams are impacted by the excess flow.

Chemistry

Water quality data is present at three sites downstream of Little Waverly Lake and four sites above Little Waverly Lake. Two sites have a suite of chemistry and physical data while the other five sites have transparency tube data through the Citizen Stream Monitoring Program (CSMP). Data for the five sites with only CSMP data is present only from 2002 – 2004 and is not summarized here. The data for the two other sites is summarized below. The two sites include one site downstream of Little Waverly Lake (S001-972) and one site upstream of the lake (S001-968).

Phosphorus

The average TP concentrations at both sites exceed the stream eutrophication criteria for TP for the Central Region in each year there is data (Table 3). The elevated TP concentrations indicate a potential eutrophication stressor in the two reaches of Twelve Mile Creek.

Table 3. Summary of P data

	TP - S001-972		TP - S001-968	
Year	Count	Average	Count	Average
2001	14	0.268	0	
2002	21	0.260	0	
2003	11	0.172	0	
2004	0		0	
2005	0		0	
2006	0		0	
2007	11	0.282	0	
2008	0		0	

	TP - S001-972		TP - S001-968	
Year	**Count**	**Average**	**Count**	**Average**
2009	0		0	
2010	0		0	
2011	0		0	
2012	0		0	
2013	0		0	
2014	0		0	
2015	0		0	
2016	0		0	
2017	5	0.282	5	0.182
2018	5	0.295	5	0.263

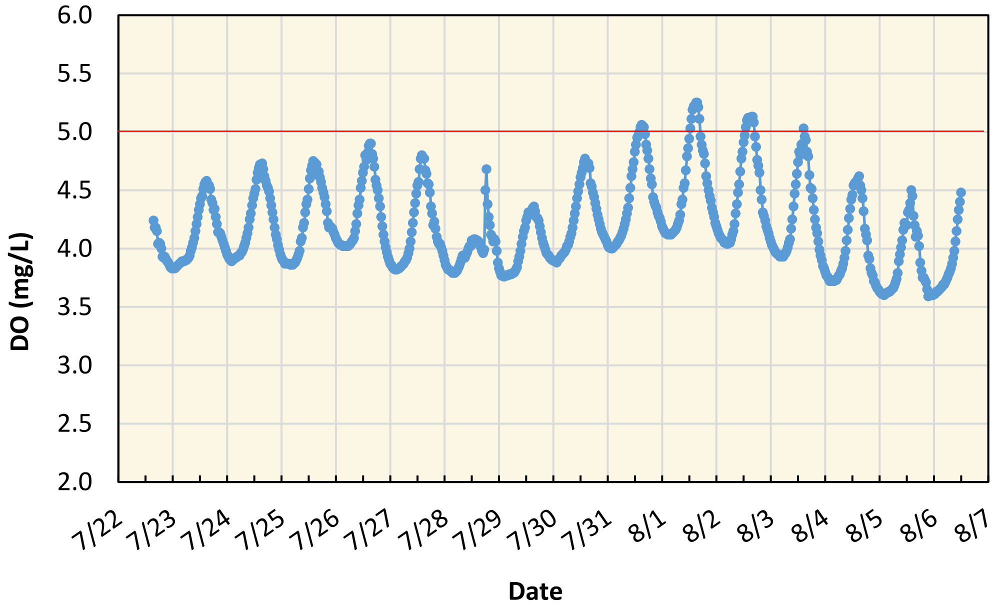
Nutrients – nitrogen

Only one recent nitrate sample has been collected in recent years, at 17UM011. It was quite low for an agricultural landscape. Ammonia was at very low concentration. The 1999 sample was quite similar to the 2017 sample. With such few samples, it is hard to describe the nitrate dynamics in the creek. Additional information will be gleaned from the biological communities, below.

Dissolved oxygen

All of the instantaneous DO measurements are relatively low, regardless of the time of day. The afternoon measurements are above the standard, but are lower than is typical of healthy streams for the afternoon period. Several morning samples are below the DO standard, particularly as the season moves to mid-summer. A continuously-measuring sonde was deployed in 2019 in late July - early August, and found that over the 15 day period of deployment, the DO almost never met the DO standard (Figure 1). The DO % saturation can provide insight into the DO dynamics, and is also data collected by the sonde. Measurements much over 100% confirm there is an abnormal amount of plants and/or algae in the stream. From the instantaneous measurements, the saturation ranged from 38 - 76%. From the 15 days long sonde data, the DO saturation averaged 49.7%, and ranged from 43.0 - 62.7%. This maximum is quite low, especially for a stream with elevated nutrients to fuel plant growth. It means that even when photosynthesis is occurring in the daytime, more oxygen is being used by decay bacteria working on organic material than is being produced by photosynthesis or diffusion of oxygen into the water from the atmosphere. These data suggest that there is limited eutrophication occurring in AUID-755.

Figure 1. Sonde DO measurements in Twelve Mile Creek at S001-968 in 2019. The red line is the DO standard.



Transparency and suspended solids

The TSS and/or Secchi tube readings at the biological sampling visits were excellent. The 10 samples collected by the District in 2017-2018 showed that TSS is often extremely low, with six of the samples below 10 mg/L, and as low as < 2 mg/L. However, TSS can get high, as two of the samples were 41 and 53 mg/L. This same pattern was found in the citizen monitoring transparency data collected in the early 2000s.

Conductivity

Specific conductivity was quite similar among the sampling visits, and similar to other sites in the NFCW. The level generally hovered around the 500 µS/cm. The measured levels should not be problematic for the fish or macroinvertebrate communities.

E. coli

The *E. coli* data for AUID-679 and -681 is present for 2017 and 2018.

The overall geometric mean of 15 samples for AUID-679, collected between June and August, is 650 orgs/100 ml.

The overall geometric mean of 17 samples for AUID-681, collected between June and August, is 221 orgs/100 ml.

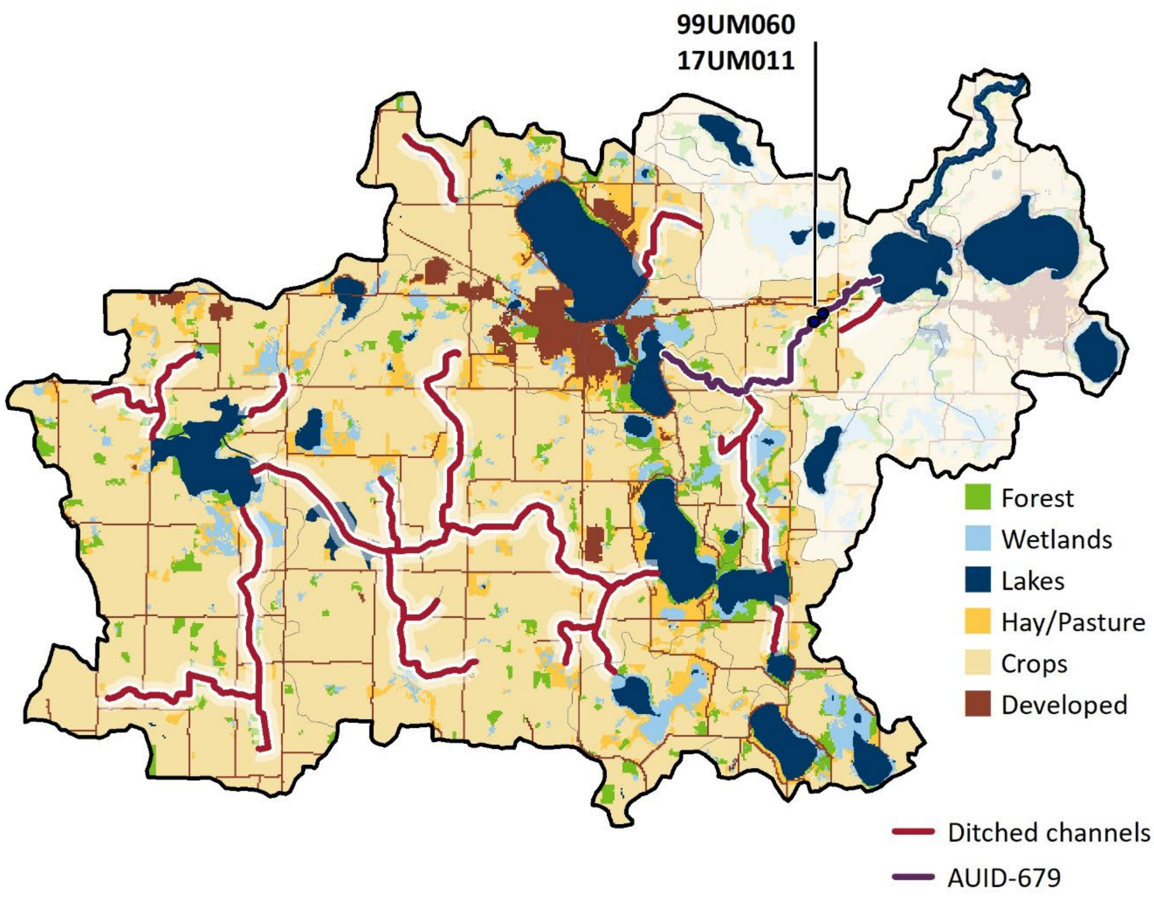
Biology

AUID-679 is an approximately 3.7 mile long reach beginning as the outflow of Dutch Lake and ending at the entrance to Little Waverly Lake. There have been two biological monitoring sites on this reach. An older site, 99UM060, was sampled in 1999, while a new site, 17UM011, was sampled in 2017. The sites are quite close to each other, just upstream of US Highway 12. Part of the AUID-679 channel has been straightened. The new site is on a natural part of the channel, and therefore, the site is held to the General Use standard. The AUID was assessed as having impairments of both the fish and macroinvertebrate communities. The Macroinvertebrate Stream Class is 5 (Southern Streams - RR), the Fish Stream Class is 6 (Northern Streams).

Sub-watershed characteristics

The middle portion of AUID-679 has been straightened, while the upper and lower parts have a natural, unmodified channel. Howard, Mallard Pass, and Dutch Lakes are the headwaters of Twelve Mile Creek. Numerous other smaller lakes spread throughout the subwatershed are connected via a ditch system that is tributary to Twelve Mile Creek, though are not surficially connected to Twelve Mile Creek. The land use/cover of the sub-watershed of AUID-679 is shown in Figure 2. The land use is predominantly row crop agriculture with lesser amounts of grassland/pasture and very little forest cover. The City of Howard Lake is just upstream of AUID-679, across Dutch Lake. There are no permitted effluent dischargers to AUID-679.

Figure 2. The subwatershed for Twelve Mile Creek and AUID-679



Data and Analyses

Chemistry

The chemistry sampled at biological monitoring visits and 2019 SID work is presented in Table 4. The 2019 data was collected a short distance downstream of the biological sample sites, (Figure 2). The Middle Fork Crow Watershed District collected water chemistry data a total of ten times in May - Sept. of 2017 and 2018. Data are discussed below by parameter.

Table 4. IWM chemistry results from 1999 (at 99UM060) and 2017 (at 17UM011).

Date	Time	Water Temp.	DO	DO %	Cond.	TP	Nitrate	Amm.	pH	Secchi (cm)	TSS	TSVS
7/7/1999	11:20	21.6	3.50	--	528	0.257	0.360	0.07	7.5	--	< 4.0	--
6/20/2017	14:10	20.7	6.72	75	522	0.179	0.244	< 0.1	7.5	> 100	3.2	--
9/13/2017	10:54	20.7	6.01	67	384	--	--	--	7.7	> 100	--	--
6/3/2019	15:45	20.4	6.92	76.5	509	--	--	--	--	--	--	--
6/4/2019	9:15	19.9	5.24	57.6	508	--	--	--	--	--	--	--
6/19/2019	9:00	19.2	6.30	68.2	493	--	--	--	7.6	--	--	--
7/2/2019	9:25	21.3	4.50	50.7	508	--	--	--	7.5	--	--	--
7/18/2019	12:00	25.8	3.13	38.1	473	--	--	--	7.5	--	--	--

County Ditch 10

County Ditch (CD) 10 is approximately 16.7 miles in length and located in the western part of the Twelve Mile Creek Watershed. The western-most branches of CD 10 drain into Grass Lake (43-0013), a Minnesota Department of Natural Resources (DNR)-designated public water. CD 10 continues past Grass Lake and outlets into Ann Lake (HUC 07010204, Lake ID 86-0190-00). Ann Lake is a 300+ acre lake, approximately 1 mile south of Howard Lake. Ann Lake is impaired for aquatic recreation due to nutrients/eutrophication. Ann Lake is connected to Lake Emma (HUC 07010204, Lake ID 86-0188-00) via a small channel. Lake Emma is also impaired for aquatic recreation due to nutrients/eutrophication. TMDLs have been completed for the lakes (Ann Lake and Lake Emma TMDL, 2011).

CD 10 brings nutrients, sediment, and high water volumes into Ann Lake and Lake Emma. Alternative side inlet control structures and buffer strips can reduce the amount of nutrients and sediment as well as slow the flow of water going into these impaired water bodies while also protecting against erosion and fulfilling landowner drainage needs.

Chemistry data for County Ditch 10 is all over 10 years old, and not particularly useful as a current baseline. However, averages for key parameters during the time period of record is summarized in Table 5. The 2002 data shown on the table above was taken as part of a fish kill investigation, and thus represents an atypical situation in the stream. The phosphorus data shown is over 10 years old, but is likely more representative of current conditions than the parameters measured only in 2002. The average total phosphorus is nearly 5 times over the impairment threshold.

Table 5. Water quality data summary for CD 10.

Sample years	# samples	Parameter	Average for time period	Current Standard
2002-2009	106	Total Phosphorus	.267 mg/l	.050 mg/1
2002	18	Total Suspended Solids	8.1 mg/l	10 mg/l
2002	10	*E. coli*	1988/100 ml	126/ 100 ml
2002	10	Dissolved Oxygen	4.894 mg/l	5 mg/l

Wetlands

Wetlands in the watershed range in size from small, isolated wetlands to the large Grass Lake wetland. Water quality data for the wetlands is limited in the watershed; however, many are degraded and likely discharge phosphorus to downstream lakes.

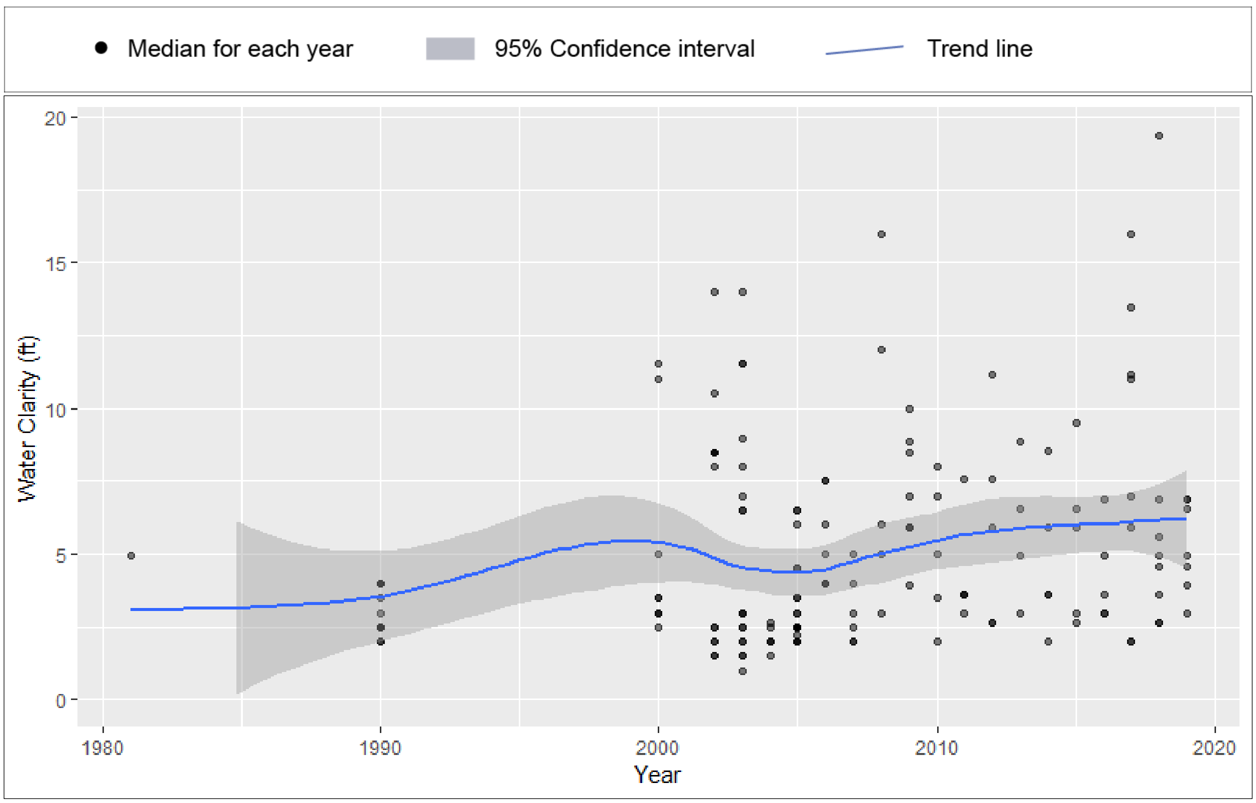
Lakes

Lake subwatershed information for individual lakes is available at the MPCA Water Quality Dashboard (https://webapp.pca.state.mn.us/wqd/surface-water). Most of the lakes within the Twelve Mile Creek HUC12 are described as "[n]ot always suitable for swimming and wading due to low clarity or excessive algae caused by the presence of nutrients such as phosphorus in the water. May not support a thriving community of fish and other aquatic organisms, as indicated by Fish bioassessments."

Howard Lake

Figure 3 illustrates the water clarity over time, with the gray shadowing indicating the range of likely clarity depths based on statistical analysis. Additional information is located at https://webapp.pca.state.mn.us/surface-water/impairment/86-0199-00.

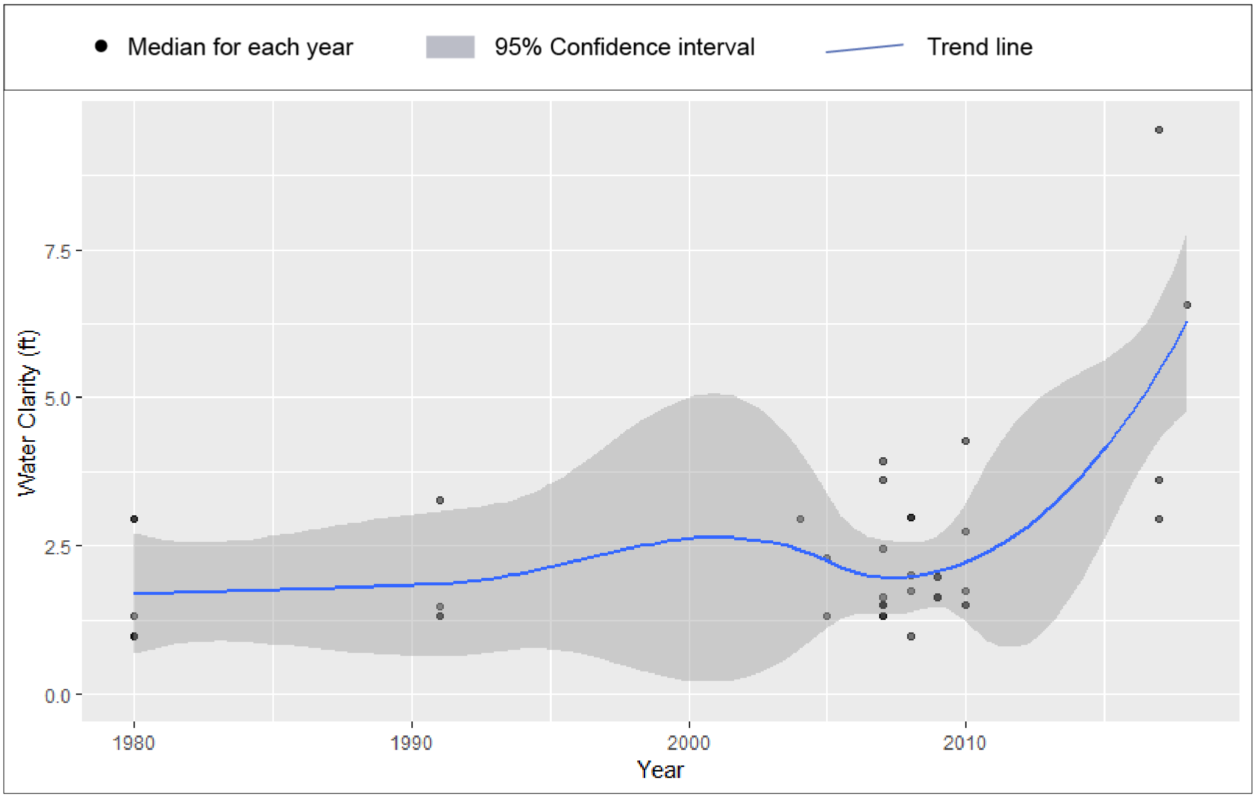
Figure 3. Water clarity trends for Howard Lake



Dutch Lake

Figure 4 illustrates the water clarity over time, with the gray shadowing indicating the range of likely clarity depths based on statistical analysis. Additional information is located at https://webapp.pca.state.mn.us/surf ace-water/impairment/86-0184-00.

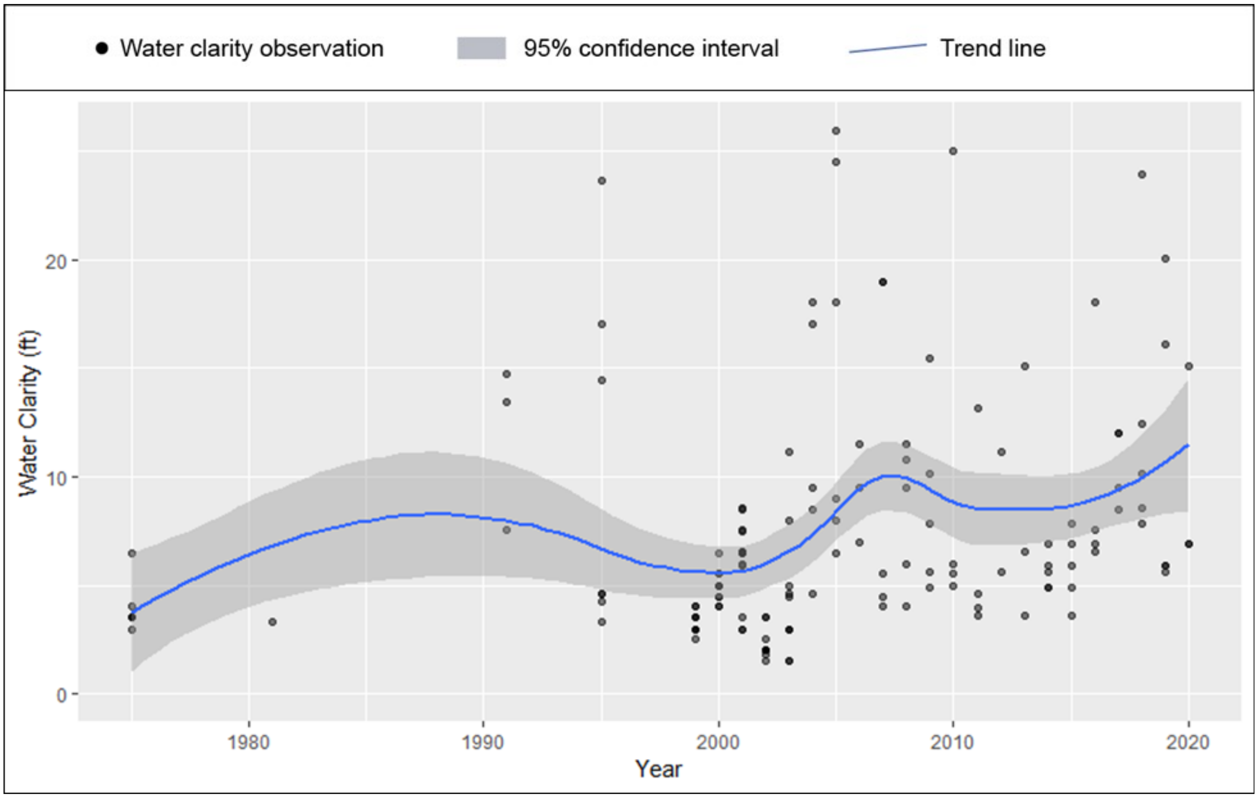
Figure 4. Water clarity trends for Dutch Lake



Waverly Lake

Figure 5 illustrates the water clarity over time, with the gray shadowing indicating the range of likely clarity depths based on statistical analysis. Additional information is located at https://webapp.pca.state.mn.us/surface-water/impairment/86-0114-00.

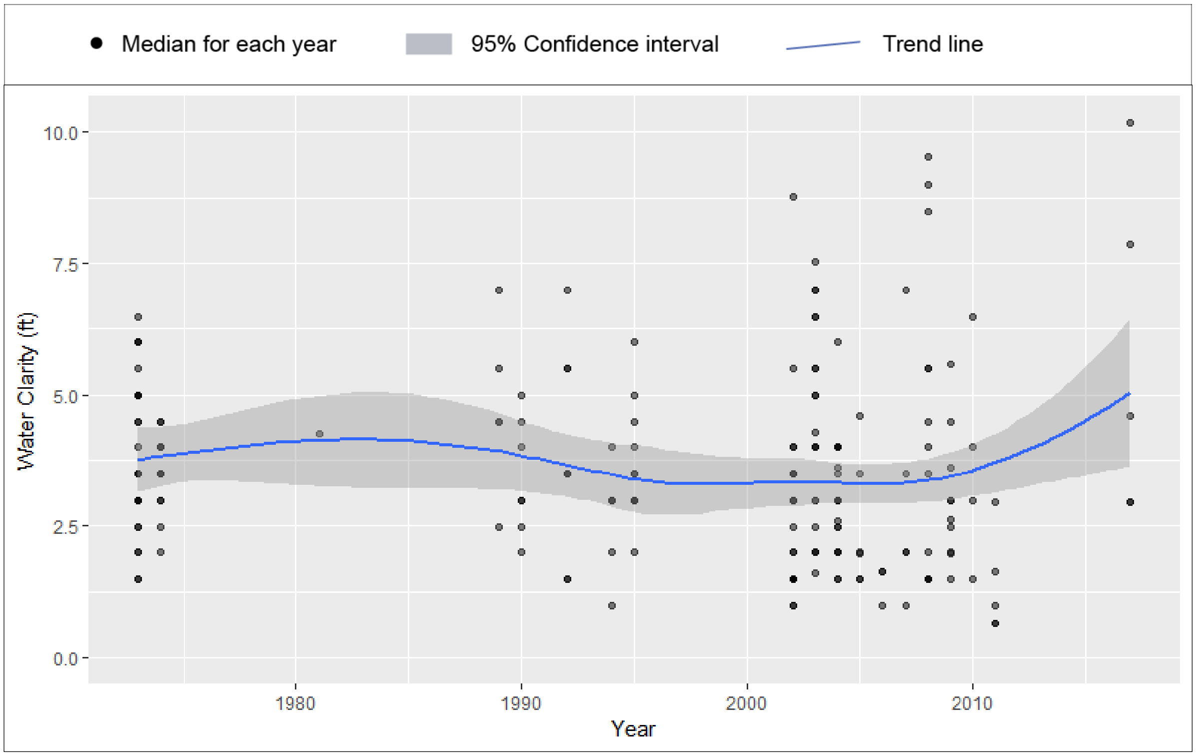
Figure 5. Water clarity trends for Waverly Lake



Little Waverly Lake

Figure 6 illustrates the water clarity over time, with the gray shadowing indicating the range of likely clarity depths based on statistical analysis. Additional information is located at https://webapp.pca.state.mn.us/surface-water/impairment/86-0106-00. Water samples were collected during the development of the Twelve Mile Creek TMDL and TP concentrations ranged from 48 to 1,150 µg/L.

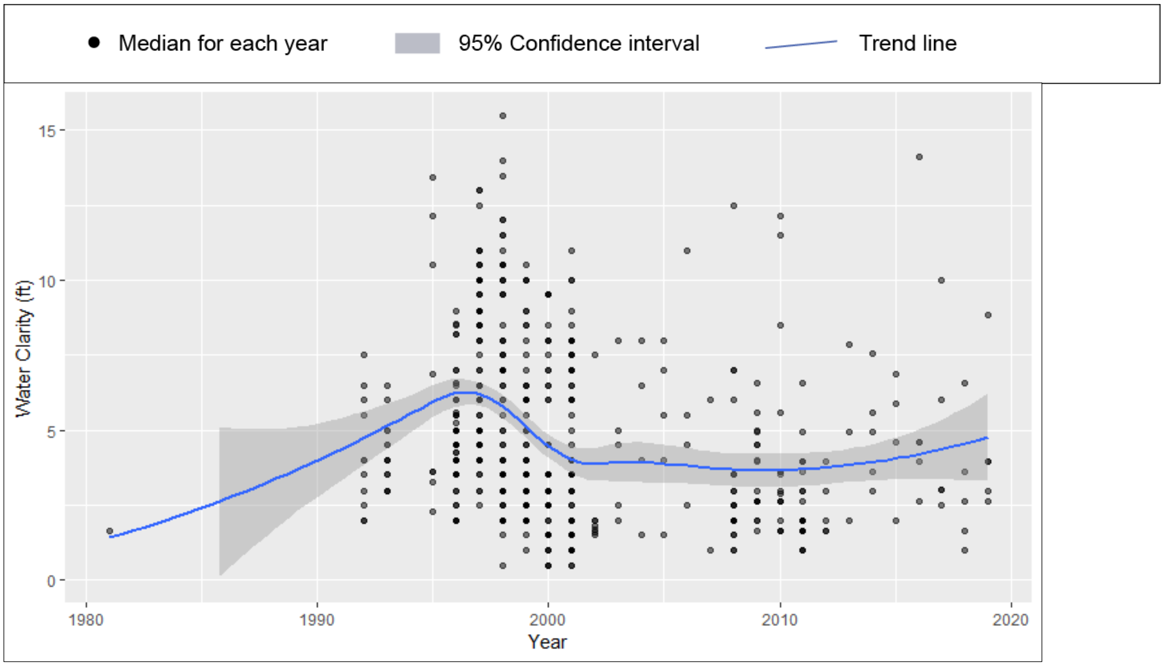
Figure 6. Water clarity trends for Little Waverly Lake



Ann Lake

Figure 7 illustrates the water clarity over time, with the gray shadowing indicating the range of likely clarity depths based on statistical analysis. Additional information is located at https://webapp.pca.state.mn.us/surface-water/impairment/86-0190-00.

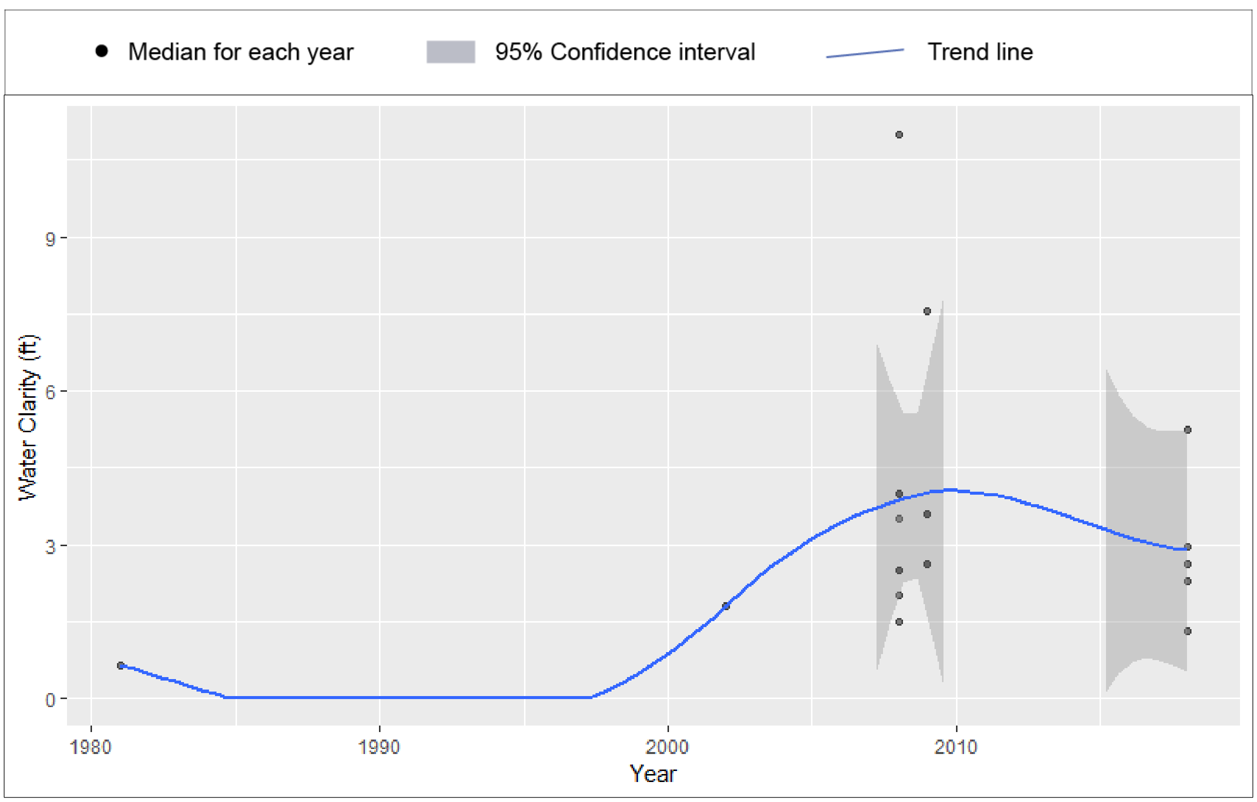
Figure 7. Water clarity trends for Ann Lake



Emma Lake

Figure 8 illustrates the water clarity over time, with the gray shadowing indicating the range of likely clarity depths based on statistical analysis. Additional information is located at https://webapp.pca.state.mn.us/surface-water/impairment/86-0188-00.

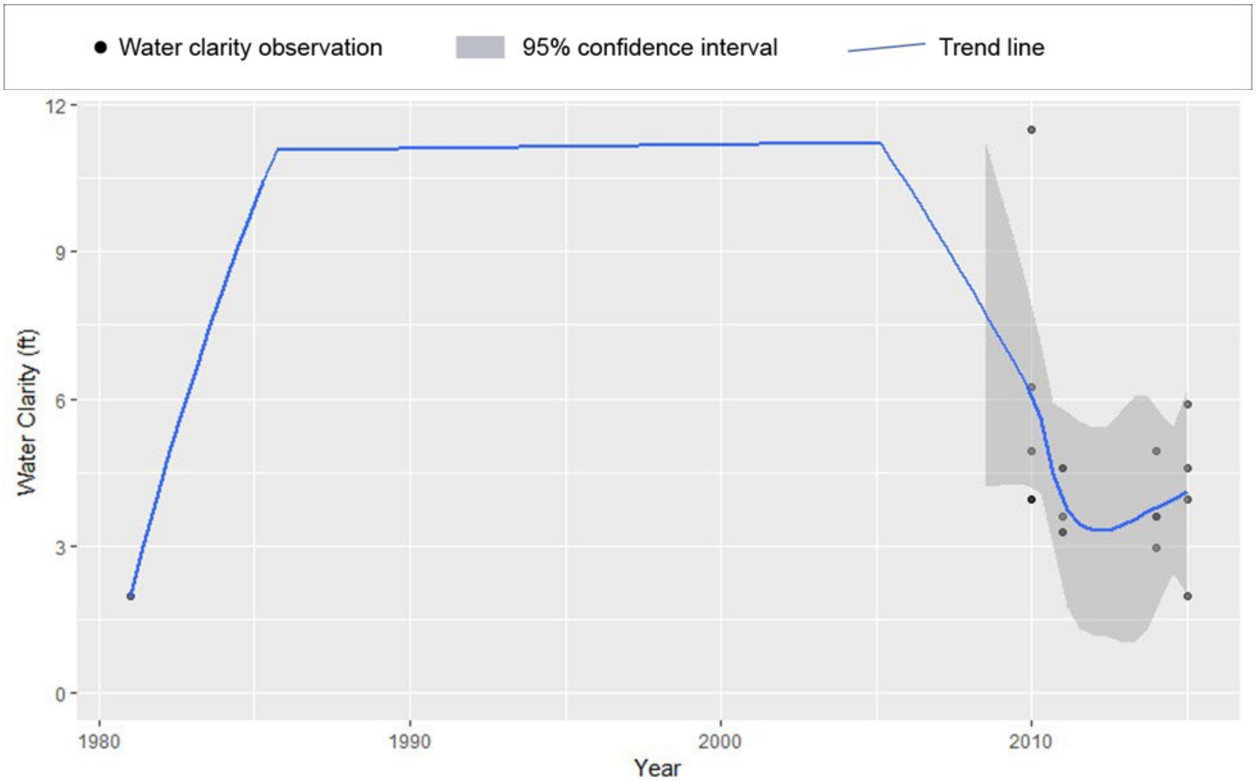
Figure 8. Water clarity trends for Emma Lake



Dog Lake

Figure 9 illustrates the water clarity over time, with the gray shadowing indicating the range of likely clarity depths based on statistical analysis. Additional information is located at https://webapp.pca.state.mn.us/surface-water/impairment/86-0178-00.

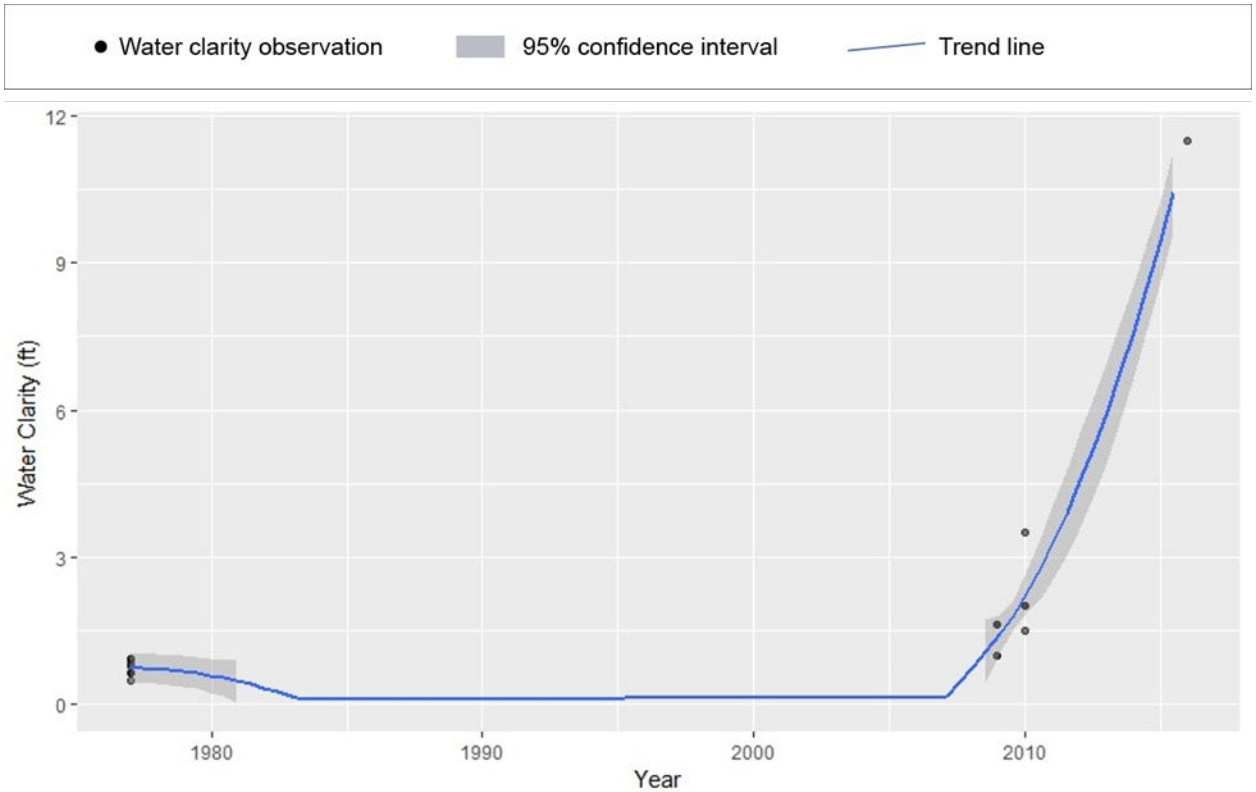
Figure 9. Water clarity trends for Dog Lake



Mary Lake

Figure 10 illustrates the water clarity over time, with the gray shadowing indicating the range of likely clarity depths based on statistical analysis. Additional information is located at https://webapp.pca.state.mn.us/surface-water/impairment/86-0139-02.

Figure 10. Water clarity trends for Mary Lake



Implementation strategies

The strategies, milestones, schedule, practice counts, goals, assessment criteria, and estimated costs for the Twelve Mile Creek HUC 12 Watershed are summarized in Table 6.

Table 6. Strategies, milestones, schedule, practice counts, goals, assessment criteria, and estimated costs for the Twelve Mile Creek Watershed HUC 12 Watershed

Table	Treatment type	Milestones					Total count practices	Total acres	Long term goals	Assessment criteria	Estimated cost
		2-year	4-year	6-year	8-year	10-year					
BMP	Construct water and sediment control basins (WASCOBs) (NRCS Code 638)	15	30	35	37	40	157	1570	To provide temporary water storage for 1,570 acres assuming 10 acres of drainage area per practice	# acres	$660,000
BMP	Construct Grassed Waterway (NRCS Code 412)	33	40	50	55	55	233	296	To provide erosion control on 296 acres of fields prone to gully erosion assuming 1.27 acres treated per grassed waterway	# acres	$932,000
BMP	Streambank Erosion Practices/Restoration		.75 mile		.75 mile				To provide streambank restoration for 1.5 miles of stream assuming two restorations at 0.75 mile each	# feet # miles	$1,000,000
BMP	Construct a farm pond (NRCS Code 378)			1			1	0.6	To provide temporary water storage and reduce sediment	# acres	$30,000
bmp	Construct Grade Stabilization Structures (NRSC Code 410)	3	3	4	4	4	18	11	To provide grade stabilization to stabilize channels to reduce erosion and nutrient runoff on 11 acres assuming 0.6 acre treated	# acres	$360,000
BMP	Construct open channels for flood prevention, drainage, wildlife habitat (NRCS Code 582)		1		1		2	1	To increase habitat, reduce channel erosion	# feet	$20,000
BMP	Construct Woodchip Bioreactors (NRCS Code 605)	5	10	10	14	15	54	3	To reduce TP and N loading	# acres # bioreactors	$2,700,000
BMP	Construct Iron and/or Limestone filters for phosphorus removal			1	1	1	3	3	To reduce TP loading	# acres	$150,000
BMP	SWCD Technical & Admin Assistance	0.25 FTE	0.25 FTE	0.25 FTE	0.25 FTE	0.25 FTE	1.25 TFE		To increase SWCD staff capacity in supporting landowner BMP implementation	# hours	$100,000
data	Inventory of abandoned/outdated wells	Landowner outreach	Landowner outreach	Complete inventory	Analysis & adjust plan as necessary					# landowners contacted # inventories completed	$10,000
data	Inventory of outdated SSTS	Landowner outreach	complete inventory	use information gathered to adjust plan as necessary						# landowners contacted # inventories completed	$10,000
data	Inventory of existing structural BMPS including operational status	remote spatial analysis to identify potential practices not in state database	field verify practices identified in remote analysis	Conduct driving/on site surveys of other potential BMPs not identified in remote analysis	Conduct driving/on site surveys of other potential BMPs not identified in remote analysis	Continue to maintain and add to database				# inventories # inspections # analysis	$50,000

Table	Treatment type	Milestones					Total count practices	Total acres	Long term goals	Assessment criteria	Estimated cost
		2-year	4-year	6-year	8-year	10-year					
data	Review waters not subject to buffer law to identify additional priority areas for which technical assistance can be provided to protect	remote spatial analysis to identify potential priority areas	field verify priority areas	Provide technical assistance to landowners interested in 33% of priority areas	Provide technical assistance to landowners interested in 33% of priority areas	Provide technical assistance to landowners interested in 33% of priority areas				Analysis completed # tech assistance % priority area addressed	$100,000
data	Continue regular inspection of projects receiving cost-share	conduct annual checks of BMPS constructed through federal, state and/or local cost-share during operational life of project	conduct annual checks of BMPS constructed through federal, state and/or local cost-share during operational life of project	conduct annual checks of BMPS constructed through federal, state and/or local cost-share during operational life of project	conduct annual checks of BMPS constructed through federal, state and/or local cost-share during operational life of project	conduct annual checks of BMPS constructed through federal, state and/or local cost-share during operational life of project				# inspections	$50,000
	Evaluate data inputs and update BATHTUB models for the lakes to improve the load estimates used in the lake TMDLs		Evaluate input data between watershed models, collect sediment P release data	Update BATHTUB models	Revise load reduction targets, if needed					# BATHTUB models updated	$20,000
data	SWCD Technical & Admin Assistance	0.1 FTE	0.1 FTE	0.1 FTE	0.1 FTE	0.1 FTE	1.0 FTE			# hours	$80,000
education	Promote conservation crop rotation	contact 5 producers of 1:1 conversations	contact 5 producers of 1:1 conversations	contact 5 producers of 1:1 conversations	contact 5 producers of 1:1 conversations	contact 5 producers of 1:1 conversations	25 producer 1:1s			# producers contacted	$15,000
education	Promote 5 soil health principles (soil armoring, minimizing soil disturbance, plant diversity, continual live plant/root, livestock integration) with demonstration site and field days	contact 3 producers of 1:1 conversations	contact 3 producers of 1:1 conversations	contact 3 producers of 1:1 conversations	contact 3 producers of 1:1 conversations	contact 3 producers of 1:1 conversations	15 producer 1:1s			# producers contacted	$7,000
education	Build relationships with small feedlot operators	1 1:1s	2 1:1s	4 1:1s	6 1:1s	7 1:1s	20 1:1s			# relationships built	$12,000
education	Identify a producer leader in the watershed to establish demonstration site	identify 2 producers/landowners, reach out to additional key producers/landowners	assist local champions in building relationships with other local producers	assist local champions in building relationships with other local producers	assist local champions in building relationships with other local producers	assist local champions in building relationships with other local producers	2 strong peer demonstration partners			# producers identified # championing events	$5,000
education	Host field day events	1 field day	1 field day	1 field day	1 field day	1 field day	5 field days			# field days	$15,000

Table	Treatment type	Milestones 2-year	4-year	6-year	8-year	10-year	Total count practices	Total acres	Long term goals	Assessment criteria	Estimated cost
education	Producer-leader demonstration site/field trials		establish 2 demonstration sites	establish 2 demonstration sites	establish 2 demonstration sites	establish 2 demonstration sites	8 demo sites			# demonstration sites	$50,000
education	conduct outreach with landowners and area youth regarding soil health	conduct 2 events annually reaching landowners and/or area youth	conduct 2 events annually reaching landowners and/or area youth	conduct 2 events annually reaching landowners and/or area youth	conduct 2 events annually reaching landowners and/or area youth	conduct 2 events annually reaching landowners and/or area youth	10 soil health events			# events # new attendees	$30,000
education	Distribute information materials increasing resident awareness of groundwater issues, testing and best practices	2 newspaper articles/podcast/radio contributions	2 newspaper articles/podcast/radio contributions	2 newspaper articles/podcast/radio contributions	2 newspaper articles/podcast/radio contributions	2 newspaper articles/podcast/radio contributions	10 news articles/ podcast/ radio contributions			# articles/podcast/radio spots	$1,000
education	Promote enrollment in conservation programs and protection of biologically significant elements in the watershed through distribution of educational materials	2 newspaper articles/podcast/radio contributions	2 newspaper articles/podcast/radio contributions	2 newspaper articles/podcast/radio contributions	2 newspaper articles/podcast/radio contributions	2 newspaper articles/podcast/radio contributions				# articles/podcast/radio spots	$1,000
education	Work with agriculture retailers and crop consultants on workshops/field days/other outreach activities	1 outreach event	1 outreach event	1 outreach event	1 outreach event	1 outreach event				# events # new attendees	$5,000
education	Conduct field walkovers, tech support, kitchen-table meetings	15	15	15	15	15	150		To build trusted relationships with landowners and provide technical advice when issues identified	# walkovers # kitchen table meetings # tech support meetings	$125,000
education	SWCD Technical & Admin Assistance	0.1 FTE	0.1 FTE	0.1 FTE	0.1 FTE	0.1 FTE	1.0 FTE		To support the SWCD's outreach program in Twelve Mile Creek HUC 12 Watershed	# hours	$80,000
Management	Develop site specific nutrient management plans (NRCS Code 590)	31	35	35	35	35	171	4275	Complete nutrient management plans for 4,275 acres to optimize nutrient application for crops and minimize nutrient loss to water.	# plans # acres	$64,000
Management	Increase and incentivize gridded soil sampling to guide precision nutrient application	2	4	6	8	10	30	120	Conduct gridded soil sampling on 120 acres for use in determining optimal nutrient application rates.	# producers soil sampling	$15,000
Management	Increase and incentivize Residue and Tillage Management Reduced Till (NRCS Code 345)	30	35	45	50	54	214	7648	Reduce tillage on 7,648 acres to reduce erosion and nutrient loss from cropland.	# acres	$76,500
Management	Increase and incentivize Residue and Tillage Management, No Till (NRCS Code 329)	45	50	52	55	60	262	9836	Reduce tillage on 9,836 acres to reduce erosion and nutrient loss from cropland.	# acres	$98,500
Management	Increase and incentivize conservation crop rotation (NRCS Code 328)	20	25	30	35	40	150	4500	Increase the use of conservation crop rotations on 4,500 acres of cropland to reduce erosion and nutrient runoff	# acres	$45,000

Table	Treatment type	Milestones					Total count practices	Total acres	Long term goals	Assessment criteria	Estimated cost
		2-year	4-year	6-year	8-year	10-year					
Management	Land retirement-Conservation Cover (NRCS Code 327)	1	1	2	2	2	8	80	To permanently add perennial cover to decrease erosion and nutrient loss	# acres	$800
Management	Cover Crop (NRCS Code 340)	35	40	50	55	59	239	8925	Increase the use of cover crops and improve soil health	# acres	$90,000
Management	Land retirement-Pasture (NRCS Code 528)	10	10	14	15	15	64	22	Remove critical source areas within pasture	# acres	$1,100
Management	Implement field Borders, Vegetative Barriers, forest Edge Buffers, or Filter Strips at edge of field (NRCS Code 386, 601, 393)	50	60	62	75	75	322	271	Reduce sediment and nutrient runoff from fields	# acres # feet	$85,000
Management	Increase the enrollment of floodplain lands in RIM, CREP, similar programs (Critical Area Planting) (NRCS Code 342)	25	35	50	50	51	211	421	To plant/seed critical loading areas in the floodplains	# acres	$84,000
Management	Establish riparian herbaceous cover (NRCS code 390)	10	20	24	25	25	104	15	To plant/seed riparian areas to reduce nutrient and sediment runoff	# acres	$4,500
Management	Construct Drainage water management systems (NRCS Code 554)	2	2	3	3	5	15	185	Temporary water storage	# acres # drainage systems	$1,900
Management	Implement streambank and shoreline protection strategies (NRCS code 580)	15	25	25	30	34	129	99	Protection of natural streambank and shoreline	# feet # acres	$225,000
BMP	Construct Saturated Buffer Strips (NRCS code 604)	10	15	17	20	25	87	100	Reduce TP and nitrates in field runoff	# feet # acres	$75,000
Management	Grazing Land Management (rotational grazing)	50	75	75	150	150		500	Reducing sediment, nutrient, and bacteria runoff	#acres	$10,000
Management	Alternative Water supply/Livestock Pipeline (NRCS Code 516)	50	75	75	150	150		500	Reducing sediment, nutrient, and bacteria runoff	# acres	$10,000
Management	Heavy Use Area Protection (NRCS Code 561)	1	2	2	2	3	10		Reducing sediment, nutrient, and bacteria runoff	# acres	$5,000
Management	Pasture & Hayland Planting (NRCS Code 550)	50	75	75	150	150		500	Reducing sediment, nutrient, and bacteria runoff	# acres	$5,000
Management	Livestock Exclusion Fencing (NRCS Code 382)	10	15	20	25	30		100	Reducing sediment, nutrient, and bacteria runoff	# feet # acres	$30,000
Management	Provide financial assistance for installation of Livestock Waste Handling (Livestock Waste Storage Facilities NRCS: 313, Waste Treatment Lagoons NRCS: 359, Manure Water Treatment NRCS: 629)	1	1	1	1	1	5		Manure management to reduce nutrient and bacteria runoff	# fixes	$200,000
Management	Promote Filter Strips around feedlots (NRCS Code 393)	10	15	20	25	30	100		Manure management to reduce nutrient and bacteria runoff	# filters # feet # acres	$10,000

Table	Treatment type	Milestones					Total count practices	Total acres	Long term goals	Assessment criteria	Estimated cost
		2-year	4-year	6-year	8-year	10-year					
Management	Provide financial assistance for small feedlot fixes/improvements (Water Facility NRCS: 614, Fence NRCS: 382, Filter Strip NRCS: 393, Vegetated Treatment Area NRCS: 635, Stormwater Runoff Control NRCS: 570, Livestock Shelter Structure NRCS: 576)	1	2	3	4	5	15		Manure management to reduce nutrient and bacteria runoff	# fixes	$150,000
Management	Promote Forage and Biomass Planting, Range Planting (NRCS Code: 512, 550)	75	100	148	150	150	623	950	Increase soil health and reduce nutrient and sediment runoff	# acres	$95,000
Management	Provide financial assistance for Well Decommissioning (NRCS Code 351)	2	4	6	8	10	30		Protect groundwater from intrusion of nutrients and bacteria	# wells	$15,000
Management	Provide financial assistance for septic upgrades	10	15	25	35	40	100		Reduce nutrient and bacteria discharge to protect human health	# SSTS upgrades	$2,000,000
Management	Continue invasive species monitoring and control	Annual monitoring at recreational access areas	Annual monitoring at recreational access areas	Annual monitoring at recreational access areas	Annual monitoring at recreational access areas	Annual monitoring at recreational access areas	10		Prevent the spread/infestation of invasive species	# acres # species	$100,000
Management	Promote enrollment in the Minnesota Agricultural Water Quality Certification Program	5	5	5	5	5	25		Increase farmer participation in water quality activities	# enrollees	$10,000
Management	SWCD Technical and Admin Assistance	0.25 FTE	0.25 FTE	0.25 FTE	0.25 FTE	0.25 FTE	1.25 FTE			# hours	$100,000
monitoring	Continue edge of field water quality monitoring at Discovery Farm site to quantify effect of management practices	Continue monitoring, cooperate with farmer to evaluate which practices should be assessed on plot	Continue monitoring, cooperate with farmer to evaluate which practices should be assessed on plot	Continue monitoring, cooperate with farmer to evaluate which practices should be assessed on plot	Continue monitoring, cooperate with farmer to evaluate which practices should be assessed on plot	Continue monitoring, cooperate with farmer to evaluate which practices should be assessed on plot			Evaluate effectiveness BMPs at edge-of-field	# samples # fields # parameters	$200,000
monitoring	Monitor private groundwater wells for nitrate, bacteria, arsenic and other emerging contaminants to characterize effectiveness of implementation	10	15	20	25	30	100		Understand the trends of water chemistry in private wells	# wells # tests	$25,000
monitoring	Promote citizen lake monitoring on all lakes (current volunteers on Howard, Ann, Mary, and Waverly; volunteers needed (Dutch, Little Waverly, Emma, and Dog)	Recruit/retain 20 volunteers	Recruit/retain 20 volunteers	Recruit/retai n 20 volunteers	Recruit/retai n 20 volunteers	Recruit/retain 20 volunteers			Build and maintain citizen volunteer monitoring and interest in the watershed	# citizens # monitoring	$10,000
monitoring	Conduct water quality and stream flow monitoring at up to six stream sites along Twelve Mile Creek,	Conduct monitoring per element i	Conduct monitoring per element i	Conduct monitoring per element i	Conduct monitoring per element i	Conduct monitoring per element i				# sites # samples	$180,000

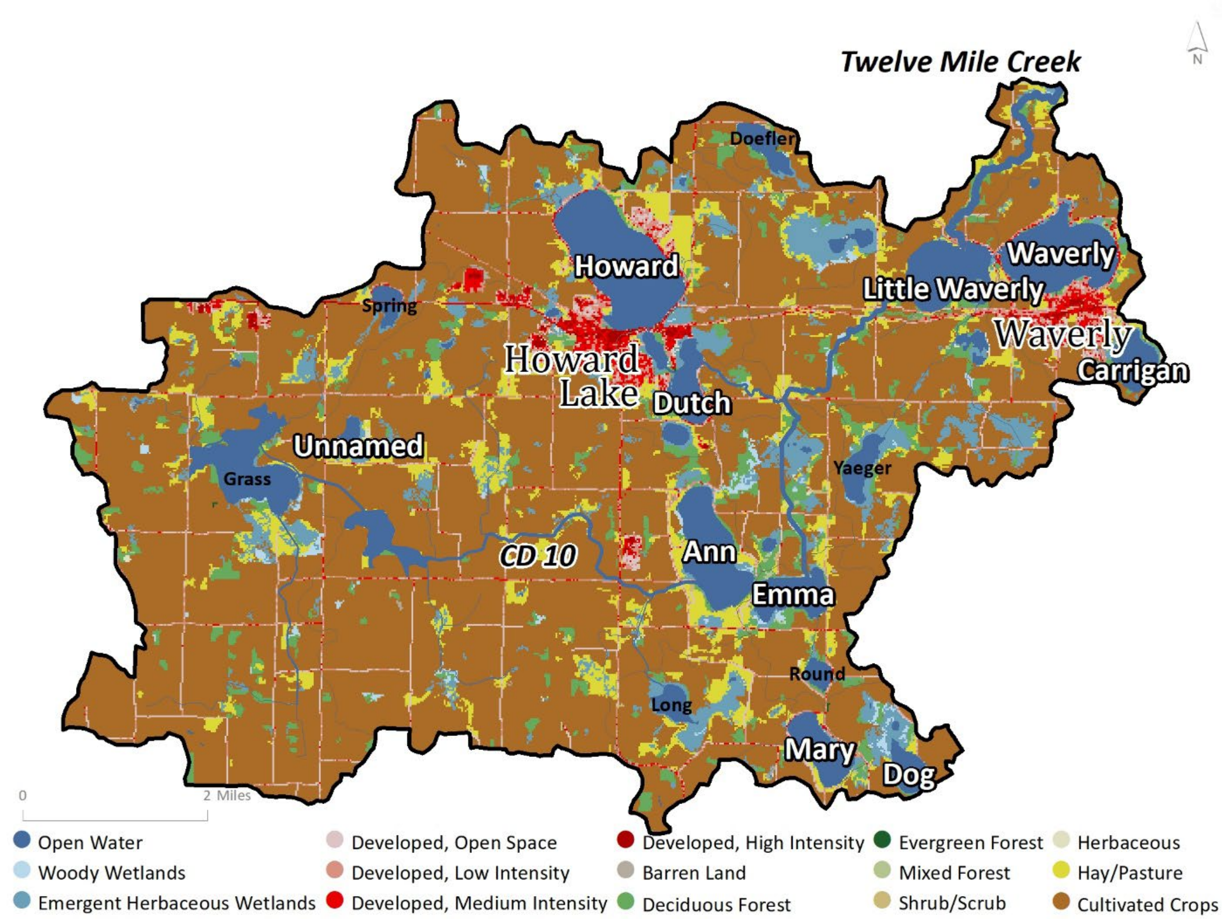
Table	Treatment type	Milestones 2-year	4-year	6-year	8-year	10-year	Total count practices	Total acres	Long term goals	Assessment criteria	Estimated cost
	a tributary, and CD 10 to evaluate the effectiveness of implemented BMPs										
monitoring	Conduct lake monitoring program for the lake in the watershed	Conduct monitoring per element i	Conduct monitoring per element i	Conduct monitoring per element i	Conduct monitoring per element i	Conduct monitoring per element i				# lakes monitored # samples collected and analyzed	$100,000
monitoring	Conduct performance evaluation monitoring for new BMPs practices (e.g., limestone filters)	Conduct monitoring per element i	Conduct monitoring per element i	Conduct monitoring per element i	Conduct monitoring per element i	Conduct monitoring per element i				# samples collected and analyzed	$200,000
monitoring	SWCD Technical & Admin Assistance	0.1 FTE	0.1 FTE	0.1 FTE	0.1 FTE	0.1 FTE	1.0 FTE			# hours	$80,000
monitoring	SWCD Technical & Admin Assistance	0.1 FTE	0.1 FTE	0.1 FTE	0.1 FTE	0.1 FTE	1.0 FTE			# hours	$80,000
Urban/ developed	urban stormwater bioretention practices	10	15	20	25	30	100		To reduce sediment, nutrient, and bacteria in stormwater runoff	# practices	$500,000
	urban stormwater filtration practices	1	1	2	3	3	10		To reduce sediment, nutrient, and bacterial runoff in stormwater runoff	# practices	$15,000
	urban stormwater impervious cover reduction	1	1	2	3	3	10		To reduce sediment, nutrient, and bacteria in stormwater runoff	# practices	$15,000
	Urban stormwater install permeable surface	1	1	2	3	3	10		To reduce sediment, nutrient and bacteria in stormwater runoff	# practices	$15,000
	urban stormwater install vegetated swale	2	2	4	6	6	20		To reduce sediment, nutrient, and bacteria in stormwater runoff	# acres # feet	$15,000
	rough fish barriers	1 barrier	1 barrier	2 barriers	evaluate and maintenance	evaluate and maintenance	4 barriers		Prevent migration of rough fish in the lakes	# barriers	$20,000
	rough fish harvest	1 harvest	1 harvest	1 harvest	1 harvest	1 harvest	5 harvests		Removal of rough fish	# pounds fish	$75,000
	Alum treatments					5	5 treatment s		Bind P to sediment, reducing internal loads	# treatments # gallons	$1,000,000
	Silva Cell Systems	2 cells	2 cells	2 cells	2 cells	2 cells	10 cells		To reduce sediment, nutrient, and bacteria in stormwater runoff	# cells	$100,000

Element a. Sources

> *An identification of the causes and sources or groups of similar sources that will need to be controlled to achieve the load reductions estimated in this watershed-based plan (and to achieve any other watershed goals identified in the watershed-based plan), as discussed in item (b) immediately below. Sources that need to be controlled should be identified at the significant subcategory level with estimates of the extent to which they are present in the watershed (e.g., X numbers of dairy cattle feedlots needing upgrading, including a rough estimate of the number of cattle per facility; Y acres of row crops needing improved nutrient management or sediment control; or Z linear miles of eroded streambank needing remediation).*
>
> *EPA Handbook for Restoring and Protecting Our Waters*

The Twelve Mile Creek HUC 12 Watershed (070102040605) is approximately 38,948 acres in size. Originally Hardwood forest dominated (Marschner), approximately 71.4% is now being used for agriculture, 4.9% is developed, 7.5% is wetland, 8.7 % is open water, and 4.9% is forested (Figure 11). Approximately 6.7% is impervious surface (DNR Watershed Health Assessment Framework). The primary surface water flowage in this watershed begins Grass Lake, (County Ditch 10), then flows to Ann, then Emma, into Twelve Mile Creek, then to Little Waverly. Howard and Dutch are connected via unnamed creek to Twelve Mile Creek between Emma and Little Waverly. Big Waverly and Little Waverly are connected by a small channel, which can flow in either direction depending on water levels, but generally Big Waverly flows to Little Waverly and out of Little Waverly to the North Fork Crow River, which eventually empties into the Mississippi River outside of the Twelve Mile subwatershed. Each of these lakes contributes water to the North Fork Crow River and the Mississippi River from this system.

Figure 11. Land Use/Land Cover in the Twelve Mile Creek Watershed



The nutrient contributions to each lake in the Twelve Mile Creek HUC12 watershed are described in Table 7.

Table 7. Nutrient sources for lakes in the Waverly Chain of Lakes (TMDL NFC)

Lake	Drainage areas	SSTS	Upstream lakes	Atmosphere	Internal load
Howard	26%	3%	--	4%	67%
Dutch	33%	8%	1%	2%	56%
Waverly	37%	15%	3%	8%	37%
Little Waverly	22%	23%	2%	1%	52%

Agriculture

The agriculture in the watershed is comprised of 42.8% Corn, 40% soybeans, beans, and peas, 15.7% hay and forage, and 1.5% miscellaneous other crops (CDL, 2018). Erosion of farmland soils has been a significant problem for farmers in this watershed for decades and the eroded soils are typically carried to surface waters, bringing attached nutrients with them. Agricultural lands, when not mitigated, create significant potential for impact to surface waters by exposing vast amounts of soil to wind and water erosion. When fertilizers or pesticides are added to the soils, these chemicals are carried with eroded soil into adjacent or connected waters, causing contamination of those waters with sediment, pesticides (including aquatic toxins such as chlorothalonil, and possible carcinogens such as chlorpyifos), nitrates, phosphates, chlorides, and other related chemicals. The activity of clearing land of native vegetation to plant domestic crops also enables the establishment of invasive species of terrestrial plants, many of which have allelopathic characteristics, enabling the plants to release chemicals that kill adjacent native vegetation and prevent it from germinating again. Without native vegetation to hold soil together, it becomes more susceptible to erosion. Erosion of organic material in soil, in turn, reduces the water holding capacity of soils, leading to increased runoff. Animal agriculture is also a significant part of the land use in the Twelve Mile creek watershed. Currently, there are 11 feedlots in the watershed that are required to be registered, but these only account for a percentage of the animal units actually present in the watershed. The following table is based on the best available data estimating animal units for each priority lake shed in the Twelve Mile Subwatershed.

Table 8. Estimated animal units by animal type and lakeshed

Animal Species	Ann Lake	Grass Lake	Little Waverly	Howard Lake	Waverly Lake	Dutch Lake	Emma Lake	12 Mile only
Cattle	1295.3	870.1	1463	412.6	11.9	936.8	814.1	381.1
Swine	23.5		38					
Horse	6.6		41.4	3			1	
Chicken	0.15	9315.14	0.045					0.429
Turkey	455.5	0.023	336	693.5				
Elk	116.2							
Llama			0.3					
Sheep		5	3.5	14.3				
Total AU	**1897.6**	**10190.3**	**1882.4**	**1123.4**	**11.9**	**936.8**	**815.1**	**381.6**

Manure and land alteration resulting from the livestock agriculture in the watershed contribute phosphorus, nitrogen, and *E.coli*, as well as other nutrients and pesticides to both ground and surface water. Their presence on the landscape compacts soils, increasing the likelihood that contaminants run off of the landscape and directly into surface waters. Trampling of stream bank vegetation leads to significant bank erosion and sediment transport into streams, which affects stream biology and flow.

Agricultural BMPs to mitigate for crop and animal impacts, such as crop rotation, nutrient management, drainage water management, and others can be found in the 2014 guide "Minnesota Nutrient Reduction Strategy"(https://www.pca.state.mn.us/water/minnesota-nutrient-reduction-strategy). Invasive species is a prevalent problem across this entire specifies. Most of the invasive species are very leggy with few leaves, without much leaf cover, which do not slow the rainfall from hitting the field. Further, the allelopathic tendencies of these plants leave more soil exposed and vulnerable to erosion. The presence of the invasive species are found frequently across the HUC 12 agricultural area.

Modern agricultural practices contribute to increased runoff into lakes and streams through increased hydrologic connections to surface waters with drainage ditches and tile along with extended periods of exposed soils between crops covering the soil surface and reduced water holding capacities in soils with decreased organic matter. Soil erosion from fields occurs with spring runoff and precipitation events when the soil is not protected and streambank and instream erosion increases with elevated stream flows from the agricultural drainage systems and increasing storm events.

Ditch banks are susceptible to erosion with elevated flows, bank slumps and failures, and unprotected tile outlets. Steep slide slopes and groundwater seepage through the ditch banks can result in ditch failures (Figure 13). Often observed examples of poorly maintained ditches are excessively steep side slopes, or failure.

Minnesota drainage law (Minn. Stat. ch. 103E) provides for regular inspections and repair of public drainage ditches; however, the deterioration of drainage systems is inevitable. Many drainage systems are not sufficiently maintained for reasons such as inadequate inspection, lack of a maintenance schedule, limited repair funds due to need of redetermination, or difficult accessibility. Under statute, the word repair has a specific meaning and is similar to what is commonly thought of as maintenance. Repair, for the purposes of this plan will use the statute definition of "restore all or a part of a drainage system as nearly as practicable to the same hydraulic capacity as originally constructed and subsequently improved…" and will be synonymous with maintenance.

Ditch repair often involves a clean out of the ditch channel to its original shape; however, the clean outs can result in a quick deterioration of the ditch banks through bank erosion and sloughing and channel sedimentation if bank slopes are not stabilized. Drainage law does provide for ditch repairs to use BMPs that increase the longevity of the drainage system while also reducing erosion and bank failures, decreasing sediment and nutrient loading, increasing in-channel storage, and increasing aquatic life habitat. It is important to coordinate ditch maintenance with other watershed work. Ditch maintenance was recently completed on a portion of CD10.

Figure 12. Poorly implemented ditch maintenance often contributes to increased sediment transport to downstream surface waters. Ditches also carry fertilizers, pesticides, and other chemicals harmful to lakes and streams.

Urban areas

Stormwater runoff from impervious surfaces in urban areas increase runoff rates carrying TSS and nutrients to lakes and streams. Most of the impervious surface in the watershed is concentrated in the cities of Waverly and Howard Lake near Little Waverly Lake, Waverly Lake, and Howard Lake. The only other concentration of impervious surface in the watershed is at the Howard Lake/Waverly/Winsted High School, located just west of Ann Lake. Runoff and nutrients come from lawns, compacted soils, and hard surfaces including roads, roofs, patios, and sidewalks.

Wooded areas

Although wooded areas only encompass five percent of the watershed, most are unhealthy forested systems that can be susceptible to increased runoff. Field examinations of forested areas in this watershed indicate that expected understory vegetation in natural mixed hardwood forests is severely degraded to non-existent throughout the watershed. Many areas are infested with buckthorn, an allelopathic invasive species of small tree that creates and spreads toxins that prevent other plants from germinating and growing. Invasive earthworms, which have been shown to reduce or eliminate the duff layer in forests, may also be present. The result is that soils in forested areas are bare of vegetation and compacted, substantially reducing the water holding capacity and the ability of the forest soils to infiltrate water. In contrast to healthy forested systems, forested areas adjacent to water bodies may actually be contributing to water quality degradation in this watershed instead of protecting against it given their poor ecological condition.

Figure 13. Buckthorn growth in both the canopy and understory of wooded systems has reduced diversity and undermined the ecological function of many areas that might otherwise protect water quality.

Lake shoreline

Development along the lake shores has resulted in little natural vegetation along the shorelines. The shoreline of several of the lakes includes grass lawns, riprapped shorelines, and a lack of aquatic vegetation due to removal practices. These combine to reduce the filtering capacity of the shoreline for sediment and nutrients resulting in increased loads. Dock density is frequently high, which creates conditions where fish and macroinvertebrate IBI scores are lower than expected. Wooded areas in residential areas were frequently degraded with buckthorn and other invasive species reducing the quantity and quality of native vegetation.

Dog Lake represents a more natural shoreline condition with much of its emergent near-shore vegetation still intact. Although the lake is impaired for nutrients, the lake was observed to remarkably clear on a hot, windy day when nearby lakes were green with algae. The drainage area of the lake is similar to the area lakes with agriculture being predominate, but only has four houses along its shore. It provides a good example of the importance of maintaining shoreline vegetation that could be used for public education.

Figure 14. Dog Lake, located at the southeastern tip of the watershed, has maintained good clarity despite its size and proximity to substantial agricultural acreage. This is likely a result of a strong buffer of aquatic and terrestrial vegetation around the perimeter of the lake.

Agricultural and urban land uses contribute to significant quantities of poor quality runoff. Some of the most degraded waters in the watershed combine characteristics of residential development, degraded forests, and agriculture draining to the same water body, as the channel between Waverly and Little Waverly Lakes demonstrates (Figure 16).

Figure 15. This algae-clogged channel between Waverly and Little Waverly Lakes demonstrates the effects of multiple landscape contributors to degradation of water quality.

Wetlands

Wetlands can function as both water quality treatment and as a source of pollutants. Wetlands in the watershed are primarily shallow marsh and open water systems. In many instances, these systems flow from basin to basin, providing a network of surface water movement that allows for transport of nutrients, sediment, and other contaminants throughout the watershed. Wetlands have frequently been degraded through drainage for agricultural production. These wetlands are apt to be sources of pollution. Protection of naturally functioning wetlands and the restoration of degraded or drained wetlands is equally as important as protecting or restoring streams or lakes.

As wetlands become saturated with nutrients or contaminants, or as flow regimes change and wetlands flush more quickly than they have historically, the management of wetlands becomes complex. It is difficult to balance what appears to be conflicting data: the known benefits of wetlands (filtering, storage, habitat, etc.) and the evidence that, in many cases, they are responsible for exporting nutrients and sediment that contribute to the degradation of waters downstream (Figure 17).

Figure 16. Wetlands in the Twelve Mile Creek Watershed have been identified as collectors of nutrients and other toxins that outlet those contaminants into lakes and rivers.

Soils

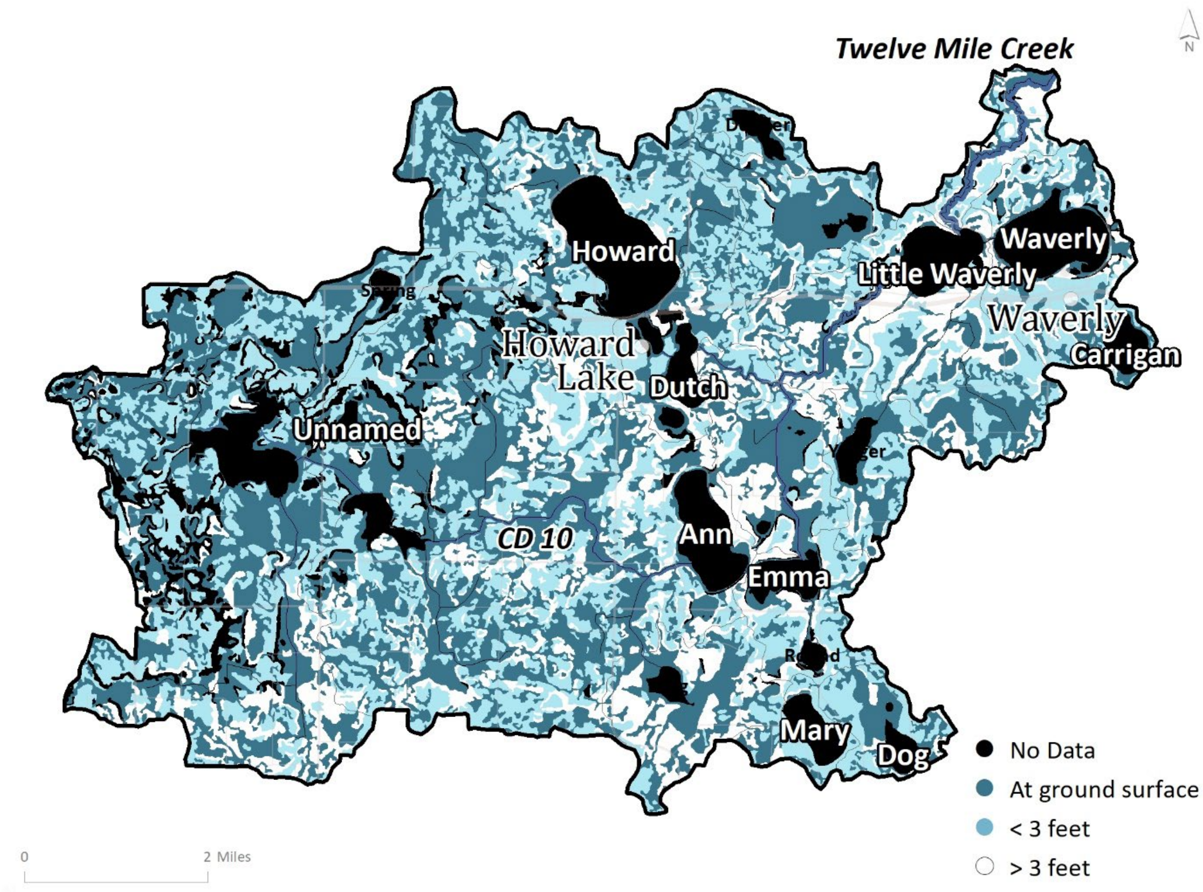
The types of soil in the watershed affect the nutrient and erosion potential from the landscape. Soils with high clay content can, under the right circumstances, be eroded more easily under wet conditions than under sandier soils; particularly in frozen conditions where clay soils are suddenly exposed to high volumes of runoff water. This has been observed by MPCA staff over the course of thousands of stormwater inspections involving a multitude of conditions. Field examination particularly at WASCOB sites indicates a higher clay content than generally identified in the county soil survey. USGS data also indicates that most soils in this watershed are "poorly drained," which generally indicates higher clay content.

Sheet erosion and resulting soil loss are a significant problem for both farmers and water quality in the watershed. Evidence of sediment transport off of row-cropped agricultural sites in the watershed was common, and especially in areas where BMPs were not present. This situation is compounded by the fact that much of the agriculture in the watershed is located immediately adjacent to connected wetlands, ditches, streams, lakes, or impervious surfaces draining to the aforementioned features.

Soils with lower clay components have higher infiltration capacities. Higher infiltration capacities come with increased risk for groundwater contamination.

The depth-to-groundwater is predominantly 0 to 10 feet in depth in over 90% of the watershed (Figure 18). The shallow depth-to-groundwater in an agricultural watershed results in groundwater being susceptible to contamination from agricultural fertilizers and pesticides.

Figure 17. Depth to groundwater in the Twelve Mile Creek Watershed



Climate and Precipitation

The region has a continental climate, marked by warm summers and cold winters. The mean annual temperature for Minnesota is 40.1 degrees Fahrenheit, the mean summer temperature for the North Fork Crow River Watershed (per the DNR Watershed Health Assessment Framework (WHAF)) is 68.8 degrees Fahrenheit, and the mean winter temperature is 15.8 degrees Fahrenheit.

The Twelve Mile Creek subwatershed is located in the Southern and Central Minnesota, and western Wisconsin precipitation region. According to the DNR WHAF, average Annual precipitation in the North Fork Crow River Watershed is 29.4 inches, and 12.5 inches of rainfall occurs, on average, in summer months (June-August).

Daily precipitation records from the DNR indicate that since 2006, there have been five 24-hour rain events over 3.31 inches. Atlas 14 (NOAA Atlas 14 Precipitation Frequency Estimates) estimates that the range of precipitation for a 24-hour, 10-year event as between 3.31-5.12 inches.

Larger rainfall events over a 24-hour period are increasing, indicating that the maximum rainfall estimates for design work need to be increased. Increasing precipitation amounts and intensities associated with climate change increase erosion and runoff. This not only effects erosion runoff, but also the function of the BMPs. The BMPs are generally designed for a 24-hour, ten year rain event, or a 24-hour, 25-year rain event. Precipitation over these amounts can result in BMP failure. Climate change is dictating that watershed professionals in the Twelve Mile Creek Watershed reexamine the design and usability of the BMPs installed.

Internal Loading

The internal load of phosphorus to most of the lakes in the watershed is significant and perhaps the most complex to address (Table 9). Internal loading occurs as the result of resuspension of bottom sediments and attached nutrients, release of phosphorus from the sediment during anoxic conditions, and release of phosphorus from the decay of lake vegetation, especially curlyleaf pondweed. A large portion of the internal load in Dutch and Waverly Lakes is likely attributable to discharges from former wastewater treatment facilities (WWTFs). Internal load is also exacerbated when sediment in watershed runoff settles to the bottom of the lakes. Factors causing resuspension include boat traffic, carp, and high winds.

Table 9. Potential internal phosphorus sources in the Twelve Mile HUC12 Watershed lakes (Wenck, 2014)

	Howard	Dutch	Waverly	Little Waverly
Sediment release	●	●	●	○
WWTF discharge (historic)		Δ	Δ	
Aquatic vegetation	Δ	Δ		
Rough fish	Δ	Δ	Δ	Δ

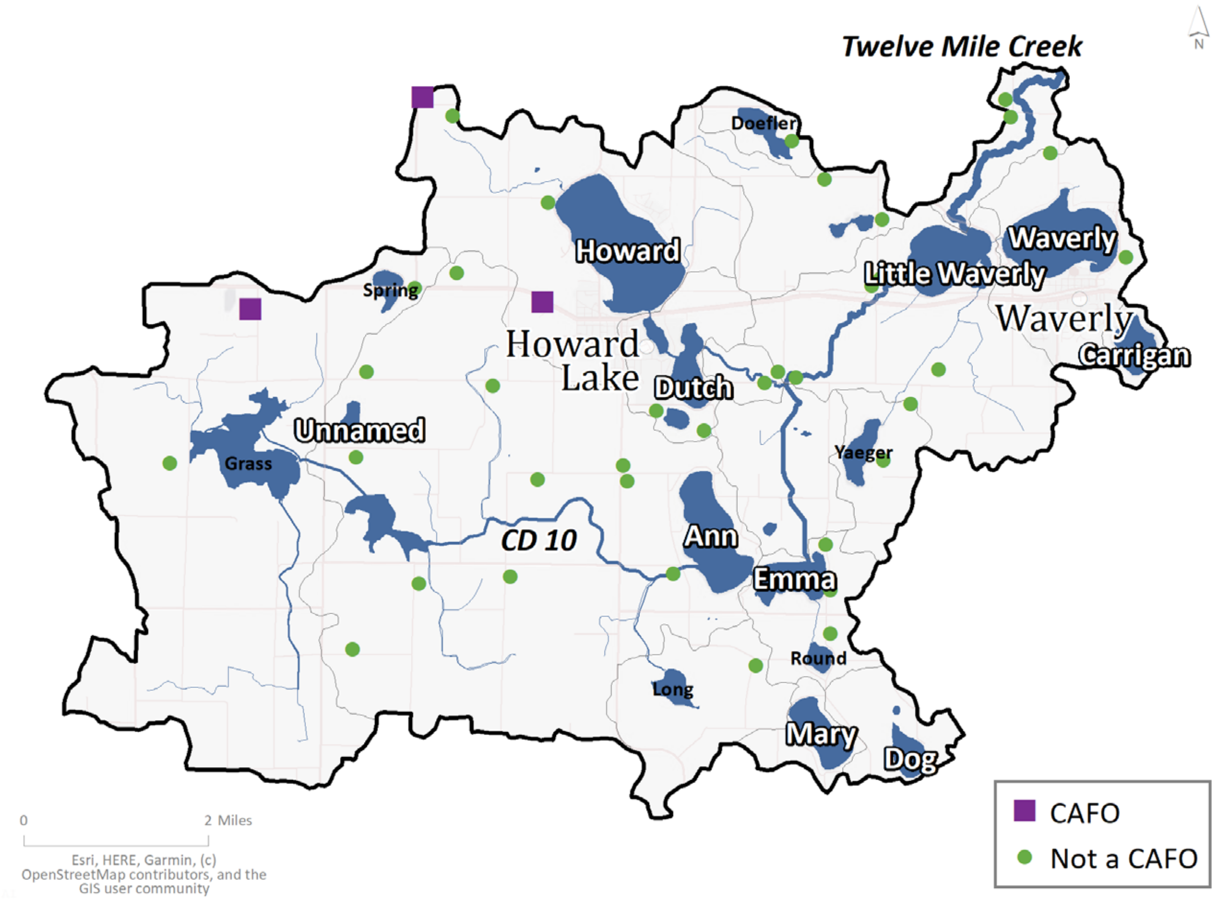
●=primary sources; ○=secondary source; Δ=potential source/unknown level of impact

Point Sources

Treated municipal wastewater is no longer discharged in the watershed. The city of Howard Lake WWTF historically discharged to Dutch Lake, but the wastewater system was connected to the Annandale/Maple Lake/Howard Lake WWTF (MN0066966) in 2009. The city of Waverly WWTF historically discharged to Carrigan Lake just upstream of Waverly Lake, but was connected to the Montrose WWTF (MN000024228) in 2004. The combined WWTFs discharge outside the Twelve Mile Creek HUC12 Watershed.

Feedlots identified as confined animal feeding operations (CAFO) with required NPDES/SDS permits are classified as point sources of pollution. The watershed only has three CAFOs, all of which are poultry operations. The other animal feedlots in the watershed are governed by state rules. Feedlots are illustrated in Figure 18.

Figure 18. Feedlots in the Twelve Mile Creek HUC 12 Watershed



In addition to point sources, there are 44 hazardous waste sites, 15 leak sites, 13 tank sites, one solid waste permit, and 24 sites listed under “multiple activities”

Element b. Reductions

> *An estimate of the load reductions expected for the management measures described under paragraph (c) below (recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time). Estimates should be provided at the same level as in item (a) above (e.g., the total load reduction expected for dairy cattle feedlots; row crops; or eroded stream banks).*
>
> EPA *Handbook for Restoring and Protecting Our Waters*

The management strategies described in Table 6 and the critical area practices identified below by subwatershed, are expected to achieve the estimated load reductions needed to protect and restore the waterbodies in the Twelve Mile Creek HUC12 Watershed to water quality standards within 10 years. Seven TMDLs have been developed and approved for waterbodies in the Twelve Mile HUC12 Watershed. The load reduction targets developed for the TMDLs are summarized in Table 10 with the estimated reductions to be achieved through this plan. Summaries for the individual TMDLs are presented in subsequent tables.

Table 10. Summarized TMDL reductions needed and estimated by waterbody

	Reductions needed		**Estimated reductions from activities in this NKE**		
Waterbody	**TP lbs/yr**	**Total oxygen demand lbs/yr**	**Estimated TP lbs/yr**	**Estimated oxygen demand**	**Difference**
Twelve Mile Creek (-679)	--	19,473		19,473*	
Howard Lake	3,488	--	3,518		-30
Dutch Lake	1,923	--	1,928		-5
Waverly Lake	185	--	247		-62
Little Waverly	12,867	--	13,301		-547
Ann Lake	6,815	--	7,592		-859
Lake Emma	2,224	--	2,391		-210

*As discussed in this NKE, the reductions for the oxygen demand will be met through the restoration of Little Waverly Lake

TMDL summaries for the Twelve Mile Creek HUC12 watershed

Table 11 provides the allocations for the oxygen demand TMDL for the dissolved oxygen impairment for the Twelve Mile Creek segment -681 by providing estimated current and TMDL allocations for oxygen demand parameters. The oxygen demand parameters include carbonaceous biochemical oxygen demand (CBOD), nitrogenous biochemical oxygen demand (NBOD), and sediment oxygen demand (SOD). The reductions in oxygen demand will be addressed through the reduction of the phosphorus load in Little Waverly Lake to achieve the target CBOD reductions. Subsequent decreases in SOD will occur as the phosphorus and algal load to the stream decreases and the stream flushes. The total required reduction in oxygen demand is 19,473 lbs/yr.

Table 11. TMDL allocations for Twelve Mile Creek (WID 07010204-681) downstream of Little Waverly Lake

Source	Oxygen Demand (kg/day) from:						Total Oxygen Demand (kg/day)	
	CBOD		NBOD		SOD			
	Current	TMDL	Current	TMDL	Current	TMDL	Current	TMDL
WLA								
Construction & Industrial Stormwater	0.01	0.01	0.003	0.003	--	--	0.01	0.01
LA								
Little Waverly Lake Headwaters[1]	6.7	1.8	0.8	0.8	--	--	7.5	2.6
Tribs/Groundwater	1.4	1.4	0.3	0.3	--	--	1.7	1.7
Sediment Fluxes	--	--	0.4	0.4	30.2	9.6	30.6	10.0
MOS[2]	--	0.3	--	--	--	1.0	--	1.3
Total	8.1	3.5	1.5	1.5	30.2	10.6	39.8	15.6

[1] Assumes Little Waverly Lake will meet NCHF shallow lake standards under TMDL conditions
[2] MOS was determined to be 10% for all sources requiring load reductions

A TMDL has not been completed for the *E. coli* impairment for Twelve Mile Creek segments -679 and -681. The TMDL is scheduled to be written in the next few years. Initial reductions targets were set by comparison of observed data and the water quality standard for *E. coli*. Estimated reductions are summarized in Table 12.

Table 12. Estimated load reductions needed for AUID -679 and -681

Stream reach	Estimated *E. coli* load (billion MPN/yr)	Estimated reduction needed (%)	Estimated load reduction (billion MPN/yr)
-679 (upstream of Little Waverly Lake)	310,416	81	251,437
-681 (downstream of Little Waverly Lake)	11,666	43	5,017

The summary for the TMDL for Howard Lake is described in Table 13. The reduction required to meet the TMDL is 3,488 lbs/yr TP.

Table 13. TMDL allocations for Howard Lake (Wenck 2014)

		Existing TP load		TP allocations (WLA & LA)		Load reduction	
	Source	**(lbs/year)**	**(lbs/day)**	**(lbs/year)**	**(lbs/day)**	**(lbs/year)**	**%**
Wasteload allocation	Construction & Industrial Stormwater	13	0.03	13	0.03	0	0
Load allocation	Drainage Areas	1,262	3.5	676	1.9	586	46
	Septic Systems	166	0.5	0	0	166	100
	Atmosphere	176	0.5	176	0.5	0	0
	Internal Load	3,358	9.2	622	1.7	2,736	81
	MOS	--	--	31	0.1	--	--
	TOTAL	**4,975**	**13.73**	**1,518**	**4.23**	**3,488**	**69**

The summary for the TMDL for Dutch Lake is described in Table 13. The reduction required to meet the TMDL is 1,923 lbs/yr TP.

Table 14. TMDL allocations for Dutch Lake (Wenck 2014)

		Existing TP load		TP allocations (WLA & LA)		Load reduction	
	Source	**(lbs/year)**	**(lbs/day)**	**(lbs/year)**	**(lbs/day)**	**(lbs/year)**	**%**
Wasteload allocation	Construction & Industrial Stormwater	7	0.02	7	0.02	0	0
Load allocation	Drainage Areas	719*	2.0	75	0.2	644	90
	Upstream Lakes	166	0.5	90	0.2	76	46
	Septic Systems	16	0.04	0	0	16	100
	Atmosphere	39	0.1	39	0.1	0	0
	Internal Load	1,234	3.4	48	0.1	1,187	96
	MOS	--	--	14	0.04	--	--
	TOTAL	**2,181**	**6.06**	**273**	**0.66**	**1,923**	**87**

*The watershed load includes historical Howard Lake WWTF load which no longer discharges to Dutch Lake.

The summary for the TMDL for Waverly Lake is described in Table 14. The reduction required to meet the TMDL is 185 lbs/yr TP.

Table 15. TMDL allocations for Waverly Lake (Wenck 2014)

	Source	Existing TP load		TP allocations (WLA & LA)		Load reduction	
		(lbs/year)	(lbs/day)	(lbs/year)	(lbs/day)	(lbs/yr)	%
Wasteload allocation	Construction & Industrial Stormwater	5	0.01	5	0.01	0	0%
Load allocation	Drainage Areas	513	1.4	444	1.2	64	13%
	Upstream Lakes	204	0.6	123	0.3	82	40%
	SSTS	39	0.1	0	0	39	100%
	Atmosphere	116	0.3	116	0.3	0	0%
	Internal Load	534	1.5	534	1.5	0	0%
	MOS	--	--	64	0.2	--	--
	TOTAL	**1,411**	**3.91**	**1,286**	**3.51**	**185**	**9**

The summary for the TMDL for Little Waverly Lake is described in Table 16. The reduction required to meet the TMDL is 12,867 lbs/yr TP. The upstream lakes contribution will be met by addressing the loading for Lake Emma and Dutch Lake.

Table 16. TMDL allocations for Little Waverly Lake (Wenck 2014)

	Source	Existing TP load		TP allocations (WLA & LA)		Load reduction	
		(lbs/year)	(lbs/day)	(lbs/year)	(lbs/day)	(lbs/yr)	%
Wasteload allocation	Construction & Industrial Stormwater	33	0.1	33	0.1	0	0
Load allocation	Drainage Areas	3,245	9.0	420	1.1	2,825	86
	Upstream Lakes	3,484	9.5	1,478	4.0	2,006	58
	SSTS	252	0.7	0	0	252	100
	Atmosphere	79	0.2	79	0.2	0	0
	Internal Load	7,903	21.6	120	0.3	7,784	98
	MOS	--	--	112	0.3	--	--
	TOTAL	**14,996**	**41.0**	**2,242**	**6.0**	**12,867**	**85**

The summary for the TMDL for Ann Lake is described in Table 16. The reduction required to meet the TMDL is 6,815 lbs/yr TP.

Table 17. TMDL total phosphorus daily loads partitioned among the major sources for Ann Lake assuming the lake standard of 60 μg/L (Wenck 2011)

	Source	Existing TP load[1] (lbs/year)	(lbs/day)[2]	TP allocations (WLA & LA) (lbs/year)	(lbs/day)[2]	Load reduction (lbs/year)	Load reduction %
Wasteload allocation	Industrial and Construction Stormwater	86	0	18	0.05	68	79
	CAFO	NA[3]	NA[3]	0	0	0	0
Load allocation	County Ditch 10/Direct	5,676	15.5	1,181	3.2	4,495	79
	Atmospheric	83	0.2	83	0.2	0	0
	Internal load	2,481	6.8	229	0.6	2,252	91
	MOS	--	--	80	0.2	--	--
	TOTAL LOAD	**8,326**	**22.5**	**1,591**	**4.25**	**6,815**	**82**

[1]Existing load is the average for the years 2003, 2005, 2008, 2009.

[2]Annual loads converted to daily by dividing by 365.25 days per year accounting for leap years

[3]Loads from feedlots are not permitted by rule, so zero loading was assumed in this TMDL

The summary for the TMDL for Lake Emma is described in Table 17. The reduction required to meet the TMDL is 2,224 lbs/yr TP.

Table 18. TMDL total phosphorus daily loads partitioned among the major sources for Lake Emma assuming the lake standard of 60 ug/L (Wenck 2011)

	Source	Existing TP load [1] (lbs/year)	(lbs/day)[2]	TP allocations (WLA & LA) (lbs/year)	(lbs/day)[2]	Load reduction (lbs/year)	%
Wasteload allocation	Industrial and Construction Stormwater	5	0.01	4	0.01	1	20
	CAFO	NA[3]	NA[3]	0	0	0	0
Load allocation	Direct Watershed	322	0.9	284	0.8	38	12
	Atmospheric	42	0.1	42	0.1	0	0
	Upstream Lake (Ann)	2,746	7.5	985	2.7	1,761	64
	Internal Load	617	1.7	193	0.5	424	69
	MOS	--	--	78	0.2	--	--
	TOTAL LOAD	**3,732**	**10.2**	**1,586**	**4.31**	**2,224**	**60**

[1]Existing load is the average for the years 2008 and 2009.
[2]Annual loads converted to daily by dividing by 365.25 days per year accounting for leap years
[3]Loads from feedlots are not permitted by rule, so zero loading was assumed in this TMDL

TMDLs have not been completed for Dog and Mary Lakes. The BATHTUB model was run using default runoff coefficients for the land covers in each watershed to obtain estimates of existing phosphorus loading to achieve the observed and water quality standard phosphorus concentrations. The difference in the two loads is used as the target load reduction for the watersheds of the two lakes. A reduction of 64 lbs TP/yr to Dog Lake represents a 30% reduction in the estimated current watershed loading to the lake (Table 19). No reductions in P loading are needed for Mary Lake given that the lake is already attaining the water quality standard (Table 20).

Table 19. BATHTUB model results for Dog Lake

	Inflow load (lbs/yr)	Atmospheric load (lbs/yr)	Net load (lbs/yr)	Outflow load (lbs/yr)	Lake Outflow (m3/yr)	Observed/ predicted TP (µg/L)
Current	215	23	238	49	0.45	49
Water quality standard met	151	23	174	40	0.45	40
Reductions needed	64		64	9		

Table 20. BATHTUB model results for Mary Lake

	Inflow load (lbs/yr)	Atmospheric load (lbs/yr)	Net load (lbs/yr)	Outflow load (lbs/yr)	Lake Outflow (m3/yr)	Observed/ predicted TP (µg/L)
Current	138	45	183	13	0.21	29
Water quality standard met						
Reductions needed	0		0			

Description of load reductions by model used

Different models were used in estimating existing conditions, developing the TMDLs, and estimating reductions for BMPs. Model results vary by the structure and assumptions of the model. Adjustments were made between model outputs by the use of ratios between the different model outputs to make them comparable. The adjustments entailed adapting numbers to correspond with the loads used in the TMDLs. The TMDLs are based on HSPF and BATHTUB modeling. BMP load reduction estimates are based on the Prioritize, Target, and Measure Application (PTMApp) and Spreadsheet Tool for Estimating Pollutant Loads (STEPL) models. The primary tool was the Prioritize, Target, and Measure Application (PTMApp) given its use of detailed parcel inputs utilizing ArcGIS and a hydroconditioned digital elevation model (DEM) that identified critical areas in addition to the load reduction estimates. The PTMApp model generates reductions for planned practices in the watershed as combined subwatersheds along user selected flow lines and as individual subwatersheds (catchments). These catchments are approximately 40 acres in size and the estimates can be referred to as “edge-of-field” reductions. Combined subwatershed reductions by flow lines and individual catchments are provided for each waterbody. Most of the individual catchments not included in a flow line have direct drainage to the lakes and the estimated loads are assumed to reach the lakes. The second tool, EPA’s Spreadsheet Tool for Estimating Pollutant Loads (STEPL), was used to estimate load reductions for practices that were implemented between 2009 and 2020, additional practices beyond those identified in PTMApp, removal of failing septic systems, and inclusion of *E. coli* reductions for the PTMApp practices. The STEPL model generates reductions for planned practices by individual subwatershed. Reductions from upstream lakes meeting water quality standards are from the BATHTUB modeling.

The estimated existing loads and load reductions with BMPs for the watersheds in the two tools are somewhat different given that they use different assumptions, inputs, and model equations. In addition to these differences, the models used in the development of the TMDLs included HSPF and BATHTUB, resulting in different values. To use the different numbers from each tool, the assumption was made to use the TMDL numbers as the "true" numbers for this plan. The PTMApp and STEPL numbers were adapted to the TMDL numbers using the ratios of the existing loads of the tools to the TMDL. These numbers are shown as the adjusted totals at the bottom of each table.

The internal loads and load reductions identified in the lake TMDLs are better described as internal load and unmeasured watershed loads to the lakes given the uncertainty present in the use of watershed model, literature estimates, and regional assumptions as inputs to the BATHTUB model. With this in mind, watershed load reductions from the plan BMPs are sometimes greater than the watershed load reduction targets of the TMDLs. These reductions are assumed to address the load reduction targets identified as internal load in the TMDLs that are likely unmeasured/unquantified (in the TMDL) watershed loads. The additional practices were selected using STEPL to help mitigate the unmeasured watershed loading that was not accounted for in the original calculation of the TMDL. The unexplained residual is likely dominated by cumulative up-gradient lake segment internal loads, with lesser amounts from developed areas and failing septic systems. Data were not available for an independent assessment of internal loading, but additional resolution of internal and unknown residual load components may be obtained through targeted monitoring and adaptive management practices as described in this NKE plan.

Reductions in actual internal loading to the lakes will occur with natural lake cycling of phosphorus as watershed inputs decrease, internal loads occur, and lake outflows continue. Internal loads not reduced in this way will be addressed through targeted alum treatments and curly leaf pondweed controls.

Estimated load reductions from work completed 2009-2021

Practices implemented in the Twelve Mile Creek HUC12 watershed prior to this plan were obtained from the Healthier Watersheds (https://www.pca.state.mn.us/water/best-management-practices-implemented-watershed) application and are listed in Table 20. The practices in this application are those reported to the BWSR eLink database and by NRCS. Pollutant load reduction estimates for these practices were computed using the STEPL combined efficiency calculator for the practices (Table 21). The reductions are presented for each subwatershed in the subsequent subsections.

Table 21. Estimated reductions by waterbody using Healthier Watershed data using STEPL

Waterbody	P reduction lb/year	*E. coli* reduction Billion MPN/year
Ann Lake	631.7	359.1
Grass Lake	533.1	396.1
Little Waverly Lake	384.3	189.6
Howard Lake	136.9	464.1
Waverly Lake	48.1	31.0
Dutch Lake	33.1	36.3

Waterbody	P reduction lb/year	*E. coli* reduction Billion MPN/year
Lake Emma	45.5	33.5
Dog Lake	22.8	14.7
Mary Lake	25.5	16.5
TMC 579	21.0	13.5
Total	**1881.8**	**1554.4**

Twelve Mile Creek (07010204-681, downstream of Little Waverly Lake)

Load reductions to address the impairments for the Twelve Mile Creek reach downstream of Little Waverly Lake are presented for phosphorus and *E. coli* in Table 22. The reductions are grouped by activity type for past completed work in Table 21, the planned BMPs and practice types in Table 6, SSTS upgrades, and reductions expected from Little Waverly Lake after restoration practices. SSTS reductions are assumed to be the target reductions in the TMDL and Little Waverly Lake reductions are those estimated in the TMDL when the TMDL is achieved.

The sum of the P reductions is expected to result in reductions in oxygen demand that meet the TMDL for DO. The DO TMDL determined that meeting the TMDL for nutrient loading in Little Waverly Lake is the primary means to achieve the DO water quality standard in Twelve Mile Creek (-681). Achieving the DO TMDL will increase the low DO concentrations in the stream and address the primary stressor for the aquatic life impairment in this stream segment. In addition to reducing phosphorus and subsequent oxygen demand, the streambank stabilization and restoration described in Table 6 will also provide better quality aquatic habitats for the biota by reducing channelization and bedded sediment.

The total estimated *E. coli* reductions will exceed the estimated reductions needed to meet water quality standards in 10 years.

Table 22. Summary of estimated reductions for Twelve Mile Creek (07010204-681, downstream of Little Waverly Lake)

Activities	P reduction lbs/yr	*E. coli* Billion MPN/yr
Reductions from past projects	21	14
Planned practices and BMPs in NKE	181	22
Reductions from SSTS	58	10,539
Expected reductions from Little Waverly Lake	12,209	--
Total	12,469	10,575
Estimated reduction needed	--	5,017
		(5,558)

It is expected that the practices in this plan will achieve total reductions of 12,411 lbs/yr P and 303,467 Billion MPN/yr, meeting water quality standards in 10 years.

Twelve Mile Creek (07010204-679, upstream of Little Waverly Lake)

Load reductions to address the *E. coli* impairment for the Twelve Mile Creek reach upstream of Little Waverly Lake are presented for *E. coli* in Table 23. The reductions are grouped by activity type for past completed work in Table 21, the planned BMPs and practice types in Table 6, SSTS upgrades.

Table 23. Summary of *E. coli* reductions for Twelve Mile Creek (-679, upstream of Little Waverly Lake)

Practice group	Load reduction from NKE plan (billion MPN/yr)
Past practices and BMPs implemented	190
STEPL practices and BMPs	498
Septic reductions	302,743
Total	303,431
Reductions	251,437
Balance	(51,994)

Grass Lake

Table 26 describes the reductions expected at the selected flow line entry point of Grass Lake. Critical area targeted practices will be summarized in Element c. Addressing the critical loading areas in the Grass Lake Subwatershed will contribute to the overall water quality of the Twelve Mile Creek HUC 12 Watershed.

Table 24. Management strategies and reductions for Grass Lake, PTMApp

Grass Lake				
NRCS code	**Practice name**	**P Reduction (lbs/year)**	**Count of practices**	**Acres**
329	No Till	141	9	842.0
340	Cover Crop	67	6	597.4
345	Reduced Till	8	1	107.7
554	Drainage Water Management	5	1	21.0
605	Bioreactors	22	2	0.1
590	Nutrient Management	225	25	571.1
Grand total		**468**	**44**	

Howard Lake

The estimated loads and load reductions for the PTMApp identified BMPs were made for a single flow line entry point to Howard Lake. The list of management strategies with number of practices and acreage implemented are summarized in Table 6.

Table 25. Management strategies and reductions for Howard Lake critical areas, PTMApp

Howard				
NRCS code	**Practice name**	**P Reduction (lbs/year)**	**Count of practices**	**Acres**
329	No Till	172	16	1098.1
340	Cover Crop	136	13	1018.5
345	Reduced Till	85	8	739.8

Howard				
NRCS code	**Practice name**	**P Reduction (lbs/year)**	**Count of practices**	**Acres**
605	Bioreactor	69	7	0.3
638	WASCOB	13	2	0.5
590	Nutrient Management	111	9	465.2
Grand Total		**586**	**55**	
	Adjusted	**922**		

Table 26 summarizes the PTMApp reductions, past completed work reductions, the additional planned BMPs and practices, SSTS upgrades, and internal loading reductions. The load reduction for SSTS upgrades was assumed to be the target reduction for SSTS in the TMDL. The reductions for the additional planned practices were calculated using a combination of individual practice and combined practice efficiencies in STEPL. The reductions for previously implemented practices reported in the Healthier Watersheds application were calculated as individual practices in STEPL.

The internal load reductions were assumed as a combination of reduced internal load through natural cycling following watershed reductions (1,065 lbs/yr) and curly leaf pondweed control at 75% removal will yield a 35% reduction in TP (326 lbs/yr) and targeted alum treatments (759 lbs/yr reduction). The reduction in internal load through natural cycling was assumed to be the same as the reduction in watershed loading with the BMPs implemented in this plan. Active treatment of excess internal loading will be designed and implemented to achieve the remaining internal load reductions needed following lake sediment P release studies and vegetation surveys. Milestones, monitoring, and assessment criteria will be used to closely track the progression of Howard Lake to update and manage the approach.

Table 26. Summary of all phosphorus load reductions for Howard Lake

Practice group	Load reduction adapted to TMDL numbers (lbs/yr)
Past practices and BMPs implemented	137
PTMApp practices and BMPs	922
STEPL practices and BMPs	143
Septic reductions per TMDL	166
Upstream lakes	--
Internal load treatment	2,150
Total	3,518
Reductions needed in TMDL	3,457
Balance	(61)

The estimated load reduction for all activities for Howard Lake is 3,518 lbs/yr P, thus exceeding the load reduction needed to achieve the TMDL (3,457 lbs/yr). The water quality standard for Howard Lake is expected to be achieved with the implementation of this plan within 10 years.

Dutch Lake

Table 27 summarizes the planned practices for the critical areas in the Dutch Lake Subwatershed utilizing PTMApp. The reductions for the practices identified for implementation were modeled for groups of catchments discharging to the lake as flow-line points and for individual catchments not associated with a flow-line in PTMApp. Table 28 summarizes the reductions with the removal of the WWTF discharge, PTMApp reductions, past completed work reductions, the additional planned BMPs and practices, reduction in upstream lake contributions, SSTS upgrades, and internal loading reductions. The table includes a reduction associated with the removal of the WWTF discharge to the lake. The load reduction for SSTS upgrades was assumed to be the target reduction for SSTS in the TMDL. Reductions from upstream lakes meeting water quality standards are from the BATHTUB modeling for Howard Lake. The reductions for the additional planned practices were calculated using a combination of individual practice and combined practice efficiencies in STEPL. The internal load reductions were assumed as a combination of reduced internal load through natural cycling following removal of the WWTF discharge (353 lbs/yr).

Table 27. Management strategies and Dutch Lake edge of field reductions, PTMApp

		P reduction lbs/yr		**Count of practices**		**Acres**	
NRCS Code	**Practice name**	**Catchment reductions**	**Flow line reductions**	**Catchment**	**Flowline**		
605	Bioreactor		4		8		
327	Perennial Cover	1.4		1		5.1	
329	No Till	4.2	10	2	19	16.7	
340	Cover Crop	3.8	9	2	17	16.7	
342	Critical Planting	8.4		15		25.1	
345	Reduced Till	3.1	5	2	10	16.7	
390	Riparian Herbaceous Cover	0.02		3		0.3	
393	Filter Strip	6.6		40		35.2	
410	Grade Stabilization	0.16		1		0.4	
412	Grassed Waterway	8.0		15		21.6	
512	Forage Planting	5.7		30		20.4	
528	Prescribed grazing	0.002		1		0.03	
580	Shoreland Protection	7.02		37		24.3	
604	Buffer	28.2		21		18.8	
638	WASCOB	44.2	1	9	3	0.9	
590	Nutrient Management	7.2	15	6	16	59.2	
Total		**128**	**44**	**185**	**87**		
	Total	**172**					
	Adjusted total		**910**				

Table 28. Phosphorus load reductions for Dutch Lake

Practice group	Load reduction adapted to TMDL numbers (lbs/yr)
Removal of WWTF discharge	353
Past practices and BMPs implemented	33
PTMApp practices and BMPs	910
STEPL practices and BMPs	126
Septic reductions per TMDL	16
Upstream lakes	311
Internal load treatment	353
Total	2,102
Reductions needed in TMDL	1,923
Balance	**(179)**

The combined reductions for the planned and completed practices in the Dutch Lake Subwatershed is 2,102 lbs/yr TP, including expected reduction in load from Howard Lake upon meeting the Howard Lake TMDL and estimated reductions in internal cycling following reduced external loads. The estimated reductions to the waterbodies will exceed the reductions required for overland and upstream loading described in the TMDL to achieve the water quality standards for Dutch Lake within 10 years.

Waverly Lake

Table 29 describes the reductions expected at the selected flow line entry point of Waverly Lake.

Table 29. Management strategies and reductions for Waverly Lake, PTMApp

Waverly				
NRCS code	**Practices**	**P Reduction (lbs/year)**	**Count of practices**	**Acres**
329	No Till	54	2	211.8
340	Cover Crop	48	2	211.8
393	Filter Strip	0.1	2	2.2
Grand total		**101**	**4**	
	Adjusted	**101.1**		

Table 30 summarizes the PTMApp reductions, past completed work reductions, the additional planned BMPs and practices, SSTS upgrades, and internal loading reductions. The load reduction for SSTS upgrades was assumed to be the target reduction for SSTS in the TMDL. The reductions for the additional planned practices were calculated using a combination of individual practice and combined practice efficiencies in STEPL.

Table 30. Phosphorus load reductions for Waverly Lake

Practice group	Load reduction adapted to TMDL numbers (lbs/yr)
Past practices and BMPs implemented	48
PTMApp practices and BMPs	101
STEPL practices and BMPs	75
Septic reductions per TMDL	39
Upstream lakes	--
Internal load treatment	--
Total	263
Reductions needed in TMDL	185
Balance	(78)

The estimated reductions of 263 lbs/yr to the Waverly Lake will exceed the reductions recommended for overland and upstream loading described in the TMDL to achieve the water quality standards for Waverly Lake within 10 years.

Little Waverly Lake

Table 31 summarizes the planned practices for the critical areas in the Little Waverly Lake subwatershed. The following practices were modeled for both the flow-line and the edge-of-field catchments.

Table 31. Management strategies and reductions for Little Waverly Lake, PTMApp

Little Waverly		P reductions lbs/yr		Count of practices		
NRCS code	Practice name	Catchment reductions	Flow line reductions	Catchment	Flow line	Acres
554	Drainage Water Management	6	29	11	2	96.5
605	Bioreactor	172	93	25	13	1.1
329	No Till	457	576	138	67	2,713
340	Cover Crop	408	472	136	58	2,667
345	Reduced Till	331	316	137	42	2,681
590	Nutrient Management	57	488	74	59	1,034
638	WASCOB	246	33	130	6	12
342	Critical Planting	80		210		396
378	Farm Pond	11		4		.6
393	Filter Strip	25		423		218
412	Grassed Waterway	61		234		273
580	Shoreland Protection	12		129		75
604	Buffer	23		83		76
327	Perennial Cover	18		8		75
390	Riparian Herbaceous Cover	2		104		15

Little Waverly		P reductions lbs/yr		Count of practices		
NRCS code	Practice name	Catchment reductions	Flow line reductions	Catchment	Flow line	Acres
410	Grade Stabilization	3		18		11
512	Forage Planting	186		611		903
528	Prescribed grazing	1		64		22
582	Open channel	1		2		.7
Grand Total		**2100**	**2,008**	**2541**	**247**	**11,270**
	Adjusted	**4,081**				

Table 32 summarizes the PTMApp reductions, past completed work reductions, the additional planned BMPs and practices, upstream lake reductions, SSTS upgrades, and internal loading reductions. The load reduction for SSTS upgrades was assumed to be the target reduction for SSTS in the TMDL. Reductions from upstream lakes meeting water quality standards are from the BATHTUB modeling for Dutch and Emma Lakes. The reductions for the additional planned practices were calculated using a combination of individual practice and combined practice efficiencies in STEPL.

The internal load reductions needed (5,373 lbs/yr) were assumed as a combination of reduced internal load through natural cycling (2,000 lbs/yr) following watershed reductions. The reduction in internal load through natural cycling was assumed to be 25% of the watershed loading reduction with the BMPs implemented in this plan. The remaining 3,373 lbs/yr of internal loading will be addressed through the management of curly leaf pondweed removal, which has an expected reduction of 1,012 lbs/yr. The remaining internal load (2,361 lbs/yr) will be addressed through an alum treatment to be evaluated, designed and applied in years 8, 9, and 10 of this plan. Active treatment of excess internal loading will be designed and implemented to achieve the remaining internal load reductions needed following lake sediment P release studies and vegetation surveys. Milestones, monitoring, and assessment criteria will be used to closely track the progression of Howard Lake to update and manage the approach.

Table 32. Phosphorus load reductions for Little Waverly Lake

Practice group	Load reduction adapted to TMDL numbers (lbs/yr)
Past practices and BMPs implemented	384
PTMApp practices and BMPs	3,483
STEPL practices and BMPs	1,889
Septic reductions per TMDL	252
Upstream lakes	1,919
Internal load treatment	5,373
Total	13,300
Reductions needed in TMDL	12,867
Balance	(433)

The estimated reductions will exceed the reductions required for overland, internal, and upstream loading described in the TMDL to achieve the water quality standards for Little Waverly Lake within 10 years.

Ann Lake

Table 33 describes the reductions expected at the PTMApp selected flow line entry-point of Ann Lake.

Table 33. Management strategies and reductions for Ann Lake, PTMApp

Ann Lake				
NRCS code	**Practice name**	**P Reduction (lbs/year)**	**Count of practices**	**Acres**
554	Drainage Water Management	30	3	67
604	Saturated Buffer	29	4	5
605	Bioreactor	219	21	1
638	WASCOB	188	24	7
329	No Till	1,252	102	489
340	Cover Crop	1,012	84	4,471
345	Reduced Till	735	67	4,094
590	Nutrient Management	1,024	81	2,123
512	Forage Planting	7	1	27
Grand total		**4,498**	**387**	
	Adjusted	**6,609**		

Table 36 summarizes the PTMApp reductions, past completed work reductions, the additional planned BMPs and practices, and SSTS upgrades reductions. The load reduction for SSTS upgrades was calculated in STEPL. The reductions for the additional planned practices were calculated using a combination of individual practice and combined practice efficiencies in STEPL.

Table 34. Phosphorus load reductions for Ann Lake

Practice group	**Load reduction adapted to TMDL numbers (lbs/yr)**
Past practices and BMPs implemented	632
PTMApp practices and BMPs	6,609
STEPL practices and BMPs	646
Septic reductions per TMDL	318
Upstream lakes	--
Internal load treatment	--
Total	8,205
Reductions needed in TMDL	6,815
Balance	(1,390)

The total reductions expected from this NKE plan and the past work will achieve an estimated 8,205 lbs/yr P. The estimated reductions to the waterbodies will exceed the reductions required in the TMDL to achieve the water quality standards for Ann Lake within 10 years.

Lake Emma

Table 35 describes the reductions expected at the selected flow line entry point of Lake Emma.

Table 35. Management strategies and reductions for Lake Emma, PTMApp

Emma				
NRCS code	**Practice name**	**P Reduction (lbs/year)**	**Count of practices**	**Acres**
554	Drainage Water Management	38	2	21
605	Bioreactor	46	4	.1
329	No Till	544	39	
340	Cover Crop	422	32	
345	Reduced Till	259	22	
590	Nutrient Management	457	35	572
Grand total		**1,767**	**134**	
	Adjusted	**1,706**		

Additional practices for the Lake Emma Subwatershed are summarized in Table 6. Table 36 summarized the reductions for those practices, past completed work, SSTS upgrades.

Table 36 summarizes the PTMApp reductions, past completed work reductions, the additional planned BMPs and practices, upstream lake loading reductions, SSTS upgrades, and internal loading reductions. The load reduction for SSTS upgrades was calculated in STEPL. Reductions from upstream lakes meeting water quality standards are from the BATHTUB modeling for Ann Lake. The reductions for the additional planned practices were calculated using a combination of individual practice and combined practice efficiencies in STEPL.

Table 36. Phosphorus load reductions for Lake Emma Subwatershed

Practice group	**Load reduction adapted to TMDL numbers (lbs/yr)**
Past practices and BMPs implemented	46
PTMApp practices and BMPs	1,706
STEPL practices and BMPs	538
Septic reductions per TMDL	46
Upstream lakes	1,761
Internal load treatment	--
Total	4,097
Reductions needed in TMDL	2,224
Balance	(1,873)

The estimated reductions to the waterbodies will exceed the reductions required for overland and upstream loading described in the TMDL to achieve the water quality standards for Lake Emma within 10 years.

Dog Lake

Practices were identified using STEPL for additional planned BMPs and practices. Table 37 summarizes the past completed work reductions and the additional planned BMPs and practices. The reductions for the additional planned practices were calculated using a combination of individual practice and combined practice efficiencies in STEPL.

Table 37. Phosphorus load reductions for Dog Lake

Practice group	Load reduction adapted to BATHTUB numbers (lbs/yr)
Past practices and BMPs implemented	23
STEPL practices and BMPs	41
Septic reductions per TMDL	9
Upstream lakes	--
Internal load treatment	--
Total	73
Reductions needed	64
Balance	(9)

It is expected that the 73 lbs/yr P reduction from this plan will reach water quality standards in Dog Lake. A TMDL will be developed to provide a better load reduction target to meet the phosphorus criterion for the lake eutrophication standard. For the purposes of the NKE plan, a reduction of 64 lbs/yr was calculated by modeling current and water quality standard conditions using the BATHTUB model.

Mary Lake

Mary Lake is not listed as impaired for eutrophication given that the TP concentration is below the numeric criterion for the water quality standard; however, practices and BMPs are identified for some reductions in phosphorus as a protection measure. Table 38 summarizes the past completed work reductions and the additional planned BMPs and practices. The reductions for the additional planned practices were calculated using a combination of individual practice and combined practice efficiencies in STEPL.

Table 38. Phosphorus load reductions for Mary Lake

Practice group	Load reduction adapted to BATHTUB numbers (lbs/yr)
Past practices and BMPs implemented	25
PTMApp practices and BMPs	
STEPL practices and BMPs	5
Septic reductions per TMDL	
Upstream lakes	--
Internal load treatment	--
Total	30
Reductions needed in TMDL	0
Balance	(30)

The P load reductions with implemented BMPs is expected to protect the lake from increasing P concentrations and, thereby, maintain its status of not being impaired for eutrophication.

Element c. best management practices

> *A description of the BMPs (NPS management measures) that are expected to be implemented to achieve the load reductions estimated under paragraph (b) above (as well as to achieve other watershed goals identified in this watershed-based plan), and an identification (using a map or a description) of the critical areas (by pollutant or sector) in which those measures will be needed to implement this plan.*
>
> EPA *Handbook for Restoring and Protecting Our Waters*

The BMPs and activities described in Table 6 will be implemented to reach the water quality goals in the Twelve Mile Creek HUC12. Implementation of the BMPs and activities requires a holistic approach to account for the complexities of a watershed and its citizens. An overall goal of this plan is to slow the amount of water running off the watershed. Areas of focus include cropland, wooded areas/forest, urban/residential development, shoreline development, and wetlands. Many practices for the different areas encompass storage, infiltration, and filtration practices.

Cropland areas

A number of practices are practical and popular within the agricultural community, given the soil types in the watershed. Light clays in the soil provides for easy compaction of soils to create berms for retention or diversion practices. This can be achieved without significant amendment of the soils reducing the chance of failure in larger rain events. Typical practices include WASCOBs and such as "farmable" WASCOBs (water and sediment control basins that can be planted over). These are appealing to landowners because they hold together well, prevent soil loss and gullying, and have little impact on net farmable areas. The benefit to water quality is that storage is provided, reducing sediment and nutrient laden runoff to surface waters.

The material used in bioreactors provides treatment through substrate bacteria denitrifies the nitrate-nitrogen before it reaches surface or groundwater. Filtration through a bioreactor can also remove *E. coli* as the water moves through the filter system.

A BMP useful in tile-drained areas with open inlets is alternative tile inlets. Alternative tile inlets involve replacing the open tile inlet, which is on the surface of the land, with practices including perforated risers, gravel/rock inlets, vegetated buffers, and pattern tiling.

Figure 19. Practices such as WASCOBs (upper right), Bioreactors (Upper left), or alternative tile intakes (bottom) are being seem more commonly across the agricultural landscape in Twelve Mile Creek.

Figure 20. WASCOBs are a common best management practice in the Twelve Mile Creek Watershed. In this photo, the grassed berm on the right holds back water until it becomes high enough to drain through the orange riser on the left, providing storage that helps water quality.

Wooded (forest) areas

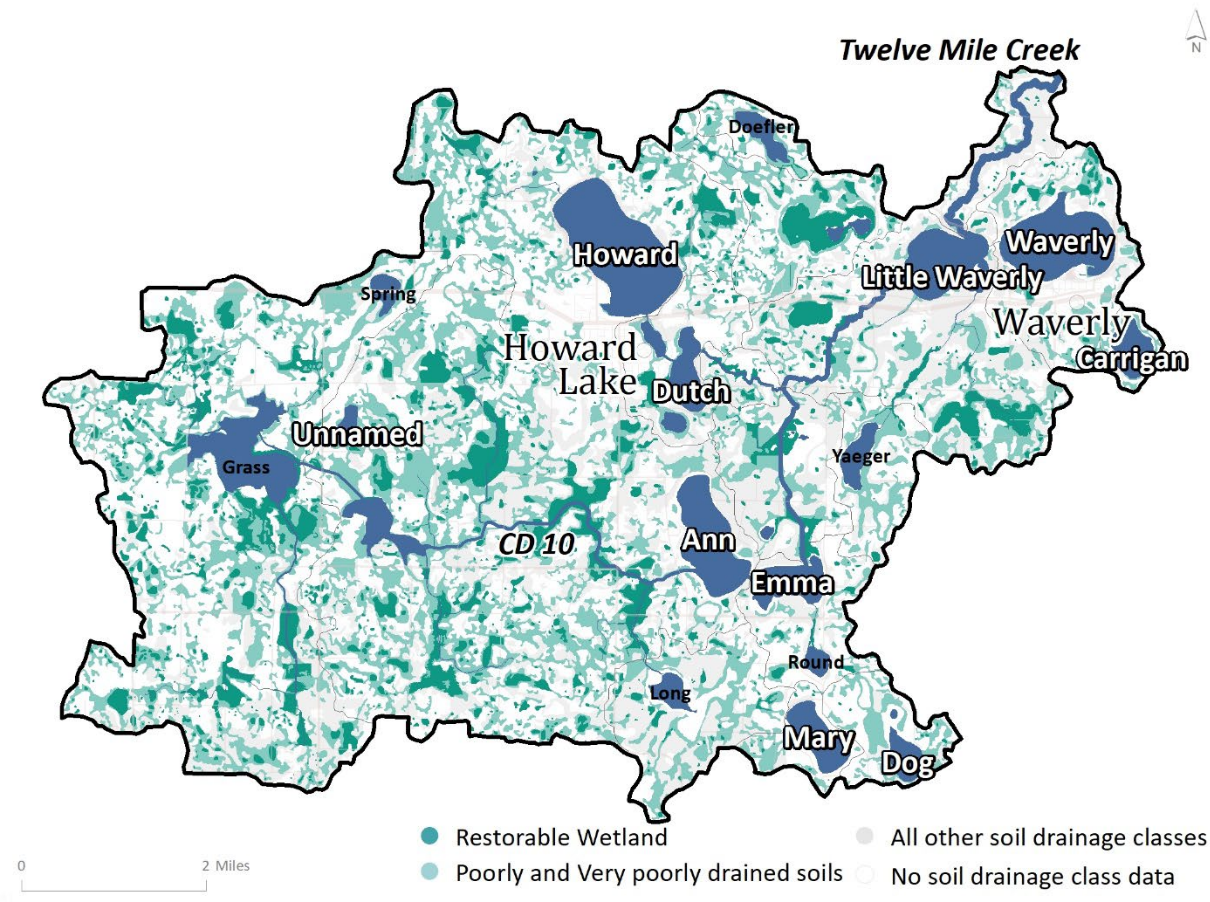
Urban/Residential forests (as well as rural forests) pose a more difficult challenge to overcome. "Forested" systems in this watershed were observed to be devoid of understory vegetation, with the exception of invasive species such as buckthorn or hemp nettle. Soils in these systems are compacted, and appear to contain little organic material. The duff layer is absent.

Buffer strips are needed on many of the shorelines in the area, as there are a high percentage of green grass lawns touching lakes in this watershed, and with education and outreach, significantly improving this situation should be an achievable outcome.

In addition to buffer zones, opportunities for urban/residential BMPs exist for infiltration basins, vegetated drainage swales, retrofitting of pervious pavements for driveways and patios, and other practices that could significantly mitigate for the development and its negation of the natural shoreline vegetation that has been altered or eliminated.

Wetlands

Figure 21. Restorable wetlands in the Twelve Mile Creek Watershed



Wetlands were prevalent in the watershed until drainage for agriculture became predominate. Many of the previously drained wetlands could be restored, but wetland restoration is not likely given the value of the drained areas as cropland. Wetlands that remain in the watershed are often degraded from ecological and water quality function perspectives. Common issues in the degraded wetlands include channelized portions and invasive vegetation. Practices that improve the hydrological function of these wetlands and nutrient processing with the conversion to native plant species would reduce phosphorus loading to the lakes.

Because wetlands are known to collect contaminants from surrounding terrain, and function as "kidneys" for aquatic systems, they are also ideal locations for practices that can supplement their function when they become saturated or overloaded. Limestone filters are an example of a practice that has been used in the past, and can be effectively used in the future to filter out contaminants as they are released by wetlands. As with all BMPs that are utilized, proper installation and materials are critical to the function of these practices, and failed practices are excellent tools to learn from.

Urban areas

The primary urban areas in the Twelve Mile Creek Watershed are the cities of Howard Lake and Waverly. They have a typical distribution of urban land uses in small Minnesota cities including residential, commercial, and industrial areas. The watershed also has lakeshore residential areas and areas of residential development on the fringes of the cities that is considered urban area for this plan. Urban BMPs identified for implementation include various detention, filtration, infiltration, and bioretention practices. Shoreline restoration and buffer establishment are included to address the shoreline developed areas.

Internal load

Reduction of phosphorus in the water column can be achieved with expensive alum treatments, but this treatment is temporary and is most effective when land use contributions to sediment are first minimized. Alum treatments can be expected to effectively reduce phosphorus levels in water for up to 20 years, but the effectiveness is significantly less if sediment contributions to the water body from the watershed are ongoing. Other practices, such as no-wake zones for boats, non-motorized boat travel, elimination of invasive fish and aquatic vegetation species (such as carp and curlyleaf pondweed), and establishment of native emergent vegetation along shorelines can reduce the contribution of internal loading to lake nutrient levels.

Curly leaf pondweed is a significant source of P loading in the Twelve Mile Creek HUC12 Watershed. Modeling completed by James et al. suggested a 36 to 48% reduction by eliminating 100% of the weed. Considering an average 75% removal rate, it is expected that the reduction of internal P loading will be approximately 30% reduction of internal loading for each lake in the Twelve Mile Creek HUC12 Watershed.

Through watershed monitoring, it will be determined if the increased watershed loading reduction and the curly leaf pond weed reductions will meet the reductions needed for each lake's internal loading issue. If there is a remaining load to be addressed, an alum treatment will be designed and applied in the lake during years 8, 9, and 10 of this plan.

Lists of BMPs by watershed

Table 39 summarizes the planned BMPs and practices to be applied in each of the subwatersheds. These practices are expected to meet the reductions needed to reach water quality standards in the next 10 years for the Twelve Mile Creek HUC12 watershed.

Table 39. All practices by subwatershed, PTMApp

Practice type	NRCS code	Count	Acres
Twelve Mile all practices			
Forage Planting	512	1	0.1
Dutch Lake all practices			
Perennial Cover	327	1	5.1
No Till	329	2	16.7
Cover Crop	340	2	16.7
Critical Planting	342	15	25.1
Reduced Till	345	2	16.7

Practice type	NRCS code	Count	Acres
Riparian Herbaceous Cover	390	3	0.3
Filter Strip	393	42	35.2
Grade Stabilization	410	1	0.4
Grassed Waterway	412	15	21.6
Forage Planting	512	30	20.4
Prescribed grazing	528	1	0.03
Shoreland Protection	580	37	24.3
Buffers	604	20	18.8
WASCOB	638	9	0.9
Nutrient Management	590	6	59.2
Howard Lake all practices			
No Till	329	19	1098.1
Cover Crop	340	17	1018.5
Reduced Till	345	10	739.8
Bioreactors	605	6	0.3
WASCOB	638	3	0.5
Nutrient Management	590	16	465.2
Little Waverly Lake all practices			
Perennial Cover	327	8	75.3
No Till	329	138	2713.1
Cover Crop	340	136	2666.6
Critical Planting	342	210	396.3
Reduced Till	345	136	2680.7
Farm Pond	378	1	0.6
Riparian Herbaceous Cover	390	104	14.7
Filter Strip	393	395	218
Grade Stabilization	410	18	10.9
Grassed Waterway	412	231	273.4
Forage Planting	512	619	902.5
Prescribed grazing	528	64	22
Drainage Water Management	554	11	96.5
Shoreland Protection	580	129	75
Open Channel	582	2	0.7
Buffers	604	82	75.9
Bioreactors	605	23	1.1
WASCOB	638	130	11.7
Nutrient Management	590	74	1033.9
Waverly Lake all practices			
No Till	329	2	211.8
Cover Crop	340	2	211.8
Filter Strip	393	2	2.2
Ann Lake all practices			

Practice type	NRCS code	Count	Acres
No Till	329	93	488.7
Cover Crop	340	78	4471.3
Reduced Till	345	66	4094.1
Filter Strip	393	1	0.4
Forage Planting	512	1	26.5
Drainage Water Management	554	3	67.1
Buffers	604	5	4.7
Bioreactors	605	19	0.9
WASCOB	638	23	6.9
Nutrient Management	590	56	2122.7
Emma Lake all practices			
Filter Strip	393	3	3.1
Drainage Water Management	554	1	21
Bioreactors	605	2	0.1
Nutrient Management	590	25	571.1
Grass Lake all practices			
No Till	329	9	842
Cover Crop	340	6	597.4
Reduced Till	345	1	107.7
Drainage Water Management	554	1	21
Bioreactors	605	2	0.1
Nutrient Management	590	25	571.1

In addition to the targeted practices in the watershed, Table 40 summarizes a suite of BMPs that would be applicable to most of the watershed and would contribute to the reduction of pollutant loads. These BMPs would contribute the average reductions, and would be used to gain additional reductions beyond those identified for critical areas. The average estimated reductions are based on an average size of practice.

Table 40. Potential BMPs, average implementation area, and average estimated reduction per practice that would benefit the Twelve Mile Creek HUC12 Watershed, PTMApp

Practice type	NRCS code	Average area acres	Average estimated reductions lbs/yr P
Bioreactors	605	.3	9.9
Buffers	604	10	15
Cover Crop	340	40	5.3
Critical Planting	342	10	3.4
Drainage Water Management	554	10	18
Farm Pond	378	.15	2.75
Filter Strip	393	10	21.2
Forage Planting	512	10	2.8
Grade Stabilization	410	10	3.9

Practice type	NRCS code	Average area acres	Average estimated reductions lbs/yr P
Grassed Waterway	412	10	3.7
No Till	329	40	6.3
Nutrient Management	590	40	9.6
Open channel	582	1	3
Perennial Cover	327	10	2.4
Prescribed grazing	528	10	.45
Reduced Till	345	40	4.6
Riparian Herbaceous Cover	390	1	.19
Shoreland Protection	580	10	1.6
WASCOB	638	5	6.5

Additional considerations

In addition to the practices and BMPs described for the different land use/cover areas, considerations for groundwater, infiltration, and soil types in the watershed are included below.

Groundwater

The “North Fork Crow River Groundwater Restoration and Protection” report (MDH 2014) identified the following groundwater and drinking water concerns in the North Fork Crow River Watershed.

Generally speaking, the groundwater in the Twelve Mile Creek Watershed is at low risk of contamination due to the composition of the soil. However, the GRAPS document does provide a list of recommended approaches to reduce the amount of nitrate that may enter groundwater:

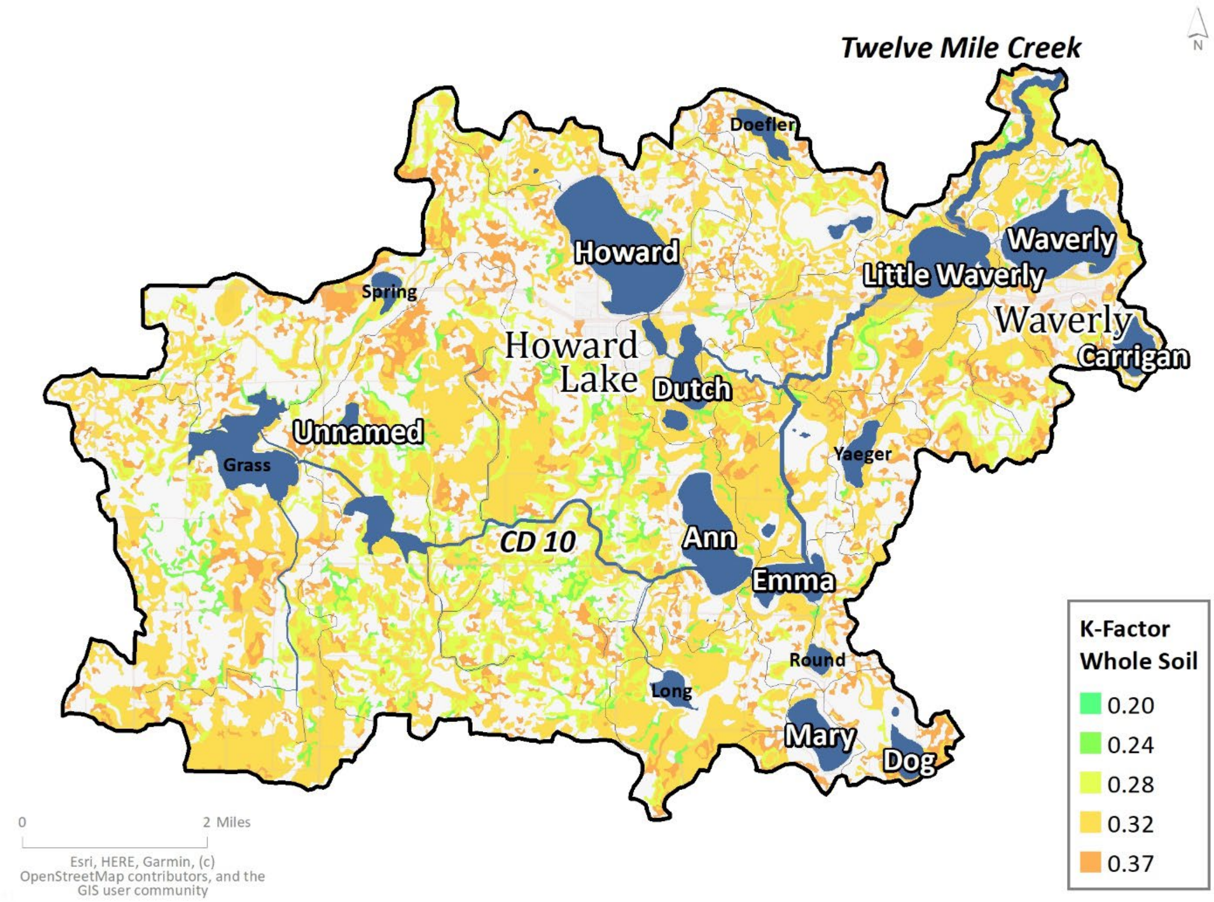
- Provide educational opportunities on the 4R nutrient management concept (right source, right rate, right time, and right place)
- Employ nutrient BMPs and cropping
- Leverage the work of existing programs focused on nutrient management
- Develop incentives and provide technical assistance for adopting nutrient BMPs
- Provide educational opportunities about turf BMPs
- Assure SSTS are constructed properly and encourage regular maintenance of the systems
- Priority feedlot inspections and the proper application of manure in areas at greatest risk to contamination in delegated feedlot counties
- Employ land use controls that safeguard public health through regulations and ordinance development.
- Implement conservation easements through programs such as the Conservation Reserve Program (CRP) and Reinvest in Minnesota (RIM) in vulnerable wellhead protection areas and areas with private wells.

Soils types

The soil composition of the watershed will influence the types of BMPs implemented and the placement and effectiveness of practices.

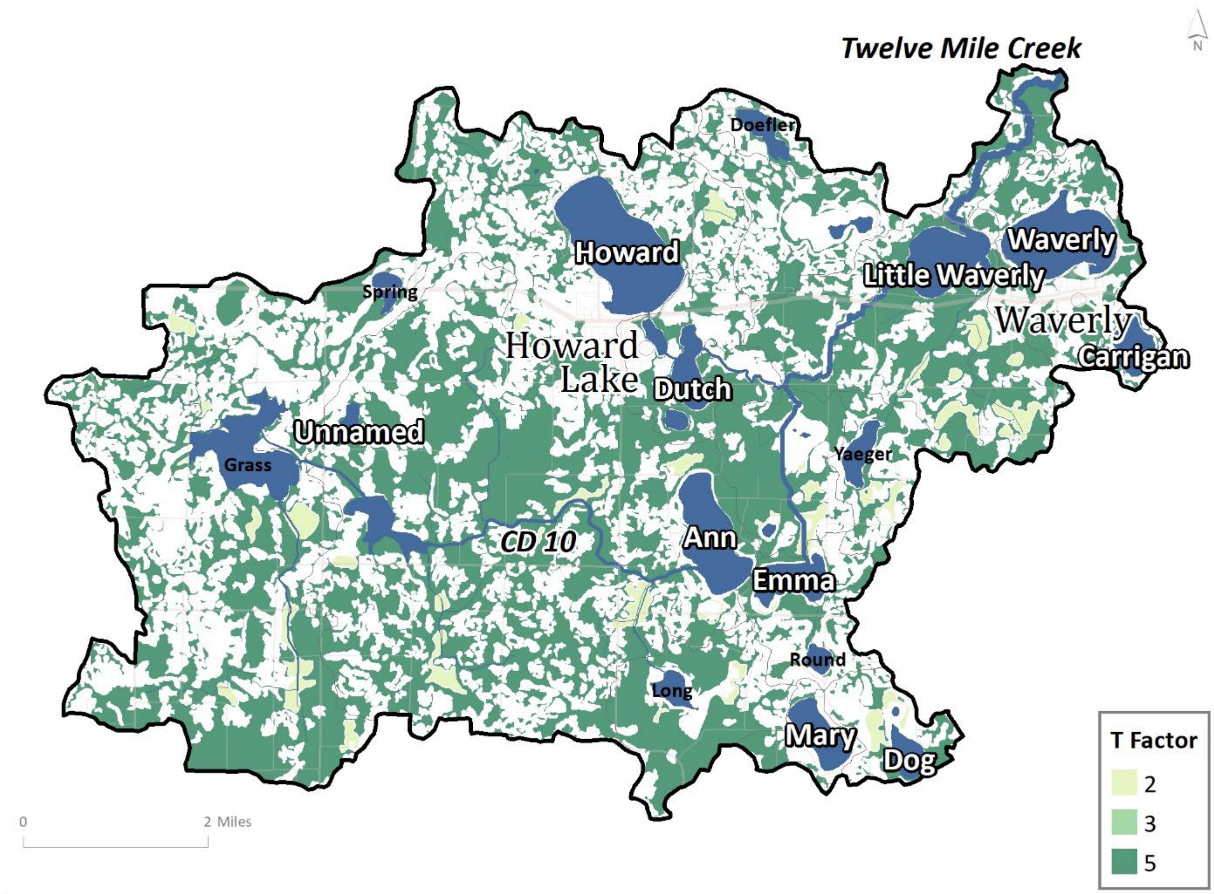
The K factor denotes the relative erodibility of a soil (Figure 22). Generally speaking, soils with K factors below 2 (low erodibility) are expected to have lower heavy clay contents. However, light clays and clay loams can have higher K values as shown here.

Figure 22. K factor for soils in the Twelve Mile Creek subwatershed.



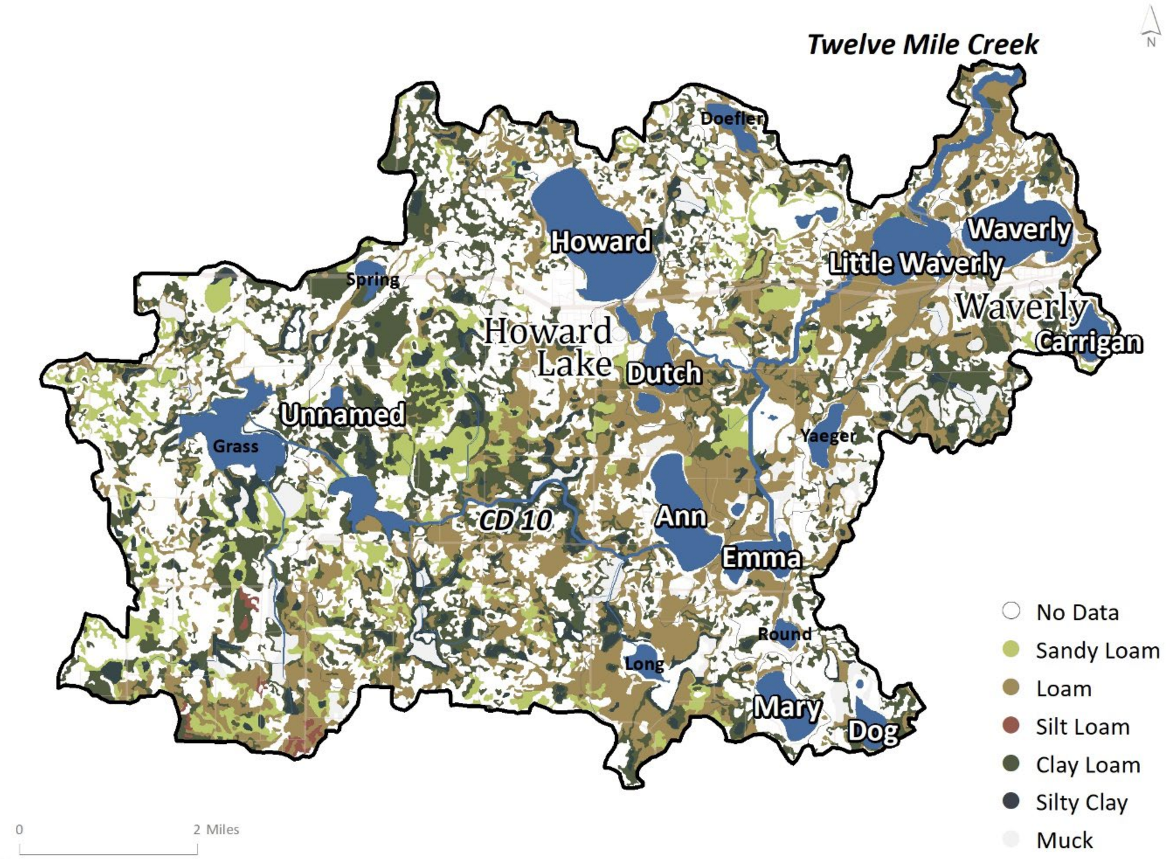
Most soils in the Twelve Mile Creek Watershed have a high "T Factor" (Figure 23), meaning that farms can lose up to 5 tons of soil on average annually before significantly impacting crop production. This means that more sediment can be carried into surface waters without affecting the farmer's crop production, although it also means that more fertilizer, chemicals, etc. may be utilized annually to make up for what has been lost over the previous year. Thus, it benefits everyone that less erosion and soil loss occur annually, and this provides opportunity for addressing the problem.

Figure 23. T factor for soils in the Twelve Mile Creek Watershed.



Soil texture refers to the mixture of size particles in a soil. Soils of different textures pose different risks for the movement of contaminants from agricultural land. Figure 24 illustrates the different soil textures in the Twelve Mile Creek HUC12 Watershed. Soil texture is an important consideration in selecting the most appropriate BMPs for the sites. Certain BMPs work better than others based on soil texture.

Figure 24. Soil texture in the Twelve Mile Creek subwatershed.

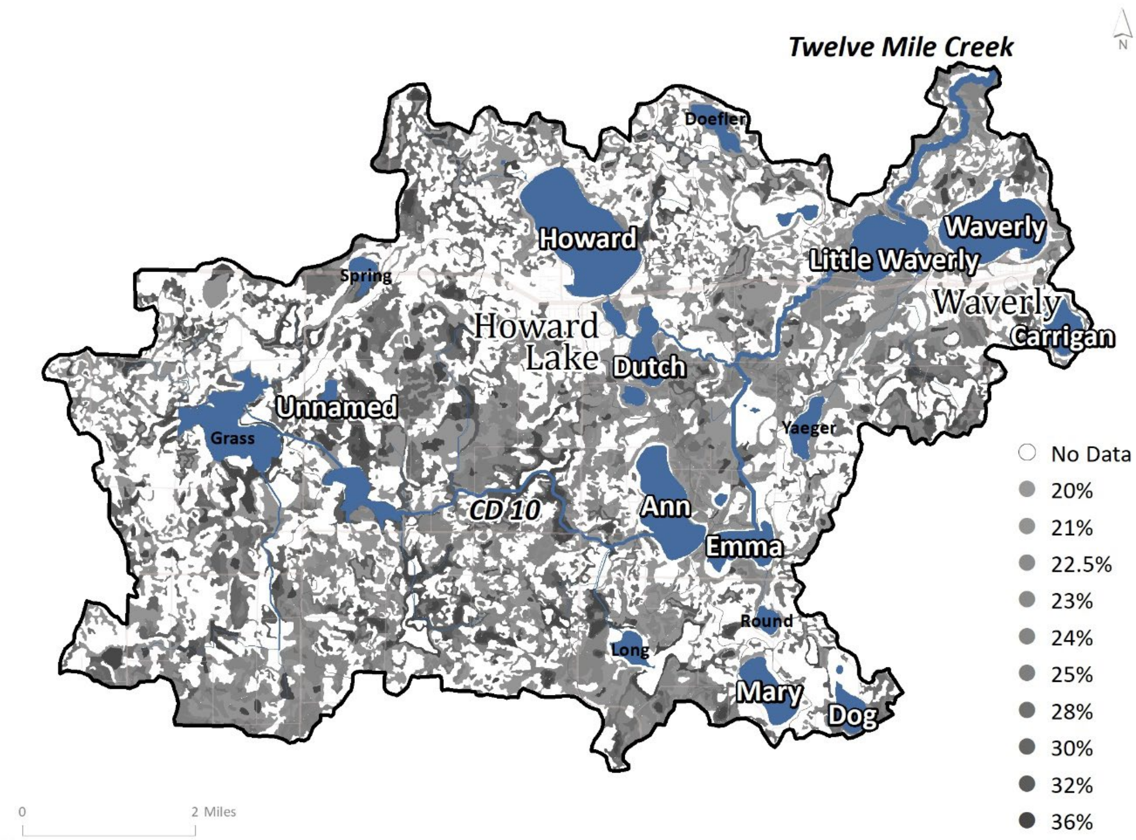


Infiltration

If soils are found to be suitable for infiltration practices, care must still be taken to ensure that the practices are installed with consideration toward the depth of the seasonally high groundwater levels relative to the bottom of the infiltration basin, and the types of contaminants that may be infiltrated. Infiltration requires a minimum of 3 feet of separation between the bottom of the infiltration basin and the seasonally high water table, which is often marked with gleying of the soils, or redox (indicated by rust-colored stains) in the soil horizon. With most soils between 0-10 feet deep, sites will have to be carefully checked to ensure that infiltration is possible by having sufficient separation, sufficiently porous soils, and that the runoff being infiltrated is not excessively contaminated by nitrogen or toxic chemicals such as perflourooctanesulfonic acid (PFOS), cholorothalonil or chlorpyifos.

Given the clay content of many areas in the Twelve Mile Creek HUC12 Watershed (Figure 25) filtration practices function better than infiltration practices. Clay soils do not infiltrate well. This means that practices chosen to aid water quality may need to rely on filtration with the addition of filter media to clean water, including wood chip bioreactors. The use of infiltration practices (bioinfiltration, rain gardens) will not be used as frequently in areas with higher clay-content soils. Selection of the proper practice will be done on a case-by-case basis.

Figure 25. Percentage of clay in soils within the Twelve Mile Creek Sub watershed (Data from NRCS SSURGO)

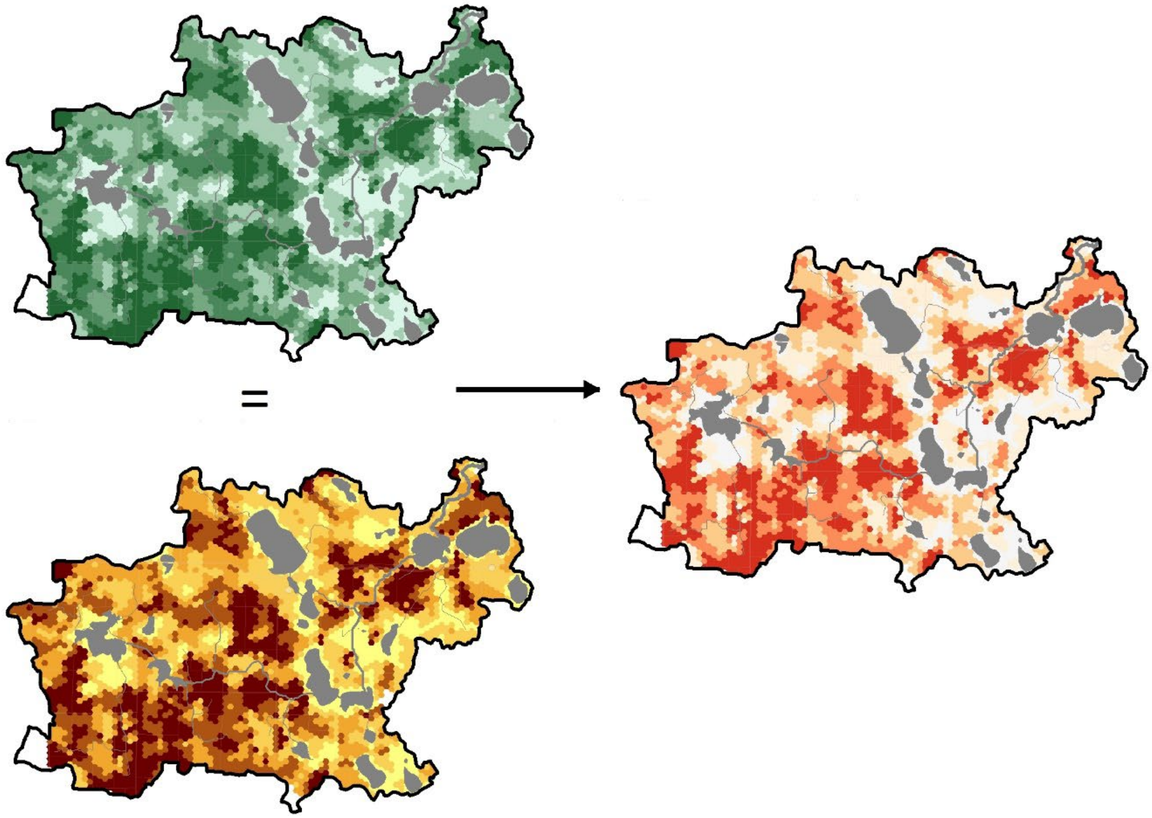


In situations where infiltration is not determined to be an effective treatment method for surface runoff, constructed “filtration” can be substituted. Structural Filtration practices can include artificially created infiltration, where stormwater/runoff is guided to a targeted area and filtered through a filter media (sand, sand/iron, limestone, etc.) to remove contaminants before being discharged through drain pipes, usually placed at the bottom of the filtration media. On average, filtration systems cost more than infiltration systems, and they will eventually require maintenance, but can be very effective in removing a number of contaminants, and can be engineered to target specific ones.

Critical area identification

Critical areas were selected based on the source assessment tool in PTMApp. First, the tool breaks the HUC 12 into “field-scale catchments” that average 40 acres in size. Then the tools uses a combination of land use, soil, rainfall, and elevation data to estimate the amount TSS and TP that is delivered to the catchment outlet annually. The TSS is estimated in tons per year and TP is estimated in pounds per year. These critical areas were determined by overlapping the PTMApp GIS layers for TSS and TP. The process is illustrated in Figure 26.

Figure 26. Analysis of TP and TSS loading layers from PTMApp



Catchments that delivered the greatest load (top 25%) for both total sediment and total phosphorus were considered critical areas (Figure 27). In The criteria for sediment in the Howard Lake and Mary Lake subwatersheds was expanded to the top 50% for sediment since none of the catchments met the 25% criteria in those areas.

The critical areas will be approached by targeting the headwaters (SW) of the watershed and working toward the mouth of Twelve Mile Creek. BMPs and placement will be selected to address the heaviest loading areas, with the most effective approach, in the most cost-efficient manner possible. There are real constraints of landowner cooperation, time, and funding, which may also influence the placement of BMPs. The watershed partners intend to invest the time to conduct the necessary outreach and education for landowners whose participation will impact the loading from critical areas.

Figure 27. Critical Areas in the Twelve Mile Creek Watershed

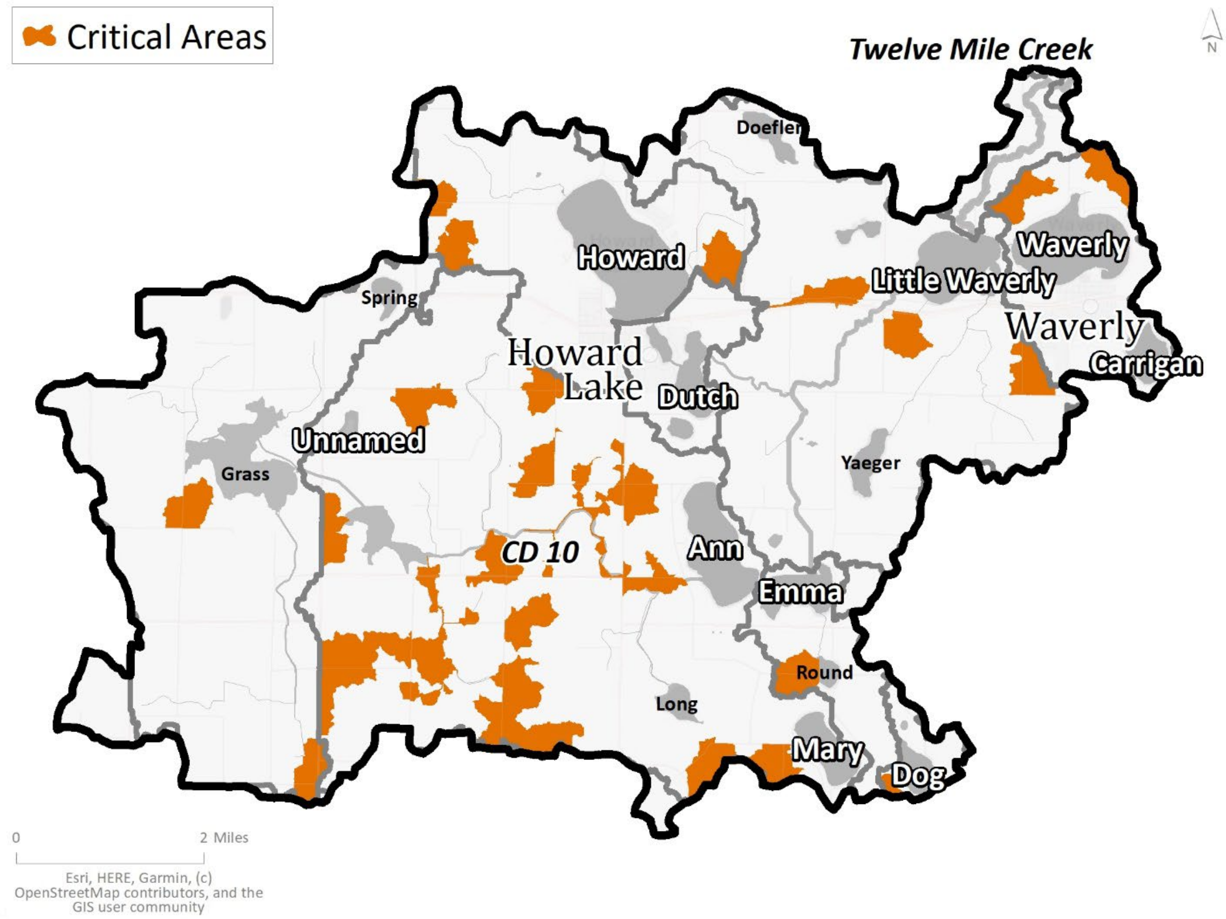


Figure 28 shows an example of the soil runoff from fields that are untreated and are not participating in soil erosion and soil health management practices, such as reduced tillage and cover crops. Because of the impact that soil health management practices have on overall water quality, the adoption will be encouraged throughout the watershed; however, particular attention will be paid to the cropland that affect the critical loading areas.

Figure 28. Sheet erosion from row crop agriculture is a common occurrence in the Twelve Mile Creek Watershed in areas where storage, retention, cover crops, or other practices have not been implemented.

Table 41 describes the practices that will be prioritized for implementation based on the analysis completed by the PTMApp program.

Table 41. Practices identified for targeting in critical areas

	NRCS code	Count	Acres
Grass Critical Area BMPS			
No Till	329	1	81.6
Howard Lake Critical Area BMPS			
No Till	329	4	275.8
Cover Crop	340	3	235.3
Reduced Till	345	3	235.3
Bioreactors	605	3	0.1
Nutrient Management	590	3	185.8
Little Waverly Lake Critical Area BMPS			
No Till	329	4	212.2
Cover Crop	340	4	212.2
Critical Planting	342	10	34
Reduced Till	345	4	212.2
Riparian Herbaceous Cover	390	2	0.1
Filter Strip	393	10	1.7
Grade Stabilization	410	1	1
Grassed Waterway	412	12	30.4
Forage Planting	512	22	68.4
Prescribed grazing	528	3	0.2

	NRCS code	Count	Acres
Shoreland Protection	580	5	1.8
Buffers	604	0	0
Bioreactors	605	2	0.1
WASCOB	638	7	1.7
Nutrient Management	590	3	146.8
Waverly Lake Critical Area BMPS			
No Till	329	2	211.8
Cover Crop	340	2	211.8

Element d. technical and financial assistance

An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon, to implement the entire plan (include administrative, Information and Education, and monitoring costs). Expected sources of funding, States to be used Section 319, State Revolving Funds, USDA's Environmental Quality Incentives Program and Conservation Reserve Program, and other relevant Federal, State, local and private funds to assist in implementing this plan.

The partnerships and activities of the participants in the Twelve Mile Creek HUC12 watershed are summarized in Table 44. It is estimated that the total cost of implementation of this plan is $12.9 million.

Table 42. Entities and their responsibilities

Entity	Description of activities
Wright County Soil and Water Conservation District	Write and implement local and comprehensive water management plans. Monitor water quality of waterbodies and streams. Design, provide technical assistance and construct for conservation practices.
Private Landowners	Implement conservation practices to improve water quality. Influence other landowners to do similar work.
Local Lake Associations (Mary, Waverly, Howard, Ann)	Collect water quality data.
Victor, Stockholm, Middleville, Marysville, Woodland Townships	Manage Township roads and invasive weeds.
Wright County	Manage County roads and enforce shoreline, SSTS, and feedlot ordinances.
Wright County Drainage Authority	Manage County ditches and support water quality projects.
Minnesota Association of Soil and Water Conservation Districts	MASWCD provides 91 Districts with information on Conservation issues, policy development, lobbying services, leadership training.
Minnesota Board of Water and Soil Resources	Providing financial, technical and administrative help to local governments manage and conserve their irreplaceable water and soil resource.
Minnesota Department of Natural Resource	Issue public water permits. Manage fish resources. Provides financial assistance for private forestry project implementation and planning.
Minnesota Pollution Control Agency	Collect water quality data and assess water quality. Identify stressors to water quality. Coordinates citizen monitoring program
Minnesota Department of Agriculture	Implement the Minnesota Agricultural Water Quality Certification Program which helps producers implement practices to improve water quality.
USDA – NRCS	Provide financial and technical assistance to implement conservation practices including forestry.

Entity	Description of activities
U.S. Fish and Wildlife Services	Conserving, protecting, and enhancing fish, wildlife and plants and their habitats
Pheasants Forever	Support habitat improvement projects.
The Nature Conservancy	Provides assistance for land protection.
Discovery Farms of Minnesota	Edge of field water quality monitoring
Ducks Unlimited	Establishing Wildlife Protection Areas (with USFWS)

Element e. education and outreach

An information/education component that will be implemented to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, implementing and maintaining the NPS management measures that will be implemented.

Much of the outreach in Twelve Mile Creek will be directed toward agricultural producers. Education with regard to alternative methods of farming, soil health, groundwater protection, surface water protection, agricultural related contaminants, etc., will be implemented through workshops, field tours, mailings, and other media releases. Specific activities are described in Table 6.

However, poor choices and implementation on the landscape open up significant opportunities for education, changing of attitudes and perception, and implementation of practices that can mitigate for land alterations that have had negative impacts until now. Soil types are higher in light clays than other areas of the North Fork Crow Watershed, making compaction of berms and structural practices more practical and durable. Agricultural impacts also tend to be easier to see and diagnose, this making potential solutions more apparent.

The Wright County SWCD staff have demonstrated extraordinarily good working relationships with farmers, making such changes possible and practicable. In fact, observations by MPCA staff indicate that farmers in the Twelve Mile Creek Watershed are perhaps the most active part of the community with regards to implementing practices beneficial to water quality, including WASCOB, cover crops, wind breaks, buffers, and alternative tile intakes. Wright County staff has successfully implemented mutually beneficial practices in the past, and clearly has a good reputation in the local agricultural community that should lead to many more successes

Farmers have also shown a willingness to attend the various field workshops on cover crops, conservation tillage, no-till, and other practices to improve soil health, which, if implemented, will increase the organic content of soils and subsequently water-holding capacity, while reducing the need for fertilizers and pesticides.

Field visits to lakes in the Twelve Mile Creek Watershed included conversations with residential shoreland owners. It was apparent when speaking with them that there was little in the way of understanding about the effects of vegetation removal, fertilizer, grass lawns, and impervious surface on lake water quality. Mentioned frequently were the “beautiful lawns” and “nice riprap” on the shorelines. There was concern about zebra mussels, and “weeds” in the lake, but the owners seemed to be unaware of the types of educational information that state and local agencies and organizations have been putting out into the community about the connection between what happens on the land and what happens in the water. Further efforts on education of lakeshore owners is important; although, work is needed to develop alternative means of reaching landowners with educational and implementation opportunities.

Element f. schedule

A schedule for implementing the activities and NPS management measures identified in this plan that is reasonably expeditious.

Timelines for proposed implementation are shown Table 6.

Implementation activities described in Table 6, combined with internal loading management, will yield estimated reductions greater than estimated reductions needed to reach water quality standards within 10 years.

Element g. milestones

A description of interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented.

The milestones column in Table 6 provide interim, measurable milestones for determining successful implementation of practices.

Element h. assessment criteria

A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards.

In Table 6, there is a column for “assessment.” The entries in this column indicate measures that will be used to determine the degree that various practices have been implemented in the watershed.

Element i. monitoring

The monitoring & evaluation component to track progress and evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (h) immediately above.

Water quality monitoring will include lake monitoring for total phosphorus, chlorophyll a, Secchi depth, dissolved oxygen, and temperature to evaluate the lakes for changes in water quality. Monitoring will be conducted one to two times a month May through September in Howard Lake, Dutch Lake, Ann Lake, Emma Lake, Dog Lake, Mary Lake, Waverly Lake, and Little Waverly Lake. Lake surface samples will be collected using a 2-meter composite sampler tube. Samples near the bottom of the lakes will be collected with a sub-surface sampler such as Kemmerer sampler. Dissolved oxygen and temperature profiles will be measured with a field meter (Table 43). Secchi disc measurements will also be made on lakes with Citizen Lake Monitoring Program volunteers.

Table 43. Number of samples/measurements for lake monitoring in Howard, Dutch, Ann, Emma, Dog, Mary, Waverly, and Little Waverly Lakes (8 sites)

	May	June	July	August	September	Total per year
Surface sample	2	2	2	2	2	10
Bottom sample	2	2	2	2	2	10
DO/ temperature profile	2	2	2	2	2	10
# sample sets	16	16	16	16	16	80

Stream monitoring will be conducted to evaluate changes in the stream conditions, changes in pollutant loads in Twelve Mile Creek affecting the low dissolved oxygen conditions and poor biota, and pollutant loading to the lakes. Six stream sites will be monitored to evaluate the effect of pollutant loading reductions with BMP implementation on Twelve Mile Creek phosphorus, TSS, nitrate, and dissolved oxygen concentrations (Table 44). Water samples will be collected during storm event flows and base flow conditions. In-situ sondes will be used to measure dissolved oxygen concentrations and temperature continuously. Gage sites will be established at two to five sites to measure stream flow continuously with stage recorders and the development of rating curves for discharge calculations.

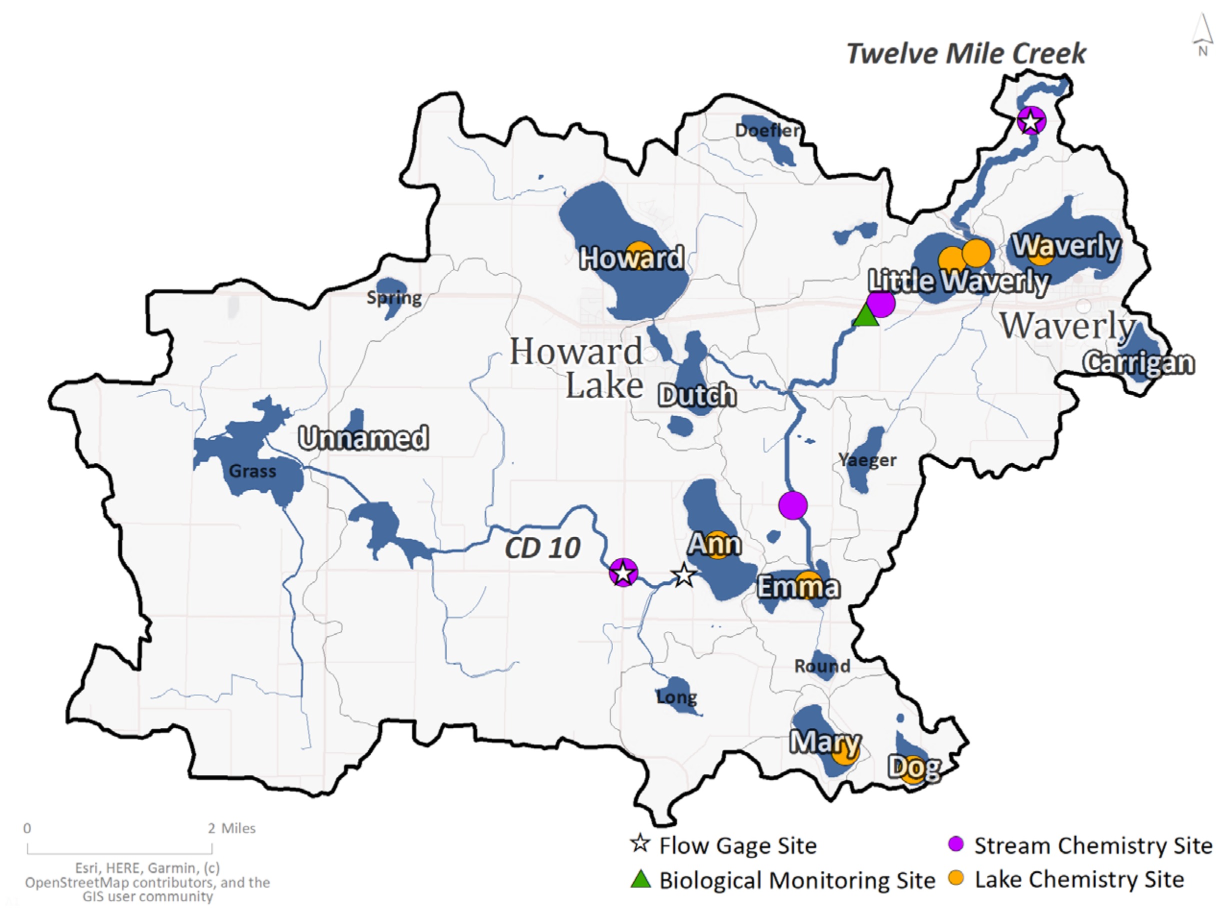
Table 44. Summary of stream monitoring sites

Site	Site ID	Flow gage site	DO sonde	WQ sampling
TMC upstream of outlet	S001-972	X (H18012001)	X	X
TMC, Gowan Ave. SW	S001-968	X	X	X
TMC upstream of tributary at 70th St SW	To be established	X	X	X
Tributary to TMC near confluence	To be established		X	X

Site	Site ID	Flow gage site	DO sonde	WQ sampling
Tributary to TMC downstream of Emma Lake	S001-973	X	X	X
CD10 upstream of Ann Lake, Ingram Ave SW or CR6 SW	S001-619	X (H18077002 or H18077003)		X

Biological monitoring will be conducted on a ten-year cycle by the MPCA. Biological monitoring was last completed in 2019. Fish and macroinvertebrate sampling will be completed at one site on Twelve Mile Creek (17UM011, upstream of Little Waverly Lake) to evaluate the stream reach for improvement in biological condition in about 2029.

Figure 29. Proposed monitoring sites in the Twelve Mile Creek HUC 12 Watershed



References

MPCA. (2015). *12-Mile Creek dissolved oxygen total maximum daily load.*

Wenck. (2011). *Ann Lake and Emma Lake excess nutrient TMDL.*

Wenck. (2014). *North Fork Crow River TMDL: Bacteria, nutrients, and turbidity.*

MDH. 2017. North Fork Crow River Watershed (07010204) Groundwater Restoration and Protection Strategies Report. https://www.health.state.mn.us/communities/environment/water/docs/cwf/grapsnfcrw.pdf.

Appendix A PTMApp

The Prioritize Target and Measure Application (PTMApp) is a decision support tool to identify critical areas in a watershed in which to prioritize and target the implementation of BMPs, identify opportunities where conservation may be best implemented, and estimate the pollutant reductions for the BMP implementation supported by the Minnesota Board of Water Resources (https://ptmapp.bwsr.state.mn.us/). PTMApp utilizes a hydrologically-conditioned digital elevation model developed from LiDAR data along with other geographic data layers to compute application outputs. PTMApp estimates the annual loads of total phosphorous, total nitrogen and sediment received at the outlet of the watershed. The loads are routed through the watershed based on an upstream to downstream analysis of water pathways. A sediment delivery ratio and first order decay equations (TP, TN) are used to account for changes in load throughout the watershed. The placement of BMPs are based on NRCS design standards and are sorted by treatment group (biofiltration, filtration, infiltration, protection, source reduction, and storage).

This appendix outlines the information contained in the document, *(PTMAPP): Theory and development documentation*, to provide an overview of the application. This and other documents are available at https://ptmapp.bwsr.state.mn.us/User/Documentation.

Overall structure includes a desktop component and a web component.

PTMApp-Desktop is comprised of Ingest Data, Catchments and Loading, Ranking, BMP Suitability, Benefits Analysis, and Cost Analysis modules. The process workflows for each module are provided in the document.

The PTMApp-Web allows users to collaboratively build, share, and analyze targeted implementation practices in a watershed. The analysis is driven by the treatment train analysis functionality built into PTMApp-Desktop. The functionality of PTMApp-Web is developed primarily with the goal of allowing local units of government to collaboratively build, share, and analyze BMP targeted implementation strategies that are prioritized, targeted, and result in measurable water quality improvements.

PTMApp generates catchments to represent field scale units with an average size of 40 acres delineated from a hydro-conditioned DEM. Stream Power Index values are computed to identify areas with high potential for erosion and gully formation. Annual sediment yields are estimated based on the implementation of the Revised Universal Soil Loss Equation (RUSLE). Sediment delivery to a channel and catchment outlet is estimated as a function of a sediment delivery ratio adjusted by distance to nearest catchment with channelized flow. Annual nutrient (total phosphorus and total nitrogen) are estimated using land use export coefficients from published literature. Nutrient delivery is estimated using a first order decay computed as a function of overland and in-channel flow travel times. The decay or loss of mass after leaving the landscape is used to represent the reduction in mass from physical, chemical and biological processes. A travel time raster is used in estimating the first order loss coefficient.

Runoff volume is calculated in PTMApp-Desktop using the NRCS runoff curve number (CN) method. Peak discharge is calculated based upon methods describe in NRCS TR-55. These calculations are performed at the raster scale, giving a spatially distributed estimate of volumes.

Sediment and nutrient load adjustments can be made using monitoring or watershed model data.

Critical areas can be evaluated using percentile ranks of the sediment, TP, and TN estimates based upon the relative magnitude of contribution towards leaving the landscape, reaching a catchment outlet, and reaching a priority resource or a Water Quality Index that combines the sediment, TP and TN ranked rasters into one composite ranking for each catchment.

PTMApp identifies potential locations for BMPs and conservation practices (CPs) based on treatment groups of storage, filtration, bio-filtration, protection, source reduction, and a user-defined option. Suitability for placement of the BMP groups is determined using suitability criteria in the application.

Pollutant reduction benefits of the BMPs are estimated using reduction ratios identified for each BMP group based on runoff volume or rate estimates for different precipitation events, literature values, and empirical statistical distributions of observed treatment data. The reduction ratios are then transformed with an empirical treatment decay function into percent reductions of the pollutants.

The cost analysis for BMPs and CPs in PTMApp is estimated on a per unit area, volume or length basis. The average per unit area, length, volume basis for different treatment groups was based upon NRCS EQIP payment schedules, but can be adjusted based on local conditions. These payments do not necessarily reflect the true total cost of installing and maintaining BMPs and CPs. Cost information is used to estimate the treatment cost of implementing BMPs on areas that are suitable for different treatment groups. The calculated costs is paired with the estimates of constituent removal for each BMP treatment group. This information is used to establish a treatment cost and total potential constituent removal for each BMP treatment group.

PTMApp estimates the use of multiple BMPs and CPs in a catchment (field) using practices in treatment trains in series, parallel, and combination of series and parallel.

Appendix B STEPL assumptions

The following practices and efficiencies were added to STEPL to calculate load reductions. These practices, efficiencies, and assumptions are summarized in Table 45.

Table 45. Type, practice, efficiency, and assumptions for Twelve Mile Creek HUC 12 Watershed STEPL model

Landuse	BMP & Efficiency	N	P	BOD	Sediment	*E. coli*	Assumptions and additions
Cropland							
Cropland	0 No BMP	0	0	0	0	0	Added all *E. coli* efficiencies
Cropland	Bioreactor	0.453	0.3	ND	ND	0.9	Assume treats 20 acres
Cropland	Buffer - Forest (100ft wide)	0.478	0.465	ND	0.586	0.9	
Cropland	Buffer - Grass (35ft wide)	0.338	0.435	ND	0.533	0.65	
Cropland	Mary Lake Healthier Watersheds Ag	0.27	0.556	ND	0.568	0.61	See STEPL outputs 4.21.21
Cropland	Combined BMPs-Calculated for Healthier Watersheds	0.093	0.183	ND	0.124	0.229	
Cropland	Combined BMPMs-Calculated for Strategy Table Ann Lake	0.104	0.202	ND	0.046	0.307	
Cropland	Combined BMPMs-Calculated for Strategy Table Grass Lake	0.107	0.205	ND	0.05	0.309	
Cropland	Combined BMPMs-Calculated for Strategy Table Little Waverly Lake	0.149	0.284	ND	0.069	0.428	
Cropland	Combined BMPMs-Calculated for Strategy Table Howard Lake	0.148	0.284	ND	0.077	0.431	
Cropland	Combined BMPMs-Calculated for Strategy Table Waverly Lake	0.105	0.202	ND	0.044	0.307	
Cropland	Combined BMPMs-Calculated for Strategy Table Dutch Lake	0.107	0.205	ND	0.05	0.309	
Cropland	Combined BMPMs-Calculated for Strategy Table Emma Lake	0.107	0.205	ND	0.05	0.309	
Cropland	Combined BMPMs-Calculated for Strategy Table Dog Lake	0.11	0.207	ND	0.052	0.311	
Cropland	Combined BMPMs-Calculated for Strategy Table Mary Lake	0.108	0.207	ND	0.051	0.311	
Cropland	Combined BMPMs-Calculated for Strategy Table TMC	0.107	0.205	ND	0.05	0.309	
Cropland	Conservation Cover	0.204	0.15	ND	0.2	0.5	Added Conservation Cover, assuming same efficencies as STEPL practice Cover Crop 3
Cropland	Conservation Tillage 1 (30-59% Residue)	0.15	0.356	ND	0.403	0.3	
Cropland	Conservation Tillage 2 (equal or more than 60% Residue)	0.25	0.687	ND	0.77	0.65	
Cropland	Contour Farming	0.279	0.398	ND	0.341	0.65	Assumed *E. coli* removal similar to grass buffer
Cropland	Controlled Drainage	0.388	0.35	ND	ND	ND	

Landuse	BMP & Efficiency	N	P	BOD	Sediment	*E. coli*	Assumptions and additions
Cropland	Cover Crop 1 (Group A Commodity) (High Till only for Sediment)	0.008	ND	ND	ND	ND	
Cropland	Cover Crop 2 (Group A Traditional Normal Planting Time) (High Till only for TP and Sediment)	0.196	0.07	ND	0.1	ND	
Cropland	Cover Crop 3 (Group A Traditional Early Planting Time) (High Till only for TP and Sediment)	0.204	0.15	ND	0.2	0.5	
Cropland	Conservation Crop Rotation	0.204	0.15	ND	0.2	0.5	Added cropland Conservation Crop Rotation, assuming same efficiencies as STEPL practice Cover Crop 3
Cropland	Critical Area Planting	0.898	0.808	ND	0.95	0.9	Added cropland Critical Area Planting, assuming same efficiencies as STEPL practice land Retirement
Cropland	Detention Basin	0.253	0.308	ND	0.4	0.3	Assume each basin is 10 acres and each basin treats 100 acres. Assume same efficiencies as STEPL practice Terrace.
Cropland	Diversions	0.898	0.808	ND	0.95	0.9	Added Diversions, assuming same efficiencies as STEPL practice Land Retirement
Cropland	Drainage Water Management	0.253	0.308	ND	0.4	0.3	Added Drainage Water Management, assuming same efficiencies as STEPL Practice Terrace, assume 50 acres treated per practice
Cropland	Field Borders	0.253	0.308	ND	0.4	0.3	Added Field Borders, assuming same efficiencies as STEPL practice Filter Strips (Terrace)
Cropland	Filter Strips	0.253	0.308	ND	0.4	0.3	Added Filter Strip, assuming same efficiencies as STEPL practice Terrace, assume 50 acres treatment per acre of of filter strip (assume 1,000 ft=1 acres)
Cropland	Filtration Practices	0.253	0.308	ND	0.4	0.3	Added Filtration Practices, assuming same efficiencies as STEPL practice Terrace, assuming 40 acres treated per practice
Cropland	Grade Stabilization Structures	0.253	0.308	ND	0.4	0.3	Added Grade Stabilization Structures, assuming same efficiencies as STEPL practice Terrace, assume 40 acres treated per practice.
Cropland	Grassed Waterways	0.253	0.308	ND	0.4	0.3	Added Grassed Waterways, assume 1,000 ft of grassed waterways treats 50 acres, assume same efficiencies as STEPL practice Terrace
Cropland	Impoundment	0.898	0.808	ND	0.95	0.9	Added Impoundment, assume same efficiencies as STEPL practice Land Retirement

Landuse	BMP & Efficiency	N	P	BOD	Sediment	*E. coli*	Assumptions and additions
Cropland	Land Retirement	0.898	0.808	ND	0.95	0.9	Added Nutrient/Manure Management, Assuming same efficiencies as STEPL practice Nutrient Management 1, increased *E. coli* efficiencies to .9
Cropland	Manure/Nutrient Management	0.154	0.45	ND	ND	0.9	
Cropland	Nutrient Management 1 (Determined Rate)	0.154	0.45	ND	ND	0.5	
Cropland	Nutrient Management 2 (Determined Rate Plus Additional Considerations)	0.247	0.56	ND	ND	0.9	
Cropland	Residue/Tillage Management	0.15	0.356	ND	0.403	0.3	Added Residue/Tillage Management, assuming same efficiencies as STEPL practice Conservation Tillage 1
Cropland	Saturated Buffer	0.338	0.435	ND	0.533	0.65	Added Saturated Buffer, assuming same efficiencies as STEPL practice Buffer-Grass; Assume 1,000 ft with treatment as 40 ac/mil (1/8 mile width) as Two-Stage Ditch
Cropland	Side water inlets	0.253	0.308	ND	0.4	0.3	Added Side Water inlets, assumed same efficiencies as Terrace
Cropland	Streambank Erosion Practices	0.253	0.308	ND	0.4	0.3	Added Streambank Erosion Practices, assuming same efficiencies as STEPL practice Terrace, assuming 5 practices treat 100 acres
Cropland	Streambank Stabilization and Fencing	0.75	0.75	ND	0.75	0.3	
Cropland	Terrace	0.253	0.308	ND	0.4	0.3	
Cropland	Two-Stage Ditch	0.12	0.28	ND	ND	0.3	
Cropland	WASCOB (Water and Sediment Control Basin	0.253	0.308	ND	0.4	0.3	Added WASCOB, assuming the same efficiencies as Terrace, assuming 40 acres treated per WASCOB
Cropland	Water Control Structures	0.253	0.308	ND	0.4	0.3	Added cropland Water Control Structures, assuming same efficiencies as STEPL practice Terrace, assume 40 acres treated per practice installed
Cropland	Wetland Restoration	0.898	0.808	ND	0.95	0.9	Added Wetland Restoration, assuming same efficiencies as STEPL practice Land retirement assuming 40 acres treated per acre of wetland
Pastureland							
Pastureland	0 No BMP	0	0	0	0	0	
Pastureland	30m Buffer with Optimal Grazing	0.364	0.653	ND	ND	0.65	
Pastureland	Alternative Water Supply	0.133	0.115	ND	0.187	0.65	
Pastureland	Cattle Exclusions	0.203	0.304	ND	0.62	0.65	Added pastureland Cattle Exclusions, assuming same efficiencies as STEPL practice Livestock exclusion fencing
Pastureland	Combined BMPs-Calculated	0	0	0	0	0	
Pastureland	Combined BMPs-Calculated Ann	0.07	0.05	ND	0.021	0.117	

Landuse	BMP & Efficiency	N	P	BOD	Sediment	*E. coli*	Assumptions and additions
Pastureland	Combined BMPs-Calculated Grass	0.134	0.173	ND	0.331	0.375	
Pastureland	Combined BMPs-Calculated Little Waverly	0.134	0.173	ND	0.3311	0.375	
Pastureland	Combined BMPs-Calculated Howard	0.106	0.137	ND	0.247	0.298	
Pastureland	Combined BMPs-Calculated Waverly	0.134	0.173	ND	0.311	0.375	
Pastureland	Combined BMPs-Calculated Dutch	0.134	0.173	ND	0.311	0.375	
Pastureland	Combined BMPs-Calculated Emma	0.134	0.173	ND	0.311	0.375	
Pastureland	Combined BMPs-Calculated Dog	0.134	0.173	ND	0.311	0.375	
Pastureland	Combined BMPs-Calculated Mary	0.134	0.173	ND	0.311	0.375	
Pastureland	Combined BMPs-Calculated TMC	0.134	0.173	ND	0.311	0.375	
Pastureland	Critical Area Planting	0.175	0.2	ND	0.42	ND	
Pastureland	Fencing and Watering Projects	0.203	0.304	ND	0.62	0.65	Added pastureland Fencing and watering projects, assuming same efficiencies as STEPL practice Livestock Exclusion Fencing
Pastureland	Forest Buffer (minimum 35 feet wide)	0.452	0.4	ND	0.533	0.65	
Pastureland	Grass Buffer (minimum 35 feet wide)	0.868	0.766	ND	0.648	ND	
Pastureland	Grazing Land Management (rotational grazing with fenced areas)	0.43	0.263	ND	ND	0.65	
Pastureland	Heavy Use Area Protection	0.183	0.193	ND	0.333	ND	
Pastureland	Litter Storage and Management	0.14	0.14	ND	0	ND	
Pastureland	Livestock Exclusion Fencing	0.203	0.304	ND	0.62	0.65	
Pastureland	Multiple Practices	0.246	0.205	ND	0.221	ND	
Pastureland	Pasture and Hayland Planting (also called Forage Planting)	0.181	0.15	ND	ND	ND	
Pastureland	Prescribed Grazing	0.408	0.227	ND	0.333	ND	
Pastureland	Rotational Grazing	0.43	0.263	ND	0.333	0.65	Added pastureland Rotational Grazing, assuming same efficiencies as STEPL practice Grazing Land Management, and TSS reduction from Prescribed Grazing
Pastureland	Streambank Protection w/o Fencing	0.15	0.22	ND	0.575	0.3	
Pastureland	Streambank Stabilization and Fencing	0.75	0.75	ND	0.75	0.65	
Pastureland	Use Exclusion	0.39	0.04	ND	0.589	0.9	
Pastureland	Winter Feeding Facility	0.35	0.4	ND	0.4	ND	

Landuse	BMP & Efficiency	N	P	BOD	Sediment	*E. coli*	Assumptions and additions
Forest							
Forest	0 No BMP	0	0	0	0	0	
Forest	Combined BMPs-Calculated	0	0	0	0	0	
Forest	Invasive species management (buckthorn, earthworms?, etc.)	0.452	0.4	ND	0.533	0.65	Assumption is that improved understory will function with efficiencies similar to STEPL Practice Pastureland Forest Buffer
Forest	Understory improvement?	0.452	0.4	ND	0.533	0.65	Assumption is that improved understory will function with efficiencies similar to STEPL Practice Pastureland Forest Buffer
Forest	Road dry seeding	ND	ND	ND	0.41	ND	
Forest	Road grass and legume seeding	ND	ND	ND	0.71	ND	
Forest	Road hydro mulch	ND	ND	ND	0.41	ND	
Forest	Road straw mulch	ND	ND	ND	0.41	ND	
Forest	Road tree planting	ND	ND	ND	0.5	ND	
Forest	Site preparation/hydro mulch/seed/fertilizer	ND	ND	ND	0.71	ND	
Forest	Site preparation/hydro mulch/seed/fertilizer/transplants	ND	ND	ND	0.69	ND	
Forest	Site preparation/steep slope seeder/transplant	ND	ND	ND	0.81	ND	
Forest	Site preparation/straw/crimp seed/fertilizer/transplant	ND	ND	ND	0.95	ND	
Forest	Site preparation/straw/crimp/net	ND	ND	ND	0.93	ND	
Forest	Site preparation/straw/net/seed/fertilizer/transplant	ND	ND	ND	0.83	ND	
Forest	Site preparation/straw/polymer/seed/fertilizer/transplant	ND	ND	ND	0.86	ND	
User_Defined							
User_Defined	0 No BMP	0	0	0	0	0	
User_Defined	Combined BMPs-Calculated	0	0	0	0	0	
Feedlots							
Feedlots	0 No BMP	0	0	0	0	0	
Feedlots	Combined BMPs--Calculated	0.325	0.296	ND	0.366	0.416	
Feedlots	Diversion	0.45	0.7	ND	ND	ND	
Feedlots	Filter strip	ND	0.85	ND	ND	0.3	
Feedlots	Runoff Mgmt System	ND	0.825	ND	ND	0.5	
Feedlots	Solids Separation Basin	0.35	0.31	ND	ND	ND	

Landuse	BMP & Efficiency	N	P	BOD	Sediment	*E. coli*	Assumptions and additions
Feedlots	Solids Separation Basin w/Infilt Bed	ND	0.8	0.85	ND	0.9	
Feedlots	Terrace	0.55	0.85	ND	ND	ND	
Feedlots	Waste Mgmt System	0.8	0.9	ND	ND	0.9	
Feedlots	Waste Storage Facility	0.65	0.6	ND	ND	0.9	
Urban							
Urban	0 No BMP	0	0	0	0	0	
Urban	Alum Treatment	0.6	0.9	0.6	0.95	ND	
Urban	Bioretention facility	0.63	0.8	ND	ND	0.9	
Urban	Bioretention practices	0.63	0.8	ND	0.85	0.9	Added Urban STEPL Bioretention practice, efficiencies for TSS and *E. coli* based on MN Stormwater manual (https://stormwater.pca.state.mn.us/index.php/Calculating_credits_for_bioretention)
Urban	Combined BMPs-Calculated	0	0	0	0	0	
Urban	Concrete Grid Pavement	0.9	0.9	ND	0.9	0.9	
Urban	Dry Detention	0.3	0.26	0.27	0.575	ND	
Urban	Extended Wet Detention	0.55	0.685	0.72	0.86	0.9	
Urban	Filter Strip-Agricultural	0.5325	0.6125	ND	0.65	0.3	
Urban	Grass Swales	0.1	0.25	0.3	0.65	ND	
Urban	Infiltration Basin	0.6	0.65	ND	0.75	0.9	
Urban	Infiltration Devices	ND	0.83	0.83	0.94	ND	
Urban	Infiltration Trench	0.55	0.6	ND	0.75	0.9	
Urban	Lakeshore restoration	0.43	0.81	ND	0.73	0.3	
Urban	LID*/Cistern	0	0	0	0	0	
Urban	LID*/Cistern+Rain Barrel	0	0	0	0	0	
Urban	LID*/Rain Barrel	0	0	0	0	0	
Urban	LID/Bioretention	0.43	0.81	ND	ND	ND	
Urban	LID/Dry Well	0.5	0.5	0.7	0.9	ND	
Urban	LID/Filter/Buffer Strip	0.3	0.3	0.4	0.6	0.9	
Urban	LID/Infiltration Swale	0.5	0.65	ND	0.9	ND	
Urban	LID/Infiltration Trench	0.5	0.5	0.7	0.9	ND	

Landuse	BMP & Efficiency	N	P	BOD	Sediment	*E. coli*	Assumptions and additions
Urban	LID/Vegetated Swale	0.075	0.175	ND	0.475	ND	
Urban	LID/Wet Swale	0.4	0.2	ND	0.8	ND	
Urban	Limestone filter	0.3	0.5	0.7	0.9	0.9	Assumption bases on information regarding Lime Filters in the MPC Stormwater Manual, used efficiencies for STEPL practice Urban LID/Filter/Buffer strip.
Urban	Oil/Grit Separator	0.05	0.05	ND	0.15	ND	
Urban	Porous Pavement	0.85	0.65	ND	0.9	0.9	
Urban	Raingardens	0.6	0.65	ND	0.75	0.9	Added Urban STEPL raingardens, assuming same efficiencies as STEPL practice Infiltration basin (urban)
Urban	Sand Filter/Infiltration Basin	0.35	0.5	ND	0.8	ND	
Urban	Sand Filters	ND	0.375	0.4	0.825	ND	
Urban	Settling Basin	ND	0.515	0.56	0.815	ND	
Urban	Shoreland buffer	0.4	0.425	0.505	0.73	0.3	
Urban	Silva cell	0.55	0.85	ND	0.95	0.9	Added Urban STEPL Silva Cells, assuming same reduction efficiencies as STEPL practice Infiltration Trench and efficiency ratings from https://www.deeproot.com/products/stormwater.html
Urban	Vegetated Filter Strips	0.4	0.4525	0.505	0.73	0.9	
Urban	Weekly Street Sweeping	ND	0.06	0.06	0.16	ND	
Urban	Wet Pond	0.35	0.45	ND	0.6	ND	
Urban	Wetland Detention	0.2	0.44	0.63	0.775	ND	
Urban	WQ Inlet w/Sand Filter	0.35	ND	ND	0.8	ND	
Urban	WQ Inlets	0.2	0.09	0.13	0.37	ND	

The following tables summarize the reductions by watershed for past practices, combined efficiencies, and BMP calculator in STEPL.

Table 46. Reductions from SSTS upgrades/replacements by subwatersheds STEPL

Watershed	P lb/yr	*E.coli* B MPN/yr
Ann Lake	540.62	98,923.99
Little Waverly Lake	1654.50	302,743.07
Howard Lake	1089.04	199,273.92
Waverly Lake	230.37	42,154.10
Dutch Lake	62.83	11,496.57
Lake Emma	48.70	8,912.07

Table 47. Reductions from past cropland practices by subwatershed STEPL (Healthier Watersheds)

Watershed	N Load (no BMP) lbs/yr	P Load (no BMP) lbs/yr	BOD Load (no BMP) lbs/yr	TSS Load (no BMP) t/yr	*E. coli* Load (no BMP) B MPN/yr	N Reduction lbs/yr	P Reduction lbs/yr	BOD Reduction lbs/yr	TSS Reduction t/yr	*E. coli* Reduction B MPN/yr	N Load (with BMP) lbs/yr	P Load (with BMP) lbs/yr	BOD (with BMP) lbs/yr	TSS Load (with BMP) t/yr	*E. coli* Load (with BMP) B MPN/yr	% N	% TP	% BOD	% TSS	% *E. coli*
Ann Lake	66305.3	16521.1	118223.2	3957.7	66906.5	1306.0	556.6	742.0	115.9	359.1	64999.3	15964.4	117481.3	3841.7	66547.4	2.0	3.4	0.6	2.9	0.5
Grass Lake	57947.4	13847.8	103968.0	2925.0	15098.4	1264.0	532.5	525.7	82.1	392.0	56683.4	13315.3	103442.3	2842.9	14706.5	2.2	3.8	0.5	2.8	2.6
Little Waverly Lake	42515.9	10523.4	80811.9	2331.5	161528.7	682.9	291.0	388.0	60.6	187.8	41833.0	10232.3	80423.9	2270.9	161341.0	1.6	2.8	0.5	2.6	0.1
Howard Lake	19941.6	4839.6	43349.6	1036.9	113257.1	312.4	133.1	177.5	27.7	85.9	19629.3	4706.4	43172.2	1009.2	113171.2	1.6	2.8	0.4	2.7	0.1
Waverly Lake	8120.1	1854.1	18329.1	387.2	30326.6	112.8	48.1	64.1	10.0	31.0	8007.3	1806.0	18265.1	377.2	30295.6	1.4	2.6	0.3	2.6	0.1
Dutch Lake	6277.6	1290.2	12242.2	207.7	10972.6	87.2	33.1	25.9	4.0	36.3	6190.4	1257.1	12216.3	203.7	10936.3	1.4	2.6	0.2	1.9	0.3
Lake Emma	6777.3	1543.6	11900.5	248.1	6310.6	107.9	45.5	44.9	7.0	33.5	6669.3	1498.2	11855.7	241.1	6277.2	1.6	2.9	0.4	2.8	0.5
Dog Lake	2656.7	680.6	5028.0	218.2	726.7	53.5	22.8	30.4	4.7	14.7	2603.2	657.8	4997.6	213.4	712.0	2.0	3.4	0.6	2.2	2.0
Mary Lake	1281.7	300.2	2748.1	82.6	994.8	59.9	25.5	34.0	5.3	16.5	1221.8	274.7	2714.1	77.3	978.4	4.7	8.5	1.2	6.4	1.7
TMC 579	4575.8	1146.8	8521.1	596.8	1116.5	49.2	21.0	27.9	4.4	13.5	4526.6	1125.9	8493.2	592.4	1102.9	1.1	1.8	0.3	0.7	1.2
Total	**216399.3**	**52547.3**	**405121.8**	**11991.6**	**407238.7**	**4035.6**	**1709.2**	**2060.3**	**321.9**	**1170.2**	**212363.7**	**50838.2**	**403061.5**	**11669.7**	**406068.5**	**1.9**	**3.3**	**0.5**	**2.7**	**0.3**

Table 48. Reductions from past pastureland practices by subwatershed STEPL (Healthier Watersheds)

Watershed	N Load (no BMP) lbs/yr	P Load (no BMP) lbs/yr	BOD Load (no BMP) lbs/yr	TSS Load (no BMP) t/yr	*E. coli* Load (no BMP) B MPN/yr	N Reduction lbs/yr	P Reduction lbs/yr	BOD Reduction lbs/yr	TSS Reduction t/yr	*E. coli* Reduction B MPN/yr	N Load (with BMP) lbs/yr	P Load (with BMP) lbs/yr	BOD (with BMP) lbs/yr	TSS Load (with BMP) t/yr	*E. coli* Load (with BMP) B MPN/yr
Grass Lake	57947.4	13847.8	103968.0	2925.0	15098.4	4.1	0.5	1.3	0.2	4.1	57943.3	13847.3	103966.7	2924.8	15094.3
Little Waverly Lake	42515.9	10523.4	80811.9	2331.5	161528.7	3.6	0.5	1.1	0.2	1.8	42512.3	10522.9	80810.7	2331.3	161526.9
Total	**216399.3**	**52547.3**	**405121.8**	**11991.6**	**407238.7**	**7.7**	**1.0**	**2.4**	**0.4**	**6.0**	**216391.6**	**52546.3**	**405119.4**	**11991.2**	**407232.7**

Table 49. Reductions from past feedlot practices by subwatershed STEPL (Healthier Watersheds)

Watershed	N Load (no BMP) lbs/yr	P Load (no BMP) lbs/yr	BOD Load (no BMP) lbs/yr	TSS Load (no BMP) t/yr	*E. coli* Load (no BMP) B MPN/yr	N Reduction lbs/yr	P Reduction lbs/yr	BOD Reduction lbs/yr	TSS Reduction t/yr	*E. coli* Reduction B MPN/yr	N Load (with BMP) lbs/yr	P Load (with BMP) lbs/yr	BOD (with BMP) lbs/yr	TSS Load (with BMP) t/yr	*E. coli* Load (with BMP) B MPN/yr
Ann Lake	66305.3	16521.1	118223.2	3957.7	66906.5	406.7	75.1	0.0	0.0	0.0	65898.6	16446.0	118223.2	3957.7	66906.5
Little Waverly Lake	42515.9	10523.4	80811.9	2331.5	161528.7	412.2	92.8	0.0	0.0	0.0	42103.6	10430.6	80811.9	2331.5	161528.7
Total	**216399.3**	**52547.3**	**405121.8**	**11991.6**	**407238.7**	**819.0**	**167.8**	**0.0**	**0.0**	**0.0**	**215580.3**	**52379.5**	**405121.8**	**11991.6**	**407238.7**

Table 50. Reductions from past urban practices by subwatershed STEPL (Healthier Watersheds)

Watershed	N Load (no BMP) lbs/yr	P Load (no BMP) lbs/yr	BOD Load (no BMP) lbs/yr	TSS Load (no BMP) t/yr	*E. coli* Load (no BMP) B MPN/yr	N Reduction lbs/yr	P Reduction lbs/yr	BOD Reduction lbs/yr	TSS Reduction t/yr	*E. coli* Reduction B MPN/yr	N Load (with BMP) lbs/yr	P Load (with BMP) lbs/yr	BOD (with BMP) lbs/yr	TSS Load (with BMP) t/yr	*E. coli* Load (with BMP) B MPN/yr
Howard Lake	19941.6	4839.6	43349.6	1036.9	113257.1	29.2	3.8	0.0	0.0	378.3	19912.4	4835.8	43349.6	1036.9	112878.9
Total	**216399.3**	**52547.3**	**405121.8**	**11991.6**	**407238.7**	**29.2**	**3.8**	**0.0**	**0.0**	**378.3**	**216370.1**	**52543.6**	**405121.8**	**11991.6**	**406860.5**

Table 51. Reductions from planned lake shore restorations by subwatershed STEPL

Watershed	N Load (no BMP) lbs/yr	P Load (no BMP) lbs/yr	BOD Load (no BMP) lbs/yr	TSS Load (no BMP) t/yr	*E. coli* Load (no BMP) B MPN/yr	N Reduction lbs/yr	P Reduction lbs/yr	BOD Reduction lbs/yr	TSS Reduction t/yr	*E. coli* Reduction B MPN/yr	N Load (with BMP) lbs/yr	P Load (with BMP) lbs/yr	BOD (with BMP) lbs/yr	TSS Load (with BMP) t/yr	*E. coli* Load (with BMP) B MPN/yr	% N	% TP	% BOD	% TSS	% *E. coli*
Ann Lake	66305.3	16521.1	118223.2	3957.7	66906.5	4.0	1.4	0.0	0.2	22.8	66301.3	16519.7	118223.2	3957.5	66883.8	0.0	0.0	0.0	0.0	0.0
Little Waverly Lake	42515.9	10523.4	80811.9	2331.5	161528.7	3.2	1.1	0.0	0.1	18.4	42512.7	10522.3	80811.9	2331.4	161510.4	0.0	0.0	0.0	0.0	0.0
Howard Lake	19941.6	4839.6	43349.6	1036.9	113257.1	3.2	1.1	0.0	0.1	18.4	19938.4	4838.5	43349.6	1036.8	113238.7	0.0	0.0	0.0	0.0	0.0
Waverly Lake	8120.1	1854.1	18329.1	387.2	30326.6	11.9	4.1	0.0	0.5	68.7	8108.2	1850.0	18329.1	386.7	30257.9	0.1	0.2	0.0	0.1	0.2
Dutch Lake	6277.6	1290.2	12242.2	207.7	10972.6	3.2	1.1	0.0	0.1	18.4	6274.4	1289.1	12242.2	207.6	10954.2	0.1	0.1	0.0	0.1	0.2
Lake Emma	6777.3	1543.6	11900.5	248.1	6310.6	0.8	0.3	0.0	0.0	4.4	6776.5	1543.4	11900.5	248.0	6306.2	0.0	0.0	0.0	0.0	0.1
Mary Lake	1281.7	300.2	2748.1	82.6	994.8	1.6	0.5	0.0	0.1	9.2	1280.1	299.7	2748.1	82.6	985.6	0.1	0.2	0.0	0.1	0.9
Total	**216399.3**	**52547.3**	**405121.8**	**11991.6**	**407238.7**	**27.8**	**9.5**	**0.0**	**1.1**	**160.1**	**216371.5**	**52537.8**	**405121.8**	**11990.5**	**407078.6**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Table 52. Reductions from planned streambank restoration in Twelve Mile Creek subwatershed STEPL

Watershed	N Load (no BMP) lbs/yr	P Load (no BMP) lbs/yr	BOD Load (no BMP) lbs/yr	TSS Load (no BMP) t/yr	*E. coli* Load (no BMP) B MPN/yr	N Reduction lbs/yr	P Reduction lbs/yr	BOD Reduction lbs/yr	TSS Reduction t/yr	*E. coli* Reduction B MPN/yr	N Load (with BMP) lbs/yr	P Load (with BMP) lbs/yr	BOD (with BMP) lbs/yr	TSS Load (with BMP) t/yr	*E. coli* Load (with BMP) B MPN/yr	% N	% TP	% BOD	% TSS	% *E. coli*
TMC 579	4575.8	1146.8	8521.1	596.8	1116.5	755.9	291.0	1511.8	410.8	0.0	3819.9	855.8	7009.3	186.0	1116.5	16.5	25.4	17.7	68.8	0.0

Table 53. Reductions from planned urban practices by subwatershed STEPL

Watershed	N Load (no BMP) lbs/yr	P Load (no BMP) lbs/yr	BOD Load (no BMP) lbs/yr	TSS Load (no BMP) t/yr	*E. coli* Load (no BMP) B MPN/yr	N Reduction lbs/yr	P Reduction lbs/yr	BOD Reduction lbs/yr	TSS Reduction t/yr	*E. coli* Reduction B MPN/yr	N Load (with BMP) lbs/yr	P Load (with BMP) lbs/yr	BOD (with BMP) lbs/yr	TSS Load (with BMP) t/yr	*E. coli* Load (with BMP) B MPN/yr	% N	% TP	% BOD	% TSS	% *E. coli*
Howard Lake	19941.6	4839.6	43349.6	1036.9	113257.1	191.3	36.0	0.0	6.5	2770.5	19750.4	4803.6	43349.6	1030.4	110486.6	1.0	0.7	0.0	0.6	2.4
Waverly Lake	8120.1	1854.1	18329.1	387.2	30326.6	191.3	36.0	0.0	6.5	2770.5	7928.8	1818.1	18329.1	380.6	27556.1	2.4	1.9	0.0	1.7	9.1
Total	**216399.3**	**52547.3**	**405121.8**	**11991.6**	**407238.7**	**382.5**	**71.9**	**0.0**	**13.1**	**5541.0**	**216016.8**	**52475.4**	**405121.8**	**11978.5**	**401697.7**	**0.2**	**0.1**	**0.0**	**0.1**	**1.4**

Table 54. Reductions from planned cropland practices in the strategy table STEPL

Watershed	N Load (no BMP) lbs/yr	P Load (no BMP) lbs/yr	BOD Load (no BMP) lbs/yr	TSS Load (no BMP) t/yr	*E. coli* Load (no BMP) B MPN/yr	N Reduction lbs/yr	P Reduction lbs/yr	BOD Reduction lbs/yr	TSS Reduction t/yr	*E. coli* Reduction B MPN/yr	N Load (with BMP) lbs/yr	P Load (with BMP) lbs/yr	BOD (with BMP) lbs/yr	TSS Load (with BMP) t/yr	*E. coli* Load (with BMP) B MPN/yr	% N	% TP	% BOD	% TSS	% *E. coli*
Ann Lake	66305.3	16521.1	118223.2	3957.7	66906.5	1669.7	719.3	388.4	60.7	679.4	64635.6	15801.7	117834.8	3897.0	66227.2	2.5	4.4	0.3	1.5	1.0
Grass Lake	57947.4	13847.8	103968.0	2925.0	15098.4	1775.7	739.7	299.3	46.8	746.7	56171.7	13108.1	103668.7	2878.2	14351.8	3.1	5.3	0.3	1.6	4.9
Little Waverly Lake	42515.9	10523.4	80811.9	2331.5	161528.7	1258.1	532.7	304.8	47.6	495.4	41257.7	9990.7	80507.1	2283.9	161033.3	3.0	5.1	0.4	2.0	0.3
Howard Lake	19941.6	4839.6	43349.6	1036.9	113257.1	580.0	246.7	155.5	24.3	228.1	19361.7	4592.9	43194.1	1012.6	113029.0	2.9	5.1	0.4	2.3	0.2
Waverly Lake	8120.1	1854.1	18329.1	387.2	30326.6	144.7	61.8	32.1	5.0	58.7	7975.4	1792.2	18297.1	382.2	30267.9	1.8	3.3	0.2	1.3	0.2
Dutch Lake	6277.6	1290.2	12242.2	207.7	10972.6	128.3	47.4	14.8	2.3	69.3	6149.3	1242.8	12227.4	205.4	10903.3	2.0	3.7	0.1	1.1	0.6
Lake Emma	6777.3	1543.6	11900.5	248.1	6310.6	151.2	63.0	25.5	4.0	63.6	6626.0	1480.6	11875.0	244.1	6247.0	2.2	4.1	0.2	1.6	1.0
Dog Lake	2656.7	680.6	5028.0	218.2	726.7	73.0	30.5	18.0	2.8	28.2	2583.8	650.0	5010.0	215.4	698.5	2.7	4.5	0.4	1.3	3.9

Watershed	N Load (no BMP) lbs/yr	P Load (no BMP) lbs/yr	BOD Load (no BMP) lbs/yr	TSS Load (no BMP) t/yr	*E. coli* Load (no BMP) B MPN/yr	N Reduction lbs/yr	P Reduction lbs/yr	BOD Reduction lbs/yr	TSS Reduction t/yr	*E. coli* Reduction B MPN/yr	N Load (with BMP) lbs/yr	P Load (with BMP) lbs/yr	BOD (with BMP) lbs/yr	TSS Load (with BMP) t/yr	*E. coli* Load (with BMP) B MPN/yr	% N	% TP	% BOD	% TSS	% *E. coli*
Mary Lake	1281.7	300.2	2748.1	82.6	994.8	32.7	13.9	8.1	1.3	12.9	1248.9	286.3	2740.1	81.4	981.9	2.6	4.6	0.3	1.5	1.3
TMC 579	4575.8	1146.8	8521.1	596.8	1116.5	65.2	27.7	15.9	2.5	25.8	4510.7	1119.1	8505.2	594.3	1090.7	1.4	2.4	0.2	0.4	2.3
Total	**216399.3**	**52547.3**	**405121.8**	**11991.6**	**407238.7**	**5878.5**	**2482.7**	**1262.2**	**197.2**	**2408.0**	**210520.8**	**50064.6**	**403859.5**	**11794.4**	**404830.7**	**2.7**	**4.7**	**0.3**	**1.6**	**0.6**

Table 55. Reductions from planned pastureland practices in the strategy table STEPL

Watershed	N Load (no BMP) lbs/yr	P Load (no BMP) lbs/yr	BOD Load (no BMP) lbs/yr	TSS Load (no BMP) t/yr	*E. coli* Load (no BMP) B MPN/yr	N Reduction lbs/yr	P Reduction lbs/yr	BOD Reduction lbs/yr	TSS Reduction t/yr	*E. coli* Reduction B MPN/yr	N Load (with BMP) lbs/yr	P Load (with BMP) lbs/yr	BOD (with BMP) lbs/yr	TSS Load (with BMP) t/yr	*E. coli* Load (with BMP) B MPN/yr	% N	% TP	% BOD	% TSS	% *E. coli*
Ann Lake	66305.3	16521.1	118223.2	3957.7	66906.5	13.5	0.8	0.6	0.1	7.5	66291.8	16520.2	118222.6	3957.6	66899.0	0.0	0.0	0.0	0.0	0.0
Grass Lake	57947.4	13847.8	103968.0	2925.0	15098.4	122.9	17.5	38.7	6.0	197.2	57824.5	13830.4	103929.3	2919.0	14901.3	0.2	0.1	0.0	0.2	1.3
Little Waverly Lake	42515.9	10523.4	80811.9	2331.5	161528.7	28.4	3.8	9.0	1.4	14.5	42487.5	10519.6	80802.8	2330.1	161514.2	0.1	0.0	0.0	0.1	0.0
Howard Lake	19941.6	4839.6	43349.6	1036.9	113257.1	93.1	13.2	29.3	4.6	74.7	19848.5	4826.3	43320.3	1032.3	113182.4	0.5	0.3	0.1	0.4	0.1
Waverly Lake	8120.1	1854.1	18329.1	387.2	30326.6	23.9	3.3	7.2	1.1	19.4	8096.2	1850.7	18322.0	386.1	30307.2	0.3	0.2	0.0	0.3	0.1
Dutch Lake	6277.6	1290.2	12242.2	207.7	10972.6	18.1	2.5	5.4	0.8	44.0	6259.5	1287.7	12236.8	206.9	10928.5	0.3	0.2	0.0	0.4	0.4
Lake Emma	6777.3	1543.6	11900.5	248.1	6310.6	20.1	2.8	6.0	0.9	32.6	6757.1	1540.8	11894.5	247.1	6278.0	0.3	0.2	0.1	0.4	0.5
Dog Lake	2656.7	680.6	5028.0	218.2	726.7	6.2	0.9	1.8	0.3	5.0	2650.6	679.7	5026.1	217.9	721.8	0.2	0.1	0.0	0.1	0.7
Mary Lake	1281.7	300.2	2748.1	82.6	994.8	10.3	1.4	3.1	0.5	8.3	1271.4	298.8	2745.1	82.1	986.5	0.8	0.5	0.1	0.6	0.8
TMC 579	4575.8	1146.8	8521.1	596.8	1116.5	33.0	4.6	9.9	1.5	26.7	4542.8	1142.2	8511.3	595.3	1089.7	0.7	0.4	0.1	0.3	2.4
Total	**216399.3**	**52547.3**	**405121.8**	**11991.6**	**407238.7**	**369.5**	**50.9**	**110.9**	**17.3**	**430.0**	**216029.8**	**52496.4**	**405010.9**	**11974.3**	**406808.7**	**0.2**	**0.1**	**0.0**	**0.1**	**0.1**

Table 56. Reductions from planned livestock waste storage facilities (NRCS 313) in the strategy table STEPL

Watershed	N Load (no BMP) lbs/yr	P Load (no BMP) lbs/yr	BOD Load (no BMP) lbs/yr	TSS Load (no BMP) t/yr	*E. coli* Load (no BMP) B MPN/yr	N Reduction lbs/yr	P Reduction lbs/yr	BOD Reduction lbs/yr	TSS Reduction t/yr	*E. coli* Reduction B MPN/yr	N Load (with BMP) lbs/yr	P Load (with BMP) lbs/yr	BOD (with BMP) lbs/yr	TSS Load (with BMP) t/yr	*E. coli* Load (with BMP) B MPN/yr	% N	% TP	% BOD	% TSS	% *E. coli*
Ann Lake	66305.3	16521.1	118223.2	3957.7	66906.6	2121.1	477.2	0.0	0.0	0.0	64184.2	16043.8	118223.2	3957.7	66906.6	3.2	2.9	0.0	0.0	0.0
Grass Lake	57947.4	13847.8	103968.0	2925.0	15098.5	623.9	140.4	0.0	0.0	0.0	57323.5	13707.5	103968.0	2925.0	15098.4	1.1	1.0	0.0	0.0	0.0
Little Waverly Lake	42515.9	10523.4	80811.9	2331.5	161528.8	1746.8	393.0	0.0	0.0	0.0	40769.1	10130.4	80811.9	2331.5	161528.8	4.1	3.7	0.0	0.0	0.0
Howard Lake	19941.6	4839.6	43349.6	1036.9	113257.1	499.1	112.3	0.0	0.0	0.0	19442.6	4727.3	43349.6	1036.9	113257.1	2.5	2.3	0.0	0.0	0.0
Waverly Lake	8120.1	1854.1	18329.1	387.2	30326.6	249.5	56.1	0.0	0.0	0.0	7870.6	1797.9	18329.1	387.2	30326.6	3.1	3.0	0.0	0.0	0.0
Dutch Lake	6277.6	1290.2	12242.2	207.7	10972.6	249.5	56.1	0.0	0.0	0.0	6028.1	1234.1	12242.2	207.7	10972.6	4.0	4.4	0.0	0.0	0.0
Lake Emma	6777.3	1543.6	11900.5	248.1	6310.6	374.3	84.2	0.0	0.0	0.0	6402.9	1459.4	11900.5	248.1	6310.6	5.5	5.5	0.0	0.0	0.0
TMC 579	4575.8	1146.8	8521.1	596.8	1116.5	249.5	56.1	0.0	0.0	0.0	4326.3	1090.7	8521.1	596.8	1116.5	5.5	4.9	0.0	0.0	0.0
Total	**216399.3**	**52547.3**	**405121.8**	**11991.6**	**407238.8**	**6113.8**	**1375.6**	**0.0**	**0.0**	**0.0**	**210285.5**	**51171.7**	**405121.8**	**11991.6**	**407238.8**	**2.8**	**2.6**	**0.0**	**0.0**	**0.0**

Table 57. Reductions from planned feedlot filter strips in the strategy table STEPL

Watershed	N Load (no BMP) lbs/yr	P Load (no BMP) lbs/yr	BOD Load (no BMP) lbs/yr	TSS Load (no BMP) t/yr	*E. coli* Load (no BMP) B MPN/yr	N Reduction lbs/yr	P Reduction lbs/yr	BOD Reduction lbs/yr	TSS Reduction t/yr	*E. coli* Reduction B MPN/yr	N Load (with BMP) lbs/yr	P Load (with BMP) lbs/yr	BOD (with BMP) lbs/yr	TSS Load (with BMP) t/yr	*E. coli* Load (with BMP) B MPN/yr	% N	% TP	% BOD	% TSS	% *E. coli*
Ann Lake	66305.3	16521.1	118223.2	3957.7	66906.6	0.0	450.7	0.0	0.0	0.0	66305.3	16070.3	118223.2	3957.7	66906.6	0.0	2.7	0.0	0.0	0.0
Grass Lake	57947.4	13847.8	103968.0	2925.0	15098.5	0.0	132.6	0.0	0.0	0.0	57947.4	13715.3	103968.0	2925.0	15098.5	0.0	1.0	0.0	0.0	0.0

Watershed	N Load (no BMP) lbs/yr	P Load (no BMP) lbs/yr	BOD Load (no BMP) lbs/yr	TSS Load (no BMP) t/yr	*E. coli* Load (no BMP) B MPN/yr	N Reduction lbs/yr	P Reduction lbs/yr	BOD Reduction lbs/yr	TSS Reduction t/yr	*E. coli* Reduction B MPN/yr	N Load (with BMP) lbs/yr	P Load (with BMP) lbs/yr	BOD (with BMP) lbs/yr	TSS Load (with BMP) t/yr	*E. coli* Load (with BMP) B MPN/yr	% N	% TP	% BOD	% TSS	% *E. coli*
Little Waverly Lake	42515.9	10523.4	80811.9	2331.5	161528.8	0.0	371.2	0.0	0.0	0.0	42515.9	10152.2	80811.9	2331.5	161528.8	0.0	3.5	0.0	0.0	0.0
Howard Lake	19941.6	4839.6	43349.6	1036.9	113257.1	0.0	106.1	0.0	0.0	0.0	19941.6	4733.5	43349.6	1036.9	113257.1	0.0	2.2	0.0	0.0	0.0
Waverly Lake	8120.1	1854.1	18329.1	387.2	30326.6	0.0	53.0	0.0	0.0	0.0	8120.1	1801.0	18329.1	387.2	30326.6	0.0	2.9	0.0	0.0	0.0
Dutch Lake	6277.6	1290.2	12242.2	207.7	10972.6	0.0	53.0	0.0	0.0	0.0	6277.6	1237.2	12242.2	207.7	10972.6	0.0	4.1	0.0	0.0	0.0
Lake Emma	6777.3	1543.6	11900.5	248.1	6310.6	0.0	79.5	0.0	0.0	0.0	6777.3	1464.1	11900.5	248.1	6310.6	0.0	5.2	0.0	0.0	0.0
TMC 579	4575.8	1146.8	8521.1	596.8	1116.5	0.0	53.0	0.0	0.0	0.0	4575.8	1093.8	8521.1	596.8	1116.5	0.0	4.6	0.0	0.0	0.0
Total	**216399.3**	**52547.3**	**405121.8**	**11991.6**	**407238.8**	**0.0**	**1299.2**	**0.0**	**0.0**	**0.0**	**216399.3**	**51248.2**	**405121.8**	**11991.6**	**407238.8**	**0.0**	**2.5**	**0.0**	**0.0**	**0.0**

Table 58. Reductions from planned feedlot runoff management systems in the strategy table STEPL

Watershed	N Load (no BMP) lbs/yr	P Load (no BMP) lbs/yr	BOD Load (no BMP) lbs/yr	TSS Load (no BMP) t/yr	*E. coli* Load (no BMP) B MPN/yr	N Reduction lbs/yr	P Reduction lbs/yr	BOD Reduction lbs/yr	TSS Reduction t/yr	*E. coli* Reduction B MPN/yr	N Load (with BMP) lbs/yr	P Load (with BMP) lbs/yr	BOD (with BMP) lbs/yr	TSS Load (with BMP) t/yr	*E. coli* Load (with BMP) B MPN/yr	% N	% TP	% BOD	% TSS	% *E. coli*
Ann Lake	66305.3	16521.1	118223.2	3957.7	66906.6	0.0	437.5	0.0	0.0	0.0	66305.3	16083.6	118223.2	3957.7	66906.6	0.0	2.6	0.0	0.0	0.0
Grass Lake	57947.4	13847.8	103968.0	2925.0	15098.5	0.0	128.7	0.0	0.0	0.0	57947.4	13719.2	103968.0	2925.0	15098.5	0.0	0.9	0.0	0.0	0.0
Little Waverly Lake	42515.9	10523.4	80811.9	2331.5	161528.8	0.0	360.3	0.0	0.0	0.0	42515.9	10163.1	80811.9	2331.5	161528.8	0.0	3.4	0.0	0.0	0.0
Howard Lake	19941.6	4839.6	43349.6	1036.9	113257.1	0.0	102.9	0.0	0.0	0.0	19941.6	4736.6	43349.6	1036.9	113257.1	0.0	2.1	0.0	0.0	0.0
Waverly Lake	8120.1	1854.1	18329.1	387.2	30326.6	0.0	51.5	0.0	0.0	0.0	8120.1	1802.6	18329.1	387.2	30326.6	0.0	2.8	0.0	0.0	0.0

Watershed	N Load (no BMP) lbs/yr	P Load (no BMP) lbs/yr	BOD Load (no BMP) lbs/yr	TSS Load (no BMP) t/yr	*E. coli* Load (no BMP) B MPN/yr	N Reduction lbs/yr	P Reduction lbs/yr	BOD Reduction lbs/yr	TSS Reduction t/yr	*E. coli* Reduction B MPN/yr	N Load (with BMP) lbs/yr	P Load (with BMP) lbs/yr	BOD (with BMP) lbs/yr	TSS Load (with BMP) t/yr	*E. coli* Load (with BMP) B MPN/yr	% N	% TP	% BOD	% TSS	% *E. coli*
Dutch Lake	6277.6	1290.2	12242.2	207.7	10972.6	0.0	51.5	0.0	0.0	0.0	6277.6	1238.7	12242.2	207.7	10972.6	0.0	4.0	0.0	0.0	0.0
Lake Emma	6777.3	1543.6	11900.5	248.1	6310.6	0.0	77.2	0.0	0.0	0.0	6777.3	1466.4	11900.5	248.1	6310.6	0.0	5.0	0.0	0.0	0.0
TMC 579	4575.8	1146.8	8521.1	596.8	1116.5	0.0	51.5	0.0	0.0	0.0	4575.8	1095.4	8521.1	596.8	1116.5	0.0	4.5	0.0	0.0	0.0
Total	**216399.3**	**52547.3**	**405121.8**	**11991.6**	**407238.8**	**0.0**	**1261.0**	**0.0**	**0.0**	**0.0**	**216399.3**	**51286.4**	**405121.8**	**11991.6**	**407238.8**	**0.0**	**2.4**	**0.0**	**0.0**	**0.0**

Table 59. Reductions from planned forest stand improvements in the strategy table STEPL

Watershed	N Load (no BMP) lbs/yr	P Load (no BMP) lbs/yr	BOD Load (no BMP) lbs/yr	TSS Load (no BMP) t/yr	*E. coli* Load (no BMP) B MPN/yr	N Reduction lbs/yr	P Reduction lbs/yr	BOD Reduction lbs/yr	TSS Reduction t/yr	*E. coli* Reduction B MPN/yr	N Load (with BMP) lbs/yr	P Load (with BMP) lbs/yr	BOD (with BMP) lbs/yr	TSS Load (with BMP) t/yr	*E. coli* Load (with BMP) B MPN/yr	% N	% TP	% BOD	% TSS	% *E. coli*
Ann Lake	66305.3	16521.1	118223.2	3957.7	66946.4	6.7	3.0	2.1	0.3	8.3	66298.5	16518.1	118221.1	3957.3	66938.2	0.0	0.0	0.0	0.0	0.0
Grass Lake	57947.4	13847.8	103968.0	2925.0	15135.1	6.2	2.8	1.9	0.3	7.6	57941.2	13845.1	103966.1	2924.7	15127.5	0.0	0.0	0.0	0.0	0.1
Little Waverly Lake	42515.9	10523.4	80811.9	2331.5	161591.7	10.7	4.7	3.3	0.5	13.1	42505.2	10518.7	80808.6	2331.0	161578.7	0.0	0.0	0.0	0.0	0.0
Howard Lake	19941.6	4839.6	43349.6	1036.9	113270.7	2.3	1.0	0.7	0.1	2.8	19939.3	4838.5	43348.9	1036.8	113267.9	0.0	0.0	0.0	0.0	0.0
Waverly Lake	8120.1	1854.1	18329.1	387.2	30335.2	1.4	0.6	0.4	0.1	1.8	8118.7	1853.4	18328.7	387.1	30333.4	0.0	0.0	0.0	0.0	0.0
Dutch Lake	6277.6	1290.2	12242.2	207.7	10982.0	1.6	0.7	0.5	0.1	1.9	6276.0	1289.5	12241.7	207.6	10980.0	0.0	0.1	0.0	0.0	0.0
Lake Emma	6777.3	1543.6	11900.5	248.1	6321.0	1.8	0.8	0.5	0.1	2.2	6775.5	1542.8	11900.0	248.0	6318.9	0.0	0.1	0.0	0.0	0.0
Dog Lake	2656.7	680.6	5028.0	218.2	732.7	1.0	0.4	0.3	0.0	1.2	2655.7	680.1	5027.7	218.1	731.5	0.0	0.1	0.0	0.0	0.2
Mary Lake	1281.7	300.2	2748.1	82.6	996.9	0.3	0.2	0.1	0.0	0.4	1281.3	300.1	2748.0	82.6	996.5	0.0	0.1	0.0	0.0	0.0
TMC 579	4575.8	1146.8	8521.1	596.8	1127.7	1.9	0.8	0.6	0.1	2.3	4573.9	1146.0	8520.5	596.7	1125.3	0.0	0.1	0.0	0.0	0.2

Watershed	N Load (no BMP) lbs/yr	P Load (no BMP) lbs/yr	BOD Load (no BMP) lbs/yr	TSS Load (no BMP) t/yr	*E. coli* Load (no BMP) B MPN/yr	N Reduction lbs/yr	P Reduction lbs/yr	BOD Reduction lbs/yr	TSS Reduction t/yr	*E. coli* Reduction B MPN/yr	N Load (with BMP) lbs/yr	P Load (with BMP) lbs/yr	BOD (with BMP) lbs/yr	TSS Load (with BMP) t/yr	*E. coli* Load (with BMP) B MPN/yr	% N	% TP	% BOD	% TSS	% *E. coli*
Total	**216399.3**	**52547.3**	**405121.8**	**11991.6**	**407439.4**	**33.9**	**15.1**	**10.5**	**1.6**	**41.7**	**216365.4**	**52532.2**	**405111.3**	**11990.0**	**407397.7**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Table 60. Total subwatershed TP reductions for practices strategy table by land use STEPL

	Cropland	Pasture	Feedlot	Forest	Streambank	Urban	Total P reductions
Ann Lake	719.3204743	0.821834141	1365.5	2.999111		1.354883	**2089.961**
Grass Lake	739.6839295	17.46935372	401.6	2.759492		0	**1161.52**
Little Waverly Lake	532.6811947	3.784000237	1124.5	4.738287		1.093414	**1666.797**
Howard Lake	246.6759405	13.23837944	321.3	1.020316		37.05004	**619.2705**
Waverly Lake	61.84847761	3.347480933	160.6	0.641562		40.04504	**266.5255**
Dutch Lake	47.3541311	2.53467375	160.6	0.7034		1.093414	**212.3285**
Lake Emma	63.000745	2.814708527	241.0	0.780697		0.261469	**307.822**
Dog Lake	30.53322531	0.861645468	0.0	0.448321		0	**31.84319**
Mary Lake	13.92291417	1.436075779	0.0	0.154593		0.546707	**16.06029**
TMC 579	27.7079386	4.61698363	160.6	0.842534	291.0181	0	**484.8285**
Total	**2482.728971**	**50.92513563**	**3935.8**	**15.08831**		**81.44497**	**6565.939**