Pearl Lake and Mill Creek TMDL Implementation Plan

Sauk River Watershed District
November 2013

CLEAN WATER LAND & LEGACY AMENDMENT

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1.0 Introduction

The Pearl Lake Nutrient Total Maximum Daily Load (TMDL) and Mill Creek Bacterial Total Maximum Daily Load Implementation Plan addresses the nutrient impairments in Pearl Lake (DNR ID 73-0037) and the E.coli bacteria impairment in Mill Creek. Pearl Lake is located in Stearns County, Minnesota and lies within the North Central Hardwood Forest (NCHF) Ecoregion. Pearl Lake has an average depth of 8 feet and is classified as a shallow, eutrophic lake. Pearl lake is approximately 750 acres in size with a littoral area of approximately 510 acres. Land use within the Pearl Lake watershed is predominantly agricultural. Mill Creek is a tributary to the Sauk River, located in the southeastern portion of the Sauk River watershed in Stearns County Minnesota. Mill Creek flows into the Sauk River in the city of Rockville, 16 miles upstream of the confluence of the Sauk River and the Mississippi River at Sauk Rapids. The Mill Creek watershed is 48 square miles in size and includes Pearl Lake and Grand Lake.

Pearl Lake was assessed for nutrient impairment in 2007, and was placed on the State of Minnesota's 303(d) list of impaired waters in 2008. At that time, both total phosphorus and chlorophyll *a* exceeded the full support thresholds, while Secchi disc depth indicated full support; however, the summer mean Secchi disc transparency had declined from 2000 to 2006, and Pearl Lake was proposed and subsequently approved for listing (MPCA 2008)

The Minnesota Pollution Control Agency (MPCA) has determined that Mill Creek from its headwaters to the Sauk River (reach ID 07010202-537) is impaired and does not meet Minnesota water quality standards for pathogen indicator bacteria (*E. coli*). This reach was placed on the 303(d) list in 2006 because monitoring data indicate that *E. coli* levels typically exceed the monthly geometric mean standard of 126 *E. coli* organisms per 100mL. *E. coli* bacteria is used in water quality monitoring as an indicator organism to identify water that is contaminated with human or animal waste and the accompanying disease-causing organisms. Bacterial abundance in excess of the water quality standards can pose a health risk to swimmers and bathers and can limit other recreational uses.

The Sauk River Watershed District (SRWD), with assistance from Barr Engineering, has completed a TMDL analysis for the Minnesota Pollution Control Agency (MPCA) to quantify the phosphorus reduction needed to meet state water quality standards for nutrients in Pearl Lake and E.*coli* reduction needed to meet state water quality standards in Mill Creek. The TMDL for Pearl Lake and Mill Creek was prepared in cooperation with local agencies and organization.

The final step in the TMDL process is the development of an implementation plan that sets forth the activities that will be undertaken to reduce phosphorus loading to Pearl Lake and E.coli bacteria in Mill Creek. This implementation plan is divided in two sections to address Pearl Lake and Mill Creek individually, although they are within the same minor watershed. For each water body, this plan will provide a brief overview of the TMDL finds, describe the proposed implementation activities and discuss agencies involved in addressing the impairments listed for Pearl Lake and Mill Creek.

2.0 Water Quality Standards for Lakes and Streams

Impaired waters are listed and reported to the citizens of Minnesota and to the EPA in the 305(b) report and the 303(d) list, named after relevant sections of the Clean Water Act. Assessment of waters for the 305(b) report identifies candidates for listing on the 303(d) list of impaired waters. The purpose of the 303(d) list is to identify impaired water bodies for which a plan will be developed to remedy the pollution problem(s).

The basis for assessing Minnesota lakes for impairment due to eutrophication includes the narrative water quality standard and assessment factors in Minnesota Rules 7050.0150. The MPCA has completed extensive planning and research efforts to develop quantitative lake eutrophication standards for lakes in different ecoregions of Minnesota that would result in achievement of the goals described by the narrative water quality standards. To be listed as impaired by the MPCA, the monitoring data must show that the standards for both total phosphorus (the causal factor), and either chlorophyll *a* or Secchi disc depth (the response factors) are not met (MPCA, 2007a). Pearl Lake is listed based on the eutrophication criteria for the North Central Hardwood Forest (NCHF) Ecoregion (Table 1).

Table 1. MPCA Lake Eutrophication Standards for Total Phosphorus, Chlorophyll *a*, and Secchi Disc in NCHF Ecoregion

Water Quality Parameter	MPCA Lake Eutrophication Standard (NCHF Ecoregion)
Total Phosphorus (µg/L)	40
Chlorophyll-a (µg/L)	14
Secchi disc (m)	1.4

Source: Minnesota Rule 7050.0222 Subp. 4. Class 2B Waters

The Minnesota Pollution Control Agency (MPCA) has determined that Mill Creek from its headwaters to the Sauk River (reach ID 07010202-537) is impaired and does not meet Minnesota water quality standards for pathogen indicator bacteria (*E. coli*). This reach was placed on the 303(d) list in 2006 because monitoring data indicate that *E. coli* levels typically exceed the monthly geometric mean standard of 126 *E. coli* organisms per 100mL. *E. coli* bacteria is used in water quality monitoring as an indicator organism to identify water that is contaminated with human or animal waste and the accompanying disease-causing organisms. Bacterial abundance in excess of the water quality standards (Table 2) can pose a health risk to swimmers and bathers and can limit other recreational uses.

Table 2. *E. coli* Water Quality Standards for Class 2 Waters

Use Class	Standard # of Organisms per 100ml of Water		Applicable Season	Use
	Monthly Geometric Mean	10% of Samples Max.		
2A	126 mpn	1260 mpn	April 1 - October 31	Primary
2Bb, 2B, 2C	126 mpn	1260 mpn	April 1 - October 32	Primary
2D	126 mpn	1260mpn	April 1 - October 33	Primary

PEAR LAKE TMDL SUMMARY

Pearl Lake is located in Stearns County, Minnesota and lies within the North Central Hardwood Forest (NCHF) Ecoregion Figure 1). Pearl Lake has an average depth of 8 feet and is classified as an eutrophic lake. Pearl lake is approximately 750 acres in size with a littoral area of approximately 510 acres. Land use within the Pearl Lake watershed is predominantly agricultural. The size of the Pearl Lake watershed is approximately 18,237 acres (28.5 square miles). Land use percentages of the Pearl Lake watershed, based on the 2001 National Land Cover Database (NLCD), are summarized as follows:

- 53% cultivated agriculture
- 21% pasture and grassland
- 13% forest
- 7% open water and wetland
- 6% developed

Pearl Lake has two main tributaries: Mill Creek is the largest, and drains an area of approximately 5,758 acres to the west of Pearl Lake. An unnamed creek drains an area of approximately 2,108 acres to the south of Pearl Lake. The combined area of the Mill Creek and unnamed creek watersheds accounts for 81% of the watershed that contributes surface flow to Pearl Lake, the remaining 19% of the watershed drains directly to the lake.

Much of the shoreline of Pearl Lake is developed with lakeshore homes, which have subsurface sewage treatment systems (SSTS). There are no municipal wastewater treatment plants or other permitted dischargers in the watershed. There are approximately 34 feedlots within the portion of the Pearl Lake watershed that contributes surface water runoff to the lake.

The MPCA reviews on all available data when assessing a waterbody for impairments. For lakes to be listed as impaired, 10% of the monitoring data must exceed state water quality standards for both total phosphorus and either Chlorophyll *a* or Secchi disc depth. Pearl Lake is listed based on the eutrophication criteria for a deep lake located in the North Central Hardwood Forest (NCHF) Ecoregion (Table 1).

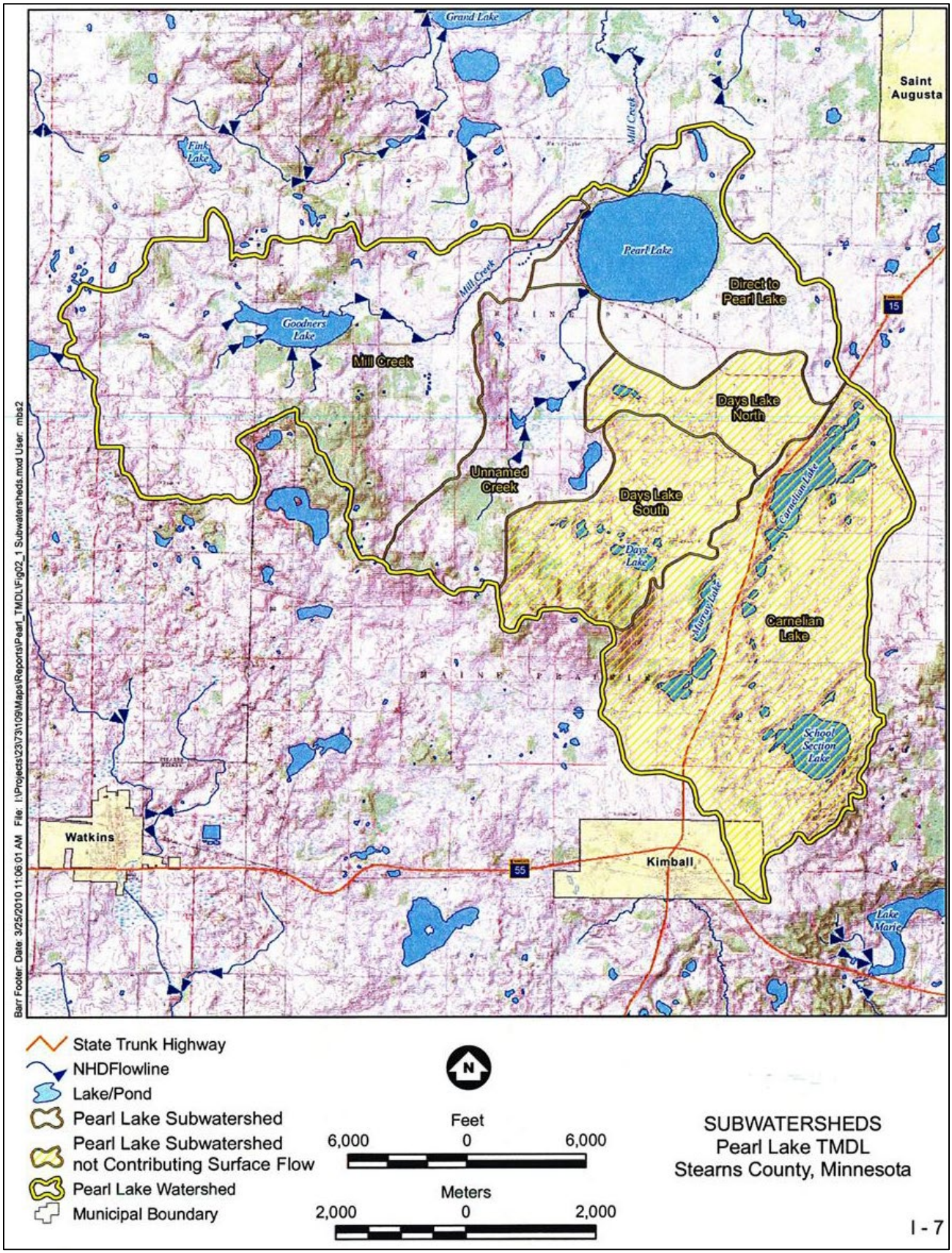
Pearl Lake was assessed for nutrient impairment and was listed as impaired in 2008. Both total phosphorus and chlorophyll *a* exceeded the full support thresholds. The transparency (Secchi disc depth) indicated full support; however, the summer mean transparency depth had declined from 2000 to 2006.

Table 3. MPCA Lake Eutrophication Standards for North Central Hardwood Forest Ecoregion

Water Quality Parameter	MPCA Lake Eutrophication Standards (NCHF Ecoregion)	Pearl Lake Summer-Mean Water Quality in 2008	Pearl Lake Summer-Mean Water Quality 2000-2009
Total Phosphorus (µg/L)	40	51	43
Chlorophyll *a* (µg/L)	14	15	17
Secchi disc (m)	1.4	2.3	2.0

As part of the TMDL Study, additional data were collected in Pearl Lake in 2008 and 2009 by the SRWD and MPCA. Summer average transparency readings met water quality standard in 2000, 2001, 2008 and 2009, but not in 2006. In the last ten years (2000-2009), summer average total phosphorus (TP) concentrations have exceeded state standard three of the four years data were collected Similar to TP, summer-average chlorophyll-*a* concentrations exceeded the water quality standard three of the four years data were collected.

Figure 1. Pearl Lake Watershed Map



The TP concentrations in Pearl Lake can vary greatly within a monitoring season. Typically, TP concentrations in late spring range from 24-29 µg/L, and concentrations hold steady into early summer. In July, TP concentrations begin to rise, peaking in August or September. TP concentrations peaked as high as 82µg/L and 76µg/L in 2006 and 2008, respectively.

Water quality data collected from Mill Creek and unnamed creek in 2008 did not meet quality assurance standards which made it difficult to determine the effect of external phosphorus loads on the in-lake TP differences observed in 2008 and 2009. As a result, TP concentration data for 2009 was only available for the tributaries to Pearl Lake. However, the rainfall data suggest that external loads were likely similar for 2008 and 2009. Rainfall totals for water year 2008 (10/1/2007-9/30/2008) and water year 2009 (10/1/2008-9/30/2009) were similar, at 22.0 inches and 27.9 inches, respectively.

Watershed loadings and in-lake TP concentrations were used to calibrate an in-lake model to determine source load impacts on water quality and potential reductions in loading needed to meet the water quality standard in Pearl Lake.
The lake modeling included estimates of atmospheric and internal loading plus the calculated watershed loading from monitoring stations. Local precipitation was measured with a weather station placed on the western shore of Pearl Lake with additional data from the St. Cloud weather station. These inputs were applied to the water quality model to predict phosphorus concentrations in Pearl Lake observed during the 2008 growing season. The year 2008 was selected because it represented an average climate year with a summer-mean total phosphorus concentration that exceeds the water quality criterion.

Table 4. Pearl Lake Total Phosphorus Wasteload and Load Allocations

Phosphorus Sources	Existing TP Load (kg/year)	TMDL Wasteload Allocation		Percent Reduction of Existing TP Load (Percent)
		Annual (kg/year)	Daily (kg/day)	
Permitted Dischargers	0	0	0	0
Total Wasteload Sources	0	0	0	0
Internal and Nonpoint Sources	Existing TP Load (kg)	TMDL Load Allocation	Daily TMDL Load Allocation	Percent Reduction of Existing TP Load (Percent)
		(LA) (kg)	(LA) (kg/day)	
Internal Sources	923	640	1.75	31
Non-point watershed sources	810	648	1.77	20
Atmospheric Sources	51.1	51.1	0.14	0
Total Load Sources	1,784	1,339	3.67	25
Margin of Safety (MOS)	0	71	0.19	0
Overall Source Total	1,784	1,410	3.86	25

Based on the 2008 water quality conditions, in order to meet the overall load capacity of the lake needed to achieve water quality standards a 25% decrease in phosphorus load will be required. To achieve this load reduction a combination of external and internal phosphorus load reductions will be needed. Phosphorus load reductions to Pearl Lake will be achieved by targeting multiple nonpoint sources (see Table 4). The following summarizes phosphorus reductions that will be targeted in the watershed:

- 20% reduction of phosphorus load from the watershed, including full compliance for all Subsurface Sewage Treatment Systems (SSTS) adjacent to Pearl Lake.
- 31% reduction of internal phosphorus loading from lake sediments and Curly leaf pondweed.

MILL CREEK TMDL SUMMARY

Mill Creek is a tributary to the Sauk River, located in the southeastern portion of the Sauk River watershed in central Minnesota (see Figure 2). Mill Creek flows into the Sauk River in the city of Rockville, 16 miles upstream of the confluence of the Sauk River and the Mississippi River at Sauk Rapids. The Mill Creek watershed makes up 48 square miles of the approximately 1050-square mile Sauk River watershed, and includes Pearl Lake and Grand Lake. Land use in the watershed is predominantly agricultural.

The SRWD has undertaken water quality monitoring of Mill Creek since 2003 as part of an initial diagnostic study and in support of the current TMDL study. Field data collection has included monthly or weekly water quality sampling, both continuous and discrete flow measurements, and field measurements of water clarity using turbidimeters and transparency tubes. This study focused only on measurements of flow and bacteria abundance (fecal coliform and *E. coli*); a more thorough presentation of the data for Mill Creek is included in the Lower Sauk River Diagnostic Study (Barr, 2006).

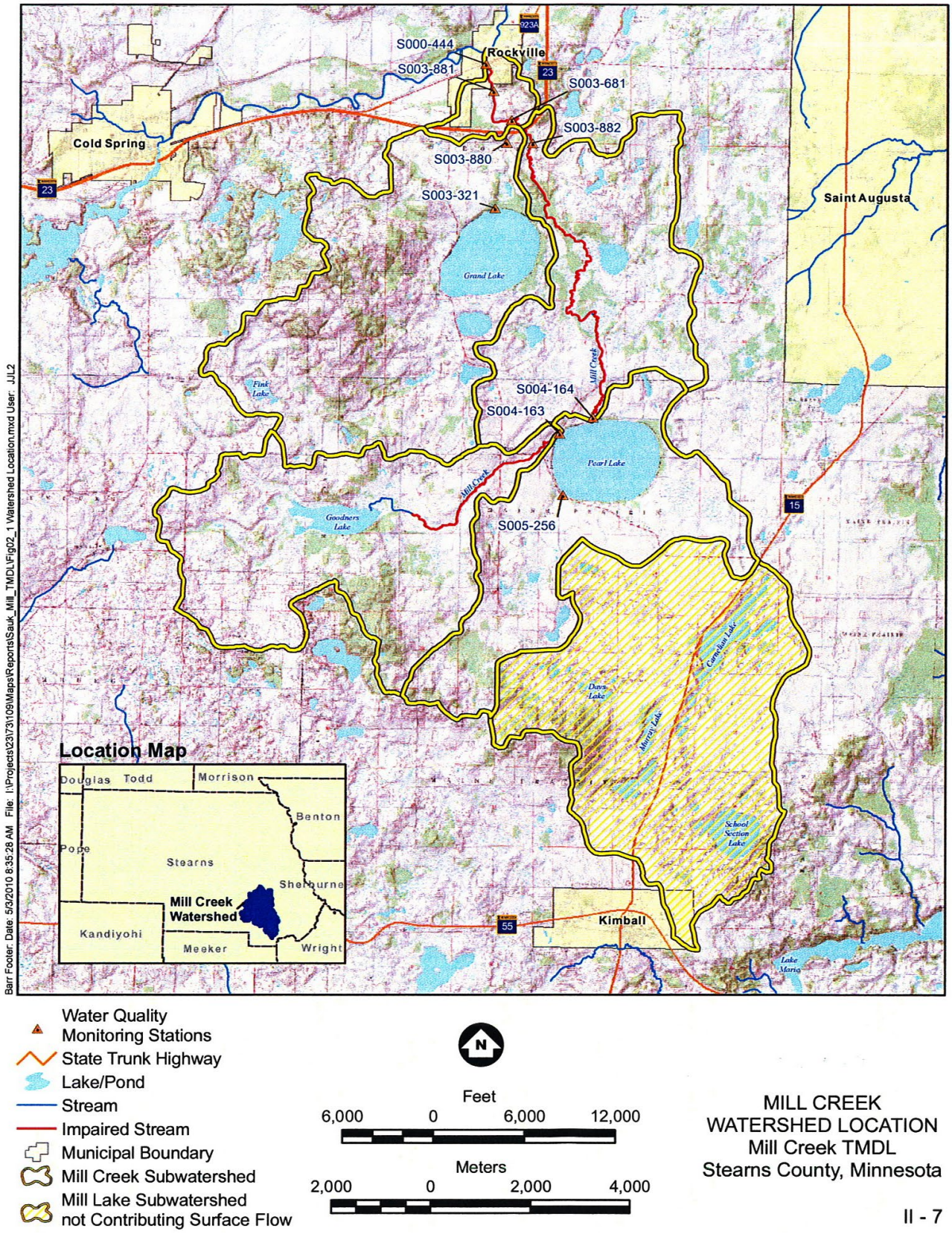
The MPCA has determined that Mill Creek from its headwaters to the Sauk River (reach ID 07010202-537) is impaired and does not meet Minnesota water quality standards for pathogen indicator bacteria (*E. coli*). This reach was placed on the 303(d) list in 2006 because monitoring data indicate that *E. coli* levels typically exceed the monthly geometric mean standard of 126 *E. coli* organisms per 100mL. *E. coli* bacteria is used in water quality monitoring as an indicator organism to identify water that is contaminated with human or animal waste and the accompanying disease-causing organisms. Bacterial abundance in excess of the water quality standards can pose a health risk to swimmers and bathers and can limit other recreational uses.

Table 5. Monitoring Locations in the Mill Creek Watershed (upstream to downstream)

Station ID	Location	Bacteria abundance as *E. coli* (organisms per 100mL)			
		Observation Frequency & Dates	Num. Obs.	Range	Geomean
S005-256	Unnamed inlet to Pearl Lake at CSAH 8	Weekly in 2008	16	1 - 894	49
S004-163	Mill Creek inlet to Pearl Lake at CR-141	Weekly in 2008	22	1 - 540	67
S004-164	Mill Creek outlet from Pearl Lake at CR-146	Biweekly in 2007, weekly in 2008	23	1 - 1296	29
S003-321	Unnamed outlet from Grand Lake at Hubbert Ln.	Occasional in 2005 and 2007	6	17 – 540	124
S003-880	Unnamed trib. from Grand Lake at 230th St.	Occasional in 2005 and 2007	8	57 – 21,700	**387**
S003-882	Mill Creek at 230th St.	Biweekly in 2005 and 2007	14	22 – 1,130	**163**
S003-681*	Mill Creek ¾ mile south of Rockville*	Weekly in 2004	2	82 – 315	**161**
S003-881	Mill Creek at Mill St.	Weekly in Sept-Oct 2005	5	630 – 7,340	**2,030**
S000-444	Mill Creek at MN-23	Biweekly in 2003 and 2004, weekly in 2005, 2007 and 2008	58	8 – 10,580	**330**

Bold values are in exceedance of the chronic *E. coli* standard of 126 org. per 100 mL (see Section 3).
* Location S003-681 is identified as being 100 feet upstream of a manure release in 2004.

Figure 2. Mill Creek Watershed Boundaries



Mill Creek is classified as a Class 2B, 3C, 4A, 4B, 5, and 6 water body. The narrative standard for Class 2B (the most stringent classification that applies to Mill Creek) is defined in *Minnesota Rules* 7050.0222:

> *The quality of Class 2B surface waters shall be such as to permit the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life, and their habitats. These waters shall be suitable for aquatic recreation of all kinds, including bathing, for which the waters may be usable.*

The numeric standard for Class 2B is in terms of *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 only between April 1 and October 31.*

Prior to 2008 the bacteria standard for Class 2B was expressed in terms of fecal coliform bacteria:

> *Not to exceed 200 organisms per 100 milliliters as a geometric mean of not less than five samples within any calendar month, nor shall more than ten percent of all samples taken during any calendar month individually exceed 2,000 organisms per 100 milliliters. The standard applies only between April 1 and October 31.*

Observations of bacteria abundance have been collected on varying schedules at the different monitoring locations in the Mill Creek watershed, as shown in Table 5. The geometric mean and maximum observed *E. coli* abundance generally increases in Mill Creek moving downstream from Pearl Lake. This indicates that bacteria loading to the stream is ongoing throughout the watershed rather than concentrated at particular reach locations. In order to capture the loading from the entire watershed the TMDL only used the fecal coliform and *E. coli* data (expressed in terms of *E. coli*) from the monitoring location at the mouth of Mill Creek in Rockville (station ID S000-444). The period of record used to determine this TMDL is October 1, 1998 to September 30, 2008. During the period of record, the monthly geometric mean *E. coli* abundance exceeded the chronic standard of 126 organisms per 100 mL for all months except April.

Figure 3. Mill Creek Monthly *E. coli* Geometric Mean

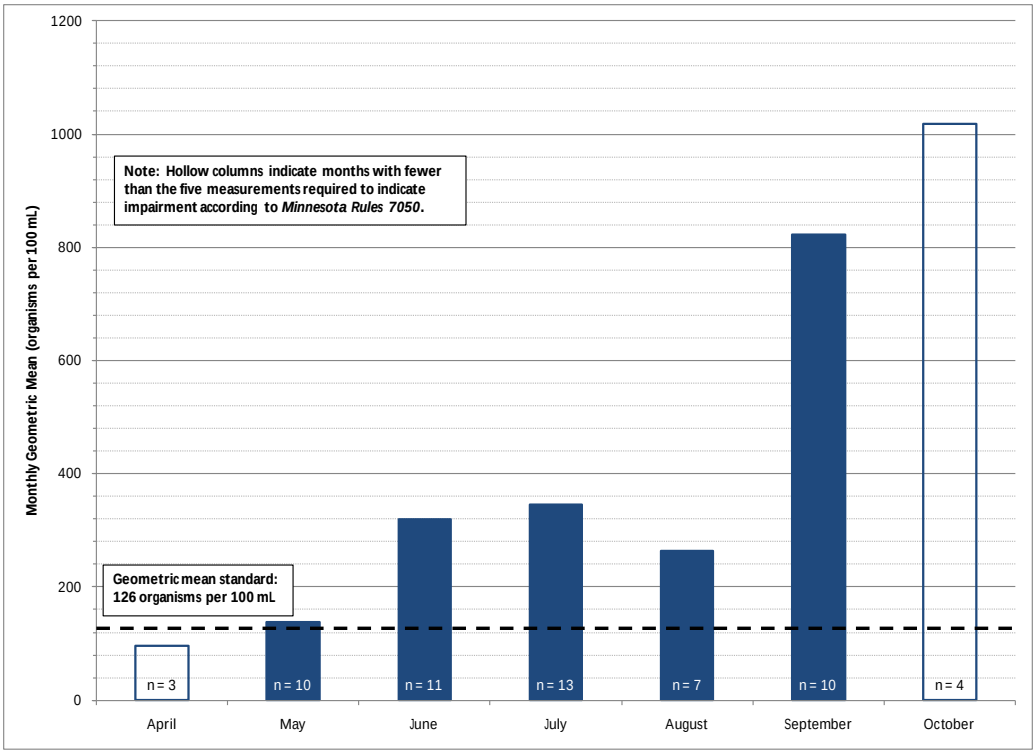


Table 6. Estimated Population and Monthly Fecal Coliform Production by Source

Category	Source	Animal Units or Population	Fecal Coliform Organisms per Unit per Month (10^9 organisms)**	Total Fecal Coliform Organisms Available per Month (10^9 organisms)
Human	Total population	1713	61.0	104,000
Urban Runoff	Cats	413	153	63,000
	Dogs	363	153	55,400
Livestock	Dairy cattle	3438 AU	2200	7,550,000
	Beef cattle	2510 AU	3970	9,950,000
	Swine	1248 AU	2440	3,040,000
	Poultry	543 AU	1040	563,000
	Horses & sheep	147 AU	12.8	1,880
	Other livestock	220 AU	1040	228,000
Wildlife	Deer	217	15.3	3,310
	Canada geese	102	0.317	32.4
	Ducks	257	0.159	40.8
	Other wildlife	Unknown	Unknown	3,310*

This TMDL study used a population source inventory and assumed bacteria availability and delivery ratios to estimate the sources of bacteria that contribute to the observed load in Mill Creek. This analysis indicates that riparian pastures, surface applied manure, and feedlots without runoff controls are likely the primary sources of *E. coli* contamination.

This TMDL study also used a load duration curve approach to determine the bacteria loading capacity of Mill Creek under a variety of flow regimes. The duration curve was used to determine the general allocations necessary to meet water quality standards. These allocations were then proportioned between the legal sources based on the proportional loading determined from the source inventory. Overall *E. coli* load reductions of between 59% and 93% are required in order to meet water quality standards, depending on the flow conditions.

Figure 4. Mill Creek *E. coli* Load

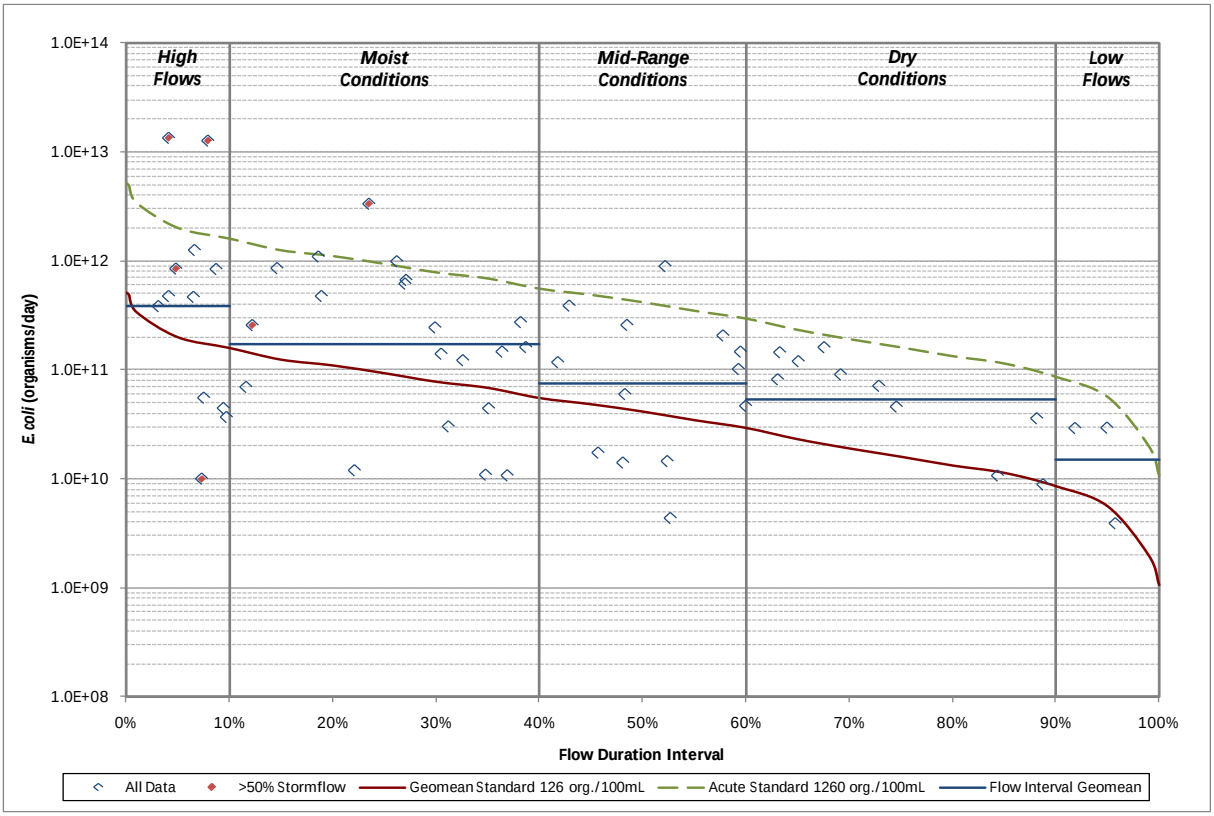


Table 7. Observed and Required Load Allocations by Source (daily loading)

Source	Estimated Existing "Wet" Loading	Estimated Existing "Dry" Loading	Load Allocation (10^9 organisms *E. coli* per day)				
			High Flow	Wet	Mid-Range	Dry	Low Flow
Riparian pastures	48%	67%	76	26	17	5.7	0.71
Non-riparian pastures	17%	15%	26	9.1	4.7	1.3	0.16
Feedlots w/o runoff controls	--*	--*	0	0	0	0	0
Applied Manure	20%	18%	31	11	5.5	1.5	0.19
Incorporated Manure	16%	0%	25	8.7	2.3	0	0
Septic systems (SSTS)	--*	--*	0	0	0	0	0
Urban runoff	0.1%	0%	0.16	0.054	0.014	0	0
Wildlife	0.01%	0.03%	0.023	0.008	0.006	0.002	0.0003
Total	100%	100%	158	54.8	29.2	8.51	1.06

* The estimated existing loading from feedlots without runoff controls and inadequately treated rural wastewater (SSTS) was excluded from this analysis because these sources are illegal and are regulated by existing permit programs. Zero load allocation was assigned to each of these sources.

* There are no permitted point discharges from industries, municipalities or waste water treatment plants or individually permitted sources within the Mill Creek watershed. Therefore the waste load allocation is zero.

3.0 Monitoring Plan to Track TMDL Effectiveness

The water quality of Pearl Lake has been monitored infrequently over the past three decades. Water quality data (phosphorus and TSS) were collected in 2009 for Mill Creek and the unnamed creek. The Sauk River Watershed District will coordinate continued monitoring of water quality in Pearl Lake, as well as Mill Creek and the unnamed creek. For the years in which monitoring is conducted (e.g., just prior to and after implementation) and with consideration of fund availability, water quality measurements should be collected monthly in Pearl Lake from May through September.

- Secchi disc transparency
- Dissolved oxygen (1-meter depth intervals)
- Temperature (1-meter depth intervals)
- pH (1-meter depth intervals)
- Total phosphorus (surface, mid-depth, and near bottom)
- Dissolved phosphorus (surface, mid-depth, and near bottom)
- Chlorophyll *a* (surface only)

For years in which monitoring is conducted (e.g., just prior to and after implementation) watershed monitoring (Mill Creek and the unnamed creek) should be conducted at a frequency of once every two weeks for the period of April through November. The following parameters should be collected from the watershed monitoring locations:

- Total phosphorus
- Dissolved phosphorus
- Total suspended solids
- Flow

Curly-leaf pondweed, which is known to increase eutrophication in North American lakes, is prevalent in Pearl Lake, but the extent and total biomass can vary from one year to the next. Curly-leaf pondweed is unique compared to native aquatic plants in that it grows under the ice and during the spring when water temperatures are still cold. Ice thickness and snow depth may affect the growth of curly-leaf pondweed by limiting the amount of light reaching the curly-leaf pondweed. Curly-leaf pondweed monitoring should be conducted as part of the implementation plan to document the coverage and density of curly-leaf prior to and after implementation.

For the years in which curly-leaf pondweed monitoring is conducted, a curly-leaf pondweed survey should be conducted during the first half of June each year to monitor the growth of curly-leaf pondweed. At a minimum, surveys would utilize GPS to record the extent of where curly-leaf pondweed is observed "topping out", or growing at the surface of Pearl Lake. More detailed aquatic plant surveys could include density ratings or stem counts. To better define the growth and die-off of curly-leaf, surveys could be conducted in late July and early September in addition to the June survey. If feasible, the pondweed surveys should be conducted the same year that water quality monitoring is conducted.

4.0 TMDL Implementation Strategies and Costs

The TMDL implementation plan focuses on reducing external sources of phosphorus to the watershed with additional work to better estimate internal sources of phosphorus loading. Annual overall total load reductions of 444 kg (25 %) in phosphorus loading in Pearl Lake is required to meet the total phosphorus growing-season average of 40 µg/L. Load-reduction projects should be implemented following a priority ranking system for the available nutrient reduction strategies. Additional monitoring is also recommended to

help ascertain the removal efficiency of planned watershed measures to reduce phosphorus loading to the lake.

Implementation strategies are also necessary to address the *E. coli* loading in Mill Creek. To achieve *E. coli* water quality standards, reductions of between 59% and 93% are needed, depending on the flow conditions from primarily agricultural sources.

The SRWD will lead the TMDL Implementation Plan. A variety of stakeholders, including the District, local agencies, local communities, and individual property owners and managers will implement watershed-wide activities and those that are specific to a subwatershed, city, neighborhood, or property. This section describes various activities that will be undertaken to reduce nutrient loads and runoff volume to Pearl Lake and Mill Creek. A summary of those activities and the stakeholders who will implement them are listed below.

1. Public Education and outreach for Water Quality Protection

The District operates an ongoing education and outreach program. An extensive outreach program for the residents of the Pearl Lake Mill Creek watershed will be developed to inform these residents of the issues facing Pearl Lake and Mill Creek and their roles in addressing these issues. This public education program will promote a community-to-community awareness and clearly identify the contribution from all communities, such as waterfront property owners and agricultural producers. This education program will integrate public relations advertising, marketing, civic engagement, public involvement, technical assistance, and training to optimize nutrient reductions from all phosphorus and *E.coli* loading sectors within the overall watershed.

Estimated Cost: $2,500 annually
Funding Source: General operating budget and grant funding

2. Environmental Planning for Urban, Rural and/or Seasonal Development

All new development, industrial, and construction projects will be designed to maintain or improve existing developed hydrology and pollutant loadings and fully comply with the SRWD and local government authorities, National Pollutant Discharge Elimination System (NPDES), and anti-degradation requirements. All rural residential, commercial, industrial, and urban development projects will be reviewed with respect to water treatment requirements to protect the environment. As redevelopment occurs, areas with little or no treatment, including street or highway reconstruction, will be required to meet current water quality standards. SRWD will work in partnership with the local communities and developers to maximize the amount of load and volume reduction on development and redevelopment projects.

Estimated Cost: Ongoing and Varies by BMP
Funding Source: Cities/counties, SRWD Cost General operating budget

3. Agricultural Drainage

An evaluation of the agricultural land drainage networks for Pearl Lake and Mill Creek watershed will be undertaken. This assessment will explore the feasibility of reducing the velocity of flow in agricultural drains and ditches to allow particulate nutrients an opportunity to settle out. The use of nutrient traps or settling basins along drains will be explored to determine their effectiveness in reducing nutrient loading. This activity will include a review of the feasibility of acquiring marginal land and constructing new wetlands, or restoring existing wetland areas that could serve as natural filters for drainage water.

Estimated Cost: $20,000
Funding Source: SRWD WMU funds and Grant funding

4. Ditch Cleaning

Private and roadside ditch cleaning has the potential to contribute significant nutrient loadings and exacerbate stream channel erosion due to leaching from dredge spoils and increasing discharge rates and erosion of channel material. An assessment of the current and planned ditch cleaning activities along with a review of their best management practices will be completed and evaluated for structural and non-structural improvements.

Estimated Cost: $5,000 annually
Funding Source: SRWD WMU and Grant funding and local partners

5. Livestock Access to Riparian Areas and Waterways

Pearl Lake drainage has a fairly high number of livestock operations in the watershed. Landowners having drainage from confined livestock areas will be encouraged to direct runoff to retention basins, grassed buffer strips, constructed wetlands, or other recommended nutrient-reduction feature. Manure accumulated in confined holding areas will be regularly remove and apply to crop or pasture lands during appropriate seasons and at appropriate agronomic rates. Livestock producers in the Pearl Lake watershed will be encouraged through enhanced incentives, education, and (when required) regulations to implement measures to protect riparian areas and waterways, such as managing livestock access in riparian areas and providing off-site watering structures. Agriculture extension programs, as well as other partnership programs, will be used to help agricultural producers assess the environmental risk of their operations. The programs will also be used to provide advice on how to prevent the contamination of groundwater and surface water.

Estimated Cost: $25,000 annually
Funding Source: WMD and Grant funding and local partners

6. **Soil Fertility and Manure Testing**

Additional strategies that promote and support annual soil testing will be developed to provide agricultural producers with the tools necessary to make sound agronomic, economic, and environmental decisions. Incentives for agricultural producers conducting soil testing and manure testing will be considered. Enhanced education on the economic and environmental benefits of soil and manure testing will be accomplished through local SWCD and NRCS offices.

Estimated Cost: $5,000 annually
Funding Source: WMD and Grant funding and local partners

7. **Septic System Maintenance**

A focused educational campaign will be undertaken to provide guidance to homeowners on how to properly maintain septic systems and how to recognize when they are failing. The SRWD will encourage the local governing agencies to conduct mandatory inspection of private sewage treatment systems at the time of sale. The sale of the property would be conditional on a properly functioning system. The SRWD and local agencies will explore the funding options to recover the costs of conducting an ongoing comprehensive septic system field inspection program and maintaining a septic system database.

Estimated Cost: $2500 annually
Funding Source: WMD and Grant funding and local partners

8. **Stream Channel Erosion**

New development, redevelopment, and other construction activity projects will be designed to maintain or improve the existing hydrology (i.e. reduce peak flows). In addition, opportunities for correcting existing channel and shoreline erosion sources will be investigated. As part of the riparian and erosion assessment a

protocol will be developed and followed to ensure that all identified erosion areas within the watershed are compared and prioritized.

Estimated Cost: $7,500 for initial assessment and $10,000 annually for implementation
Funding Source: WMD and Grant funding and local partners

9. **Internal Load Reduction**

Internal loading is a substantial portion of the total phosphorus load to Pearl Lake and load reduction is needed to meet in-lake water quality standards for phosphorus. Internal load reduction will be investigated as a means to reduce phosphorus levels in Pearl Lake. External load reductions of phosphorus have the potential to lead to a long term reduction of internal loading in Pearl Lake. However, it is not clear how long this process will take therefore internal loading will be reevaluated periodically. In addition, if external loads are reduced the longevity of internal load reduction technologies, such as an alum treatment, can be increased substantially.

Internal phosphorus load reduction can include reduction due to Curlyleaf pondweed, as well as what is released from lake sediments. The most common management strategy for Curlyleaf pondweed is eradication from chemical herbicide application. Before the MDNR will issue a permit for the large scale treatment of a lake for Curlyleaf pondweed, an aquatic plant management plan will be required and it must be developed in conjunction with the MDNR. This plan will detail the current status of the aquatic plant community in Pearl Lake, along with specific treatment objectives and activities.

Estimated Cost: $500,000 (treatment for 5 years for 150 acres of the lake).
Funding Source: WMD and Grant funding and local partners

Phosphorus reduction for lake sediments can be achieved through inactivation or removal. Inactivation can be accomplished by applying a chemical such as alum, which will bind with phosphorus in the sediment and prevent its release back into the water column. Removal of phosphorus can be accomplished with dredging of the sediment. These potential phosphorus reduction efforts will require a permit from the DNR and a treatment plan with specific treatment objectives and activities.

Estimated Cost: approx$1,000,000 ($1,300/ac for 750 acres)
Funding Source: WMD and Grant funding and local partners

Additional attention will be given to internal phosphorus load reduction using biological treatment options. Carp and bullhead are bottom feeding fish found in Pearl Lake that disturb the lake sediment, causing phosphorus to be recycled back into the water column. Additional attention will be given to measuring the amount of carp present in Pearl Lake during the next fisheries survey. Possible carp removal will be reviewed after survey results are compiled.

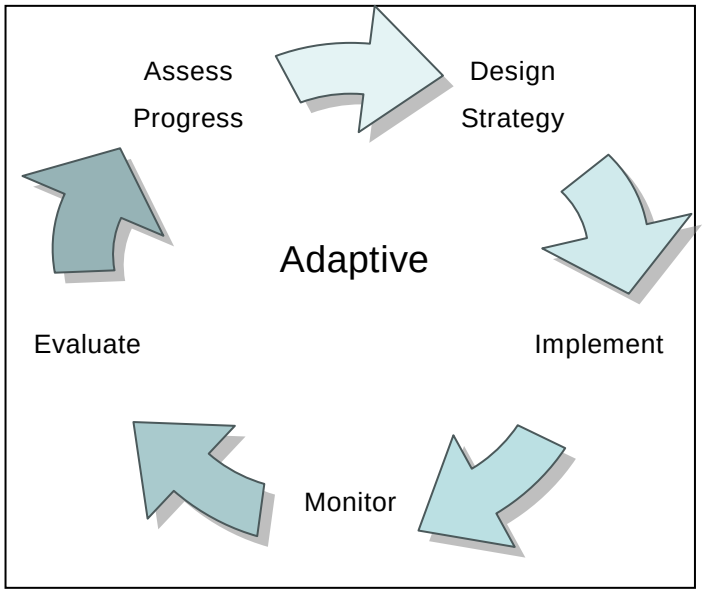
Estimated Cost: $1,500
Funding Source: WMD and Grant funding and local partners

5.0 Adaptive Management

The implementation strategies summarized above will be implemented in order to achieve reductions in phosphorus and E.coli loading necessary to achieve water quality targets in Pearl Lake and Mill Creek. Overall, this

implementation strategy will be adaptive as projects are completed. The implementation strategies will be reevaluated and updated as new data becomes available. Consideration will be given on how implementation of upstream phosphorus reduction strategies affects downstream phosphorus sources as well as E.coli concentrations at the lower reaches of Mill Creek. Because there are no known point sources in the project area watershed, the implementation elements will focus exclusively on non-point source controls.

Figure 5. Adaptive management



The implementation activities listed will be ongoing for 20+ years. The nutrient reduction needs for Pearl Lake and E.coli reduction in Mill Creek watershed identified in the TMDL require aggressive goals. Implementation activities will be conducted using an adaptive management approach. Adaptive management is based on assessment, planning, action, monitoring, evaluation and adjustment based on knowledge gained. Changes in water quality standards, technology, research, and weather may alter the course of actions listed in this plan. Continued monitoring and adjustments responding to monitoring results are the most appropriate strategy for attaining the water quality goals established in the Pearl Lake and Mill Creek TMDL.

The SRWD will coordinate efforts to determine what best management practices would be practical, economically feasible, and environmentally effective in reducing nutrient loading in Pearl Lake and its watersheds. BMP cost-effectiveness, combined with information about local water quality impairments and nutrient delivery to Pearl Lake and leveraged funding from outside sources, will be used to finalize a priority ranking system for implementing individual nutrient reduction strategies throughout the watershed.