MEMORANDUM

The Minnehaha Creek Watershed District is committed to a leadership role in protecting, improving and managing the surface waters and affiliated groundwater resources within the District, including their relationships to the ecosystems of which they are an integral part. We achieve our mission through regulation, capital projects, education, cooperative endeavors, and other programs based on sound science, innovative thinking, an informed and engaged constituency, and the cost effective use of public funds.

TO: MCWD Planning and Policy Committee

FROM: James Wisker
Director of Planning, Projects and Land Conservation

RE: Agenda Item 5.1 and 5.2: Six Mile Creek Subwatershed Planning

At the March 20, 2014 Planning and Policy Committee Meeting, during Item 5.1, staff will review the 2007 Six Mile Creek Subwatershed Plan, the 2013 Six Mile Creek Subwatershed Diagnostic, the proposed 2014-2016 Carp Assessment, and previous Committee discussions on these topics.

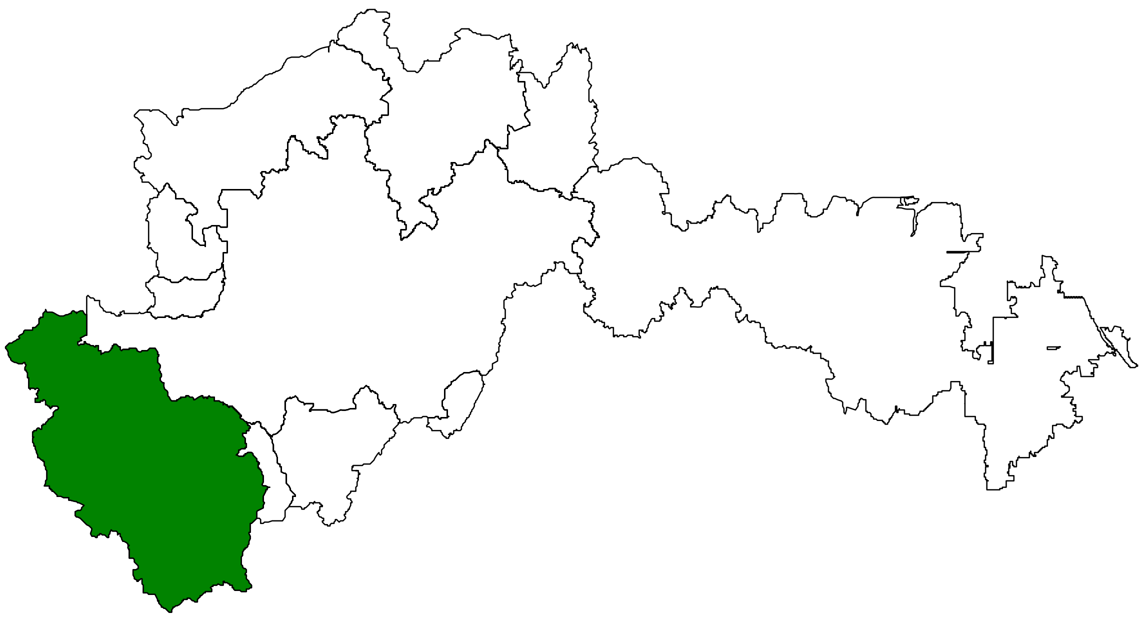
During Item 5.2 staff will revisit drafted policy topics related to this subwatershed and begin to outline a draft framework for conducting implementation planning within this subwatershed.

For review in advance, please find attached:

- 2007 Six Mile Creek Subwatershed Plan
- 2013 Six Mile Creek Diagnostic
- July 18, 2013 Planning & Policy Committee Minutes
- August 1, 2013 Planning & Policy Committee Minutes
- August 13, 2013 Draft Policy Discussion List
- September 5, 2013 Planning & Policy Committee Minutes

For questions in advance of the meeting, please contact James Wisker at 952.641.4509 or Jwisker@minnehahacreek.org

Six Mile Marsh Subwatershed Plan



Minnehaha Creek Watershed District
Water Resources Management Plan

April 2007

Minnehaha Creek Watershed District

Improving Quality of Water, Quality of Life

Table of Contents

TABLES

FIGURES

1.0 Introduction and Summary

The Six Mile Marsh subwatershed is located along the southwestern boundary of the Minnehaha Creek Watershed District (MCWD or District) and within the cities of St. Bonifacius and Victoria and in Laketown Township and Watertown Township. The subwatershed is the most rural and undeveloped in the District, with agriculture the most common land use. The Three Rivers Park District's Carver Park Reserve in the central subwatershed contains rolling, wooded terrain, lakes, and wetlands, and is home to a wide variety of wildlife.

The subwatershed contains several major lakes, including Pierson, Wasserman, East and West Auburn, Steiger, Zumbra-Sunny, Stone, Lunsten, and Parley Lakes. Six Mile Creek is formed at the outlet of Pierson Lake and flows 12 miles to Halsted's Bay on Lake Minnetonka. The creek is mainly comprised of ditches running through large wetland and marsh areas connecting several of these lakes.

Two of the lakes in the subwatershed are listed on the State's 303(d) list of Impaired Waters for excess nutrients, and Total Maximum Daily Load (TMDL) studies are being developed to plan for their improvement. Other lakes in the subwatershed either meet their water quality goals or strategies for their improvement have been developed in this plan. Many of these lakes are popular fisheries, and water quality improvement will assist in preserving their integrity. Six Mile Creek conveys significant phosphorus and sediment loads to Halsted's Bay, and is a major cause of its poor water quality. The water quality in Six Mile Creek, its low gradient and the large number of wetlands through which it flows limit the biotic integrity of the creek. Numerous high-value wetlands are present in the subwatershed.

Over the next ten years, the District's focus in the Six Mile Marsh subwatershed includes sustaining and improving ecological integrity of the subwatershed as it develops. The following will be particular focus areas:

- Conserving ecological integrity through Land Conservation Program activities in key conservation areas.
- Minimizing impacts on water resources from future development through enhanced regulation that requires higher levels of pollutant removal and increased infiltration of runoff.
- Improving water quality in the lakes through regulation and treatment of runoff as well as through implementation of capital improvement projects.

2.0 Land and Water Resources Inventory

2.1 Location

The Six Mile Marsh subwatershed is located along the southwestern boundary of the MCWD and within the cities of St. Bonifacius, and Victoria and in Laketown Township and Watertown Township (see Figure 1). The subwatershed is 17,030 acres in size (27 square miles).

2.2 Physical Environment

2.2.1 Topography and Drainage

The subwatershed is mainly located within the Lonsdale-Lerdal till region, an area characterized by thinly spread glacial drift and circular, level-topped hills with low slopes, small streams, numerous lakes and peat bogs. The western edge of the subwatershed is within the Waconia-Waseca moraine, a landform characterized by numerous lakes and wetland areas formed when glacial ice fell apart. It is defined by circular, level topped hills with smooth sides and steeper slopes. The 2003 MCWD *Hydrologic, Hydraulic, and Pollutant Loading Study* (HHPLS) subdivided the subwatershed into 66 subwatershed units, designated SMC-1 through SMC-66 (see Figure 2).

The subwatershed is drained by Six Mile Creek, which flows 11 miles from Lake Pierson to Halsteds Bay of Lake Minnetonka.

2.2.2 Geology and Soils

The depth to bedrock within the subwatershed varies from 200 to 400 feet. Quaternary deposits – the surficial material overlaying the bedrock – are generally high relief New Ulm loamy till common to the upper watershed, with pockets of peat and muck and a few isolated pockets of clay deposits. Soils within the watershed are predominantly classified as Natural Resources Conservation Service Hydrologic Soil Group B (loamy soils with moderate infiltration potential) and D (clayey soils with very low infiltration potential) (see Figure 3). The Group D soils are found in low-lying areas and are generally hydric, or showing indications of inundation (see Figure 4) or are in areas of mucky soils. There are also scattered areas of Group C soils, finer-grained soils with low infiltration potential.

2.2.3 Unique Features and Scenic Areas

The Three Rivers Park District's Carver Park Reserve covers much of the central subwatershed. The park includes numerous wetlands and several lakes, and bicycle/hiking trails provide access to many natural features. The Minnesota Historic Features database notes about 50 historic features in this subwatershed, mostly residences or farmhouses or agricultural buildings. The listing also includes 5 churches and several commercial buildings in Victoria and St. Bonifacius. Part of the Three Rivers Park District's Lake Minnetonka Regional Park is located in the subwatershed.

2.3 Biological Environment

2.3.1 Vegetation

Figures 5a and 5b, land cover as classified by the Minnesota Land Cover Classification System (MLCCS), illustrate the wide variety of land cover types in the subwatershed. Agricultural landforms dominate the southwest and northwest subwatershed, while forest and woodland along with grass and shrubland is predominant through the central section. Smaller areas of lower density landforms are present in the southeast corner of the subwatershed. Wetlands are scattered throughout the subwatershed.

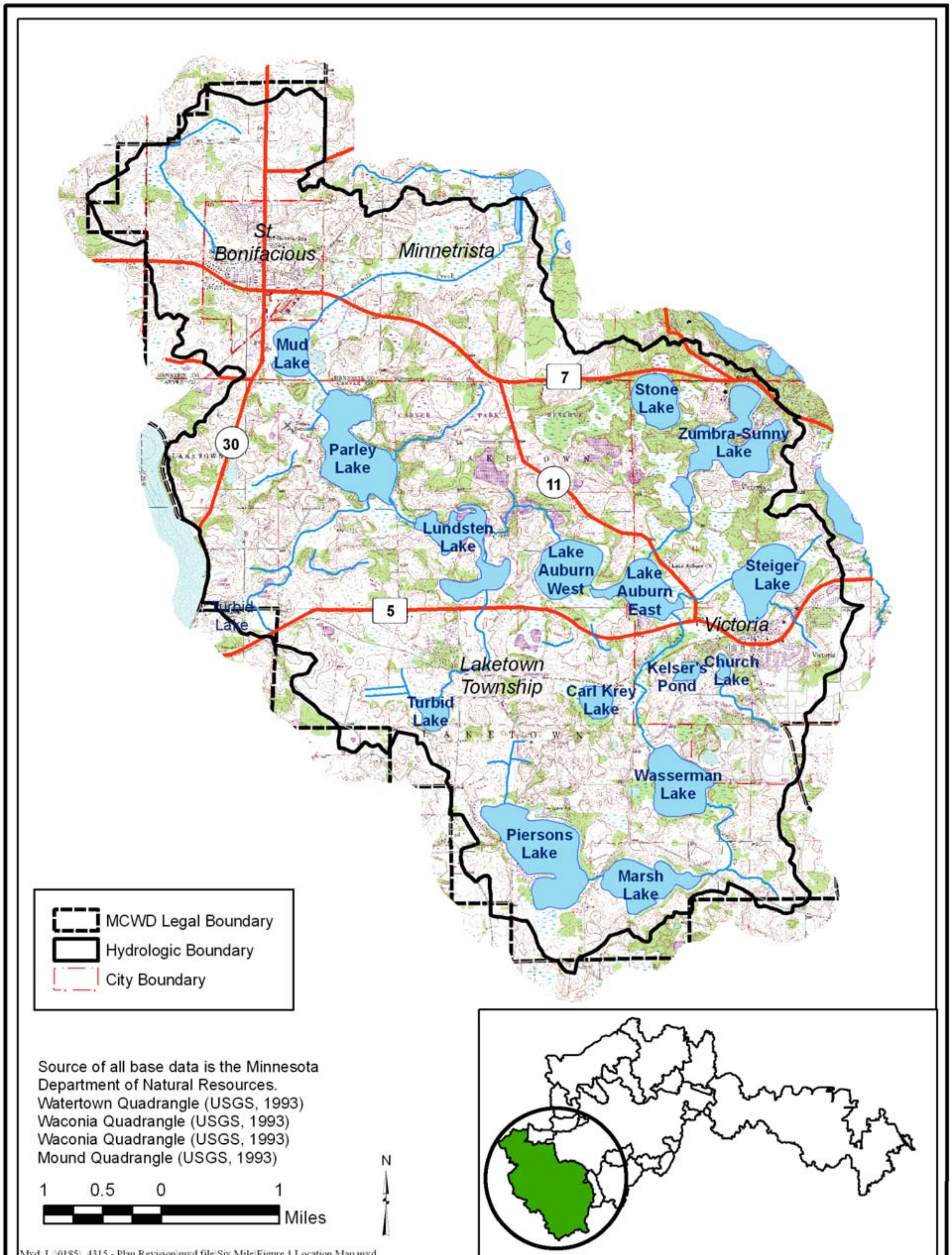
2.3.2 Biologic Integrity

Landscape. Large areas of undisturbed or minimally disturbed forest and wetland in the subwatershed have been designated Regionally Significant Ecological Areas by the DNR (see Figure 6), including nearly all of the Carver Park Reserve. The Minnesota County Biological Survey (MCBS) identified several areas of moderate or high biodiversity significance both within and outside of the regional park, including a large area of maple-basswood forest and tamarack swamp surrounding and west of Stone, Steiger and Zumbra Lakes.

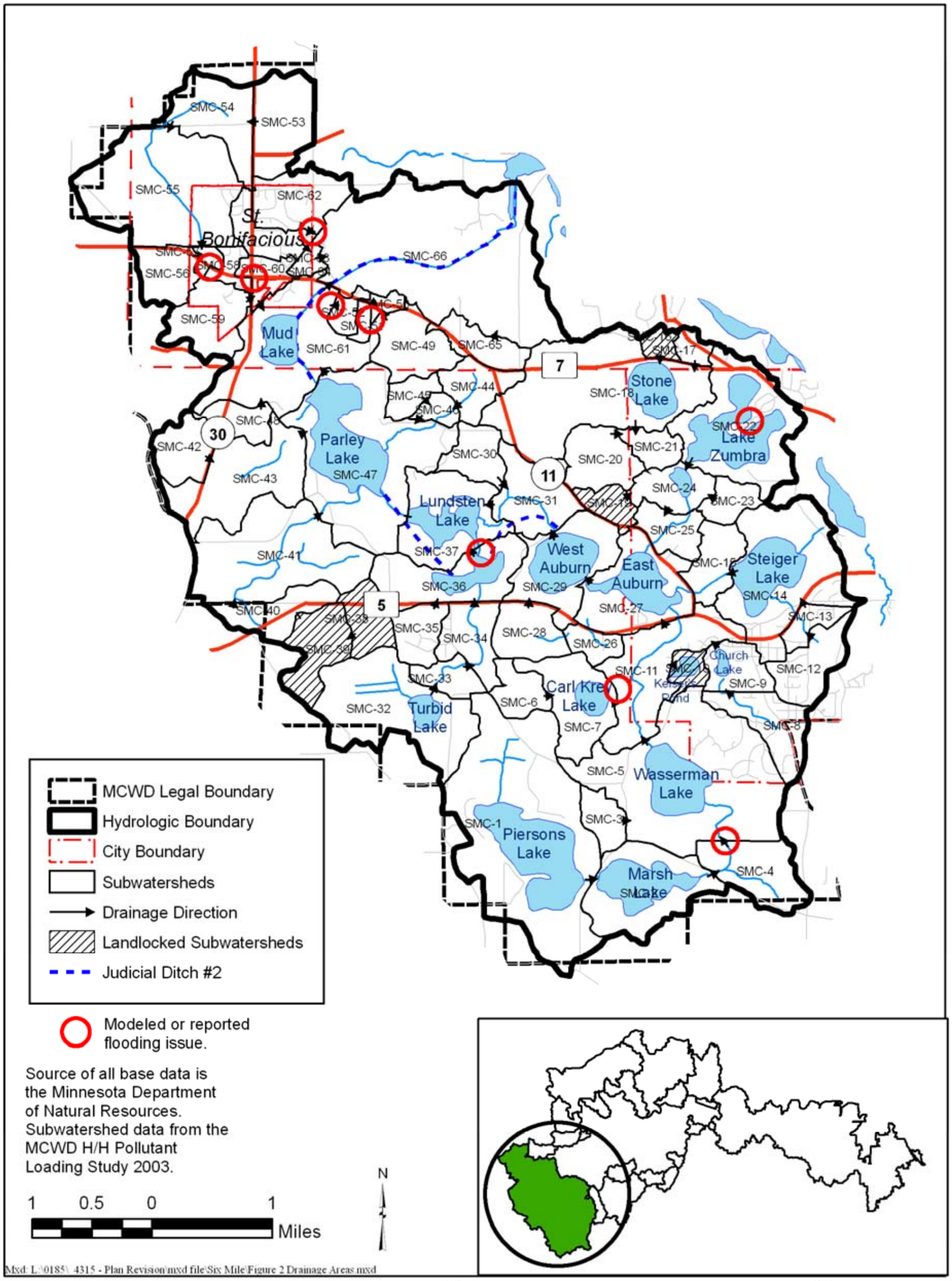
The Minnesota Natural Heritage Information System lists several rare natural features in this subwatershed. These include bald eagle, a federally-listed threatened species; trumpeter swans, a state-listed threatened species; and cerulean warbler, a bird of state species special concern, and the least darter, a fish of state species of special concern.

Lakes. There are eleven lakes in the Six Mile Marsh subwatershed in-line or connected by channels to Six Mile Creek, and numerous other water resources. Many of the lakes support DNR-managed fisheries. Steiger Lake in the Carver Park Reserve has had a catch and release requirement for northern pike and largemouth bass since 1988 in an attempt to foster a population of trophy-size fish. Zumbra-Sunny has also been managed for largemouth bass.

While no comprehensive data is available on aquatic vegetation, several of the lakes - including Auburn, Parley, Piersons, Steiger, Stone, Wasserman, and Zumbra – have documented Eurasian watermilfoil infestations. Auburn and Wasserman have excessive amounts of the plant, which on Auburn can impede navigation around the perimeter of the lake. Zumbra has been treated for milfoil in 1993-94 and for curlyleaf pondweed in 2004.



MINNEHAHA CREEK WATERSHED DISTRICT	Minnehaha Creek Watershed District	DEC 2005
Six Mile Marsh Subwatershed Location		Figure 1



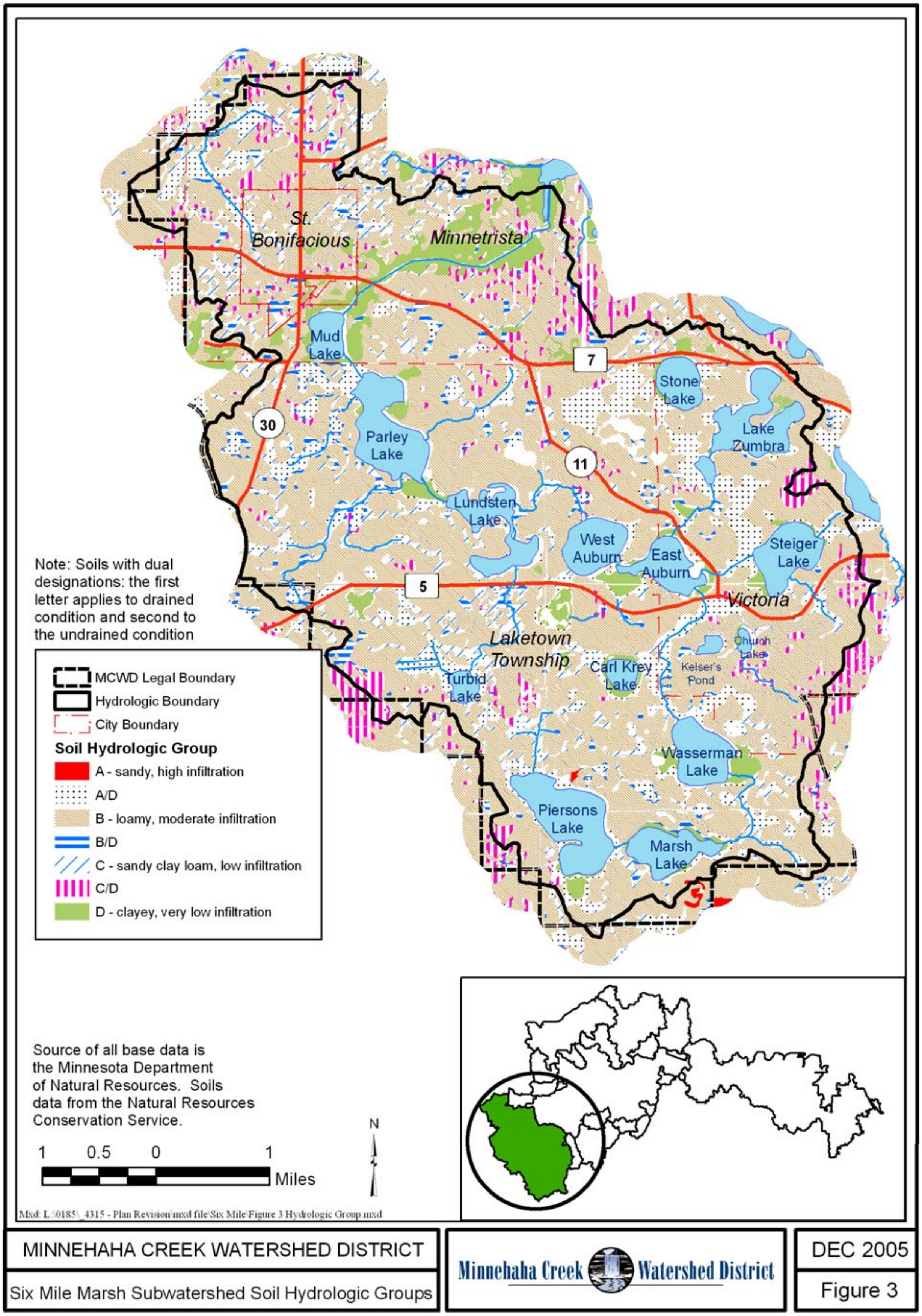
MINNEHAHA CREEK WATERSHED DISTRICT

Six Mile Marsh Subwatershed Drainage Areas

Minnehaha Creek Watershed District

DEC 2005

Figure 2



St. Bonifacious
Minnetrista
Mud Lake
7
Stone Lake
30
Parley Lake
Lake Zumbra
11
Lundsten Lake
West Auburn
East Auburn
Steiger Lake
5
Victoria
Laketown Township
Church Lake
Carl Krey Lake
Kelser's Pond
Turbid Lake
Wasserman Lake
Piersons Lake
Marsh Lake
Note: Soils with dual designations: the first letter applies to drained condition and second to the undrained condition
MCWD Legal Boundary
Hydrologic Boundary
City Boundary
Soil Hydrologic Group
A - sandy, high infiltration
A/D
B - loamy, moderate infiltration
B/D
C - sandy clay loam, low infiltration
C/D
D - clayey, very low infiltration
Source of all base data is the Minnesota Department of Natural Resources. Soils data from the Natural Resources Conservation Service.
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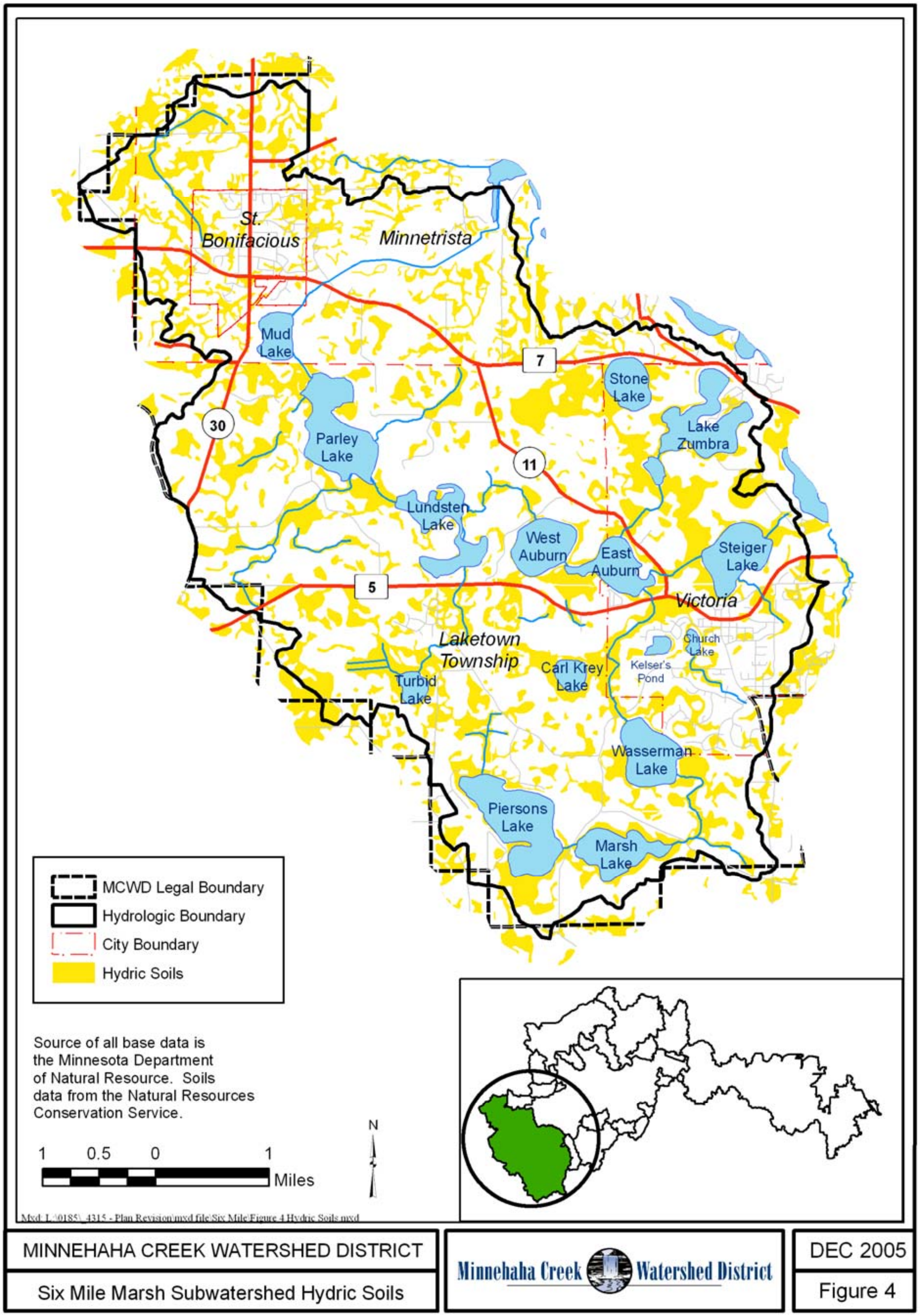
MINNEHAHA CREEK WATERSHED DISTRICT
Six Mile Marsh Subwatershed Soil Hydrologic Groups
Minnehaha Creek Watershed District
DEC 2005
Figure 3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Hydric Soils
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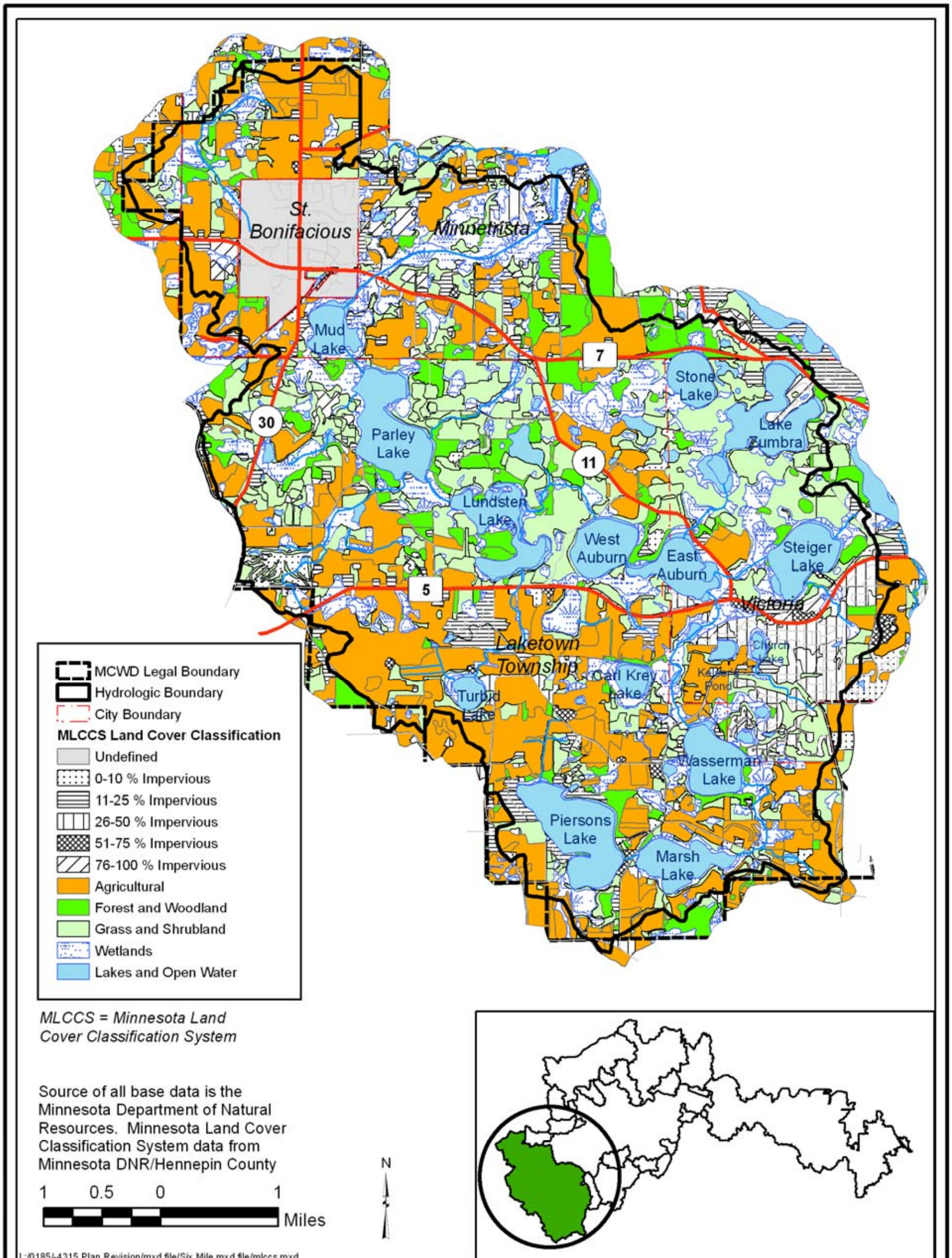
MINNEHAHA CREEK WATERSHED DISTRICT
Six Mile Marsh Subwatershed Hydric Soils
Minnehaha Creek Watershed District
DEC 2005
Figure 4



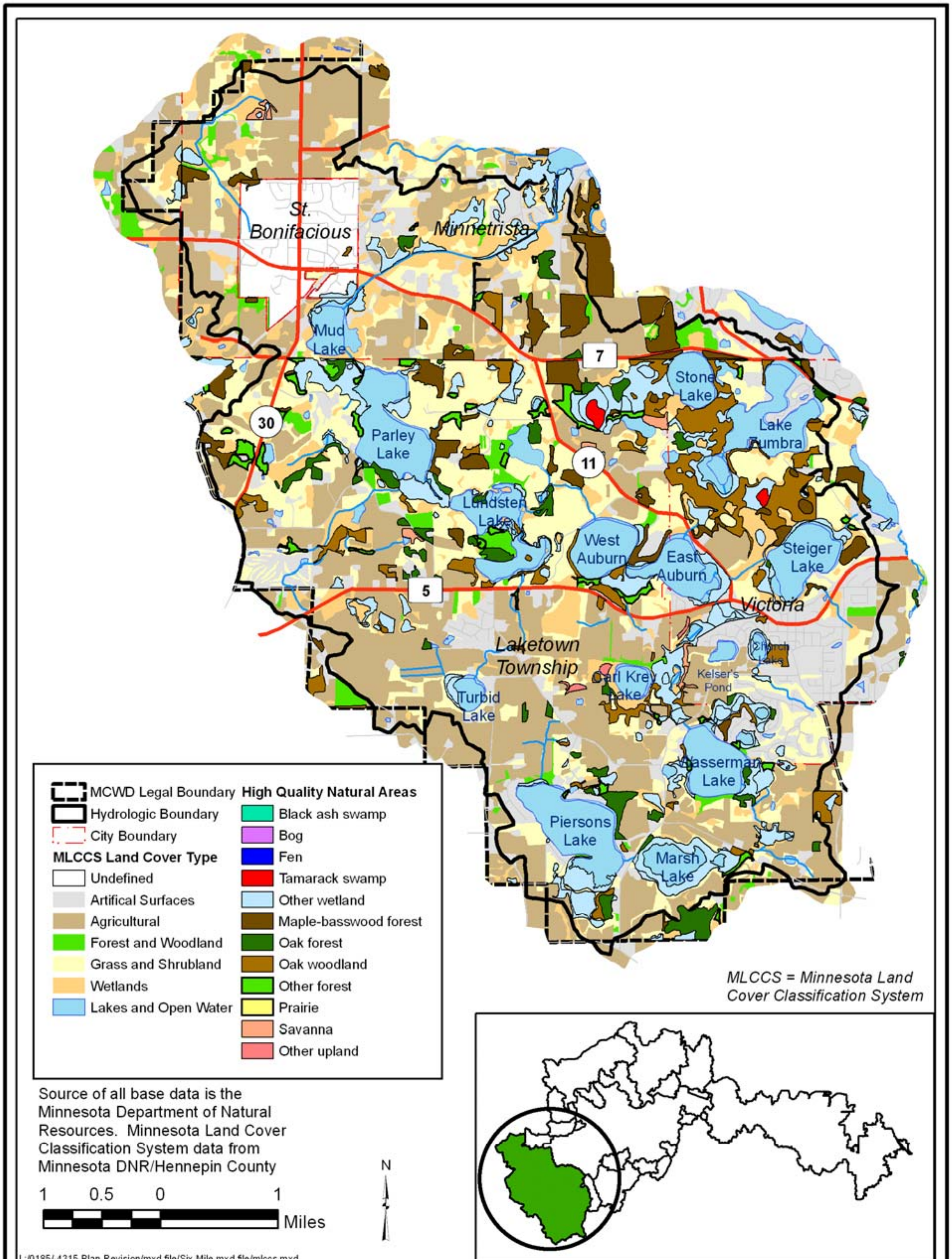
MINNEHAHA CREEK WATERSHED DISTRICT

Six Mile Marsh Subwatershed
MLCSS Land Cover: Imperviousness

Minnehaha Creek Watershed District

DEC 2005

Figure 5a



MINNEHAHA CREEK WATERSHED DISTRICT	Minnehaha Creek Watershed District	DEC 2005
Six Mile Marsh Subwatershed MLCSS Land Cover: Cover Type		Figure 5b

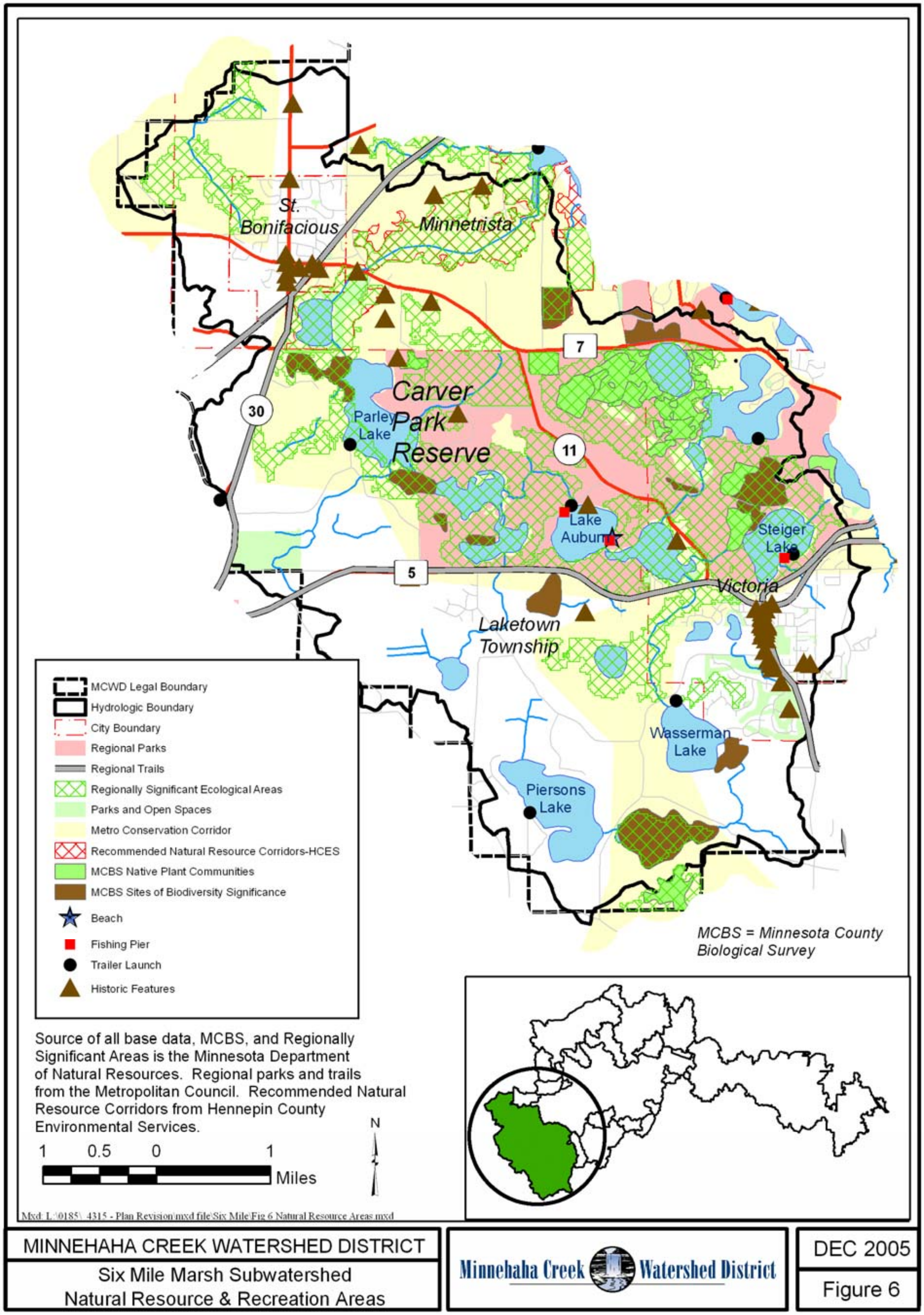
Table 1. DNR fish survey data.

Lake	Survey Year	Fishery	Dominant Fish
Parley	2004	Sport - walleye	Black crappie, bluegill, black bullhead, yellow perch
Auburn (east & West)	2000	Panfish	Black bullhead, black crappie, northern pike, bluegill
Pierson	2001	Panfish	Black crappie, bluegill, largemouth bass, carp
Wasserman	1999	Panfish	Black bullhead, black crappie, bluegill, carp
Steiger	2003	Sport	Black crappie, bluegill, northern pike
Zumbra	2004	Sport	Bluegill, black bullhead, largemouth bass, northern pike
Stone	1996	Panfish	White crappie, black bullhead

Source: Minnesota DNR

Streams. Biological sampling on Six Mile Creek was conducted as a part of the *Upper Watershed Stream Assessment.* Eight sites were sampled; only five yielded more than the 100 organisms typically needed to assure a statistically valid score. The F-IBI – an Index of Biotic Integrity identified to the organism's family level – for most of the sites fell into the Fairly Poor category. However, the F-IBI does not allow discrimination between low scores due to poor water quality or low scores due to lack of habitat. Six Mile Creek showed the most diversity of the upper watershed streams, with thirteen aquatic invertebrate taxa representing thirteen families. Most of the taxa found were those that are tolerant of poor water quality, although some taxa that are less tolerant were identified in some reaches. Six Mile Creek is mainly a wetland stream, and lacks the habitat complexity necessary to sustain a varied macroinvertebrate community. Additional sampling and identification of organisms to the species level would be necessary to adequately characterize the biological integrity of Six Mile Creek.

Wetlands. A high density of wetlands is present in the subwatershed. A number of them were identified in the 2003 MCWD *Functional Assessment of Wetlands* (FAW) as having exceptional to high vegetative diversity and wildlife habitat potential as well as having high aesthetic values. Tamarack swamp is present in the Carver Park Reserve. Much of the riparian area along Six Mile Creek is wetland and contains mostly invasive or non-native vegetation, which includes cattails and some reed canary grasses. There are small patches of forest and woodland as well as larger, more extensive grasslands in the upland areas of the Carver Park Reserve (see Figure 12).


St. Bonifacious
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Piersons Lake
MCWD Legal Boundary
Hydrologic Boundary
City Boundary
Regional Parks
Regional Trails
Regionally Significant Ecological Areas
Parks and Open Spaces
Metro Conservation Corridor
Recommended Natural Resource Corridors-HCES
MCBS Native Plant Communities
MCBS Sites of Biodiversity Significance
Beach
Fishing Pier
Trailer Launch
Historic Features
MCBS = Minnesota County Biological Survey
Source of all base data, MCBS, and Regionally Significant Areas is the Minnesota Department of Natural Resources. Regional parks and trails from the Metropolitan Council. Recommended Natural Resource Corridors from Hennepin County Environmental Services.
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MINNEHAHA CREEK WATERSHED DISTRICT
Six Mile Marsh Subwatershed
Natural Resource & Recreation Areas
Minnehaha Creek Watershed District
DEC 2005
Figure 6

2.4 Human Environment

2.4.1 Present Land Use

The predominant land use in the subwatershed is agricultural, followed by vacant or undetermined areas and park and open space (see Figure 7). Much of the vacant land is large wetland or woodland tracts or grass and shrubland. Most of the impervious area is concentrated in a few areas of low-density residential development in Victoria and Laketown Township. Some large agricultural uses are present in Laketown Township, Victoria and St. Bonifacius. There are also other areas scattered throughout the west central and northwest parts of the subwatershed.

Table 2. Percent of Six Mile Marsh subwatershed by 2000 land use.

Land Use 2000	Acres	% of Subwatershed
Agricultural	5,019.4	29.5%
Vacant or Undetermined	4,267.2	25.1%
Parks and Open Space	3,727.3	21.9%
Water	2,403.8	14.7%
Single - Family Residential	1,211.3	7.1%
Institutional	172.9	1.0%
Roads and Highways	105.2	0.6%
Industrial	57.9	0.1%
Commercial	51.3	0.3%
Multi - Family Residential	16.6	0.01%
	17,032.9	

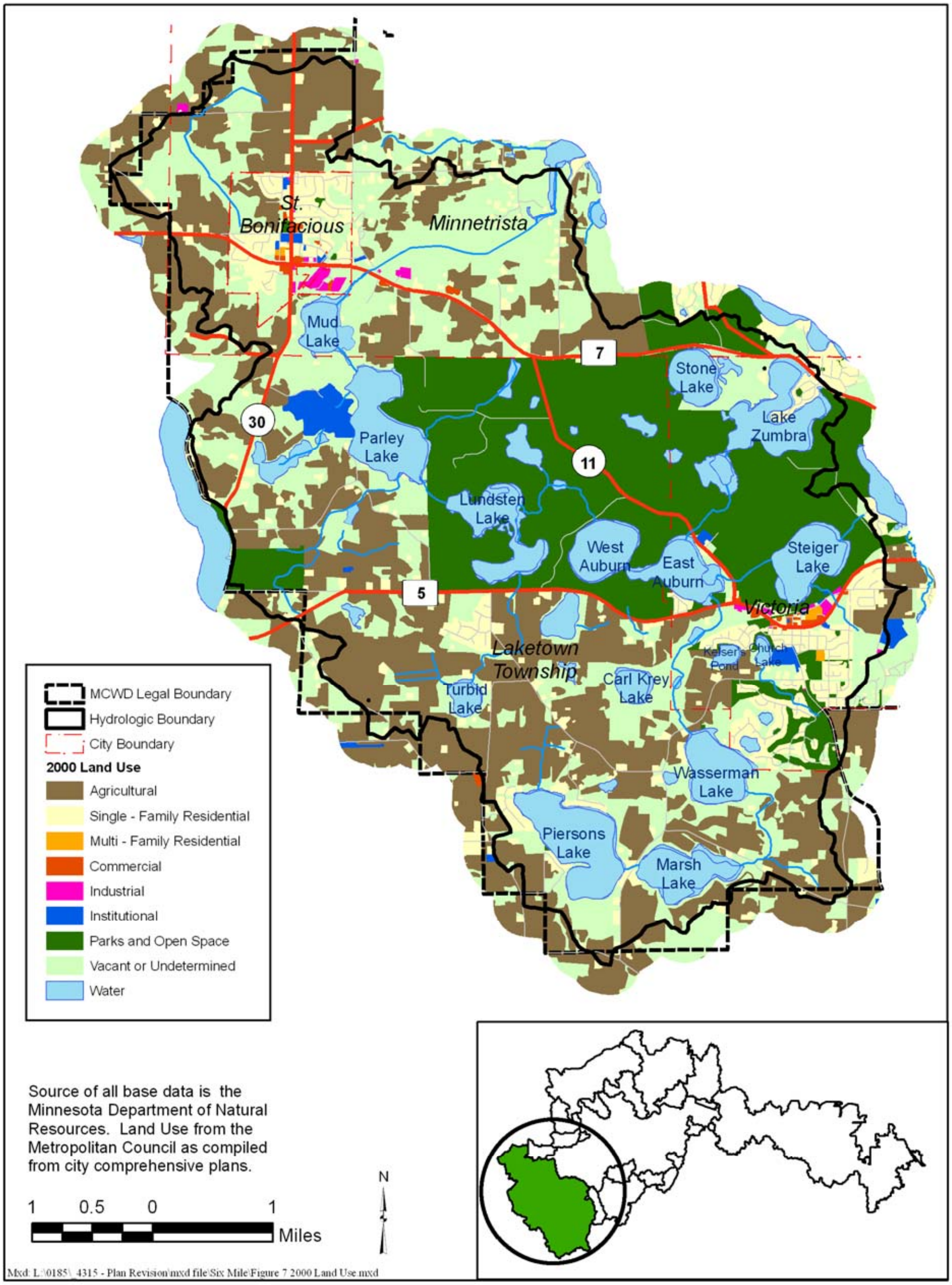
Source: Metropolitan Council. See Figure 7.

2.4.2 2020 and 2030 Land Use Planning

While agriculture is expected to continue to be an important land use in the subwatershed, significant areas of Victoria, Minnetrista, and Laketown Township within the subwatershed are expected to be developed by 2020 or 2030 (see Figures 8 and 9). The 2030 Metropolitan Council Planning Framework classifies much of the non-agricultural area of this subwatershed as Diversified Rural, a land use the Metropolitan Council describes as "… the widest variety of farm and non-farm land uses. They include a mix of a limited amount of large-lot residential and clustered housing, agriculture, and facilities and services requiring a rural location" (Metropolitan Council 2004).

2.4.3 Aquatic Recreation

The Carver Park Reserve offers numerous opportunities for aquatic recreation in the Six Mile Marsh subwatershed (see Figure 6). Three fishing piers are available, with one located on the south side of Steiger Lake and two on West Lake Auburn. Public water access can be found at Piersons Lake, Wassermann Lake, Steiger Lake, Lake Auburn, and Lake Zumbra. A beach is located on West Lake Auburn. There are no access points directly to Six Mile Creek.



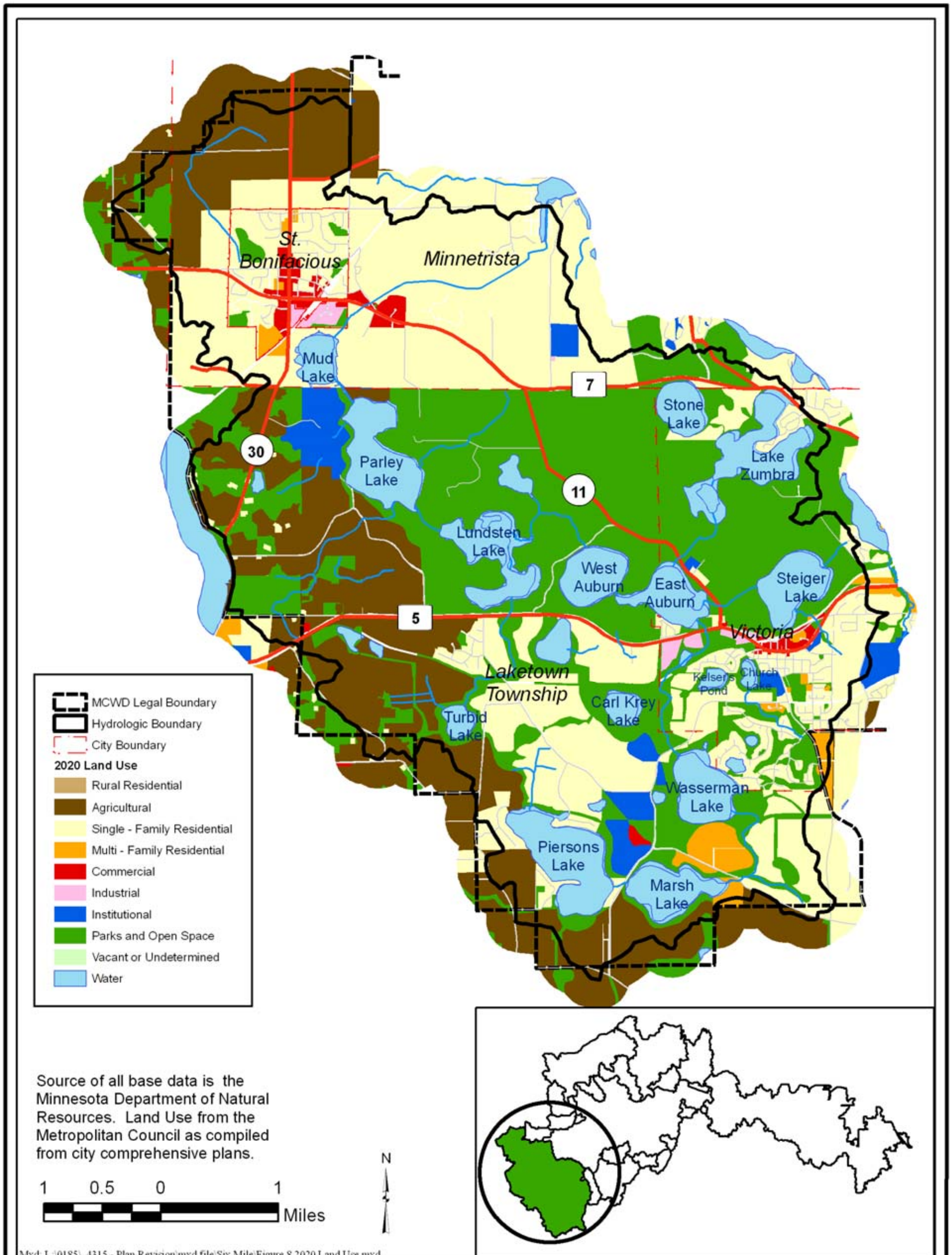
MINNEHAHA CREEK WATERSHED DISTRICT

Six Mile Marsh Subwatershed 2000 Land Use

Minnehaha Creek Watershed District

DEC 2005

Figure 7



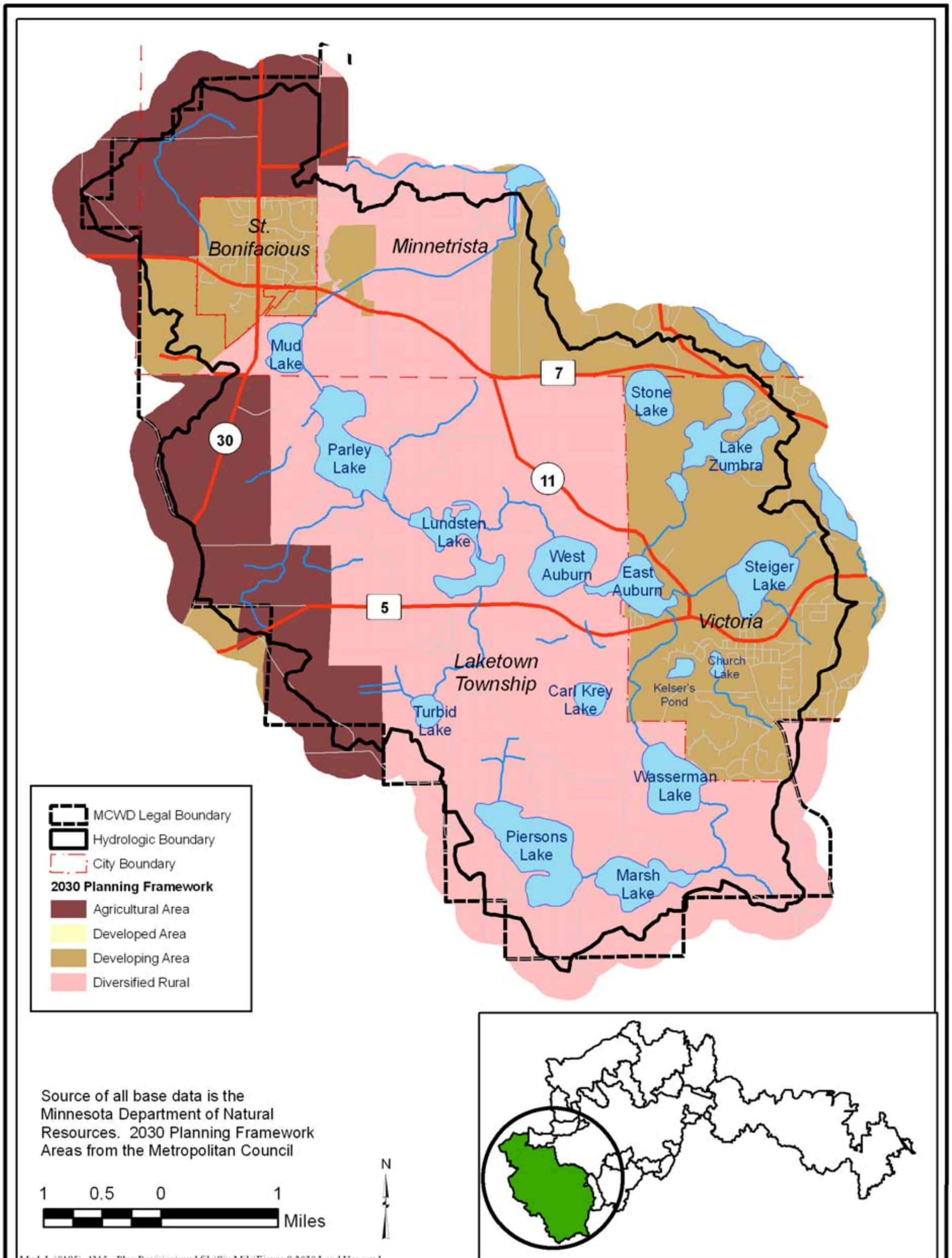
MINNEHAHA CREEK WATERSHED DISTRICT

Six Mile Marsh Subwatershed 2020 Land Use

Minnehaha Creek Watershed District

DEC 2005

Figure 8



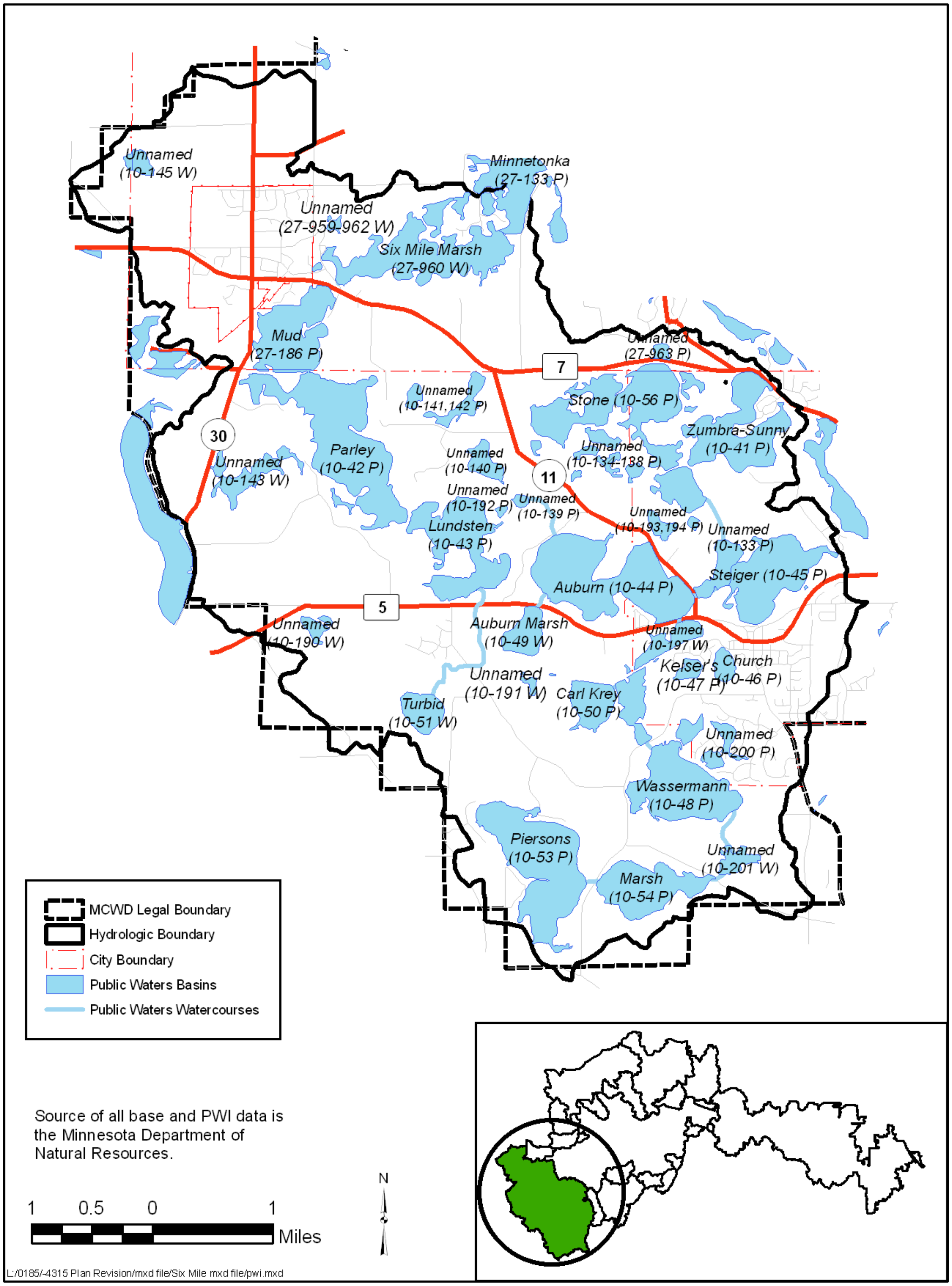
MINNEHAHA CREEK WATERSHED DISTRICT

Six Mile Marsh Subwatershed 2030 Planning Framework

Minnehaha Creek Watershed District

DEC 2005

Figure 9



MINNEHAHA CREEK WATERSHED DISTRICT

Six Mile Marsh Subwatershed Public Waters

Minnehaha Creek Watershed District

DEC 2005

Figure 10

2.5 Hydrologic Systems

The Department of Natural Resources' Public Waters Inventory identifies numerous basins within the Six Mile Marsh subwatershed as under the jurisdiction of the DNR (see Figure 10). These include several lakes and numerous unnamed basins as well as several watercourses:

Table 3. Public Waters in the Six Mile Marsh subwatershed.

DNR ID #	Name	DNR ID #	Name	DNR Public Waters Watercourses
10-41P	Zumbra-Sunny Lake	27-959W	Unnamed	Six Mile Creek Sec 10 T116R24 to Sec 9 T116R24
10-42P	Parley Lake	10-200P	Unnamed	
10-43P	Lunsten Lake	10-201W	Unnamed	Unnamed watercourse to Lunsten
10-44P	Auburn Lake	10-197W	Unnamed	Unnamed watercourse to Auburn
10-45P	Steiger Lake	10-194P	Unnamed	Unnamed watercourse to Auburn
10-48P	Wassermann Lake	10-193P	Unnamed	Unnamed tributary
10-49W	Auburn Marsh	10-192P	Unnamed	Unnamed tributary
10-53P	Piersons Lake	10-191W	Unnamed	Unnamed watercourse to Wasserman
10-54P	Marsh Lake	10-190W	Unnamed	Unnamed watercourse to Marsh
10-56P	Stone Lake	10-145W	Unnamed	Unnamed watercourse to Auburn
10-46P	Church Lake	10-143W	Unnamed	Unnamed watercourse to Auburn
10-51W	Turbid Lake	10-142P	Unnamed	Unnamed watercourse to Zumbra
27-133P	Lake Minnetonka	10-141P	Unnamed	
27-960W	Six Mile Marsh	10-140P	Unnamed	
27-186P	Mud Lake	10-139P	Unnamed	
10-50P	Carl Krey Lake	10-138P	Unnamed	
10-47P	Kelser's Pond	10-137P	Unnamed	
10-134P	Sunny Lake	10-136P	Unnamed	
27-963W	Unnamed	10-135P	Unnamed	
27-962W	Unnamed	10-133P	Unnamed	
27-961W	Unnamed	10-141P	Unnamed	

Source: Minnesota DNR. See Figure 10.

The HHPLS included detailed modeling of the current and 2020 hydraulic and hydrologic conditions in the subwatershed. That modeling includes the following results for modeled locations (lakes, ponds, channels, and crossings) within the subwatershed:

- Existing Normal Water Level;
- Existing High Water Level, peak discharge, and peak velocity for the 1.5 year, 24-hour and 100-year, 24-hour events;
- 2020 predicted HWL, peak discharge, and peak velocity for the 100-year, 24-hour event; and the
- Existing High Water Level for the 100-year, 10-day snowmelt event.

Those detailed results are not reproduced here, but are incorporated by reference. The HHPLS model predicted that development in the subwatershed, particularly in the city of Victoria and along Highway 7 that are now lightly developed, agricultural, or wooded, would increase local discharges resulting in an overall increase in flow in Six Mile Creek by more than 30 cfs for the 100-year event The model predicts that high water elevations on some individual wetland basins may increase slightly. The HHPLS scour analysis identified one reach of Six Mile Creek as having high erosion potential based on soils; but no visible erosion was noted in that reach during the *Stream Assessment*. The scour analysis revealed two other reaches of Six Mile Creek as having modeled velocity in excess of 1.5 fps for the 1.5 event; one of those reaches includes two areas of spot erosion noted in the *Stream Assessment*. Three reaches on small streams elsewhere in the subwatershed were identified as having high erosion potential, but those tributaries were not surveyed in the *Stream Assessment.*

Table 4. Modeled peak discharge from the Six Mile Marsh subwatershed (cfs).

Event	Existing	2020	Snowmelt
1.5 year, 24 hour	23.4	-	-
100 year, 24 hour	97.7	122.2	-
100-year, 10-day	-	-	51.0

Source: 2003 MCWD *Hydrologic, Hydraulic, and Pollutant Loading Study* (HHPLS)

2.5.1 Lakes

The subwatershed includes several lakes through which Six Mile Creek flows, as well as other lakes not associated with that stream. Tables 5 and 6 below detail the physical and water quality characteristics of the lake. Many of these lakes are located within the Carver Park Reserve. The HHPLS modeled water quality and established goals for nine of those lakes. An additional four lakes had established goals in the 1997 plan but those goals were not modeled in the HHPLS. Most of these lakes are monitored either as part of the District's monitoring program or by Three Rivers Park District. Little or no water quality data is available for smaller lakes scattered throughout the subwatershed.

Table 5. Physical characteristics of lakes in the Six Mile Marsh subwatershed.

Lake	Surface Area	Maximum Depth	Watershed to Lake Area Ratio	DNR Classification
Pierson	277	N/A	4:1	Recreational Development
Wasserman	153	41	16:1	Recreational Development
Steiger	158	37	4:1	Recreational Development
Zumbra	162	58	22:1	Recreational Development
Stone	100	30	7:1	Natural Environment
Auburn West	140	84	48:1	Recreational Development
Auburn East	120	34	53:1	Recreational Development
Lunsten	153	N/A	80:1	Natural Environment
Parley	242	18	44:1	Recreational Development
Carl Krey	41	N/A	8:1	Natural Environment
Church	12	54	26:1	Recreational Development
Turbid	31	N/A	16:1	Natural Environment
Mud	70	N/A	178:1	Natural Environment

Source: Minnesota DNR

Table 6. Selected water quality goals and current conditions of the Six Mile Marsh subwatershed.

Lake	1997 TP Goal	HHPLS TP Goal	1997-2004 Average TP	2004			
				TP (µg/L)	Chl-a (µg/L)	Secchi (m)	TSI
Pierson*	27	27	n/a	19	13	n/a	51
Wasserman	50	50	85	88	36	1.0	65
Steiger	50	30	39	41	18	1.5	57

Lake	1997 TP Goal	HHPLS TP Goal	1997-2004 Average TP	2004			
				TP (µg/L)	Chl-a (µg/L)	Secchi (m)	TSI
Zumbra	35	25	28	32	12	3.1	51
Stone	90	36	57	47	15	1.9	56
Auburn East	50	50	N/A	N/A	N/A	0.5-1**	N/A
Auburn West	30	27	38	41	14	2.8	53
Lunsten	90	70	N/A	N/A	N/A	0.5-1**	N/A
Parley*	50	50	81	75	70	0.8	61
Carl Krey	90	N/A	N/A	N/A	N/A	2-4	N/A
Church	90	N/A	N/A	N/A	N/A	0.5-1**	N/A
Turbid	N/A	N/A	N/A	N/A	N/A	0.5-1**	N/A
Mud	N/A	N/A	N/A	N/A	N/A	0.5-1**	N/A

*2003 data
** Clarity as estimated by the University of Minnesota using satellite imagery
Source: MCWD and Minnesota DNR/University of Minnesota.

2.5.2 Streams

There is one primary stream within the subwatershed: Six Mile Creek, which flows to Halsteds Bay. Several other small streams and channels provide drainage and local conveyance within the subwatershed. The creek was channelized as Judicial Ditch #2 in 1905 (see the following section). Six Mile Creek is included in the District's Annual Hydrologic Data monitoring program, and was also studied in-depth in 2004 as part of the District's *Upper Watershed Stream Assessment*. There are no known storm sewer outfalls to the creek, mainly due to minimal near stream development. There are 5 bridge crossings, and some culvert crossings, which are mainly park trail, and path crossings.

The creek flows through several large wetlands prior to discharging to Halsteds Bay. The *Stream Assessment* identified eight erosion sites and only a few sites with debris in the channel. The erosion was mainly localized streambank sloughing.

Water quality and flow in the creek is monitored at two locations. Six Mile Creek carries a significant phosphorus and sediment load to Lake Minnetonka at Halsteds Bay. Phosphorus loads are generally low at Lunsten Lake but substantially increase near Parley and Mud Lake downstream. Six Mile Marsh is a likely source of phosphorus loads to Halsteds Bay. Dissolved oxygen within the stream in the summer months falls below the 5 mg/L State of Minnesota standard for class 2B waters. *E. coli* bacteria were monitored in Six Mile Creek in 2004; counts did not exceed state standards.

2.5.3 Ditches

A public drainage ditch established under Minnesota Statutes Chapter 103E is located within this subwatershed. Six Mile Creek was channelized as Judicial Ditch #2 in 1903. The purpose of the ditch was to promote the public health. The ditch served as a way to remove stagnant water and "miasma" and helped the conversion of a large amount of land to agricultural uses. Judicial Ditch #2 still drains agricultural land as it was originally intended when it was first constructed.

2.5.4 Wetlands

Approximately 48 percent of the land area within the Six Mile Marsh subwatershed is shown on the National Wetland Inventory as wetland (see Table 7).

Table 7. National Wetlands Inventory wetlands in the Six Mile Marsh subwatershed.

Circular 39 Type	Area (acres)	Cowardin Class	Area (acres)
Seasonal	136.8	Emergent	2,591.7
Wet Meadow	2,448.1	Forested	116.8
Shallow Marsh	51.8	Scrub Shrub	246.0
Deep Marsh	1,992.9	Unconsolidated Bottom	2,053.6
Open Water	246.0		
Scrub Shrub	115.7		
Forested	16.8		
TOTAL	5,008.1		5,008.1

Source: Minnesota DNR.

In 2001-2003 the District undertook a *Functional Assessment of Wetlands* (FAW) on all wetlands greater than one-quarter acre in size. This assessment used a variant of the Minnesota Routine Assessment Method. In contrast to Table 7 above, which shows wetland acreage and type from the National Wetlands Inventory completed in the 1980s, Table 8 below shows the acreage and type as assessed in the field. Using the results of that analysis, individual wetlands were assigned to one of four categories – Preserve, and Manage 1, 2, or 3 (see Figure 12 and Table 9). Wetlands that were evaluated as Exceptional or High on certain ecological or hydrologic values were assigned to the Preserve category. The balance of evaluated wetlands were assigned to a category based on this assessment of current functions and values, with Manage 1 wetlands exhibiting higher values and Manage 2 and 3 moderate or lower values. Refer to the *Functional Assessment of Wetlands* (2003) for details of methodology, classification, and management recommendations.

Table 8. Dominant wetland type in the Six Mile Marsh subwatershed as assessed in the *Functional Assessment of Wetlands*.

Circular 39 Type	Area (acres)
Seasonal	401.2
Wet Meadow	592.8
Shallow Marsh	1,784.4
Deep Marsh	268.6
Open Water	748.0
Scrub Shrub	105.4
Forested	278.4
Bogs	202.1
Lakes	1,687.2
Not typed	30.7
TOTAL	6,098.8

Note: Based on field assessment. Excludes those areas determined in the field not to be wetlands, and stormwater ponds clearly excavated out of upland. Includes some small areas that were not field assessed.

Source: MCWD 2003 *Functional Assessment of Wetlands.* See Figure 11.

Table 9. Wetland management classifications of wetlands in the Six Mile Marsh subwatershed as determined in the *Functional Assessment of Wetlands*.

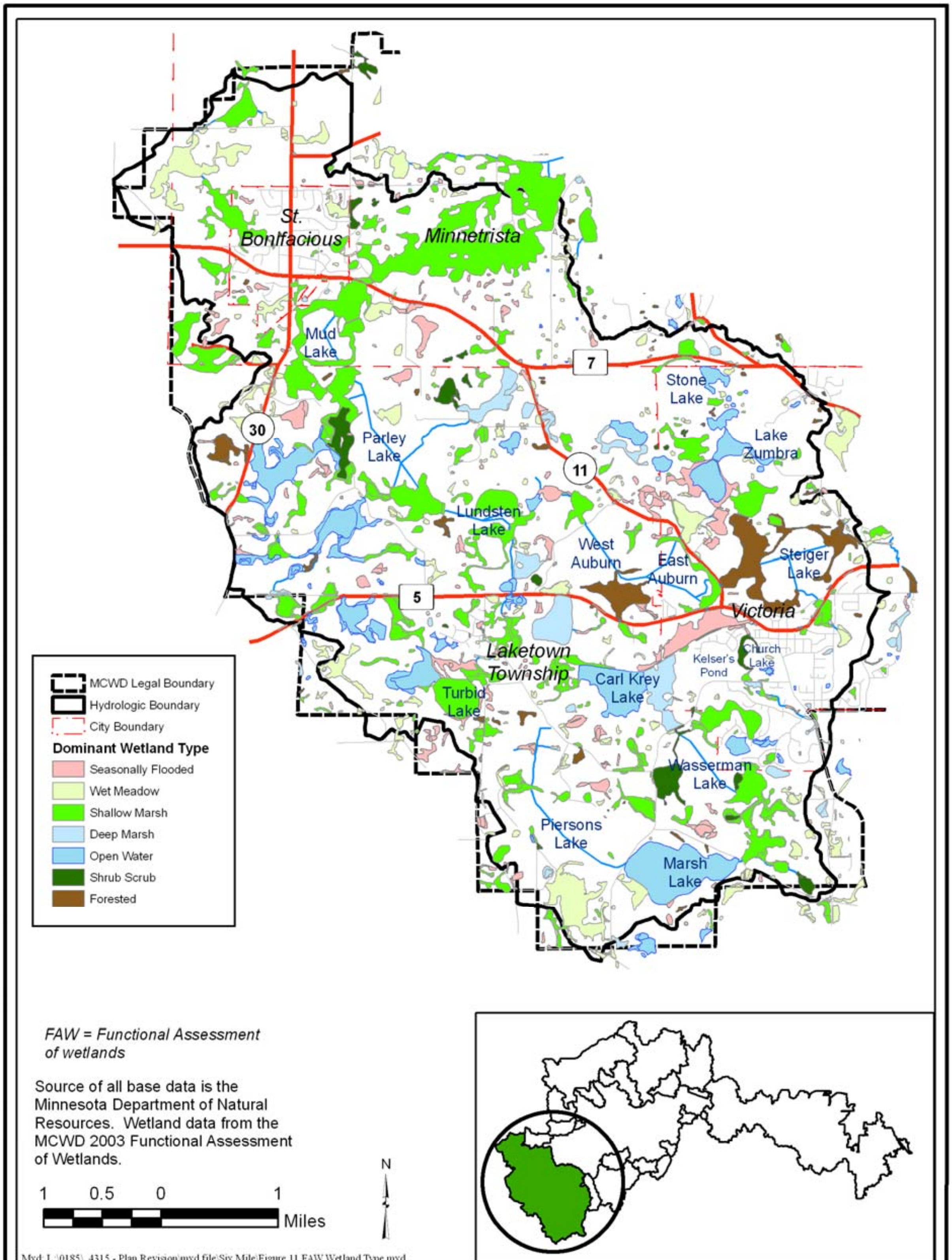
Classification	Number	Area (acres)	% of total
Preserve	92	332.0	7.4
Manage 1	411	1,175.0	26.3
Manage 2	224	494.2	11.1
Manage 3	148	2,466.6	55.2
TOTAL	875	4,467.8	

Note: The FAW excluded large lakes and wetlands less than ¼ acre in size; those areas are included in the NWI, so total will not match Tables 7 or 8.

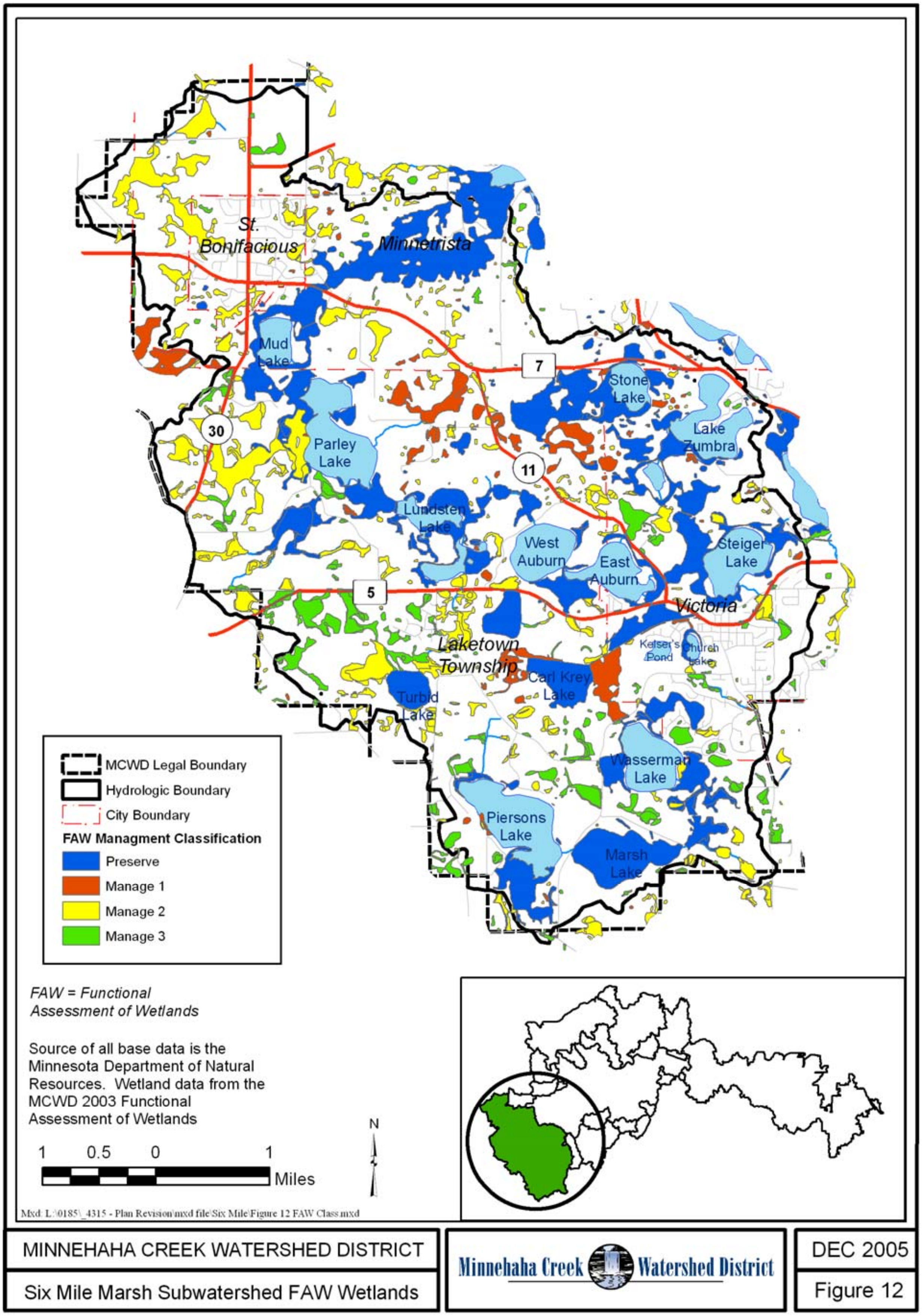
Source: MCWD 2003 *Functional Assessment of Wetlands.* See Figure 12.

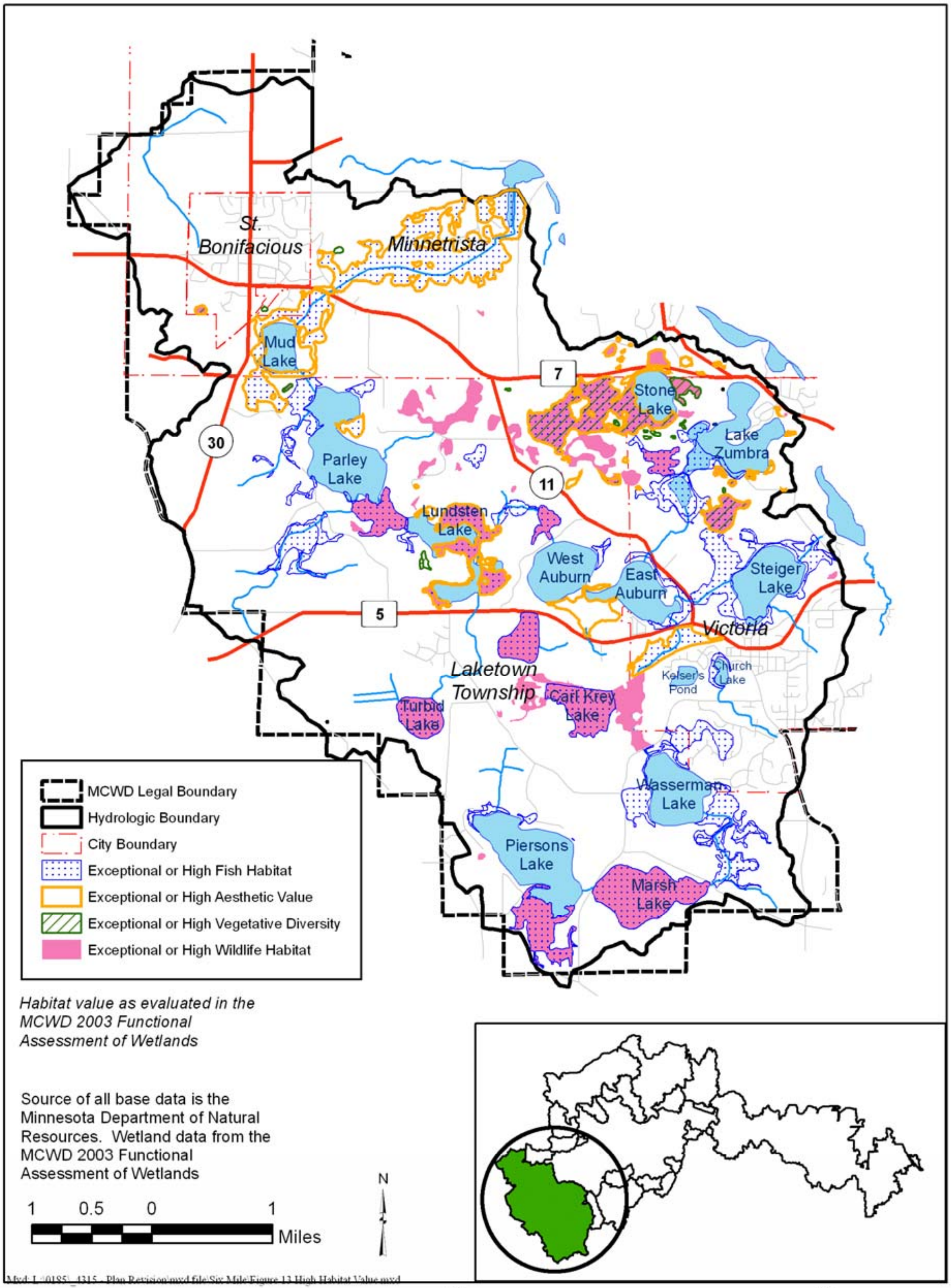
The Six Mile Marsh subwatershed has a large number of wetlands of various sizes distributed across the landscape, including several very large wetlands. Many scored highly on vegetative diversity, fish and wildlife habitat, or aesthetics (see Figure 13). Some of the wetlands were also evaluated for restoration potential. Factors considered were the ease with which the wetland could be restored, the number of landowners within the historic basin, the size of the potential restoration area, the potential for establishing buffer areas or water quality ponding, and the extent and type of hydrologic alteration. Several wetlands of moderate or high restoration potential are located throughout the subwatershed, including wetlands through which Six Mile Creek flows (see Figure 14).

A large amount of restorable wetland exists within the Six Mile Marsh Subwatershed. MCWD will consider restoring wetlands as a primary approach to reducing nutrient loading, reducing runoff volumes, restoring ecology and achieving other District Goals within this subwatershed.



MINNEHAHA CREEK WATERSHED DISTRICT	Minnehaha Creek Watershed District	DEC 2005
Six Mile Marsh Subwatershed FAW Wetland Type		Figure 11


St. Bonifacious
Minnetrista
Mud Lake
7
Stone Lake
Lake Zumbra
30
Parley Lake
11
Lundsten Lake
West Auburn
East Auburn
Steiger Lake
5
Victoria
Laketown Township
Keiser's Pond
Church Lake
Carl Krey Lake
Turbid Lake
Wasserman Lake
Piersons Lake
Marsh Lake
MCWD Legal Boundary
Hydrologic Boundary
City Boundary
FAW Managment Classification
Preserve
Manage 1
Manage 2
Manage 3
FAW = Functional Assessment of Wetlands
Source of all base data is the Minnesota Department of Natural Resources. Wetland data from the MCWD 2003 Functional Assessment of Wetlands
1 0.5 0 1
Miles
N
Mxd: L:\0185_4315 - Plan Revision\mxd file\Six Mile\Figure 12 FAW Class.mxd
MINNEHAHA CREEK WATERSHED DISTRICT
Six Mile Marsh Subwatershed FAW Wetlands
Minnehaha Creek Watershed District
DEC 2005
Figure 12



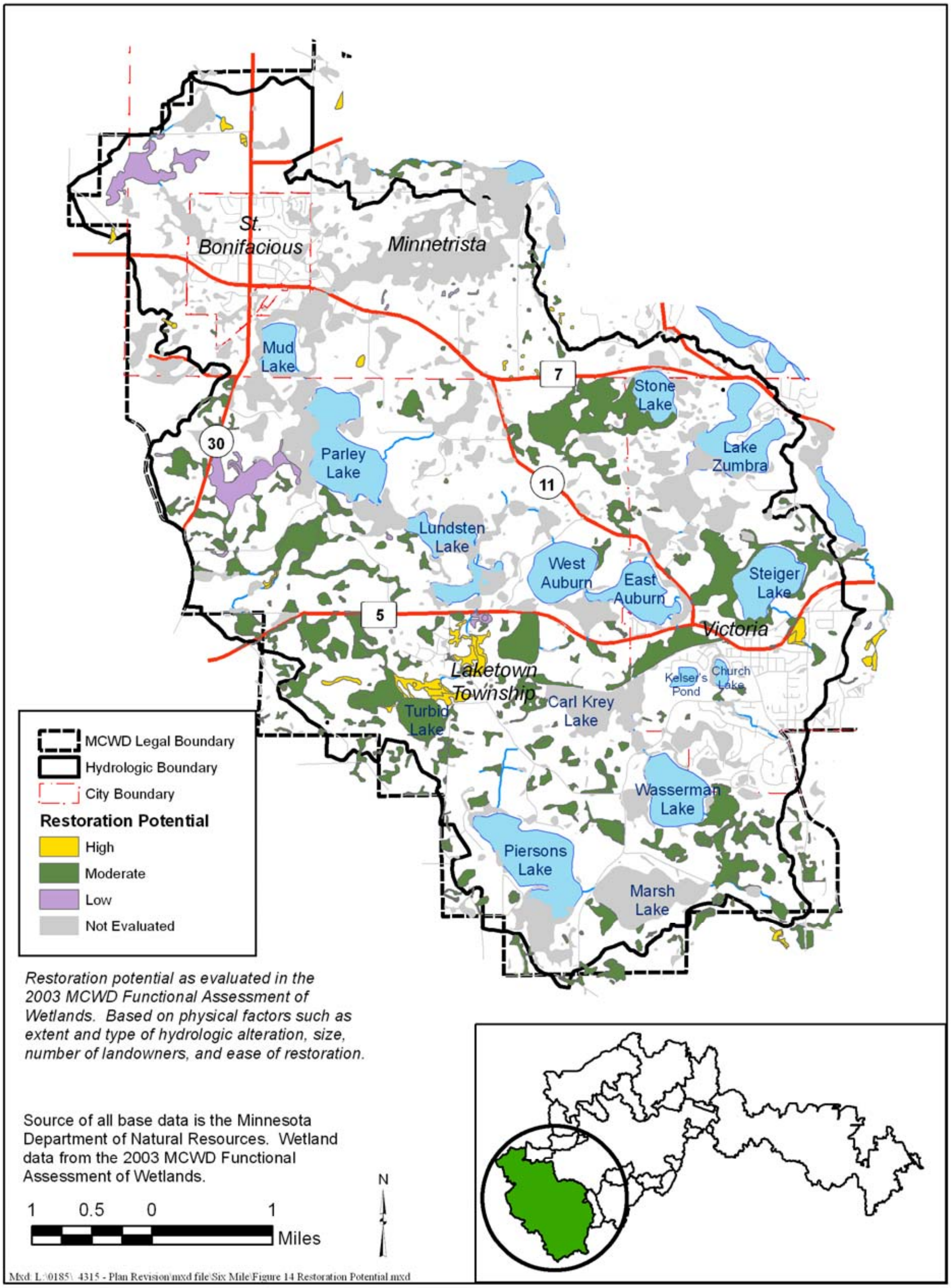
MINNEHAHA CREEK WATERSHED DISTRICT

Six Mile Marsh Subwatershed
High Habitat Value Wetlands

Minnehaha Creek Watershed District

DEC 2005

Figure 13



MINNEHAHA CREEK WATERSHED DISTRICT

Six Mile Marsh Subwatershed
Wetland Restoration Potential

Minnehaha Creek Watershed District

DEC 2005

Figure 14

2.5.5 Floodplain

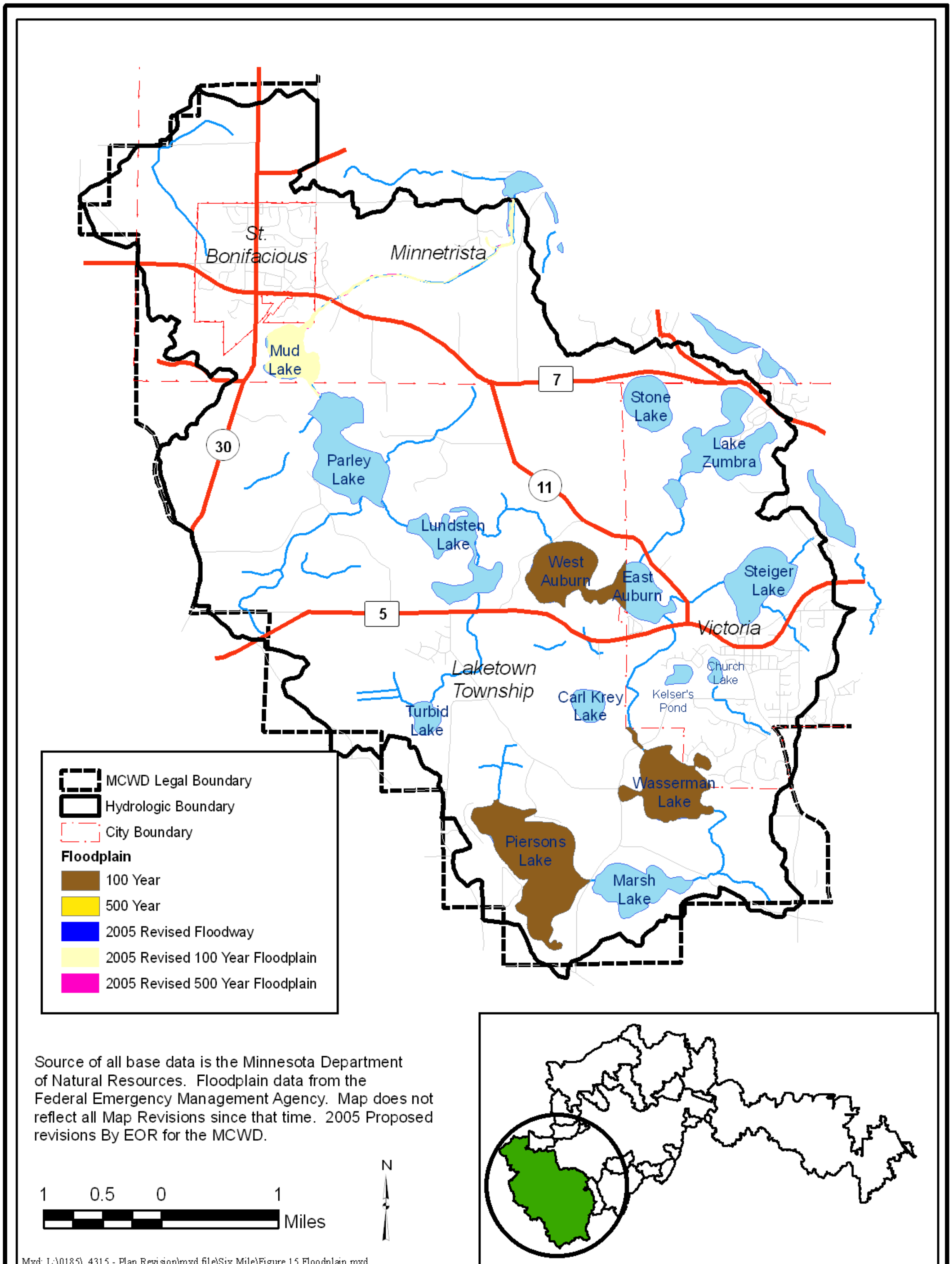
Floodplain is shown on Figure 15. In 2005 the District completed an evaluation of flood elevations on Minnehaha Creek, and four upper watershed streams: Gleason Creek, Long Lake Creek, Painter Creek, and Six Mile Creek. Figure 15 shows the elevations of floodplains modeled by the District and other floodplains in the subwatershed.

2.5.6 Groundwater

The HHPLS identified the infiltration potential of the upland areas within the subwatershed as medium to low with some areas of variability where the soils are organic in nature (see Figure 16). Areas of high aquifer sensitivity are generally related to wetlands. There are also some areas of high sensitivity west of Piersons Lake and south of Marsh Lake, in pockets where ice- stratified deposits of gravel underlay the soil rather than the till deposits that typically underlay the subwatershed (see Figure 17).

An area within St. Bonifacius has been designated a Wellhead Protection Area and a Drinking Water Sensitivity Management Areas (DWSMA) for a City of St. Bonifacius well. A small area north of Stone Lake has been designated a DWSMA for a City of Minnetrista well. The Minnesota Department of Health has designated these areas to be of low risk and vulnerability to contamination of the drinking water supply. Figure 18 shows the DWSMAs and associated Wellhead Protection Areas.

The County Well Index has records of approximately 215 wells in the subwatershed, mostly shallow (less than 300 feet deep) domestic water supply wells and about six deeper, municipal wells.



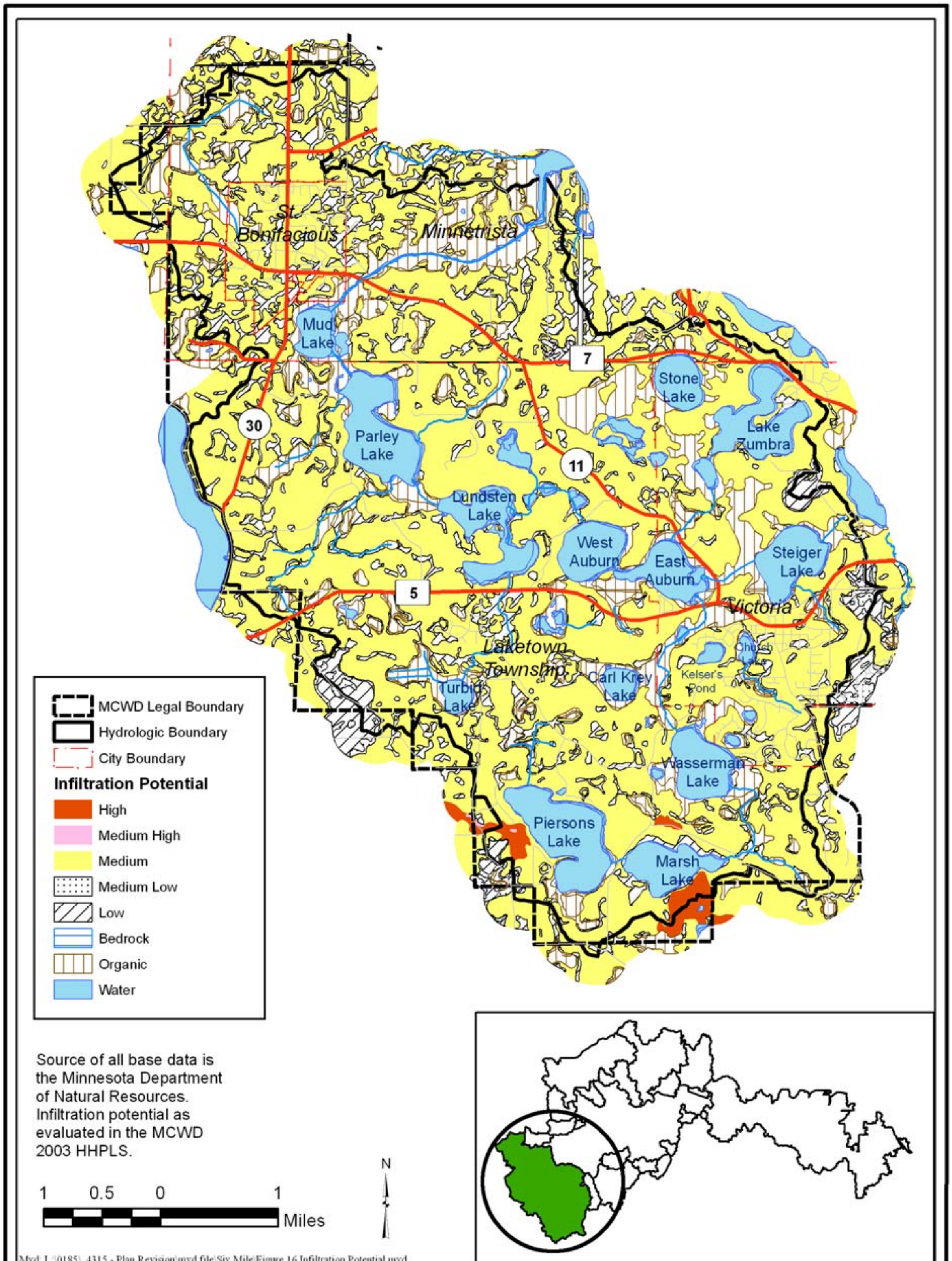
MINNEHAHA CREEK WATERSHED DISTRICT

Six Mile Marsh Subwatershed Floodplain

Minnehaha Creek Watershed District

DEC 2005

Figure 15



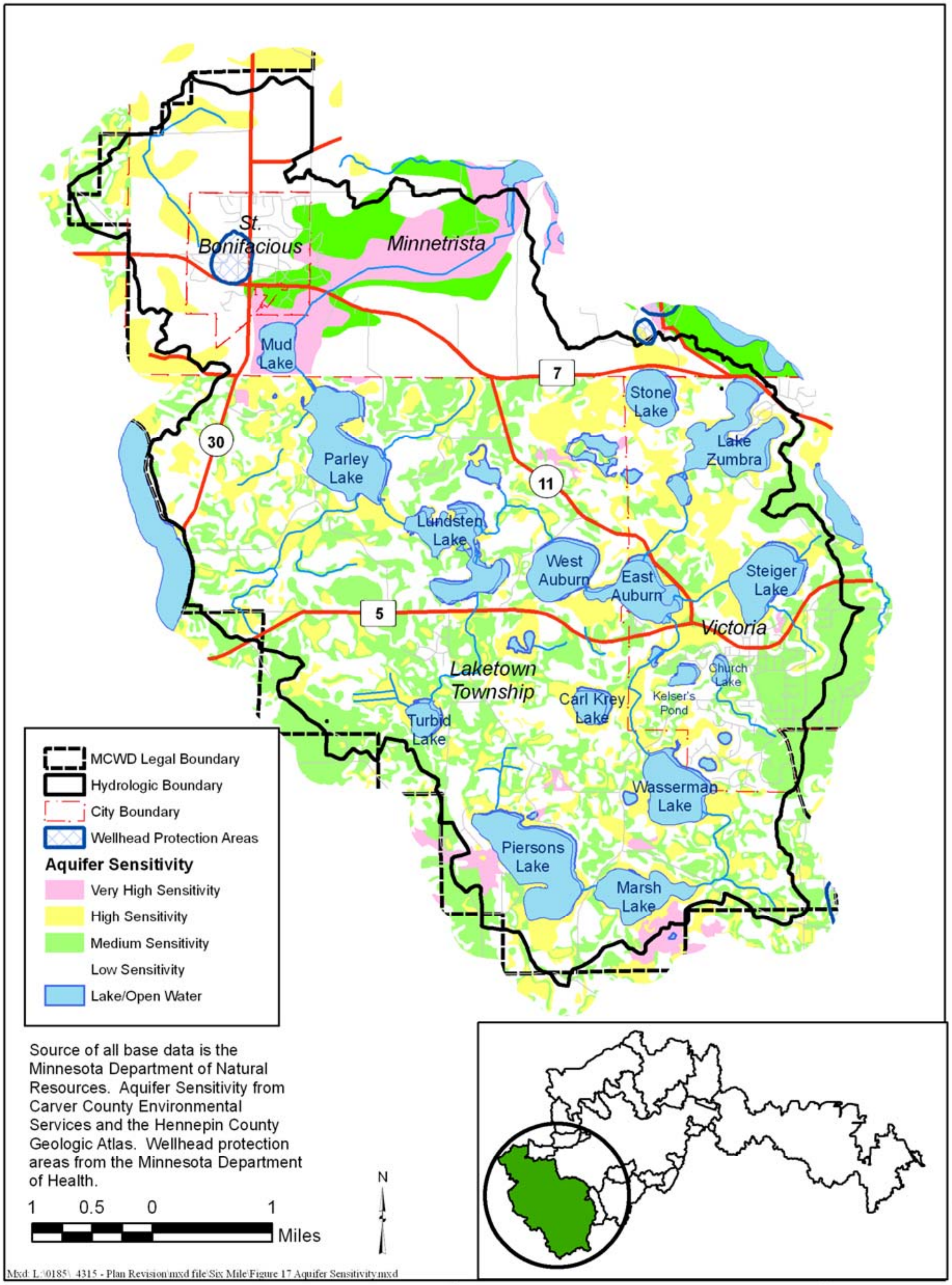
MINNEHAHA CREEK WATERSHED DISTRICT

Six Mile Marsh Subwatershed Soil Infiltration Potential

Minnehaha Creek Watershed District

DEC 2005

Figure 16



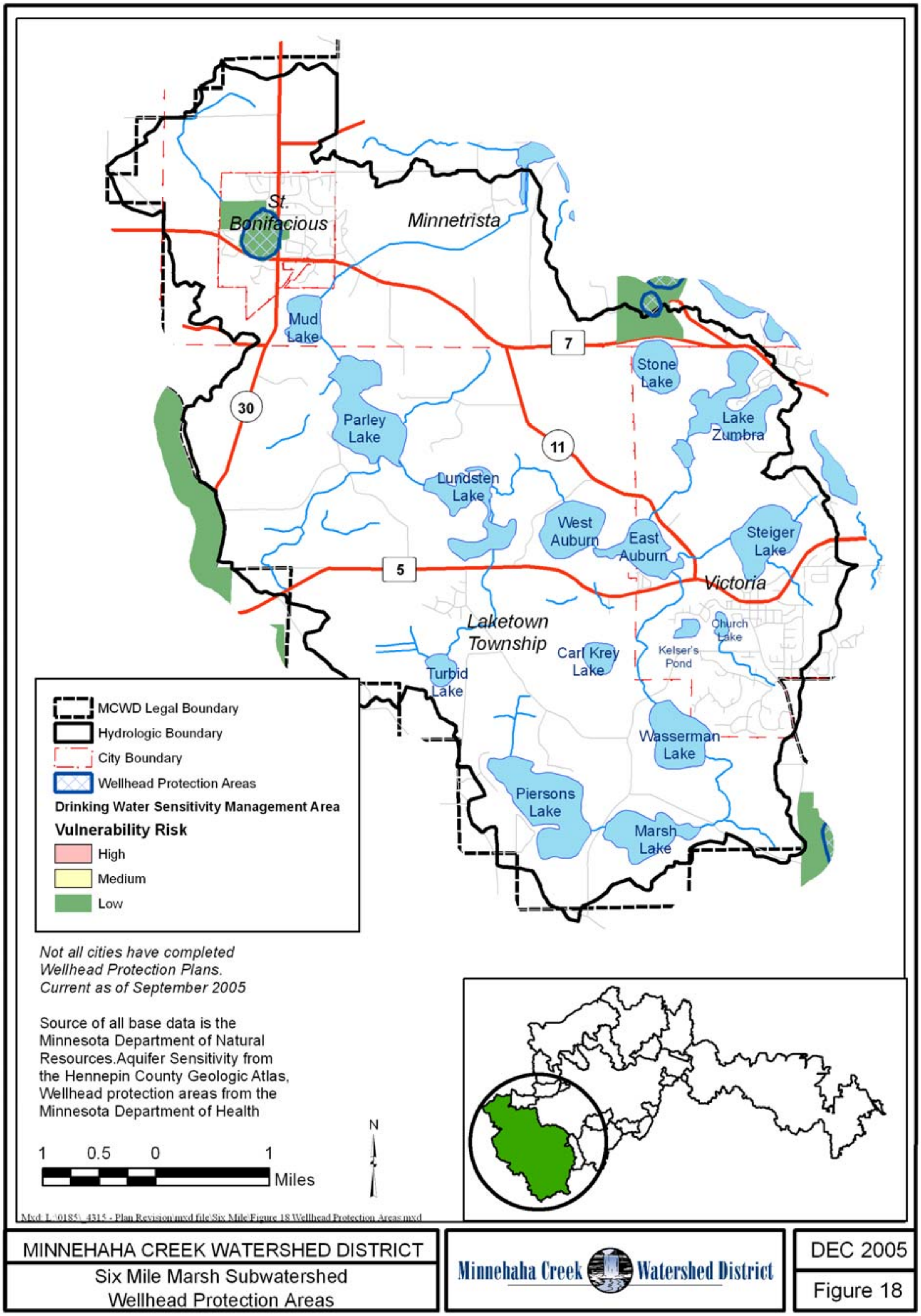
MINNEHAHA CREEK WATERSHED DISTRICT

Six Mile Marsh Subwatershed Aquifer Sensitivity

Minnehaha Creek Watershed District

DEC 2005

Figure 17


St. Bonifacious
Minnetrista
Mud Lake
7
Stone Lake
30
Parley Lake
Lake Zumbra
11
Lundsten Lake
West Auburn
East Auburn
Steiger Lake
5
Victoria
Laketown Township
Church Lake
Carl Krey Lake
Kelser's Pond
Turbid Lake
Wasserman Lake
Piersons Lake
Marsh Lake
MCWD Legal Boundary
Hydrologic Boundary
City Boundary
Wellhead Protection Areas
Drinking Water Sensitivity Management Area
Vulnerability Risk
High
Medium
Low
Not all cities have completed Wellhead Protection Plans.
Current as of September 2005
Source of all base data is the Minnesota Department of Natural Resources.Aquifer Sensitivity from the Hennepin County Geologic Atlas, Wellhead protection areas from the Minnesota Department of Health
1 0.5 0 1
Miles
N
MINNEHAHA CREEK WATERSHED DISTRICT
Six Mile Marsh Subwatershed
Wellhead Protection Areas
Minnehaha Creek Watershed District
DEC 2005
Figure 18

3.0 Problems and Issues

3.1 Water Quality

1. Two lakes in the subwatershed have been designated as Impaired Waters on the State's 303(d) list due to an excess of nutrients. The District is preparing Total Maximum Daily Load (TMDL) studies, including plans to reduce phosphorus loads into the lakes, for Parley and Wasserman Lakes.
2. Other lakes in the subwatershed meet state phosphorus standard but do not meet the more stringent total phosphorus concentration goals established in the HHPLS, including Pierson, Steiger, Stone, and Auburn West. Lake Zumbra-Sunny is very close to meeting its HHPLS goal. Auburn East and Lunsten Lake do not meet their HHPLS water quality goals. No or limited data is available for East Auburn, Lunsten, Carl Krey, Church, Turbid, and Mud Lakes.
3. Phosphorus and sediment loads in Six Mile Creek increase from upstream to downstream, and the creek and its subwatershed are a significant source of phosphorus load to Halsteds Bay.
4. Development, redevelopment, and reconstruction in the subwatershed are predicted to increase nutrient and TSS loads from the watershed as well as increasing the volume of stormwater runoff, potentially further degrading water quality.

3.2 Water Quantity

1. Drainage is conveyed through the subwatershed through several streams and channels to lakes and wetlands, which outlet to or an in-line with Six Mile Creek. The *Upper Watershed Stream Assessment* identified eight erosion locations on the creek. The HHPLS predicted that development between 2000 and 2020 would increase average flow in the creek.
2. The HHPLS identified a number of locations that are predicted to overtop during the 100 year event, as well as others with a minimal amount of freeboard. Some residences on Lake Zumbra have less than desirable freeboard over the 100-year elevation of the lake, which may increase slightly due to development. More detail is available in the HHPLS.
3. Development is predicted to increase the volume of stormwater runoff from the subwatershed, increasing nutrient and TSS loads conveyed downstream.
4. The HHPLS identified several locations where for both existing and future conditions higher velocities than desired may result in erosive velocities at outlets or culverts. These include several road culverts and the Turbid and Lunsten Lake outlets. Erosion control or energy dissipation measures may be required in those locations.

Several landlocked basins are present in the subwatershed. Within these landlocked basins, any future development or redevelopment should minimize creation of new stormwater volumes. Outletting will generally be discouraged unless there is a demonstrated threat to property structures or public safety.

3.3 Wetlands

1. As described in Section 2.5.4, the subwatershed includes numerous wetlands with high to exceptional vegetative diversity, fish and wildlife habitat and aesthetic values that need to be protected.
2. The subwatershed includes numerous degraded wetlands with high to moderate restoration potential that could be considered for protection and restoration to increase the quantity and quality of wetlands present and begin to mitigate past wetland losses from fill and degradation.

3.4 Ecological Integrity

1. Much of the subwatershed is characterized by large open areas of forest, grasslands, and wetlands punctuated by agriculture and low density development. Intensive uses are concentrated along the US Highway 7 corridor and in the cities of Victoria and St. Bonifacius. The Carver Park Reserve dominates the subwatershed, and includes large areas designated as Regionally Significant Ecological Areas and high value native plant communities. Wetlands with high ecological value are present and those wetlands and associated upland areas should be conserved to preserve their values, create larger areas of ecological value, and connect existing resources.
2. The fisheries are regularly surveyed and actively managed by the DNR and Three Rivers Park District.
3. Eurasian water milfoil is present in most of the lakes.
4. No aquatic plant survey data is available for many of these lakes.
5. Macroinvertebrate communities in Six Mile Creek are limited by the type of habitat available and its character as primarily a wetland stream.
6. Corridor connections between Key Conservation Areas (see Figure 19) need to be preserved, enhanced and restored. Functioning corridors provide benefits to water quality, wildlife habitat (including threatened and endangered species) as well as the general health of the ecosystem. Figure 19 identifies a corridor throughout the subwatershed which should be implemented through District efforts as well as through local planning. The corridor functions to provide connectivity of the peripheral areas of the District to major resources such as Lake Minnetonka and Minnehaha Creek. The riparian area of Six Mile Creek serves as a major component of the plan.

3.5 Groundwater

1. Many of the major wetlands in the subwatershed were identified in the FAW as discharge or combination recharge-discharge wetlands. Several recharge wetlands are located in the two areas of the subwatershed north where depth to bedrock is lower than in other parts of the subwatershed. As development occurs it will be critical to maintain runoff and infiltration rates to help maintain hydrology to these wetlands.
2. As described in Section 2.5.6 and Figures 16, 17, and 18, there are a number of areas in the subwatershed that are very highly or highly sensitive aquifer impacts.
3. Wellhead Protection Areas and associated Drinking Water Sensitivity Management Areas have been identified for the cities of St. Bonifacius and Minnetrista within this subwatershed. Stormwater management within those areas should be coordinated with wellhead protection plans.
4. Groundwater hydrology is an important component in the base flow for area streams. Protecting existing groundwater flow regimes must remain a priority.

3.6 Impacts of Future Growth

<u>Water Quantity and Quality.</u> Land use change impacts downstream water quality by increasing the volume of runoff and the concentration and load of nutrients and sediment transported to receiving waters. Table 10 illustrates how land use change such as the expected conversion of vacant land to other uses could be expected to ultimately impact water quality in the lakes in the subwatershed as well as Halsteds Bay. The table also illustrates the impact of a regulatory program managing these impacts.

'Ultimate development' is defined as the conversion of all agricultural lands and one-half the upland forested area that remains undeveloped in the 2020 local government land use plans. This conversion may take place by 2030 or require significantly more time; but it is assumed that at some point in the future these conversions will occur. More detail regarding this modeling can be found in Technical Appendix A.

Table 10 contrasts three loading reduction scenarios. Scenarios 1 and 2 contrast the required load reductions if there were no regulatory program to the requirements under the existing regulatory program. The HHPLS assumed that there would be no load increase from future development; the third scenario in Table 10 indicates that even with a stringent regulatory program that strictly prohibits any new phosphorus loading, additional reductions would be necessary to achieve the desired phosphorus concentration goal of 50 µg/L in Halsteds Bay.

Table 10. Lake modeled 2020 and ultimate development water quality and the total phosphorus loading reduction necessary to achieve in-lake total phosphorus concentration goals.

Pierson Lake Goal = 27 µg/L	2000	2020	Ultimate Development
Scenario 1: No Regulatory Program			
Predicted in-lake TP (µg/L)		43	47
P load decrease needed to achieve 27 µg/L (lbs/year)			305
Scenario 2: Current Regulatory Program			
Predicted in-lake TP (µg/L)	39		43
P load decrease needed to achieve 27 µg/L (lbs/year)			228
Scenario 3: Regulatory Program That Prohibits A Net Increase in Loading from New Development (As assumed in HHPLS)			
Predicted in-lake TP (µg/L)			38
P load decrease needed to achieve 27 µg/L (lbs/year)			151

Wasserman Lake Goal = 50 µg/L	2000	2020	Ultimate Development
Scenario 1: No Regulatory Program			
Predicted in-lake TP (µg/L)		83	86
P load decrease needed to achieve 50 µg/L (lbs/year)			598
Scenario 2: Current Regulatory Program			
Predicted in-lake TP (µg/L)	75		77
P load decrease needed to achieve 50 µg/L (lbs/year)			464
Scenario 3: Regulatory Program That Prohibits A Net Increase in Loading from New Development (As assumed in HHPLS)			
Predicted in-lake TP (µg/L)			69
P load decrease needed to achieve 50 µg/L (lbs/year)			345

Steiger Lake Goal = 30 µg/L	2000	2020	Ultimate Development
Scenario 1: No Regulatory Program			
Predicted in-lake TP (µg/L)		41	44
P load decrease needed to achieve 30 µg/L (lbs/year)			126
Scenario 2: Current Regulatory Program			
Predicted in-lake TP (µg/L)	39		42
P load decrease needed to achieve 30 µg/L (lbs/year)			109
Scenario 3: Regulatory Program That Prohibits A Net Increase in Loading from New Development (As assumed in HHPLS)			
Predicted in-lake TP (µg/L)			41
P load decrease needed to achieve 30 µg/L (lbs/year)			92

Zumbra Lake Goal = 25 µg/L	2000	2020	Ultimate Development
Scenario 1: No Regulatory Program			
Predicted in-lake TP (µg/L)		27	28
P load decrease needed to achieve 25 µg/L (lbs/year)			20
Scenario 2: Current Regulatory Program			
Predicted in-lake TP (µg/L)	27		27
P load decrease needed to achieve 25 µg/L (lbs/year)			17
Scenario 3: Regulatory Program That Prohibits A Net Increase in Loading from New Development (As assumed in HHPLS)			
Predicted in-lake TP (µg/L)			27
P load decrease needed to achieve 25 µg/L (lbs/year)			14

Stone Lake Goal = 36-44 µg/L	2000	2020	Ultimate Development
Scenario 1: No Regulatory Program			
Predicted in-lake TP (µg/L)		50	51
P load decrease needed to achieve 36 µg/L (lbs/year)			81
Scenario 2: Current Regulatory Program			
Predicted in-lake TP (µg/L)	44		47
P load decrease needed to achieve 36 µg/L (lbs/year)			59
Scenario 3: Regulatory Program That Prohibits A Net Increase in Loading from New Development (As assumed in HHPLS)			
Predicted in-lake TP (µg/L)			43
P load decrease needed to achieve 36 µg/L (lbs/year)			37

Auburn East Lake Goal = 50 µg/L	2000	2020	Ultimate Development
Scenario 1: No Regulatory Program			
Predicted in-lake TP (µg/L)		69	69
P load decrease needed to achieve 50 µg/L (lbs/year)			386
Scenario 2: Current Regulatory Program			
Predicted in-lake TP (µg/L)	63		60
P load decrease needed to achieve 50 µg/L (lbs/year)			192
Scenario 3: Regulatory Program That Prohibits A Net Increase in Loading from New Development (As assumed in HHPLS)			
Predicted in-lake TP (µg/L)			57
P load decrease needed to achieve 50 µg/L (lbs/year)			129

Auburn West Lake Goal = 27 µg/L	2000	2020	Ultimate Development
Scenario 1: No Regulatory Program			
Predicted in-lake TP (µg/L)		43	44
P load decrease needed to achieve 27 µg/L (lbs/year)			376
Scenario 2: Current Regulatory Program			
Predicted in-lake TP (µg/L)	41		38
P load decrease needed to achieve 27 µg/L (lbs/year)			244
Scenario 3: Regulatory Program That Prohibits A Net Increase in Loading from New Development (As assumed in HHPLS)			
Predicted in-lake TP (µg/L)			37
P load decrease needed to achieve 27 µg/L (lbs/year)			232

Lunsten Lake Goal = 70 µg/L	2000	2020	Ultimate Development
Scenario 1: No Regulatory Program			
Predicted in-lake TP (µg/L)		80	86
P load decrease needed to achieve 70 µg/L (lbs/year)			220
Scenario 2: Current Regulatory Program			
Predicted in-lake TP (µg/L)	80		73
P load decrease needed to achieve 70 µg/L (lbs/year)			36
Scenario 3: Regulatory Program That Prohibits A Net Increase in Loading from New Development (As assumed in HHPLS)			
Predicted in-lake TP (µg/L)			70
P load decrease needed to achieve 70 µg/L (lbs/year)			-

Parley Lake Goal = 50-60 µg/L	2000	2020	Ultimate Development
Scenario 1: No Regulatory Program			
Predicted in-lake TP (µg/L)		84	90
P load decrease needed to achieve 60 µg/L (lbs/year)			800
Scenario 2: Current Regulatory Program			
Predicted in-lake TP (µg/L)	85		82
P load decrease needed to achieve 60 µg/L (lbs/year)			575
Scenario 3: Regulatory Program That Prohibits A Net Increase in Loading from New Development (As assumed in HHPLS)			
Predicted in-lake TP (µg/L)			79
P load decrease needed to achieve 60 µg/L (lbs/year)			485

Halsteds Bay Goal = 50 µg/L	2000	2020	Ultimate Development
Scenario 1: No Regulatory Program			
Predicted in-lake TP (µg/L)		124	124
P load decrease needed to achieve 50 µg/L (lbs/year)			5,795
Scenario 2: Current Regulatory Program			
Predicted in-lake TP (µg/L)	122		109
P load decrease needed to achieve 50 µg/L (lbs/year)			4,370
Scenario 3: Regulatory Program That Prohibits A Net Increase in Loading from New Development (As assumed in HHPLS)			
Predicted in-lake TP (µg/L)			107
P load decrease needed to achieve 50 µg/L (lbs/year)			4,224

<u>Other Impacts.</u> The Six Mile Marsh subwatershed ecosystem faces varying threats from degradation as a result of development pressure, urbanization, and subsequent channelization of stream conveyances that go beyond impacts to water quality and hydrology. Development can directly or indirectly degrade and fragment habitat, and reduce or eliminate the opportunities for natural stormwater management provided by minimally disturbed grasslands, forests, woodlands, and wetlands.

The establishment of the connectivity between ecosystems will become increasingly difficult as development encroaches on the corridor. Currently about 10 percent of the subwatershed is urbanized, and about one-third agricultural. It is expected that about three-fourths the existing agricultural and one-half of the forested lands will be converted to low-density residential development by 2020. These conversions to large-lot development would likely create a patchwork of remnant woodland, grassland, and wetland. Many species require significant contiguous areas of habitat in which to hunt or brood. The fragmentation that would result from development would limit the ecological integrity of the entire area.

4.0 Resource Management Goals and Strategies

The following section presents the 17 watershed goals approved by the MCWD, measurable objectives, metrics and the specific goals and actions for the Six Mile Marsh subwatershed.

4.1 Abstraction/Filtration

MCWD Goal 1: Abstraction/Filtration. Promote abstraction and filtration of surface water where feasible for the purposes of improving water quality and increasing groundwater recharge throughout the watershed.

Discussion: Development and the associated creation of new impervious surface increases the volume of stormwater runoff. The new runoff volume can convey more pollutants to receiving waters and may increase erosion and sediment transport, negatively affecting water quality. Development also decreases the amount of stormwater that naturally percolates into the soil to recharge groundwater, thus reducing baseflow in streams, changing hydrology in groundwater-fed wetlands, and decreasing water availability in drinking water aquifers.

Abstraction of stormwater (retained on site through infiltration, evapotranspiration, or capture and reuse) reduces the amount of runoff from the site conveying pollutants. The most common type of abstraction, infiltration, reduces runoff, which helps recharge groundwater. Filtration offers an opportunity to use soil to naturally cleanse stormwater prior to discharge. Increased abstraction in the Six Mile Marsh subwatershed is desirable for three primary reasons: 1) to recharge groundwater inputs and reduce pollutant loading into the lakes and Six Mile Creek; 2) to help prevent localized flooding in landlocked basins with no natural outlet; and to protect the hydrology of the large discharge (groundwater-fed) wetlands in the subwatershed. Many of those wetlands are key resources with high ecological values that are dependant on groundwater to maintain those functions and values.

A key strategy to achieve this goal is the adoption of a volume management standard for new development and redevelopment that requires the abstraction of one inch of rainfall. Much of the subwatershed has at least moderate infiltration potential. Requiring new development and redevelopment to abstract some of the new stormwater generated would:

- Minimize additional pollutant loading that would have been conveyed by that stormwater; The phosphorus load reduction plans for the lakes in the subwatershed and for Halsteds Bay assumes that permitted new development and redevelopment will achieve a much higher rate of phosphorus load removal than can be achieved through traditional stormwater management such as detention ponds. Abstraction and infiltration are important tools in achieving the load reductions necessary to achieve water quality goals in those lakes, and to prevent further degradation of the other lakes, streams, and wetlands;

- Reduce runoff volumes and help reduce future downstream erosion in streams and channels or flooding in landlocked basins; and
- Help maintain groundwater levels, preserving wetland hydrology and groundwater flow to lakes and streams.

Desired Outcomes: Increased infiltration, reduction in pollutant loading and volumes of runoff to supplement other goals.

Metrics: Acre-feet of infiltration to meet nutrient loading reductions for water quality and volume reductions for water quantity goals.

Six Mile Marsh Goal 1.1: Increase abstraction and infiltration to reduce runoff volumes carrying pollutant loads and to promote groundwater recharge.

Action A. In consultation with LGUs through an appropriate rulemaking process, amend existing or establish new District rules to increase stormwater requirements through consideration of abstraction of the first one inch of rainfall on new permitted development and redevelopment.

Action B. Conduct a survey of the Six Mile Marsh subwatershed to identify areas suitable for regional infiltration areas.

Action C. Construct regional infiltration basins on a cooperative basis with LGUs where additional infiltration is desired.

Action D. Promote reforestation and revegetation with native plants to increase infiltration.

Action E. Develop infiltration strategies appropriate to wellhead protection areas and areas of groundwater sensitivity.

Action F. Provide technical assistance to LGUs and developers to foster low impact development and redevelopment that minimizes new impervious surface and provides for increased infiltration.

i. Develop and distribute model ordinances and design standards that incorporate low impact design principles.

ii. Sponsor educational opportunities for LGU staff, developers, elected and appointed officials and other interested parties to provide practical information and opportunities for sharing experiences.

iii. Provide education and training opportunities, technical and planning assistance for property owners and LGUs on methods to reduce runoff from and increase infiltration on their property by incorporating BMPs into landscaping, infrastructure maintenance, and reconstruction.

iv. Develop a small grant program to provide financial assistance to property owners desiring to retrofit their property with BMPs to increase infiltration.

4.2 Ecological Integrity

MCWD Goal 2: Ecological Integrity. Promote activities that maintain, support and enhance floral, faunal quantity and ecological integrity of upland and aquatic resources throughout the watershed.

Discussion: The Six Mile Marsh subwatershed is notable for its ecological resources and large tracts of park reserve and minimally developed area, including wetlands, forests, and grasslands. Some areas within the subwatershed are located in an MCWD, local or regional conservation corridor. There is potential to create ecological corridors through the watershed centered on the streams and wetland complexes through which they flow, connecting to high-value resources in the Carver Park Reserve.

Connected corridors are desirable as they provide a variety of habitats both aquatic and terrestrial as well as protected areas for passage. Within these conservation areas wherever possible the District would promote the preservation or establishment of native vegetation to increase or maintain infiltration rates; decrease or maintain runoff rates and pollutant conveyance to water resources; and minimize erosion of shorelines and streambanks. Sustaining or improving water quality and ecological integrity is necessary to meet the District goals in this plan as well as to meet state and federal nondegradation, water quality and biological integrity requirements and to prevent the need for future TMDLs.

The Six Mile Marsh subwatershed includes numerous wetlands with exceptional or high fish or wildlife habitat value as well as wetlands with exceptional or high vegetative diversity. The Key Conservation Areas identified in this plan (see Figure 19) include those wetlands as well as associated upland areas of high ecological value such as maple-basswood forest. Conservation of those associated upland areas not only provides additional habitat type, but also helps preserve local runoff and infiltration rates. The plan also identifies areas within the Carver Park Reserve as high-value resources, and coordination between the Three Rivers Park District, DNR, the MCWD, and other interested parties will be essential to protecting and improving those resources.

The fisheries in the subwatershed are generally actively managed by the DNR and Three Rivers Park District. There is little information on aquatic vegetation communities in the lakes, although it is known that Eurasian watermilfoil is present in most of the lakes. The ecological community in Six Mile Creek is limited by its hydrology, lack of habitat and large riparian wetlands. The primary strategies for improving aquatic communities are the acquisition of new data such as vegetation surveys and management plans, and improvement of water quality. The several wetlands in the subwatershed with exceptional or high vegetative diversity would be inspected at least annually for invasive vegetative species.

Desired Outcomes: Functional and healthy ecological corridors and waters throughout the subwatershed.

Metrics:
- Macroinvertebrate Index of Biotic Integrity (M-IBI) in Six Mile Creek
- Stream Visual Assessment Protocol (SVAP) in Six Mile Creek
- Acres of land conserved in Key Conservation Areas
- Linear feet and width of riparian areas protected in Key Conservation Areas
- Acres of restored/created wetland within Key Conservation Areas

Six Mile Marsh Goal 2.1: Maintain and improve overall ecological integrity within the subwatershed.

Action A. Continue Land Conservation Program efforts to proactively seek out conservation opportunities in areas identified in this plan as priority areas.

Action B. Protect existing fish and wildlife habitat and promote the development of additional habitat areas and corridors by the conservation and restoration of key ecological areas (see Figure 19).

i. Require LGUs to recognize District key conservation areas in their natural resources and land use planning and to identify in their Local Water Management plans how they intend to conserve their ecological values.

ii. Restore areas of degradation within key conservation areas.

iii. Provide education and training opportunities, technical and planning assistance, and financial incentives to LGUs to actively conserve key ecological areas.

Action C. Work cooperatively with other agencies and organizations to improve upon existing conservation corridors and where practical, develop new conservation corridors connecting wetlands within the Six Mile Marsh subwatershed of exceptional or high wetland functions and values and subwatershed stream corridors with areas that have been identified by others as having high local, county, regional, or national ecological significance.

Action D. Identify keystone, umbrella, and indicator species to serve as indicators of ecological integrity, evaluate existing habitat within the subwatershed, and develop strategies for the conservation of that habitat.

Action E. Provide regulatory incentives for the preservation of undisturbed native vegetation as sites develop.

Action F. Require MCWD review of preliminary plats and vegetation surveys so the District may comment on proposals and how they relate to District ecological integrity goals.

Action G. Require submittal of a Natural Resources Inventory and Conservation Plan as a condition of permit approval.

Six Mile Marsh Goal 2.2: Maintain conditions suitable for healthy and varied sport fish communities within the lakes.

Action A. Work cooperatively with the DNR and Three Rivers Park District in lake fishery management efforts, and request that fish surveys be conducted regularly.

Action B. Achieve lake water quality and clarity goals to maintain or improve habitat conditions.

Action C. Manage aquatic vegetation in accordance with vegetation management plans that take into account fishery habitat requirements.

Six Mile Marsh Goal 2.3: Maintain healthy aquatic vegetation communities.

Action A. Perform a baseline survey of aquatic vegetation in the lakes and update those surveys every five years.

Action B. Develop and implement aquatic vegetation management plans for the lakes that evaluate and implement options for the management of internal phosphorus loads as well as maintenance of a desirable aquatic vegetation community.

Action C. Recruit and train volunteers to monitor aquatic vegetation in the lakes on an ongoing basis, and work cooperatively with Three Rivers Park District on lakes within the park reserve.

Action D. Develop and implement a plan to monitor wetlands with exceptional or high vegetative diversity for presence of exotic vegetative species.

Six Mile Marsh Goal 2.4: Maintain conditions suitable for a healthy and varied biologic community in Six Mile Creek, given its natural limitations.

Action A. Reduce phosphorus and sediment in Six Mile Creek and minimize periods of low dissolved oxygen.

i. Implement the water quality improvement actions of this plan to reduce load discharged into the creek from the lakes and washed off from the watershed.

ii. Work cooperatively with riparian property owners to repair eroded streambanks.

iii. Implement the water quantity improvement actions of this plan to limit periods of erosive velocities in the creek.

Action B. Increase macroinvertebrate and fish habitat where feasible in Six Mile Creek to achieve M-IBI scores above the MPCA threshold for impairment and to achieve a Stream Visual Assessment Protocol mean score above 5.0.

i. Increase the variety of habitat features such as improved substrate, cobble and boulders, vegetated streambanks, root wads, and large woody debris.

Action C. Periodically update the Six Mile Creek stream assessment to assess current stream condition and ecological integrity.

Action D. Monitor macroinvertebrate community every 3 years.

Action E. Improve degraded stream reaches for the purposes of bank stabilization, reducing sediment loads, preserving existing stream courses, improving habitat, and enhancing biotic integrity.

Action F. Woody debris that falls in Six Mile Creek or other streams shall only be removed if it causes an obstruction to flow such that streambanks are destabilized or eroded or the creek is caused to overtop its banks. Such debris shall be removed by the District or by cooperative arrangement with the LGU at the owner's expense.

4.3 Water Quality

MCWD Goal 3. Water Quality. Preserve, maintain and improve aesthetic, physical, chemical and biological composition of surface waters and groundwater within the District.

<u>Discussion</u>: The HHPLS used an extensive public input process to establish water quality goals for the primary receiving waters in the District, focusing primarily on identifying target total phosphorus concentrations. In addition, two lakes in this subwatershed are currently undergoing development of a TMDL to reduce excess nutrient concentrations. This plan identifies those plus additional goals related to water quality. This plan sets forth a set of actions the District will undertake to reduce pollutant loading in the subwatershed and achieve and maintain water quality goals. The achievement of these water quality goals is not only necessary to meet state and federal water quality requirements and to prevent future TMDLs, but also to meet this plan's ecological integrity goals.

<u>Desired Outcomes</u>: Achievement of in-lake nutrient concentration goals through achievement of nutrient loading reductions.

<u>Metrics</u>:

- In-lake nutrient concentrations/Trophic State Index Scores (TSI) for Halsteds Bay and the lakes within the subwatershed
- Nutrient loading goals (lbs) for Halsteds Bay and the lakes within the subwatershed

<u>Six Mile Marsh Goal 3.1:</u> Achieve in-lake total phosphorus concentration goals as identified in this plan and the lake TMDLs.

Action A. Conduct a diagnostic study of internal or unknown lake phosphorus loading in Stone Lake and on East and West Auburn Lakes, prepare a feasibility study, and implement improvements to reduce internal or unknown loading by at least 70 percent.

Action B. Consider amending existing or establishing new District rules requiring greater than 50 percent phosphorus removal on new permitted developments within the Six Mile Marsh subwatershed.

Action C. Provide assistance to LGUs and developers to foster low impact development and redevelopment that minimizes new phosphorus and sediment loading.

i. Develop and distribute model ordinances and design standards that incorporate low impact design principles.

ii. Sponsor educational opportunities for LGU staff, developers, elected and appointed officials and other interested parties to provide practical information and opportunities for sharing experiences.

Action D. Promote the general application of BMPs across the subwatershed.

i. Consider developing a small grant program to provide financial assistance to property owners desiring to retrofit their property with BMPs to reduce phosphorus and sediment loading.

Action E. Continue regular water quality monitoring in the lakes to assess progress toward achieving the in-lake phosphorus goals.

Action F. Require LGUs to maintain or reduce phosphorus loading from developed uses as set forth in Section 5.6.1 of this plan within 10 years.

i. Provide education and training opportunities, technical and planning assistance for property owners and LGUs on methods to reduce phosphorus and sediment loading by incorporating BMPs into landscaping, infrastructure maintenance, and reconstruction.

Six Mile Marsh Goal 3.2: Achieve and maintain other state lake water quality standards including >1.4 m Secchi clarity and 14 ug/L chl-a for deep lakes, and >1.0 m Secchi clarity and 20 ug/L chl-a for shallow lakes.

Action A. Achieve and maintain in-lake total phosphorus goals.

Action B. Manage aquatic vegetation in accordance with vegetation management plans that take into account water clarity goals.

Action C. Develop a water quality index which encompasses the District's broader definition of water quality.

Six Mile Marsh Goal 3.3: Prevent degradation of existing water quality in Carl Krey, Church, Turbid, and Mud Lakes.

Action A. Obtain baseline water quality data for Carl Krey, Church, Turbid, and Mud Lakes and update every three to five years.

Six Mile Marsh Goal 3.4: Minimize pollutant loading contribution to Halsteds Bay from Six Mile Creek.

Action A. Inspect known erosion-prone areas of Six Mile Creek at least annually to assess its condition, and the entire creek at least every five years.

Action B. Repair identified erosion locations in Six Mile Creek and develop strategies to prevent future erosion and sediment transport.

Action C. Continue to investigate possible causes of periodic low dissolved oxygen in Six Mile Creek and develop strategies to minimize periods of low dissolved oxygen.

Action D. Continue to monitor water quality in Six Mile Creek.

4.4 Public Health

MCWD Goal 4. Public Health. Minimize the risks of threats to public health through the development of programs, plans and policies that improve the quality of surface and groundwater resources.

Discussion: There are several potential threats to public health in the Six Mile Marsh subwatershed. Much of the subwatershed is outside the Municipal Urban Services Area (MUSA), and property owners use individual sewage treatment systems for their sanitary service. Agricultural and animal husbandry land uses generate and use animal waste that if improperly managed could be a source of pathogens. Where sewer service is available, sewage overflows from sanitary sewer breaks or improperly functioning infrastructure could result in overflows discharged to downstream water resources. An additional potential source of pathogens is waterfowl, which are attracted to open water with easy routes from the water to vegetation on shore. The District's role in minimizing the threats to public health in the Six Mile Marsh subwatershed is mainly to provide targeted information to landowners and LGUs.

Desired Outcomes: Minimization of threats to public health from contact with contaminated surface waters.

Metrics: Reported cases of illness transmission via surface water contact.

Six Mile Marsh Goal 4.1: Minimize risks to human health and water quality from land use activities.

Action A. Develop and implement a plan to systematically identify manure management and individual sewage treatment system locations in the subwatershed and assess the risks to human health and water quality

Action B. Work cooperatively with the state, University of Minnesota Extension Service, Hennepin and Carver Counties and LGUs to provide animal waste management information and technical assistance to landowners engaged in plant and animal agriculture or husbandry.

Action C. Work cooperatively with the state, Hennepin and Carver Counties and LGUs to provide BMP information and technical assistance to individual sewage treatment system owners.

Six Mile Marsh Goal 4.2: Maintain vegetated shorelines on the lakes where practical and effective to reduce overpopulation of the lakes with waterfowl.

Action A. Conduct shoreline vegetation surveys to identify current shoreline status and to identify locations where restoration may be desirable and feasible.

Action B. Promote native vegetation over structural shoreline stabilization where appropriate in District policies, regulations, and programs.

Action C. Work cooperatively with LGUs and property owners to restore native shoreline vegetation where appropriate.

i. Provide education and training opportunities, technical and planning assistance, and demonstration project funding to LGUs to assist them in restoring shorelines and buffers on public property such as parks and open spaces, taking into consideration the balance between recreational use and ecosystem needs.

ii. Develop and distribute written material to shoreline property owners explaining the benefits of shoreline restoration and buffer creation to waterfowl control and providing design, plant selection, installation, and maintenance advice.

Six Mile Marsh Goal 4.3: Require LGUs and other agencies to manage public sanitary sewer infrastructure to minimize sewage overflows and to minimize impacts from those overflows on District water resources.

4.5 Water Quantity

MCWD Goal 5. Water Quantity. Maintain or reduce existing flows from drainage within the watershed to decrease the negative effects of stormwater runoff and bounce from existing and proposed development as well as provide low flow augmentation to surface waters.

Discussion: Development and the associated creation of new impervious surface increases the volume of stormwater runoff, changes the rates and times to peak runoff flow, and decreases the amount of stormwater that naturally percolates into the soil to recharge groundwater. The District's long term goal in the Six Mile Marsh subwatershed is to achieve no increase in the volume of stormwater discharged from the subwatershed into the lake. Implementation strategies will include minimizing new runoff volumes from development, encouraging infiltration and groundwater recharge to maintain baseflow in Six Mile Creek and adequate hydrology to groundwater-fed wetlands, and limiting new volumes in landlocked subwatersheds.

A key strategy to achieve this goal is the adoption of a volume management standard for new development and redevelopment that requires the abstraction (removal from runoff through infiltration, capture and reuse, evapotranspiration, etc.) of one inch of rainfall. Approximately 70 percent of annual runoff volume in Minnesota results from precipitation events of 1" or less (MPCA, 2000). Requiring new development and redevelopment to abstract (retain on site through infiltration, evapotranspiration, or capture and reuse) runoff from that size event would significantly reduce new volumes of runoff flowing downstream and help reduce future erosion in streams and channels; minimize new pollutant loading that would have been conveyed by that stormwater; and help maintain groundwater levels, preserving wetlands.

Limiting discharges from subwatersheds and basins that are currently landlocked is necessary to prevent further degradation of downstream water quality as well as to limit new volumes discharged downstream to channels that are already experiencing erosion. Encouraging infiltration in landlocked basins is one means of controlling runoff volumes to help prevent localized flooding.

The additional new volume could be mitigated through construction of regional infiltration basins, restoring drained wetlands, reforestation and revegetation, or other means.

Table 11. Modeled annual volume of runoff in the Six Mile Marsh subwatershed, and estimated reductions resulting from application of a proposed 1" abstraction rule for new development and redevelopment (acre-feet).

2000 modeled annual subwatershed runoff volume	4,158
2020 modeled annual subwatershed runoff volume	4,822
Ultimate Development modeled annual subwatershed runoff volume	5,242
Increase between 2000 and Ultimate Development	1,084
Estimated volume abstracted by 1" rule	758
New volume to be abstracted through other means such as capital projects, wetland restorations, reforestation and revegetation, etc.	326

<u>*Desired Outcomes*</u>: Management of water volumes discharged from the subwatershed.

<u>*Metrics*</u>: Acre-feet volume abstraction.

<u>Six Mile Marsh Goal 5.1:</u> Reduce volume of stormwater runoff from new development and redevelopment and maintain or reduce existing water volumes discharged from the subwatershed into Halsteds Bay.

Action A. Amend existing or establish new District rules requiring abstraction of the first one inch of rainfall on new permitted development and redevelopment.

Action B. Track volumes abstracted and new volumes created resulting from permitted development.

Action C. Provide assistance to LGUs and developers to foster low impact development and redevelopment that minimizes new stormwater volumes.

i. Develop and distribute model ordinances and design standards that incorporate low impact design principles.

ii. Sponsor educational opportunities for LGU staff, developers, elected and appointed officials and other interested parties to provide practical information and opportunities for sharing experiences.

Action D. Encourage the development and maintenance of depressional storage within the subwatershed.

Six Mile Marsh Goal 5.2: Manage water volumes conveyed to Six Mile Creek to prevent further erosion.

Action A. Work cooperatively with the Three Rivers Park District to evaluate and implement strategies for operating outlet control structures in the Carver Park Reserve to maximize storage capacity and manage flows.

Action B. Inspect known erosion-prone areas of Six Mile Creek at least annually to assess its condition, and the entire Creek at least every five years.

Action C. Repair identified erosion locations in Six Mile Creek and develop strategies to reduce volumes as necessary.

Action D. Continue to monitor flows in Six Mile Creek.

Six Mile Marsh Goal 5.3: Limit new discharges from land locked basins and subbasins to prevent new impacts to downstream lakes.

Action A. Require the LGUs to continue to manage SMC-10, 16, 19, 38, and 39, as well as other basins without outlets as landlocked basins unless they can demonstrate that providing outlets would not negatively impact downstream water resources (see Figure 2 for landlocked basin locations).

Six Mile Marsh Goal 5.4: Require public stormwater conveyance and control structures in the watershed be sized and maintained properly to convey current and ultimate stormwater flows to minimize flooding and erosion potential.

Action A. Require LGUs to provide to the District a copy of their annual NPDES report.

4.6 Shorelines and Streambanks

MCWD Goal 6. Shorelines and Streambanks. Preserve the natural appearance of shoreline areas and minimize degradation of surface water quality which can result from dredging operations.

Discussion: Eroding shorelines and streambanks contribute to the degradation of water quality. Native vegetation can effectively stabilize these areas, filter runoff for sediment and other pollutants, and provide habitat. Restoration of shoreline and streambanks on the lakes, Six Mile Creek, and wetlands within the subwatershed is a key strategy for meeting this plan's goals.

The key areas identified in this plan for conservation activities include buffer zones adjacent to streams and channels. In some cases these buffer zones are riparian or flow-through wetlands, and those wetlands have been identified as key conservation areas. Where streams and channels flow through upland areas, conservation of native vegetation within these zones would also increase or maintain infiltration rates; decrease or maintain runoff rates and pollutant conveyance to water resources; and help minimize erosion. Restoration of lakeshore would have the same benefits. Sustaining or improving water quality and ecological integrity is necessary to meet District goals as well as to meet state and federal nondegradation, water quality and biological integrity requirements and to prevent the need for future TMDLs.

Desired Outcomes: Stable streambanks and shorelines to supplement other goals.

Metrics:

- Stream Visual Assessment Protocol (SVAP) in Six Mile Creek
- Linear feet of stabilized eroded shoreline and streambank
- Linear feet of shoreline and streambank protected in Key Conservation areas
- Linear feet and width of riparian areas protected in Key Conservation Areas

Six Mile Marsh Goal 6.1: Promote shoreline restoration and shoreline buffer creation as methods to help meet pollutant loading reduction and ecological integrity goals.

Action A. Restore degraded streambanks on Six Mile Creek to achieve a Stream Visual Assessment Protocol mean score above 5.0 and on other streams to stabilize streambanks; reduce pollutant loading, erosion and sediment transport; and increase habitat. Figure 20 illustrates areas of high priority for improvement because of bank failure as identified in the *Upper Watershed Stream Assessment* or in the lakes TMDLs.

Action B. Periodically update the Six Mile Creek stream assessment to assess current stream condition and ecological integrity.

Action C. Promote native vegetation over structural shoreline stabilization in District policies, regulations, and programs.

i. Provide education and training opportunities, technical and planning assistance, and demonstration project funding to LGUs to assist them in restoring shorelines and buffers on public property such as parks and open spaces.

ii. Develop and distribute written material to shoreline property owners explaining the benefits of shoreline restoration and buffer creation to the reduction of pollutant loads and creation of shoreline habitat and providing design, plant selection, installation, and maintenance advice.

iii. Develop a small grant program to provide financial assistance to property owners desiring to restore their shoreline or plant a buffer.

4.7 Navigation

MCWD Goal 7. Navigation. Maintain the hydraulic capacity of and minimize obstruction to navigation without compromising wildlife habitat in watercourses and preserve water quality and navigation appearance in shoreland areas.

Discussion: The District recognizes the riparian rights of property owners to have and maintain access to public waters. The District will not participate in the removal of nuisance aquatic vegetation solely for the purpose of improving navigation, but may consider macrophyte control where excessive growth contributes to poor water quality.

Desired Outcomes: Minimization of impacts on water resources from dredging.

Metrics: Compliance with the dredging policy.

Six Mile Marsh Goal 7.1: Manage dredging activities so as to preserve the natural appearance of shoreline areas; recreational, wildlife and fisheries resources of surface waters; surface water quality and ecological integrity of the riparian environment.

Action A. Regulate dredging activities in a manner consistent with local policy and Minnesota Rules Chapter 6115.0200

4.8 Best Management Practices

MCWD Goal 8. Best Management Practices. Improve water quality by promoting best management practices (BMPs), requiring their adoption in local plans and their implementation on development sites.

Discussion: This plan and District regulations stipulate the use of Best Management Practices (BMPs) to reduce stormwater volumes and pollutant loadings, but do not prescribe which practices should be used. This allows the LGU and developers the flexibility to implement those that are most appropriate for local conditions and opportunities. A key strategy for plan implementation is providing early consultation with and technical assistance to and education of stakeholders including city staff, residents, and developers to increase knowledge and acceptance of various BMPs and to promote their adoption.

Desired Outcomes: Implementation of Best Management Practices on private and public property to supplement other goals.

Metrics: Compliance with the early consultation requirement.

Six Mile Marsh Goal 8.1: Promote best management practices as methods to help meet pollutant loading and volume management goals established in this subwatershed plan.

Action B. Require LGUs to identify in their local water management plans how they plan to minimize pollutant loading and stormwater volumes from developed uses through the implementation of BMPs in the subwatershed.

i. Provide education and training opportunities, technical and planning assistance for LGUs on methods to reduce phosphorus and sediment loading by incorporating BMPs into landscaping, infrastructure maintenance, and reconstruction.

Action B. To promote BMPs and encourage early consultation by developers, amend District rules to incorporate a requirement for stormwater management plan approval prior to submittal of a preliminary plat.

Action C. Develop and distribute model ordinances and design standards that illustrate the proper application of various BMPs.

4.9 Education and Communications

MCWD Goal 9. Education and Communications. Enhance public participation and knowledge regarding District activities and provide informational and educational material to municipalities, community groups, businesses, schools, developers, contractors and individuals.

Discussion: The District conducts an active and strategic education and communication program watershed-wide to provide general information and to various stakeholder groups in accordance with its five-year strategic education and outreach plan. Targeted information will be necessary in the Six Mile Marsh subwatershed to educate these stakeholders as to the District's specific goals for this subwatershed, the actions the District plans to take, and their role in conserving water resources in the subwatershed. The specific targeted messages will emphasize conservation of the wide range of high-value resources in the subwatershed and developer education targeting Better Site Design, infiltration, and conservation of undisturbed native vegetation as sites develop.

Desired Outcomes: Stewardship over water resources by residents of the subwatershed to assist District activities and supplement other goals.

Metrics: Telephone Survey.

<u>Six Mile Marsh Goal 9.1:</u> Provide focused education and outreach opportunities within this subwatershed to supplement the general education and outreach program and assist in the achievement of these subwatershed goals.

Action A. Develop and distribute targeted written material to stakeholder groups (e.g., residents, shoreline property owners agricultural property owners, developers) explaining the need for natural resource conservation and low impact development approaches to reduce phosphorus and other pollutant loading and providing strategies that each stakeholder group can employ to assist in meeting this goal.

Action B. Sponsor educational opportunities for LGU staff, developers, elected and appointed officials and other interested parties to provide practical information and opportunities for sharing experiences.

Action C. Prepare and distribute timely news releases to coincide with education efforts to inform the public of BMPs and other District actions that affect them directly.

<u>Six Mile Marsh Goal 9.2:</u> Provide participation and outreach activities to increase awareness of water and other natural resources within the subwatershed

Action A. Promote the development of lake associations where none now exist, and identify and work cooperatively with existing associations.

Action B. Recruit and train volunteers to monitor aquatic vegetation on the lakes on an ongoing basis.

<u>Six Mile Marsh Goal 9.3:</u> Work cooperatively with other agencies and groups to coordinate education and outreach efforts to avoid duplication of efforts and maximize resources.

4.10 Ditches

MCWD Goal 10. Public Ditches. Maintain public ditch systems within the District as required under Statutory jurisdiction.

<u>Discussion</u>: The public ditch within this subwatershed continues to perform the function for which it was originally established – to drain lands for the promotion of agriculture and protection of public health. The Board will continue to maintain jurisdiction over Judicial Ditch #2.

<u>Desired Outcomes</u>: Manage public ditches to maintain drainage and preserve natural features.

<u>Metrics</u>: Stream Visual Assessment Protocol (SVAP) in Six Mile Creek.

Six Mile Marsh Goal 10.1: Manage Judicial Ditch #2 in accordance with statutory rights and responsibilities.

Action A. Conduct periodic inspections and perform maintenance as required.
Action B. Manage the ditch portion of Six Mile Creek in accordance with the other goals of this plan.

4.11 Wetlands

MCWD Goal 11. Wetlands. Preserve, create and restore wetland resources and maximize the benefits and functionality of wetlands to the watershed.

Discussion: The *Functional Assessment of Wetlands* (FAW) evaluated 4,468 acres of wetlands in the Six Mile Marsh subwatershed, of which 332 acres were in the Preserve classification. There are numerous wetlands of exceptional and high quality functions and values within this subwatershed. Their conservation is integral to achieving ecological integrity goals, as well as water quality, stormwater management, and floodplain management goals. There are also opportunities for wetland restoration.

A key strategy of this plan is regulation of wetland impacts in accordance with a management classification based on the functions and values findings of the *Functional Assessment of Wetlands.* Wetlands are assigned to a classification – either Preserve or Manage 1, 2, or 3 – and allowable impacts would be based on that classification. The wetlands with the highest values – those in the Preserve classification – would be allowed minimal impacts. The Manage classifications would be allowed some impacts, such as accepting new stormwater discharges, depending on classification. This strategy will preserve existing high values such as habitat, vegetative diversity, and sensitivity, while also recognizing that wetlands play an important part in managing stormwater. Wetlands provide essential storm and flood water storage.

Wetlands of exceptional or high vegetative diversity or fish or wildlife habitat value have been designated key conservation areas (see Figure 19), as have wetlands that are riparian to streams or channels, have high restoration potential, provide key floodplain storage, or are located in important natural resources conservation areas such as wildlife corridors. Except for those in the Preserve classification, which will be managed to an even higher standard, these conservation wetlands will be managed as if they were Manage 1 classification wetlands, with limitations on the amount of new runoff that can be directed to them, and a requirement to pretreat any new discharges to them.

An important part of achieving the goal of no net loss of wetland size, quality, and type will be tracking wetland impacts to assist in identifying future restoration or wetland creation needs.

Equally important to the regulation of wetlands is the restoration of degraded wetlands within the subwatershed. Figure 14 identifies wetlands based on restoration potential. Restoring wetlands increases specific functions and values of the resource within the watershed ranging from management of flows to water quality improvement to enhancement of the overall ecosystem, particularly within identified corridors.

Desired Outcomes: Maintain existing quantity and quality of wetlands throughout subwatershed; improve wetland and surface water quality within Key Conservation Areas.

Metrics:

- Wetland quantity (acres)
- Wetland quality (acres/management classification)
- Acres of restored/created wetland within Key Conservation Areas

Six Mile Marsh Goal 11.1: Maintain existing acreage of wetlands in the subwatershed and achieve no net loss in their size, quality, type, and biological diversity.

Action A. Regulate wetland impacts commensurate with the quality of the wetland as determined by the Management Classifications identified in the *Functional Assessment of Wetlands* (FAW).

Action B. In consultation with LGUs through an appropriate rulemaking process, amend existing or establish new District rules requiring mitigation of all fill in Preserve category wetlands; and specifying by management classification stormwater discharge pretreatment, buffer, hydroperiod, and other wetland standards.

Action C. Require that wetland losses be mitigated within the lakeshed in which they occur.

Action D. Track wetland losses resulting from permitted fill.

Action E. Restore degraded wetlands in Key Conservation Areas to improve vegetative diversity and ecological integrity, with priority given to wetlands where restoration could improve management classification to at least a Manage 1. Restore other wetlands as opportunities arise.

Action F. Restore vegetative diversity and ecological integrity of all wetlands in which the District acquires an interest.

Action G. Update the *Functional Assessment of Wetlands* to maintain a current inventory of wetland location, size as well as function and value.

Six Mile Marsh Goal 11.2: Increase the quantity, quality, and biological diversity of Six Mile Marsh subwatershed wetlands through the restoration of impacted wetlands.

Action A. Evaluate potential locations for future wetland restoration, including wetland complexes between Turbid and Lunsten Lakes and wetlands west of Parley Lake as identified in the Parley Lake TMDL (see Figure 20).

Action B. Restore other hydrologically impacted wetlands in Key Conservation Areas determined in the FAW to be “restorable,” where restoration could improve vegetative diversity and ecological integrity.

4.12 Groundwater

Watershed Goal 12. Groundwater. Protect and maintain existing groundwater flow, promote groundwater recharge and improve groundwater quality and aquifer protection.

Discussion: Maintenance of groundwater recharge is important in the Six Mile Marsh subwatershed to maintain hydrology to the groundwater-fed discharge or combination wetlands as well as to recharge aquifers that supply public and private water wells. Development, with the associated creation of new impervious surface, increases the volume of stormwater runoff and reduces the amount of stormwater that naturally percolates into the soil to recharge groundwater. Increased infiltration in the Six Mile Marsh subwatershed is desirable for three primary reasons: 1) to recharge groundwater inputs and reduce pollutant loading into the lakes and streams; 2) to help prevent localized flooding in landlocked basins with no natural outlet; and 3) to protect the hydrology of discharge (groundwater-fed) wetlands in the subwatershed. Some of those wetlands are key resources with high ecological values that are dependant on groundwater to maintain those functions and values. Much of the subwatershed has at least moderate infiltration potential. Requiring new development and redevelopment to infiltrate some of the new stormwater generated would reduce new volumes downstream and help reduce future erosion in streams and channels; minimize new pollutant loading that would have been conveyed by that stormwater; and help maintain groundwater levels, preserving wetlands.

Some parts of the subwatershed are areas of aquifer sensitivity or area may be designated in the future as drinking water wellhead protection areas, where care should be taken when infiltrating stormwater. Proper design of infiltration practices is necessary to avoid groundwater contamination.

Groundwater management in the Six Mile Marsh subwatershed will focus on increasing the amount of infiltration in the subwatershed, and minimizing opportunity for groundwater contamination from land use practices.

Desired Outcomes: Maintain function of existing groundwater flow, assist in the protection of drinking water supply, no degradation in surficial groundwater quantity or quality.

Metrics:

- Acre-feet volume abstraction
- Surficial groundwater levels and parameters

Six Mile Marsh Goal 12.1: Protect and maintain groundwater recharge and groundwater quality.

Action A. Amending existing or establish new District rules requiring abstraction of the first one inch of rainfall on new permitted development and redevelopment.

Action B. Establish new District rule requiring an additional level of analysis and review of permitted development and redevelopment where there is a potential to adversely impact groundwater connected to a surface water feature.

Action C. Require pretreatment of stormwater discharged to wetlands or infiltration areas in the in the areas of high aquifer sensitivity.

Action D. Coordinate stormwater and groundwater management within identified drinking water management areas and wellhead protection areas with city and private wellhead protection plans.

Action E. Develop infiltration strategies appropriate to wellhead protection areas and areas of groundwater sensitivity.

Action F. Work cooperatively with Hennepin and Carver Counties, the Minnesota Department of Health, and other agencies charged with managing individual sewage treatment systems and private and public groundwater wells to assess the potential impacts of surface water management practices on groundwater quality.

Action G. Provide assistance to LGUs and developers to foster low impact development and redevelopment that minimizes new impervious surface and provides for increased infiltration.

i. Develop and distribute model ordinances and design standards that incorporate low impact design principles.

ii. Sponsor educational opportunities for LGU staff, developers, elected and appointed officials and other interested parties to provide practical information and opportunities for sharing experiences.

Action H. Require developers to identify existing drain tile lines on property proposed for development.

Action I. Identify a network of surficial aquifer monitoring wells across the entire Minnehaha Creek watershed, monitor groundwater levels and groundwater quality, and if change is detected identify strategies for addressing that change.

<u>Six Mile Marsh Goal 12.2:</u> Protect and maintain groundwater flow.

Action A. Identify base level flow in Six Mile Creek, monitor for trends, and if change is suspected identify strategies for addressing that change.

Action B. Monitor tamarack swamps in the Carver Park Reserve and other groundwater-dependant resources to determine trends, and if change is suspected identify strategies for addressing that change.

4.13 Floodplains

Watershed Goal 13. Floodplains. Reduce the severity and frequency of flooding and high water by preserving and increasing the existing water storage capacity below 100-year flood elevations on all waterbodies within MCWD.

Discussion: The primary strategy in the management of stormwater and prevention of flooding in the Six Mile Marsh subwatershed is the preservation of the stormwater storage. Key areas identified in this plan for conservation include wetlands that provide floodplain storage and areas that provide channel and stream floodplain and riparian zones.

Desired Outcomes: No net loss of floodplain storage.

Metrics: Acres net floodplain fill.

Six Mile Marsh Goal 13.1: Preserve the existing water storage capacity below the 100-year event elevation.

Action A. Minimize development below the 100-year event elevation.

Action B. No net loss of the large wetland complexes that provide substantial stormwater storage throughout this subwatershed.

Action C. Work cooperatively with the Three Rivers Park District to evaluate and implement strategies for operating outlet control structures in the Carver Park Reserve to maximize storage capacity and manage flows.

Action D. Encourage the development and maintenance of depressional storage within the subwatershed.

i. Promote the acceptability of minor flooding within the floodplain.

Six Mile Marsh Goal 13.2: Utilize District hydrologic and hydraulic data to identify potential public infrastructure high water impacts.

Action A. The HHPLS noted that the 100-year water level was expected to overtop a number of public roads and private driveways. Work together with the respective communities to determine specific impacts and potential improvements.

4.14 Recreation

Watershed Goal 14. Recreation. Promote the recreational use, where appropriate, of surface waters within MCWD by providing recreation opportunities for citizens by promoting the use and enjoyment of water resources with the intent of increasing the livability and quality of life within the watershed.

Discussion: The lakes are the primary recreational water resource in this subwatershed, although Six Mile Creek and wetlands provide aesthetic enjoyment, wildlife viewing, and other recreational values. There are several public lake accesses and fishing piers as well as a beach on West Lake Auburn. District and local efforts to improve ecological integrity and conserve corridors will enhance those aesthetic and recreational values across the subwatershed. The District's primary strategies in promoting and supporting recreational use of the lakes is improving water quality and managing aquatic vegetation.

Desired Outcomes: Manage surfaces waters to achieve water quality goals so designated use is maintained and unimpaired.

Metrics:

- In-lake nutrient concentrations/Trophic State Index Scores (TSI) for Halsteds Bay and the lakes in the subwatershed
- Nutrient loading goals (lbs) for Halsteds Bay and the lakes of the subwatershed
- Macroinvertebrate Index of Biotic Integrity (M-IBI) in Six Mile Creek
- Stream Visual Assessment Protocol (SVAP) in Six Mile Creek

Six Mile Marsh Goal 14.1: Support recreational use of lakes in the subwatershed by achieving the District's summer mean total phosphorus and other water quality goals through the implementation of the programs and projects identified in this plan to reduce phosphorus loads and improve lake water quality.

Six Mile Marsh Goal 14.2: Support the fisheries through the implementation of the programs and projects identified in this plan to maintain ecological integrity and promote shoreline restoration.

4.15 Erosion Control

Watershed Goal 15. Erosion Control. Control temporary sources of sediment resulting from land disturbance and identify, minimize and correct the effects of sedimentation from erosion-prone and sediment source areas.

Discussion: Erosion within the subwatershed can result in sediment being transported to lakes, wetlands, and streams, where it can degrade water quality and habitat. Sediment accumulating in channels, culverts, and other facilities can reduce their ability to convey stormwater, while erosion can undermine their stability.

The key areas identified in this plan for conservation activities include buffer zones adjacent to streams and channels. In some cases these buffer zones are riparian or flow-through wetlands, and those wetlands have been identified as key conservation areas (see Figure 19). Where streams and channels flow through upland areas, conservation of native vegetation within these zones would also increase or maintain infiltration rates; decrease or maintain runoff rates and pollutant conveyance to water resources; and help minimize erosion. Restoration of lakeshore would have the same benefits. Identifying, addressing, and preventing erosion is necessary to meet District goals as well as to meet state and federal nondegradation, water quality and biological integrity requirements and to prevent the need for future TMDLs.

Requiring new development and redevelopment to infiltrate some of the new stormwater generated would reduce post-development volumes downstream and help reduce future erosion in streams and channels; minimize new pollutant loading that would have been conveyed by that stormwater; and help maintain groundwater levels, preserving wetlands. Limiting discharges from subwatersheds and basins that are currently landlocked is necessary to prevent further degradation of downstream water quality as well as to limit new volumes discharged to channels that are already experiencing erosion.

The *Upper Watershed Stream Assessment* identified several localized areas of erosion on Six Mile Creek. Other streams and channels within the subwatershed may currently be experiencing erosion or may develop erosion problems as development in the upper subwatershed increases the amount of impervious surface and stormwater runoff. Strategies in the Six Mile Marsh subwatershed will focus on identifying erosion problems on an ongoing basis and working with LGUs to correct them, as well as considering potential downstream impacts of new volumes discharged from development.

Desired Outcomes: Reduction in pollutant loading of temporary and permanent nature from erosion to supplement other goals.

Metrics:

- In-lake nutrient concentrations/Trophic State Index Scores (TSI) for Halsteds Bay and the lakes in the subwatershed
- Nutrient loading goals (lbs) for Halsteds Bay and the lakes in the subwatershed
- Macroinvertebrate Index of Biotic Integrity (M-IBI) in Six Mile Creek
- Stream Visual Assessment Protocol (SVAP) in Six Mile Creek

Six Mile Marsh Goal 15.1: Identify and address erosion problems in the subwatershed.

Action A. Identify, inventory, and prioritize gully, channel, shoreline and other erosion problems in addition to those already identified in the HHPLS and *Upper Watershed Stream Assessment*.

Action B. The HHPLS modeled higher than desirable velocities at several culverts that could lead to inlet or outlet erosion. Work cooperatively with the respective cities, Carver County, and Three Rivers Park District to evaluate the need to provide erosion control or take energy dissipation measures at these crossing to prevent erosion and downstream sediment transport.

Action C. Restore degraded streambanks on Six Mile Creek to achieve a Stream Visual Assessment Protocol mean score above 5.0 and other on streams to stabilize streambanks; reduce pollutant loading, erosion and sediment transport; and increase habitat. Figure 20 illustrates areas identified in the *Stream Assessment* and the lakes TMDLs as high priorities for restoration.

i. Periodically update the Six Mile Creek stream assessment to assess current stream condition and ecological integrity.

Action D. Spot repair identified erosion locations in Six Mile Creek and develop strategies to prevent future erosion and sediment transport.

Action E. Regulate new development and redevelopment and ensure compliance with erosion control standards.

<u>Six Mile Marsh Goal 15.2:</u> Manage water volumes to Six Mile Creek to prevent further erosion.

Action A. Implement the regulatory and management actions identified in this plan.

Action B. Inspect erosion-prone areas of Six Mile Creek periodically to assess their condition.

Action C. Work cooperatively with the adjacent property owners and LGUs to prevent erosion and sediment transport and stabilize streambanks as necessary.

4.16 Regulation

Watershed Goal 16. Regulation. Promote effective planning to minimize the impact of development and land use change on water resources as well as achieve watershed District Goals.

<u>*Discussion*</u>*:* The District's regulatory program is the means by which many of the goals enumerated here would be accomplished. As development and redevelopment occurs, property owners and developers are required to treat and control stormwater, limit impacts to wetlands, and meet other standards. Additional regulation may be necessary in the Six Mile Marsh subwatershed to implement the actions in this Plan.

<u>*Desired Outcomes*</u>: Utilize regulatory program to cost-effectively manage land use to achieve other goals.

<u>*Metrics*</u>:

- Acre-feet volume abstraction
- In-lake nutrient concentrations/Trophic State Index Scores (TSI) for Halsteds Bay and the lakes in the subwatershed
- Nutrient loading goals (lbs) for Halsteds Bay and the lakes in the subwatershed
- Wetland quantity (acres)

<u>Six Mile Marsh Goal 16.1:</u> In consultation with LGUs through an appropriate rulemaking process, amend existing or adopt new rules to implement the actions identified here within two years of adoption of this plan.

Action A. Amend District rules as set forth in this Plan within two years of adoption of this plan.

Action B. Provide technical assistance to LGUs in the implementation of existing or new rules.

i. Develop and distribute model ordinances and design standards that could be used to implement existing or new rules.

ii. Sponsor educational opportunities for LGU staff, developers, elected and appointed officials and other interested parties to provide practical information and opportunities for sharing experiences.

iii. Promote "Conservation Ordinances" related to low-impact development, tree-preservation, open space preservation, etc.

4.17 Public Involvement

Watershed Goal 17. Public Involvement. Solicit input from the general public with the intent that policies, projects and programs will address local community values and goals as well as protect historic and cultural values regarding water resources; strive to manage expectations; base decisions on an educated public; foster an educated and informed public within the watershed.

Discussion: The District has good working relationships with the LGUs within the watershed, and maintains a Citizens Advisory Committee to obtain regular public input on issues of concern to the District and its citizens. As the District implements the actions identified in this plan, including the education and communication actions described above, it will be important to obtain direct input from water resource users. The primary strategies for the subwatershed will be fostering the development of lake associations where there are none, working cooperatively with existing associations, and continuing to work cooperatively with Three River Park District on issues of mutual concern within the Carver Park Reserve.

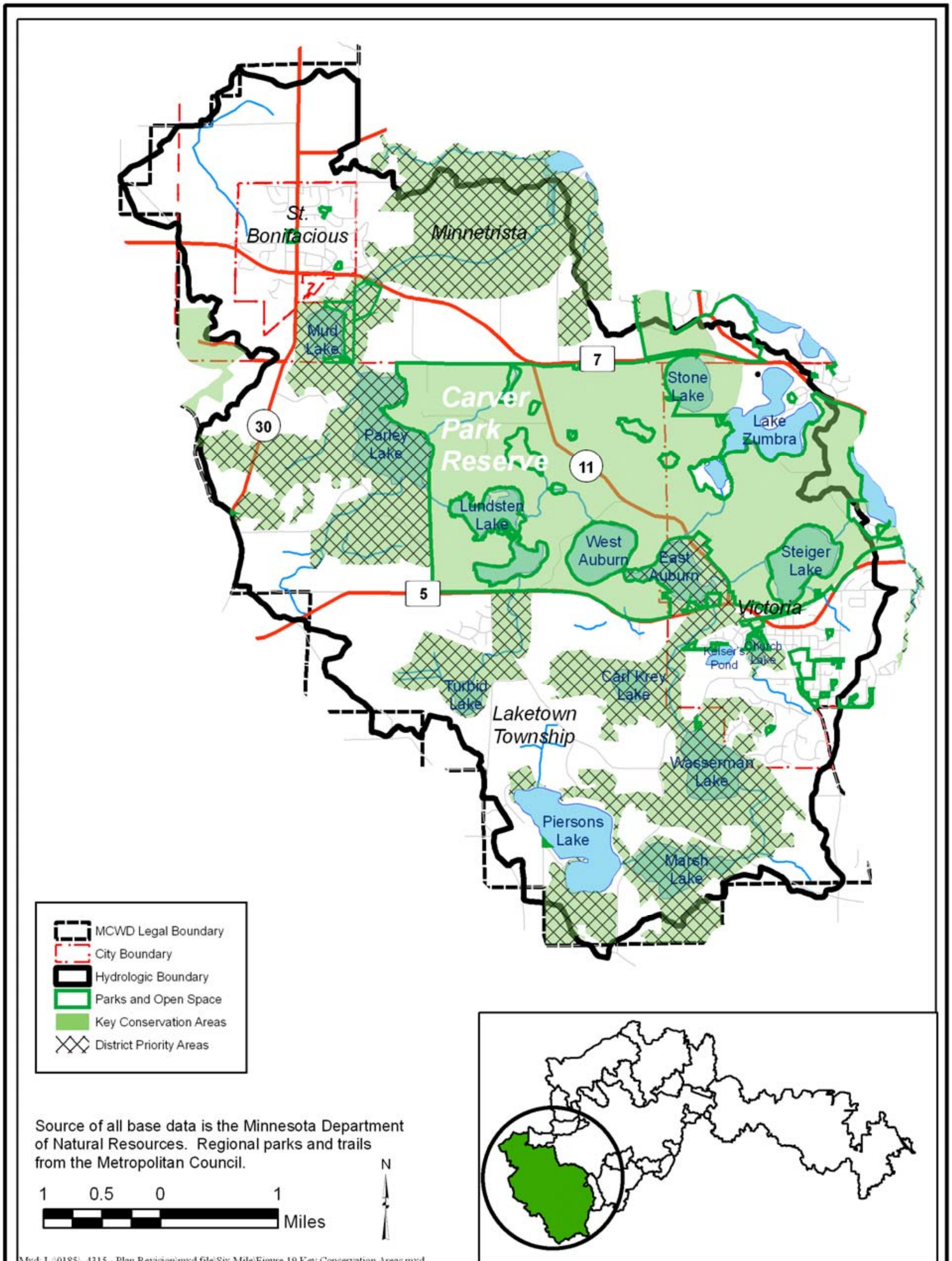
Desired Outcomes: Engage the public to encourage involvement in District activities and stewardship of area resources.

Metrics: Positive contacts with property owners and interest groups.

Six Mile Marsh Goal 17.1: Promote the development of lake associations and work cooperatively with existing associations.

Action A. Provide information and assistance as requested.

Action B. Attend meetings as requested to share information, hear concerns, and maintain a good working relationship.



MINNEHAHA CREEK WATERSHED DISTRICT	Minnehaha Creek Watershed District	MAY 2006
Six Mile Marsh Subwatershed Key Conservation Areas		Figure 19

5.0 Implementation Program

The goals set forth in Section 4.0, Resource Management Goals and Strategies will require an integrated set of programs and projects oriented toward the conservation and improvement of water resources within the watershed. The following sections describe generally the activities that will be undertaken by various parties and identifies parties responsible for each activity. Table 25 in Section 5.9 provides a cost estimate and schedule for the District's responsibilities for new activities in the implementation program.

5.1 Regulatory Program

As discussed in Section 3.6 above, future development is expected to contribute additional stormwater volume and phosphorus loads to the lakes, Six Mile Creek, and thus to Halsteds Bay, further degrading water quality. The current regulatory program will not be sufficient to control these impacts. To mitigate these future impacts and to address other goals such as increased infiltration, wetland management, and improved ecological integrity, additional regulation may be necessary. A decision on rulemaking needs/standards can only be made after the formal rulemaking process. In addition, further amendments to the rules should not be precluded by the content of the plan.

Additional regulatory controls on permitted development and redevelopment will be considered for this subwatershed to increase phosphorus load reduction requirements, add volume management and infiltration requirements, implement wetland management in accordance with management classification, and increase scrutiny of development that may impact groundwater or key conservation resources. Regulations providing an incentive such as a volume reduction credit to developers to maintain undisturbed areas, reforest, or plant native vegetation may be considered.

The following are revised or additional regulatory controls in this subwatershed that would be necessary to assist the District in meeting the goals of this Plan:

1. Amend existing or establish new District rules requiring abstraction of the first one inch of rainfall on new permitted development and redevelopment.
2. Provide regulatory constraints and incentives for the conservation of undisturbed native vegetation as sites develop.
3. Require MCWD review of preliminary plats and vegetation surveys so the District may comment on proposals and how they relate to District ecological integrity goals.
4. Require submittal of a Natural Resources Inventory and Conservation Plan as a condition of permit approval.
5. Amend existing or establish new District rules requiring greater than 50 percent phosphorus removal on new permitted developments within the Six Mile Marsh subwatershed.

6. Amend District rules to incorporate a requirement for stormwater management plan approval prior to submittal of a preliminary plat.
7. Amend existing or establish new District rules requiring submittal of a functions and values assessment for all proposed wetland impacts requiring a permit; mitigation of all fill in Preserve category wetlands; and specifying by management classification stormwater discharge pretreatment, buffer, hydroperiod, and other wetland standards.
8. Establish new District rule requiring an additional level of analysis and review of permitted development and redevelopment where there is a potential to adversely impact groundwater connected to a surface water feature.
9. Require pretreatment of stormwater discharged to wetlands or infiltration areas in the areas of high aquifer sensitivity.
10. Require developers to identify existing drain tile lines on property proposed for development.

5.2 Land Conservation Program

Prior to the encroachment of additional development, the opportunity exists to create connections between ecosystems within the Six Mile Marsh and Lake Minnetonka Subwatersheds to improve water quality, preserve natural conveyances, and facilitate the movement and proliferation of native species as well as enhance recreational opportunities. Figure 19 identifies high priority areas, the conservation of which will improve the characteristics of the aquatic ecosystem and the water quality within the subwatershed as well as areas downstream.

The District operates a Land Conservation Program that undertakes conservation activities ranging from assisting property owners in enrolling property in conservation programs to acquiring easements or fee title over high value resources. Key conservation areas identified on Figure 19 are located within the current Land Conservation Program target area or have been proposed for addition to the target area. The District will continue to proactively investigate opportunities to conserve key resources in these areas and work cooperatively with other agencies and groups to accomplish this subwatershed's conservation goals. The District will provide technical assistance to the LGUs to identify and implement strategies for local conservation efforts in support of program goals.

5.3 Education Program

The District operates a watershed-wide Strategic Education and Communications program that provides general watershed information as well as targeted information. The targeted education and public involvement activities identified in this plan will be implemented to assist in the reduction of existing pollutant loading to the lakes, Six Mile Creek, and other water resources in the subwatershed as well as to minimize the impacts of future development. The specific targeted messages will emphasize conservation of the wide range of high-value resources in the subwatershed and developer education targeting Better Site Design, infiltration, and conservation of undisturbed native vegetation as sites develop.

5.4 Monitoring and Data Collection

Hydrologic Data Program. To monitor progress toward meeting water quality and quantity goals, routine monitoring of water quality and quantity in Six Mile Creek will continue to be a part of the District's annual Hydrologic Data Program, as will monitoring of lakes that have established goals in this plan or a TMDL. Monitoring data on East Auburn, Lunsten, Carl Krey, Church, Turbid, and Mud Lakes may be obtained to establish baseline conditions. Monitoring these lakes every three to five years will provide sufficient information to assess changes in water quality and progress toward goals. Macroinvertebrate monitoring should be completed on Six Mile Creek every three to five years.

Aquatic Vegetation. Lake aquatic plant monitoring provides information needed to manage aquatic plants, evaluate control measures, and plan for future actions. This monitoring is especially useful as water quality management activities are implemented and plant communities change in response to changing water quality. Baseline aquatic vegetation surveys and shoreline surveys will be conducted on Pierson, Wasserman, Steiger, Zumbra, Stone, Auburn East and West, Lunsten, and Parley and aquatic vegetation management plans developed as part of any internal load reduction project. The survey should be updated by staff/contractor after five years at an estimated cost of $6,000 each. Interim monitoring could be conducted by trained volunteers.

Wetland Monitoring. Wetlands with exceptional value vegetation are present in the subwatershed. Because of the importance to overall subwatershed ecological integrity of preserving these values, these wetlands will be regularly monitored for invasive species by staff, Three Rivers Park, or trained volunteers.

5.5 Operations and Maintenance

Activities detailed in this implementation plan will require both ongoing and new operations and maintenance activities in this subwatershed. These include inspection of erosion-prone areas of Six Mile Creek annually to maintain conveyance capacity and identify erosion that could contribute sediment downstream or impede proper function of the channel, and maintenance activities for existing and proposed capital projects (see Table 12).

Table 12. Ongoing District operations and maintenance tasks for the Six Mile Marsh subwatershed.

Task	Spring	Summer	Fall
Routine Ditch Inspection	As needed	Every five years	As needed
Inspect Erosion-Prone Reaches of Creek	Early Spring and After Storm	After Storm	Late Fall and After Storm
Inspect High Vegetative Diversity Wetlands	Regularly	Regularly	Regularly
Painter Creek Wetland Restoration Area Vegetation Management	Regularly	Regularly	Periodic burns, mowing, or herbicide as needed

Task	Spring	Summer	Fall
Remove debris in Six Mile Creek and other streams that poses an obstruction to flow or causes flooding	As needed	As needed	As needed

5.6 LGU Requirements

5.6.1 Local Government Units Subwatershed Phosphorus Load Reductions

Part of the phosphorus load reduction plans for various lakes is a required reduction of phosphorus load contributed by existing land uses in the subwatershed. Where a TMDL study has not identified a specific watershed load reduction, this requirement is a 15 percent reduction in loading from existing residential land use; 25 percent from existing agricultural land use; and 10 percent from other developed land use. This reduction can be accomplished through application of BMPs such as additional street sweeping, local water quality ponds, rain gardens and infiltration swales, and agricultural BMPs that reduce erosion or treat runoff or drain tile discharge; prevention of future load increases through the conservation of lands previously identified for development; or achieving load removals in excess of the minimum required. The LGUs identified below must identify in their local water management plans specific steps to accomplish these minimum reductions. The LGUs must also annually report to the District their progress toward accomplishing this requirement.

Table 13. Allocation of Six Mile Marsh subwatershed LGU phosphorus load reductions (lbs/yr).

Lakeshed	Laketown Township	Victoria	Minnetrista	St. Bonifacius	Watertown Township	Total
Pierson	19	-	-	-	-	19
Wasserman*	60	198	-	-	-	258
Steiger	-	28	-	-	-	28
Zumbra	-	8	-	-	-	8
Stone	2	-	-	-	-	2
Auburn East	13	21	-	-	-	34
Auburn West	3	-	-	-	-	3
Lunsten	23	-	-	-	-	23
Parley	99	-	-	-	-	99
Six Mile Marsh			20	11		31
Mud	2		25	12		39
TOTAL	221	255	45	23	0	544

***Load reductions as shown in the draft TMDL for the lake.**

5.6.2 Land Conservation

A key element in achieving overall ecological integrity goals in the Six Mile Marsh subwatershed is the conservation of key ecological areas, including high-value wetlands and connecting uplands. LGUs must identify in their local water management plans the areas shown on Figure 19. The local plan must also identify strategies the LGU will undertake to protect the ecological values of those areas. These may include such strategies as land use regulation; acquisition and management; and property owner education regarding land management strategies to maintain ecological integrity.

5.6.3 Other Issues

Landlocked Basins. There are existing land-locked subwatershed units and basins within this subwatershed that the cities have been considering for outlet drainage projects. To protect the quality of downstream resources, local plans must either no longer consider this an option, or demonstrate how this could be achieved without impact to downstream water quantity or quality impacts. Outletting will generally be discouraged unless there is a demonstrated threat to property structures or public safety.

Modeled High Water Locations. The HHPLS identified a number of locations where modeling predicts that public roads, private roads, or private drives might overtop during infrequent events, or where there may be minimal freeboard above the flood level. Local plans should identify observed or these potential locations and assess whether the risk of occasional flooding is acceptable or should be addressed.

Flow Velocity or Erosion Issues. The HHPLS identified a number of locations where modeling predicts that under existing or future development conditions higher velocities than desired ay result in erosion at outlets or culverts, potentially warranting erosion control or energy dissipation. Local plans should identify observed or these potential locations, assess the need for such measures, and set forth a plan for preventing future erosion.

5.7 Phosphorus Load Reduction

One of the water quality goals for this subwatershed is the reduction of phosphorus loading into the lakes that exceed their total phosphorus goal or that are subject to a TMDL load reduction requirement. Reduction of phosphorus loads from the subwatershed to achieve lake water quality goals will require the combined efforts of the regulatory program, operational programs, and capital projects. The following tables set forth summary plans for how this could be accomplished.

The tables break down modeled phosphorus loading to each lake by source: atmospheric deposition, external sources, and internal sources. Atmospheric deposition is a regional issue and is not dealt with here. The primary means of addressing external loading are through the regulation of new loads generated by development and the reduction of existing loads from the subwatershed.

In some cases the phosphorus load contributed from the subwatershed is not sufficient to explain the current in-lake phosphorus concentration. The most likely sources for this discrepancy are internal loading from lake sediments or aquatic vegetation. Internal load management such as alum treatment to control sediment sources coupled with control of aquatic vegetation often helps to alleviate some internal loading. Rough fish management may also be required. A feasibility study would determine the most appropriate internal load reduction options.

Pierson Lake. Pierson Lake's total phosphorus goal is 27 µg /L. It has a relatively small lakeshed, so opportunities for structural load reduction are limited. The water quality varies considerably year to year. It does not appear to respond as if it had an internal load problem, so there may be an unusual incoming load from some unknown sources or some other phenomenon may explain the variation. A diagnostic study would be required to identify the source of variation before any strategies could be developed for its reduction (see Table 14).

Table 14. Phosphorus load reduction plan for Pierson Lake.
(In-lake nutrient concentration goal = 27 µg/L TP).

Source	Reduction	Ultimate Phosphorus Load [lb/yr]	Planned Reductions [lb/yr]	Final Loading [lb/yr]	
Atmospheric					
Atmospheric deposition	NA	56	NA	56	
External Loads					
External load determined from modeling land use		271			
	LGU load reduction allocation (Table 13)		19		
	Existing regulation		77		
	Additional regulation		39		
Total After Reductions				136	
Internal / "Unknown" Loads					
Internal/"unknown" loads determined from modeling land use		171			
	Internal load management		120		Diagnostic study required to identify achievable reduction
Total After Reductions				51	
Total Load					
TOTAL		498		245	
LOAD GOAL				193	
DIFFERENCE				50	Adaptive management

<u>Wasserman Lake.</u> A TMDL study including a phosphorus reduction plan is currently being developed for Wasserman Lake. Proposed reductions from the TMDL include: implementation of agricultural BMPs; utilization of a wetland between Marsh Lake and Wasserman Lake to treat flow from Pierson Lake; stream stabilization of an erosion area noted in the *Upper Watershed Stream Assessment;* reductions due to the new prohibition on the use of fertilizer with phosphorus; application of Low Impact Development techniques to future development in the city of Victoria; and an evaluation and implementation of internal load management. Table 15 below sets forth a summary plan for how this could be accomplished in accordance with the TMDL. *The TMDL calculates reductions from the current conditions rather than future conditions.*

Table 15. Phosphorus load reduction plan for Wasserman Lake.
(In-lake nutrient concentration goal = 40 µg/L TP).

Source	Reduction	Current Phosphorus Load [lb/yr]	Planned Reductions [lb/yr]	Final Loading [lb/yr]	
Atmospheric					
Atmospheric deposition	NA	42	NA	42	
External Loads					
External load determined from modeling land use		553			
Reductions proposed in the draft TMDL	Local agricultural BMPs		60		
	Marsh/Wasserman wetland restoration		37		
	Marsh/Wasserman stream stabilization		62		
	Phosphorus free fertilizer		26		
	Application of LID in Victoria development		198		
	Regulations				
	No increase in load				
Total After Reductions				170	
Internal / "Unknown" Loads					
Internal/"unknown" loads determined from modeling land use		549			
	Internal load management		375		Est 70% reduction of internal loading
Total After Reductions				174	
Total Load					
TOTAL		1,144		386	
LOAD GOAL				395	
DIFFERENCE				(-9)	

Steiger Lake. Steiger Lake is located in the Carver Park Reserve. It has a small lakeshed, so opportunities for structural external load reduction are limited. Downtown Victoria redevelopment may provide opportunity-driven reductions to accomplish the LGU load reduction allocation. A wet detention pond could be constructed to treat runoff from subwatersheds SMC 12 and 13 (see Figure 20). After implementation of those reductions opportunities for additional reductions to meet the goal would be assessed as well as the long-term appropriateness of the goal (see Table 16).

Table 16. Phosphorus load reduction plan for Steiger Lake.
(In-lake nutrient concentration goal = 30 µg/L TP).

Source	Reduction	Ultimate Phosphorus Load [lb/yr]	Planned Reductions [lb/yr]	Final Loading [lb/yr]	
Atmospheric					
Atmospheric deposition	NA	38	NA	38	
External Loads					
External load determined from modeling land use		230			
	LGU load reduction allocation (Table 13)		28		
	Pond at SMC-12/13		67		
	Existing regulation		17		
	Additional regulation		9		
Total After Reductions				109	
Internal / "Unknown" Loads					
Internal/"unknown" loads determined from modeling land use		0			
	Internal load management		0		
Total After Reductions				0	
Total Load					
TOTAL		268		147	
LOAD GOAL				142	
DIFFERENCE				5	

Zumbra Lake. Lake Zumbra has a small lakeshed, so opportunities for structural external load reduction are limited. Some small load reductions have been identified, such as application of residential BMPs. Aquatic vegetation management may assist in reducing the small internal load (see Table 17).

Table 17. Phosphorus load reduction plan for Zumbra Lake.
(In-lake nutrient concentration goal = 25 µg/L TP).

Source	Reduction	Ultimate Phosphorus Load [lb/yr]	Planned Reductions [lb/yr]	Final Loading [lb/yr]	
Atmospheric					
Atmospheric deposition	NA	39	NA	39	
External Loads					
External load determined from modeling land use		72			
	LGU load reduction allocation (Table 13)		8		
	Existing regulation		3		
Total After Reductions				61	
Internal / "Unknown" Loads					
Internal/ "unknown" loads determined from modeling land use		10			
	Internal load management		0		
Total After Reductions				10	
Total Load					
TOTAL		121		110	
LOAD GOAL				100	
DIFFERENCE				10	Adaptive management

<u>Stone Lake.</u> Stone Lake is located in the Carver Park Reserve. Phosphorus load from watershed washoff cannot explain phosphorus concentrations in Stone Lake. The large, unknown load to Stone Lake may be from an internal source, or the wetlands adjacent to the lake may be exporting phosphorus to the lake. A diagnostic study would be required to identify the source of this unknown load and to develop strategies to reduce it. An internal load reduction project followed by curly-leaf pondweed treatment (see Table 18) is proposed to help achieve water quality goals.

Table 18. Phosphorus load reduction plan for Stone Lake.
(In-lake nutrient concentration goal = 36 µg/L TP).

Source	Reduction	Ultimate Phosphorus Load [lb/yr]	Planned Reductions [lb/yr]	Final Loading [lb/yr]	
Atmospheric					
Atmospheric deposition	NA	25	NA	25	
External Loads					
External load determined from modeling land use		70			
	LGU load reduction allocation (Table 13)		2		
	Existing regulation		22		
Total After Reductions				46	
Internal / "Unknown" Loads					
Internal/ "unknown" loads determined from modeling land use		92			
	Internal load management		65		Est 70% reduction of internal loading
Total After Reductions				27	
Total Load					
TOTAL		187		98	
LOAD GOAL				105	
DIFFERENCE				(-7)	

Auburn East. Auburn Lake East received City of Victoria wastewater treatment plan effluent until 1973. There is a large, unaccounted for phosphorus load source that may be a remnant of those old discharges or due to some other source or sources. A diagnostic study would be required to determine the source and evaluate options for improvement. Auburn East's in-lake phosphorus goal is 50 µg/L. However, because it discharges directly to Auburn West and that discharged volume conveys a significant phosphorus load to Auburn West, Auburn West cannot attain its water quality goal unless Auburn East attains better water quality than its goal. Water quality modeling shows that the in-lake phosphorus concentration in Auburn East would have to be reduced to about 44 µg /L for Auburn west to attain its goal. The load reduction plan in Table 19 assumes that 44 µg /L goal and also assumes that upstream lakes that contribute to Auburn East – Wasserman, Steiger, Stone, and Zumbra – meet their water quality goals. An internal load reduction project followed by curly-leaf pondweed treatment is proposed.

Table 19. Phosphorus load reduction plan for Lake Auburn East. (In-lake nutrient concentration goal = 44 µg/L TP).

Source	Reduction	Ultimate Phosphorus Load [lb/yr]	Planned Reductions [lb/yr]	Final Loading [lb/yr]	
Atmospheric					
Atmospheric deposition	NA	29	NA	29	
External Loads					
External load determined from modeling land use		646			
	LGU load reduction allocation (Table 13)		34		
	Reduction due to upstream lakes at goal		131		
	Existing regulations		63		
Total After Reductions				418	
Internal / "Unknown" Loads					
Internal/ "unknown" loads determined from modeling land use		406			
	Internal load management		284		Est 70% reduction of internal loading
Total After Reductions				122	
Total Load					
TOTAL		1,081		569	
LOAD GOAL				580	
DIFFERENCE				(-11)	

Auburn West. Lake Auburn West is located downstream of Lake Auburn East and other lakes upstream of that lake. Their water quality influences its water quality. The lakes upstream of Auburn West have higher total phosphorus goals than Auburn West's stringent 27 ug/L. To achieve that goal, the upstream lakes must also attain their goals. Alternatively, the goal for Auburn West could be revised to reflect its location in the series of lakes. An internal load reduction project followed by curly-leaf pondweed treatment is proposed, and should be completed at the same time improvements are made to Auburn East (see Table 20).

Table 20. Phosphorus load reduction plan for Lake Auburn West. (In-lake nutrient concentration goal = 27 µg/L TP).

Source	Reduction	Ultimate Phosphorus Load [lb/yr]	Planned Reductions [lb/yr]	Final Loading [lb/yr]	
Atmospheric					
Atmospheric deposition	NA	34	NA	34	
External Loads					
External load determined from modeling land use		477			
	LGU load reduction allocation (Table 13)		3		
	Reduction due to upstream lakes at goal		157		
	Existing regulations		12		
Total After Reductions				305	
Internal / "Unknown" Loads					
Internal/ "unknown" loads determined from modeling land use		267			
	Internal load management		187		Est 70% reduction of internal loading
Total After Reductions				80	
Total Load					
TOTAL		778		419	
LOAD GOAL				401	
DIFFERENCE				18	

Lunsten Lake. Lunsten Lake is a very shallow lake that responds more as a wetland. It has a very high modeled internal load, which is not unexpected for a lake of this type. The load reduction plan below assumes that lakes upstream of Lunsten will meet their phosphorus goals, and that application of regulation to development in the subwatershed will provide the necessary load reduction to meet Lunsten's goal of 70 ug/L (see Table 21).

Table 21. Phosphorus load reduction plan for Lunsten Lake. (In-lake nutrient concentration goal = 70 µg/L TP).

Source	Reduction	Ultimate Phosphorus Load [lb/yr]	Planned Reductions [lb/yr]	Final Loading [lb/yr]	
Atmospheric					
Atmospheric Deposition	NA	26	NA	26	
External Loads					
External Load Determined from Modeling Land Use		581			
	LGU load reduction allocation (Table 13)		23		
	Reduction due to upstream lakes at goal		110		
	Existing regulations		110		
Total After Reductions				338	
Internal / "Unknown" Loads					
Internal/ "unknown" loads determined from modeling land use		408			
	Internal load management		0		
Total After Reductions				408	
Total Load					
TOTAL		1,015		772	
LOAD GOAL				794	
DIFFERENCE				(-22)	

Parley Lake. A TMDL study including a phosphorus reduction plan is currently being developed for Parley Lake. Proposed reductions from the TMDL include: implementation of agricultural BMPs; corridor and wetland restoration between Turbid Lake and Lunsten Lake; stream corridor and wetland restoration on tributaries to Parley Lake; stormwater management improvements at the Crown College campus; achievement of upstream water quality goals; application of more stringent regulations prohibiting new net phosphorus loading from development; a prohibition on outletting currently landlocked areas; and a diagnostic of sources of internal loading and implementation of internal load management. Table 22 below sets forth a summary plan for how this could be accomplished in accordance with the TMDL. *The TMDL calculates reductions from the current conditions rather than future conditions.*

Table 22. Phosphorus load reduction plan for Parley Lake.
(In-lake nutrient concentration goal = 60 µg/L TP).

Source	Reduction	Ultimate Phosphorus Load [lb/yr]	Planned Reductions [lb/yr]	Final Loading [lb/yr]	
Atmospheric					
Atmospheric eposition	NA	64	NA	64	
External Loads					
External load determined from modeling land use		1,168			
Reductions proposed in the draft TMDL	Local agricultural BMPs		77		
	Turbid-Lunsten corridor restoration		146		
	Parley tributary wetland restoration		95		
	Local Crown College runoff improvements		22		
	Reduction due to upstream lakes at goal		53		
	Regulations				
	No net increase in P				
Total After Reductions				775	
Internal / "Unknown" Loads					
Internal/ "unknown" loads determined from modeling land use		1,971			
	Internal load management		1,129		
Total After Reductions				842	
Total Load					
TOTAL		3,203		1,681	
LOAD GOAL				1,684	
DIFFERENCE				(-3)	

5.8 Capital Improvement Program

Capital projects in the Six Mile Marsh Creek subwatershed include projects to improve water quality, including projects identified in the lakes TMDLs; stream restoration projects to repair erosion noted in the *Upper Watershed Steam Assessment;* and wetland restoration projects.

These projects and others identified below will progress the District toward achieving its various goals for the subwatershed. This program is not a comprehensive list of all capital needs or potential projects within the subwatershed, and is limited by available financial resources and staff capacity to manage projects. These priority projects are intended to:

- Achieve nutrient load reductions to Halsteds Bay to prevent future listing as an Impaired Water that would require a TMDL study.
- Progress improvements to water quality as identified in the TMDLs for Parley and Wassermann Lakes.
- Stabilize and restore reaches of Six Mile Creek identified in the *Upper Watershed Stream Assessment* with the highest concentration of erosion issues and to improve biotic integrity.
- Begin addressing the historic loss of wetlands in the subwatershed through restoration of degraded or drained wetlands.
- Mitigate the impacts of future development on downstream resources.

These proposed projects emphasize the achievement of multiple objectives. For example, stream restoration would not only stabilize streambanks and prevent further erosion, it would provide an opportunity to improve in-stream and buffer habitat, conserve existing high-value resources, and reduce sediment and nutrient transport downstream. Wetland restorations would not only restore degraded or drained wetlands, they would provide an opportunity to improve downstream water quality, increase infiltration, improve habitat, and conserve existing high-value resources.

5.8.1 Wasserman Lake Internal Load Management Project

Project *Lake Wasserman Internal Load Management Project*

Description Design and implementation of strategies to reduce internal phosphorus loading, including: feasibility study; aquatic vegetation survey update and management plan; fishery survey update and management plan; biomanipulation strategies that may include aquatic vegetation management, zooplankton community and fishery manipulation, and chemical treatment

Need A TMDL study including a phosphorus reduction plan is currently being developed for Wasserman Lake. Proposed reductions include control of external sources of phosphorus through various efforts in the watershed and internal load management. The TMDL identified a need to reduce internal loading by 375 pounds annually.

This project would identify and implement a suite of strategies to manage aquatic vegetation, the fishery, and zooplankton community to achieve water quality and clarity goals. The project includes an ongoing vegetation and fishery management plan. Management of invasive aquatic vegetation that contributes to lake water quality and usability issues would require annual treatment for three to five years.

Outcome Reduction in phosphorus load from internal sources; improved water clarity; more diverse aquatic vegetation community; improved aesthetics

Estimated	Investigation, permitting, fish, vegetation,	$17,200	Design, surveys
Cost and	and zooplankton surveys, and implementation	$214,400	Construction

Funding	of strategies. Funding source is the District capital levy.	$231,600 Total

Schedule 2013 Fish, vegetation, and zooplankton surveys, development of management plans
2014 Implementation of strategies

5.8.2 Marsh/Wasserman Lake Wetland Restoration and Stream Stabilization

Project *Marsh/Wasserman Lake Wetland Restoration and Stream Stabilization*

Description Restoration of 1,500 feet of stream and 30 acres of wetland along Six Mile Creek and riparian wetlands between Marsh Lake and Wasserman Lake

Need A TMDL study including a phosphorus reduction plan is currently being developed for Wasserman Lake. Proposed reductions include control of external sources of phosphorus through various efforts in the watershed and internal load management. The TMDL identified a need to reduce external loading by 383 pounds annually.

The TMDL identified two improvements to the corridor between Marsh and Wasserman Lakes as potential means to reduce phosphorus load to Wasserman Lake: stabilization of eroded portions of the stream connecting Marsh Lake and Wasserman Lake, and restoration of the wetland complex through which that stream flows. The *Upper Watershed Stream Assessment* identified the Marsh Lake Road culvert crossing as in need of improvement and stabilization, and streambank erosion was noted just downstream of the culvert.

The TMDL is not yet final as of this writing and details of the specific improvements have not been developed. However, there is a potential to restore approximately 1500 linear feet of Six Mile Creek channel, and potentially 30 or more acres of riparian wetland. This Preserve classification wetland is identified in the MCWD 2003 *Functional Assessment of Wetlands* as providing significant downstream water quality and flood storage benefits. The wetland currently exhibits moderate wildlife habitat and low vegetative diversity, being primarily cattails with reed canary grass and buckthorn in areas.

Stream restoration could repair existing eroded sites and improve streambank stability using bioengineering techniques. This restoration would also reduce sediment-bound phosphorus contributions to downstream Wasserman Lake. Wetland restoration could provide the opportunity to replace the invasive vegetative species with more diverse species to enhance wildlife habitat. Creating a more defined channel meandering through the wetland could reduce internal loading of phosphorus from wetland sediments, and the flushing of particulate matter from the wetland. The

TMDL estimated a 99 pound phosphorus load reduction could be achievable through these restorations.

There are two distinct wetland areas in the corridor (see Figure 20). The wetland area between Marsh Lake Road and a local private road, the Marsh Lake Road culvert repair and downstream stream restoration are here designated "Phase I." The wetland and stream restoration north of the local private road and Wasserman Lake are "Phase II." *These wetlands are located within the Key Conservation Area identified for this subwatershed.*

Outcome	Reduction in phosphorus load from external sources estimated at 99 pounds annually; improved water clarity in Wasserman Lake; more diverse wetland vegetation community; improved habitat in Six Mile Creek; streambank stabilization and reduced sediment transport from eroding streambanks		
Estimated Cost and Funding	Phase I: Culvert repair, stream restoration and wetland restoration. Source of funding is the District capital levy.	$67,600 $653,700 $721,300	Design, easmnt Construction Total
	Phase II: Stream and wetland restoration. Source of funding is the District capital levy.	$73,600 $613,900 $687,500	Design, easmnt Construction Total
Schedule	Phase I: 2007 Design, acquire easements; 2008 construct Phase II: 2009 Design, acquire easements, 2010 construct		

5.8.3 Steiger Lake Pond

Project	*Steiger Lake Wetland Detention Pond*		
Description	Construction of a stormwater treatment pond to treat runoff to Steiger Lake		
Need	The phosphorus reduction plan for Steiger Lake requires a reduction of 121 pounds of phosphorus per year from the subwatershed. A wet detention pond is proposed to treat runoff from subwatersheds SMC-12 and SMC-13 (see figure 20). This pond would be designed to remove at least half the phosphorus load projected to be contributed by those drainage areas under the ultimate development conditions.		
Outcome	This pond could remove an estimated 67 pounds of phosphorus annually, along with other pollutants such as sediment.		
Estimated Cost and Funding	Design, easement acquisition, construction, and project management. Source of funding is the District capital levy.	$96,800 $708,700 $805,600	Design, easmnt Construction Total

Schedule	2011 Design, acquire easements 2012 Construction

5.8.4 Auburn Lake Internal Load Management Project

Project	*Auburn East Lake Internal Load Management Project*
Description	Design and implementation of strategies to reduce internal phosphorus loading, including: feasibility study; aquatic vegetation survey update and management plan; fishery survey update and management plan; biomanipulation strategies that may include aquatic vegetation management, zooplankton community and fishery manipulation, and chemical treatment
Need	The modeled watershed phosphorus wash-off load to East and West Auburn Lakes is not sufficient to explain the in-lake concentration of total phosphorus that exceeds the lakes' total phosphorus goals. An "unknown load" is attributed to internal loading, and is likely a combination of bottom sediments, aquatic vegetation, and model accuracy. A watershed and lake diagnostic / feasibility study will be required to confirm the internal and external phosphorous loading to the lakes, as well as the necessary load reductions. In particular, the "unknown load" must be identified as either an external or internal load before specific strategies can be selected. A variety of strategies would be investigated in the diagnostic and treatment study proposed in this plan. This project would identify and implement a suite of strategies to manage aquatic vegetation, the fishery, and zooplankton community to achieve water quality and clarity goals. Because Auburn East discharges directly to Auburn West, both lakes should be investigated at the same time. The project includes an ongoing vegetation and fishery management plan. Management of invasive aquatic vegetation that contributes to lake water quality and usability issues would require annual treatment for three to five years.
Outcome	Reduction in phosphorus load from internal sources estimated at 284 pounds annually in Auburn East and 187 pounds annually in Auburn West; improved water clarity; more diverse aquatic vegetation community; improved aesthetics.
Estimated Cost and Funding	Investigation, permitting, fish, vegetation, and zooplankton surveys, and implementation of strategies. Funding source is the District capital levy. $17,600 Design, survey $169,700 Construction $187,300 Total
Schedule	2013 Fish, vegetation, and zooplankton surveys, development of management plans, cooperative agreement with Three Rivers Park District 2014 Implementation of strategies

5.8.5 *Turbid/Lunsten Lake Corridor Restoration*

Project Description

Turbid/Lunsten Lake Corridor Restoration

Restoration of wetlands around, and along the tributary between, Turbid and Lunsten Lakes

Need

A TMDL study including a phosphorus reduction plan is currently being developed for Parley Lake. Proposed reductions include control of external sources of phosphorus through various efforts in the watershed and internal load management. The TMDL identified a need to reduce external loading by 393 pounds annually.

The TMDL for Parley Lake, which is in progress at the time of this writing, identified wetland restoration in the corridor between Turbid and Lunsten Lakes upstream of Parley Lake as a potential means to reduce phosphorus load to Parley Lake.

The TMDL is not yet final as of this writing and details of the specific improvements have not been developed. However, a small stream that connects Turbid and Lunsten Lakes has been partially ditched, and restoration of the hydrologically altered wetland complex through which it flows could provide for treatment of agricultural runoff. There is a potential to restore approximately 55 acres of riparian wetland. The wetland currently exhibits moderate wildlife habitat and low vegetative diversity. There are two distinct wetland areas for potential restoration: approximately 40 acres of ditched, tiled and farmed wetland on the northwest side of Turbid Lake ("Phase I"), and approximately 15 acres riparian to the stream downstream of Laketown Road ("Phase II"). *These wetlands are located within the Key Conservation Areas identified for this subwatershed.*

Outcome

Reduction in phosphorus load from external sources estimated at 146 pounds annually; improved water clarity in Lunsten and Parley Lakes; more diverse wetland vegetation community; restoration and enhancement of a wildlife corridor between lakes.

Estimated Cost

Phase I: Wetland restoration on the northwest side of Turbid Lake. Source of funding is the District capital levy.	$ 675,000	Design, easmnt
	$1,394,414	Construction
	$2,069,914	Total
Phase II: Wetland restoration adjacent to channel just south of Laketown Road. Source of funding is the District capital levy.	$54,100	Design, easmnt
	$442,200	Construction
	$496,300	Total

Schedule

Phase I: 2011 Design, acquire easements 2011 Construct
Phase II: 2012 Design, acquire easements 2011 Construct

5.8.6 Parley Lake Tributary Wetland Restoration

Project *Parley Lake Tributary Wetland Restoration*

Description Restoration of 20 acres of wetland along riparian wetlands on a tributary between Turbid and Lunsten Lakes

Need A TMDL study including a phosphorus reduction plan is currently being developed for Parley Lake. Proposed reductions include control of external sources of phosphorus through various efforts in the watershed and internal load management. The TMDL identified a need to reduce external loading by 393 pounds annually.

The TMDL for Parley Lake, which is in progress at the time of this writing, identified a potential wetland restoration site in drainage area SMC-41 that could provide for treatment of agricultural and other runoff from upstream. There is a potential to restore up to 20 acres or more of riparian wetland that currently exhibits moderate wildlife habitat and low vegetative diversity. *This wetland is located within the Key Conservation Areas identified for this subwatershed.*

Outcome Reduction in phosphorus load from external sources estimated at 95 pounds annually; improved water clarity in Parley Lake; more diverse wetland vegetation community; restoration and enhancement of a wildlife corridor.

Estimated Cost and Funding Design, easement acquisition, construction, construction management, vegetation management contract. Source of funding is District capital levy.

$53,100	Design, easmnt
$494,500	Construction
$547,600	Total

Schedule
2007 Design, easement acquisition
2008 Construction

5.8.7 Parley Lake Internal Load Management Project

Project *Parley Lake Internal Load Management Project*

Description Design and implementation of strategies to reduce internal phosphorus loading, including: feasibility study; aquatic vegetation survey update and management plan; fishery survey update and management plan; biomanipulation strategies that may include aquatic vegetation management, zooplankton community and fishery manipulation, and chemical treatment

Need A TMDL study including a phosphorus reduction plan is currently being developed for Parley Lake. Proposed reductions include control of external sources of phosphorus through various efforts in the watershed and internal load management. The TMDL identified a need to reduce internal loading by 1,129 pounds annually.

This project would identify and implement a suite of strategies to manage aquatic vegetation, the fishery, and zooplankton community to achieve water quality and clarity goals. The project includes an ongoing vegetation and fishery management plan. Management of invasive aquatic vegetation that contributes to lake water quality and usability issues would require annual treatment for three to five years.

Outcome Reduction in phosphorus load from internal sources; improved water clarity; more diverse aquatic vegetation community; improved aesthetics

Estimated Cost Investigation, permitting, fish, vegetation, and zooplankton surveys, and implementation of strategies. Funding source is the District capital levy.

$17,200	Design, surveys
$214,400	Construction
$231,600	Total

Schedule 2012 Fish, vegetation, and zooplankton surveys, development of management plans
2013 Implementation of strategies

5.8.8 Spot Repairs on Six Mile Creek

Project *Parley Lake Internal Load Management Project*

Description Repair of isolated areas of streambank erosion identified in the *Stream Assessment* as well as any additional spots identified in periodic inspections.

Need The *Upper Watershed Stream Assessment* identified several locations as among those where eroded banks or outfalls require spot repairs. Completing these repairs would restore stability, reduce new erosion, and reduce sediment transport from sloughing streambanks.

Outcome Streambank stability; reduced erosion; opportunity to create habitat; more diverse aquatic vegetation community; improved aesthetics.

Estimated Cost Design, easement acquisition, construction. Funding source is the District capital levy. $60,900

Schedule 2015 Construction

5.8.9 Regional Infiltration

Project	*Six Mile Marsh Subwatershed Regional Infiltration*
Description	Implementation of opportunities to increase infiltration, including but not limited to construction of infiltration basins and devices, wetland restoration, reforestation, revegetation
Need	The proposed rule requiring new development and redevelopment to infiltrate one inch of rainfall would capture approximately 70 percent of new runoff volume from the watershed. The remaining 30 percent would continue to convey pollutants to Six Mile Creek and the lakes and other resources in the watershed. To minimize this pollutant loading and to minimize new stormwater volumes generated from the subwatershed, regional infiltration opportunities such as wetland restoration, underground storage and infiltration, or native vegetation restoration and reforestation may be necessary. Prior to implementing any of these options, opportunities in the subwatershed should be investigated for the most cost-effective and suitable locations. Regional infiltration will be focused on those subwatershed units that are expected to see significant new runoff volumes between 2000 and ultimate development.
Outcome	Minimized new pollutant loads conveyed by runoff; minimized new volumes generated by new development; protection of wetland and surficial groundwater hydrology; wetland restorations; conservation of high-value native vegetation and habitat

Estimated Cost and Funding

Project 1: Improvements in SMC-1. Funding source is District capital levy.	$788,600
Project 2: Improvements in SMC-11. Funding source is District capital levy.	$689,200
Project 3: Improvements in SMC-55. Funding source is District capital levy.	$590,700
Project 4: Improvements in SMC-66. Funding source is District capital levy.	$1,434,000
Project 5: Improvements in SMC-7. Funding source is District capital levy.	$365,700
Project 6: Improvements in SMC-49. Funding source is District capital levy.	$522,400
Project 7: Improvements in SMC-56. Funding source is District capital levy.	$313,400
Project 8: Improvements in SMC-61. Funding source is District capital levy.	$470,100

	Project 9: Improvements in HB-1. Funding source is District capital levy.	$156,700

Schedule

2011: Identify and construct improvements in SMC-1
2014: Identify and construct improvements in SMC-11
2014: Identify and construct improvements in SMC-55
2016: Identify and construct improvements in SMC-66
No Year Assigned: Identify and construct improvements in SMC-7
No Year Assigned: Identify and construct improvements in SMC-49
No Year Assigned: Identify and construct improvements in SMC-56
No Year Assigned: Identify and construct improvements in SMC-61
No Year Assigned: Identify and construct improvements in HB-1

5.8.10 Land Conservation

Project *Six Mile Marsh Subwatershed Land Conservation Activities*

Description Implementation of Land Conservation program activities in the Six Mile Marsh subwatershed, including but not limited to acquisition of conservation easements or fee title to land as well as facilitating partnerships, encouraging conservation planning and activities, providing technical assistance, and education and outreach.

Need The Land Conservation Program is an integral strategy to achieving the goals in this subwatershed plan. Land conservation activities help to maintain and improve ecologic integrity, surface and groundwater quantity and quality, wetlands integrity, and streambank stability. High priority areas are located in this subwatershed, including areas with high ecological values. Conservation of key land cover types may be beneficial to reducing runoff and associated pollutant transport, preserving high-infiltration areas, conserving native vegetation, conserving habitat and natural resource corridors, and improving ecologic integrity.

Outcome Minimized new pollutant loads conveyed by runoff; protection of wetland and surficial groundwater hydrology; wetland restorations; conservation of high-value native vegetation and habitat

Estimated Cost and Funding	Estimated cost to achieve conservation goals in the Six Mile Marsh subwatershed 2007-2017	$8,985,000 District capital levy

Schedule Implement both proactively and as opportunities arise during the period 2007-2017

5.8.11 Other Projects

This Plan identified the need to consider a number of additional projects, but those projects additional, but those projects were not included in the 2007-2016 prioritized CIP. Projects considered but not included are: lake vegetation management projects, internal load management projects for Stone Lake and Auburn West, and regional infiltration opportunities in subwatershed units SMC-7, SMC-49, SMC-56, SMC-61, and HB-1 (see Section 5.8.9 above). The Board may consider such a project during the time frame of this Plan if funds are available.

Project	*Lake Aquatic Vegetation Management*	
Description	Design and implementation of strategies to manage aquatic vegetation that contributes to internal phosphorus loading or degradation of water quality, biotic integrity	
Need	As water quality in lakes improves, the aquatic vegetation communities may change. Improved water clarity may result in accelerated growth of aquatic vegetation that may increase internal phosphorus loading, negatively impact fish or aquatic invertebrate habitat, or increase susceptibility to invasive aquatic species. Management of aquatic vegetation that contributes to lake water quality and biotic integrity issues may require annual treatment for three to five years.	
Outcome	Improved water clarity; more diverse aquatic vegetation and biotic communities; improved aesthetics	
Estimated Cost and Funding	Project 1: Application of vegetation management techniques in Parley Lake. Funding source is the District capital levy.	$54,500
	Project 2: Application of vegetation management techniques in Wasserman Lake. Funding source is the District capital levy.	$42,100
	Project 3: Application of vegetation management techniques in Stone Lake. Funding source is the District capital levy.	$26,600
	Project 4: Application of vegetation management techniques in Auburn Lake East. Funding source is the District capital levy.	$39,300
	Project 5: Application of vegetation management techniques in Auburn Lake West. Funding source is the District capital levy.	$26,600

Schedule	No year has been assigned to these projects, which would be implemented on an as-needed basis. Vegetation management is most effective if applied annually for at least three years in a row.
Project	*Stone Lake Internal Load Management Project*
Description	Design and implementation of strategies to reduce internal phosphorus loading, including: feasibility study; aquatic vegetation survey update and management plan; fishery survey update and management plan; biomanipulation strategies that may include aquatic vegetation management, zooplankton community and fishery manipulation, and chemical treatment
Need	The modeled watershed phosphorus wash-off load to Stone Lake is not sufficient to explain the in-lake concentration of total phosphorus that exceeds the lake's total phosphorus goal. An "unknown load" to Stone Lake is attributed to internal loading, and is likely a combination of bottom sediments, aquatic vegetation, and model accuracy. A watershed and lake diagnostic / feasibility study will be required to confirm the internal and external phosphorous loading to Stone Lake, as well as the necessary load reductions. In particular, the "unknown load" must be identified as either an external or internal load before specific strategies can be selected. A variety of strategies would be investigated in the diagnostic and treatment study proposed in this plan. This project would identify and implement a suite of strategies to manage aquatic vegetation, the fishery, and zooplankton community to achieve water quality and clarity goals. The project includes an ongoing vegetation and fishery management plan.
Outcome	Reduction in phosphorus load from internal sources estimated at 65 pounds annually; improved water clarity; more diverse aquatic vegetation community; improved aesthetics
Estimated Cost and Funding	Investigation, permitting, fish, vegetation, and zooplankton surveys, and implementation of strategies. Funding source is the District capital levy. $18,700 Design, surveys $139,500 Construction $158,200 Total
Schedule	One Year Prior to Implementation: Fish, vegetation, and zooplankton surveys, development of management plans No Year Assigned: Implementation of strategies

Project	*Auburn Lake West Internal Load Management Project*
Description	Design and implementation of strategies to reduce internal phosphorus loading, including: feasibility study; aquatic vegetation survey update and management plan; fishery survey update and management plan; biomanipulation strategies that may include aquatic vegetation management, zooplankton community and fishery manipulation, and chemical treatment
Need	The modeled watershed phosphorus wash-off load to East and West Auburn Lakes is not sufficient to explain the in-lake concentration of total phosphorus that exceeds the lakes' total phosphorus goals. An "unknown load" is attributed to internal loading, and is likely a combination of bottom sediments, aquatic vegetation, and model accuracy. A watershed and lake diagnostic / feasibility study will be required to confirm the internal and external phosphorous loading to the lakes, as well as the necessary load reductions. In particular, the "unknown load" must be identified as either an external or internal load before specific strategies can be selected. A variety of strategies would be investigated in the diagnostic and treatment study proposed in this plan. This project would identify and implement a suite of strategies to manage aquatic vegetation, the fishery, and zooplankton community to achieve water quality and clarity goals. Because Auburn East discharges directly to Auburn West, improvement of Auburn East is critical to improving Auburn West. The project includes an ongoing vegetation and fishery management plan.
Outcome	Reduction in phosphorus load from internal sources estimated at 187 pounds annually; improved water clarity; more diverse aquatic vegetation community; improved aesthetics
Estimated Cost	Investigation, permitting, fish, vegetation, and zooplankton surveys, and implementation of strategies. Funding source is the District capital levy. $18,700 Design, surveys $152,700 Construction $171,400 Total
Schedule	One Year Prior to Implementation: Fish, vegetation, and zooplankton surveys, development of management plans No Year Assigned: Implementation of strategies

5.9 Summary

The following tables summarize the proposed implementation action items and their relationship to the problems and issues identified in Section 3.0 above, the metrics by which the District will be evaluating progress toward resolving those issues and problems, the estimated District cost of implementing these actions, and anticipated implementation schedule.

Table 23. Problems and issues identified in the Six Mile Marsh subwatershed and actions proposed to address them.

	Problem or Issue	Actions in Implementation Plan	Degree of Improvement
Water Quality	Two lakes in the subwatershed have been designated as Impaired Waters on the State's 303(d) list due to an excess of nutrients. The District is preparing Total Maximum Daily Load (TMDL) studies, including plans to reduce phosphorus loads into the lakes, for Parley and Wasserman Lakes	• The draft TMDLs identify potential improvement projects that have been incorporated into this Plan. • Continue monitoring the lakes to assess progress.	Implementation of all the actions in the phosphorus load reduction plans for the lakes would theoretically reduce in-lake P concentrations, improve water clarity, and meet District goals and state and federal water quality standards.
	Other lakes in the subwatershed do not meet the total phosphorus concentration goals established in the HHPLS. No or limited data is available for some lakes.	• A series of improvements projects including detention ponding, wetland and stream restorations intended to work together to reduce phosphorus load conveyed between lakes so that all progress toward meeting the water quality goals. • Obtain baseline data for lakes where no data is available.	Implementation of all the actions in the phosphorus load reduction plans for the lakes would theoretically reduce in-lake P concentrations, improve water clarity, and meet District goals for water quality.
	Phosphorus and sediment loads in Six Mile Creek increase from upstream to downstream, and the creek and its subwatershed are a significant source of phosphorus load to Halsteds Bay.	• A series of improvements projects including detention ponding, wetland and stream restorations intended to work together to reduce phosphorus load conveyed between lakes so that all progress toward meeting the water quality goals. • Proposed treatment of Six Mile Creek prior to its discharge into Halsteds Bay	Implementation of all the actions in the phosphorus load reduction plans for the lakes would theoretically reduce in-lake P concentrations, improve water clarity, and meet District goals for water quality.
	Development, redevelopment, and reconstruction in the subwatershed will increase nutrient and TSS loads from the watershed as well as increasing the volume of stormwater runoff, potentially further degrading water quality.	• Rules will be amended to require more stringent pollutant load reduction on new development and redevelopment, including adding a volume management requirement. • Cooperatively construct regional infiltration improvements to mitigate impact of new runoff from development.	• Would depend on ability of developers to incorporate adequate BMPs on their projects and properly maintain them to sustain removal efficiencies. • Depends on ability to develop cooperative or collaborative improvements.

	Problem or Issue	Actions in Implementation Plan	Degree of Improvement
Water Quantity	Drainage is conveyed through the subwatershed through several streams and channels to lakes and wetlands, which outlet to or an in-line with Six Mile Creek. The *Upper Watershed Stream Assessment* identified eight erosion locations on the creek. The HHPLS predicted that development between 2000 and 2020 would increase average flow in the creek	A stream restoration projects to stabilize areas of a reach with numerous erosion problems, and a project to construct spot repairs.	Completion of projects would repair existing erosion and stabilize the creek where it is most at risk for future erosion.
	The HHPLS idenitified a number of locations that are predicted to overtop during the 100 year event.	LGUs directed to evaluate these locations as part of their local water management planning.	Completed as LGUs complete their local plans.
	Development is predicted to increase the volume of stormwater runoff from the subwatershed, increasing nutrient and TSS loads conveyed downstream.	• Rules will be amended to require more stringent pollutant load reduction on new development and redevelopment, including adding a volume management requirement. • Cooperatively construct regional infiltration improvements to mitigate impact of new runoff from development.	• Would depend on ability of developers to incorporate adequate BMPs on their projects and properly maintain them to sustain removal efficiencies. • Depends on ability to develop cooperative or collaborative improvements.
	The HHPLS identified several locations where for both existing and future conditions, higher velocities than desired may result in erosion at outlets or culverts.	LGUs directed to evaluate these locations as part of their local water management planning.	Completed as LGUs complete their local plans.
	Several landlocked basins are present in the subwatershed. Within these landlocked basins, any future development or redevelopment should minimize creation of new stormwater volumes.	Cities are prohibited from adding outlets to landlocked basins, and must provide for adequate storage and volume control.	Completed as LGUs complete their local plans.
Wetlands	The subwatershed includes numerous wetlands with high to exceptional vegetative diversity, fish and wildlife habitat and aesthetic values that need to be protected.	• Key Conservation Areas identified that include high-value wetlands. Some of these areas are identified as District priorities for continued implementation of the Land Conservation Program, and thus the District would proactively look for opportunities to conserve these resources. The Capital Improvement Program includes funds for Land Conservation Activities. In all key areas, LGUs are required to include in their local plans strategies for conserving these values. • Rules will be amended to establish management standards based on management classification for impacts to wetlands from development and redevelopment.	• Ongoing effort that is dependant on property owner willingness to pursue conservation, District budget and staff capacity, and LGU plan completion. • Implementation of revised rules would help minimize future impacts to the highest-value wetlands while still providing a measure of protection to those that provide mainly downstream resource protection.

	Problem or Issue	Actions in Implementation Plan	Degree of Improvement
	Degraded wetlands with high to moderate restoration potential should be considered for protection and restoration.	• Several wetland restorations are identified as part of the lake TMDL implementation plans and are included in the CIP. • Wetlands identified as being of high to moderate wetland potential would be managed according to a Manage 1 wetland classification if they have been assessed as a Manage 2 or 3. This would minimize further degradation that might make future restoration more difficult or costly.	An initial effort that identifies for restoration those wetlands that would result in improvement to water quality in the lakes. This would begin to mitigate wetland losses from past development and help to increase the quantity and quality of wetlands present.
Ecological Integrity	Most of the subwatershed is characterized by large open areas of forest, grasslands, and wetlands punctuated by low density development. Intensive uses are concentrated along the US Highway 7 corridor and in the cities of Victoria and St. Bonifacius. The Carver Park Reserve dominates the subwatershed, and includes large areas designated as Regionally Significant Ecological Areas and high value native plant communities. Wetlands with high ecological value are present and those wetlands and associated upland areas should be conserved to preserve their values, create larger areas of ecological value, and connect existing resources.	Key Conservation Areas identified that include high-value wetlands. Some of these areas are identified as District priorities for continued implementation of the Land Conservation Program, and thus the District would proactively look for opportunities to conserve these resources. The Capital Improvement Program includes funds for Land Conservation Activities. In all key areas, LGUs are required to include in their local plans strategies for conserving these values.	Ongoing effort that is dependant on property owner willingness to pursue conservation, District budget and staff capacity, and LGU plan completion.
	The fisheries are regularly surveyed and actively managed by the DNR and Three Rivers Park District.	• Continue to work cooperatively with the DNR and Three Rivers on fisheries issues. • Support the fisheries through the improvement of water quality.	Depends on response of natural community to habitat improvement.
	Eurasian water milfoil is present in most of the lakes.	• Support the DNR in its management efforts. • Evaluate milfoil management as part of internal load management diagnostic and feasibility study.	Depends on the extent of infestation. If control of milfoil and other invasive aquatic vegetation will help achieve internal phosphorus load reduction goals, then a significant improvement can be had through chemical or other control. If control would not benefit lake water quality, then there would be no improvement.

	Problem or Issue	Actions in Implementation Plan	Degree of Improvement
	No aquatic plant survey data is available for many of these lakes.	Conduct aquatic plant surveys as part of internal load reduction project feasibility studies and include aquatic vegetation management as part of projects where it would improve water quality	Completion of these surveys would fill this data gap.
	Macroinvertebrate communities are limited by the type of habitat available and its character as primarily a wetland stream.	Stream restoration project to stabilize streambanks and improve habitat	Depends on response of natural community to habitat improvement.
	Corridor connections between Key Conservation Areas need to be preserved, enhanced, and restored.	Key Conservation Areas identified that include this corridor. Some of these areas are identified as District priorities for continued implementation of the Land Conservation Program, and thus the District would proactively look for opportunities to conserve these resources. The Capital Improvement Program includes funds for Land Conservation Activities. In all key areas, LGUs are required to include in their local plans strategies for conserving these values.	Ongoing effort that is dependant on property owner willingness to pursue conservation, District budget and staff capacity, and LGU plan completion.
Groundwater	Most of the major wetlands in the subwatershed were identified in the FAW as discharge or combination recharge-discharge wetlands. As development occurs it will be critical to maintain runoff and infiltration rates to help maintain hydrology to these wetlands.	• Amend rules to require infiltration or abstraction of the first one inch of rainfall on new permitted development and redevelopment. • Identify a network of surficial aquifer monitoring wells across the watershed, monitor groundwater levels and quality. • Promote Better Site Design (Low Impact Development) principles for new development that mimic predevelopment hydrologic regime.	Infiltration on site will assist in preventing further modification of surficial groundwater recharge and help to maintain wetland hydrologic regimes.
	There are a number of areas in the subwatershed that are very highly or highly sensitive to aquifer impacts.	• Amend rules to require pretreatment of stormwater discharged to wetlands or infiltration areas in the areas of high aquifer sensitivity. • Establish a new District rule that requires an additional level of analysis and review of permitted development and redevelopment where there is a potential for development to adversely impact groundwater connected to a surface water feature.	Will help minimize future impacts to groundwater and provide for proactive management rather than reactive

	Problem or Issue	Actions in Implementation Plan	Degree of Improvement
	Wellhead Protection Areas and associated Drinking Water Sensitivity Management Areas have been identified for the cities of St. Bonifacius and Minnetrista within this subwatershed.	• Stormwater and groundwater management within those areas will be coordinated with wellhead protection plans.	• Will help minimize future impacts to drinking water and provide for proactive management rather than reactive
	Groundwater hydrology is an important component in the base flow for area streams. Protecting existing groundwater flow regimes must remain a priority.	• Amend rules to require infiltration or abstraction of the first one inch of rainfall on new permitted development and redevelopment. • Identify a network of surficial aquifer monitoring wells across the watershed, monitor groundwater levels and quality. • Identify baseflow in Six Mile Creek and monitor for trends.	• Infiltration on site will assist in preventing further modification of surficial groundwater recharge and help to maintain wetland hydrologic regimes. • Implementation of monitoring network will fill data gap and allow for identification of trends • Identification of baseflow will fill data gap, allow for identification of trends, and improve understanding of hydrology and hydraulics of Six Mile Creek

Table 24. Summary of metrics to be used in evaluating progress toward Six Mile Marsh subwatershed goals.

Objective	Metric	Existing	Desired	Location
Water Quality	Phosphorus Loading (lbs annually)	498 (Ultimate)	245	Pierson Lake
	Phosphorus Loading (lbs annually)	1,144 (Ultimate)	395	Wasserman Lake
	Phosphorus Loading (lbs annually)	268 (Ultimate)	142	Steiger Lake
	Phosphorus Loading (lbs annually)	121 (Ultimate)	100	Zumbra Lake
	Phosphorus Loading (lbs annually)	187 (Ultimate)	105	Stone Lake
	Phosphorus Loading (lbs annually)	1,081 (Ultimate)	580	Auburn East
	Phosphorus Loading (lbs annually)	778 (Ultimate)	401	Auburn West
	Phosphorus Loading (lbs annually)	1,015 (Ultimate)	794	Lunsten Lake
	Phosphorus Loading (lbs annually)	3,023 (Ultimate)	1,684	Parley Lake
Water Quantity	Volume Reduction (Acre-feet)		1,084	Watershed-wide
	1.5 year discharge (cfs)	23.4	23.4	Watershed-wide
	100 year discharge (cfs)	97.7	97.7	Watershed-wide
Ecologic Integrity	Index of Biotic Integrity	N/A	Above MPCA impairment threshold	Six Mile Creek Reach 15
		N/A	Above MPCA impairment threshold	Six Mile Creek Reach 14
		6.3 (F-IBI)	Above MPCA impairment threshold	Six Mile Creek Reach 13
		N/A	Above MPCA impairment threshold	Six Mile Creek Reach 12
		5.97-6.21 (F-IBI)	Above MPCA impairment threshold	Six Mile Creek Reach 11
		N/A	Above MPCA impairment threshold	Six Mile Creek Reach 10
		N/A	Above MPCA impairment threshold	Six Mile Creek Reach 9
		6.21-6.59 (F-IBI)	Above MPCA impairment threshold	Six Mile Creek Reach 8
		N/A	Above MPCA impairment threshold	Six Mile Creek Reach 7
		6.41 (F-IBI)	Above MPCA impairment threshold	Six Mile Creek Reach 6
		N/A	Above MPCA impairment threshold	Six Mile Creek Reach 5
		5.5 (F-IBI)	Above MPCA impairment threshold	Six Mile Creek Reach 4
		N/A	Above MPCA impairment threshold	Six Mile Creek Reach 3
		N/A	Above MPCA impairment threshold	Six Mile Creek Reach 2

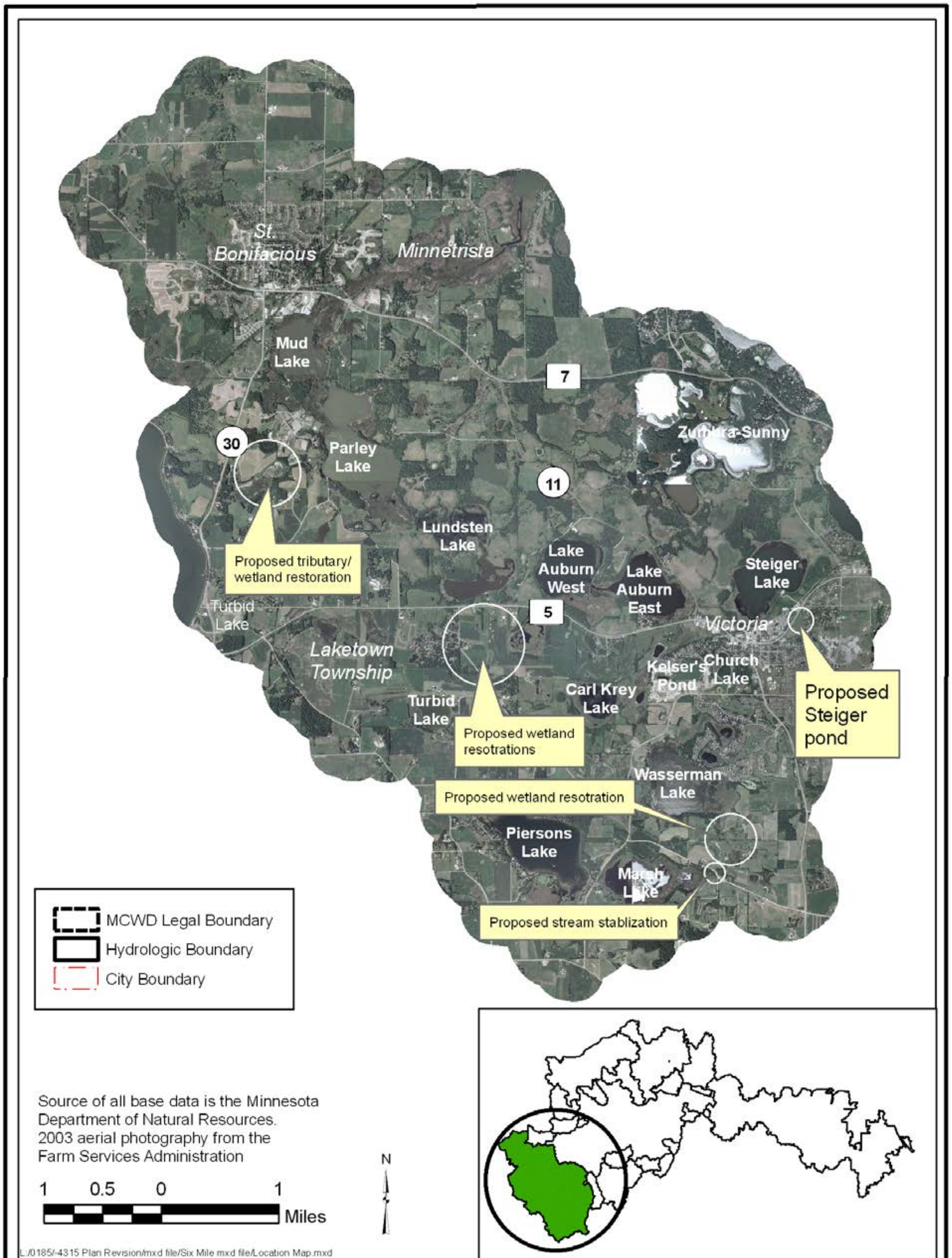
Objective	Metric	Existing	Desired	Location
		6.29 (F-IBI)	Above MPCA impairment threshold	Six Mile Creek Reach 1
	Stream Visual Assessment Protocol	N/A	5.0 or 1+ existing	Six Mile Creek Reach 15
		N/A	5.0 or 1+ existing	Six Mile Creek Reach 14
		N/A	5.0 or 1+ existing	Six Mile Creek Reach 13
		N/A	5.0 or 1+ existing	Six Mile Creek Reach 12
		N/A	5.0 or 1+ existing	Six Mile Creek Reach 11
		N/A	5.0 or 1+ existing	Six Mile Creek Reach 10
		N/A	5.0 or 1+ existing	Six Mile Creek Reach 9
		N/A	5.0 or 1+ existing	Six Mile Creek Reach 8
		N/A	5.0 or 1+ existing	Six Mile Creek Reach 7
		N/A	5.0 or 1+ existing	Six Mile Creek Reach 6
		N/A	5.0 or 1+ existing	Six Mile Creek Reach 5
		N/A	5.0 or 1+ existing	Six Mile Creek Reach 4
		N/A	5.0 or 1+ existing	Six Mile Creek Reach 3
		N/A	5.0 or 1+ existing	Six Mile Creek Reach 2
		N/A	5.0 or 1+ existing	Six Mile Creek Reach 1
	Key Conservation Areas conserved (acres)		788	Watershed-wide
Wetlands	Wetland Acreage	6,098.8	6,098.8 or greater	Watershed-wide
		332.0	332.0 or greater	Preserve
		1,175.0	1,175.0 or greater	Manage 1
		494.2	494.2 or greater	Manage 2
		2,466.6	2,466.6 or greater	Manage 3

Table 25. Summary of Six Mile Marsh subwatershed implementation program.

Item	Description	Estimated Cost	Schedule	Problems Addressed
MCWD Capital Projects				
1	Internal load reduction: Wasserman Lake	$211,700	2015	3.1.1, 3.1.3, 3.1.4
2	Wasserman Phase I culvert/stream/wetland restoration	$721,300	2008	3.1.1, 3.1.3, 3.1.4, 3.3.2, 3.4.1, 3.4.6
3	Wasserman: stream/wetland restoration	$687,500	2010	3.1.1, 3.1.3,3.1.4
4	Steiger Lake pond	$805,600	2012	3,1,2 3.1.3, 3.1.4
5	Turbid/Lunsten Hwy 5 wetland restoration	$463,300	2012	3.1.1, 3.1.3, 3.1.4, 3.3.2, 3.4.1, 3.4.6
6	Turbid/Lunsten: Laketown Rd wetland restoration	$200,800	2011	3.1.1, 3.1.3, 3.1.4, 3.3.2, 3.4.1, 3.4.6
7	Parley: tributary wetland restoration	$547,600	2008	3.1.1, 3.1.3, 3.1.4, 3.2.1, 3.2.3, 3.4.1, 3.4.6
8	Internal load reduction: Parley Lake	$231,600	2013	3.1.1, 3.1.3, 3.1.4
9	Internal load reduction: Auburn East	$187,300	2014	
10	Spot repairs to eroded sites on Six Mile Creek	$60,900	2015	3.1.23,3.1.3, 3.1.4, 3.2.1, 3.2.3, 3.4.1, 3.4.6
11	Regional infiltration	$788,600	2011	3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.2.3, 3.2.5,
		$689,200	2014	

Item	Description	Estimated Cost	Schedule	Problems Addressed
		$590,700	2014	3.3.1, 3.4.1, 3.5.1, 3.5.4
		$1,434,000	2016	
MCWD Data Acquisition/Study				
1	Develop infiltration/filtration strategies appropriate to wellhead protection areas and areas of groundwater sensitivity	Part of watershed-wide study	2008	3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.2.1, 3.2.2, 3.2.3, 3.2.4, 3.2.5, 3.3.1, 3.3.2, 3.4.1, 3.4.6, 3.5.1
2	Identify keystone, umbrella, and indicator species, evaluate habitat, and develop conservation strategies	Part of watershed-wide study	2010 and ongoing	3.3.1, 3.4.1, 3.4.2, 3.4.4, 3.4.5, 3.4.6
3	Identify feedlot and animal waste management locations and develop plan for implementing agricultural BMPs	Part of watershed-wide effort	2008 and ongoing	3.1.1, 3.1.2, 3.1.3
MCWD Land Conservation Program				
1	Undertake land conservation efforts in accordance with Figure 19	$8,985,000	Part of ongoing watershed-wide program	3.1.1, 3.1.2, 3.3.1, 3.3.2, 3.4.1, 3.4.6, 3.5.1
MCWD Regulatory Program				
1	Amend District Rules to increase stormwater management requirements for new development and redevelopment	Part of watershed-wide effort	2007-2009	3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.2.1, 3.3.1, 3.3.2, 3.4.1, 3.4.3, 3.4.5, 3.4.6
2	Amend District Rules to require abstraction of 1” of rainfall on permitted development and redevelopment	Part of watershed-wide effort	2007-2009	3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.2.1, 3.2.2, 3.2.3, 3.2.4, 3.2.5, 3.3.1, 3.3.2, 3.4.1, 3.4.3, 3.4.5, 3.4.6
3	Amend District Rules to adopt wetland management rules based on wetland management classification	Part of watershed-wide effort	2007-2009	3.3.1, 3.3.2, 3.4.1, 3.4.6, 3.5.1
MCWD Hydrodata Program				
1	Monitor Six Mile Creek in accordance with Hydrodata Program	Part of watershed-wide hydrologic data program	Part of ongoing watershed-wide program	3.1.1, 3.1.2, 3.1.3, 3.14, 3.2.1, 3.2.3,
2	Monitor macroinvertebrates in Six Mile Creek every five years	Part of watershed-wide hydrologic data program	2009, 2013	3.4.1, 3.4.5
3	Identify base level flow in Six Mile Creek	Part of watershed-wide study	Part of ongoing watershed-wide program	3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.2.1, 3.2.3, 3.4.5, 3.5.1
4	Monitor lakes in accordance with Hydrodata Program	Part of watershed-wide hydrologic data program	Part of ongoing watershed-wide program	3.1.1, 3.1.2
5	Identify shallow wells to monitor groundwater levels	Part of watershed-wide study	2008 and ongoing	3.2.1, 3.3.1, 3.3.2, 3.4.1, 3.4.6, 3.5.1, 3.5.2
MCWD Education/Communication Program				
1	Provide targeted education materials to key stakeholder groups to meet objectives of plan	Part of watershed-wide education program	Part of ongoing watershed-wide program	All

Item	Description	Estimated Cost	Schedule	Problems Addressed
2	Provide educational opportunities for LGU staff, developers, elected and appointed officials and other interested parties	Part of watershed-wide education program	Part of ongoing watershed-wide program	All
3	Develop and distribute model ordinances and design standards that incorporate low impact design principles	Part of watershed-wide education program	Part of ongoing watershed-wide program	3.1.1, 3.1.3, 3.1.4, 3.2.1, 3.2.3, 3.4.1, 3.4.6
4	Develop a small grant program to provide financial assistance to property owners desiring to implement BMPs on their property or to install demonstration projects on public property	Part of watershed-wide program	2008 and ongoing	3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.2.1, 3.2.2, 3.2.3, 3.2.4, 3.2.5, 3.3.1, 3.3.2, 3.4.1, 3.4.3, 3.4.5, 3.4.6
MCWD Operations and Maintenance				
1	Inspect Six Mile Creek erosion-prone areas at least annually	Part of watershed-wide program	Part of ongoing watershed-wide program	3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.2.1, 3.2.3, 3.2.4, 3.2.5, 3.2.6
2	Monitor high vegetative-diversity wetlands for exotic species	Part of watershed-wide program	Part of ongoing watershed-wide program	3.3.1, 3.3.2, 3.4.1, 3.4.6, 3.5.1
3	Inspect and maintain improvements as set forth in cooperative agreements	Incorporate into life-cycle cost of project	Part of ongoing watershed-wide program	3.1.2, 3.1.3, 3.2.1, 3.3.1, 3.3.2, 3.4.5, 3.4.6
Collaborative Projects				
1	Work in partnership with Three Rivers Park District to develop and implement lake aquatic management plans for Auburn West, Lunsten, Stone, and Steiger Lakes	$10,000	2009 and later	3.1.2, 3.1.3, 3.1.4, 3.4.2, 3.4.2, 3.4.4, 3.4.6
2	Work in partnership with Three Rivers Park District to evaluate and implement strategies for operating outlet control structures in the Carver Park Reserve to maximize storage capacity and manage flows	Staff time	Ongong	3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.2.1, 3.2.2, 3.2.3, 3.2.4, 3.4.5



MINNEHAHA CREEK WATERSHED DISTRICT	Minnehaha Creek Watershed District	DEC 2005
Six Mile Marsh Implementation Plan		Figure 20

Wenck
Engineers • Scientists
Business Professionals

Wenck File #0185-5050

MARCH 2013

Six Mile Creek Diagnostic Study

Prepared for:

MINNEHAHA CREEK WATERSHED DISTRICT

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APPENDICES

Acronyms and Units of Measurement

APPLE	Area Partnership for Pierson Lake Enhancement
BMP	Best Management Practice
DNR	Minnesota Department of Natural Resources
MCWD	Minnehaha Creek Watershed District
mg/L	milligrams per liter
$mg/m^2/day$	milligrams per meters square per day
MLCCS	Minnesota Land Cover Classification System
OP	Ortho-phosphorus
P	Phosphorus
SAV	Submerged Aquatic Vegetation
SCS	Soil Conservation Service (now the Natural Resource s Conservation Service)
SSTS	Subsurface Sewage Treatment System
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TSS	Total Suspended Solids
UAL	Unit Area Load
µg/L	micrograms per liter

Executive Summary

The Six Mile Creek watershed covers 26.6 square miles including parts of Victoria, Laketown Township, St. Bonifacius, and Minnetrista. The Carver Park Reserve, owned and operated by the Three Rivers Park District, also covers a large portion of the watershed, including the areas draining to Stone, Zumbra, Steiger, East and West Auburn, and North and South Lundsten lakes. The watershed is relatively flat and is dominated by hydric soils and low lying wetland areas. The watershed is highly altered with development in parts of the watershed and drained agricultural lands throughout. Many of the wetlands are highly ditched and the channels themselves indicate alterations, such as straightening for drainage improvements.

The purpose of the diagnostic study is to develop a holistic-comprehensive analysis of the subwatershed that will help refine a strategic implementation approach that will examine Six Mile Creek Subwatershed to develop an approach to the watershed's issues using a phased systematic method. The diagnostic study analyzed the subwatershed by developing refined water and phosphorus budgets, including internal loading, for lakes in the Six Mile Creek watershed to identify implementation actions to improve water quality. The water and phosphorus budgets include the development of lake response models for the major lakes to refine our understanding of internal versus external loading and target reductions to meet water quality goals. The diagnostic study also investigates fish and plant communities in the lakes to develop an understanding of the health of the biological communities and how these conditions may affect water quality.

The Six Mile Creek Implementation Plan will focus on integrating water projects with city, county and TRPD land use planning and development objectives to accomplish mutual goals through economical and efficient use of public dollars. Integrated watershed planning is defined as "the process of formulating and implementing a course of action involving natural and human resources in a watershed, taking into account the social, political, economic and institutional factors operating within the watershed and surrounding river basin and other relevant regions to achieve specific social objectives.[1]

The Six Mile Creek Subwatershed Implementation plan will incorporate broad-based goals and principles for the Six Mile Creek Subwatershed that incorporate social, political, economic, and natural objectives. Principles will focus on the fact that watershed management is continuous process and needs a multi-disciplinary approach to solve the multi-faceted problems a watershed faces. A strong implementation plan for Six Mile Creek watershed will use sound science, facilitate communication and partnerships, foster thoughtful action, stimulate actions and tracks results.

[1] "Watershed Resources Management: Studies from Asia and the Pacific"; edited by K. William Easter, John Alexander Dixon, Maynard M. Hufschmidt

Minnehaha Creek Watershed District and the City of Victoria hosted over twenty residents, policy makers and staff at the July 19th 2012, Six Mile Creek Diagnostic meeting. The meeting featured an informational portion in which staff described the purpose, scope and methodology of the study.

Top concerns for six mile creek community meeting participants include:

- Game Fish Health
- AIS Control
- Runoff Control
- Agricultural Impacts
- Development impacts
- Aeration of shallow lakes/wetlands
- Water quality (differences between lakes)
- Management of Lakes (Public Use)
- Internal Loading (How do we deal with it?)
- Degraded Wetlands (Carp Habitat)
- Life After Carp
- What can Lake Associations and Residents do now?

The Diagnostic study culminated with watershed and lake restoration strategies developed for the Six Mile Creek watershed based on sound science and waterbody needs. Activities are broken into three categories, including monitoring activities aimed at improving our scientific understanding of the system, restoration activities aimed at improving water quality or ecological health of the watershed, and protection activities aimed at protecting good water quality or ecological conditions in the watershed.

Carp Management

Carp play a large role in water quality in the Six Mile Creek subwatershed. An essential component of the Six Mile Creek implementation plan is to develop a thorough understanding of carp population, movement, reproduction locations and age. MCWD intends to work with Dr. Peter Sorenson at the University of Minnesota to better understand carp movement and reproduction in the Six Mile Creek watershed. Carp management in the watershed should focus on four distinct areas, including the Pierson-Marsh-Wassermann, Carver Park Reserve, Turbid-South Lundsten, and the Parley-Mud Management Unit. Although there is potential for carp to mingle among the watersheds, the conditions of the lakes and anecdotal evidence in the watershed suggest that this is minimal.

Management of carp in the watershed needs to focus on removing current carp biomass from the system and eliminating carp reproduction areas in the watershed. For removals to be effective, areas where carp tend to congregate need to be identified so that seining can be completed. Often times this requires tracking carp or using side-scan sonar to identify the location of the fish. Other techniques include the use of whole lake drawdown or rotenone (a fish poison) to kill large numbers of fish.

Nutrient Management

Watershed nutrient reduction projects and monitoring activities were identified for each of the subwatersheds in the Six Mile Creek watershed. Some of the identified subwatersheds had degraded (ditched or altered) wetlands that appear likely to be contributing phosphorus to surface waters. Other projects include retrofitting existing ponds with iron enhanced sand filters.

Monitoring locations were identified to verify mass balances and assumptions made from completion of the lake response models. In 2013, MCWD plans to monitor Sunny Lake and the two ponds flowing into Wassermann Lake as well as 3 additional stream sites including an inflow to Mud Lake (off County Road 92), 2 Parley Lake inflows including one on the Crown College property and another by the Parley Lake Winery.

In the upper watershed, a few subwatersheds demonstrated a large potential for nutrient loading. For some watersheds (SMC-11, SMC-15, SMC-25), the loading appears to be coming from degraded wetlands that are discharging high phosphorus concentrations. Other subwatersheds were more developed where loading is likely from increased impervious areas (SMC-5, SMC-13). In the lower watershed, the sources of phosphorus loading are less clear, mostly because the tributaries to the lakes lack good monitoring data. However, the lake response models suggest that both Parley and Mud lakes receive relatively high nutrient loads from the watershed. Sources in the lower watershed are likely a mix of developed and agricultural sources.

Internal Nutrient Load Reductions

Four lakes were identified for internal load control projects including Wassermann, Turbid, South Lundsten, and Parley lakes. Each demonstrated sufficient internal loads to warrant load projects.

Lake Restoration Projects

Three lakes need to be considered for whole- lake drawdown, including South Lundsten, Parley, and Mud Lake. A drawdown on South Lundsten Lake can be conducted concurrently with carp removal efforts as the drawdown will make it easier to remove carp. However, reintroduction from Turbid Lake should be controlled. South Lundsten Lake appears to be the primary reproduction area, so a large carp removal paired with preventing future winterkills should restore the lake for the long term.

Drawdown on Parley and Mud is much more complex due to the large runoff volumes entering the lake and the potential backwater effects from Halsted Bay. However, a drawdown should be evaluated for the lakes.

Invasive Species and Vegetation Management

Most of the lakes in the watershed contain curly-leaf pondweed and Eurasian watermilfoil, which can lead to decreased SAV diversity and other problems in the lakes. Curly-leaf pondweed can be problematic in the lakes due to midseason senescence, exposing lake sediments and possibly contributing to internal loading. Most of the lakes sampled had robust populations of SAV; however, they were dominated by coontail, a native species indicative of more eutrophic conditions.

Watershed Protection Strategies

Several of the subwatersheds in the Six Mile Creek watershed have receiving waters with good or excellent water quality including Piersons Lake, Zumbra Lake, and North Lundsten Lake among others. Therefore, activities in these watersheds are considered protection activities. Protection activities can include BMP implementation such as iron enhanced sand filters or septic system upgrades. Protection activities also include such things as implementation of MCWD rules to protect water quality during development.

1.0 Introduction and Watershed Description

1.1 PURPOSE AND SCOPE

The purpose of the diagnostic study is to develop a holistic-comprehensive analysis of the subwatershed that will help refine a strategic implementation approach that will examine Six Mile Creek Subwatershed to develop an approach to the watershed's issues in thorough phased systematic method. The diagnostic study analyzed the subwatershed through developing refined water and phosphorus budgets, including internal loading, for lakes in the Six Mile Creek watershed to identify implementation actions to improve water quality. The water and phosphorus budgets include the development of lake response models for the major lakes to refine our understanding of internal versus external loading and target reductions to meet water quality goals. The diagnostic study also investigates fish and plant communities in the lakes to develop an understanding of the health of the biological communities and how these conditions may affect water quality.

The Six Mile Creek Implementation Plan will focus on integrating water projects with city, county and TRPD land use planning and development objectives to accomplish mutual goals through economical and efficient use of public dollars. Integrated watershed planning is defined as "the process of formulating and implementing a course of action involving natural and human resources in a watershed, taking into account the social, political, economic and institutional factors operating within the watershed and surrounding river basin and other relevant regions to achieve specific social objectives.[2]

The Six Mile Creek Subwatershed Implementation plan will incorporate broad-based goals and principles for the Six Mile Creek Subwatershed that incorporate social, political, economic, and natural objectives. Principles will focus on the fact that watershed management is continuous process and needs a multi-disciplinary approach to solve the multi-faceted problems a watershed faces. A strong implementation plan for Six Mile Creek watershed will use sound science, facilitate communication and partnerships, foster thoughtful action, stimulate actions and tracks results.

1.2 WATERSHED DESCRIPTION

The Six Mile Creek watershed covers 26.6 square miles including parts of Victoria, Laketown Township, St. Bonifacius, and Minnetrista (Figure 1-1). The Carver Park Reserve, owned and operated by the Three Rivers Park District, also covers a large portion of the watershed, including the areas draining to Stone, Zumbra, Steiger, East and West Auburn, and North and South Lundsten lakes. The watershed is relatively flat and is dominated by hydric soils and low lying wetland areas. The watershed is highly altered with development in parts of the watershed and drained agricultural lands throughout. Many of

[2] "Watershed Resources Management: Studies from Asia and the Pacific"; edited by K. William Easter, John Alexander Dixon, Maynard M. Hufschmidt

the wetlands are highly ditched and the channels themselves indicate alterations, such as straightening for drainage improvements.

Figure 1-1 Six Mile Creek watershed.

Drainage Patterns

Six Mile Creek is the dominant creek in the watershed, running approximately 12 miles from the outlet of Pierson Lake to Halsted Bay on Lake Minnetonka (Figure 1-2). Six Mile Creek largely flows through lakes or wetlands as it winds its way through the watershed. The creek starts at Pierson Lake, discharging into shallow Marsh Lake. From Marsh Lake the creek works its way through a series of wetlands before discharging into Wassermann Lake. From Wassermann the creek flows through a large wetland area, which receives drainage from Carl Krey and Church lakes as well as Kelser's Pond before discharging to East Auburn Lake. East Auburn Lake receives additional drainage from the east, including the outlets of Steiger and Sunny lakes. The discharge from both Sunny and Steiger lakes flows through large wetlands prior to discharging to East Auburn Lake. From there the creek flows through West Auburn, which discharges to a large wetland complex. This wetland drains to North Lundsten, ultimately flowing to Parley Lake and Halsted's Bay through Mud Lake. Lundsten Lake is divided into two basins, North and South, by a horse trail maintained by the Three Rivers Park District. The two basins are connected by a two-foot culvert under the trail. The lake can also overtop the trail just east of the culvert during high water conditions. South Lundsten Lake receives drainage from Turbid Lake through a series of ditched wetland areas. The outlet of Lundsten Lake is a three-foot arch pipe that likely blocks fish passage from downstream to upstream. Six Mile Creek ends its journey to Halsted Bay after flowing through the Six Mile Marsh, a 300-acre wetland complex that includes a primary channel that is partially used for boat access to Halsted Bay.

Six Mile Creek is a low gradient stream (average slope around 0.06%) characterized by straightened channels and wetland reaches where the channel appears to have been maintained at some point. There are numerous water control structures throughout the watershed. Drainage in the Stone Lake area is quite complex with a number of water control structures maintained by the Three Rivers Park District (Figure 1-3).

The watershed appears to be impacted by backwater effects from Halsted Bay as far up as Parley Lake. The water control structure at the outlet of North Lundsten Lake acts as a hydrologic "break" in the watershed, which prevents backwater or other impacts from the lower lakes.

Land Use

Land use in the Six Mile Creek watershed is a mix of agricultural and developed areas pocketed with wetlands (Figure 1-4; Table 1-1). Development in the watershed is generally found in the southeast portion of the watershed in the drainage areas around Wassermann, Church, and Steiger lakes. The watershed includes two golf courses, Deer Run Golf Club in the southeast and Island View Golf Club on the western edge of the watershed. The lakes in the southern portion of the watershed, notably Pierson and Wassermann lakes, have concentrated development along their shorelines. Further development, including the City of St. Bonifacius, occurs in the north part of the watershed and drains to Mud Lake.

Table 1-1. Land use based on the MLCCS data set in the Six Mile Creek watershed.

Land Use	Acres	Percent Total
Agriculture	2,829	17%
Grassland	2,647	16%
Forest	2,467	14%
Open Water	2,309	14%
Emergent Marsh	2,193	13%
26% to 50% impervious cover	998	6%
Row Crops	860	5%
11% to 25% impervious cover	782	5%
Corn	715	4%
4% to 10% impervious cover	368	2%
76% to 90% impervious cover	220	1%
91% to 100% impervious cover	211	1%
Wetland	140	1%
51% to 75% impervious cover	130	1%
Shrubland	122	1%
Corn on hydric soils	36	0.2%

Figure 1-2 Drainage patterns in the Six Mile Creek watershed.

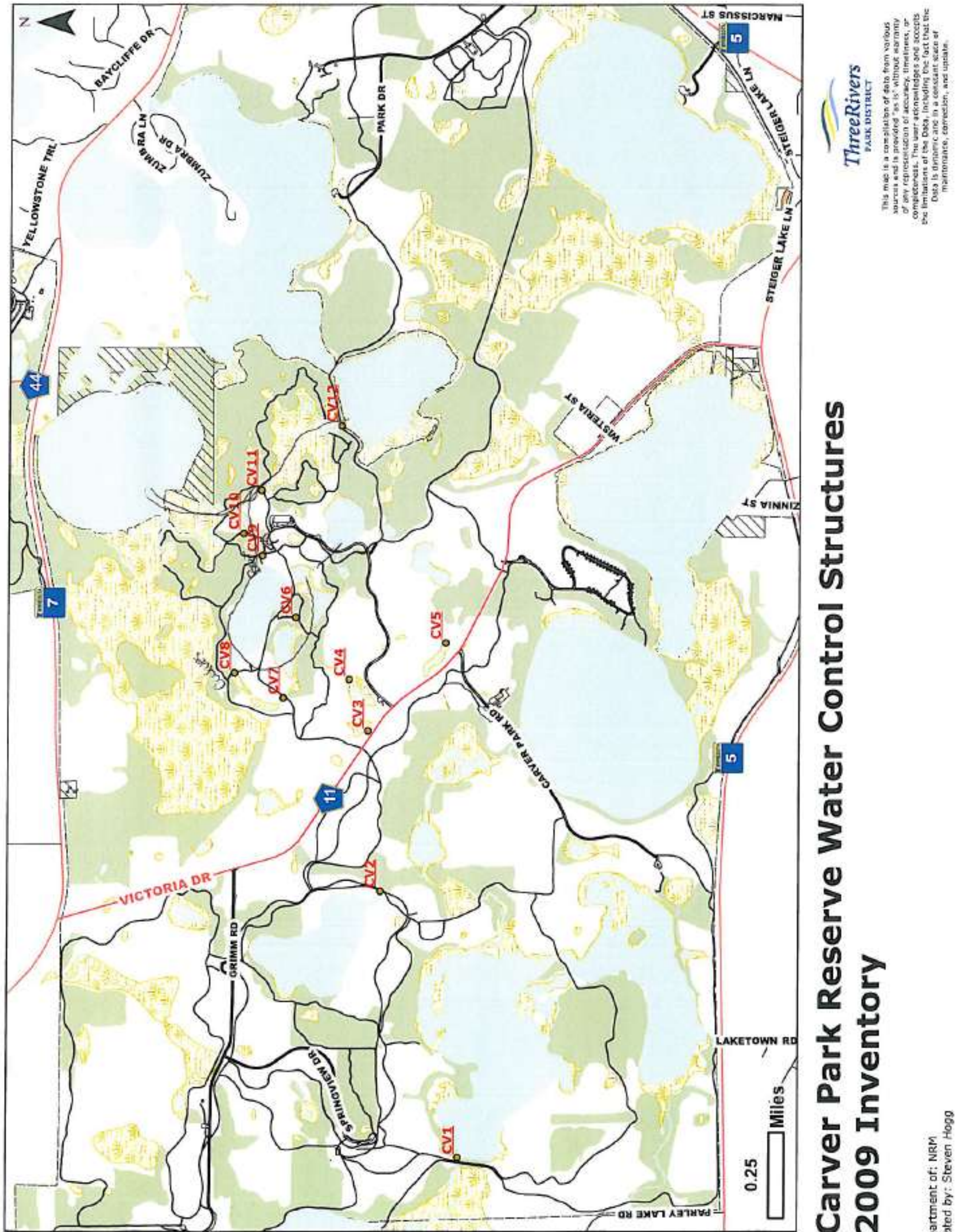

Figure 1-3 Water control structures in the Stone Lake watershed.
Note: Provided by Three Rivers Park District.

The central portion of the watershed is dominated by the Carver Park Reserve, a 250-acre preserve that includes eight lakes interconnected by wetlands. Carver Park Reserve is home to the Lowry Nature Center, Grimm Farm Historic Site, and King Waterbird Sanctuary. Activities include hiking and biking trails, rolling wooded terrain, and interconnected lakes and marshes for exploring and cross country skiing as well as numerous other activities. Land in the park area is relatively flat and open with minimal development that includes the Nature Center, the Lake Auburn Campground, and paved and unpaved trails.

The lower portion of the watershed is dominated by agricultural land and low-lying wetlands. The drainage area to the west of Parley and Mud lakes includes agricultural fields, orchards, and the Island View Golf Club. The northern drainage area of Mud Lake includes some development, mostly single family residential in and around St. Bonifacius.

Laketown Township, Minnesota, entered into an orderly annexation agreement in 1972 with the municipalities of Chaska, Victoria, and Waconia (Figure 1-5). The annexations are restricted to specific areas delineated in the provisions of the agreement. Provisions governing the annexations include: township areas to be annexed must abut the annexing city, the area must be urban or suburban in character (or about to become so), the annexing city must be capable of providing services to the area to be annexed within a reasonable timeframe, and the area being annexed must be contiguous. Land can be annexed immediately if it meets these criteria, unless there is a petition against annexation signed by 80% of the owners of the property proposed to be annexed, and Laketown Township supports the petition. The municipalities that are party to the agreement are expected to meet semi-annually to discuss problems and to coordinate provision of governmental services within the orderly annexation area.

Agriculture in the Six Mile Creek watershed is a mixture of row and non-row crops with a few orchards in the watershed (Figure 1-8, Table 1-2). Although there is a fair amount of row crop in the watershed, it appears to be less intensive based on the relatively flat topography, stable soils, and lack of manure production and application in the watershed. Based on the MLCCS land cover, approximately 4,044 of 17,025 acres (24%) in the Six Mile Creek watershed are in agricultural use. The MLCCS categories were relatively general, so the National Agricultural Statistical Survey data set was used to estimate the types of crops in the watershed. Approximately half is currently in a corn/soybean rotation.

Table 1-2. Predominant agricultural land cover in the Six Mile Creek watershed based on the NASS data set.

Agricultural Land Cover	Acres
Corn	1,512
Alfalfa	791
Soybeans	785
Other Crops	351
Barren	63
Grains	21

1.3 DEEP AND SHALLOW LAKE ECOLOGY

Shallow lakes are ecologically different than deep lakes due to a greater interaction with lake sediment and a greater influence of the biology of the lake. In shallow lakes, there is a greater area of sediment-water interface, allowing for potentially larger sediment contributions to nutrient loads as well as sediment resuspension that can decrease water clarity. Biological organisms also play a greater role in maintaining water quality. Rough fish, especially carp, can uproot submerged aquatic vegetation and stir up sediment, contributing to sediment nutrient loading and sediment resuspension. Submerged aquatic vegetation stabilizes the sediment, reducing the amount that can be resuspended in turn protecting water clarity. Submerged aquatic vegetation also provides refugia for zooplankton, a group of small crustaceans that can reduce algae populations through grazing.

All of these interactions result in the lake residing in one of two alternative stable states: a clear-water state and a turbid water state. The clear water state is characterized by clear water, a robust and diverse submerged aquatic vegetation community, a balanced fish community, and large daphnia (a zooplankton that is very effective at algal grazing). Alternatively, the turbid water state typically lacks submerged aquatic vegetation, is dominated by rough fish, and is characterized by turbid water from both sediment resuspension and algal productivity. Which state persists depends on the biological community as well as the nutrient conditions in the lake. Therefore, lake management must focus on the biological community as well as the water quality of the lake.

A five-step process developed for restoring shallow lakes in Europe also is applicable in the United States. The steps established for restoring shallow lakes include:

1. Forward switch detection and removal
2. External and internal nutrient control
3. Biomanipulation (reverse switch)
4. Plant establishment
5. Stabilization and management of the restored system

The first step refers to identifying and eliminating those factors that are driving the lake into a turbid water state (also known as switches). These can include high nutrient loads, invasive species such as carp and curly-leaf pondweed, altered hydrology, and direct physical impacts such as plant removal. Once the switches have been eliminated, an acceptable nutrient load must be established for the lake. After the first two steps, the lake is likely to remain in the turbid water state even though conditions have improved. The lake must be forced back into the clear lake state by manipulating the biology of the lake, also known as biomanipulation. Biomanipulation typically includes whole-lake drawdown and fish removal. Once the submerged aquatic vegetation has been established, management will focus on stabilizing the lake in the clear state (steps 4 and 5).

The purpose of this study is to identity the forward switches (steps 1 and 2) currently limiting water quality in the Six Mile Creek watershed. Once those forward switches are identified and nutrient budgets developed, appropriate management actions can be recommended.

1.4 COMMUNITY ENGAGEMENT

Minnehaha Creek Watershed District and the City of Victoria hosted over twenty residents, policy makers and staff at the July 19, 2012, Six Mile Creek Diagnostic meeting. The meeting featured an informational portion in which staff described the purpose, scope and methodology of the study. Holly Kreft from the City of Victoria spoke about how the city will use the results from the diagnostic study and the results from the evening's engagement portion. Dr. Peter Sorensen, from the University of Minnesota, gave a fascinating presentation on the history of carp in Europe and America as well as details of his recent work in Lake Susan on estimating a population of carp, tracking their movements and ultimately removing carp from the system.

After Dr. Sorenson presented, the meeting moved into the community input portion of the evening, led by Alex Gehrig of the Freshwater Society. The question we asked participants to focus on and discuss was: "What are the significant water resource issues in your area?" The engagement portion of the evening produced lively discussion and preliminary results suggested that game fish health, AIS control, runoff control and agricultural impacts were the most significant issues of concern for residents in Six Mile Creek subwatershed.

Top concerns for six mile creek community meeting participants include:

- Game Fish Health
- AIS Control
- Runoff Control
- Agricultural Impacts
- Development impacts
- Aeration of shallow lakes/wetlands
- Water quality (differences between lakes)
- Management of Lakes (Public Use)
- Internal Loading (How do we deal with it?)
- Degraded Wetlands (Carp Habitat)
- Life After Carp
- What can Lake Associations and Residents do now?

Minnehaha Creek Watershed District will hold community meetings and input sessions once the Diagnostic Study is finalized MWCD staff will present the findings to the MCWD Board and partners. At the community meeting staff will explain the results and post the report online. Staff will use the findings, along with input from communities and partners, to develop a long-term strategic plan for protecting and improving the Six Mile Creek subwatershed.

1.5 WETLANDS

Wetlands are a predominant feature in the watershed as a result of low gradients and hydric soils (Figure 1-6). Historically, wetlands covered approximately 6,238 acres of the watershed (based on 1930 aerial photos). Since the 1930s, almost 2,000 acres of wetlands have been lost from the watershed, likely as a result of increased drainage. These practices continue to impact the remaining wetlands by changing the hydrology of the wetland, ultimately affecting its water quality. Increased wet and dry periods can lead to net exports of phosphorus from wetlands, resulting in increased eutrophication of the receiving waters. Furthermore, these practices can lead to concentrated water in parts of the wetlands that are prone to winterkill. These shallow areas can support carp reproduction in the watershed. Carp are a major problem for lake water quality in Six Mile Creek, especially in shallow lakes, and ultimately need to be controlled for other restoration efforts to be effective.

Changes to the wetlands in the Six Mile Creek watershed are likely a large contributing factor to current conditions in the watershed. Increased phosphorus release, support for invasive species such as carp and invasive plants, and changes in the overall drainage behavior of the watershed contribute to water quality degradation in the receiving waters. Evaluating and restoring wetlands in the Six Mile Creek watershed is critical to restoring ecological functions.

Wetland Management

Wetlands in the Six Mile Creek were classified by the MCWD to identify critical wetlands for protection and restoration. The wetland management classification system was developed based on wetland management concepts presented in *Storm-Water and Wetlands: Planning and Evaluation Guidelines for Addressing Potential Impacts of Urban Storm-Water and Snow-Melt Runoff on Wetlands* (State of Minnesota Storm Water Advisory Group, 1997) and in other wetland management plans from the Twin Cities area. Wetland classifications include:

Preserve
Avoid and preserve wetland if at all possible. No change in wetland hydrology. No increase in nutrient load.

Manage 1
Minimize impacts to the wetland. Control change in wetland hydrology. Remove sediment and pretreat water entering the wetland.

Manage 2
Minimize impacts to the wetland. Control change in wetland hydrology. Remove sediment from water entering the wetland.

Manage 3
Consider for restoration or enhancement. Where necessary, allow use of wetland for flood storage and pretreatment of water entering other, higher quality wetlands.

The wetland management classification determines the standard to which the wetland will be managed. These classifications provide a reasonable guideline for selecting wetlands for restoration in the Six Mile Creek watershed.

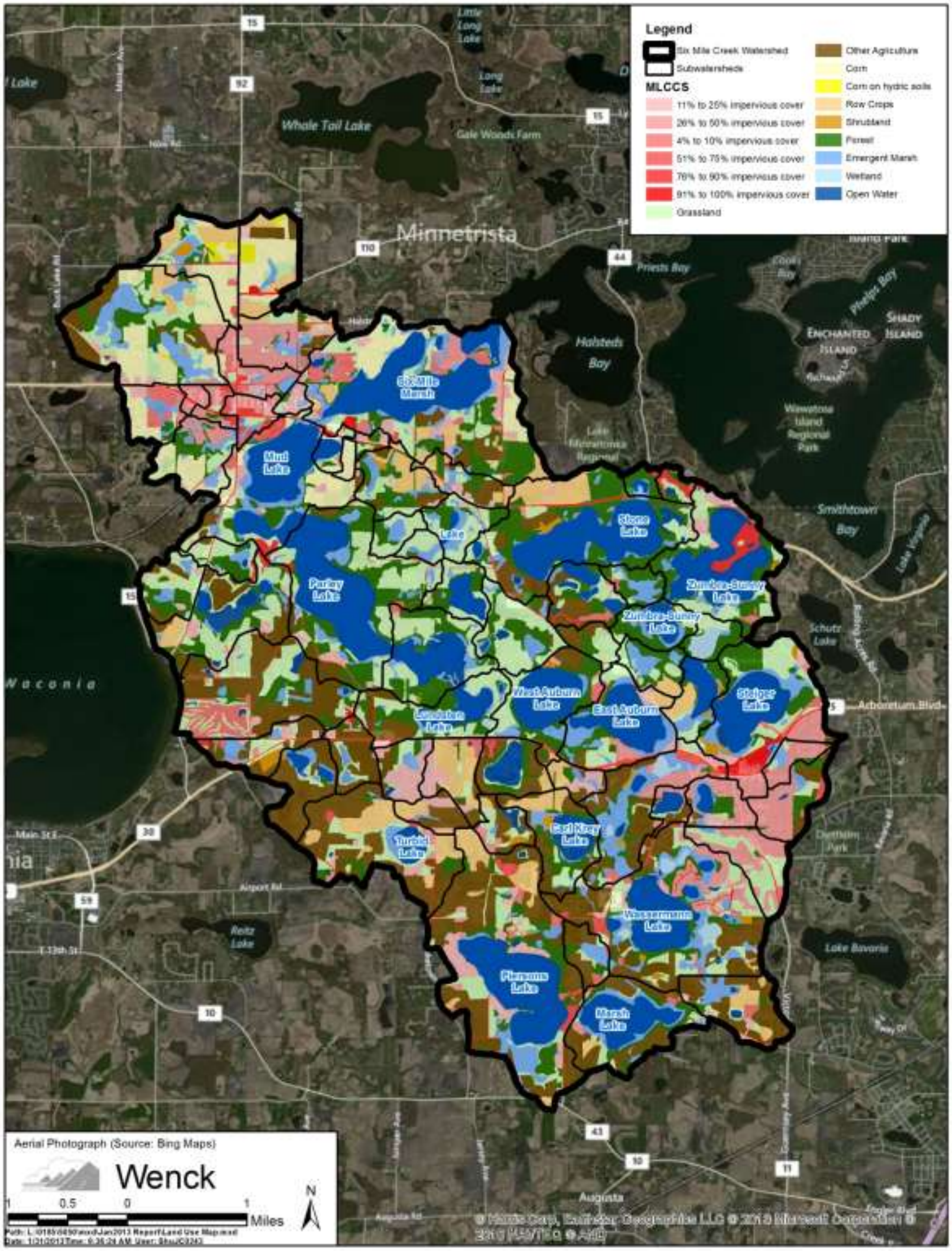

Figure 1-4 Land use in the Six Mile Creek watershed.

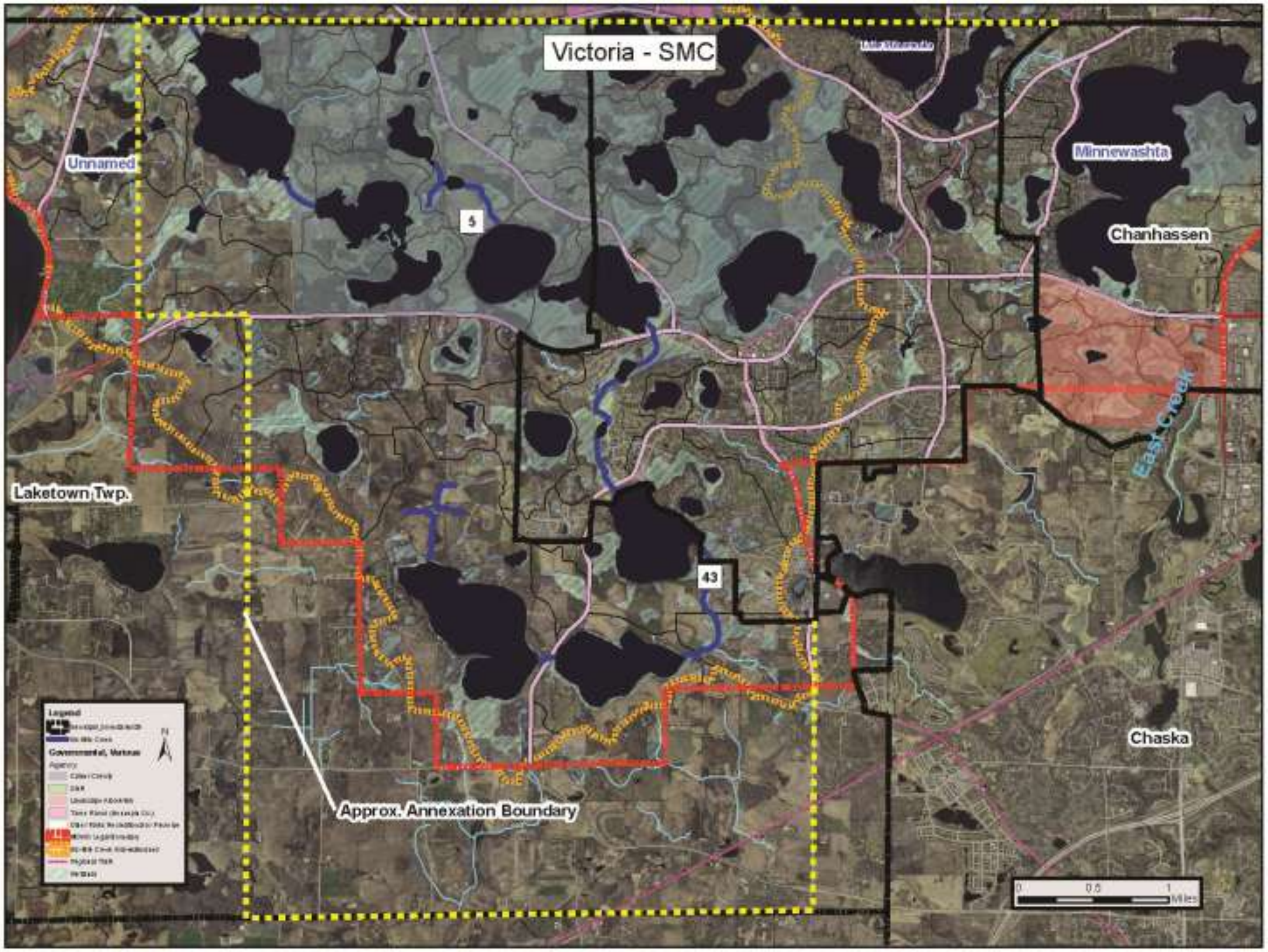

Figure 1-5. Proposed annexation for the City of Victoria.

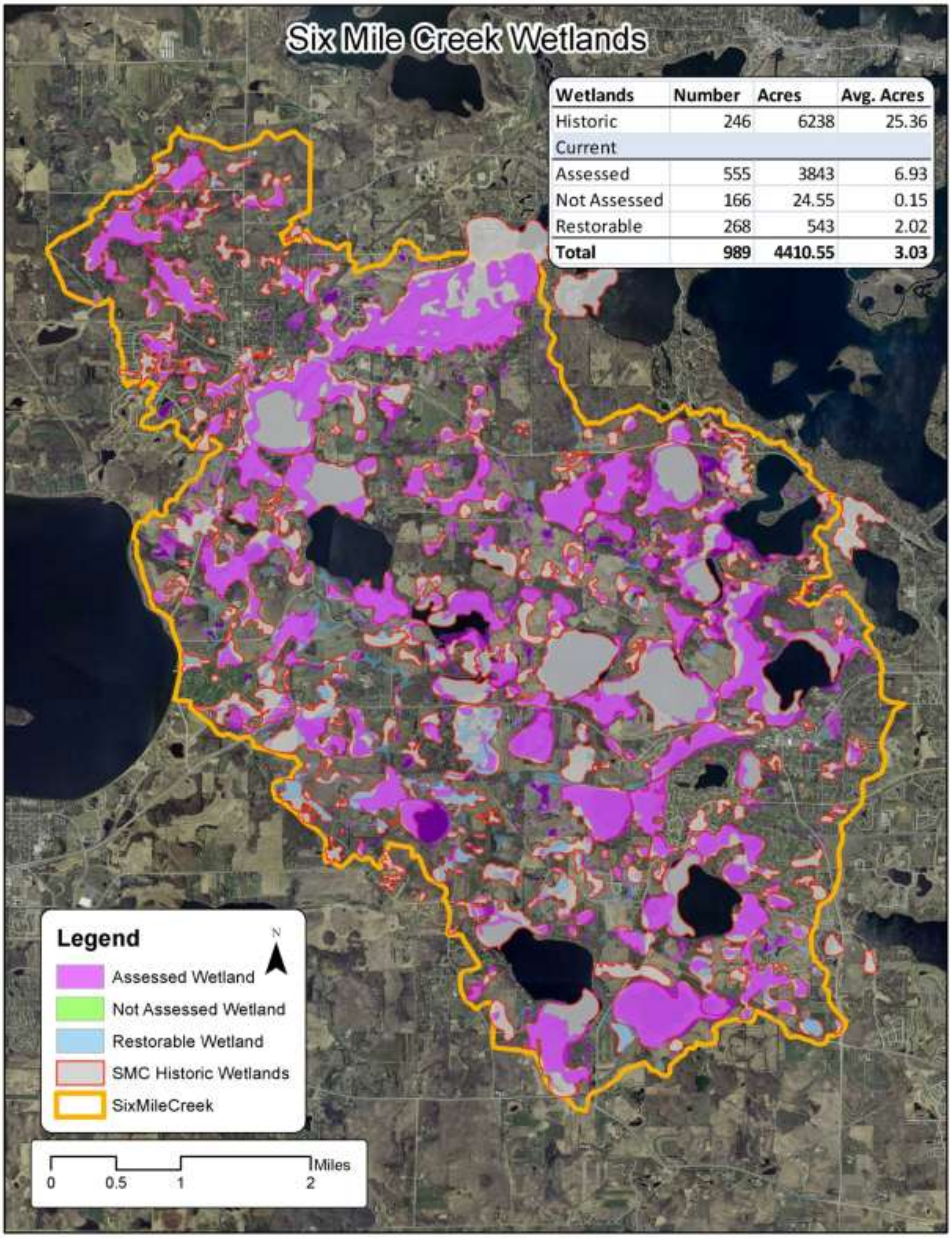

Figure 1-6. Current wetlands in the Six Mile Creek watershed. Map provided by the Minnehaha Creek Watershed District.

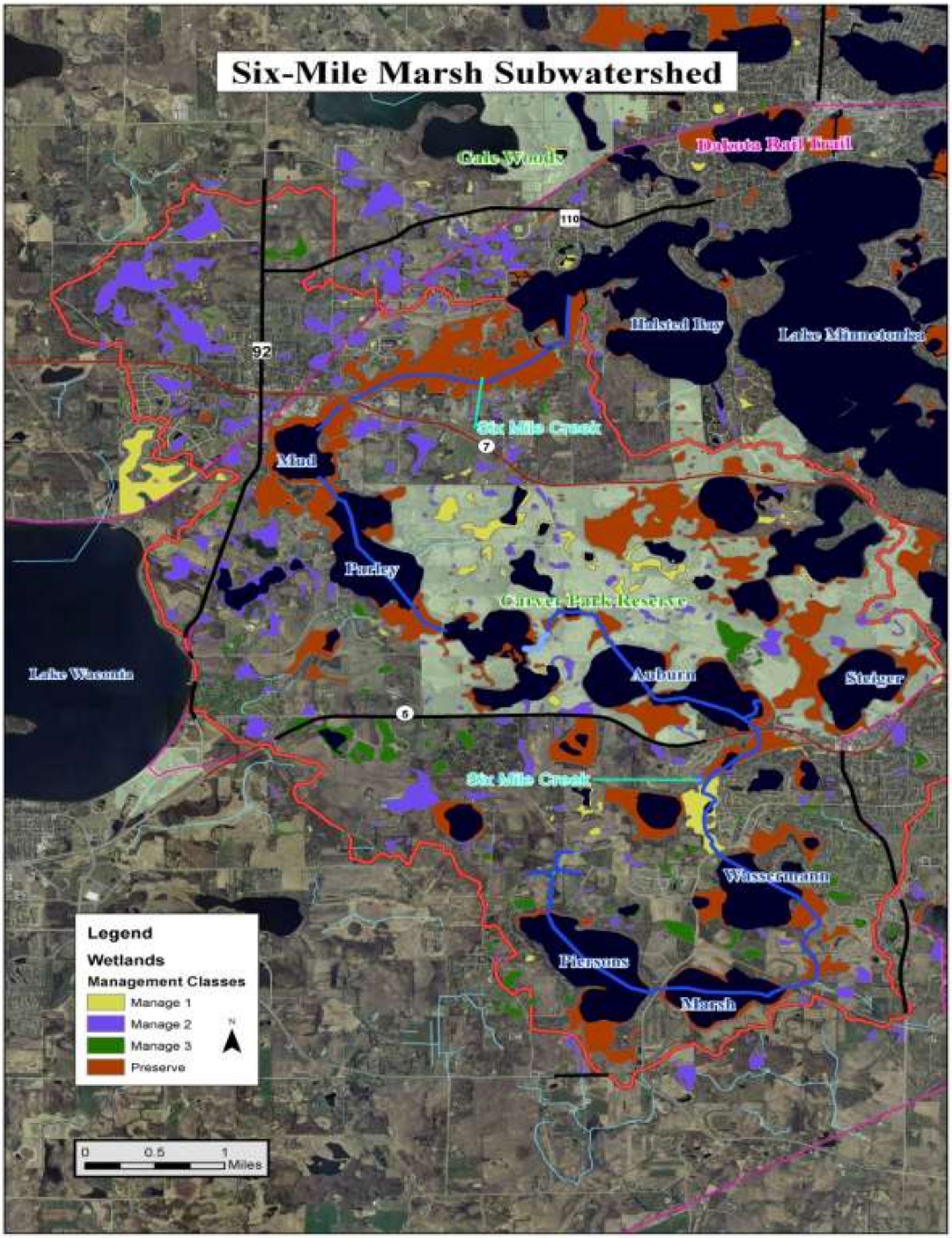

Figure 1-7. Wetland management classes in the Six Mile Creek watershed.

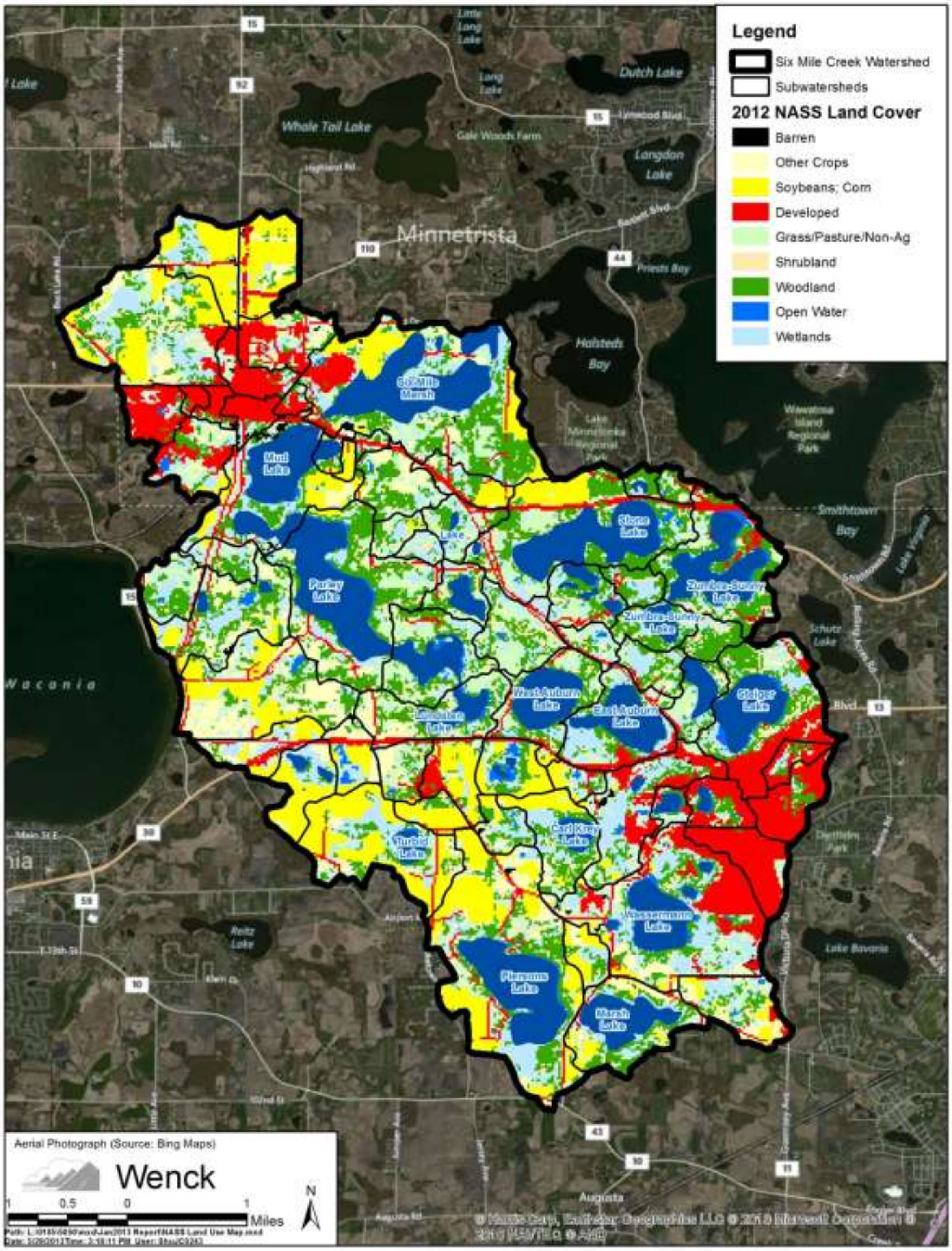

Figure 1-8. NASS land cover in the Six Mile Creek watershed.

2.0 Methods

2.1 OVERALL APPROACH

To evaluate water quality in the Six Mile Creek watershed, Wenck developed watershed runoff and nutrient load models as well as ecological reviews of water resources. Water and nutrient loads to the lakes were combined with a lake response models to develop nutrient budgets for the lakes. However, restoration of the lakes is linked not only to nutrient loading; ecological conditions also play a large role in the condition of the lakes. For example, algal response to increased nutrients is quite different in a turbid shallow lake affected by carp than in a shallow lake without carp. Therefore, both fish and vegetation data were collected or compiled to better understand the ecological condition of the lakes. Once all of this information was analyzed, recommendations were developed for restoration of the lakes and watershed.

2.2 WATERSHED MODELING

Watershed modeling was conducted for the Six Mile Creek watershed to develop nutrient and phosphorus loads to the lake. The first step was to develop an XP-SWMM model calibrated to annual runoff to estimate runoff volumes. Once the volumes were estimated, a P8 model was developed matching the XP-SWMM runoff volumes on a monthly basis. Since water quality data are not available everywhere in the watershed and the P8 model is limited in agricultural parts of the watershed, a Unit Area Load (UAL) model was developed for the watershed. The P8 model was updated to match monitored water quality or UAL estimated concentrations. In a few instances, watershed runoff concentrations were based on mass balance calculations for particular watersheds. Calibration notes for each of the subwatersheds are listed in Appendix A.

XP-SWMM Model

The existing XP-SWMM model for Six Mile Creek was obtained from Emmons and Olivier Resources, Inc. (EOR), which completed a Hydrologic and Hydraulics Study for the area in 2005. Wenck Associates used this model and modified several parameters for the Six Mile Creek study, including infiltration values, impervious fractions, lake evaporation rates, and lake bathymetry to reflect current conditions. The model was set to run daily long-term simulations using hourly precipitation and temperature data from a National Weather Service station in Chaska, MN. DNR lake level information is available within the study area at Pierson Lake, Wassermann Lake, Kelser's Pond, Stone Lake, Turbid Lake, and Parley Lake. The most complete data record at these locations within the period of interest was water-year 2010 (October 1, 2009 through September 30, 2010). Therefore, Wenck calibrated the model at these locations to the 2010 water-year lake elevation data. The model was also calibrated to instantaneous MCWD stream monitoring data collected at S006-149, S004-377, S004-361, S003-755, S004-376, S005-567, S002-754, and S003-752 locations. See Figure 4-2 for locations. See Appendix B for a more detailed calibration discussion.

Unit Area Load Model

To determine direct watershed loading, a hydrologic budget was calculated and a unit areal load (UAL) model was developed for each of the subwatersheds. The hydrologic budget for each of the subwatersheds was calculated from the P8 model, which was matched to the XP-SWMM model. The UAL model was developed by using the Minnesota Land Cover Classification System (MLCCS 2007) and assigning categories a loading rate of lbs TP/acre (Table 2-1). The loading rates for each land use category were based on literature review values for land uses in Minnesota (Reckhow et al. 1980). The direct watershed loads were then calculated by multiplying the percent of each land use category by its respective loading rate.

Table 2-1 Land use loading rates used to estimate runoff concentrations.

MLCCS Land Use Category	Acres	Phosphorus Load (lbs/acre/year)
4% to 10% impervious cover	368	0.03
11% to 25% impervious cover	782	0.03
26% to 50% impervious cover	998	0.31
51% to 75% impervious cover	130	0.41
76% to 90% impervious cover	220	0.41
91% to 100% impervious cover	211	0.41
Agriculture	2,829	0.22
Emergent Marsh	2,193	0
Forest	2,467	0.03
Grassland	2,647	0.06
Open Water	2,309	0
Row Crops	860	0.13
Shrubland	122	0.06
Wetland	140	0
Corn on hydric soils	36	0.47
Corn	715	0.47

P8 Model

The P8 model was developed to determine watershed loading for each of the subwatersheds in Six Mile Creek. The device volumes used in the P8 model were copied from the XP-SWMM model. The P8 model uses the SCS method, which has inputs of curve number and impervious fraction, to simulate runoff. The inputs parameters were calculated in GIS using land use and soil type. Since the P8 model and XP-SWMM model used different runoff methods, the impervious fractions vary slightly between the two. The P8 model was calibrated to match stream flow and basin volumes from the XP-SWMM model and monitored data. To calibrate the model to the watershed loads, determined through the UAL model and monitored data, the pervious and impervious load scale factors were modified. More details on the P8 model calibration can be found in Appendix B.

2.3 INTERNAL PHOSPHORUS RELEASE

Internal phosphorus loading from lake sediments has been demonstrated to be an important aspect of the phosphorus budgets of lakes. However, measuring or estimating internal loads can be difficult, especially in shallow lakes that may mix many times throughout the year. To estimate internal loading in the lakes, sediment cores were collected from the deepest portion of the lake. Phosphorus release rates were then measured in the lab under both anoxic (without oxygen) and oxic (with oxygen) conditions (UW-Stout 2012; Appendix C). Sediment chemistry was also collected to evaluate the potential sources of phosphorus from the sediment as well as to provide initial dosing calculations for chemical addition. These measured release rates are then combined with measured oxygen conditions in the lake to estimate the mass of phosphorus released into the water column.

To quantify anoxia, an anoxic factor (AF; Nürnberg 2004), which estimates the period where anoxic conditions exist over the sediments, is calculated from the dissolved oxygen profile data. The anoxic factor is expressed in days and represents the number of days anoxia existed over an area equal to the lake surface area. The anoxic factor is then used along with a sediment release rate to estimate the total phosphorus load from the sediments.

2.4 BATHTUB LAKE RESPONSE MODELING

The lake response modeling focuses on total phosphorus, chlorophyll-*a* and Secchi depth. For this TMDL, the BATHTUB model was selected to link phosphorus loads with in-lake water quality. A publicly available model, BATHTUB was developed by William W. Walker for the U.S. Army Corps of Engineers (Walker 1999). BATHTUB has been used successfully in many lake studies in Minnesota and throughout the United States.

BATHTUB is a steady-state annual or seasonal model that predicts a lake's summer (June – September) mean surface water quality. BATHTUB's time-scales are appropriate because watershed phosphorus loads are determined on an annual or seasonal basis, and the summer season is critical for lake use and ecological health. BATHTUB has built-in statistical calculations that account for data variability and provide a means for estimating confidence in model predictions. The heart of BATHTUB is a mass-balance phosphorus model that accounts for water and phosphorus inputs from tributaries, watershed runoff, the atmosphere, sources internal to the lake, and (if appropriate) groundwater; and outputs through the lake outlet, groundwater (if appropriate), water loss via evaporation, and phosphorus sedimentation and retention in lake sediments. BATHTUB allows choice among several different mass-balance phosphorus models.

For deep lakes in Minnesota, the option of the Canfield-Bachmann lake formulation has proven to be appropriate in most cases. The Canfield-Bachmann equation is a simple empirical model that predicts phosphorus sedimentation and ultimately in-lake phosphorus concentrations based on phosphorus and water loads. For shallow Minnesota lakes, other options, such as a second order decay model, have often been more useful. BATHTUB's in-lake water quality predictions include two response variables, chlorophyll-*a* concentration and Secchi depth, in addition to total phosphorus concentration. Empirical relationships among in-lake total phosphorus, chlorophyll-*a*, and Secchi depth form the basis for predicting the two response variables. Among the key empirical model parameters is the ratio of the inverse of Secchi depth (the inverse being proportional to the light extinction coefficient) to the chlorophyll-*a* concentration. The ratio's default value in the model is 0.025 meters squared per milligram (m^2/mg); however, the experience of Minnesota Pollution Control Agency staff supports a lower value, as low as 0.015 m^2/mg, as typical of Minnesota lakes in general.

A BATHTUB lake response model was constructed for key lakes in the Six Mile Creek watershed. The selection of the subroutines is based on past experience in modeling lakes in Minnesota and is focused on those that were developed based on data from natural lakes. The Canfield-Bachmann natural lake model was chosen for the phosphorus model. For more information on these model equations, see the BATHTUB model documentation (Walker 1999). Model coefficients are also available for calibration or adjustment based on known cycling characteristics. Results of the BATHTUB modeling are included in Appendix D.

3.0 Lakes and Watershed Description

3.1 MANAGEMENT UNIT DEVELOPMENT

To facilitate the analyses and planning, the watershed was broken into management units based on physical and biological conditions in the watershed (Figure 3-1). Consideration was given to the drainage patterns of the watershed, the conditions of the lake, and biological conditions where information was available. The first break in the watershed is at the outlet of Lundsten Lake, where the outlet structure separates the lower watershed and the upper watershed hydrologically. SWMM modeling for the watershed suggested that backwater effects from Lake Minnetonka can reach as far up as Parley Lake. However, it is important to note that the SWMM model did not include Halsted Bay, so the observations are based on Halsted Bay lake elevations where available.

Other breaks were determined using the conditions of the lake biological communities such as fish populations or submerged aquatic vegetation. For Example, North and South Lundsten lakes appear to be biologically separated in that South Lundsten Lake is infested with carp and lacks submerged aquatic vegetation, whereas North Lundsten Lake has a healthy, robust submerged aquatic vegetation community and little or no evidence of carp activity. These differences suggested that their drainage areas be divided into separate management units.

Land use was also a consideration in the selection of the management units. For example, the Carver Park Reserve Management Unit is mostly open parkland managed by the Three Rivers Park District. This distinction led to grouping this area into one management unit with similar land management and water resource conditions.

The Six Mile Creek watershed was broken into five Management Units including Pierson-Marsh-Wassermann, Carver Park Reserve, Turbid-Lundsten, Auburn-North Lundsten, and Parley-Mud. Each of these units were assessed as individual subwatersheds but also as a whole based on interactions among the Watershed Management Units.

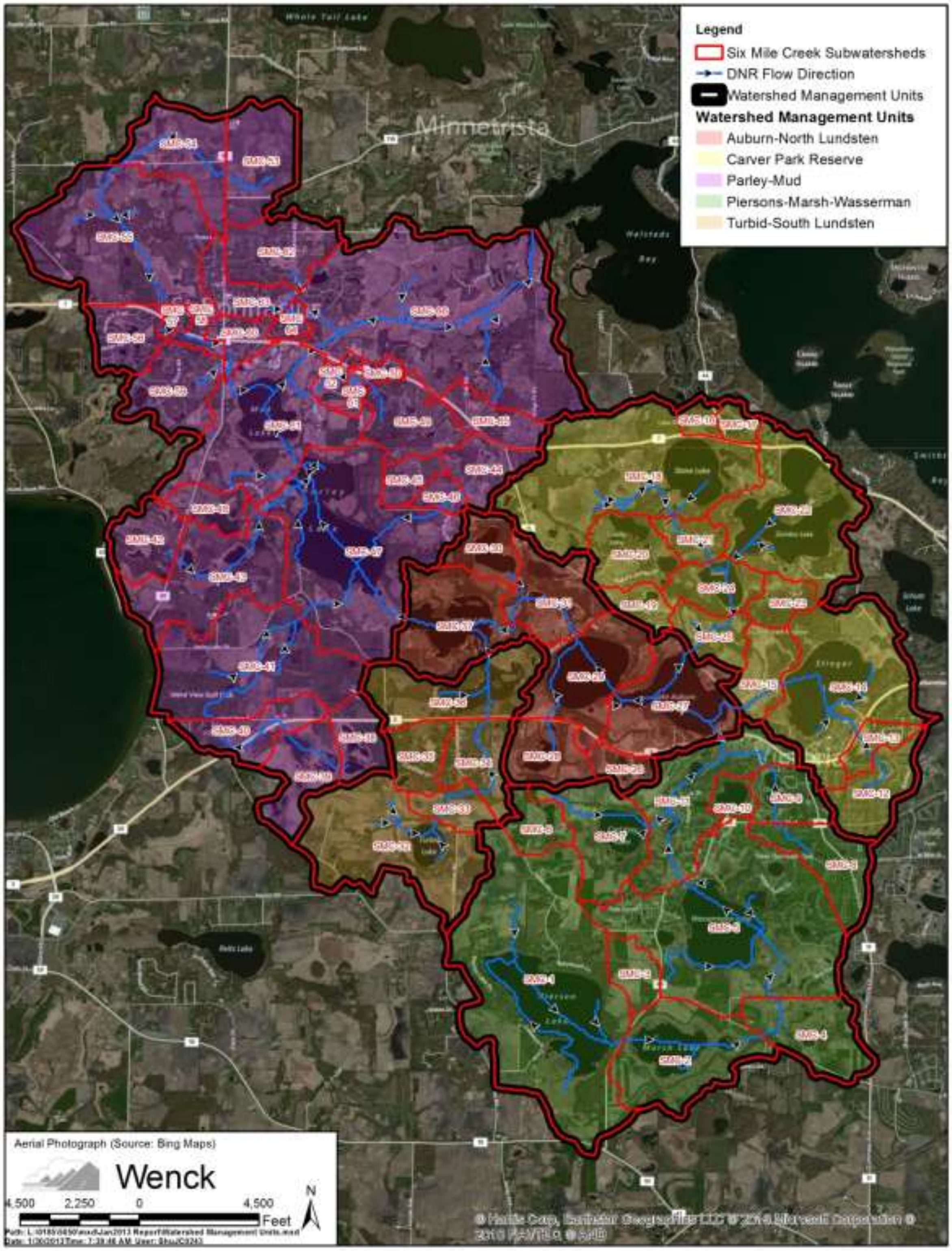

Figure 3-1. Watershed Management Units in the Six Mile Creek watershed.

3.2 WATER QUALITY MONITORING

Water quality in Minnesota lakes is often evaluated using three associated parameters: total phosphorus, chlorophyll-*a*, and Secchi depth. Total phosphorus is typically the limiting nutrient in Minnesota's lakes, meaning that algal growth will increase with increases in phosphorus. However, there are cases where phosphorus is widely abundant and the lake becomes limited by nitrogen or light availability. Chlorophyll-*a* is the primary pigment in aquatic algae and has been shown to have a direct correlation with algal biomass. Since chlorophyll-*a* is a simple measurement, it is often used to evaluate algal abundance rather than expensive cell counts. Secchi depth is a physical measurement of water clarity by lowering a black and white disk until it can no longer be seen from the surface. Higher Secchi depths indicate less light-refracting particulates in the water column and better water quality. Conversely, high total phosphorus and chlorophyll-*a* concentrations point to poorer water quality and thus lower water clarity. Measurements of these three parameters are interrelated and can be combined into an index that describes water quality.

Extensive water quality monitoring has been conducted in the Six Mile Creek watershed by the Minnehaha Creek Watershed District and the Three Rivers Park District (Figure 3-2). Data includes both in-lake monitoring (Table 3-1) and stream monitoring (Table 3-2).

Most of the lakes were sampled periodically over the past ten years with only South Lundsten having one year of data available.

Table 3-1. Available lake monitoring data in the Six Mile Creek watershed.

Site	Parameter	Year
Pierson	Chl-a, Secchi, TP, TKN	2002-2003, 2005-2011
Marsh	Chl-a, Secchi, TP, TSS	2010-2012
Wassermann	Chl-a, Secchi, TP, OP, TKN	2000-2011
Carl Krey	Chl-a, Secchi, TP, TSS	2006-2008, 2012
Church	Chl-a, Secchi, TP, TSS	2006-2008, 2012
Kelser's	Chl-a, Secchi, TP, TKN	2009-2012
Steiger	Chl-a, Secchi, TP, OP	2000, 2002-2003, 2005-2006, 2008, 2010-2012
Zumbra	Chl-a, Secchi, TP, OP, TKN	2000-2012
Stone	Chl-a, Secchi, TP, OP	2000, 2002, 2007-2008, 2010-2012
East Auburn	Chl-a, Secchi, TP, TKN	2006-2008, 2010, 2012
West Auburn	Chl-a, Secchi, TP, OP	2002-2012
Turbid	Chl-a, Secchi, TP, TKN	2006-2008, 2010-2012
South Lundsten	Chl-a, Secchi, TP, TKN	2012
North Lundsten	Chl-a, Secchi, TP, TKN, TSS	2006-2008, 2010-2012
Mud	Chl-a, Secchi, TP, TKN, TSS	2006-2008, 2012
Parley	Chl-a, Secchi, TP, TKN	2000-2003, 2004-2011

Stream sampling occurred at 13 different sites in the Six Mile Creek watershed over the past 13 years (Figure 3-2). Because the watershed is so flat, long term daily flow records were difficult to develop.

Currently, all of the flow data available are discrete flow samples. However, MCWD is currently developing a long term continuous flow monitoring station just downstream of the Mud Lake outlet. MCWD is planning on deploying newer technology that can detect very low flows and correct for backwater effects that may be caused by Halsted's Bay. These data allow for future improvements of the hydrologic models.

Table 3-2. Available stream monitoring data.

Site	Parameter	Year
S002-754	Flow*; TP, OP, TKN, TSS	2000- 2012
S003-752	Flow	2001-2002, 2005-2012
	TP, OP, TKN, TSS	2000-2003, 2005-2012
S003-753	Flow	2001, 2003-2005
	TP, OP, TKN, TSS	2001-2005
S003-754	Flow; TP, OP, TKN, TSS	2005
S003-755	Flow	2005, 2007-2012
	TP, OP, TKN, TSS	2003, 2005, 2007-2012
S004-361	Flow; TP, OP, TKN, TSS	2006-2012
S004-375	Flow; TP, OP, TSS	2006
S004-376	Flow; TP, OP, TKN, TSS	2006-2012
S004-377	Flow; TP, OP, TKN, TSS	2006-2012
S004-426	Flow; TP, OP, TSS	2006
S004-427	Flow; TP, OP, TSS	2006
S005-567	Flow; TP, OP, TKN, TSS	2009-2012
S006-149	Flow; TP, OP, TKN, TSS	2010-2012

* All flows were discrete samples

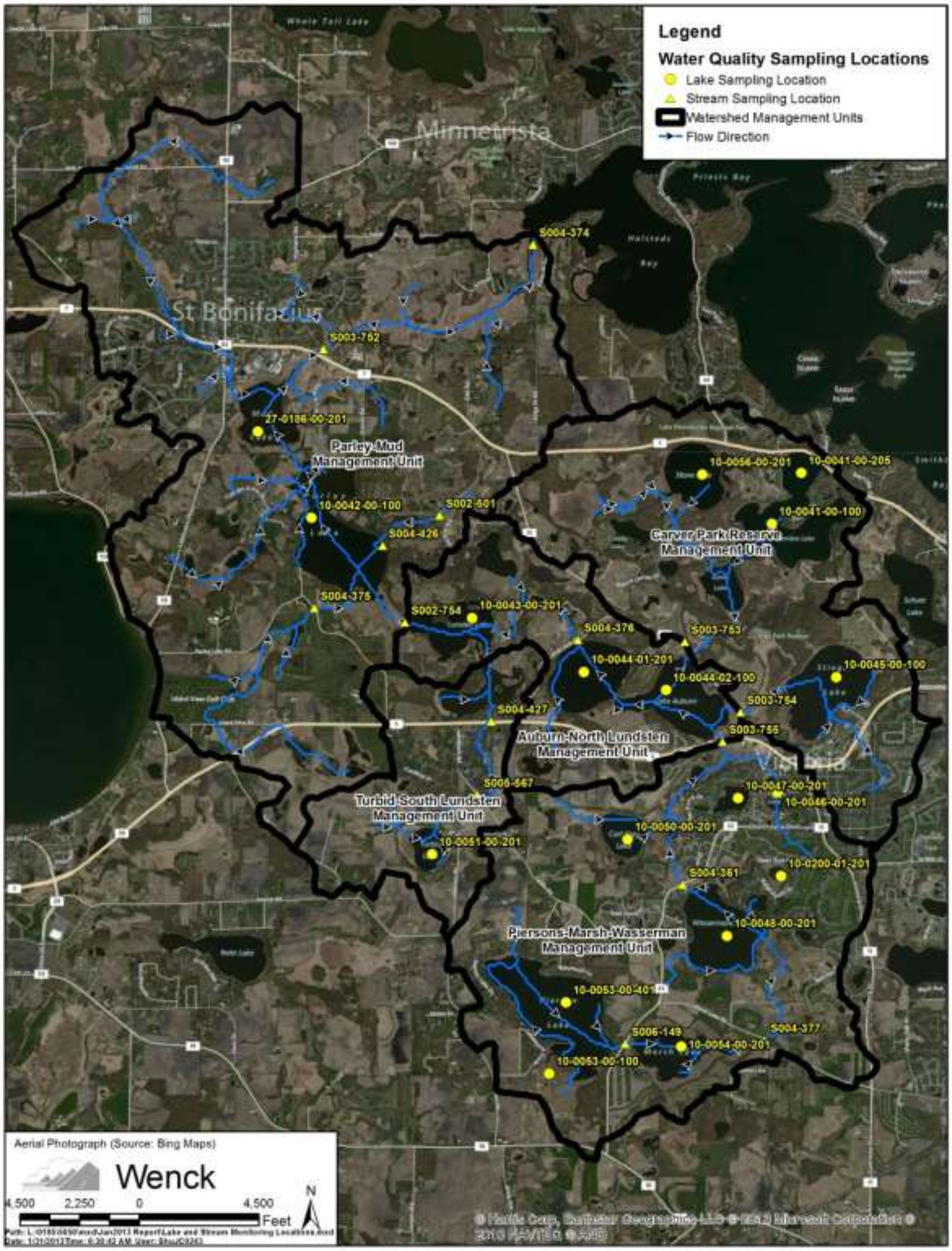

Figure 3-2. Water quality monitoring locations in the Six Mile Creek watershed.

3.3 FISHERIES ASSESSMENT

Fisheries in each of lakes were assessed using available DNR Fish Surveys. Following is a description of the methods used to describe and assess the fish communities in the Six Mile Creek watershed.

DNR Fish Surveys

Standard survey methods used by the DNR include gill net and trap nets. These sampling methods do have some sampling bias, including focusing on game management species (i.e., northern pike and walleye), under-representing small minnow and darter species presence/abundance, and under-representing certain management species, such as largemouth bass. The current methods also likely under-represent carp populations in the lakes. However, in our experience, when carp are present in the lakes, the sampling methods do capture some of the population. So, although carp density is likely under-represented, the methods provide a reasonable year-to-year comparison.

Fish community data for each lake was summarized by trophic groups. Species within a trophic group serve the same ecological process in the lake (i.e., panfish species feed on zooplankton and invertebrates and may be prey). Analyzing all the species as a group is often a more accurate summary of the fish community then analyzing individual species trends. Trophic groups include top predators (pike, walleye, bass), panfish (sunfish, crappie), forage species (perch), and rough fish (bullheads, carp). Carp are typically displayed separately from other rough fish in the lake due to their particularly destructive nature.

Carp

Common carp have both direct and indirect effects on aquatic environments. Carp uproot aquatic macrophytes during feeding and spawning and resuspend bottom sediments and nutrients. These activities can lead to increased nutrients in the water column, ultimately resulting in increased nuisance algal blooms. Standard DNR methods are not particularly effective at capturing carp and are limited in developing carp population estimates. To begin to understand the extent of carp populations, Wenck compiled DNR fish survey information and anecdotal reports of carp movement in the Six Mile Creek watershed. MCWD plans to work with Dr. Peter Sorenson at the University of Minnesota to conduct a comprehensive carp assessment in the Six Mile Creek watershed.

3.4 AQUATIC VEGETATION

Aquatic plants are beneficial to lake ecosystems, providing spawning and cover for fish, habitat for macroinvertebrates, refuge for prey, and stabilization of sediments. However, in high abundance and density they limit recreation activities, such as boating and swimming, and may reduce aesthetic value. Excess nutrients in lakes can lead to non-native, invasive aquatic plants taking over a lake. Some exotics can lead to special problems in lakes. For example, under the right conditions, Eurasian watermilfoil can reduce plant biodiversity in a lake because it grows in great densities and out-competes all the other plants. Ultimately, this can lead to a shift in the fish community because these high densities favor panfish over larger game fish. Species such as curly-leaf pondweed can cause very specific problems by changing the dynamics of internal phosphorus loading. All in all, there is a delicate balance within the aquatic plant community in any lake ecosystem.

The littoral zone, defined as that portion of the lake that is less than 15 feet deep, is where the majority of the aquatic plants are found. The littoral zone of the lake also provides the essential spawning habitat for most warm water fishes (e.g. bass, walleye, and panfish). The key is fostering a diverse population of rooted aquatic plants that is dominated by native (non-invasive) species.

Aquatic Plant Surveys

Three Rivers Park District, Army Corps of Engineers, Wenck, and MCWD completed plant surveys in the Six Mile Creek watershed using point intercept surveys (Table 3-3). Spring surveys were conducted in 2012 on key lakes without spring data to assess curly-leaf pondweed populations, time permitting. Spring and fall surveys were conducted on key shallow lakes where vegetation plays a key role in water quality conditions in the lake.

Table 3-3. Plant surveys in the Six Mile Creek watershed.

Lake	2012 Survey*	Previous Plant Surveys (Fall)
Pierson	None	McComas 2011
Marsh	Spring; Fall	
Wassermann	Spring	McComas 2011
East Auburn	Spring	2007 (Army Corps); 2009 & 2010 (Three Rivers)
West Auburn	Spring	2007 (Army Corps); 2009 & 2010 (Three Rivers)
Lundsten	Spring; Fall	
Mud	Spring; Fall	
Carl Krey	Spring; Fall	
Steiger	None	2008 (Three Rivers)
Zumbra	None	2007 (Army Corps); 2009 & 2010 (Three Rivers)
Stone	None	2008 (Three Rivers)
Turbid[1]	Spring; Fall	MCWD 2013
Kelser's[1]	Spring; Fall	MCWD 2013

** All surveys conducted were point-intercept surveys.*
[1]MCWD staff plan on conducting plant surveys during the Spring and Fall of 2013.

DNR Vegetation Surveys

The Minnesota DNR also collects vegetation data along with fish surveys on the lakes. The Minnesota DNR use transects methods to collect data, which is limited in scope for the lakes. However, the data do provide a good snapshot of aquatic vegetation at the time the fish surveys were conducted.

3.5 PIERSON-MARSH-WASSERMANN MANAGEMENT UNIT

The Pierson-Marsh-Wassermann Management Unit includes the Pierson and Wassermann drainage areas as well as the wetland area between Wassermann Lake and East Auburn Lake (Figure 3-4). The drainage area starts at Pierson Lake and flows through Marsh Lake and then Wassermann Lake. Wassermann discharges into a large wetland that also receives drainage from Carl Krey and Church lakes as well as Kelser's Pond before discharging into East Auburn Lake. The watershed is mostly agricultural in the headwaters except for heavy development along the shores of Pierson Lake. Development in the watershed starts to show up in the Wassermann watershed with single family residential and downtown Victoria. Wassermann Lake also receives drainage from the Deer Run Golf Club. The management unit is a mix of agriculture, development, and low-lying wetlands that are hydrologically connected through the drainage network.

Morphology

There are six lakes in the Pierson-Marsh-Wassermann Management Unit, including three on the main stem of the creek and three tributary to the creek. Marsh and Carl Krey are shallow lakes with average depths less than 6 feet and maximum depths of 5 and 16 feet, respectively (Table 3-4). Although Carl Krey is a shallow lake, it has a small watershed and a long residence time. Other than Pierson and Church lakes, all of the lakes have shallow characteristics with littoral areas greater than 60% of the lake.

Table 3-4. Physical characteristics of lakes in the Pierson-Marsh-Wassermann Management Unit.

Parameter	**Pierson**	**Marsh**	**Wassermann**	**Carl Krey**	**Church**	**Kelser's**
Surface Area (acres)	297	143	164	50	16	21
Average Depth (ft)	18.1	2.8	10.3	5.7	13	10
Maximum Depth (ft)	40	5	41	16	54	34
Volume (acre-feet)	5,383	394	1,698	353	207	200
Residence Time (years)	6.0	0.6	0.94	1.9	0.9	2.5
Littoral Area (acres)	119	143	112	50	7	13
Littoral Area (%)	40%	100%	68%	99%	46%	62%
Direct Watershed Area (acres)	903	250	876	265	109	87

Water Quality

In-lake total phosphorus and chlorophyll-*a* over the past 13 years were evaluated to identify water quality conditions in the management unit (Figure 3-4; Appendix E). Water quality is relatively good in Pierson and Marsh lakes, with total phosphorus concentrations typically below the state water quality standards for shallow and deep lakes (<60 µg/L and <40 µg/L as a summer average, respectively). However, water quality is significantly degraded in downstream Wassermann Lake with total phosphorus concentrations ranging between 60 and 80 µg/L and some values over 100 µg/L. Chlorophyll-*a* concentrations are quite high in Wassermann Lake, ranging between 40 and 60 µg/L with severe algal blooms as high as 80 µg/L. Both Carl Krey Lake and Kelser's Pond have relatively good water quality with total phosphorus values typically below 40 µg/L. Church Lake has high total phosphorus concentrations, with some values exceeding 160 µg/L. Overall, lake water quality in the management unit is mixed, with the headwater lakes demonstrating fair water quality while downstream lakes tend to demonstrate poor water quality.

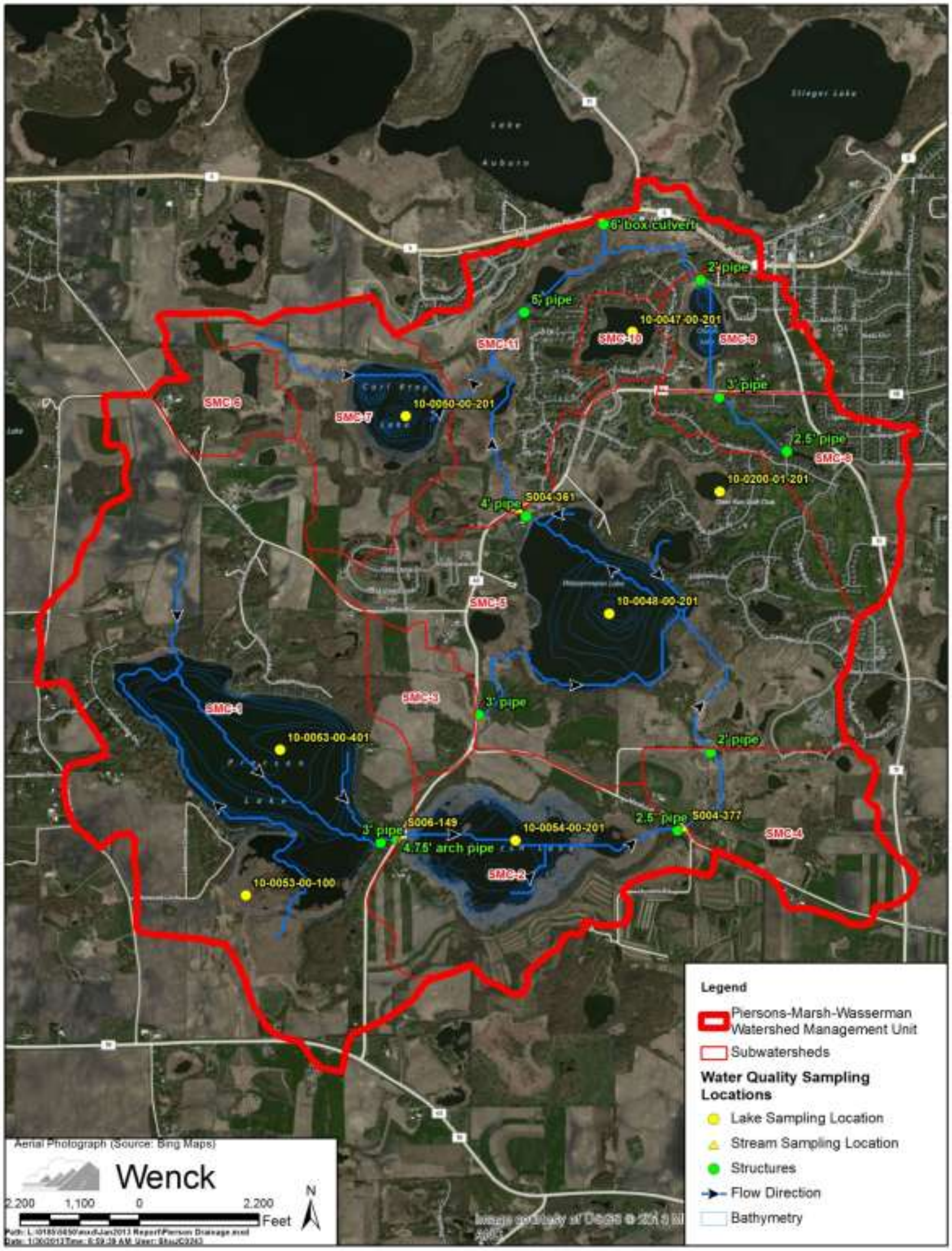

Figure 3-3. The Pierson-Marsh-Wassermann Management Unit.

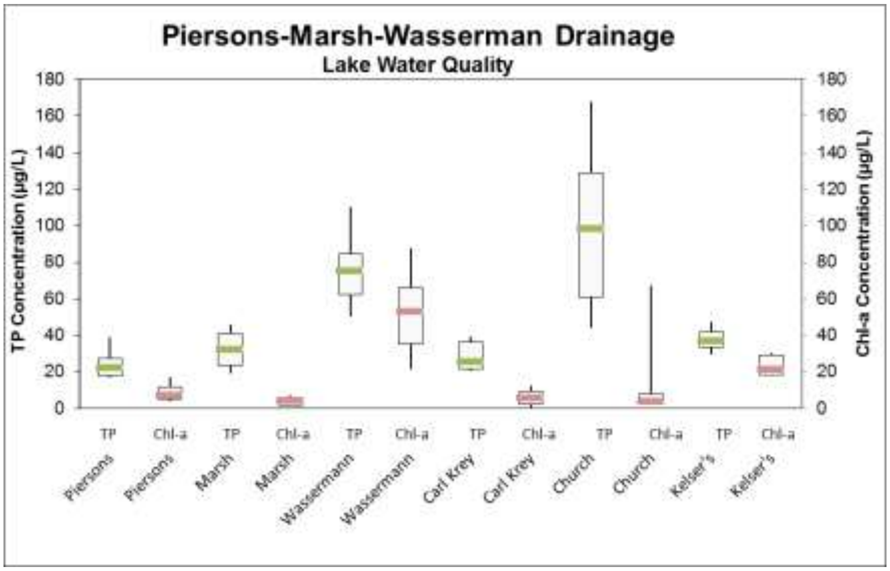

Figure 3-4. Lake total phosphorus and chlorophyll-*a* concentrations over the past 13 years.

To evaluate sources, total phosphorus concentrations were plotted from upstream to downstream including both total phosphorus and ortho-phosphorus where available (Figure 3-5). Phosphorus concentrations are relatively low through Pierson and Marsh lakes. However, the outlet of Marsh Lake demonstrated significantly higher phosphorus concentrations than in-lake measurements, suggesting that the downstream end of Marsh Lake may be contributing phosphorus, possibly through internal release or carp activity. The next monitoring station is Wassermann Lake, which receives water from other drainage areas as well as Marsh Lake. Six Mile Creek flows out of Marsh Lake through a large wetland before entering Wassermann Lake. It is possible that this wetland area is contributing phosphorus to Wassermann Lake; however, data need to be collected to verify the role of this wetland.

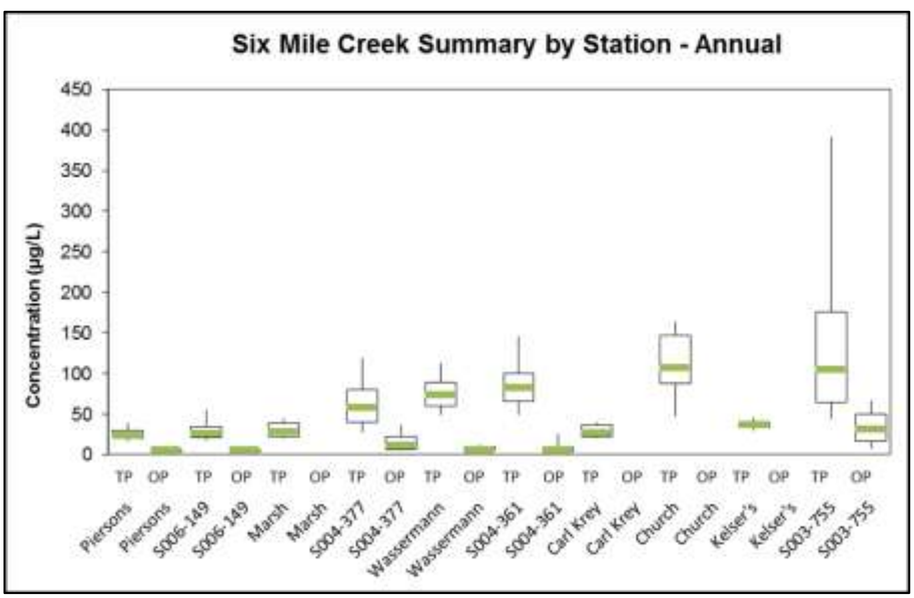

Figure 3-5. Total and ortho-phosphorus concentrations in the Pierson-Marsh-Wassermann Management Unit.
Note: Data is plotted upstream to downstream where possible.

The next downstream station is S003-755, which is the inlet to East Auburn Lake. The area between Wassermann Lake and East Auburn Lake is a large wetland area that receives drainage from Wassermann, Carl Krey, and Church lakes as well as Kelser's Pond. Total phosphorus concentrations in Kelser's Pond and Carl Krey Lake are below state water quality standards and therefore not significantly contributing phosphorus to East Auburn Lake. Church Lake exceeds state water quality standards and is likely contributing phosphorus to East Auburn Lake. However, the Church Lake watershed and subsequent phosphorus load is relatively small. Mass balance calculations for the wetland between Wassermann and East Auburn lakes suggest that wetland discharge exceeds 800 µg/L total phosphorus and may account for over 600 pounds of phosphorus loading to East Auburn Lake annually.

Fisheries

The most recent fish data for the six lakes in the Pierson-Marsh-Wassermann Management Unit were reviewed to assess fishery conditions in the lakes (Figures 3-6 and 3-7; Appendix F). Pierson Lake has abundant panfish populations and moderate numbers of top predators, although they are large individuals. Pierson Lake is primarily managed for hybrid muskellunge and largemouth bass, with secondary emphasis on bluegill. The management plan schedules this lake for hybrid muskellunge stocking of 1.5 per littoral acre every three years; however, due to availability of stock and lake priority, the last four stocking events occurred in 2006, 2001, 1997, and 1994. No data are available for Marsh Lake, although field sampling in the summer of 2012 identified heavy carp activity in Marsh Lake. Wassermann is managed for northern pike, largemouth bass, and bluegill. Tiger muskellunge have previously been stocked, but this has ceased. The last tiger muskellunge stocking was fingerlings in 2006. Bluegill abundance is high, as they were collected in trap nets at a rate of 56.6 per net. Bluegill abundance and size has fluctuated over the previous assessments. Carp were collected in all three lakes.

Kelser's Pond is a panfish- and bass-dominated lake with a good balance between top predators and panfish populations. Black crappies and black bullhead are very abundant in Church Lake, while top predators are lacking. However, no carp were sampled in either of these lakes.

Anecdotal evidence shows carp movement between Wassermann and Marsh lakes, with Marsh Lake showing pockets of vegetation degradation from the carp population. A density/surface area survey using side scan sonar by a licensed commercial fisherman estimated 140,000 pounds of carp to be present in Pierson Lake and 70,000 – 90,000 pounds of carp to be present in Wassermann Lake. Based on the carp population and water quality conditions, these lakes appear to be linked and should be managed together.

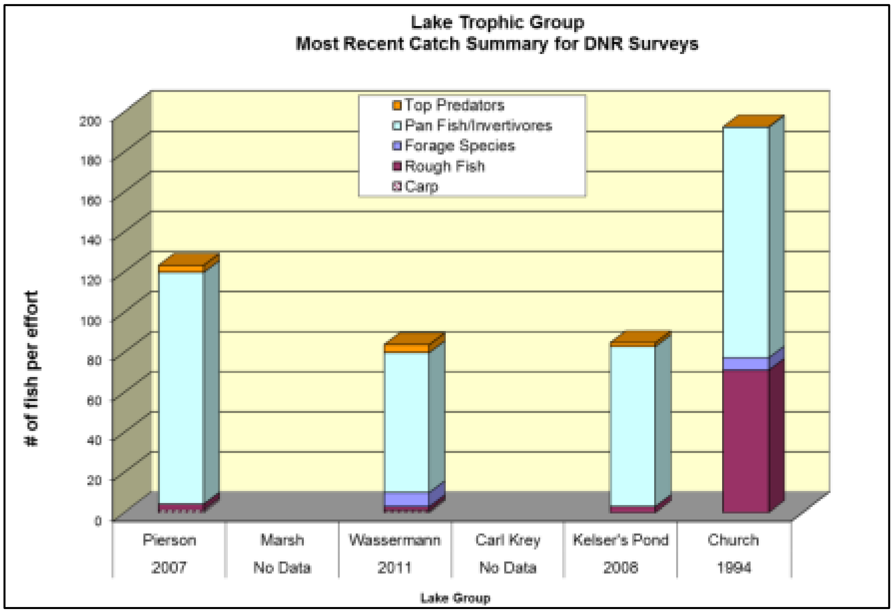

Figure 3-6. Fisheries summary by trophic group for the Pierson-Marsh-Wassermann Management Unit.

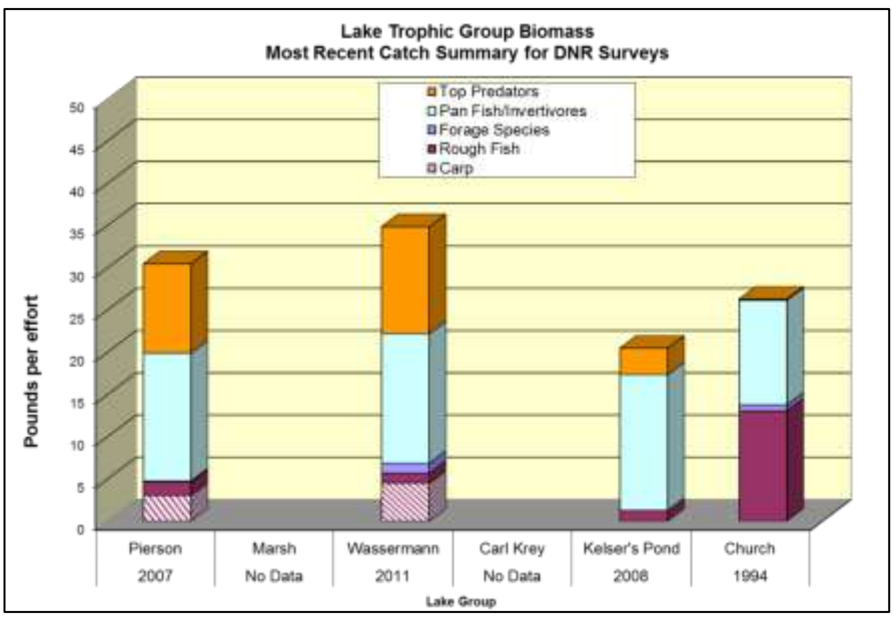

Figure 3-7. Fisheries summary by trophic group biomass for the Pierson-Marsh-Wassermann Management Unit.

Previous efforts to manage carp in Pierson, Marsh, and Wassermann lakes were undertaken by the MCWD. Some of these efforts include:

1. Area Partnership for Pierson Lake Enhancement (APPLE) members and neighbors trapped, caught, and disposed of 2,685 carp averaging 5 – 6 pounds (~15,000 pounds total) for the month of May 2011 (Figure 3-8).
2. Area Partnership for Pierson Lake Enhancement (APPLE) members and neighbors trapped, caught, and disposed of 1,114 carp averaging 5 lbs - 6 lbs. (~6,000 lbs.) for the month of June 2011.
3. The licensed commercial fishermen attempted open water seining on the south shoreline of Lake Wassermann on May 16, 2011. They were able to net only about 1,000 lbs. of carp. The carp were placed in a holding pen. On May 17, 2011, the licensed commercial fishermen baited Lake Wassermann with corn in an attempt to bring the carp closer in to the shoreline.
4. MCWD staff met Don Geyer and his crew at Lake Wassermann for a second attempt at capturing the carp using open water seining on May 18, 2011. The nets were set up approximately 300 feet from shore near the boat landing on the northern part of the lake. The nets were getting caught in the mud on the bottom of the lake. The mud was too thick to pull in the nets, so the fishermen had no choice but to gather their nets back into their boats. There were no additional carp caught at this time.

Further details on carp management activities undertaken by MCWD can be found in Appendix F.

Figure 3-8. Carp harvested by the Area Partnership for Pierson Lake Enhancement in May 2011.

Aquatic Plants

Vegetation data was available for four of the six lakes in the Management Unit including Pierson, Marsh, Wassermann and Carl Krey Lake (Figure 3-9). All three of the lakes are dominated by coontail, a native species that thrives under more eutrophic (higher nutrient) conditions. Pierson, Marsh, and Wassermann all have Eurasian watermilfoil and curly-leaf pondweed present with Pierson Lake demonstrating the densest populations. Most of the lakes have some native species still present including sago pondweed, bushy pondweed, and flatstem pondweed. Wassermann Lake had the most degraded plant community, with only coontail and Eurasian watermilfoil as the only submerged plant species found in the lake.

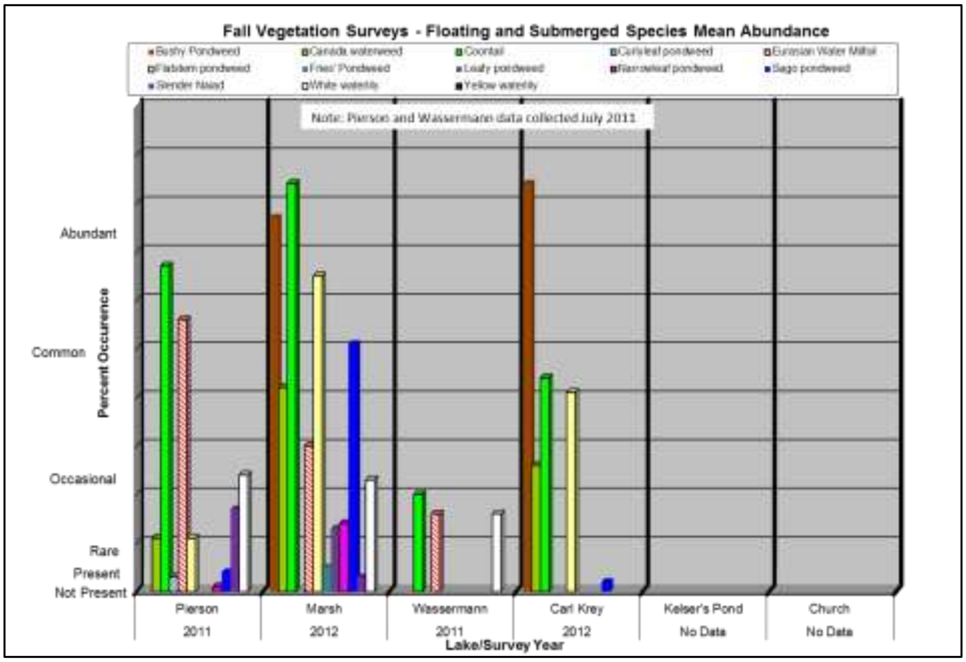

Figure 3-9. Vegetation conditions of lakes in the Pierson-Marsh-Wassermann Management Unit.
Note: Date includes the most recent fall vegetation surveys. Curly-leaf pondweed was present in both Marsh and Wassermann lakes in spring 2012 vegetation surveys (Appendix G) and also present in Pierson Lake.

Nutrient Budgets

Nutrient budgets were developed for the lakes exceeding current state water quality standards including Wassermann and Church lakes.

Watershed Sources

Watershed nutrient loading in the Management Unit is highest in the area directly draining to Wassermann Lake and the SMC-11 and Church Lake watersheds (Figure 3.10). Nutrient loads were relatively low for Pierson and Marsh lakes and Kelser's Pond. Nutrient loading was highest in the SMC-11 subwatershed where runoff concentrations appear to exceed 800 µg/L total phosphorus. Although the highest loading to Church Lake appears to be the direct watershed to the lake, opportunities for nutrient reductions are also available in SMC-8, which includes a good part of the Deer Run Golf Club.

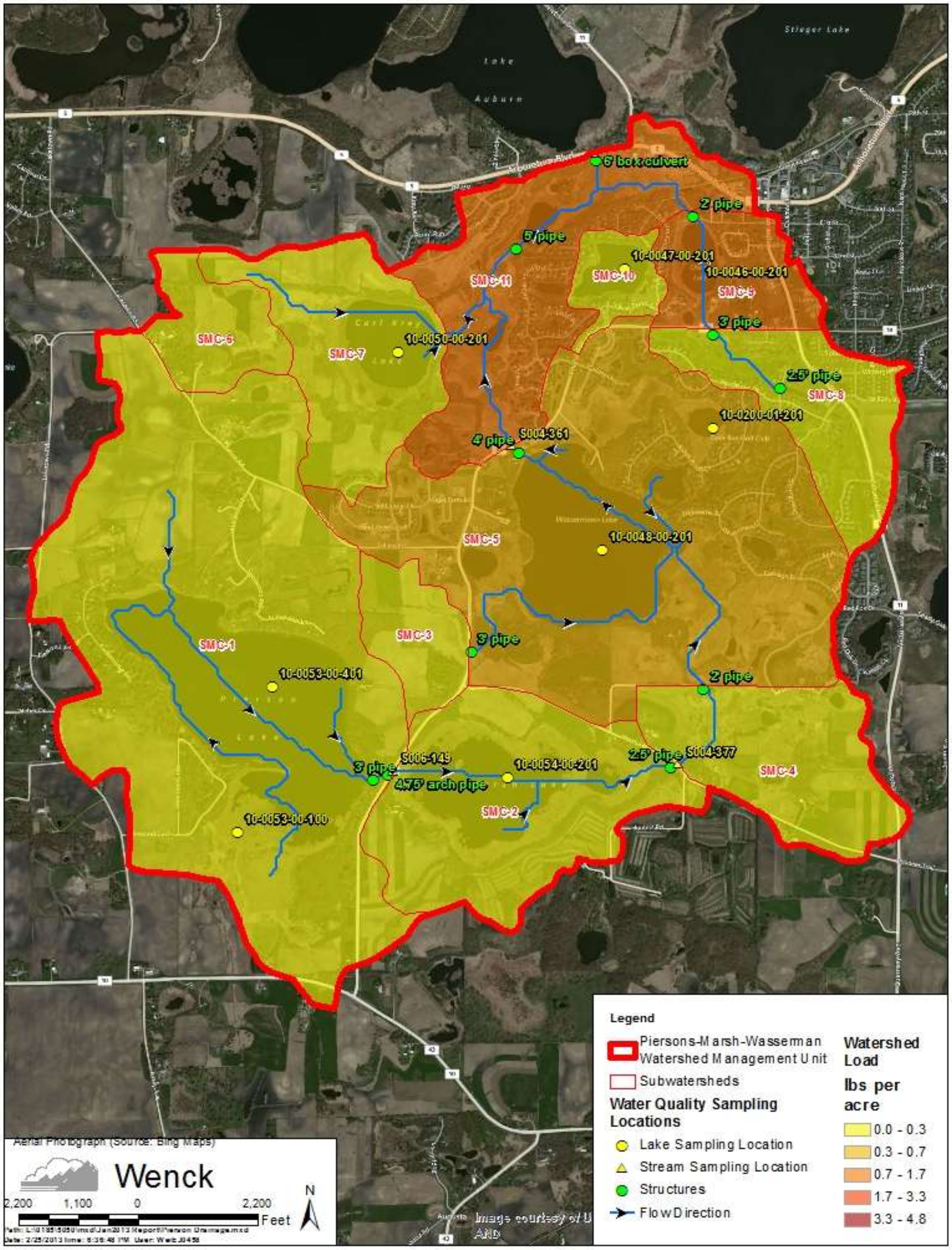

Figure 3-10. Watershed nutrient loading in the Pierson-Marsh-Wassermann Management Unit.

Internal Loading

Internal release rates were measured in both Marsh and Wassermann lakes under oxic and anoxic conditions. For Marsh Lake, no phosphorus release occurred under oxic or anoxic conditions (Table 3-5). In Wassermann Lake, cores were collected from a shallow area to assess oxic release and the deep hole to assess anoxic release. Wassermann Lake demonstrated a low to moderate phosphorus release rate (Table 3-5). More detailed information on phosphorus release rates and sediment chemistry can be found in Appendix C.

Table 3-5. Measured internal release rates for lakes in the Pierson-Marsh-Wassermann Management Unit.

Lake	Oxic P Release	Anoxic P Release
	(mg/m^2/day)	(mg/m^2/day)
Marsh	0.0	0.0
Wassermann (shallow)	0.5	--
Wassermann (deep)	--	3.7

Nutrient Budgets

External and internal loads were used to develop nutrient budgets for key lakes in the Management Unit.

<u>Wassermann Lake</u>

Nutrient sources for Wassermann Lake are dominated by direct watershed drainage areas followed by internal loading and contributions from upstream lakes including Pierson and Marsh lakes (Figure 3-11). Internal release rates are moderate to low, suggesting that external loads are driving more of the nutrient budget for Wassermann Lake. Upstream lake contributions are small, with low phosphorus concentrations.

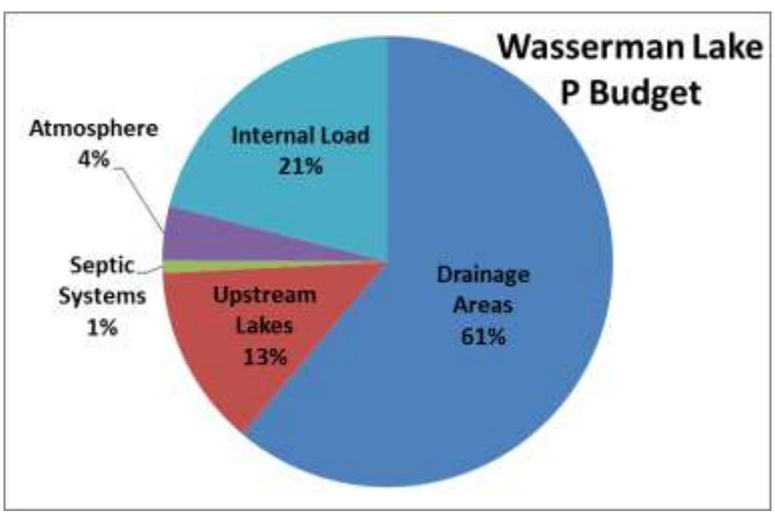

Figure 3-11. Average nutrient loading to Wassermann Lake.

To meet state water quality standards, a 60% load reduction is necessary with approximately two-thirds coming from watershed reductions and the remaining coming from internal load reductions. Watershed sources likely include the large wetland between Marsh Lake and Wassermann Lake, as well as the drainage area to the east of the lake (Table 3-6). A few septic systems likely need to be upgraded in the watershed.

Table 3-6. Nutrient loads and required reductions to meet state water quality standards (<40 µg/L TP) in Wassermann Lake.

Source	Existing TP Load	TP Allocations	Load Reduction	
	(lbs/year)	**(lbs/year)**	**(lbs/year)**	**%**
Drainage Areas	613	156	457	**75%**
SSTS	9	0	9	**100%**
Upstream Lakes	83	83	0	**0%**
Atmosphere	39	39	0	**0%**
Internal Load	374	165	209	**56%**
TOTAL	**1,118**	**443**	**675**	**60%**

<u>Church Lake</u>

Phosphorus loading to Church Lake is dominated by watershed sources representing 78% of the phosphorus budget to the lake (Figure 3-12). Internal loading is the next largest source at 18% of the nutrient load. Phosphorus reductions need to focus on watershed sources.

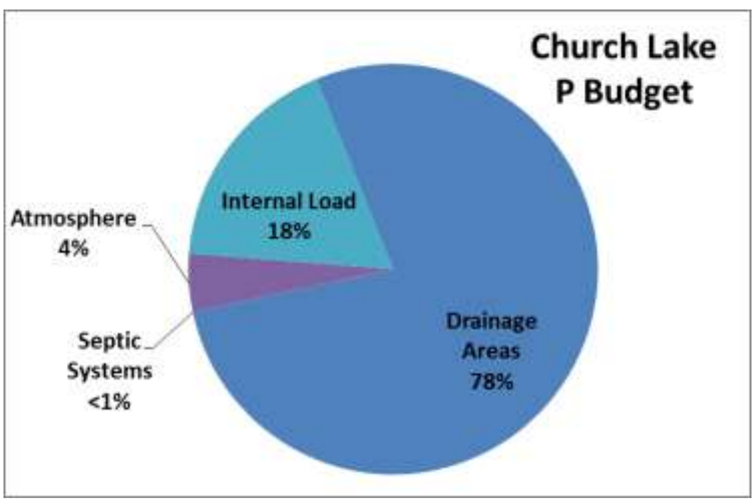

Figure 3-12. Average nutrient loading to Church Lake.

For Church Lake to meet state water quality standards, phosphorus loading needs to be reduced by almost 64% with the majority coming from watershed loading (Table 3-7). Internal loading also needs to be reduced, although it is such a small source that this should be the last step in the restoration process.

Table 3-7. Nutrient loads and required reductions to meet state water quality standards (<40µg/L TP) in Church Lake.

Source	Existing TP Load [1]	TP Allocations	Load Reduction	
	(lbs/year)	(lbs/year)	(lbs/year)	%
Drainage Areas	132	49	83	**63%**
SSTS	3	0	3	**100%**
Atmosphere	4	4	0	**0%**
Internal Load	15	3	12	**80%**
TOTAL	**154**	**56**	**98**	**64%**

3.6 CARVER PARKE RESERVE DRAINAGE

The Carver Park Reserve Management Unit includes most of the lakes in the Carver Park Reserve, which all have relatively good water quality (Figure 3-13). These lakes receive most of their drainage from the relatively undeveloped park areas and are managed by the Three Rivers Park District. Drainage in much of the area can be quite complex, with the Stone Lake drainage having numerous water control structures. There are also some backwater conditions, with Zumbra Lake reportedly receiving much of its water as backflow from Sunny Lake. Steiger Lake has a relatively straightforward drainage pattern, draining directly to East Auburn Lake.

Morphology

There are three major lakes in the Carver Park Reserve Management Unit including Steiger, Stone and Zumbra lakes (Table 3-8). Two other lakes in the watershed are Crosby Lake and Sunny Lake, but neither has bathymetric information. The three major lakes are deep lakes with maximum depths greater than 30 feet and average depths greater than 10 feet. Both Crosby Lake and Sunny are thought to be shallow basins. All three of the deep lakes have relatively small watersheds and long residence times. Sunny lake is connected to Zumbra Lake and backflows into the lake. However, water quality has not been measured in Sunny Lake.

Figure 3-13. The Carver Park Reserve Management Unit.

Table 3-8. Physical characteristics of lakes in the Carver Park Reserve Management Unit.

Parameter	Steiger	Stone	Zumbra
Surface Area (acres)	166	99	193
Average Depth (ft)	13.2	10.2	14.9
Maximum Depth (ft)	37	30	50
Volume (acre-feet)	2,183	1,009	2,872
Residence Time (years)	2.8	1.8	12.0
Littoral Area (acres)	103	71	77
Littoral Area (%)	62%	72%	40%
Watershed (acres)	412	692	331

Water Quality Monitoring

Lakes in the Carver Park Reserve demonstrate relatively good water quality with typical summer average total phosphorus concentrations below state water quality standards (Figure 3-14, Appendix E). Stone Lake has historically demonstrated summer average concentrations above the state water quality standards, but water quality has been improving over the past 10 years and has not exceeded the standard since 2007. Steiger Lake exceeded the standard in two of the past ten years, but only slightly. Chlorophyll-*a* concentrations are low in all three lakes.

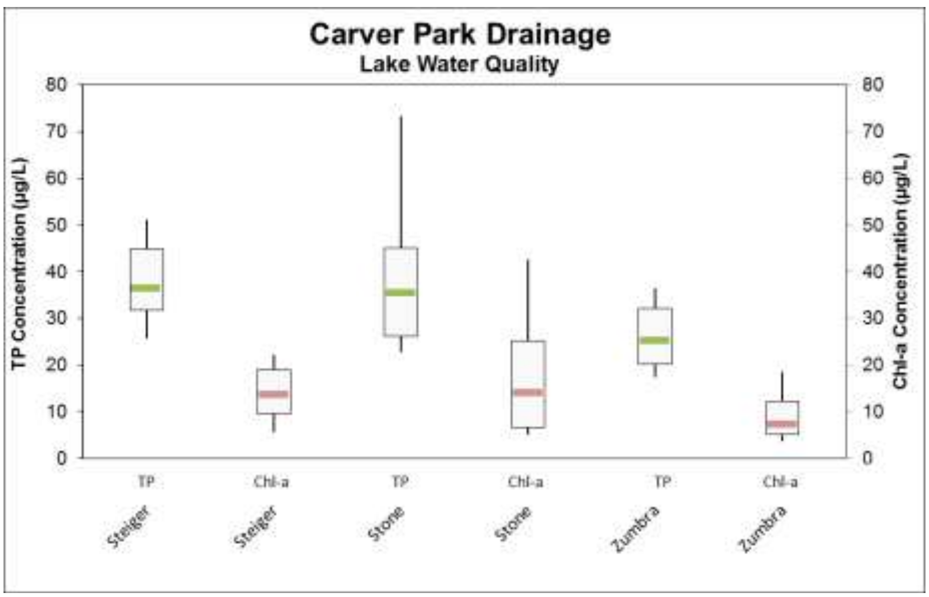

Figure 3-14. Lake total phosphorus and chlorophyll-*a* concentrations over the past 13 years.

Measured phosphorus concentrations in the watershed are relatively low coming out of the lakes, but jump significantly prior to discharging to Auburn Lake (Figure 3-15; site S003-754). The jump in phosphorus between the lakes suggests that the wetland area is contributing phosphorus to surface waters. The same phenomenon occurs between the outlet of Sunny Lake as it discharges to East Auburn Lake. These jumps in concentration with little additional contributing area suggest that the wetlands have been impacted in a way to cause them to discharge phosphorus. Carp could play a role in the discharge by stirring up sediments, but altered wetland hydrology may also be a factor.

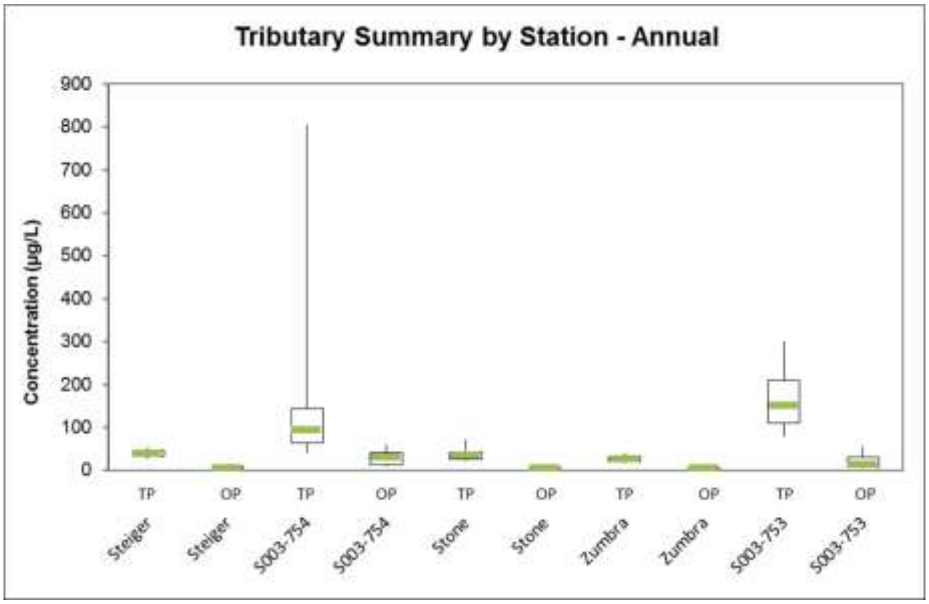

Figure 3-15. Total and ortho-phosphorus concentrations in the Carver Park Reserve Management Unit.
Note: Data is plotted upstream to downstream where possible.

Fisheries

All of the lakes demonstrated relatively large panfish populations (Figures 3-16 and 3-17; Appendix F). According to the Minnesota DNR, bluegill in Zumbra Lake are becoming stunted. In the Metro area, stunting in size is likely due to overpopulation and size-selective harvest by anglers. Overpopulation reduces the amount of food available to all fish, reducing growth rates. Harvest of larger (keeper size) fish by anglers reduces the number of quality fish in a lake. Harvesting large fish also removes the spawning stock and reduces the biological incentive to grow large. Larger fish compete for spawning habitat and food more effectively. Stunted panfish populations can also present a large grazing pressure on large zooplankton, which are key algal grazers. However, chlorophyll-*a* concentrations in Zumbra Lake are not out of line with expected response to phosphorus concentrations.

A catch-and-release regulation for largemouth bass and northern pike was implemented in 1988 for Steiger Lake. Efforts to increase the size of panfish in Steiger Lake through a catch and release regulation for large-mouth bass and walleyes (sic) have been unsuccessful (Larry Gillette, pers. comm.).

All three of the lakes have relatively low rough fish population. Rough fish are present in low numbers in Zumbra Lake and common carp were not sampled in the 2010 survey. Black bullhead abundance in Zumbra Lake decreased to an all-time low in the most recent survey. Bullhead relative abundances in Stone Lake are down from the 1991 assessment that demonstrated black and brown bullheads in excess of both state and local averages. Common carp numbers remain average in Steiger Lake (Figures 3-16 and 3-17).

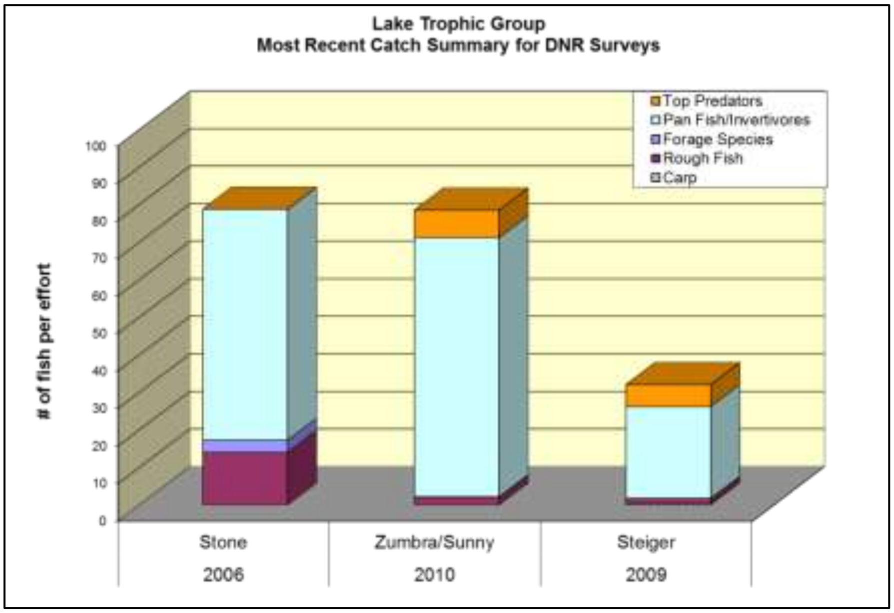

Figure 3-16 Fisheries summary by trophic group for Stone, Zumbra/Sunny, and Steiger lakes.

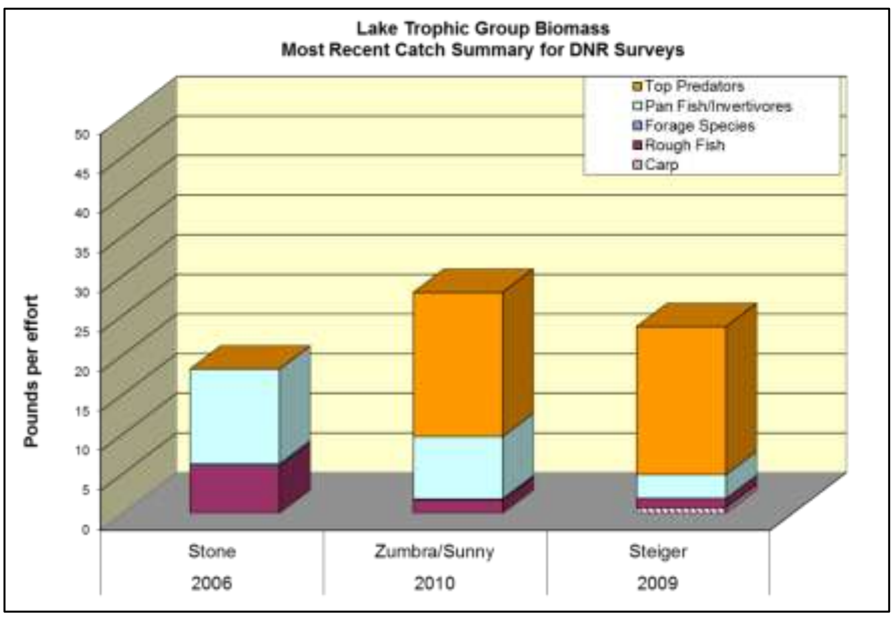

Figure 3-17 Fisheries summary by trophic group biomass for Stone, Zumbra/Sunny, and Steiger lakes.

Sunny Lake suffers from frequent winterkills and may allow carp reproduction (Larry Gillette, pers. comm.). Stone Lake suffered a couple of winterkills in the late 1970s and early 1980s, but has not been observed since. There is a culvert between Zumbra Lake and Sunny Lake that acts as an equalizer between the lakes. Based on field observations from Three Rivers Park District staff, carp congregate at this culvert in both directions depending on the direction of flow.

There is a water control structure between Sunny Lake and Stone Lake that effectively keeps carp out of Stone Lake. The control is on the upstream side of the culvert under the bike trail that runs along the north side of Sunny Lake. Three Rivers Park District staff report never observing a carp in Stone Lake or in the marsh between Stone Lake and Sunny Lake, but carp have gathered just below the control structure by Sunny Lake.

Crosby Lake, which flows into Stone Lake, is shallow and winterkills frequently. However, carp have not been observed in the lake and bullheads and green sunfish move into the basins annually.

The flow between Lake Auburn and Steiger lakes is more intermittent and flows through a cattail marsh, both of which may limit the movement of carp (Larry Gillette, pers. comm.). Carp are in Steiger Lake, but it may be primarily the result of reproduction within the lake.

Aquatic Plants

Aquatic vegetation data were available for Zumbra and Steiger Lake (Figure 3-18; Appendix G), but no data are available for Sunny or Stone lakes. Both of the lakes are dominated by coontail, a native species tolerant of more eutrophic conditions. Both lakes have Eurasian watermilfoil and curly-leaf pondweed with Steiger being heavily infested with Eurasian watermilfoil. Both lakes also have occasional occurrences of native species and would likely benefit from long-term control of the invasives to allow the natives to flourish. Nutrient control over the long term will also help reduce the coontail population and allow room for other native species.

Sunny Lake in particular needs a vegetation survey. The lake has been known to winterkill in the past and may be in a turbid water state. Restoration may need to focus on reestablishing the submerged aquatic vegetation community and preventing winterkill; however, vegetation survey data is needed to confirm this hypothesis.

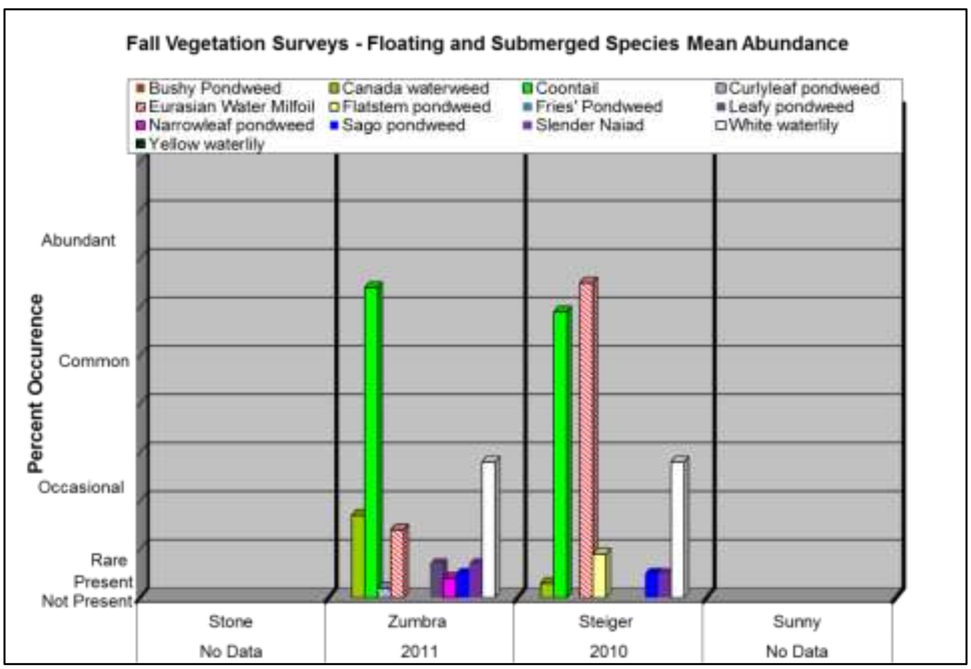

Figure 3-18. Vegetation survey data for lakes in the Carver Park Reserve Management Unit.
Note: Both Zumbra and Steiger had curly-leaf pondweed in spring surveys (Appendix G).

Nutrient Budgets

Nutrient budgets for the lakes were developed for those lakes that demonstrate degraded water quality conditions. Of those lakes with measured water quality, only Stone and Steiger lakes have years that exceeded state water quality standards, and both of these lakes have not exceeded the standard since 2007 and 2006, respectively. Consequently, nutrient budgets and reductions were not developed for these lakes. Rather, watershed areas that demonstrate a high potential for loading were assessed for protection projects.

Watershed Sources

Watershed sources are highest in the southern portions of the watershed and the land area draining to East Auburn Lake (Figure 3-19). Both SMC-15 and SMC-25 demonstrated runoff concentrations greater than 1 mg/L phosphorus, likely as a result of degraded wetlands between the outlets of the lakes and the inflow into East Auburn Lake. Loading to Steiger Lake appears to be a little higher due to development in the watershed; however, water quality in the lake is relatively good and watershed practices can be considered protection activities.

Internal Loading

In the Carver Park Reserve Management Unit, only Stone Lake was assessed for internal phosphorus release. One set of cores was collected from the deep spot in the lake and analyzed for anoxic phosphorus release (Table 3-9). Stone Lake demonstrated a moderate internal phosphorus release rate typical of mesotrophic to slightly eutrophic lakes. More detailed information on phosphorus release rates and sediment chemistry can be found in Appendix C.

Table 3-9. Measured internal release rates for lakes in the Carver Park Reserve Management Unit.

Lake	Oxic P Release ($mg/m^2/day$)	Anoxic P Release ($mg/m^2/day$)
Stone Lake	--	3.5

Nutrient Budgets

<u>Stone Lake</u>

Water quality in Stone Lake has improved every year since 2000, with the last three years meeting state water quality standards. Based on these results, Stone Lake and its watershed should be considered protection areas unless future monitoring shows deterioration of water quality in the lake.

<u>Zumbra and Sunny Lakes</u>

Zumbra Lake has excellent water quality likely due to its very small watershed. Sunny is connected to Zumbra, but water quality data are not available for the lake. Water quality is expected to be good because the majority of the lake’s water comes from Stone and Zumbra lakes, which have very good water quality. Consequently, it is likely that management should focus on ecological management, such as preventing fish kills and managing submerged aquatic vegetation.

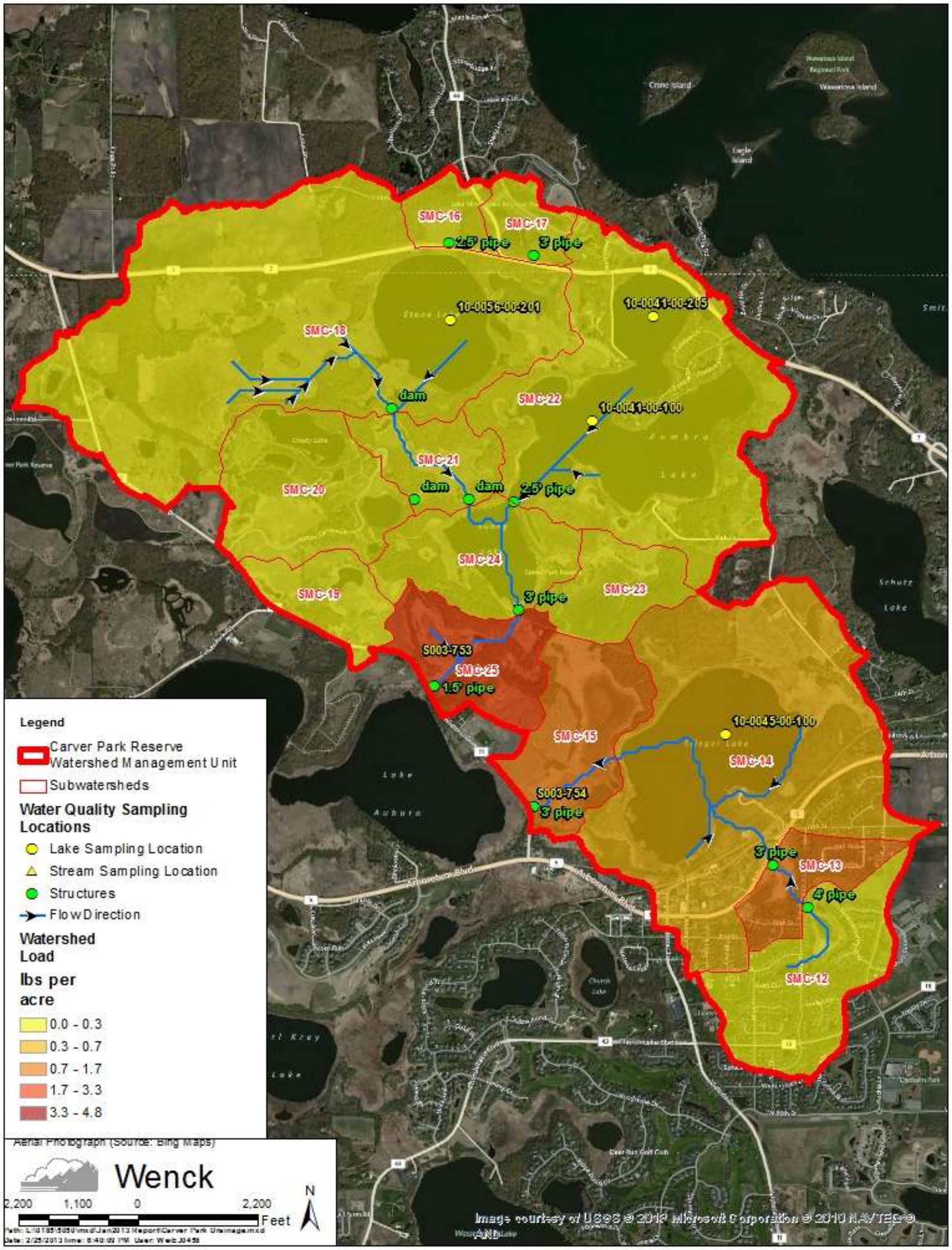

Figure 3-19. Phosphorus loading in the Carver Park Reserve Management Unit.

Steiger Lake

Steiger Lake has fairly good water quality in those years where greater than four samples were collected. Based on its water quality, Steiger Lake is considered more of a protection area. Managing stormwater runoff from the watershed will benefit the lake in the long term. In fact, MCWD engaged in a wetland restoration in 2012 in one of the primary inlets to Steiger Lake from the City of Victoria to reduce nutrient loading. The wetland is located on the south side of Highway 5, between 80th Street and 78th Street West in Victoria. More information on this project can be found in Section 4.5.

3.7 AUBURN-NORTH LUNDSTEN DRAINAGE

This management unit includes Auburn and North Lundsten lakes. These lakes act as collection points from the rest of the upper watershed, receiving drainage from Sunny, Steiger, Wassermann, Church, and Carl Key lakes as well as Kelser's Pond. All three of these lakes have healthy, dense aquatic vegetation populations, suggesting minimal impacts from carp. Additionally, water quality in both North Lundsten and West Auburn lakes is good, with East Auburn Lake taking the brunt of water quality impacts from the upper watershed. These similarities led to the formation of the Auburn-North Lundsten Management Unit.

Morphology

There are three lakes in the Auburn-North Lundsten Management Unit, including East and West Auburn lakes, which are essentially two bays of a large lake connected by a small shallow channel. East Auburn Lake is a deep lake with a large littoral area while West Auburn is deep with a small littoral area. West Auburn Lake has a very long residence time. North Lundsten Lake is a classic shallow lake with an average depth of 4 feet and a maximum depth of 7 feet. North Lundsten Lake has a very short residence time, flushing on average once every 36 days (Table 3-10, Figure 3-20).

Table 3-10. Physical characteristics of lakes in the Auburn-North Lundsten Management Unit.

Parameter	East Auburn	West Auburn	North Lundsten
Surface Area (acres)	148	145	114
Average Depth (ft)	12.0	25.0	4.4
Maximum Depth (ft)	40	80	7
Volume (acre-feet)	1,781	3,615	508
Residence Time (years)	0.7	4.7	0.1
Littoral Area (acres)	42	83	114
Littoral Area (%)	28%	58%	100%
Watershed (acres)	214	184	232

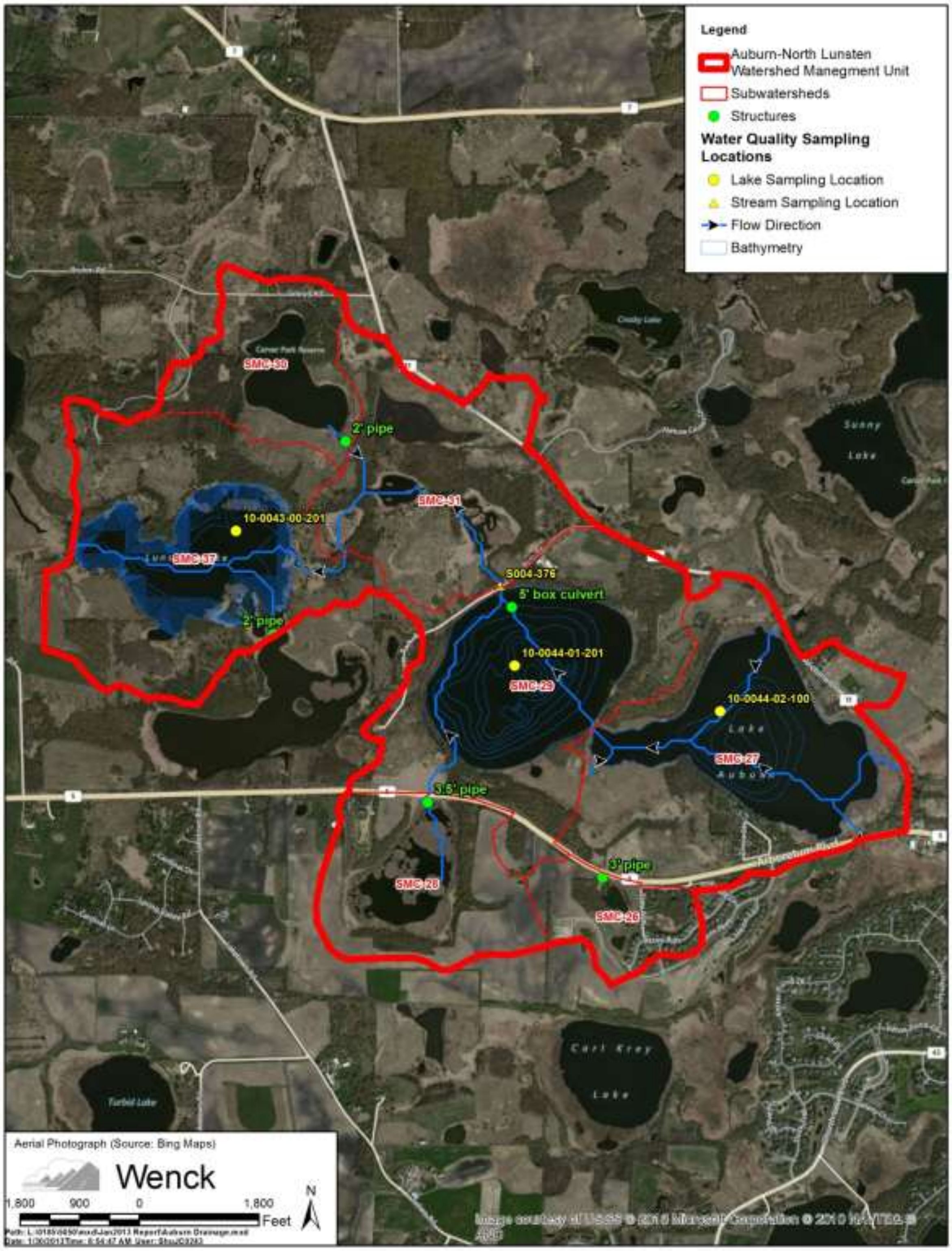

Figure 3-20. The Auburn-North Lundsten Management Unit.

Water Quality Monitoring

East Auburn Lake demonstrates some eutrophication, with four out of the last five monitoring years exceeding the state water quality standards (Figure 3-21). Chlorophyll-*a* values are typical of lakes with these phosphorus levels. West Auburn Lake, which receives most of its drainage from East Auburn Lake, demonstrates very good water quality with all the years meeting the state water quality standard in the past 13 years.

Water Quality in North Lundsten Lake has some potential for eutrophication, although none of the summer average data with four or more samples exceeded the water quality standard. Furthermore, the lake receives most of its drainage from West Auburn Lake and South Lundsten Lake, with only South Lundsten Lake having very poor water quality.

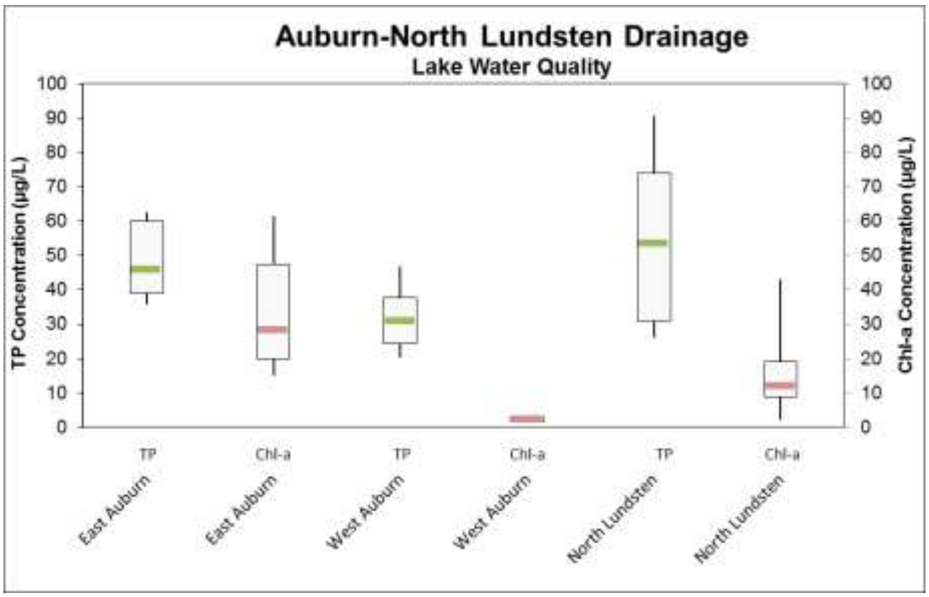

Figure 3-21. Lake total phosphorus and chlorophyll-*a* concentrations over the past 13 years.

In this part of the Six Mile Creek drainage, water flows through East then West Auburn lakes before discharging through a large wetland to North Lundsten Lake. Total phosphorus decreases from East to West Auburn, but increases again at the outlet of West Auburn Lake. Phosphorus concentrations then slightly increase as they move through the system and out to Parley Lake. It is not clear why phosphorus concentrations jump at the outlet of the lake, but the increase is likely due to increased loading from other parts of the watershed, such as South Lundsten Lake. Overall, the key drivers for water quality in this segment of the watershed are East Auburn Lake and inflow from South Lundsten Lake (Figure 3-22).

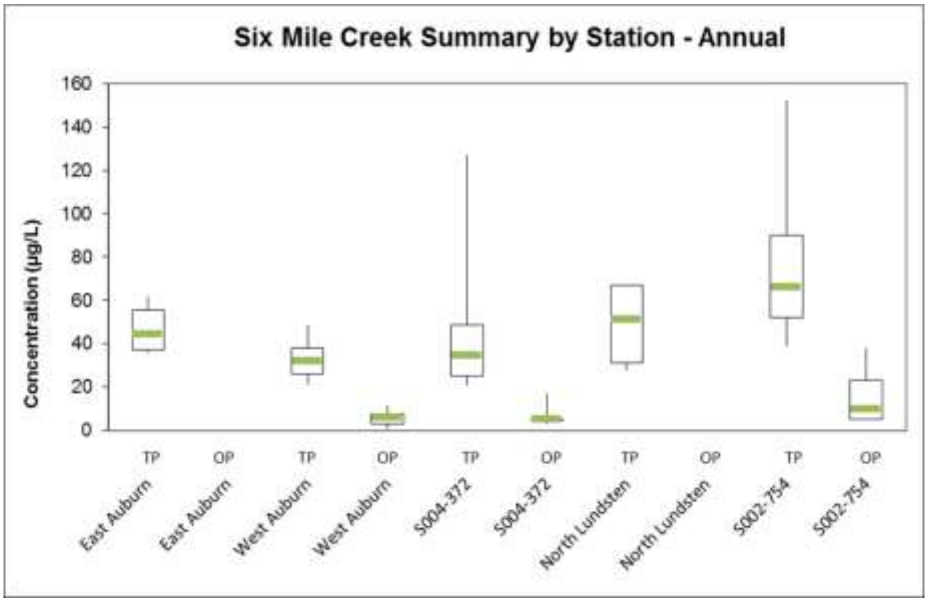

Figure 3-22. Total and ortho-phosphorus concentrations in the Auburn-North Lundsten Management Unit.

Note: Data is plotted upstream to downstream where possible.

Fisheries

Auburn Lake was sampled for fish in 2012 by the Minnesota DNR (Figure 3-23; Appendix F). No data are available for North Lundsten Lake. The fish population in Auburn Lake is relatively balanced with a large panfish population. The Minnesota state record largemouth bass was caught from Auburn Lake on October 5, 2005. The fish measured 23.5 inches and weighed 8 pounds 15 ounces. Although bass are not sampled well by trap and gill nets, there does appear to be a healthy top predator population in the lake.

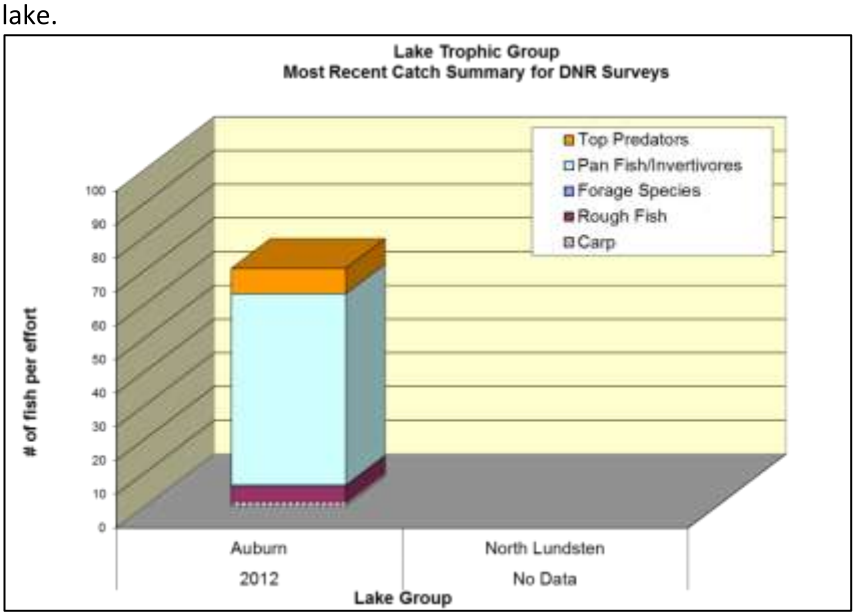

Figure 3-23. Fisheries summary by trophic group for the Auburn-North Lundsten Management Unit.

East Auburn Lake has reportedly winterkilled in the past but has not in recent years (Larry Gillette, pers. comm). Carp reproduction in East Auburn Lake appears possible, but there is no direct evidence of this occurring in the past.

Carp can move upstream out of Lake Auburn in three directions. They can go east up seasonal streams under Highway 11 to Sunny Lake or to Steiger Lake. They can also go south under Highway 5 into Wassermann Lake and Pierson Lake. The flow between Lake Auburn and Steiger lakes is more intermittent and it flows through a cattail marsh, which may limit the movement of carp. However, carp can move freely to and from Sunny Lake, which has been known to frequently winterkill.

Fish movement upstream from North Lundsten Lake was initially blocked by a riprap dam that washed out in the late 1990s. A carp barrier/trail crossing culvert is now located at the site of the former riprap dam, which is just upstream from the inflow to North Lundsten Lake from West Auburn Lake (Figure 3-24). This culvert has been in place 3-4 years and it may stop carp movements upstream into Lake Auburn. Some carp go downstream from North Lundsten Lake to Parley Lake, bypassing the control structure, especially during periods of high water.

Figure 3-24. The location of the potential carp barrier just upstream of North Lundsten Lake.

Overall, none of these lakes demonstrate significant impacts from carp populations. All three lakes have healthy, robust submerged aquatic vegetation populations. No fish surveys have been conducted in North Lundsten Lake, but it does not appear to have a high density of carp.

Aquatic Plants

All three of the lakes in the Management Unit had recent vegetation survey data. The three lakes are dominated by coontail, a native species that is tolerant of more eutrophic conditions. East and West Auburn lakes are dominated by Eurasian watermilfoil and all three lakes have curly-leaf pondweed. Eurasian watermilfoil was not found in North Lundsten Lake. A few native species still occur in the lakes, including some native pondweeds such as sago and narrow leaf pondweeds (Figure 3-25; Appendix G).

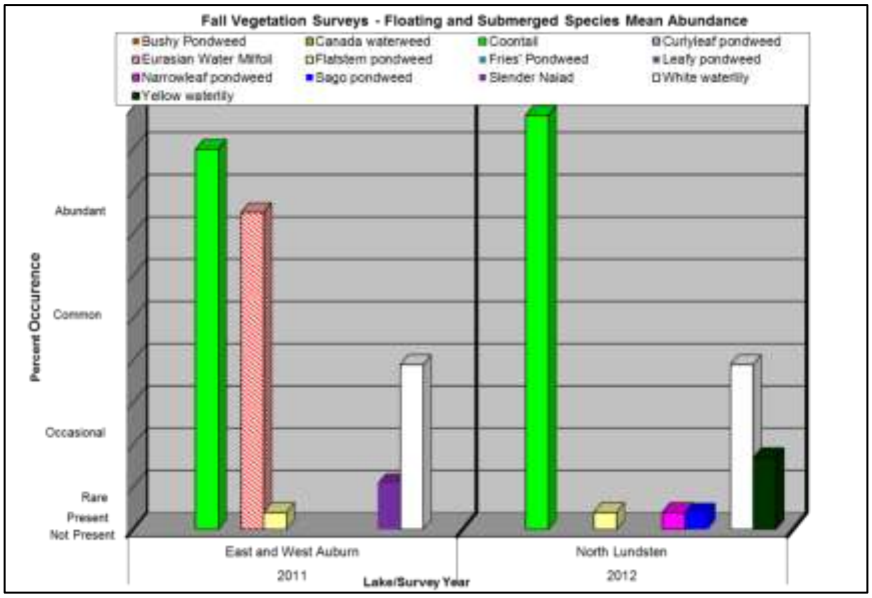

Figure 3-25. Aquatic vegetation in the Auburn-North Lundsten Management Unit.
Note: All three lakes contained curly-leaf pondweed in spring surveys.

Nutrient Budgets

Watershed Sources

Nutrient loading in the direct subwatersheds to East and West Auburn and North Lundsten lakes is relatively low. Most of the load to these lakes comes from upstream lakes, such as Wassermann Lake and South Lundsten Lake. The two subwatersheds between Sunny and Steiger lakes, SMC15 and SMC-25, also are large contributors to East Auburn Lake. A third large contributor is the large wetland between Wassermann Lake and East Auburn Lake (SMC-11, Figure 3-26).

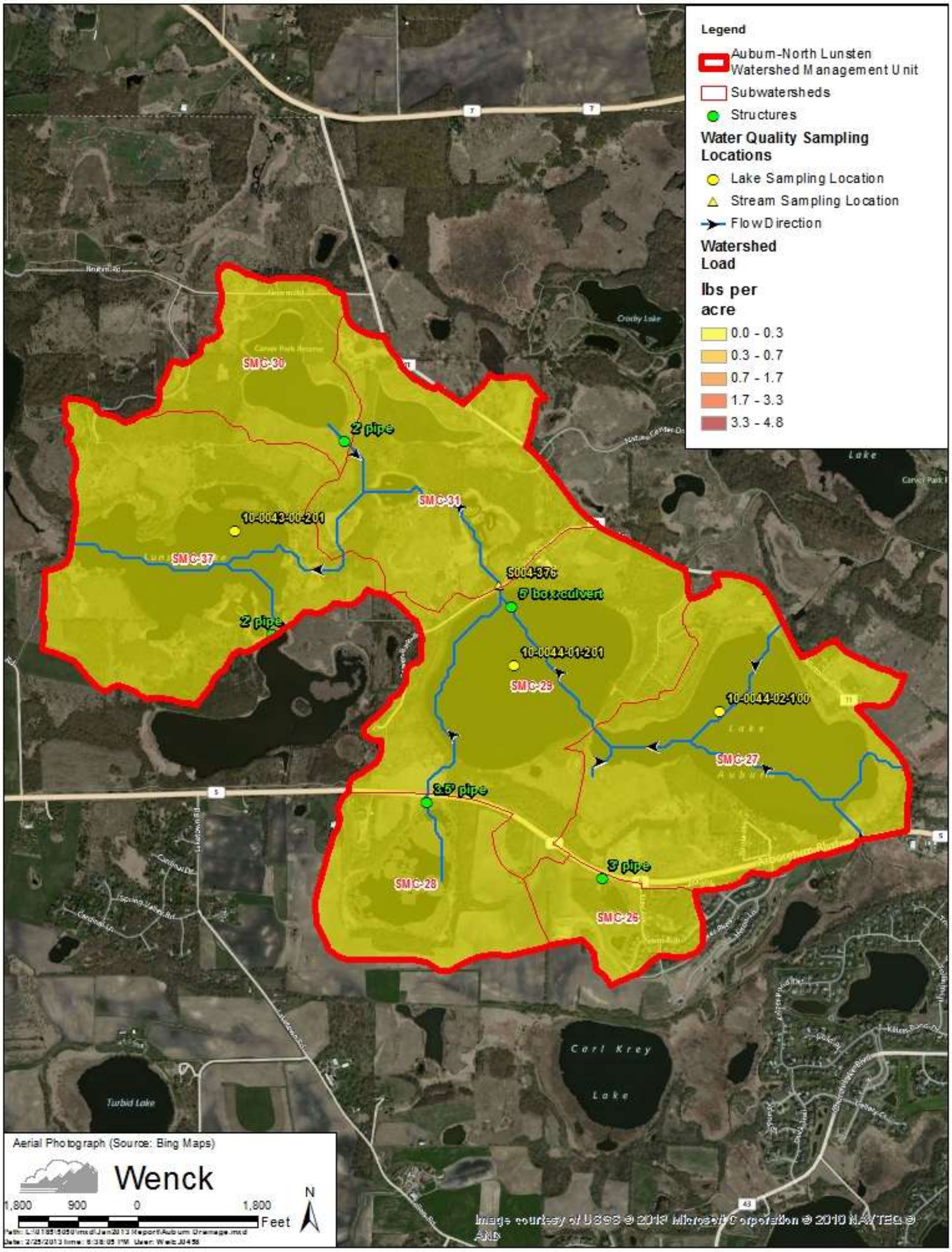

Figure 3-26. Watershed loading in the Auburn-North Lundsten watershed.

Internal Loading

Cores were collected from East Auburn Lake and North and South Lundsten lakes to determine internal sediment phosphorus release rates. East Auburn demonstrated a moderate release rate under anoxic conditions, whereas North Lundsten had relatively low rates more typical of mesotrophic lakes. South Lundsten demonstrated very high internal release rates with oxic loading at 6 mg/m^2/day. To put this in perspective, the majority of other lakes measured for oxic phosphorus release in Minnesota were less than 0.6 mg/m^2/day. Anoxic release rates in South Lundsten Lake were high, typical of highly eutrophic lakes (Table 3-11).

Table 3-11. Measured internal release rates for lakes in the Auburn-North Lundsten Management Unit.

Lake	Oxic P Release (mg/m^2/day)	Anoxic P Release (mg/m^2/day)
East Auburn	--	7.0
South Lundsten	6	14.4
North Lundsten	0.3	2.2

Nutrient Budgets and Reductions

<u>East Auburn Lake</u>

The key lake in this management unit is East Auburn Lake, which receives water and nutrients from the entire upper watershed. The majority of phosphorus coming into East Auburn Lake comes from the drainage areas, specifically subwatersheds SMC-11, SMC-15, and SMC-25. All three subwatersheds have altered wetlands that likely discharge phosphorus to surface waters. Upstream lake inputs represent 36% of the phosphorus budget and most of this is coming from Wassermann and Church lakes. Internal loading is not a key phosphorus source to East Auburn Lake (Figure 3-27).

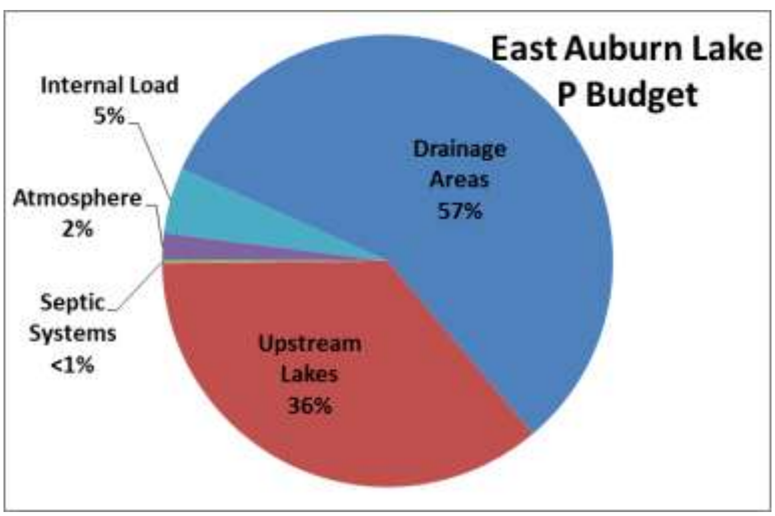

Figure 3-27. Average phosphorus loading for East Auburn Lake.

To meet state water quality standards, both Church and Wassermann lakes need to meet state water quality standards and then watershed loading needs to be reduced 26% (Table 3-12). Watershed reductions can come from restoring wetlands in SMC-15, SMC-25, and SMC-11.

Table 3-12. Nutrient loads and required reductions to meet state water quality standards (40 µg/L TP) in East Auburn Lake.

Source	Existing TP Load (lbs/year)	TP Allocations (lbs/year)	Load Reduction	
			(lbs/year)	%
Drainage Areas	1,337	996	341	**26%**
Upstream Lakes	680	480	199	**29%**
SSTS	6	0	6	**100%**
Atmosphere	35	35	0	**0%**
Internal Load	41	41	0	**0%**
TOTAL	**2,099**	**1,553**	**546**	**26%**

North Lundsten Lake

North Lundsten Lake has relatively good water quality but is demonstrating some eutrophication pressures such as heavy aquatic plant biomass and blue-green algae blooms along the fringes of the lakes. The majority of phosphorus coming into North Lundsten Lake is from South Lundsten Lake. Consequently, nutrient reductions for North Lundsten Lake can be achieved by restoring South Lundsten Lake. The other primary inflow to North Lundsten Lake is from West Auburn Lake, which has very good water quality.

3.8 TURBID-SOUTH LUNDSTEN DRAINAGE

The Turbid-South Lundsten Management Unit includes two poor quality lakes, with Turbid draining into South Lundsten. Both of these lakes have anecdotal reports of large carp populations, with South Lundsten Lake having very poor water quality and no submerged aquatic vegetation. This is in contrast to the connected North Lundsten basin, which has a robust SAV population.

Morphology

There are two lakes in the Turbid-South Lundsten Management Unit. Turbid Lake is a deep lake that sits at the headwaters of the management unit. Even though it is a deep lake, it has a large littoral area covering 65% of the lake. At the bottom of the management unit sits South Lundsten Lake, a shallow lake with an average depth of 3.5 feet and maximum depth of 9 feet (Table 3-13, Figure 3-28).

Table 3-13 Physical characteristics of lakes in the Turbid-South-Lundsten Management Unit.

Parameter	Turbid	South Lundsten
Surface Area (acres)	40	77
Average Depth (ft)	10.4	3.5
Maximum Depth (ft)	35	9
Volume (acre-feet)	417	267
Residence Time (years)	1.3	0.3
Littoral Area (acres)	26	77
Littoral Area (%)	65%	100%
Watershed (acres)	492	121

Figure 3-28. The Turbid-South Lundsten Management Unit.

Water Quality Monitoring

There are two lakes in the Turbid-South Lundsten Management Unit, including Turbid, a deep lake, and South Lundsten, a shallow lake. Both lakes exhibit poor water quality with total phosphorus concentrations well above state water quality samples. Turbid exceeded state standards for phosphorus in all years monitored (six years) since 2006, with summer average concentrations ranging from 40 to 70 µg/L as a summer average (Figure 3-29; Appendix E). Water quality has been sampled only in 2012, but concentrations in South Lundsten Lake were extremely high, with a summer average of almost 450 µg/L. To put this in perspective, the state shallow lake standard for total phosphorus is 60 µg/L as a summer average.

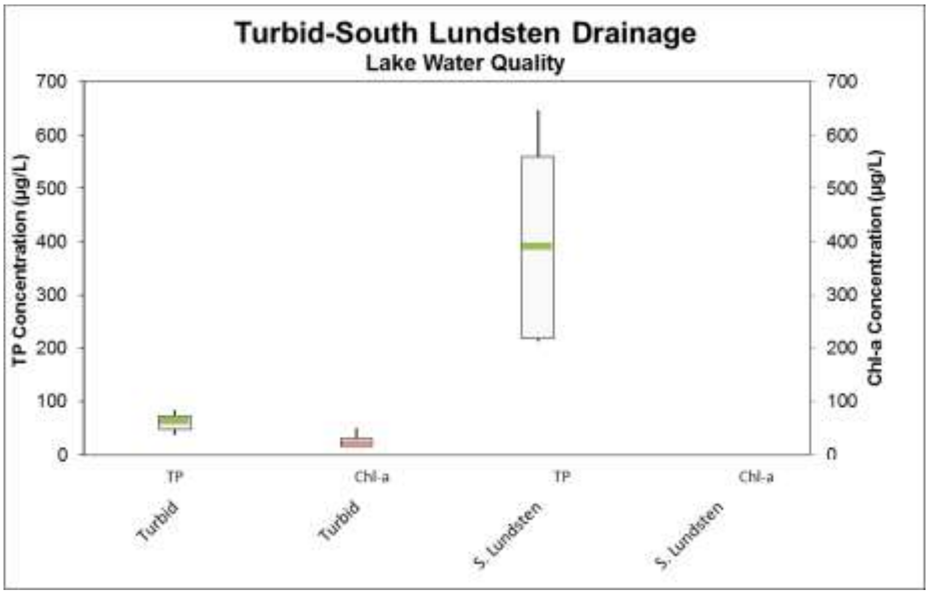

Figure 3-29. Lake total phosphorus and chlorophyll-*a* concentrations over the past 13 years.

Turbid Lake discharges to a low gradient stream that meanders through wetlands as it makes its way to South Lundsten Lake. Monitoring data was collected between Turbid Lake and South Lundsten Lake (Figure 3-30). Phosphorus concentrations increase after leaving Turbid Lake, and then remain relatively constant as the water moves to lower Lundsten Lake. By the time the water reaches the first water quality station, S005-527, phosphorus concentrations have almost doubled with the majority dissolved ortho-phosphorus, which is an indicator of wetland phosphorus release. Based on the water quality data, it appears that the wetlands between Turbid and South Lundsten lakes are contributing phosphorus to surface waters.

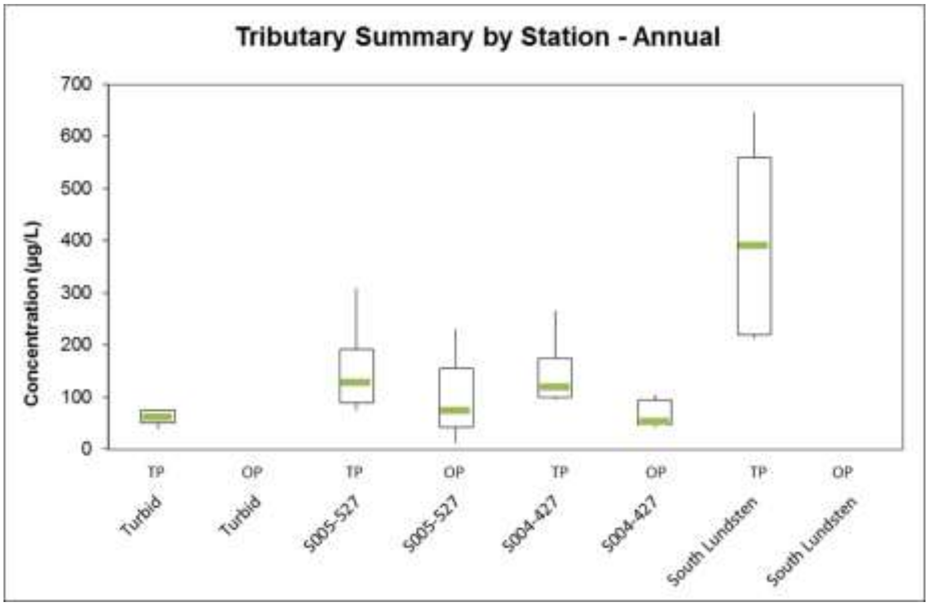

Figure 3-30. Total and ortho-phosphorus concentrations in the Turbid-South Lundsten Management Unit.

Note: Data is plotted upstream to downstream where possible.

Fisheries

The most recent fish survey for Turbid Lake is from 1992, more than 20 years ago (Appendix F). At this time, the fish population was dominated by rough fish, mostly black bullheads. No carp were captured during this sampling event. Overall, the lake had a very poor fish community (Figures 3-31 and 3-32).

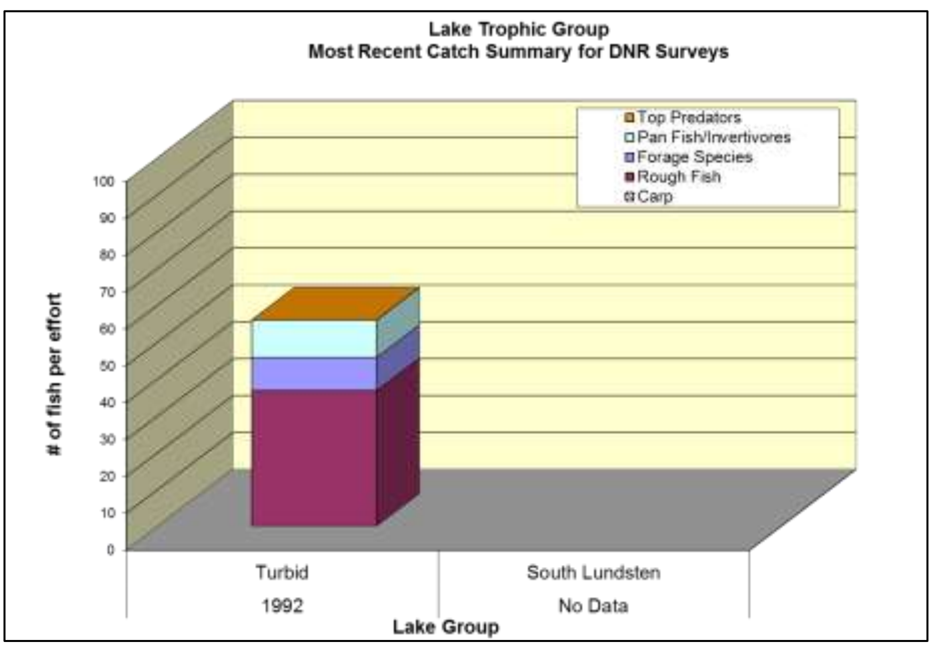

Figure 3-31. Fisheries summary by trophic group for the Turbid-South Lundsten Management Unit.

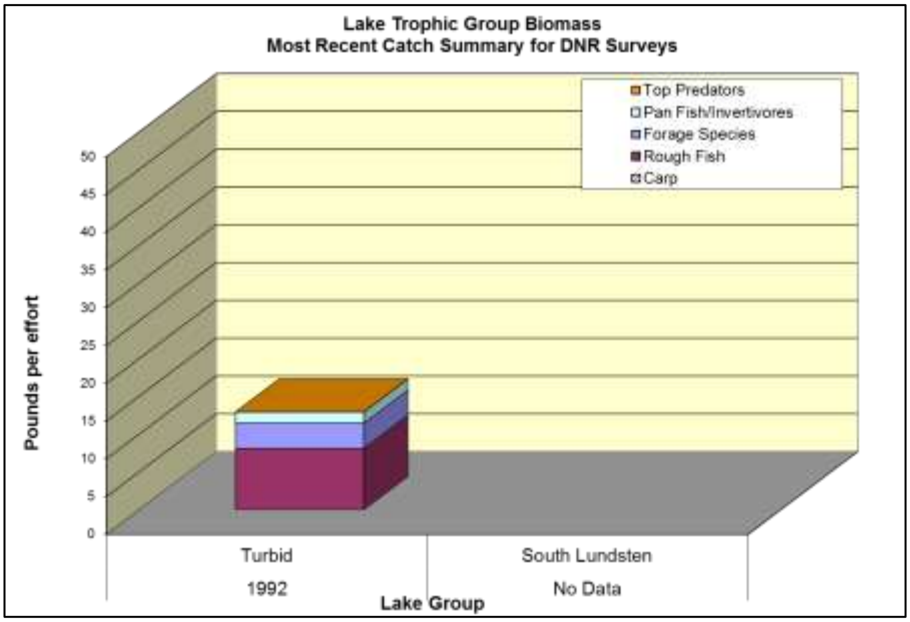

Figure 3-32. Fisheries summary by trophic group biomass for the Turbid-South Lundsten Management Unit.

South Lundsten Lake suffered periodic winterkills in the past (Larry Gillette pers. comm.). It is suspected that carp move south under Highway 5 to Turbid Lake.

It appears that the carp populations are disconnected in these two basins because of the contrast in current conditions. Therefore, management should focus on the South Lundsten-Turbid corridor separately from North Lundsten.

Aquatic Plants

Wenck conducted spring and fall aquatic vegetation surveys on South Lundsten Lake in 2012. No data are available for Turbid Lake (Figure 3-33; Appendix G). South Lundsten Lake lacks a robust submerged vegetation community with only a few species found sporadically around the lake. A few coontail plants were found along with some narrow leaf pondweed. Overall, the vegetation community in South Lundsten Lake is in very poor condition. MCWD plans on conducting vegetation surveys for Turbid Lake in 2013.

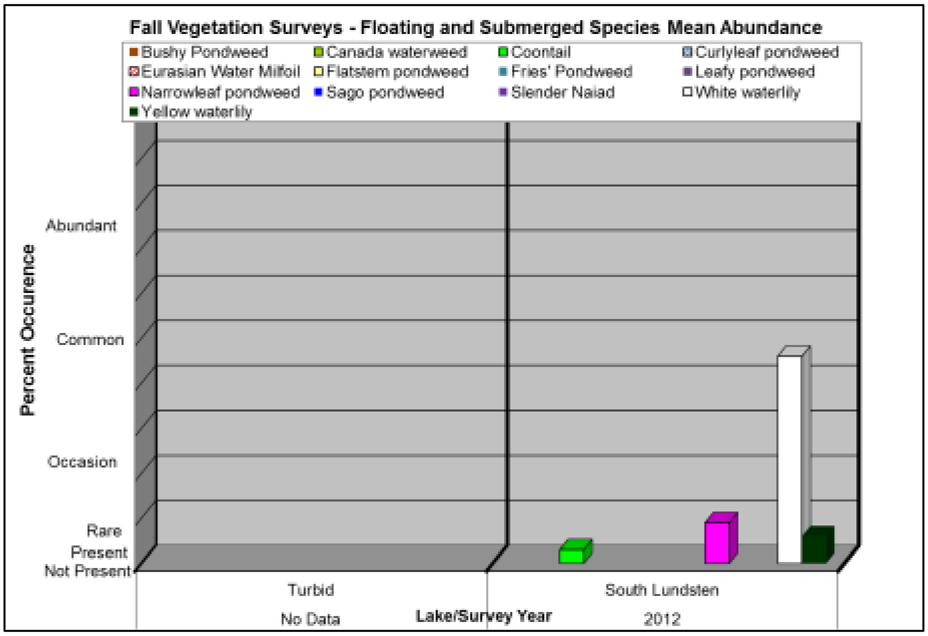

Figure 3-33. Recent mean plant abundance in Turbid and South Lundsten Lakes.

Nutrient Budgets

Watershed Sources

Watershed nutrient loading to Turbid Lake is relatively low with average runoff concentrations estimated around 80 µg/L phosphorus. The lake then discharges to a drainage ditch that flows through several modified wetlands prior to discharging to South Lundsten Lake. Based on monitoring data and mass balance calculations, runoff from these watersheds averages 225 to 325 µg/L total phosphorus. Consequently, it appears that most of the loading to South Lundsten Lake is coming along the drainage ditch between Turbid and South Lundsten Lake (Figure 3-34).

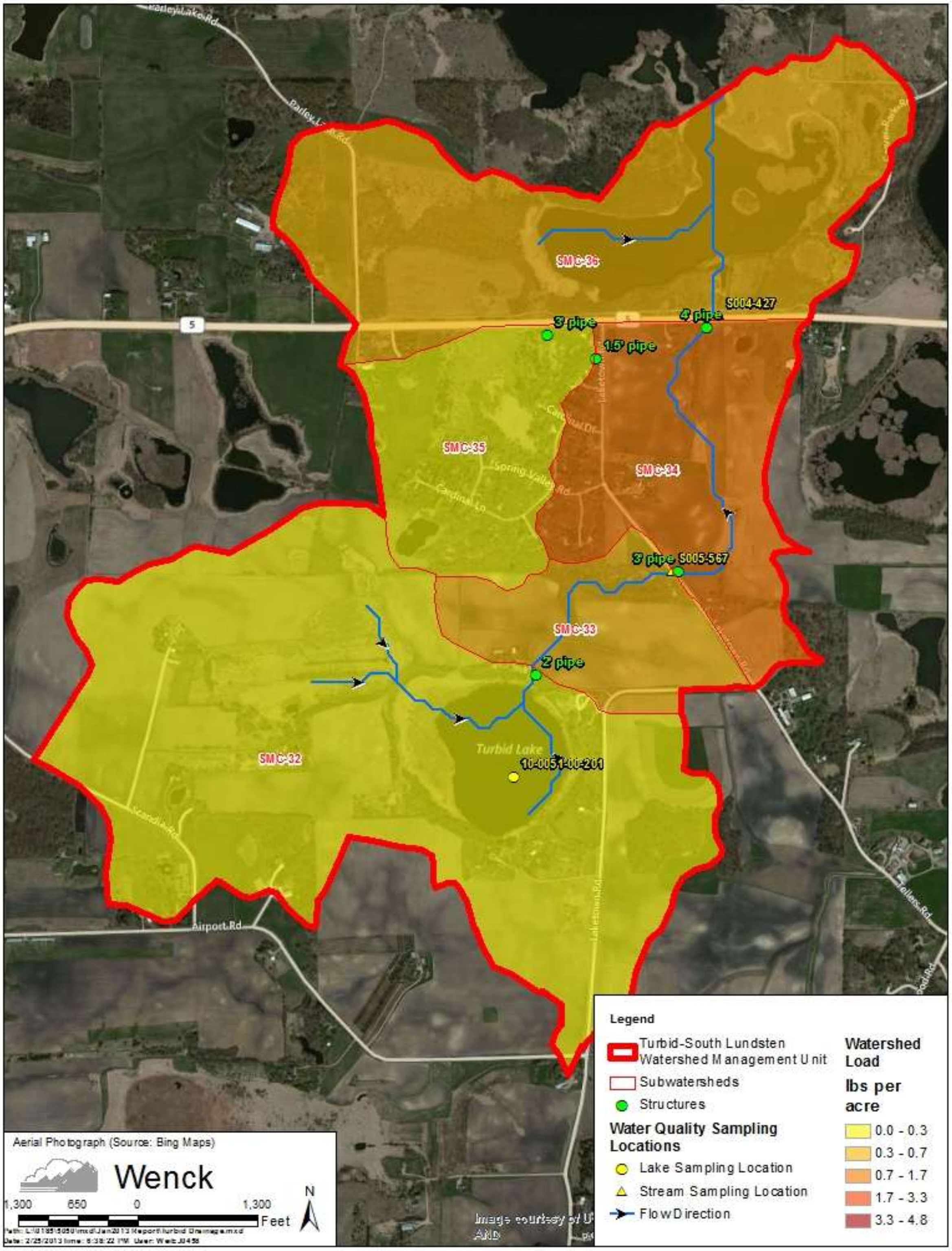

Figure 3-34. Phosphorus loading in the Turbid-South Lundsten Management Unit.

Internal Loading

Cores were collected from Turbid and South Lundsten lakes to determine oxic and anoxic release of phosphorus from sediments. Turbid Lake had a relatively high release rate typical of moderately eutrophic lakes (Table 3-14). Lower Lundsten Lake had very low rates for both oxic and anoxic release of phosphorus more typical of healthy shallow lake systems.

Table 3-14. Measured internal release rates for lakes in the Turbid-South Lundsten Management Unit.

Lake	Oxic P Release ($mg/m^2/day$)	Anoxic P Release ($mg/m^2/day$)
Lower Lundsten Lake	0.3	2.2
Turbid Lake	--	9.3

Nutrient Budgets and Reductions

Turbid lake

Nutrient loading to Turbid Lake is dominated by internal loading representing 65% of the phosphorus load to the lake (Figure 3-35). Watershed loading represented around 23% of the overall phosphorus load to the lake, but runoff concentrations appear to be reasonably low (approximately 90 µg/L), so reductions from the watershed will be difficult. Monitoring to verify watershed runoff concentrations is recommended.

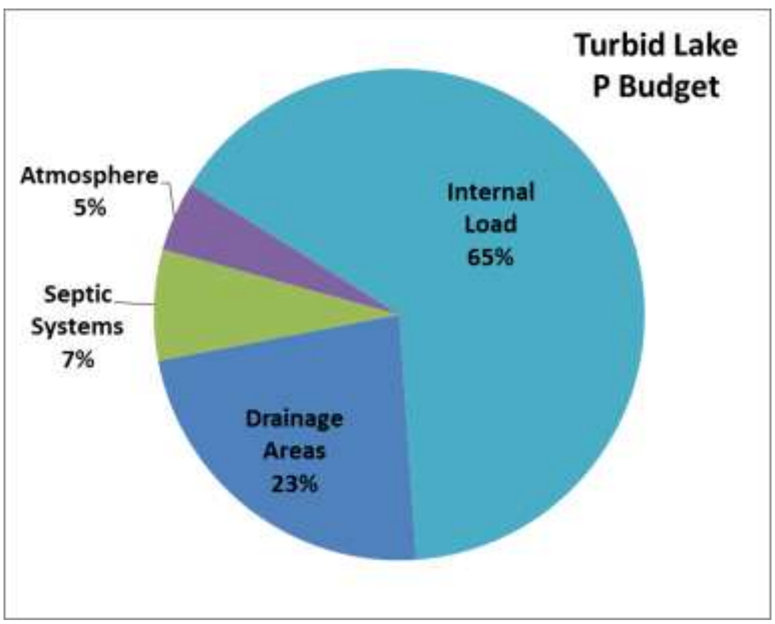

Figure 3-35. Average phosphorus loading to Turbid Lake.

Overall, Turbid Lake needs a 53% reduction in phosphorus loading to the lake with the majority of the reduction coming from internal loading (Table 3-15). Failing septic systems are another potential source in the watershed. Turbid Lake would benefit most from an internal load reduction project.

Table 3-15. Nutrient loads and required reductions to meet state water quality standards (<40 μg/L TP) in Turbid Lake.

Source	Existing TP Load [1]	TP Allocations	Load Reduction	
	(lbs/year)	(lbs/year)	(lbs/year)	%
Drainage Areas	89	77	12	**14%**
SSTS	15	0	15	**100%**
Atmosphere	10	10	0	**0%**
Internal Load	135	31	104	**77%**
TOTAL	**249**	**117**	**132**	**53%**

South Lundsten Lake

South Lundsten Lake is also dominated by internal phosphorus loading and demonstrated an extremely high internal phosphorus release rate. Watershed phosphorus sources represent approximately 17% of the phosphorus load the South Lundsten Lake (Figure 3-36).

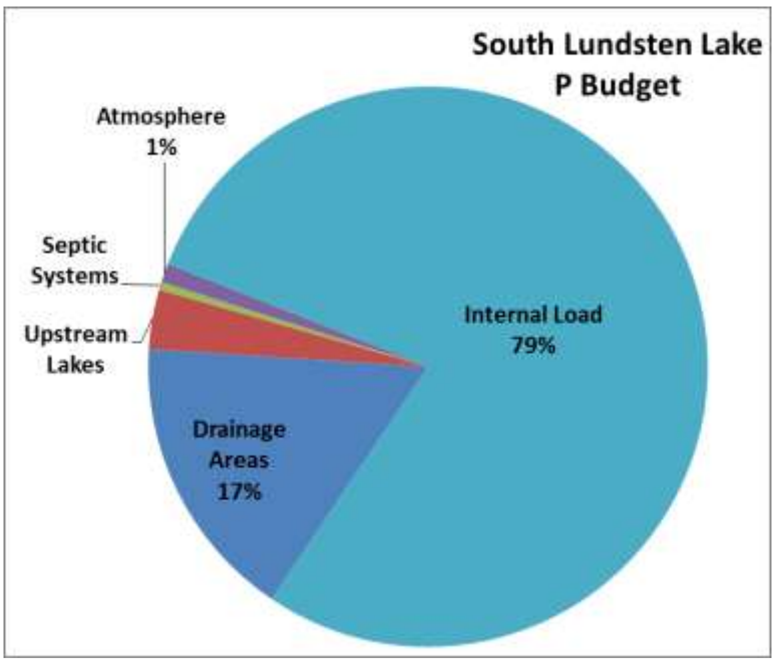

Figure 3-36. Average phosphorus loading to South Lundsten Lake.

For South Lundsten Lake to meet state water quality standards, large reductions are needed from the watershed and internal loads. Internal load needs to be reduced by 97%, whereas watershed loading needs to be reduced by 82%. Not all of these reductions need to occur prior to drawdown and carp management. Watershed load reduction projects need to be implemented concurrently with carp control and drawdown feasibility studies (Table 3-16).

Table 3-16. Nutrient loads and required reductions to meet state water quality standard (<60 µg/L TP) in South Lundsten Lake.

Source	Existing TP Load	TP Allocations	Load Reduction	
	(lbs/year)	(lbs/year)	(lbs/year)	%
Drainage Areas	388	68	320	**82%**
Upstream Lakes	84	71	13	**15%**
SSTS	8	0	8	**100%**
Atmosphere	18	18	0	**0%**
Internal Load	1,319	35	1,284	**97%**
TOTAL	**1,817**	**193**	**1,624**	**89%**

3.9 PARLEY-MUD DRAINAGE

The lower part of the watershed was separated into the Parley-Mud Management Unit (Figure 3.37). This management unit is also separated biologically from the rest of the watershed, since the outlet structure on North Lundsten Lake acts as a fish barrier. It is likely that carp and other fish in Parley and Mud lakes come from Halsted Bay more so than the upper part of the watershed. Both Parley and Mud lakes have dense carp populations and lack submerged aquatic vegetation. The vast majority of shoreline surrounding Parley and Mud lakes is in a natural state. Despite very little development around the lakes, water quality is poor.

Morphology

Parley and Mud Lakes are extremely shallow lakes with average depths less than 6.5 feet and maximum depths of 19 and 6 feet, respectively (Table 3-17). The lakes receive water from a large portion of the Six Mile Creek watershed and have sort residence times. Both lakes should support large submerged aquatic vegetation communities from shore to shore.

Table 3-17. Physical characteristics of lakes in the Parley-Mud Management Unit.

Parameter	Parley	Mud
Surface Area (acres)	257	144
Average Depth (ft)	6.4	3.5
Maximum Depth (ft)	19	6
Volume (acre-feet)	1,654	501
Residence Time (years)	0.4	0.6
Littoral Area (acres)	257	144
Littoral Area (%)	100%	100%
Watershed (acres)	565	423

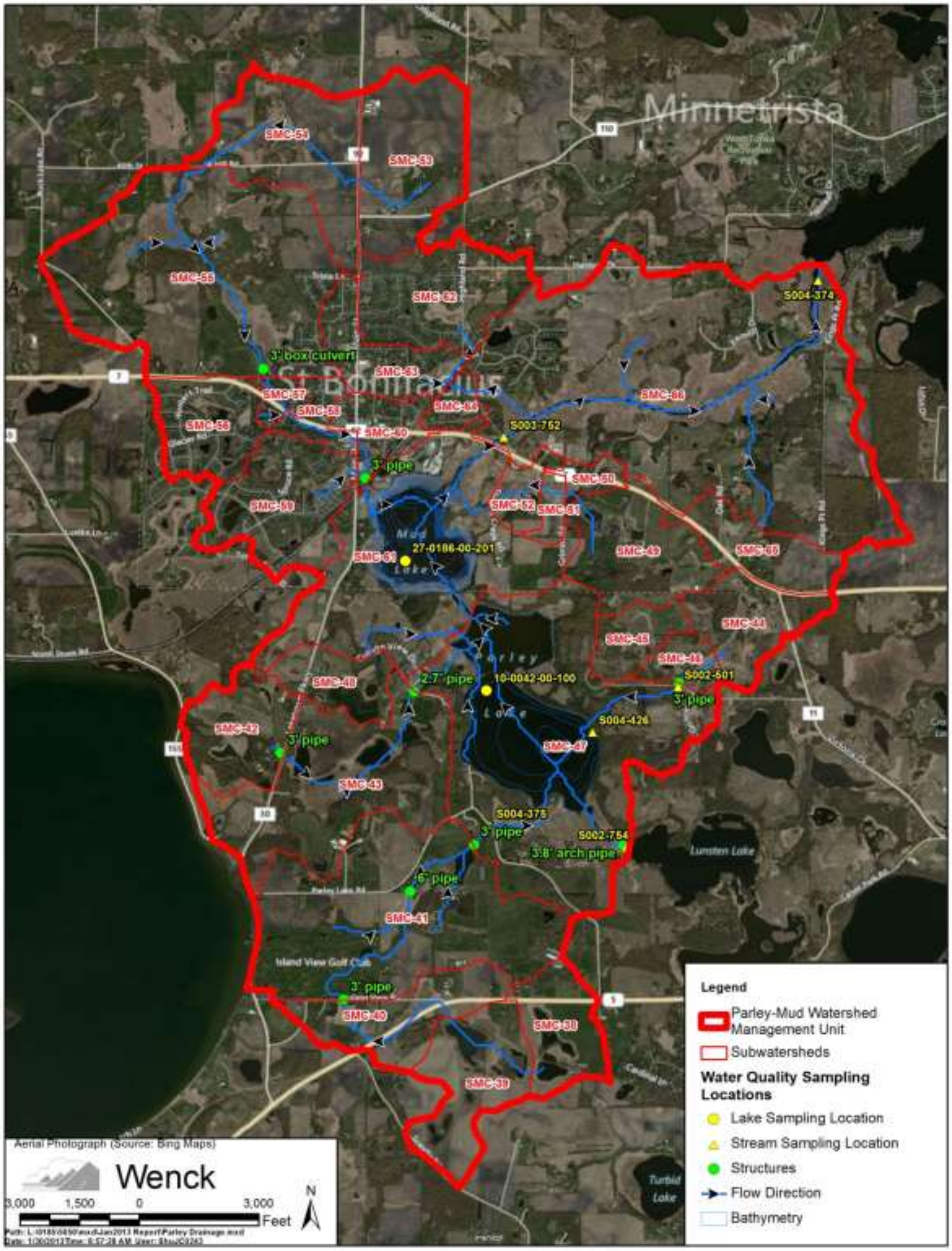

Figure 3-37. The Parley-Mud Management Unit.

Water Quality Monitoring

Parley and Mud lakes are highly eutrophic shallow lakes with high total phosphorus concentrations (Figure 3-38; Appendix E). Total phosphorus concentrations in Parley Lake averaged around 80 µg/L, with some values as high as 150 µg/L. Parley Lake experiences severe algal blooms in most years, with chlorophyll-*a* concentrations at times nearing 150 µg/L. Water quality in Mud Lake is even more severely degraded, with total phosphorus concentrations at times reaching almost 350 µg/L. Mud Lake also experiences severe algal blooms, with chlorophyll-*a* concentrations reaching over 200 µg/L at some periods during the summer.

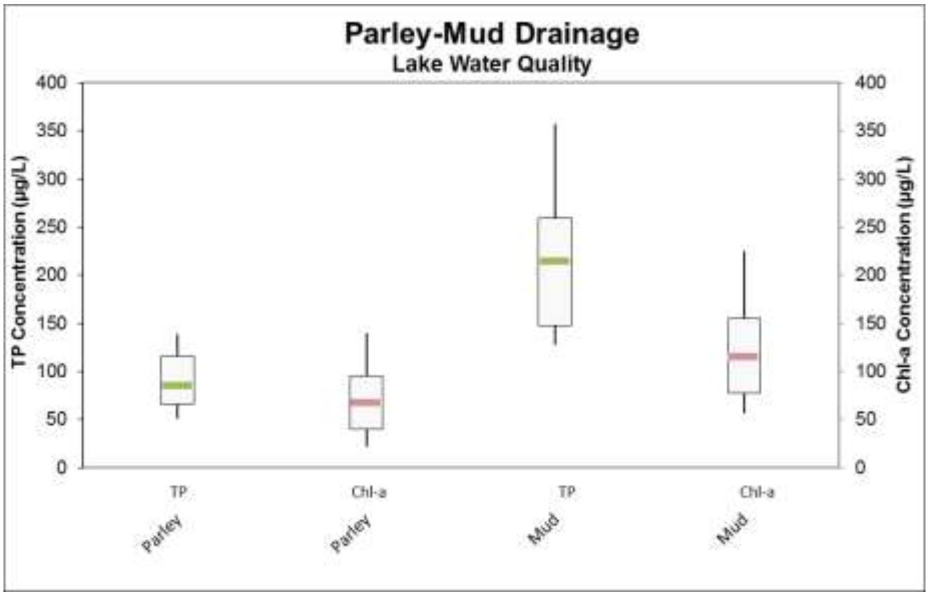

Figure 3-38. Lake total phosphorus and chlorophyll-*a* concentrations over the past 13 years.

The primary inflow to Parley Lake comes from North Lundsten Lake, which has excellent water quality with total phosphorus concentrations typically below 90 µg/L in the summer (Figure 3-39). A monitoring station just below the outlet of the lake demonstrated similar concentrations, with some values reaching 150 µg/L. This may be a result of internal phosphorus loading in the wetland. Parley Lake demonstrates slightly higher concentrations than the upstream station. Parley Lake discharges to Mud Lake, which demonstrates significantly higher total phosphorus concentrations that are carried through to the outlet of the lake.

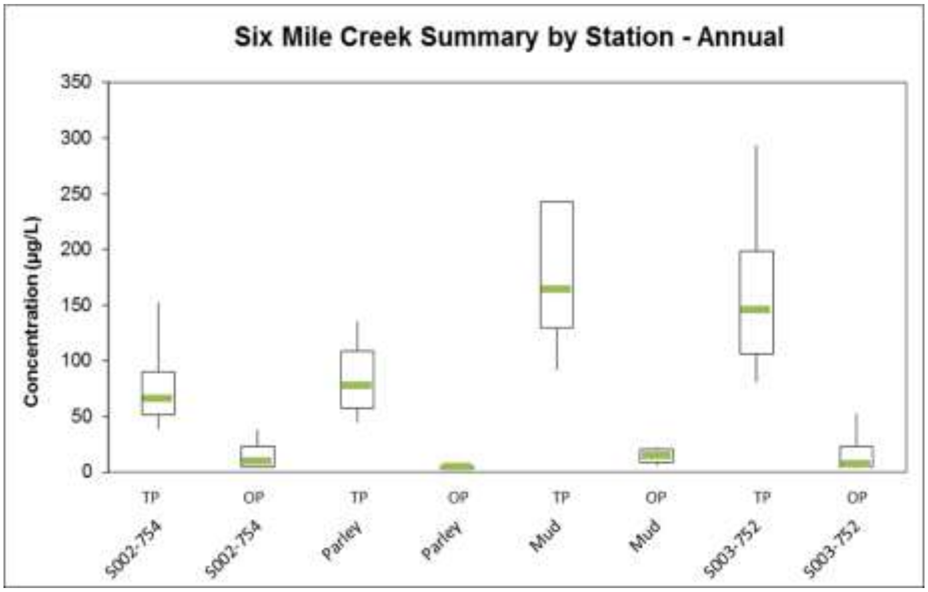

Figure 3-39. Total and ortho-phosphorus concentrations in the Parley-Mud Management Unit.
Note: Data is plotted upstream to downstream where possible.

Fisheries

The DNR management plan for Parley Lake concludes that the lake has a fairly stable fish community with sufficient numbers and size of a variety of species. The lake has been prone to winterkills at times. However, the connectivity of Parley Lake to Six Mile Creek, adjacent wetlands, and Lake Minnetonka provides refugia for fish to escape winterkill conditions, a mechanism to repopulate the lake in the event that winterkill occurs. It also provides additional spawning habitat for a variety of species.

Three species compose the predator community in Parley Lake: walleye, northern pike, and largemouth bass (Appendix F). Parley Lake is stocked with walleye fry every other year. In the 2010 population assessment, very few largemouth bass were sampled.

Parley Lake has a relatively large panfish population although only moderate sized individuals make up the class. Five species of panfish are present in Parley Lake: black crappie, bluegill, yellow perch and pumpkinseed. Bluegill abundance increased dramatically compared to the 2004 survey, and abundance is at an all-time high for Parley Lake (Figures 3-40 and 3-41).

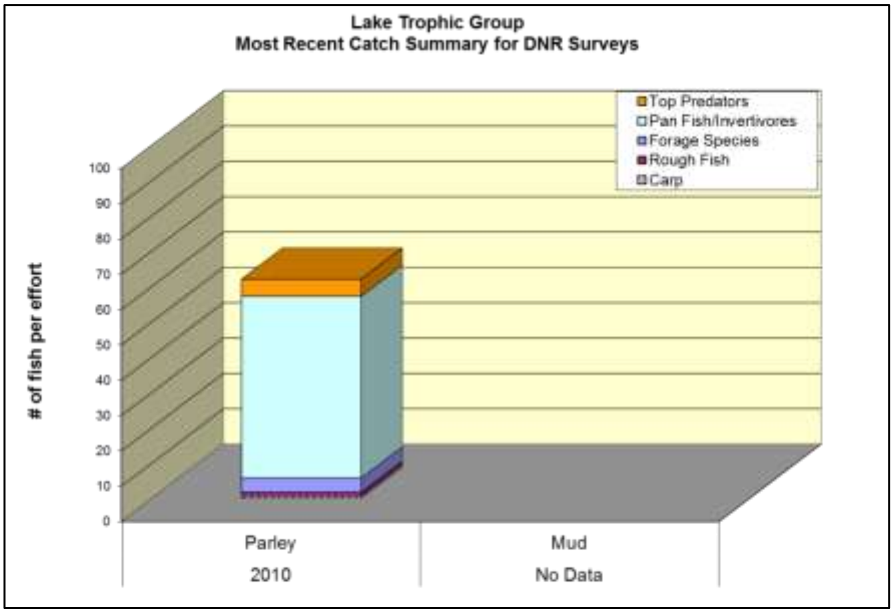

Figure 3-40. Fisheries summary by trophic group for the Parley-Mud Management Unit.

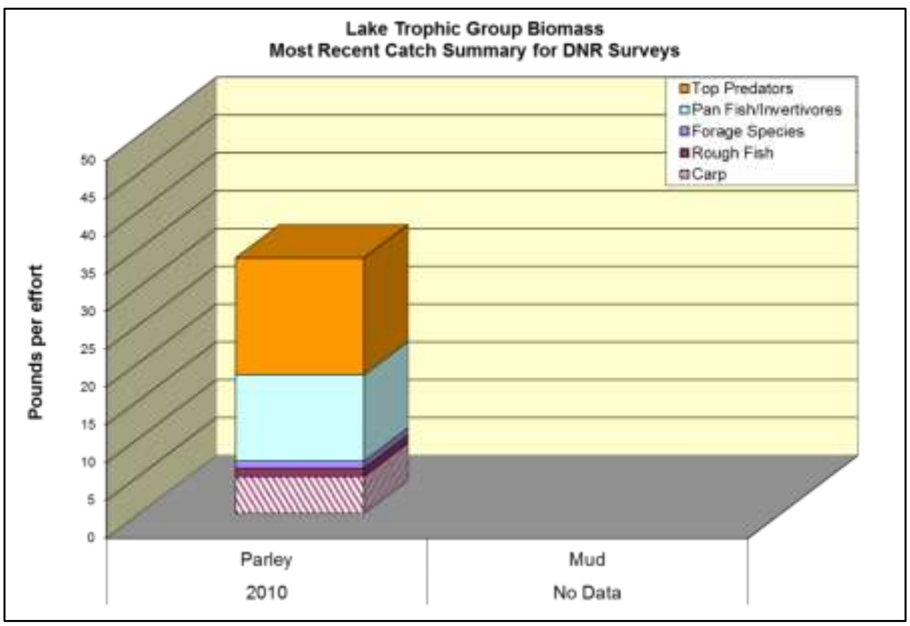

Figure 3-41. Fisheries summary by trophic group biomass for the Parley-Mud Management Unit.

At least some common carp have been captured in seven out of the eight DNR surveys conducted since the 1940s in Parley Lake. Based on year-to- year comparisons from DNR surveys, current carp populations appear to be moderate. Common carp abundance decreased since the 2004 survey from previous years, while black and yellow bullheads were sampled at record low abundances. Records from the DNR indicate that carp were removed from the lake in the 1940s, '50s and '60s, indicating carp have been a real or perceived nuisance species for many years in the lake. Further analysis may be needed to better characterize the carp population in Parley Lake and the Six Mile Creek subwatershed.

Carp move relatively freely between Lake Minnetonka and Parley Lake, passing through Mud Lake. It appears likely that there is a strong migration up the creek each spring, and breeding occurs in both Mud Lake and Parley Lake (Larry Gillette, pers. comm). Movement upstream from Parley Lake is blocked by the water control structure for North Lundsten Lake. Anecdotal reports suggest that each spring, northern pike, bass, crappies, bluegills, bullheads, and carp congregate on the downstream side of the structure.

Aquatic Plants

Plant surveys have been conducted on Parley Lake dating back to as early as 1940 by the DNR wildlife biologists. Overall, the plant community in Parley Lake is not very diverse, with only a handful of species present during each survey (Figure 3-42; Appendix G). Exotics such as curly-leaf pondweed have been present within the lake during each of the last four surveys conducted by the Minnesota DNR. Native species such as sago pondweed and coontail are the other main submerged species present within the lake. The abundance of coontail has increased over the past three surveys (1980 to 1998), indicating the lake is moving toward more eutrophic conditions. However, curly-leaf pondweed appears to have decreased in abundance during that same period. Eurasian watermilfoil was noted in the 1998 survey.

Based on DNR lake survey reports, curly-leaf pondweed has been present in Parley Lake for decades. A survey of Parley Lake performed by DNR wildlife managers in 1946 listed the species as common. This initial survey was conducted in September, when the species should be less visible in the basin as compared to the peak species abundance in late spring to early summer. Recent DNR aquatic plant surveys on Parley have been mainly conducted in June and have described the presence of curly-leaf pondweed in the lake as ranging from abundant in 1962 to present in 1998.

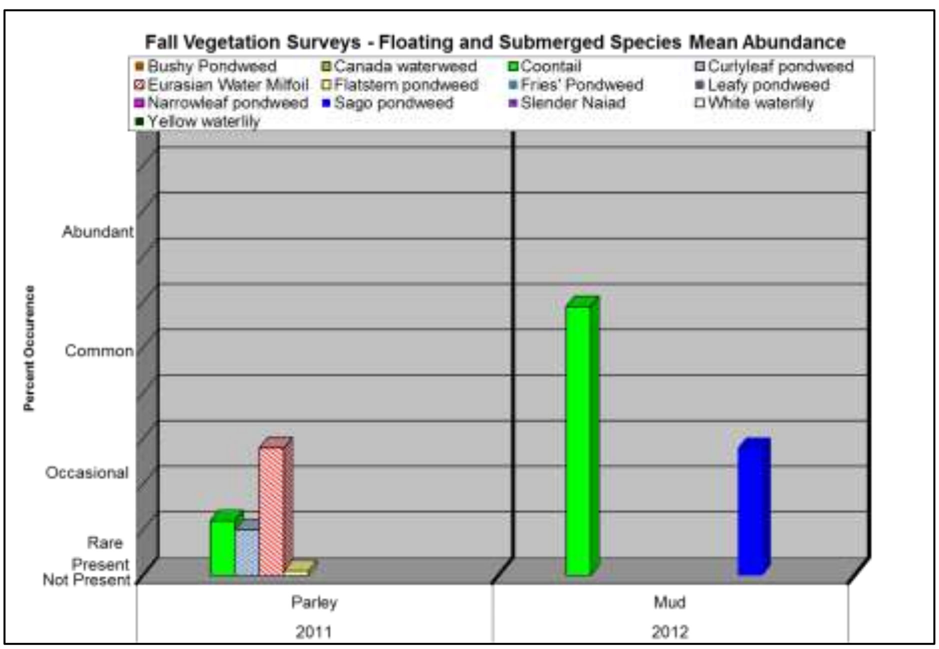

Figure 3-42. Aquatic vegetation in Parley and Mud Lakes.

Nutrient Budgets

Watershed Loading

Watershed loading varied throughout the watershed with watershed loading assumed to be the highest to Mud Lake (Figure 3-43). Parley Lake also demonstrates a moderate phosphorus load from the watershed. It is important to note that water quality data for tributaries to Mud Lake are limited and current loading is based on residuals from the Mud and Parley lake response models. Water quality data needs to be collected to verify inflow concentrations and sources. The Mud Lake response model is discussed in more detail later in this section.

It is also important to note that no calibration factors were applied to the P8 output for the watershed below Mud Lake draining to Six Mile Marsh since no data are currently available to adjust the model. Further monitoring and calibration needs to be completed for this part of the watershed. MCWD is currently developing a study for the lower part of the Six Mile Creek watershed and Halsted's Bay which will provide more information on this part of the watershed in the future.

Overall, watershed phosphorus loading appears to be high in this part of the watershed. Controlling watershed loading will be critical in restoring both Parley and Mud Lake.

Internal Loading

Cores were collected from Parley Lake in 2011 and Mud lake in 2012 to measure phosphorus release under both oxic and anoxic conditions (Table 3-18). Both lakes had relatively low oxic release rates of phosphorus, with both being below 1 $mg/m^2/day$. However, there was a surprising difference in anoxic release rates, with Mud Lake demonstrating relatively a low release of 2.0 $mg/m^2/day$. Parley Lake had a higher release rate, but the lack of anoxia over most of the lake suggests that internal loading may not be as important as previously suspected. However, the high anoxic release rate suggests that Parley Lake may be sensitive to periodic anoxia in years with high temperatures and quiescent conditions that promote anoxia.

Table 3-18. Measured internal release rates for lakes in the Parley-Mud Management Unit.

Lake	Oxic P Release ($mg/m^2/day$)	Anoxic P Release ($mg/m^2/day$)
Mud Lake	0.9	2.0
Parley Lake	0.6	9.7

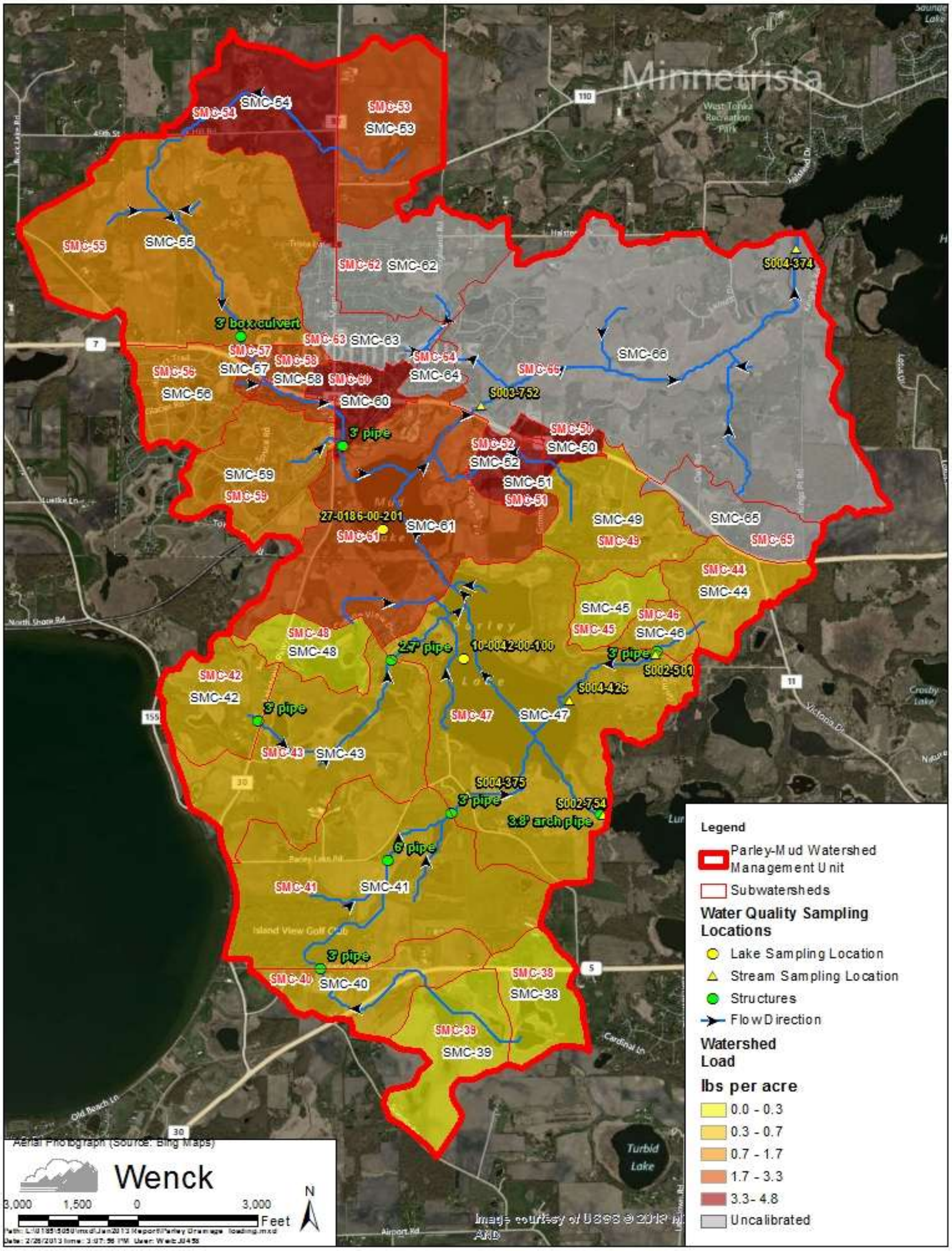

Figure 3-43. Watershed loading in the Parley-Mud Management Unit.

Nutrient Budgets

Parley Lake

Based on the predicted inputs and the predicted lake response, a phosphorus budget for Parley Lake can be developed. A phosphorus budget was developed for each year and an average of the three modeled years. Internal loading was determined to be on average 17% of the phosphorus loading to Parley Lake. The direct drainage area to the lake was 38%, while loading from Lundsten Lake represents 41% of the phosphorus load to Parley Lake. Based on this assessment, internal loading is a relatively small proportion of the phosphorus load to Parley Lake.

Mud Lake

The phosphorus budget for Mud Lake is driven mostly by watershed loading and inflow from Parley Lake (Figure 3-44). Internal loading represents only a small proportion of the phosphorus budget (6%).

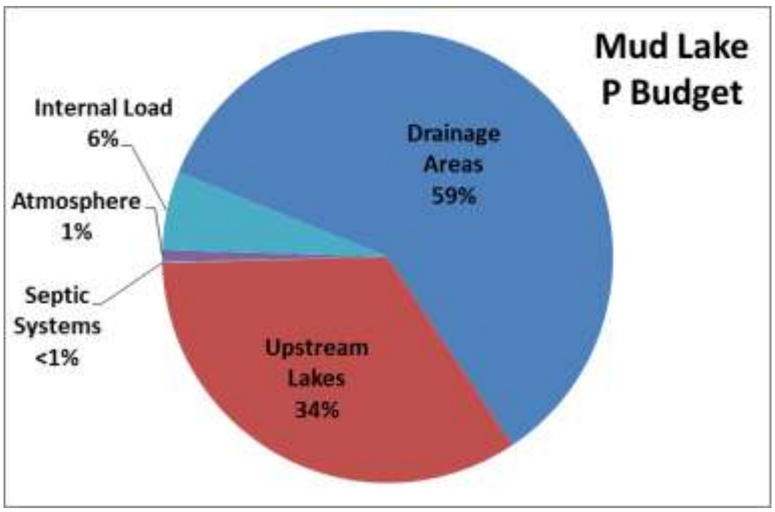

Figure 3-44. Average phosphorus loading to Mud Lake.

For Mud Lake to meet state water quality standards for shallow lakes, aggressive reductions are required for internal and watershed phosphorus loading – 67% and 95%, respectively (Table 3-19). Targeted watershed runoff concentrations would need to be 35 µg/L and internal loading all but eliminated.

Table 3-19. Nutrient loads and required reductions to meet state water quality standards (<60 µg/L TP) in Mud Lake.

Source	Existing TP Load	TP Allocation	Load Reduction	
	(lbs/year)	(lbs/year)	(lbs/year)	%
Drainage Areas	2,377	119	2,258	**95%**
Upstream Lakes	1,659	1,141	518	**31%**
Septic	3	0	3	**100%**
Atmosphere	34	34	0	**0%**
Internal Load	312	103	209	**67%**
TOTAL	**4,385**	**1,397**	**2,988**	**68%**

The level of phosphorus reductions described to meet state water quality standards may not be necessary to make significant improvements in the ecological condition in Mud Lake. Moss et al. (1997) suggest a target value of 150 µg/L as a summer average as a good place to start thinking about more drastic measures to shift the lake to a clear lake state. If watershed concentrations were targeted at 150 µg/L, in-lake concentrations should drop to around 80 µg/L, providing prime conditions for considering a drawdown. A target of 80 µg/L still requires a 78% reduction in watershed loading (Table 3-20). It is important to note that watershed runoff concentrations need to be verified prior to large implementation efforts in the watershed.

Table 3-20. Nutrient loads and required reductions to meet a set target of <80 µg/L total phosphorus in Mud Lake.

Source	Existing TP Load	TP Allocations	Load Reduction	
	(lbs/year)	(lbs/year)	(lbs/year)	%
Drainage Areas	2,377	513	1,864	**78%**
Upstream Lakes	1,659	1,141	518	**31%**
Septic	3	0	3	**100%**
Atmosphere	34	34	0	**0%**
Internal Load	312	312	209	**0%**
TOTAL LOAD	**4,385**	**1,999**	**2,594**	**54%**

4.0 Watershed Restoration Strategy

4.1 INTRODUCTION

The purpose of this study is to identify restoration strategies to improve the water quality and overall ecological health of lakes in the Six Mile Creek watershed. Improving the health of the lakes leads to overall better water quality in the watershed, better fish habitat, and overall improved ecological health of the watershed.

4.2 LAND CONSERVATION PROGRAM

Conservation of high-value resources provides an opportunity to improve the characteristics of aquatic ecosystems, and can help address water quality, infiltration, volume management, and ecological integrity needs. Prior to the encroachment of additional development, the opportunity exists to conserve high value resources, maintain corridor connections between ecosystems in the watershed to improve water resources, conserve natural conveyances, and facilitate the movement and proliferation of native species as well as enhance recreational opportunities.

The District currently operates a Land Conservation Program that undertakes conservation activities ranging from assisting property owners in enrolling property in conservation programs to acquiring conservation easements or fee title over high value resources. This Plan identifies Key Conservation Areas in each subwatershed that contain valuable natural resources such as high-quality wetlands, minimally disturbed upland vegetation, and rare resources. Within these areas LGUs will be required to identify in their Local Plans strategies for conserving those high value resources. Some of those areas have been identified as District Priority Areas where the District will continue to proactively investigate and implement opportunities to conserve key resources and to work cooperatively with other agencies and groups to accomplish conservation goals (Figure 4-1). District staff will provide technical assistance to the LGUs to support their accomplishment of program goals.

The Key Conservation Areas contain resources that are protective of surface water and groundwater quality and quantity; demonstrate high-value habitat characteristics; are protective of aquatic habitat; or provide a variety of habitats supportive of aquatic-based species abundance (Table 4-1).

These Key Conservation Areas include:

- Create corridors along streams and channels to provide buffers for water quality and stream stability as well as to create linkages and wildlife corridors.
- Include wetlands that were identified in the Functional Assessment of Wetlands as having exceptional or high vegetative diversity or wildlife habitat or are wetlands with moderate to high restoration potential.
- Include high-value upland areas, such as forested areas that provide connected habitat as well as high potential infiltration or evapotranspiration.

- Incorporate land cover types identified in the Minnesota Land Cover Classification System (MLCCS) survey conducted by Hennepin County as being minimally disturbed, with potential high-value habitat.
- Contain areas that have multiple natural resource values, such as Minnesota County Biological Survey (MCBS) sites of biodiversity significance; Metro regionally significant ecological areas; or areas where rare or threatened species have been documented by the DNR.
- Incorporate green and natural resource corridors as designated by the DNR, Metropolitan Council, Hennepin County, and local communities.

Table 4-1. MCWD Land Conservation Program current ranking criteria.

Topic	Criteria
District Planning Priorities	Within MCWD Conservation Plan Area
	Benefits a Planned or Existing MCWD Project Area (e.g. Stubbs Bay, Painters Creek, Minnehaha Creek, Six Mile Creek, etc.)
Water Resources	Wetland Management Class
	Wetland Restoration Potential
	Wetland Protection
	Creek Frontage
	Lakeshore
	Buffer Width
	Creates opportunity to fix erosion problems
	Steep slopes
	Infiltration potential
	Wellhead protection area
Habitat	DNR Site of Biodiversity Significance
	Unique or significant ecological resource per MLCCS, MCBS, Etc. - consider type of habitat, size, condition, landscape context
	Habitat restoration potential (biological potential and well as feasibility (cost and partnerships))
	Regionally Significant Natural Area
Leverage	Connectivity with/proximity to other conservation lands
	Creates opportunities to leverage conservation on additional proximate or adjacent lands
	Potential cost and opportunities for cost-share/recovery
Other Public/Planning Considerations	Parcel size
	Degree of threat
	Provides public access/ educational/demonstration opportunities
	Consistency with municipal plans
	Located within Metro Wildlife Corridor Focus Area

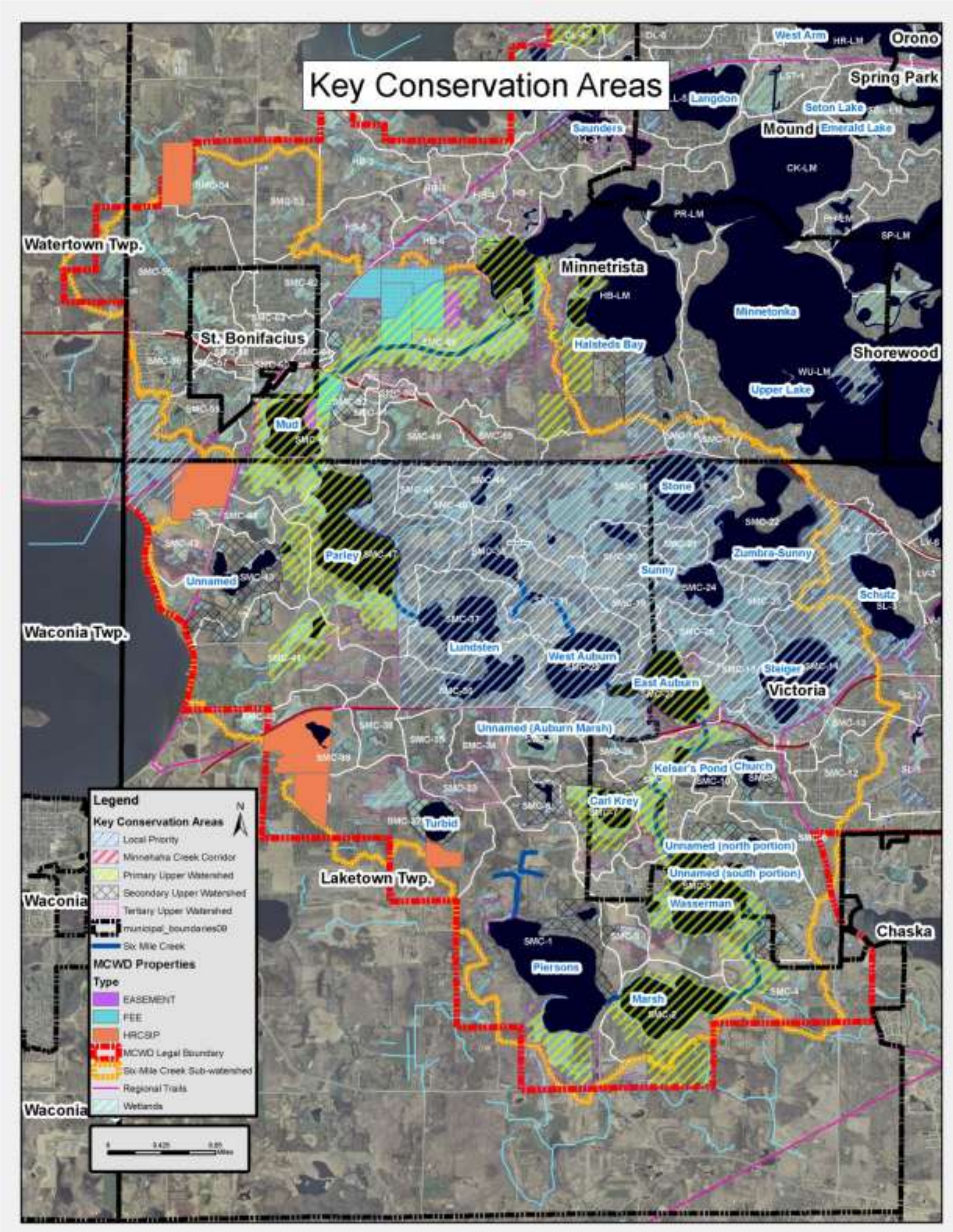

Figure 4-1. Key conservation areas in the Six Mile Creek watershed.

4.3 RESTORATION AND PROTECTION ACTIVITIES

Watershed and lake restoration strategies were developed for the Six Mile Creek watershed. Activities are broken into three categories, including monitoring activities aimed at improving our scientific understanding of the system, restoration activities aimed at improving water quality or ecological health of the watershed, and protection activities aimed at protecting good water quality or ecological conditions in the watershed. These activities are described for each of the management units and then an overall restoration strategy is presented for the watershed.

Previous Studies and Potential Projects

A number of previous feasibility studies were conducted in several areas of Six Mile Creek watershed to evaluate potential projects for improving water quality. These studies include:

- Wassermann Lake Wetland Restoration Project Phase II (Barr 2010)
- Six Mile Marsh Corridor Natural Resource Assessment (Cross River Consulting 2010)
- Wasserman Lake Wetland Restoration Project (Howard R. Green and Interfluve 2007)
- Turbid/Lundsten Corridor Restoration Phase II (MCWD 2011)
- Turbid-Lundsten Wetland Restoration (Wenck 2010)

Several of these studies include project that are ready for implementation when funding and access are available. These projects were included in the implementation actions below where appropriate.

4.4 WATERSHED RESTORATION SEQUENCING AND PRIORITIES

Prioritizing Management Units

The watershed was divided into smaller management units based on their hydrologic and biological connectivity. The major divide in the watershed is the outlet structure of North Lundsten Lake, separating the watershed into an upper and lower watershed. These two areas can be managed separately, but concurrently. In the upper watershed, working from upstream to downstream will provide the most benefits to the watershed. Focusing on the restoration of Wassermann benefits the water bodies downstream. Watershed projects for East Auburn Lake can be undertaken at the same time; however, the lower part of the watershed is protected by East and West Auburn Lake. The Turbid-South Lundsten Management Unit appears to be separated biologically and can be evaluated independently.

The Six Mile Creek Implementation Plan will focus on integrating water projects with city, county and TRPD land use planning and development objectives to accomplish mutual goals through economical and efficient use of public dollars. Integrated watershed planning is defined as “the process of formulating and implementing a course of action involving natural and human resources in a watershed, taking into account the social, political, economic and institutional factors operating within the watershed and surrounding river basin and other relevant regions to achieve specific social objectives.[3]

The Six Mile Creek Subwatershed Implementation plan will incorporate broad-based goals and principles for the Six Mile Creek Subwatershed that incorporate social, political, economic, and natural objectives. Principles will focus on the fact that watershed management is continuous process and needs a multi-disciplinary approach to solve the multi-faceted problems a watershed faces. A strong implementation plan for Six Mile Creek watershed will use sound science, facilitate communication and partnerships, foster thoughtful action, stimulate actions and tracks results.

Overall Strategy

The Minnehaha Creek Watershed District adheres to a strong belief that integrated and coordinated planning and implementation is necessary to improve natural systems, stimulate economic development and strengthen communities through connections. MCWD staff will develop an implementation plan for the Six Mile Creek Subwatershed to determine phased implementation for projects identified in the Diagnostic Study. This implementation plan will detail short and long-term priority projects, some of which will require further investigation, as well as potential projects and programs that should be pursued immediately. It will take into account biological watershed factors as well as potential partnerships in the subwatershed and will utilize adaptive management techniques to remain responsive to opportunities. MCWD staff will develop the implementation plan for the Six Mile Creek Subwatershed in 2013 and will engage stakeholders and communities within the subwatershed for guidance and approval.

The overall strategy for restoring the Six Mile Creek watershed can be summarized in five steps:

1. Manage carp to appropriate levels to minimize impacts on lakes.
    a. Identify high priority potential reproduction areas.
    b. Track carp movements to identify spawning and wintering areas.
    c. Prevent winterkill in shallow water lakes and wetlands.
2. Implement watershed nutrient reduction projects.
3. Assess feasibility for whole-lake drawdown in South Lundsten, Parley, and Mud lakes.
4. Once carp are controlled, implement internal load reduction projects.
5. Manage and protect lake vegetation.
    a. Focus on nutrient reduction to increase diversity.
    b. Focus on invasive species control to increase diversity.

Steps one through three can be implemented concurrently. The following sections provide a more detailed description of each of these activities.

Stream Assessment and Restoration

[3] "Watershed Resources Management: Studies from Asia and the Pacific"; edited by K. William Easter, John Alexander Dixon, Maynard M. Hufschmidt

A stream assessment was completed for Six Mile Creek in 2012 and 2013 to assess the current conditions of the stream channels in Six Mile Creek (Interfluve 2013). The stream assessment focused on channel conditions and geomorphology. A number of projects were identified that focused on bank stability, grade control, and wetland restoration. Many of the identified projects cross over with projects identified as a part of this study. Implementation will focus on incorporating results from the stream assessment and this diagnostic study to provide the best approach for restoring the watershed.

Carp Management

Carp management in the watershed should focus on four distinct areas, including the Pierson-Marsh-Wassermann, Carver Park Reserve, Turbid-South Lundsten, and the Parley-Mud Management Unit (Figure 4-2, Table 4-2). Although there is potential for carp to mingle among the watersheds, the conditions of the lakes and anecdotal evidence in the watershed suggest that this is minimal. Each of the lakes were rated for carp activity based on fish surveys where available, impacts to the vegetation community, and field observations. South Lundsten, Mud, and Parley Lakes demonstrated the greatest carp impacts with little to no submerged aquatic vegetation and field observations of heavy carp densities. Carp are also known to move between Pierson, Marsh and Wasserman Lake with Marsh Lake demonstrating some pockets of uprooted vegetation as a result of carp activity. Anecdotal reports suggest that Sunny Lake has moderate carp activity. The remaining lakes likely have carp moving through them, but do not demonstrate heavy populations or impacts such as loss of the submerged aquatic vegetation community.

Management of carp in the watershed needs to focus on removing current carp biomass from the system and eliminating carp reproduction areas in the watershed. For removals to be effective, areas where carp tend to congregate need to be identified so that seining can be completed. Often times this requires tracking carp or using side-scan sonar to identify the location of the fish. Other techniques include the use of whole lake drawdown or rotenone (a fish poison) to kill large numbers of fish. This technique may be feasible in South Lundsten, Mud, and Parley lakes, but not in deeper lakes such as Wassermann. Carp traps can be used at key locations, such as previous removals in the stream between Marsh and Wassermann lakes. MCWD intends to work with Dr. Peter Sorenson at the University of Minnesota to better understand carp movement and reproduction in the Six Mile Creek watershed.

For carp removals to have long-term effectiveness, carp recruitment habitat needs to be managed or eliminated in the watershed. Based on recent work conducted by the University of Minnesota, shallow water bodies that are prone to winterkill provide the most likely successful spawning and recruitment areas for carp. These areas should be eliminated or aerated to prevent winterkill conditions. There are three lakes in the upper watershed that likely contribute to carp recruitment, including South Lundsten, Sunny, and Marsh lakes. In the lower watershed, both Parley and Mud appear likely to support carp recruitment. There are also numerous other shallow wetlands in the watershed that should be evaluated for carp spawning habitat potential.

The final step in carp management is to prevent access to recruitment areas if carp reproduction cannot be eliminated. The current technology for carp barriers is not well tested and likely does not eliminate all carp movement. Furthermore, the barriers may block some native fish movement, which may impact local native species. Carp barriers should be considered a last resort.

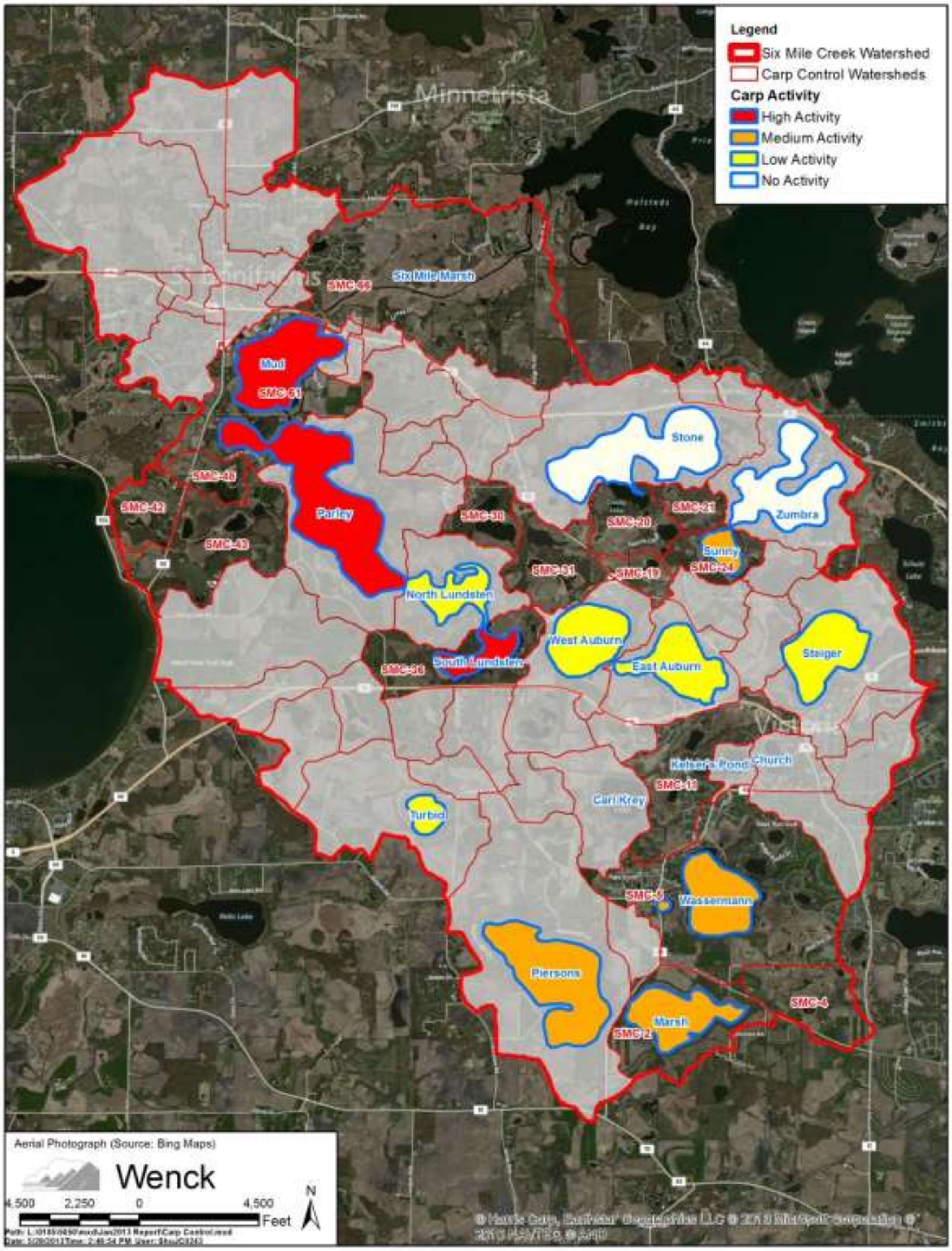

Figure 4-2. Watersheds with potential carp reproduction habitat and lakes that demonstrate some carp impacts.

Table 4-2. Carp management activities specified in each of the management units.

Watershed Management Unit	Subwatershed/Lake	Monitoring Activities	Management Activities
Pierson-Marsh-Wassermann	SMC-5 (Wassermann Direct)	• Evaluate carp reproduction potential in ponds and shallow wetland areas.	•
	Marsh Lake	• Evaluate carp reproduction potential through fish surveys, tracking and winterkill monitoring.	• Remove carp population and prevent reintroduction or recruitment through aeration or total winterkill.
	SMC-11	• Evaluate carp reproduction potential in open water areas of the wetland by fish surveys or winterkill evaluations.	•
	Overall Unit	• No action	• Carp tracking study to identify potential reproduction areas. • Carp removal.
Carver Park Reserve	SMC-24 (Sunny Lake)	• Evaluate winterkill potential for Sunny Lake.	• Implement carp management activities if Sunny Lake is determined to provide carp spawning and recruitment.
Turbid-South Lundsten	SMC-32 (Turbid Lake)	• Evaluate carp movement and reproduction potential in the lake.	• Remove carp from Turbid Lake if deemed appropriate for managing carp in the Management Unit.
	SMC-33, SMC-34	• No action	• Prevent carp movement through the corridor through a barrier at South Lundsten Lake.
	SMC-36 (South Lundsten Lake	• Conduct fish surveys in South Lundsten Lake.	• Implement a carp removal and control project. • Evaluate whole-lake draw-down and rotenone to control carp and reestablish the submerged aquatic vegetation population.

Watershed Management Unit	Subwatershed/Lake	Monitoring Activities	Management Activities
Auburn-North Lundsten	SMC-37 (North Lundsten Lake)	• Conduct fish surveys in North Lundsten Lake.	• Evaluate connection to South Lundsten Lake for carp barrier.
	SMC-27	• Monitor carp movement between East Auburn Lake and Wassermann Lake.	• Evaluate a carp barrier between East Auburn Lake and Sunny Lake to prevent carp recruitment.
	SMC-31, SMC-31	• Evaluate carp spawning and movement through the wetland.	• Evaluate trail culvert upstream of North Lundsten Lake as a carp barrier.
Parley-Mud	SMC-47 (Parley Lake)	• Monitor carp movement through Parley and Mud lakes and Halsted Bay.	• Implement a carp removal and control project. • Evaluate whole lake draw-down and rotenone to control carp and reestablish the submerged aquatic vegetation population.
	SMC-38, SMC-39, SMC41	• No action	• Evaluate open water wetland areas for carp reproduction.
	SMC-61 (Mud Lake)	• No action	• Implement a carp removal and control project. • Evaluate whole-lake draw-down and rotenone to control carp and reestablish the submerged aquatic vegetation population. • Consider carp passage barrier between Mud Lake and Halsted Bay.

Watershed Nutrient Reductions and Monitoring

Subwatersheds were identified for nutrient control projects based on calibrated P8 model results (Figure 4-3), monitoring data in the watershed, and watershed and lake mass balances in the watershed. Several areas of the watershed stood out as potential nutrient contributors (Figure 4-3); however, several of these should be verified prior to implementation of the projects.

Watershed nutrient reduction projects and monitoring activities were identified for each of the subwatersheds (Table 4-3). Nutrient reduction projects included a variety of activities based on the identified nutrient sources. Some of the identified subwatersheds had degraded (ditched or altered) wetlands that appear likely to be contributing phosphorus to surface waters. Other projects include retrofitting existing ponds with iron enhanced sand filters.

Monitoring locations were identified to verify mass balances and assumptions made from completion of the lake response models. For example, watershed runoff water quality flowing into Mud Lake was not available. Model residuals from lake response modeling for Mud Lake suggested that watershed runoff concentrations are around 600 µg/L, which is higher than expected based on the land use of the watershed. Consequently, these runoff concentrations need to be verified prior to large expenditures on watershed nutrient reduction projects. In 2013, MCWD plans to monitor Sunny Lake and the two ponds flowing into Wassermann Lake as well as 3 additional stream sites including an inflow to Mud Lake (off County Road 92), 2 Parley Lake inflows including one on the Crown College property and another by the Parley Lake Winery. Monitoring is further discussed in the following sections for each Management Unit.

In the upper watershed, a few subwatersheds demonstrated a large potential for nutrient loading. For some watersheds (SMC-11, SMC-15, SMC-25), the loading appears to be coming from degraded wetlands that are discharging high phosphorus concentrations. Other subwatersheds were more developed where loading is likely from increased impervious areas (SMC-5, SMC-13). In the lower watershed, the sources of phosphorus loading are less clear, mostly because the tributaries to the lakes lack good monitoring data. However, the lake response models suggest that both Parley and Mud lakes receive relatively high nutrient loads from the watershed. Sources in the lower watershed are likely a mix of developed and agricultural sources.

Although agriculture represents less than 25% of the watershed, agricultural BMPs should be considered to both improve and protect water quality. Some of the agricultural portions of the watershed drain to waterbodies with good water quality such as Pierson's Lake, and implementation is considered a protection activity. Other areas such as the Turbid Lake watershed and the area draining to Mud Lake north of St. Bonifacius likely contribute to water quality issues. There are a number of appropriate BMPs that should be considered for nutrient management in the watershed including:

- Conservation cover and crop rotation
- Contour and waterway buffer strips
- Fertilizer management and soil testing
- Conservation tillage
- Filter strips and field borders
- Water and sediment control basins

These practices should be considered on a farm by farm basis depending on the local site conditions including the slope of the field, soils types, and crops grown.

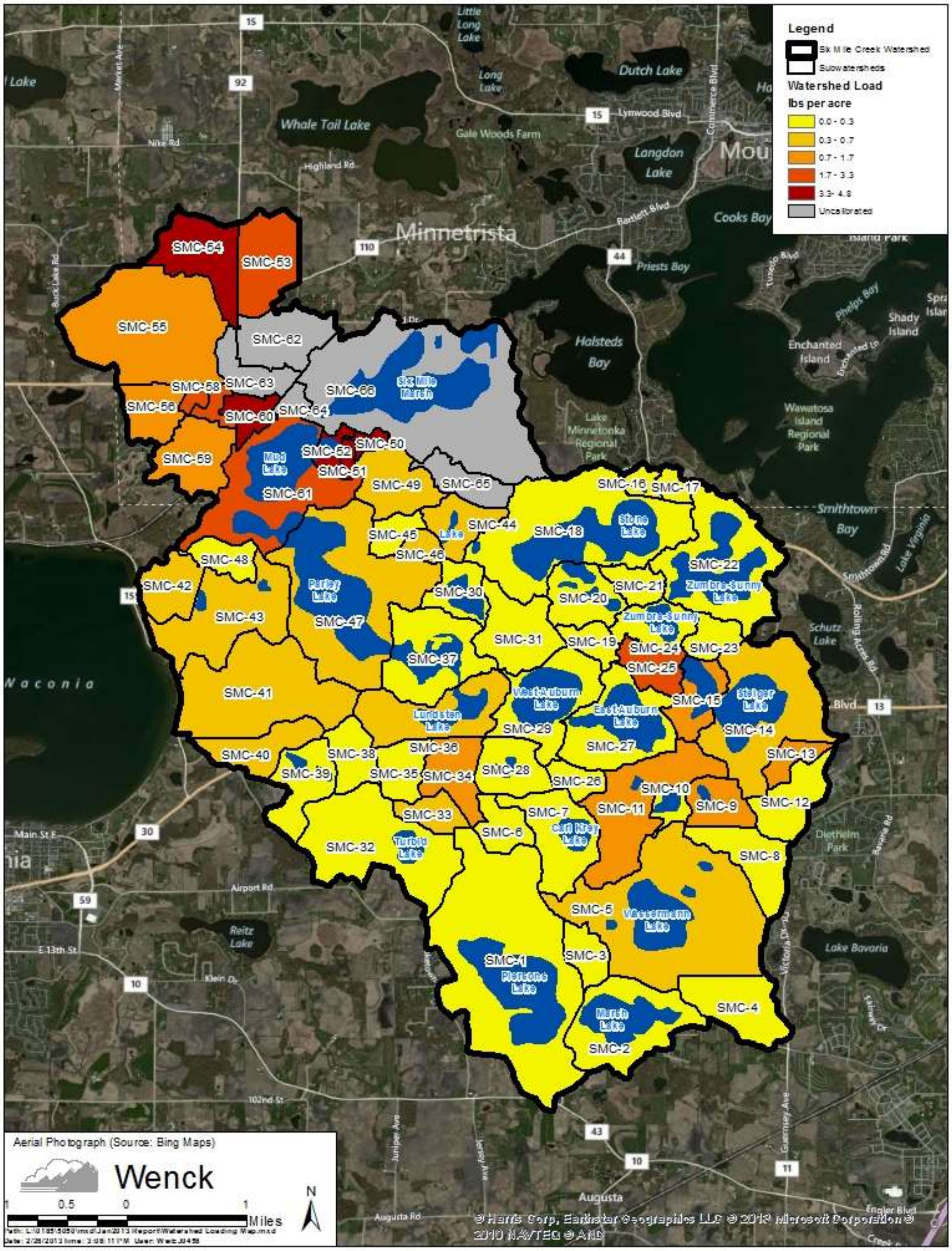

Figure 4-3. Modeled watershed loading in the Six Mile Creek watershed.

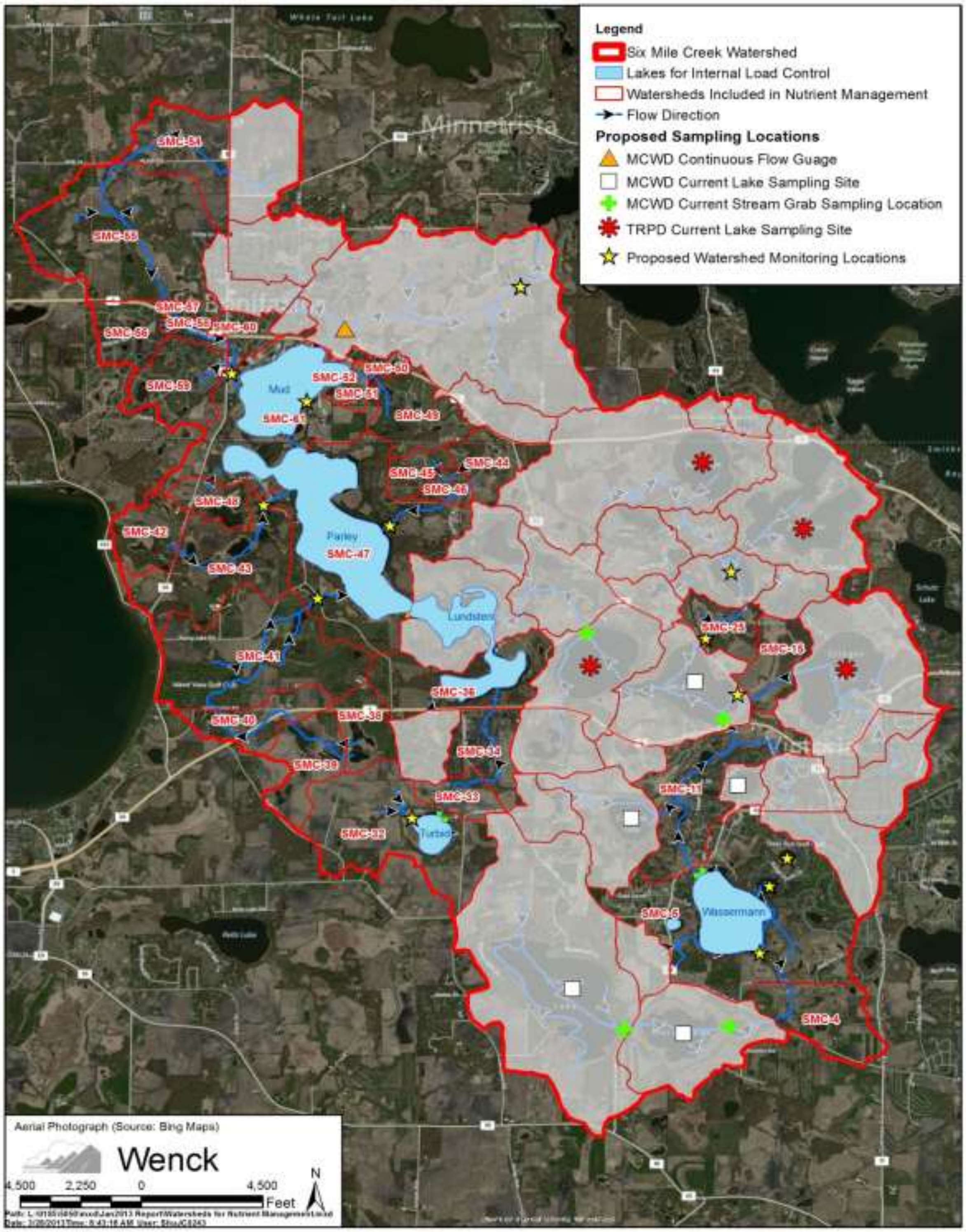

Figure 4-4. Subwatersheds identified for nutrient reduction projects, internal load control projects and monitoring.

Table 4-3. Watershed nutrient reduction and monitoring actions.

Watershed Management Unit	Subwatershed/Lake	Monitoring Activities	Management Activities
Pierson-Marsh-Wassermann	SMC-1	• No action.	• Manage nutrients from major inlet to Pierson Lake (ponds designed and ready for implementation)
	SMC-5 (Wassermann Direct)	• Monitor inflow/outflow chemistry[1] from Marsh Lake to Wassermann • Monitor pond chemistry[1] from Deer Run Golf Course • Assess fish in two large ponds coming from the Deer Creek Golf Club	• Phosphorus load reduction feasibility study for wetland area between Marsh Lake and Wassermann Lake. • Identify iron enhanced sand filter pond retrofit opportunities. • Evaluate role of golf course runoff in phosphorus loading to Wassermann. • Evaluate potential for iron-enhanced sand filter at Six Mile Creek inlet.
	Church Lake	• No action.	• Evaluate the potential for an iron enhanced sand filter on the primary inlet to Church Lake. • Identify and implement stormwater practices such as rain gardens, ponding, and filtration throughout the watershed.
	SMC-11	• No action.	• Evaluate wetland restoration opportunities to minimize phosphorus export from the wetland.
Carver Park Reserve	SMC-15	• Paired monitoring of lake outflow from Steiger Lake and inflow into East Auburn Lake.	• Evaluate wetland restoration opportunities to minimize phosphorus export from the wetland or consider altering outlet of Steiger Lake to a pipe.
	SMC-25	• Paired monitoring of lake outflow from Sunny Lake and inflow into East Auburn Lake.	• Evaluate wetland restoration opportunities to minimize phosphorus export from the wetland.
	SMC-24 (Sunny Lake)	• Water quality monitoring for Sunny Lake[2]	• No action.

Watershed Management Unit	Subwatershed/Lake	Monitoring Activities	Management Activities
	SMC-12, SMC13	• Monitor effectiveness of wetland restoration on the east side of the wetland	• Restore/enhance the wetland to reduce nutrient loading (east side of wetland was restored in 2012) • Evaluate need and feasibility of iron enhanced sand filter on west side wetland/pond before discharging to Steiger Lake.
Turbid-South Lundsten	SMC-32 (Turbid Lake)	• Monitor outlet of wetland that represents the primary inflow to Turbid Lake.	• Implement an internal load reduction project such as alum treatment. • Implement agricultural BMPs in watershed where opportunities arrive. • Implement wetland restoration at the Brose property (Wenck 2010).
	SMC-33, SMC-34	• No action.	• Work with Carver SWCD to implement agricultural BMPs. • Implement feasibility studies.
	SMC-36 (South Lundsten Lake)	• No action.	• Evaluate iron enhanced sand filter at pond at the primary inlet to South Lundsten Lake.
Parley-Mud	SMC-47 (Parley Lake)	• Monitor major inflows (1 from the east, 2 from the west).	• No action.
	SMC-53-SMC-50	• No action.	• Identify and evaluate nutrient reduction projects such as pond retrofits with iron enhanced sand filters.
	SMC-61 (Mud Lake)	• Monitor two major inflows (1 from the north, 1 from the east).	• No action.

[1]Chemistry monitoring should include TP, OP, TKN, and TSS where possible. Field measurements should include DO, temperature, and conductivity.
[2]Lake monitoring should include TP, chlorophyll-a, Secchi, and TSS. Field measurements should include temperature and dissolved oxygen profiles.

Internal Load Control Projects

Four lakes were identified for internal load control projects including Wassermann, Turbid, South Lundsten, and Parley lakes. Each demonstrated sufficient internal loads to warrant load projects.

The two deep lakes, Wassermann and Turbid, are the most straightforward projects because the deep areas can be treated and are not susceptible to mixing by carp activity. However, both lakes have large littoral areas that need consideration for treatment. These areas should not be treated until carp have been controlled in the watershed. Alum dosing and cost estimates should be conducted concurrently with carp management.

South Lundsten and Parley Lake are more difficult to manage internal load because they are shallow lakes with dense carp populations and lack submerged aquatic vegetation. Before implementing any internal load control, the carp population must be controlled. However, based on the internal load study, South Lundsten Lake will need some chemical addition to control internal loading. Parley Lake, on the other hand, should undergo lake restoration prior to an internal load control project because the role of internal loading is still unclear.

Lake Restoration Projects

An important aspect of any shallow restoration is reestablishing the submerged aquatic vegetation populations once carp and other destructive fish have been controlled. Reestablishment of the submerged vegetation population is typically accomplished through whole-lake drawdown, which exposes lake sediments to drying and consolidates the sediments while promoting nitrogen loss through denitrification. Submerged vegetation may be reestablished without drawdown, but the outcomes without drawdown are much more uncertain.

Three lakes need to be considered for whole- lake drawdown, including South Lundsten, Parley, and Mud Lake. A drawdown on South Lundsten Lake can be conducted concurrently with carp removal efforts as the drawdown will make it easier to remove carp. However, reintroduction from Turbid Lake should be controlled. South Lundsten Lake appears to be the primary reproduction area, so a large carp removal paired with preventing future winterkills should restore the lake for the long term.

Drawdown on Parley and Mud is much more complex due to the large runoff volumes entering the lake and the potential backwater effects from Halsted Bay. However, a drawdown should be evaluated for the lakes.

Planning a drawdown takes considerable effort and permitting, with the process often exceeding two years. Planning and feasibility efforts should be conducted concurrently with watershed nutrient management and carp assessments.

Invasive Species and Vegetation Management

The final step in the process of restoring the lakes is to enhance and manage the SAV population. For those lakes with robust SAV populations, controlling invasive species is an important step that can be undertaken immediately. For long-term management, nutrient reductions are the best approach for allowing native species to thrive in the lakes. Once desired nutrient levels are reached, further actions for vegetation management can be identified.

Most of the lakes in the watershed contain curly-leaf pondweed and Eurasian watermilfoil, which can lead to decreased SAV diversity and other problems in the lakes (Table 4-4). Curly-leaf pondweed can be problematic in the lakes due to midseason senescence, exposing lake sediments and possibly contributing to internal loading. Most of the lakes sampled had robust populations of SAV; however, they were dominated by coontail, a native species indicative of more eutrophic conditions.

Table 4-4 Lakes with curly-leaf pondweed and Eurasian watermilfoil.

Lake	Curly-Leaf Pondweed	Eurasian Water Milfoil	Available Vegetation Data
Pierson	x	x	McComas 2011
Marsh	x	x	Wenck 2012
Wassermann	x	x	McComas 2011; Wenck 2012; Wenck 2012
Carl Krey			MCWD 2012
Kelser's Pond	No Data	No Data	MCWD 2013
Church	No Data	No Data	MCWD 2013 (spring)
Stone	No Data	No Data	2008 (Three Rivers)
Zumbra	x	x	2007 (Army Corps); 2009 & 2010 (Three Rivers)
Steiger	x	x	2008 (Three Rivers)
Sunny	No Data	No Data	
East Auburn	x	x	2007 (Army Corps); 2009 & 2010 (Three Rivers); Wenck 2012
West Auburn	x	x	2007 (Army Corps); 2009 & 2010 (Three Rivers); Wenck 2012
North Lundsten	x		Wenck 2012
South Lundsten	x		Wenck 2012
Turbid	No Data	No Data	MCWD 2013
Parley	x	x	Wenck 2012
Mud	x		Wenck 2012
Halsted's Bay	?	?	MCWD 2013

Invasive species should be controlled in the lakes to allow native species to compete and thrive in the lakes. As nutrients are reduced, this should allow for native species to be more competitive with coontail.

Watershed Protection Strategies

Several of the subwatersheds in the Six Mile Creek watershed have receiving waters with good or excellent water quality (Figure 4-5). Therefore, activities in these watersheds are considered protection activities. Protection activities can include BMP implementation such as iron enhanced sand filters or septic system upgrades. Protection activities also include such things as implementation of MCWD rules to protect water quality during development. Table 4-5 outlines suggested protection activities in the Six Mile Creek watershed.

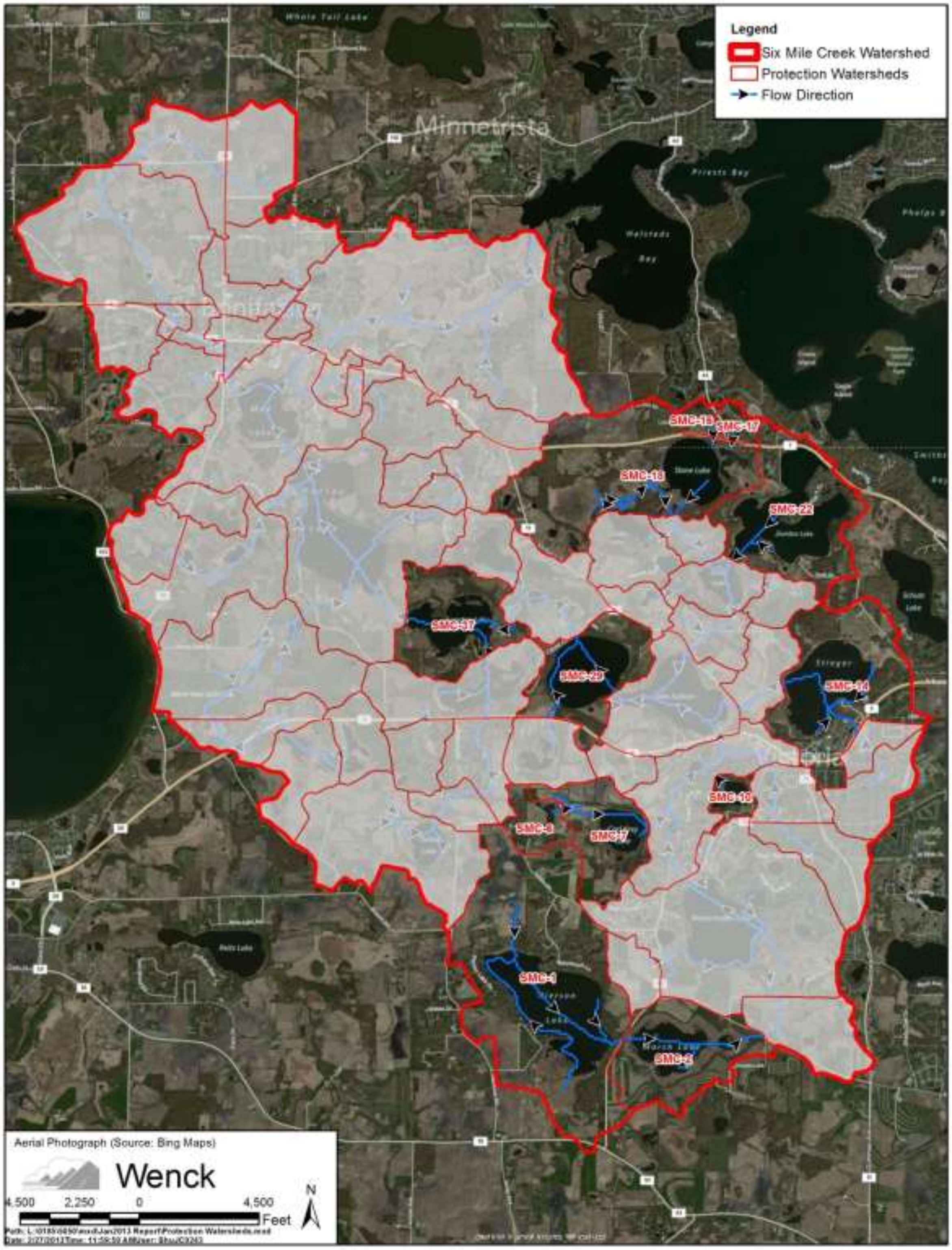

Figure 4-5. Protection watersheds in the Six Mile Creek watershed.

Table 4-5. Watershed protection strategies.

Watershed Management Unit	Subwatershed/Lake	Management Activities
Pierson-Marsh-Wassermann	SMC-1 (Pierson Lake)	• Implement MCWD rules as development occurs in the watershed. • Evaluate and upgrade septic systems, especially those directly around the lake. • Monitor and manage curly-leaf pondweed and Eurasian watermilfoil.
	SMC-2 (Marsh Lake)	• Monitor and manage curly-leaf pondweed and Eurasian watermilfoil. • Monitor Lake water quality .
	SMC-6, SMC-7 (Carl Krey Lake)	• Implement MCWD rules as development occurs in the watershed.
	SMC-10 (Kelser's Pond	• Identify opportunities for BMP retrofits such as rain gardens.
Carver Park Reserve	All	• Implement MCWD rules as development occurs in the watershed. • Manage stormwater around new park developments. • Maintain park open space. • Monitor and manage curly-leaf pondweed and Eurasian watermilfoil.
Turbid-South Lundsten	All	• Implement MCWD rules as development occurs in the watershed. • Monitor and manage curly-leaf pondweed and Eurasian watermilfoil.
Auburn-North Lundsten	All	• Implement MCWD rules as development occurs in the watershed. • Monitor and manage curly-leaf pondweed and Eurasian watermilfoil.
Parley-Mud	All	• Implement MCWD rules as development occurs in the watershed. • Monitor and manage curly-leaf pondweed and Eurasian watermilfoil.

4.5 PIERSON-MARSH-WASSERMANN MANAGEMENT UNIT

There is a mix of protection and restoration projects in the Pierson-Marsh-Wassermann Management Unit. Following is a description of the proposed major efforts.

Watershed Nutrient Reductions

Pierson and Marsh Lake

Water quality in both Pierson and Marsh Lake is relatively good, so protection of water quality conditions is the most appropriate approach. Protection activities should focus on maintaining or reducing current nutrient loading activities through opportunistic projects in the watershed. Pierson Lake has a high density of septic systems around the lake that need to be assessed and evaluated to make sure they are in compliance with current technical standards. Other projects to control agricultural runoff, runoff from development, or runoff from shoreline properties can be implemented as opportunities and funds arise.

MCWD designed ponds in 2012 to reduce nutrients from the northern tributary to Pierson Lake. This project is ready to be developed and implemented but siting constraints need to be resolved before the project can move forward. This project protects long term water quality in Pierson Lake.

Wassermann Lake

Wassermann Lake is degraded and receives discharge from Pierson and Marsh Lake. There are three primary drainage inputs into Wassermann Lake, including Six Mile Creek from the south, developed areas from the east through two large ponds, and agricultural areas from the west.

Most of the phosphorus load is likely coming from Six Mile Creek through a large wetland complex between Marsh and Wassermann Lake (Figure 4-6). This wetland area may represent the greatest opportunity for nutrient reductions to the lake. Wetland restoration for phosphorus reduction can be difficult; however, several options should be evaluated. Evaluating a chemical filter at the outlet of the wetland may be the most straightforward approach, but the feasibility of such a project needs to be evaluated further.

Figure 4-6. Six Mile Creek flows through a large wetland prior to discharging to Wassermann Lake.

The second opportunity for nutrient reductions includes the drainage area to the east that includes single family residential areas and the Deer Run Golf Club (Figure 4-7). These drainage areas appear to be well ponded; however, they ultimately drain through two large ponds surrounded by wetland. The downstream pond may be a candidate for chemical filtration and the ponds should be evaluated for carp reproduction potential. These ponds should also be monitored for water quality to validate their role in nutrient loading to the lake.

Figure 4-7. The primary inlet to Wassermann Lake from the east.
Note: This drainage area flows through two ponds surrounded by wetlands prior to discharging to the lake.

Carl Krey Lake and Kelser's Pond

Both Carl Krey Lake and Kelser's Pond exhibit good water quality and therefore require only protection activities where opportunities arise.

Church Lake

Restoration of Church Lake should focus on watershed loading to the lake. The primary inflow drainage area includes drainage from the south, including portions of Deer Run Golf Club. The south drainage enters the lake through a creek that flows through a wetland before discharging to Church Lake. One option could be to evaluate an iron enhanced sand filter on the outlet of the wetland. Other options include looking at more diffuse stormwater practices, including golf course management, additional ponding, retrofitting ponds, or infiltration practices such as rain gardens (Figure 4-8).

Figure 4-8. The wetland to the south of Church Lake.
Note: The wetland receives the majority of watershed runoff prior to entering Church Lake. One option is to determine the feasibility of an iron enhanced sand filter at the outlet of the wetland.

Subwatershed SMC-11

Land area in subwatershed SMC-11 is dominated by a large wetland that receives discharge from Wassermann, Carl Krey, and Church lakes as well as Kelser's Pond (Figure 4-9). Mass balance calculations for the wetland between Wassermann and East Auburn Lake suggest that wetland discharge exceeds 800 µg/L total phosphorus and may account for over 600 pounds of phosphorus loading annually to East Auburn Lake. The wetland also has large open water areas that may be prone to winterkill and should be evaluated for carp recruitment potential.

Figure 4-9. A large wetland in subwatershed SMC-11.

Note: The wetland receives drainage from Carl Krey, Wassermann, and Church Lake as well as Kelser's Pond. Mass balance calculations demonstrate that the wetland is likely contributing significant amounts of phosphorus (>600 pounds) to surface waters and ultimately East Auburn Lake.

Internal Load Control

In the long term, internal load control projects such as alum application may be necessary in both Wassermann and Church lakes. Since the watershed loads are the dominant nutrient source, watershed nutrient loading needs to be implemented prior to internal load controls.

4.6 CARVER PARK RESERVE MANAGEMENT UNIT

Watershed Nutrient Reductions

For the most part, water quality in the lakes in the Carver Park Reserve Management Unit have good water quality and deserve protection considerations. However, two subwatersheds, SMC-15 and SMC-25, demonstrated high export concentrations, suggesting that the wetland areas may be contributing phosphorus to surface waters.

Mass balance calculations for the outlet of Steiger Lake and the monitoring station at Victoria Drive suggest that runoff from this watershed has an average concentration over 1 mg/L phosphorus and contributes over 270 pounds of phosphorus annually. Land use in the subwatershed is mostly open land with the only remarkable feature being a ditched wetland between Steiger Lake and East Auburn Lake (Figure 4-10). It is likely that this wetland is acting as phosphorus source to surface waters. One possible solution is to bypass the wetland between Steiger and East Auburn using a pipe or open channel, but this may have other fish passage or wetland hydrology implications.

Figure 4-10. The outlet of Steiger Lake discharging to East Auburn Lake.

The same situation occurs between Sunny Lake and East Auburn Lake, where mass balance calculations suggest that runoff from this subwatershed exceed 1.5 mg/L phosphorus, accounting for over 400 pounds of phosphorus loading from the watershed. Again, land use is mostly open space, so the wetland seems a likely source of the phosphorus (Figure 4-11). One possible solution is to pipe the outlet between Sunny and East Auburn, but this may have other fish passage or wetland hydrology implications.

Figure 4-11. The outlet of Sunny Lake which discharges to East Auburn Lake.

The final area that demonstrates some need for water quality improvements are two subwatersheds draining to Steiger Lake (SMC-12 and SMC-13). These two subwatersheds drain to a wetland pond area on both sides of Steiger Lake Lane (Figure 4-12). MCWD completed a wetland restoration on the east side of Highway 5 in 2012 (Figure 4-12) aimed at reducing almost 98 pounds of phosphorus loading to Steiger Lake. The wetland restoration focused on removing the ditch from the wetland, spreading the water naturally thought the wetland and eventually stored in small ponds.

The west side pond could be evaluated for retrofitting with an iron enhanced sand filter to improve phosphorus removal performance if additional phosphorus reductions are needed after the wetland restoration is completed.

Figure 4-12. The primary inlet into Steiger Lake.
Note: The inlet receives drainage from two large developed watersheds (SMC-12 and SMC-13).

Carp and Fish Management

Carp movement and reproduction in the Carver Park Reserve Management Unit is complex, with the fish being able to move in and out of the lakes. There are a few areas where fish reproduction may be occurring and other areas where passage may be difficult. Based on anecdotal information, carp may be reproducing in Sunny Lake, which is prone to fish kill. The carp would then have free access to the rest of the system. Sunny Lake should be evaluated for carp management.

Although Crosby Lake is prone to winterkill, carp have not been observed in Crosby or Stone Lake, and Three Rivers Park District field staff suggests that the Stone Lake drainage area may be cut off from carp by a structure between Sunny and Stone Lake, where carp have been observed congregating on the downstream end. Consequently, this area does not seem likely to provide carp recruitment.

The channel between Steiger Lake and East Auburn is somewhat intermittent and may inhibit fish passage between the lakes. However, it is unknown if carp move between the lakes. While this is being evaluated, carp assessment and management should focus on Sunny Lake.

Internal Load Control

None of the lakes in the Carver Park Reserve Management Unit demonstrated high internal loading and therefore no internal load projects are necessary at this time.

4.7 TURBID-SOUTH LUNDSTEN MANAGEMENT UNIT

Carp and Fish Management

Based on the fish survey data, carp density estimates from commercial fisherman, and anecdotal reports from field staff, carp appear to be quite abundant in this Management Unit. The watershed has numerous areas that are shallow enough to be prone to winterkill including large areas such as Marsh Lake as well as numerous small shallow open water areas in wetlands throughout the watershed. Carp recruitment areas need to be identified and eliminated in the watershed. This activity, along with aggressive carp removal, should control carp in the watershed. Carp may be able to move up from East Auburn Lake to Wassermann Lake, so a carp barrier may be necessary for long-term control. Auburn Lake did have carp in its most recent survey, but the lake is not demonstrating significant effects from carp such as substantial SAV loss.

Watershed Nutrient Reductions

Turbid Lake

Turbid Lake is dominated by internal loading, so minimal watershed reductions are required. For watershed loading, monitoring should occur at the primary inlet to Turbid Lake, which is at the bottom of a ditched wetland (Figure 4-13). A feasibility study for restoring this wetland was developed by Wenck Associates in 2010 (Wenck 2010). One important aspect of the project needs to be preventing the creation of carp reproduction areas in the wetland after restoration.

Figure 4-13. The primary inlet to Turbid Lake.
Note: The inlet is at the bottom of a ditched wetland. Monitoring should occur at this wetland to assess potential phosphorus inputs.

South Lundsten Lake

Watershed loading to South Lundsten Lake is dominated by the drainage ditch running from Turbid Lake to South Lundsten Lake. Feasibility studies have looked at restoration options along the corridor, including channel restoration, agricultural runoff management, and wetland restoration (Figure 4-14; MCWD 2011; Cross River Consulting 2010; Wenck 2010). It is difficult to determine the sources of phosphorus in the watershed, especially because portions of the ditch run through drained wetlands that can export P. All of the options need to be explored and implementation should occur as time, money, and land availability permits. One primary activity needs to be limiting carp movement through the corridor.

Figure 4-14. The primary drainage ditch flowing between Turbid Lake and South Lundsten Lake.

Another option is to treat the outflow from the ditch at the bottom of the watershed, where the ditch discharges to a large pond prior to entering South Lundsten Lake (Figure 4-15). The pond could be evaluated for retrofits such as an iron enhanced sand filter and a carp barrier. This type of project would have a more immediate impact on water quality in the lake. Long-term, the ditch improvements should be considered to improve habitat and overall fish migration ability.

Figure 4-15. The pond at the end of the drainage ditch prior to discharging into South Lundsten Lake.

Carp and Fish Management

Based on anecdotal reports from field staff (Wenck, MCWD), South Lundsten Lake is severely infested with carp that move freely between South Lundsten Lake and Turbid Lake. South Lundsten Lake demonstrates the impacts of carp due to its very poor water quality and lack of submerged aquatic vegetation. Interestingly, the connected downstream basin, North Lundsten Lake, does not appear impacted by carp because it has a healthy, robust submerged aquatic vegetation population, although it is demonstrating signs of water quality degradation. Based on these observations, carp management is critical for both restoring South Lundsten Lake and protecting North Lundsten Lake.

To manage carp, migration barriers should be considered at the inlet and outlet of South Lundsten Lake. It may be that the outlet is acting as a carp barrier now, but this needs to be verified. Preventing carp from moving in from Turbid Lake and up from South Lundsten Lake will help with improvements to the ditch as well as South Lundsten Lake. A whole-lake drawdown for South Lundsten Lake should be evaluated to help with carp removal (possible rotenone treatment) as well as reestablishing the submerged aquatic vegetation community. Once the carp have been controlled, water quality improvements will have a greater impact on the lake.

Internal Load Control

Turbid Lake and South Lundsten Lake have very high internal loads that dominate the phosphorus budget for the lake. Consequently, internal load control is a high priority in the lakes. Because Turbid Lake is a deep lake, alum is a good choice for internal load control. South Lundsten Lake is more difficult because it is very shallow and has carp. However, alum may be effective if the carp are controlled and submerged aquatic vegetation is reestablished.

4.8 AUBURN-NORTH LUNDSTEN MANAGEMENT UNIT

Watershed Nutrient Reductions

Watershed nutrient loading for East Auburn Lake should focus on subwatershed SMC-11, SMC-15, and SMC-25 as described in Section 4.6.

Carp and Fish Management

The role carp play in these three lakes is difficult to identify, but it is clear that carp can move through the lakes to spawning areas. However, none of these lakes demonstrate typical carp impacts such as submerged vegetation loss and turbid water conditions. Because South Lundsten Lake is heavily carp infested, it stands to reason that these carp would move into North Lundsten if it was possible. However, there is no evidence of carp in North Lundsten Lake. Carp can move freely between Sunny Lake, a likely carp reproduction area, and East Auburn Lake, but Auburn Lake shows no ill effects from the carp. It is possible these carp move upstream to Wassermann Lake. Steiger Lake has some carp in fish surveys, but the connection is intermittent between the lakes.

Due to the complex connections between the lakes in this part of the watershed, more investigation is needed on carp movement. However, a good place to start in carp management is to prevent winterkills in Sunny Lake and South Lundsten Lake. Based on the conditions of the lakes and anecdotal information on carp movement, there appears to be distinct and separate carp populations in the watershed.

Internal Load Control

None of the lakes demonstrated a large internal load and therefore no internal load control projects are required.

4.9 PARLEY-MUD MANAGEMENT UNIT

Watershed Nutrient Reductions

Watershed projects in the Parley lake watershed likely include wetland restoration and agricultural BMPs. One area identified as having higher loads from monitoring data includes the wetland to the east of Parley Lake (Figures 4-16 through 4-20).

Figure 4-16. The drainage area to the east of Parley Lake.

Note: The drainage area demonstrated high total and ortho-phosphorus concentrations.

Figure 4-17. Potential monitoring locations for the west inlet to Parley Lake.

Figure 4-18. Potential monitoring site for the west tributary to Parley Lake.

Figure 4-19. Potential monitoring site for the east tributary to Mud Lake.

Figure 4-20. Potential monitoring site for the northern tributary to Mud Lake.

Carp and Fish Management

Controlling carp and bullhead in Parley Lake will require controls throughout the Six Mile Creek watershed and developing a plan for reducing and controlling rough fish. The plan will focus on key connections of water bodies, potential spawning areas, key rearing areas, and overall management strategies aimed at reducing rough fish populations in the watershed (Figure 4.21). One of the first steps will be to radio tag carp in the watershed to identify fish movement. Key area removals will need to be conducted as well.

Figure 4-21. The Parley Lake watershed has numerous shallow wetlands that can potentially act as carp reproduction areas.

Internal Load Control

Internal phosphorus release may need to be controlled in Parley Lake. Mud Lake had relatively low phosphorus release rates and does not need to be considered at this time. Shallow lakes are more difficult to manage internal load because of dense carp populations and no submerged aquatic vegetation. Prior to implementation of any internal load control, the carp population must be controlled. Parley Lake should undergo lake restoration prior to an internal load control project because the role of internal loading is still unclear.

Vegetation Management

Parley Lake contains both Eurasian watermilfoil and curly-leaf pondweed and Mud Lake lacks an SAV population. Currently, neither is dominating the vegetation community in Parley Lake. However, as water quality improves, these species will likely become more aggressive. Long term control actions will be necessary, including some chemical control or harvesting as well as whole-lake drawdown to reduce the seed bank.

Lake Restoration

Once the rough fish and nutrients have been controlled, a whole lake drawdown will be necessary to switch the lake from the turbid water state to the clear water state. Drawdown should occur during two periods, one winter period to reduce curly-leaf pondweed and one summer period to promote denitrification and invigorate the native seed bank.

Once the lake is in the clear lake state, water levels will need to be managed to maintain the clear lake state. This includes the ability for periodic whole- or partial-lake drawdown.

Planning a drawdown takes considerable effort and permitting, with the process often exceeding two years. Planning and feasibility efforts should be conducted concurrently with watershed nutrient management and carp assessments.

5.0 References

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6.0 Additional Resources

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Appendix A

P8 Model Documentation

Appendix B

XP-SWMM Model Documentation

Appendix C

Internal Phosphorus Release Study

Appendix D

BATHTUB Model Documentation

Appendix E

Water Quality Data Summary

Appendix F

Fish Data Summary

Appendix G

Vegetation Data Summary

Wenck
Engineers • Scientists
Business Professionals

Minnehaha Creek Watershed District
PLANNING & POLICY COMMITTEE
Meeting Minutes
July 18, 2013

Committee Members Present: Sherry White, chair; Dick Miller.

Staff Present during Meeting: Erik Dahl, James Wisker

The Committee meeting began at 7:00 p.m. in the breakout room of the new District Offices at 15320 Minnetonka Boulevard.

1. Agenda Approval

The agenda was approved as presented.

2. 6 Mile Creek Subwatershed Planning Efforts

Erik Dahl summarized an outline for presentation and discussion of planning and policies regarding the 6 Mile Creek Subwatershed planning efforts:

- Summarize results of 6 Mile Creek Subwatershed Diagnostic
- Diversity of issues within each of the five management units
- Discussion of goals for planning and implementation within the subwatershed
- Discussion of how goals relate to goals of 2007 Comprehensive Plan
- Identify additional policy and planning discussions needed by the Committee

After reviewing the results and issues within the discrete management units, the committee discussed the following:

- Following on the District's ongoing efforts to pursue subwatershed focused strategic planning, the 6 Mile Diagnostic serves an important purpose as a comprehensive overview of specific issues driving water quality and ecological integrity. As such, studies such as this allow the District to:
    - Recognize opportunities versus threats, measured against a strategic vision
    - Take advantage of opportunities as they present themselves
    - Evaluate opportunities against an overarching plan that includes principles, goals and strategies
    - Create new innovative opportunities where they didn't exist before
    - Remain responsive to project requests or outside pressures by having a long term vision and strategy for an area
    - More formally integrate its planning efforts with those of communities, counties, park districts, lake associations, etc.

- The District has 17 goals embedded in the Comprehensive Plan, a subset of these goals could and should be prioritized to provide the level of strategic focus required to guide a vision for the subwatershed, and future action and spending by the District. The Committee discussed that these goals could begin as broad objectives that would inform specific management strategies, and could include:

    - Preserving and enhancing water quality
    - Improving overall ecological integrity
    - Preserving and enhancing riparian corridors

- The Committee discussed that this level of focus would not mean operating without regard to the Comprehensive Plan Goals, but would rather provide increased focus to develop a long term plan of action for the subwatershed that would resonate with the public and outside agencies.

- In order to work towards overarching goals of improving water quality, ecological integrity, and riparian quality the 6 Mile Diagnostic outlined the need for a multifaceted and dynamic approach to implementation that could include use of strategies such as: wetland restoration, addressing agricultural issues, internal load management, comprehensive protection for stream corridors including 1st and 2nd order streams, fisheries management, lake drawdown, aquatic plant management/establishment, integration with development and land use planning, unique multi-agency partnerships, innovative funding strategies, and more. Some of these strategies could be lead and funded by MCWD while other prioritized strategies should be supported by the District but lead and funded by other entities.

- The Committee discussed the results of the 6 Mile Diagnostic and efforts that could be taken within the subwatershed as they relate to 6 Mile Marsh and meeting water quality goals for Halsted Bay which requires addressing internal load as well as upstream load. The Committee identified that there would need to be future policy discussion on the District's approach to implementation for the subwatershed versus Halsted, in relation to the timing, scope and budgeting of upstream versus downstream implementation.

- The Committee identified many potential policy discussions regarding specific implementation strategies such as fisheries management, upstream and downstream implementation, and financing mechanisms to support ongoing strategic focus within the subwatershed. The Committee determined to recommend to the Board of Managers that the 6 Mile Creek Subwatershed planning effort be the subject of ongoing discussion at the Planning and Policy Committee over the next 12 months with full discussion by the Board as needed.

- Further, the Committee determined to recommend to the Board of Managers that as a first step, staff work with the Committee to develop a framework for a long term programmatic effort to implementation within the Subwatershed. At a preliminary level this framework would include discussion of technical approaches, costs, program strategies, philosophies, possible multi-jurisdictional partnerships, education & communication strategies, financing strategies, relation to Comprehensive Plan, etc.

- The Committee discussed how such a programmatic approach could provide additional detail beyond the Comprehensive Plan, serve as a basis for the next generation plan, provide a planning template for other subwatersheds in the future and ensure the District moved forward in a coordinated thoughtful manner.

3. 6 Mile Land Investigation

- The Committee received an update on key parcels within the 6 Mile Creek corridor. Staff informed the committee that the corridor remains a focal area and that the District's real estate consultants remain engaged in identifying opportunities that support goals for the area.

4. Adjournment

The Committee adjourned at 10:30PM

Respectfully submitted,

James Wisker, recorder

Minnehaha Creek Watershed District
PLANNING & POLICY COMMITTEE
Meeting Minutes
August 1, 2013

Committee members present: Sherry White, chair; Dick Miller, Brian Shekleton

Non-Committee members present: Manager Casale

Staff present during meeting: Erik Dahl, James Wisker, Steve Christopher, Eric Evenson

The Committee meeting began at 7:00 p.m.

1. Agenda Approval

The agenda was approved as presented with a request from Manager Miller that a review of wetland restoration science be presented at a future committee meeting for discussion of how wetland restoration may play a role in achieving the District's strategic objectives.

1. Offsetting stormwater regulatory requirements
2. 6 Mile Creek subwatershed planning

2. Offsetting regulatory requirements:

Discussion:
Steve Christopher summarized the memorandum outlining the policy history of regional treatment and regulatory offsets. He noted three primary discussions in recent history:

- During development of the Stormwater Management rule
- During feasibility analysis of the Taft-Legion Project
- During the May 2, 2013 Planning and Policy Committee Meeting

The committee identified that policy considerations during rule development were largely technical in nature. Technical considerations resulted in rule language that only allows regional treatment in place of on-site stormwater management where there would be no adverse impacts to local groundwater or natural resources located upstream of the regional facility, including but not limited to, reduced water quality, altered wetland hydrology, changes to stream velocities or baseflow, erosion or reduced groundwater recharge.

Staff highlighted that these technical considerations were reinforced by the MCWD Board during consideration of the Taft-Legion project where the District recognized that intermediate resources (groundwater, wetlands, streams, etc.) would not be negatively impacted. The committee reviewed language from the Taft-Legion resolution for project ordering which included language noting that the project solution would not be broadly applicable across the District:

WHEREAS, the Board of Managers recognized that the solutions proposed within the Taft-Legion Lake Feasibility Study may be applicable in fully developed areas such as Richfield, but would not broadly apply across other parts of the District; and

The committee then reviewed the minutes from the May 2, 2013 Planning and Policy Committee where the committee concluded that depending on the situation, both regional treatment and site specific BMPs are effective stormwater management tools that the District should continue to utilize.

At this time the committee discussed the considerations that could comprise a formal policy on how the District may utilize regional treatment to offset regulatory requirements. The committee agreed that the emphasis of any such policy for the District should remain on water resources. The committee discussed the need for caution in developing the policy as there were likely many situations where the District may wish to provide large scale regional treatment *and* require redevelopment to meet stormwater rules.

As a counterpoint the committee identified situations where offsetting regional treatment may generate or strengthen existing partnerships, and/or catalyze larger water resource project opportunities. Further discussion centered on criteria the District may wish to use to identify situations and leverage its regional treatment to capitalize on such opportunities.

The committee discussed the economics and financing of District projects in relation to providing future regulatory offsets. The committee agreed that the District should be particularly prudent in how it establishes reimbursement parameters for applicants using MCWD projects to offset stormwater regulations. There was consensus among the committee that while capital expense and long term maintenance could be recouped, the District would want to be perceived only as covering costs, not generating additional revenue.

The committee also discussed whether the District would want to broadly advertize the availability of stormwater credit, or more selectively use available credits to leverage new partnerships and project opportunities. It was generally agreed that a more strategic approach would create a balance that both yields new partnerships and utilizes the regulatory requirements to maximize water resource benefit within a specific area.

At this point the committee discussed that a finite and prescriptive set of evaluative criteria to determine when regulations could be offset was not realistic. Staff reviewed that the committee's discussion had revolved around a general set of principles that included:

- Offsetting regulatory requirements must make technical sense and not negatively affect intermediate water resources.
- Evaluation of viability of managing stormwater on a particular property.
- Would offsetting regulatory requirements in a particular instance leverage additional water resource benefit, create/strengthen partnerships or catalyze a larger public benefit.

- The District should only cost recover, and not use regulatory offsets to generate additional revenue.

Recommendation:
The committee determined that its recommendation to the Board of Managers would be to direct staff to draft a policy resolution, incorporating all discussions to date, for review and approval at a future Board Meeting.

Specifically, the recommended policy framework would allow some permit applicants to use MCWD projects to offset on-site regulatory requirements as allowed by the District's stormwater rule. Further, the policy framework would include a broad set of guiding principles regarding when, where, and how District projects may be used to offset on-site stormwater requirements.

3. 6 Mile Creek Subwatershed Planning:

The Committee reviewed the July 18, 2013 Planning and Policy Committee meeting. The committee reinforced that due to the diverse array of water resource issues within the five discrete management units, and how these related to downstream Halsted Bay, that a broad multi-jurisdictional programmatic approach needed to be developed.

The Committee outlined with staff the need to develop and prioritize a list of future policy discussions that would help facilitate the development of a programmatic approach. The committee noted that discussion of discrete policy issues would help drive planning forward due to the complexity of technical issues, implementation strategies, program costs and financing, partnerships, and upcoming revision to the MCWD Comprehensive Plan.

The committee identified that specific policy discussions may be further bifurcated into emerging and long-term issues. For example, land-use was discussed as an obvious driving force in water quality, riparian corridor health, and overall ecological integrity. The committee recognized that development pressure and associated land-use decisions would be made in the next year as well as over the next ten years, requiring emerging and long-term policy strategies.

The committee discussed the need to continue the District's efforts to become better integrated with land-use planning and decision making at a local level. This discussion included potential strategies to facilitate a desired level of integration. The committee noted that approaching this task strictly through the lens of water resource management may generate conflict. The committee outlined the need of the District to remain cognizant of the interrelation between water resource planning, land use, economics, infrastructure planning, and the broader goals of livable communities.

The committee discussed that, in relation to the recent presentation to the Board on community capacity, a concerted effort should be made to work at all levels to achieve support for a broad and long-term strategic initiative within the 6 Mile Creek subwatershed. This may include but not be limited to individual land owners; lake associations; county, township and municipal agencies; and park districts. The committee noted that agency integration and coordination would be required at both a staff and policy maker level in order to build trust and support for a multi-jurisdictional approach. As an example of efforts that might need to be taken, the committee discussed the merits of increasing staff and/or policy maker presence at outside agency meetings, such as council meetings.

The committee discussed that this would require increasing the focus of existing staff resources, the alignment of staff/financial resources around specific objectives, and increasing the integration between District programs. The committee discussed increasing the integration between the regulatory and planning programs as an example. It was thought that such efforts may provide a first level filter on land use decisions within strategic focal areas, such as the Minnehaha Creek and 6 Mile Creek subwatershed.

Staff recommended that the September committee meeting be focused on developing a prioritized list of policy issues, and discussion of a strategy for developing support for a long-term, multi-jurisdictional approach to implementation within the 6 Mile Creek subwatershed.

4. Adjournment

The Committee adjourned at 9:30PM

Respectfully submitted,

James Wisker, recorder

DRAFT: Planning Committee – Umbrella Policy Discussions:

***(This list is not intended to be inclusive and will be modified in response to committee discussion and Board direction)**

1) **Institutionalizing the Minnehaha Creek Community Works (MCCW) Planning Framework:**
   ***Follow up from Board Retreat**
   a. How is this different from how the District has planned in the past?
   b. Why is this a sound planning strategy?
   c. What are barriers to success?
   d. What does Board mean by developing non-regulatory relationships?
   e. What are guiding principles/philosophies of this approach?
   f. What needs to be different moving forward to facilitate success under this framework?

2) **Integrated Investment Framework for MCCW:**
   ***Recent Board discussion during budgeting**
   a. How do we pay for programs and project in the coming years?
   b. District levy
   c. Hennepin vs. Carver
   d. Special Taxing Districts
   e. Role of grant programs and grant funding
      i. History – What partnerships and grants has the District engaged in and how did it go?
         1. USACE
         2. The Glen
         3. Chain of Lakes
         4. Big Island
         5. Others
   f. Special Legislative Funding
   g. Sharing the burden (municipalities, TRPD, SWCD, etc.)
   h. Goals of other potential partner agencies:
      i. Who are all the partners in Six Mile Subwatershed?
      ii. What are their goals?
      iii. How are they financed?
      iv. What leverage may exist?

3) **Geographic Prioritization:**
   ***Identified need for implementation of strategic MCCW**
   a. What criteria are used to prioritize focal geographies?
      i. Resource Need
      ii. Opportunities
      iii. Relationships/Politics
      iv. Development pressures
      v. Regional impact
      vi. Community Works benefits
   b. What geographies are next?
   c. How is the order of focus determined?
   d. How do we know we're 'done' in a subwatershed?
      i. What are the metrics?

        ii. What are the benchmarks?
        iii. How long do we “stay” in a subwatershed? What’s next?

4) **Remaining Responsive to Communities Outside Priority Geographies:**
   ***Byproduct of geographic focus**
   a. What does it mean to ‘remain responsive’?
   b. What are the messages?
   c. How can District programs be used strategically to manage outside pressures?
      i. LID, Cost Share, Communications, etc.
   d. What are these program roles in priority geographies?

5) **Integration with Land Use Planning Authorities:**
   ***Land use drives water quality**
   a. How are land use decisions made and/or influenced?
   b. Immediate vs. long-term
   c. How will District strategically engage with communities to affect land use policies
      i. Zoning
      ii. Outlots
      iii. Shoreland ordinances
   d. What strategies will District employ to engage with private sector?
      i. Subsidizing conservation development and corridors.
   e. What is the role of the Regulatory Department?
   f. Role of District in enhancing tax base?
   g. Relationship between regional connections and conservation corridors?
   h. Relationship with park commissions and districts?
   i. Model Ordinances/Documents
   j. Regional Approach – How to work with regional authorities to use as a lever to MCWD priorities be the regional priority

6) **Politics/Community Capacity:**
   *** How will District engage all levels of ‘community’ to succeed?**
   a. What are values of various levels of ‘community’? (grassroots, political, private)
   b. How will District identify strategies to address ‘community capacity’ before engaging in priority geographies?
   c. What is the role of the Board, staff, CAC, and consultants in building ‘community capacity’
   d. What are the messages to deliver to communities as we develop community capacity within the Six Mile Creek Sub?
   e. Other?

7) **Role of Regulation:**
   ***Building non-regulatory relationships through regulatory filter**
   a. How can specialized regulation create leverage within priority geographies?
   b. Subwatershed specific regulatory revisions
   c. Protection of 1st and 2nd order streams? As community connection corridors?
   d. Criteria/Objectives for targeted regulation?

6 Mile Implementation Policy Discussions:

1) **Phasing/Timing:**
   a. Upstream vs. Downstream
   b. Concurrently vs. Phased (what needs to happen when?)
   c. How do politics play into timing/phasing
   d. How does momentum play a role?

2) **Controversial/Creative Management Approaches**
   e. Drawdown
   f. Chemical Applications
      i. Rotenone
      ii. Alum dosing
      iii. Etc.
   g. SAV reestablishment
   h. Bubblers in Wetlands
   i. Other Controversial management approaches

3) **Regulatory obstacles (ie: Water Appropriations)**
   a. Fees from DNR for WQ projects that remove water from waterbody
   b. Legislative revisions
   c. Lobbying agencies

4) **Fisheries**
   a. What's the purpose of the Sorenson Carp study (3-yrs)?
   b. Who manages?
   c. Who pays?
   d. What is the end goal? What are the metrics to know we have achieved the fisheries goal?
   e. What is the timeframe?
      i. What needs to be managed immediately (protection)?
      ii. What needs to be managed long term?

5) **Regional Treatment**
   a. Halsted offline alum-injection system/dosing of lake
   b. Who pays for regional treatment options?
   c. Who receives credit?

6) **Ditch Abandonment**
   a. Does the District want to seek ditch abandonment in Six Mile Creek Subwatershed? To what end?
   b. How does this carry forward to other subwatersheds within MCWD? What are the criteria for MCWD deciding to support abandoning ditches?
   c. How does this fit into goals for Six Mile Creek Sub?

7) **Agriculture:**
   a. Is a regulatory approach feasible?
   b. Does MCWD lead?
   c. What are creative opportunities for addressing Agriculture issues?

d. Is there a role for Cost Share? LID? Another new program?

8) **Septic:**

a. What role can Planning play in dealing with Septic issues in Six Mile and District wide?
b. Is there a role for other departments?

9) **Role of Land Conservation, other programs?:**

Minnehaha Creek Watershed District
PLANNING & POLICY COMMITTEE
Meeting Minutes
September 5, 2013

Committee members present: Sherry White, chair; Dick Miller, Brian Shekleton

Non-Committee members present: Larry Blackstad, Louis Smith

Staff present during meeting: Erik Cedarleaf Dahl, Michael Hayman, James Wisker

The Committee meeting began at 7:00 p.m.

1. Agenda Approval
Chair White called the meeting to order and the agenda was approved as distributed.

2. Follow up to 2013 Board Retreat:
Staff noted that while preparing to draft a list of future Committee topics, the Committee had requested more global discussions be prioritized ahead of 6 Mile Creek planning. The Committee was reminded that in addition to the current topic, the list included items such as: future financing strategies (integrated investment framework), geographic prioritization, responsiveness outside priority geographies, integration with land-use planning, community capacity, and future roles of regulation.

Staff then reviewed the Board's request, made during the 2013 Retreat, to prioritize discussion on delineating a framework to integrate the District's "*work into the plans and work of others,*" by expressing a "*commitment to complement the efforts of cities and private development*," and by moving "*away from regulatory focused relationships.*"

Staff noted that the Board's desire to bolster its philosophy of partnerships and integration with land-use may establish a central theme for the 2017 Comprehensive Plan. It was discussed that by comparison, while the District has enjoyed a history of partnerships, central tenants of the 2007 Comprehensive Plan included requirements for LGUs (TMLD approach) and the need to update water resource regulations. This planning process was followed by a four year rulemaking process that further defined MCWD as a strong regulatory agency.

The Committee reinforced that partnerships and integration with outside entities should be driving forces behind the next generation comprehensive plan. 6 Mile Creek was cited as an example of how large-scale implementation in a rural, developing watershed would be constrained by the District's financial resources. The Committee noted that success in these situations required the use of strong multi-jurisdictional relationships to integrate investment between the District, local land-use authorities, counties, park-districts, private developers, and lake associations.

Staff summarized background information from academia calling for improved integration between water and land-use planning, and various policy analyses within MN calling for the same. The Committee acknowledged that given the relationship between water resources and the surrounding landscape, substantial coordination is required between the District, land-use planning agencies, and private landowners.

Mr. Smith summarized the District's authorities related to land-use, noting that while the District may take on additional authorities, limitations exist regarding fundamental tensions between water management organizations and traditional land-use authorities. The Committee discussed that while regulations are vital and provide a foundation for water resource protection, the level of coordination and integration necessary for future management activities required the development of an integrated planning framework.

In review of planning models Mr. Blackstad outlined his role in implementing the Hennepin Community Works Program for Hennepin County. He noted that Community Works provided a planning framework that enhanced Hennepin County's ability to work in close coordination with land-use authorities, to develop and implement large-scale projects for community benefit.

Mr. Blackstad reminded the Committee that he had previously attended the October 1, 2009, Board Meeting to present the principles of the Hennepin Community Works partnership model, its operating methods, and the opportunities it could provide for enhancing the District's work within the Minnehaha Creek urban corridor. He noted that presently, while District's work was not designated a Community Works project by Hennepin County, the District had succeeded in informally implementing a Community Works style partnership program to achieve its water resource goals.

The Committee identified that the District's vision, committing to a leadership role in managing water resources and their related ecosystems, was a founding principle of Community Works. Mr. Blackstad agreed citing that through extensive analysis Hennepin County had concluded that natural systems underpin local identity, creating social and economic value, and therefore should guide project planning.

Mr. Blackstad noted central to the County's success, and a second founding principle, was the need to build bridges for effective planning. The Committee agreed that this had direct application to the District. Mr. Smith noted that this was largely accomplished by the County taking a lead role in convening agencies as well as the private sector. Further, he identified that it was the intensive effort to coordinate resources into a comprehensive plan that enabled the County to accomplish multiple goals with limited resources.

The Committee acknowledged that convening partners through a formal process to accomplish large initiatives was relevant to the District's purposes, and consistent with the organizations evolving brand of partnerships. The Committee made note of the parallels between Hennepin County and MCWD, identifying that both agencies require multi-jurisdictional partnerships between many political and private entities to accomplish large-scale shared interests; and that both require a framework to bridge the divide.

Mr. Smith briefly highlighted his history of developing public-private partnerships, referencing his white paper, Watershed Partnerships. He noted that a large amount of private economic activity drives landscape changes and therefore successful watershed planning must identify strategies to engage private sector entities. The Committee commented on Community Works' ability to accomplish this task by identifying a specific agenda, and then convening stakeholders to participate in a planning process that may directly affect them.

In relation to a recent presentation to the Board of Managers, the Committee discussed that convening groups was essentially an exercise in building community capacity to achieve large strategic initiatives through multi-jurisdictional partnerships. Mr. Blackstad agreed, noting that in his experience capacity building may be required at a multiple levels, (policy, staff, business, and residential level), depending on the specific needs of a particular initiative.

The Committee discussed how these concepts may or may not be applied universally across the District's jurisdiction. It was agreed that accomplishing large-scale water resource initiatives would be made easier by convening planning around strategic project geographies; that these geographies should be identified by large, multi-jurisdictional resource needs and corridors of opportunity; and that success required cultivating relationships around shared goals. It was noted that to generate the partnerships necessary around shared goals that the District must remain cognizant of others goals of economic development, tax base preservation, and job growth.

The Committee discussed that existing resource availability may limit the District's ability to implement such a framework to only one or two priority geographies at a time, noting that the County utilized both dedicated program staff and funds. The Committee agreed that pursuit of such a framework would require the identification of target project areas and strategies to remain responsive to resource needs across the District.

The Committee noted that while large scale strategic initiatives would be limited by available resources, the philosophies of integrated planning, recognition of mutual goals, and natural resource economics would benefit all of the District's initiatives. Specifically by broadening their impact and assisting in efforts to remain responsive to community needs.

The Committee again discussed how a framework for integration with public/private sector partners would facilitate the 2017 Comprehensive Planning Process. Specifically, the Committee identified that the District's interest in convening multi-jurisdictional partnerships, pursuing non-regulatory relationships, and using water resource improvements to enhance others goals, would provide a solid platform for communications and program development.

The Committee requested that Mr. Smith assume a leadership role, working with staff, to refine and draft the Committee's findings in preparation for the Committee's presentation and discussion with the full Board of Managers.

3. Adjournment

The Committee adjourned at 8:30 PM

Respectfully submitted,

James Wisker, recorder