Big Sandy Lake and Lake Minnewawa Total Maximum Daily Load (TMDL)

Implementation Plan

May 2013

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Big Sandy Lake and Lake Minnewawa TMDL Implementation Plan

Prepared for
Minnesota Pollution Control Agency

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Executive Summary

Big Sandy Lake and Lake Minnewawa are currently listed on the Minnesota Pollution Control Agency's (MPCA) 2008 303(d) Impaired Waters List due to excessive nutrients (phosphorus). Both lakes are located in Aitkin County, Minnesota and are within the Northern Lakes and Forests (NLF) ecoregion. A Total Maximum Daily Load (TMDL) Report was completed for Big Sandy Lake and Lake Minnewawa in January 2010.

Big Sandy Lake is a reservoir operated by the U.S. Army Corps of Engineers (USACOE). Big Sandy Lake has a surface area of 6,526 acres and a maximum depth of approximately 84 feet. Lake Minnewawa is within the watershed of Big Sandy Lake. Lake Minnewawa has a surface area of 2,355 acres and a maximum depth of approximately 21 feet.

Phosphorus load reductions to Big Sandy Lake and Lake Minnewawa will be achieved by targeting multiple nonpoint sources. The following summarizes phosphorus reductions that will be targeted in the watershed:

- 1% reduction from forested lands;
- 25% reduction from agriculture/pasture/hay field land use areas;
- 25% reduction from streambank erosion;
- 50% reduction from developed land use areas;
- 93% reduction from wild rice farms (based on assumed conversion to non-agricultural land use). This load reduction percentage represents a high estimate of what may be attainable based on a conservatively high assumption of what has been discharged in the past.
- Full conformance for all SSTS adjacent to both lakes;
- Significant reduction of internal loading from lake sediment in Big Sandy Lake (representing most of the internal loading above the implicit load already included in the empirical lake water quality modeling).

1.0 Introduction

Big Sandy Lake (DNR ID 01-0062) and Lake Minnewawa (DNR ID 70-0033) are located in the Upper Mississippi River Basin in Aitkin County (Figure 1-1). Both lakes are within the Northern Lakes and Forest (NLF) Ecoregion (Figure 1-2). Lake Minnewawa is within the watershed of Big Sandy Lake. Big Sandy Lake is a reservoir system, created by the construction of a dam in 1886. The U.S. Army Corps of Engineers (USACOE) is responsible for dam operations and controls the water level of Big Sandy Lake.

Big Sandy Lake and Lake Minnewawa are currently listed on the Minnesota Pollution Control Agency's (MPCA) 2008 303(d) Impaired Waters List due to excessive nutrients (phosphorus). A Total Maximum Daily Load (TMDL) report was completed in January 2010 (Barr 2010). The eutrophication criteria for the Northern Lakes and Forest (NLF) ecoregion are listed in Table 1-1.

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

Water Quality Parameter	MPCA Lake Eutrophication Standard (NLF Ecoregion)
Total Phosphorus (µg/L)	30
Chlorophyll-a (µg/L)	9
Secchi disc (m)	2.0

This Implementation Plan describes the activities planned by the Big Sandy Area Lakes Watershed Management Project and other involved parties over the next 20 years in order to achieve the load reductions defined in the Big Sandy Lake and Lake Minnewawa TMDL.

Figure 1-1 Regional Features

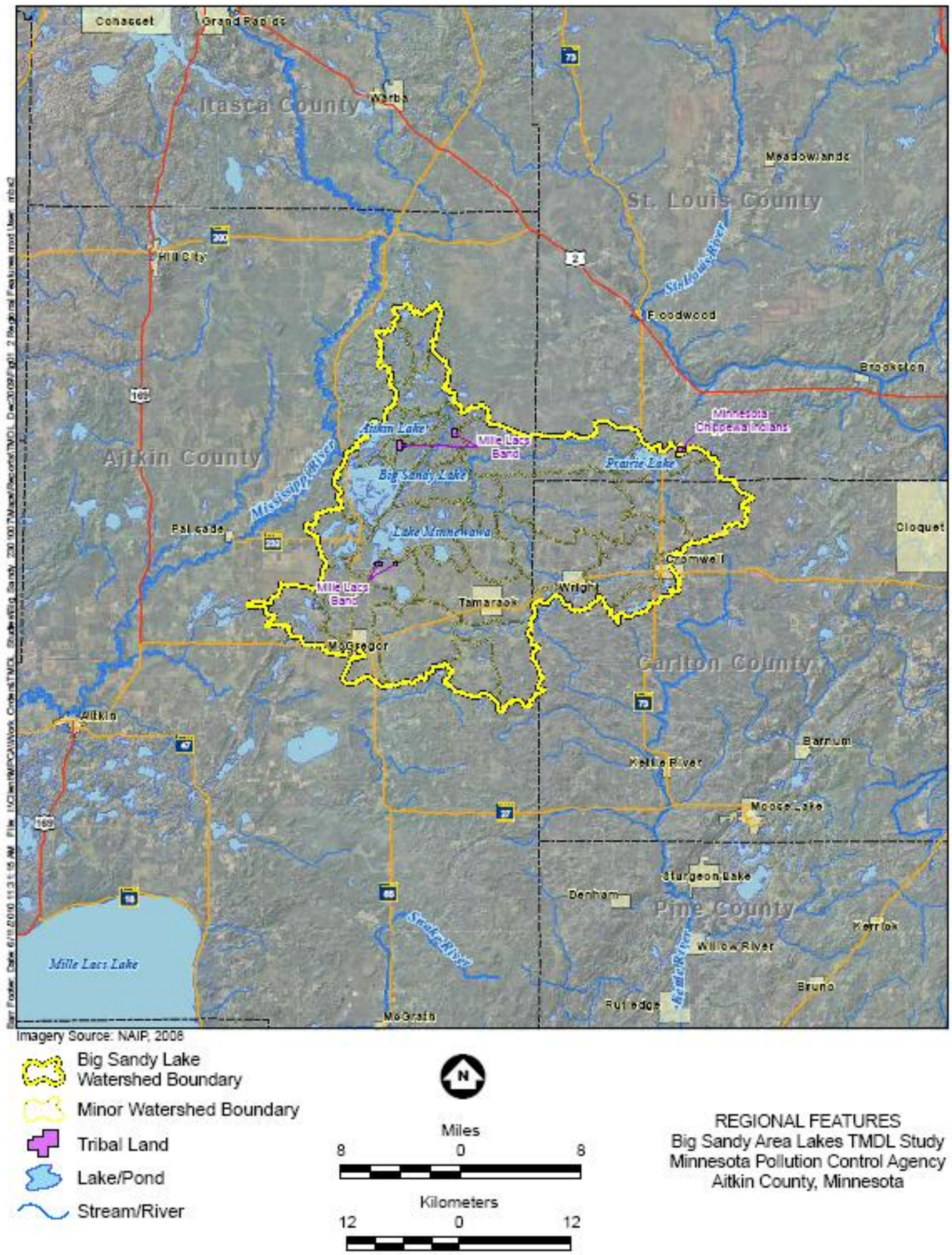
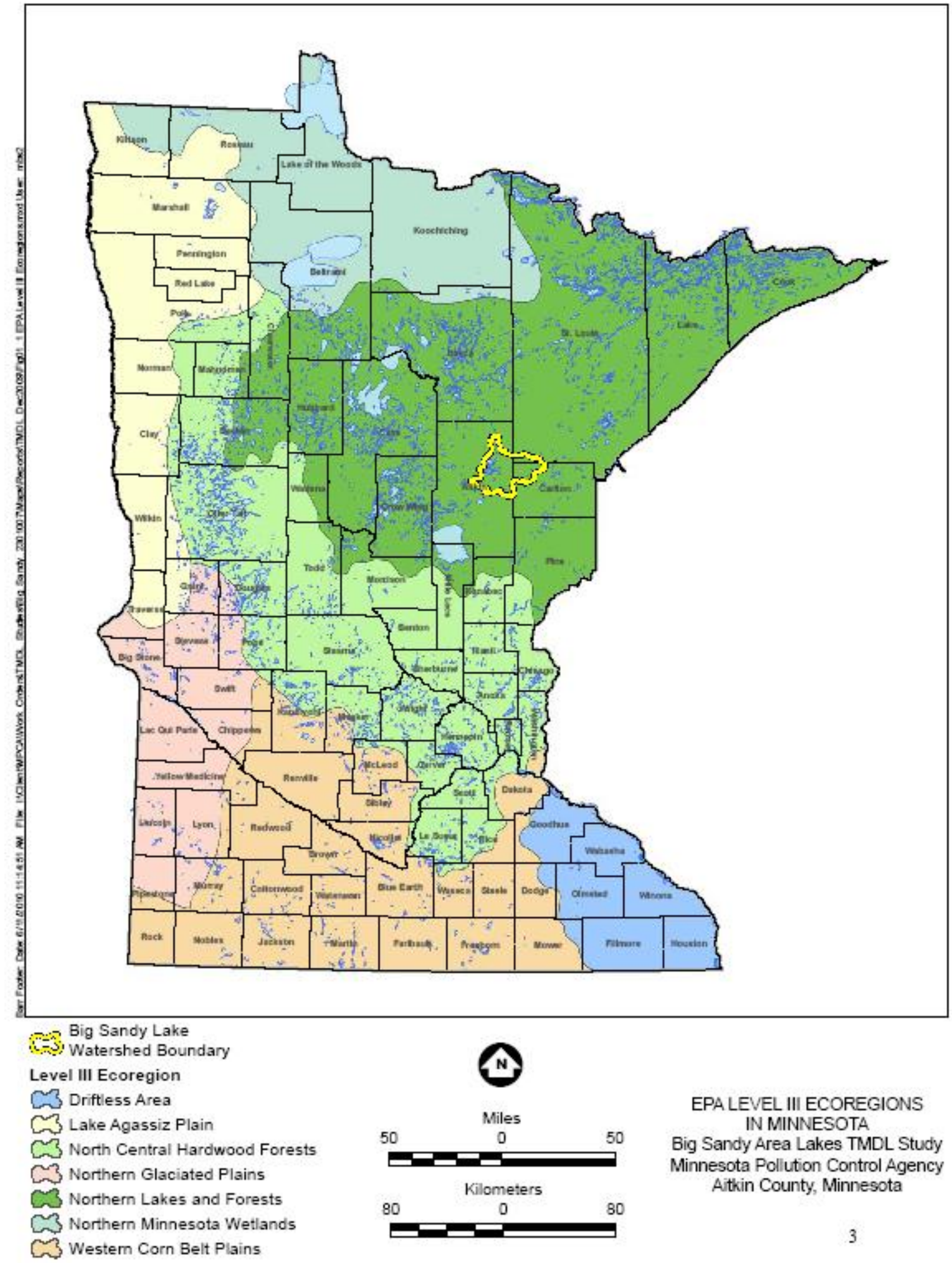


Figure 1-2 EPA Level III Ecoregions in Minnesota



2.0 General Characteristics and Water Quality Conditions

The following sections describe the general characteristics of Big Sandy Lake and Lake Minnewawa and their respective watershed, as well as water quality conditions in the lakes.

2.1 General Lake Characteristics

Big Sandy Lake is a reservoir system, with a large watershed (260,000 acres, or 406 square miles) and variable water flow that fluctuates from year to year. Big Sandy Lake was a natural lake system prior to construction of a dam at the lake outlet (1895) which was upgraded to its current design in 1911. The dam has raised the average water level approximately 9 feet above natural lake levels. Water levels in Big Sandy Lake are controlled by the U.S. Army Corps of Engineers through operation of the dam at the lake's outlet. Big Sandy Lake is approximately 6,526 acres in size, with a maximum depth of 84 feet. The littoral area (area with a depth of 15 feet or less) is approximately 3,085 acres. Big Sandy Lake can generally be divided into three sections: Webster's Bay, Bellhorn Bay, and Main Bay (Figure 2-1). Webster's Bay is the shallowest of the three sections, and receives flow from the Sandy River. Bellhorn Bay is the deepest section of the lake, and receives flow from the Prairie River. Main Bay has the greatest surface area of the three sections, but does not receive direct flow from any of the major rivers in the watershed. The outlet of Big Sandy Lake is via the Sandy River, in the northwest corner of Main Bay.

Lake Minnewawa is 2,355 acres in size, with a maximum depth of 21 feet (Figure 2-2). The majority of the lake (2,286 acres) is 15 feet deep or less.

Significant portions of the shorelines of Lake Minnewawa and Big Sandy Lake are developed with seasonal and year-round homes. Both lakes are popular recreational resources.

Figure 2-1 Big Sandy Lake Water Quality Monitoring Locations

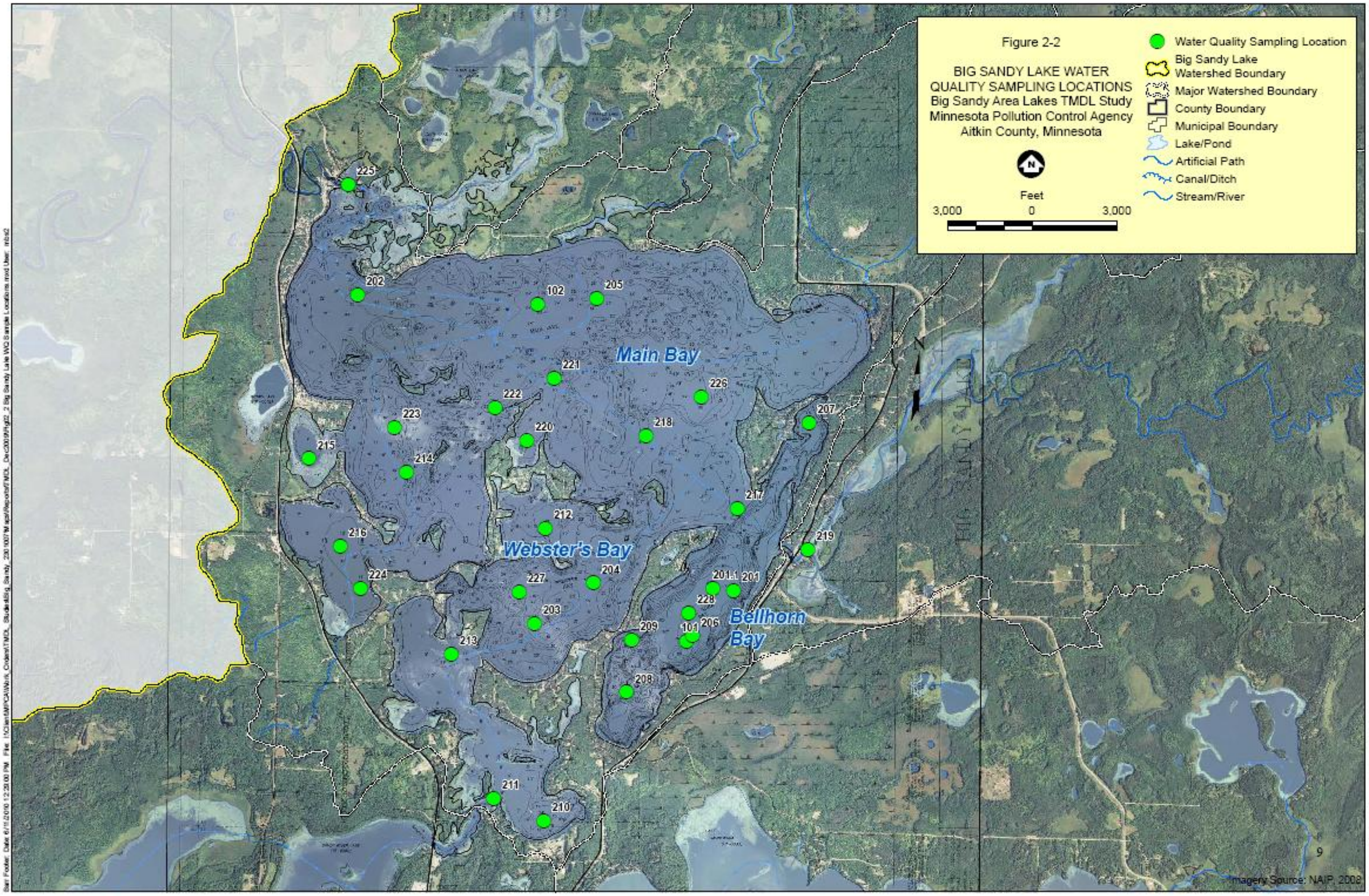
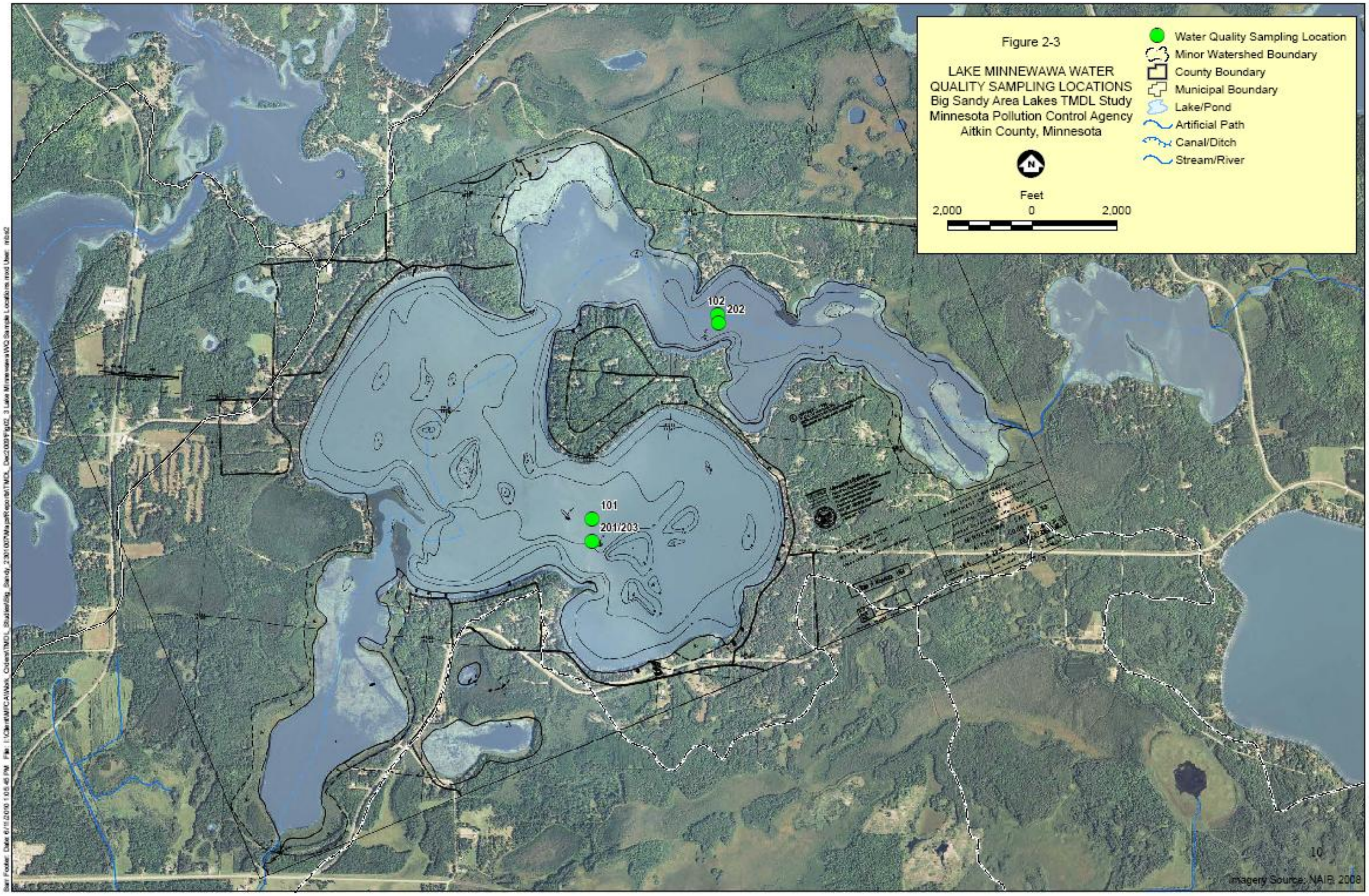


Figure 2-2 Lake Minnewawa Water Quality Monitoring Locations



2.2 General Watershed Characteristics

The 2001 National Land Cover Database (NLCD) was used to characterize current land use in the watershed. Land use in the watersheds of Big Sandy Lake and Lake Minnewawa is predominantly forest and wetlands (Figure 2-3). The land uses in the watersheds of each lake are summarized in the following sections.

2.2.1 Big Sandy Watershed

The Big Sandy watershed is approximately 260,000 acres (406 square miles) in size. Land use percentages of the Big Sandy Lake watershed, based on the 2001 National Land Cover Database (NLCD), are summarized as follows:

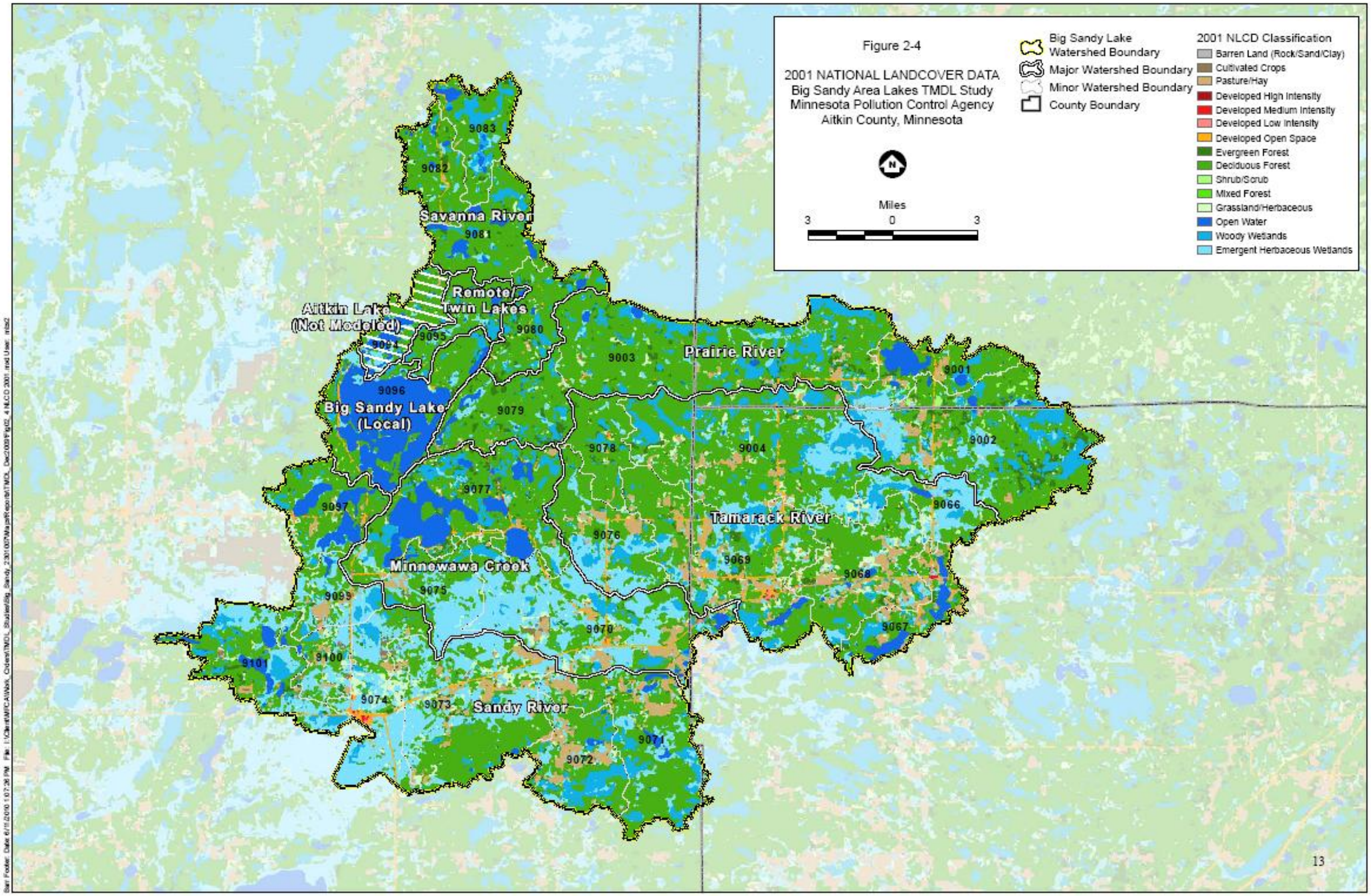
- 54% forest
- 29% wetland
- 5.7% pasture/hay/cultivated crops
- 4.3% grassland
- 4.1% open water
- 2.4% developed (low, medium, and high density)

In addition to land use changes from natural conditions, the Big Sandy watershed has been altered in other ways. Extensive ditching of wetlands in portions of the watershed has occurred as early as the early 1900s when an effort was made to establish increased farmlands (MN DNR Fisheries 2002). More recently, wetlands have been ditched and drained to allow for peat and wild rice farming. The ditches have likely affected the hydrology and nutrient transport dynamics of the watershed. A detailed discussion of potential water quality impacts is provided in MNDNR Fisheries (2002).

Four rivers constitute the majority of the Big Sandy watershed: Sandy River, Tamarack River, Prairie River, and West Savanna River. The Sandy River drains the southern portion of the Big Sandy watershed and drains into Webster's Bay, at the south end of the lake. The Sandy River flows through two smaller lakes (Flowage Lake and Sandy River Lake) immediately prior to entering Webster's Bay. The Sandy River also receives outflow from Minnewawa Lake, via Minnewawa Creek. Tamarack River and Prairie River originate in the eastern most regions of the Big Sandy watershed. West Savanna River originates in the northern most region of the Big Sandy watershed. The Tamarack and West Savanna Rivers combine with Prairie River, before Prairie River drains into Bellhorn Bay at the east end of

Big Sandy Lake. Big Sandy Lake also receives flow from two smaller watersheds to the north of the lake: the Twin/Remote Lakes watershed, and Aitkin Lake. The narrow stream channel connecting Aitkin Lake to Big Sandy Lake is in the northwest corner of Big Sandy Lake, and is immediately adjacent to the outflow of Big Sandy Lake. For this purposes of this study, it was assumed that flow from Aitkin Lake is immediately directed to the Big Sandy Lake outlet and does not contribute phosphorus loading to the main bay of Big Sandy Lake.

Figure 2-3 2001 National Land Cover Data



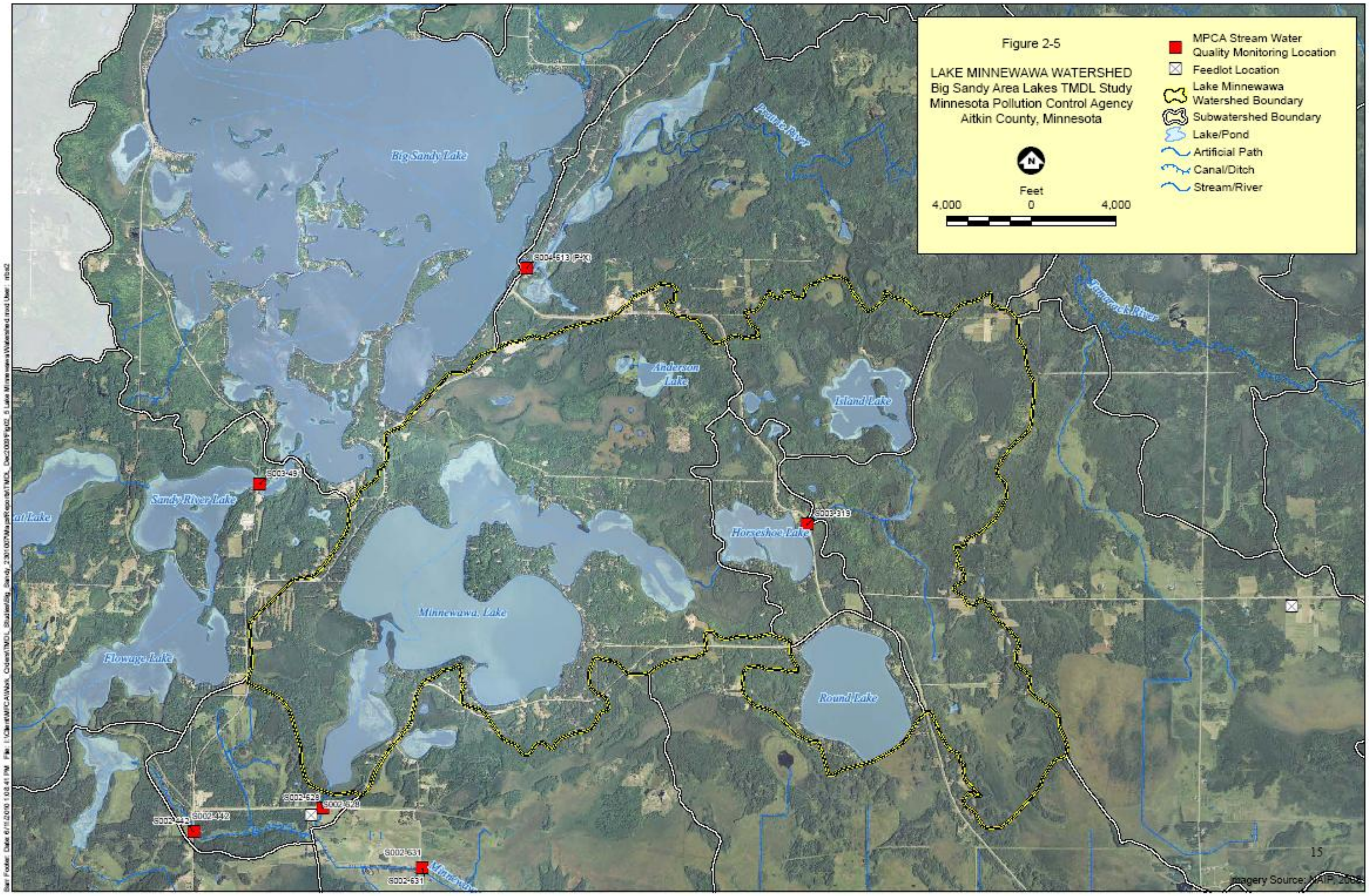
2.2.2 Lake Minnewawa Watershed

Lake Minnewawa has a much smaller watershed when compared to Big Sandy Lake. Lake Minnewawa receives flow from Horseshoe Lake to the east, as well as from the local watershed immediately surrounding the lake (Figure 2-4). The watershed for Lake Minnewawa is smaller than the extent of subwatershed “9077” shown in Figure 2-3, as the southwest corner of subwatershed “9077” does not contribute to Minnewawa Lake.

The Lake Minnewawa watershed is approximately 13,243 acres (20.7 square miles) in size. Land use percentages of the Lake Minnewawa watershed, based on the 2001 National Land Cover Database (NLCD), are summarized as follows:

- 51.4% forest
- 20.3% wetland
- 4.3% pasture/hay/cultivated crops
- 2.0% grassland
- 21.5% open water
- 0.5% developed (low, medium, and high density)

Figure 2-4 Lake Minnewawa Watershed



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2.3 Big Sandy Lake Water Quality

Current and historic water quality monitoring locations on Big Sandy Lake are presented in Figure 2-1. Summer (June-September) mean Secchi disc transparencies for Big Sandy Lake are below the NLF ecoregion standard of 2.0 meters for all three bays during the period of 1983-2008, with the exception of Bellhorn Bay in 1988 (Figure 2-5). Summer mean total phosphorus concentrations are presented in Figure 2-6. Summer average chlorophyll *a* concentrations are presented in Figure 2-7.

Big Sandy Lake is generally highly colored, with historic reading ranging from 100 to 300 Platinum-Cobalt Units (PCU). These color readings represent high concentrations of light-absorbing dissolved organic compounds that can severely reduce water transparency. Typical color readings for lakes in the NLF ecoregion are in the range of 10-35 PCU (MN DNR Fisheries 2002). Big Sandy has a large watershed with a high percentage of wetlands, including large areas of peatlands. The decaying organic matter in these wetlands and peatlands are a significant source of dissolved organic compounds, as evidenced by high color readings in the Sandy River and Prairie River.

2.4 Lake Minnewawa Water Quality

Current and historic water quality monitoring locations on Lake Minnewawa are presented in Figure 2-2. After several years of summer mean Secchi disc transparency below the water quality standard (1996-2003), summer mean Secchi disc transparencies have been variable in recent years (Figure 2-8). Total phosphorus data for Lake Minnewawa are limited, but summer mean concentrations are generally lower in recent years compared to the period 1979-1996 (Figure 2-9). Available chlorophyll *a* data are also limited (Figure 2-10), but mean summer concentration are generally lower in recent years compared to available data from the period 1989-1993. The results of the recent monitoring data indicate that there is improved water quality in Lake Minnewawa.

Figure 2-5 Big Sandy Summer Mean Secchi Disc Transparency

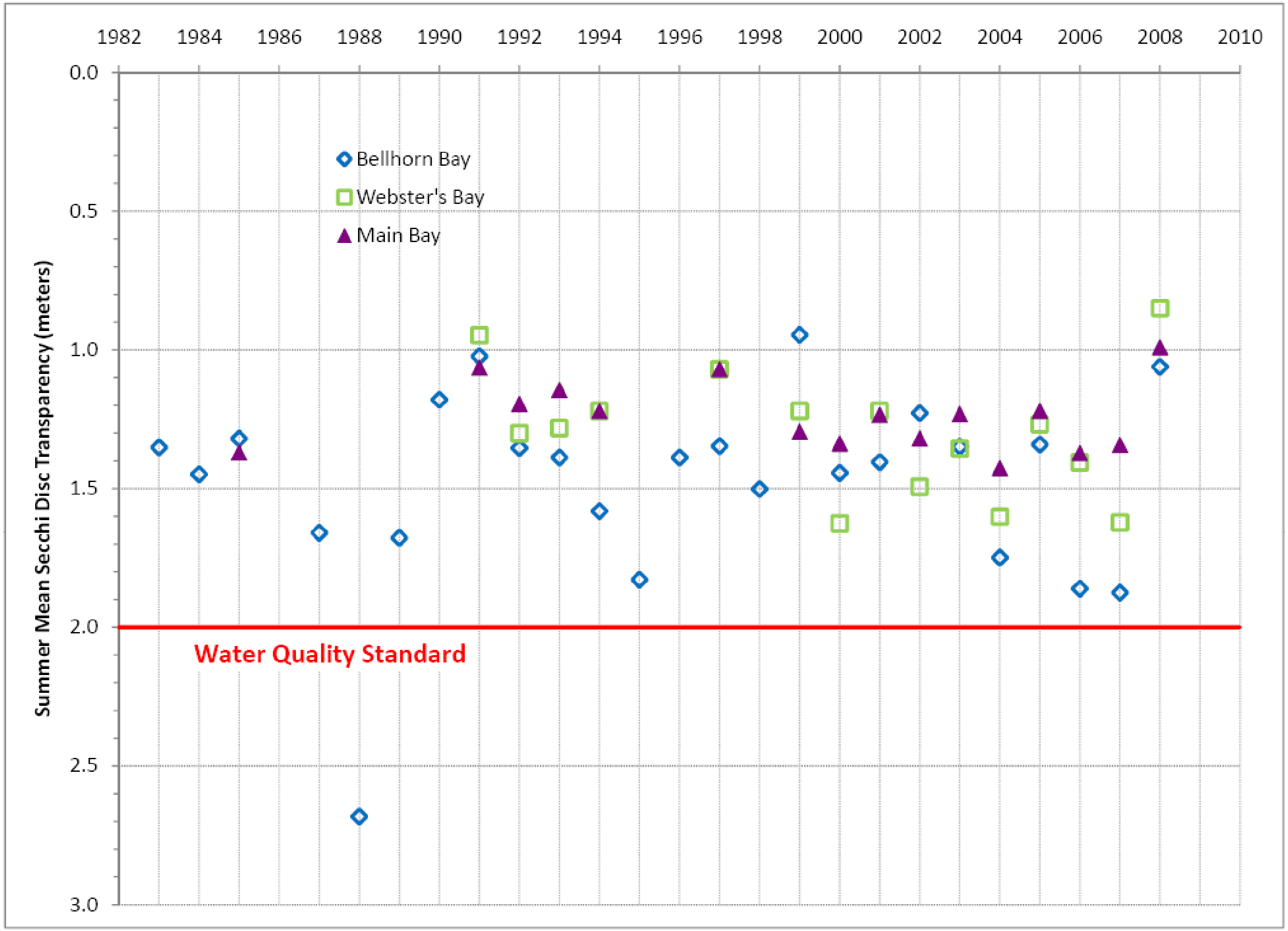


Figure 2-6 Big Sandy Lake Summer Mean Total Phosphorus

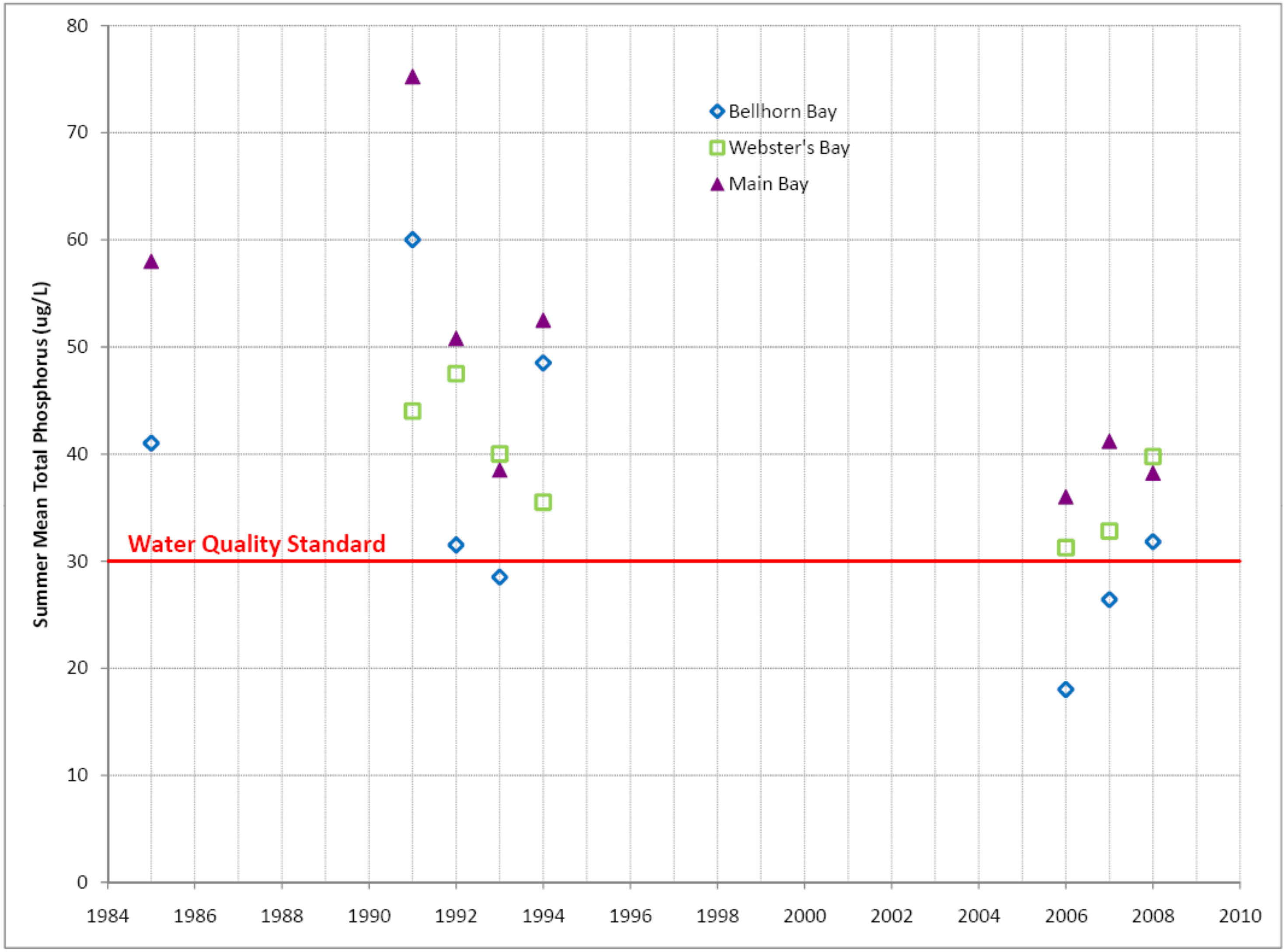


Figure 2-7 Big Sandy Lake Summer Mean Chlorophyll *a*

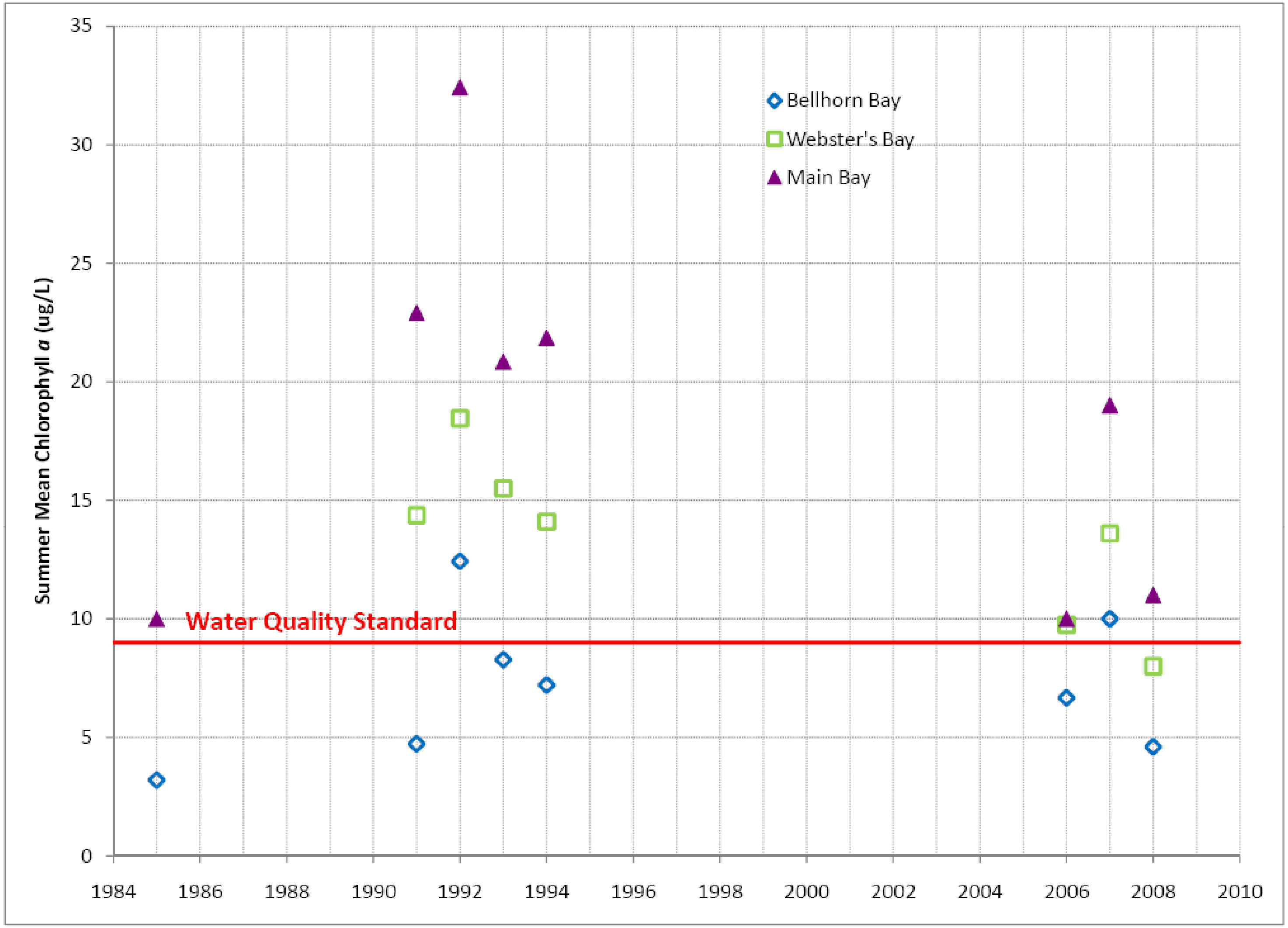


Figure 2-8 Lake Minnewawa Summer Mean Secchi Disc Transparency

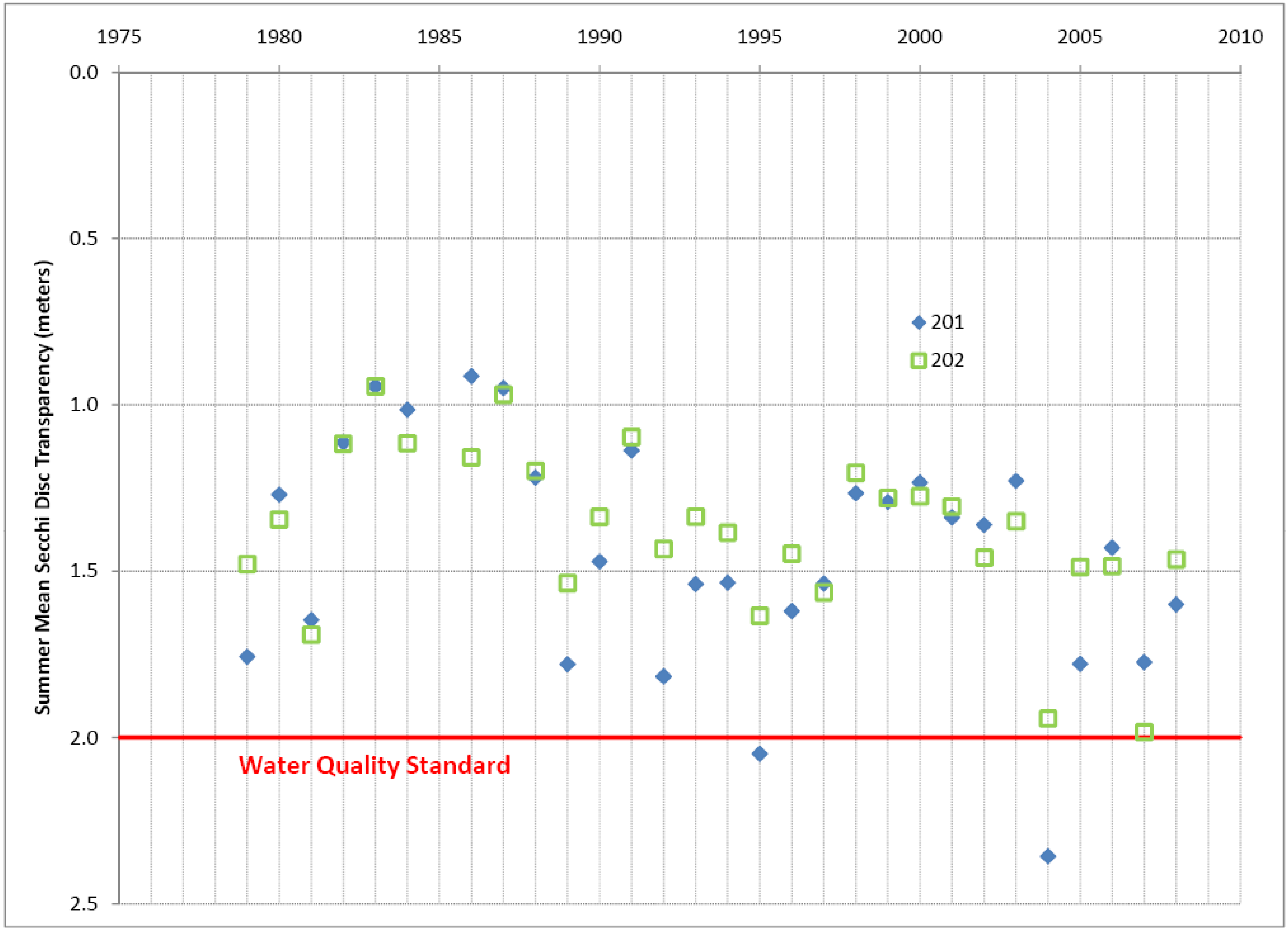


Figure 2-9 Lake Minnewawa Summer Mean Total Phosphorus

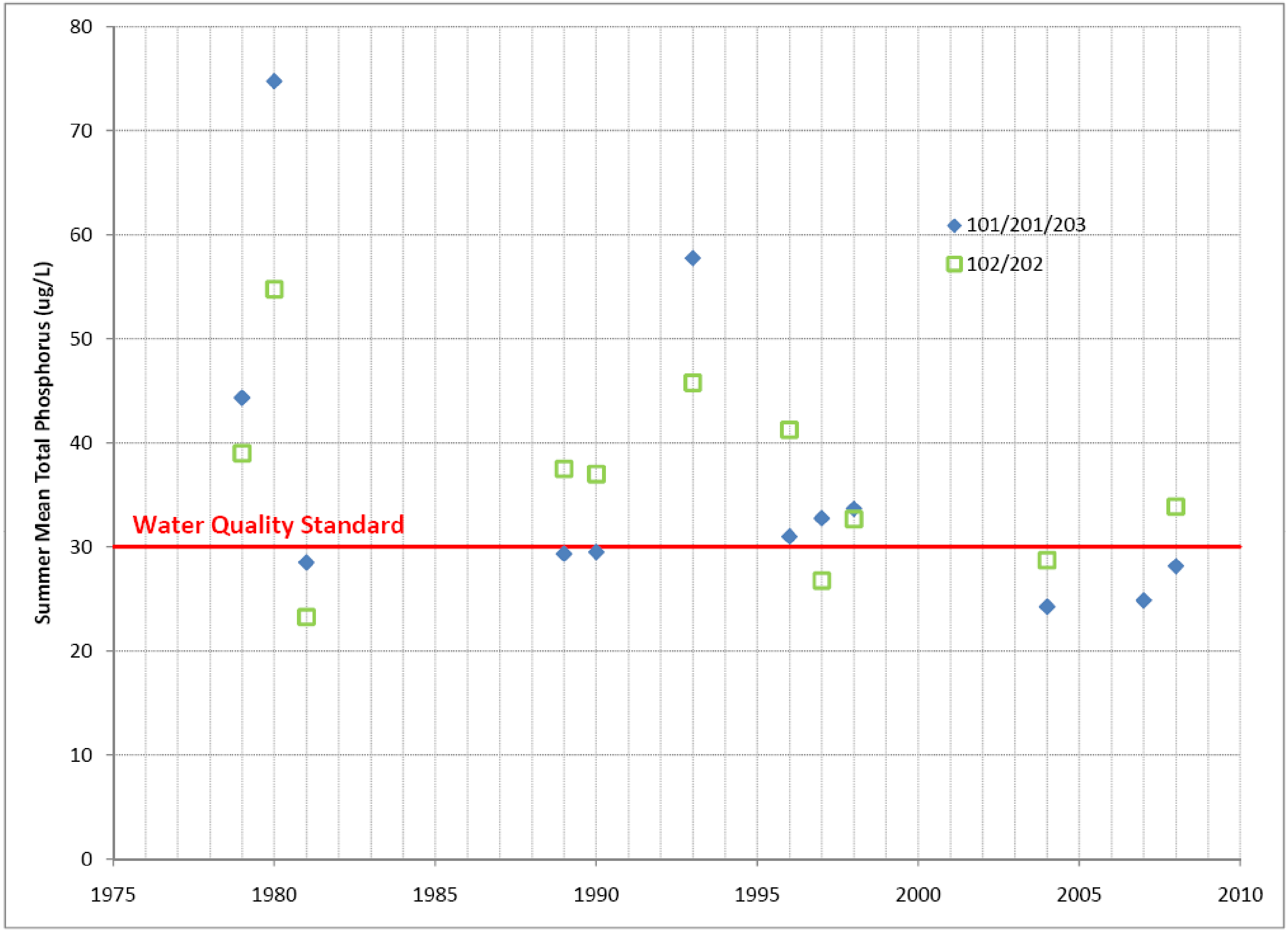
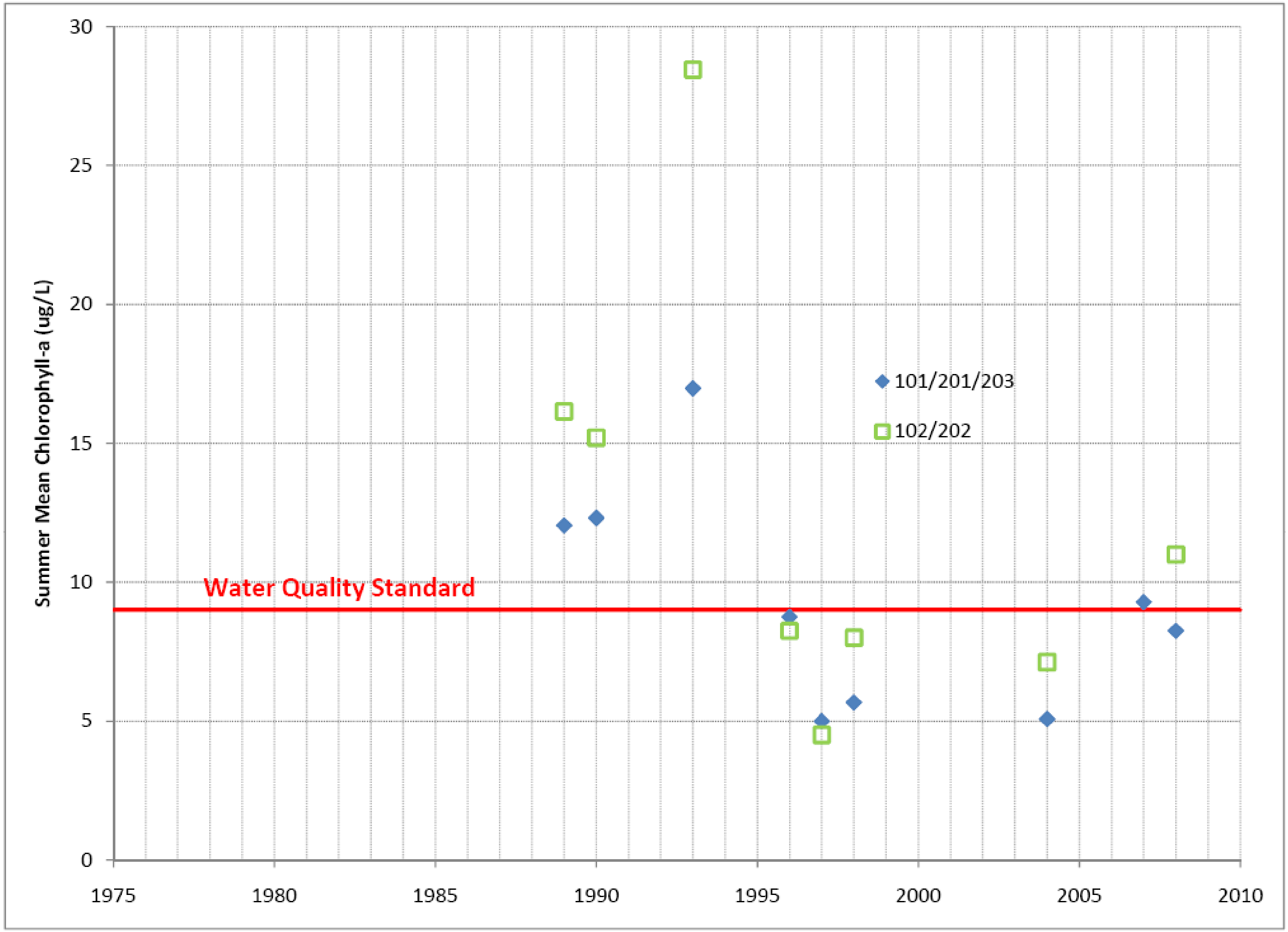


Figure 2-10 Lake Minnewawa Summer Mean Chlorophyll *a*



3.0 Summary of the TMDL Allocations

The TMDL equation is defined as follows:

TMDL = Wasteload

TMDL = Wasteload Allocation (WLA) + Load Allocation (LA) + Margin of Safety (MOS) + Reserve Capacity.

For Big Sandy Lake, the Load Capacity is 14,920 kilograms (kg) of total phosphorus (TP) per water year.

The TMDL equation used to derive this Load Capacity for Big Sandy Lake is:

Expressed as water year (October 1 through September 30) totals:

TMDL = 248 kg TP (WLA) + 13,852 kg TP (LA) + 746 kg TP (MOS) + 73 kg (Reserve Capacity) = 14,920 kg per water year

Expressed in daily terms (water year)

TMDL = 0.68 kg/d (WLA) + 38.0 kg/d (LA) + 2.0 kg/d (MOS) + 0.21 kg/d (Reserve Capacity) = 41 kg/d, on average

The Wasteload Allocation represents a 0% reduction in load to Big Sandy Lake. The Load Allocation represents a 32% total phosphorus reduction. This will be achieved through a 93% reduction of internal phosphorus load in Big Sandy Lake through management of sediment phosphorus loading. Loading from the tributary watershed will be reduced by 14% through best management practices (BMPs). To meet the overall load capacity of the lake, a 32% decrease in phosphorus load (based on 2008 existing conditions), will be required.

For Lake Minnewawa, the Load Capacity is 809 kg of total phosphorus (TP) per growing season.

The TMDL equation used to derive this Load Capacity for Lake Minnewawa is:

Expressed as water year (October 1 through September 30) totals:

TMDL = 0 kg TP (WLA) + 769 kg TP (LA) + 40 kg TP (MOS) + 0 kg (Reserve Capacity) = 809 kg per water year

Expressed in daily terms (water year)

TMDL = 0 kg/d (WLA) + 2.1 kg/d (LA) + 0.11 kg/d (MOS) + 0 kg (Reserve Capacity) = 2.2 kg/d, on average

Because there is no Wasteload Allocation, there is a 0% reduction in this load to Lake Minnewawa. The Load Allocation represents an 18% total phosphorus reduction. This will be achieved through a 23% reduction of loading from the tributary watershed through best management practices (BMPs). To meet the overall load capacity of the lake, a 14% decrease in phosphorus load (based on 2008 existing conditions), will be required.

The Margin of Safety for each lake is set at five percent (5%) of the overall loading capacity since extensive long-term monitoring for these lake watersheds greatly diminishes the level of uncertainty in setting the TMDL allocations. Reserve capacities have been included for Big Sandy to allow for a future wastewater treatment plant (WWTP) for the city of Wright, as well as conversion of existing subsurface sewage treatment systems (SSTS) to a WWTP system. No reserve capacity has been set for Lake Minnewawa since significant future development is not expected within the tributary watersheds.

3.1 Wasteload Allocations

Wasteload allocations were developed based on State discharge limits for each discharger. If no limits were set for phosphorus, a value of 1 mg/L total phosphorus was used in combination with the average flow capacity of the facility (as indicated in the permit) to calculate the annual permitted limit in kg/yr. The actual monitoring results for the 2008 water year are shown in Table 3-1.

Table 3-1 Phosphorus Loads From Monitored Permitted Dischargers, 10/1/07 – 9/30/08

Permitted Discharger	Phosphorus (kg/yr)	Flow (ac-ft)	Permitted			Tributary Watershed
			Flow (mgd)	TP Limit (mg/L)	TP Load (kg/y)	
McGregor WWTP	232	76	0.0729	1*	101*	Sandy River
Tamarack WWTP	33	4	0.007	3.5	34	Sandy River
AgriPeat	10	66	--	1	22	Sandy River
Cromwell WWTP	42	27	0.052	1	71.8*	Prairie River

Premier Horticulture	40**	181**	.017	1*	110***	Prairie River
Total	357	353	NA	NA	339	

* Permit limits estimated using 1 mg/L discharge limit
**Values are estimated due to erroneous DMR reports for 2008
*** Value estimate of average yearly load for period of 2005-2009

3.2 Load Allocations

The load allocations for Big Sandy Lake and Lake Minnewawa are attributable to the internal, atmospheric, and non-point source (watershed) loads of phosphorus to each lake. Load allocations were set so that each lake met the total phosphorus criterion of 30 µg/L for the NLF Ecoregion. The results for the 2008 water year were used to determine the daily load and wasteload allocations of phosphorus for each lake (shown in Tables 3-2 and 3-3).

Phosphorus load reductions to Big Sandy Lake and Lake Minnewawa will be achieved by targeting multiple nonpoint sources. The following summarizes phosphorus reductions that will be targeted in the watershed:

- 1% reduction from forested lands;
- 25% reduction from agriculture/pasture/hay field land use areas;
- 25% reduction from streambank erosion;
- 50% reduction from developed land use areas;
- 93% reduction from wild rice farms (based on assumed conversion to non-agricultural land use). This load reduction percentage represents a high estimate of what may be attainable based on a conservatively high assumption of what has been discharged in the past.
- Full conformance for all SSTS adjacent to both lakes;

- Significant reduction of internal loading from lake sediment in Big Sandy Lake (representing most of the internal loading above the implicit load already included in the empirical lake water quality modeling).

The load and wasteload allocations for Big Sandy Lake and Lake Minnewawa are detailed in Tables 3-2 and 3-3, respectively.

Table 3-2 Big Sandy Lake Total Phosphorus Wasteload and Load Allocations

Watershed TP Sources	Existing TP Load (kg)	TMDL Wasteload Allocation (WLA) (kg)	Daily TMDL Wasteload Allocation (WLA) (kg/day)	Percent Reduction of Existing TP Load (Percent)
Permitted Discharges	248	248	0.68	0
Total Wasteload Sources	**248**	**248**	**0.68**	**0**
Internal and Nonpoint Sources	**Existing TP Load (kg)**	**TMDL Load Allocation (LA) (kg)**	**TMDL Load Allocation (LA) (kg/day)**	**Percent Reduction of Existing TP Load (Percent)**
Internal Sources	4,709	330	0.90	93
Non-point watershed sources				
Wild Rice	748	52	0.14	93
Agriculture	2,153	1,615	4.4	25
Forest	5,615	5,559	15	1
Developed	1,100	640	1.8	42
Open Water/Wetlands	4,124	4,124	11	0
Stream channel erosion	1,452	1,089	3.0	25
Atmospheric Sources	443	443	1.2	0
Total Load Sources	**20,344**	**13,852**	**38**	**32**
Transfer of SSTSs to WWTPs Reserve Capacity (RC)	0	31	**0.09**	0
City of Wright WWTP Reserve Capacity (RC)	0	42	**0.12**	0
Margin of Safety (MOS)	**0**	**746**	**2.0**	**0**
Overall Source Total	**20,592**	**14,920**	**41**	**28**

Table 3-3 Lake Minnewawa Total Phosphorus Wasteload and Load Allocations

Watershed TP Sources	Existing TP Load (kg)	TMDL Wasteload Allocation (WLA) (kg)	Daily TMDL Wasteload Allocation (WLA) (kg/day)	Percent Reduction of Existing TP Load (Percent)
Permitted Dischargers	0	0	0	0
Total Wasteload Sources	**0**	**0**	**0**	**0**
Internal and Nonpoint Sources	**Existing TP Load (kg)**	**TMDL Load Allocation (LA) (kg)**	**TMDL Load Allocation (LA) (kg/day)**	**Percent Reduction of Existing TP Load (Percent)**
Internal Sources	0	0	0	0
Non-point watershed sources				
Agriculture	57	43	0.12	25
Forest	214	212	0.58	1
Developed	344	187	0.51	46
Open Water/Wetlands	149	149	0.41	0
Atmospheric Sources	178	178	0.49	0
Total Load Sources	**942**	**769**	**2.1**	**18**
Margin of Safety (MOS)	**0**	**40**	**0.11**	**0**
Overall Source Total	**942**	**809**	**2.2**	**14**

4.0 Monitoring Plan to Track TMDL Effectiveness

The water quality of Big Sandy and Minnewawa Lakes has been monitored in some capacity for the past three decades and will continue to be monitored for the foreseeable future. A watershed program is also in place with different types of ongoing monitoring in different areas of the watershed being conducted. It will also be important to monitor the long-term effectiveness of any water quality improvement projects being constructed in the Big Sandy or Minnewawa Lake watersheds. Various agencies working within the watershed will cooperate to coordinate the ongoing monitoring. Measurements should be collected at a frequency of once every two weeks during the period of May through September. At a minimum, all of the following parameters, except Secchi disc, color, DOC, and chlorophyll *a*, should be measured at multiple depths in the water column (every 1 to 2 meters) of each lake:

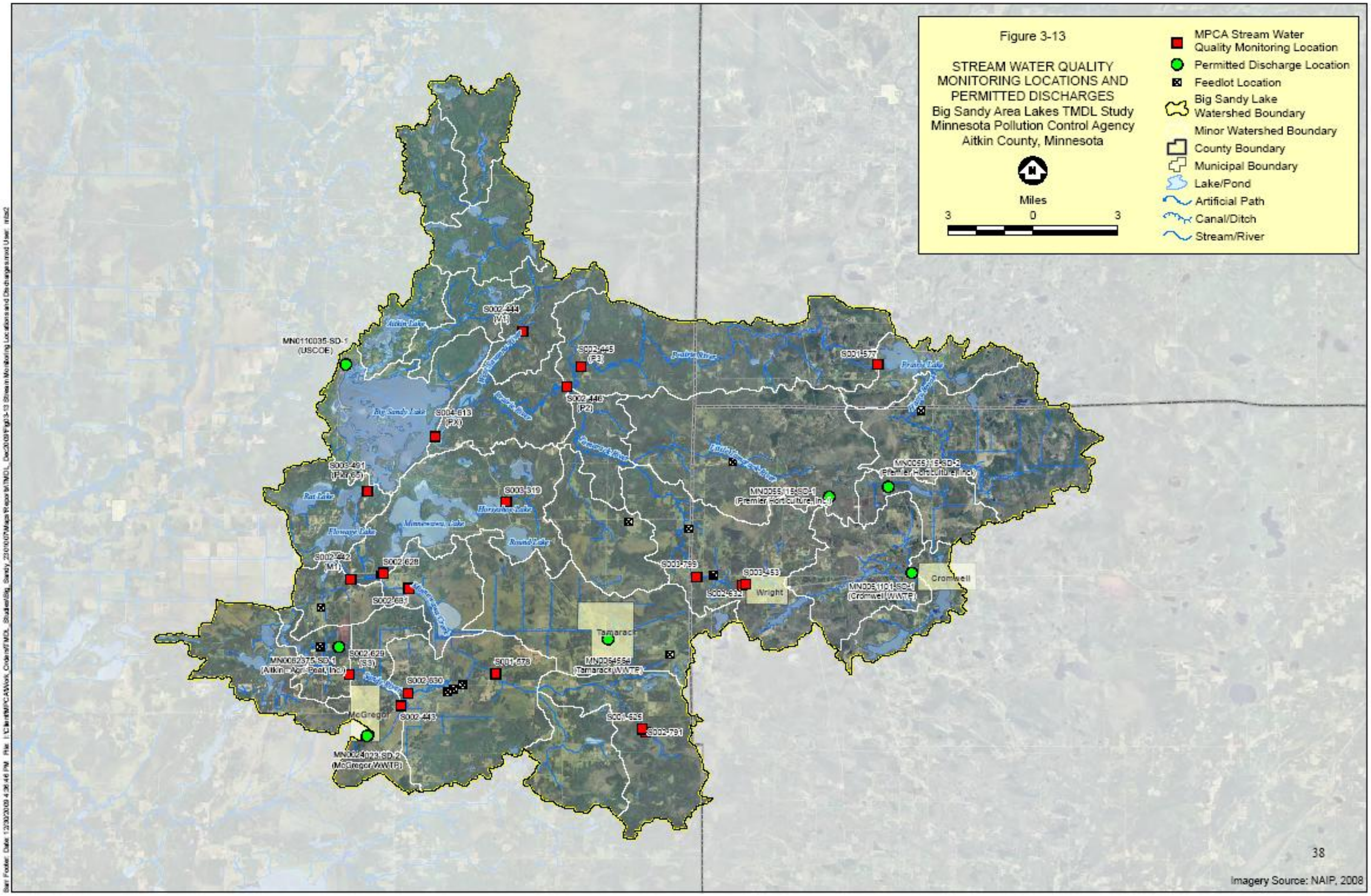
- Secchi disc
- Dissolved Oxygen
- Temperature
- Total Phosphorus
- Dissolved Phosphorus
- Chlorophyll *a*
- Color
- Dissolved Organic Carbon (DOC)
- pH
- Turbidity

Watershed monitoring should continue at a frequency of once every two weeks for the period of April through November. Stream water quality monitoring locations are identified on 4-1. The following parameters should be collected from the watershed monitoring locations:

- Total Phosphorus
- Dissolved Phosphorus
- Color
- Dissolved Organic Carbon (DOC)
- pH

- Total Suspended Solids
- Turbidity
- Flow

Figure 4-1 Stream Water Quality Monitoring Locations and Permitted Dischargers



4.1 Additions to Current Monitoring Program

An additional monitoring site will be added to the current program that focuses on determining the impact of peat wetland systems on nutrient export and delivery to downstream surface waters, and whether ditching of these systems increases phosphorus export. A location that contains a high percentage of peat wetlands, but is minimally impacted by other factors (e.g. development, agriculture, etc.), should be selected and monitored for the same parameters listed above for the other watershed monitoring sites.

Color and DOC have been added to the monitoring plan to help determine the impact nutrient mobilization from peat wetlands may have on water quality in both lakes. Climactic conditions and changes in hydrology can substantially affect nutrient and organic matter export from peat wetlands, causing varying color and DOC in surface waters. Measuring color and DOC, along with the traditional nutrient related parameters listed and the additional monitoring site described above, will help determine the impact peat wetlands have on water quality in Big Sandy Lake, and to a lesser extent Lake Minnewawa.

Comprehensive phytoplankton, zooplankton, macrophyte, and fisheries surveys should be conducted in both lake basins during at least one of the years when surface water quality monitoring occurs.

5.0 TMDL Implementation Strategies & Framework

The following sections summarize implementation strategies that will be adopted in order to achieve the reductions in phosphorus loading necessary to reach water quality targets in Big Sandy Lake and Lake Minnewawa. Overall, the implementation strategy will be adaptive. Implementation strategies will be reevaluated and updated as new data becomes available. Consideration will be given on how implementation of upstream phosphorus reduction strategies may affect downstream phosphorus sources (e.g. reductions in external loading may lead to a reduction in internal phosphorus in the long term). It is anticipated that it will take more than 20 years to implement all of the projects required to achieve the annual load reduction. The cost estimate for implementing this TMDL is conservatively set at just over $ 3 million, but may reach as high as $ 50 million.

Through the discussion of policies and practices, current activities, and ongoing research, project stakeholders have developed and will continue to refine, principles to guide the implementation of the load reduction plan. Strategies will be adjusted to ensure that activities are being focused where the greatest improvement may be made, while utilizing available funding judiciously. Practices will be designed to implement a well rounded, comprehensive approach to meeting the water quality standards.

5.1 Annual Load Reductions

The TMDL implementation plan focuses on reducing external sources of phosphorus to the watershed with additional work to better estimate internal sources of phosphorus loading. Annual overall reductions of 5,672 kg (28 %) and 133 kg (14%) in phosphorus loading in Big Sandy Lake and Lake Minnewawa, respectively, are required to meet the total phosphorus growing-season average of 30 µg/L in Big Sandy and Minnewawa Lakes. Load-reduction projects will be implemented following a priority ranking system for the available nutrient reduction strategies.

5.2 Sector-Specific Strategies

The following section provides detailed implementation strategies associated with each of the significant phosphorus loading sources within the Big Sandy and Minnewawa Lake watersheds. Strategies for reaching the nutrient reduction goals for Big Sandy and Minnewawa Lakes have been grouped into three key work elements: Watershed Activities, In-Lake Activities, and Education Activities. These elements are broken into specific action items.

5.2.1 Watershed Activities

One of the most important long term efforts of this project is to provide practical ways to prevent pollution by the use of Best Management Practices (BMPs). Demonstration projects and implementation of BMPs throughout the watershed will serve to reduce the pollutant load. Projects will include Runoff Management BMPs, Lakeshore Erosion Management Projects, Sewage Treatment / Septic System Management, Planning and Zoning Controls, Stream Channel Erosion Control, and Ditch System Monitoring & Maintenance. Proper Operation and Maintenance Plans for the installed BMPs are critical to their success. These practices will provide examples of a variety of proper land management strategies throughout the watershed.

1). Treatment of Stormwater Sources / Runoff Management : Unmanaged stormwater can have devastating consequences on water quality. Reductions in nutrient loading will be made through controlling runoff from residential sites – especially those in shoreland areas throughout the watershed. Low-impact design principles can be incorporated into new designs as well as plans for redevelopment or expansion. Where it is not feasible or cost-effective to improve the existing developed hydrology and pollutant loadings, government entities will pursue other options for providing regional management of stormwater runoff.

Practices including rain gardens, rain barrels, pervious pavers, sediment basins, and stormwater diversions will be supported.

Implementation Priority: High
Estimated Cost: $ 10,000/yr x 20 yrs = $ 200,000
Responsible Parties: BSALWMP, SWCDs, Lake Associations
Timeline: Ongoing

2). Lakeshore Erosion Management: Control of lakeshore soil erosion throughout the watershed will be implemented to reduce nutrient loading. Big Sandy Lake is operated as a reservoir. As such, the water level is subject to fluctuations which can enhance shoreline erosion. The first step will be an assessment and inventory of eroding sites (a portion of this will be a follow up review of sites previously identified as eroding). Stabilization methods such as vegetative buffers, rock rip rap, and various stabilization products will be employed as dictated by the needs of the site.

Implementation Priority: High
Estimated Cost: Shoreline Assessments $ 2,000
$ 10,000/yr x 20 yrs = $ 200,000
Total = $ 202,000
Responsible Parties: BSALWMP, SWCDs, Lake Associations
Timeline: Ongoing, with Assessments in year 1 and 2

3). Sewage Treatment/ Septic System Management / Water Usage: Sewage treatment facilities (both community and individual systems), should be maintained and operating at their peak performance in order to safeguard human health and water quality. State and local governments should promote and facilitate regionalization of wastewater treatment systems. Options for regionalization must be fully explored and comprehensive sewage management plans developed for areas throughout the watershed where existing sewage treatment practices such as septic fields and holding tanks are releasing excessive nutrients. Nutrient reduction strategies for larger facilities, such as biological nutrient removal, chemical treatment, effluent irrigation, constructed wetlands, and other proven technologies need to be evaluated for their effectiveness and practicality. Point of sale inspections and upgrades will continue to be supported. State and/or local governments will explore funding options to recover the costs of conducting an ongoing comprehensive septic field inspection program and maintaining a septic field database. Water conservation measures must be implemented whenever possible.

Implementation Priority: High
Estimated Cost: $ 30,000

Responsible Parties: Aitkin County, Cities of Cromwell, Tamarack, and McGregor
Timeline: Ongoing

4). Environmental Planning for Urban, Rural and/or Seasonal Development: All new development, redevelopment, industrial, and construction projects should be designed to maintain or improve existing developed hydrology and pollutant loading and fully comply with the local watershed and government authorities, NPDES, and anti-degradation requirements. The state and local governments have established and will enforce regulations, such as minimum set-back distances from shorelines for new developments, to prevent significant disturbances which would result in increased erosion along lakes and waterways.

Low Impact development concepts will be considered in future land use planning. Support of Planning and Zoning efforts and enforcement of zoning ordinances is important. Establishment of conservation easements on high priority sites is an acceptable method for managing development.

Implementation Priority: Moderate
Estimated Cost: $ 35,000/yr x 20 yrs = $ 700,000
Responsible Parties: Aitkin County, Carlton County, St. Louis County
Timeline: Ongoing

5). Stream Channel Erosion Control: Opportunities for correcting existing stream channel erosion sources will be investigated. Appropriate stabilization methods will be implemented, as dictated by the requirements of each site. Assessments of all-terrain vehicle (ATV) traffic as a source of erosion should be conducted to determine the potential water quality and biotic habitat impacts to the watershed.

Implementation Priority: Moderate
Estimated Cost: $ 10,000/yr x 20 yrs = $ 200,000
Responsible Parties: BSALWMP, SWCDs
Timeline: Ongoing

6). Ditch System Monitoring / Maintenance: Judicial, private and roadside ditch cleaning has the potential to contribute significant nutrient loadings and exacerbate stream channel erosion due to leaching from dredge spoils and increased discharge rates and erosion of channel material. An assessment of current and planned ditch cleaning activities by each jurisdiction in the watershed, along with a review of their best management practices, should be completed and evaluated for structural and non-structural improvements and/or potential solutions for conflicts with jurisdictional requirements. Control of beaver problems, which affect the functionality of the ditch system, should also be undertaken. A sediment fingerprinting study is recommended to determine the major sources of sediment loading to the lakes. Stream bank erosion and sediment and nutrient loading due to ditching or other changes in hydrology can be quantified using this process. This could be followed with an in-field evaluation of the rivers and ditches, in order to prioritize the stream reaches and drainage ditches for stabilization. This would be based on apparent sediment loading and likely cost to stabilize the system.

Implementation Priority: Low

Estimated Cost: Inventory project / Sediment Study = $ 22,000

$ 2,500/yr x 20 yrs = $ 52,000

Total Estimated Cost = $ 74,000

Responsible Parties: SWCDs, Counties, Townships

Timeline: Inventory in years 1 and 2, ongoing

7). Agricultural BMPs and Management: Agricultural activities in the watershed have declined in recent years. Agricultural BMPs should be applied in all appropriate situations. Efforts should be directed at keeping existing farms in production, while providing them the tools producers need to make wise landuse decisions. Priority management activities include retention basins, grassed buffer strips, constructed wetlands, livestock exclusion fencing, and rotational grazing systems. Livestock producers will be encouraged through enhanced incentives, education, and (when required) regulations to implement measures to protect riparian areas and waterways, such as managing livestock access in riparian areas and providing off-site watering structures. Other generally recommended nutrient-reduction features may be implemented as appropriate.

Additional strategies that promote and support annual soil testing will be developed to provide producers with the tools necessary to make sound agronomic, economic, and environmental decisions. Incentives for producers conducting soil testing and manure testing will be considered.

The wild rice farm north of McGregor has been identified as a potential source of phosphorus load to Big Sandy Lake. Efforts will be taken to ensure management appropriate to minimize phosphorus export and manage short term and long term drainage. It should be noted that this is a significant reduction to the contribution from wild rice farms, not to the overall problem input to Big Sandy Lake.

Implementation Priority: Low

Estimated Cost: $ 3,000/yr x 20 yrs = $ 60,000

Responsible Parties: SWCDs, NRCS

Timeline: Ongoing

8). Silviculture: Silviculture/forest management operations should implement BMPs that are appropriate for each site and process based on the recommendations in *Water Quality and Forest Management: Best Management Practices in Minnesota* or other state approved forestry BMP guidebooks. Forest Stewardship Plans for private landowners will be encouraged. Although phosphorus export per acre is relatively small, the total acreage of forested lands within this watershed is large.

Implementation Priority: Low

Estimated Cost: $ 1,000/yr x 20 yrs = $ 20,000

Responsible Parties: SWCDs, Counties, NRCS, DNR

Timeline: Ongoing

9). Turf Farms / Golf Course Nutrient Management Plans: Additional strategies that promote and support annual soil testing should be developed to provide landowners / operators with the tools necessary to make sound agronomic, economic, and/or environmental decisions. Incentives for conducting soil testing should be considered. In addition to soil fertility testing, other BMPs should be implemented to minimize water usage and treat surface water discharge from each site.

Implementation Priority: Low

Estimated Cost: $ 500/yr x 20 yrs = $ 10,000

Responsible Parties: SWCDs, Counties

Timeline: Ongoing

5.2.2 In-Lake Activities

Internal nutrient loads on Big Sandy Lake will need to be reduced to meet the TMDL load allocations. There are numerous options for reducing internal nutrient loads, ranging from simple chemical inactivation of sediment phosphorus to complex infrastructure techniques including hypolimnetic aeration.

1). Internal Load Reduction Feasibility Study: Internal load reduction will be investigated as a means to reduce phosphorus levels in Big Sandy Lake. Internal loading is a substantial portion of the total phosphorus load to Big Sandy Lake. In addition, phosphorus released from the sediment is in the dissolved form readily available for uptake by algae, whereas external phosphorus loads generally contain both dissolved and particulate phosphorus. A lake-wide feasibility study should be completed to evaluate the cost and feasibility of the lake management techniques available to reduce or eliminate internal loading in each basin of Big Sandy Lake. Several options need to be considered to manage internal sources of nutrients including chemical treatment such as alum, vegetation management, and aeration. Reductions in external loading of phosphorus can lead to a long term reduction of internal loading in Big Sandy Lake. Therefore internal loading should be reevaluated periodically as part of the overall adaptive management strategy. Collection and analysis of sediment samples for phosphorus release potential is recommended in 10 year intervals. Additionally, the longevity of internal load reduction technologies is increased substantially if external loads are reduced.

Implementation Priority: Moderate

Estimated Cost: $ 30,000

Responsible Parties: BSLA, Aitkin SWCD, DNR

Timeline: Years 1 and 2

2). Implement Recommendations of Feasibility Study: Once the feasibility studies for internal load reductions are completed, and preferred alternatives identified, the selected techniques will be implemented. Costs associated with each alternative vary, however each option would require some engineering in addition to the capital costs

Implementation Priority: Moderate

Estimated Cost: Approximately $ 1,000 per treated acre, depending on the results of the feasibility study = $ 500,000

Responsible Parties: BSLA, Aitkin County SWCD, Minnesota DNR

Timeline: Years 3, 4, and 5

3). Develop and Implement Lake Management Plans : Lake Management Plans have been developed for several watershed lakes. Additional lakes throughout the watershed would benefit from developing Lake Management Plans which identify goals and prioritize restoration / protection efforts. Implementation of these plans is an important step in meeting beneficial use goals for the lakes.

Implementation Priority: Moderate

Estimated Cost: $ 5,000/yr x 20 yrs = $ 100,000

Responsible Parties: Lake Associations

Timeline: Ongoing

4). Mississippi River Backflow Study: Periodic backflow from the Mississippi River has significant potential to affect the water quality in Big Sandy Lake, especially on a short-term basis. A review of outlet management protocol(s) should be conducted to evaluate whether the system could be managed in a way that would reduce the frequency and minimize the potential magnitude of water quality impacts associated with Mississippi River backflow events. Collection of flow and water quality/chemistry data at the outlet and the main basin of Big Sandy Lake during these events should be undertaken.

Implementation Priority: Low

Estimated Cost: $ 30,000

Responsible Parties: BSALWMP, BSLA, Aitkin SWCD, USACOE

Timeline: Years 1 and 2, then event based

5.2.3 Education Activities

Restoration of Big Sandy and Minnewawa Lakes requires participation from all stakeholders in the watershed, as well as lake users. Education and outreach activities will be a key component in successfully achieving the implementation goals. Behavioral changes are one of the most cost effective efforts in improving water quality. A wide variety of education efforts will be used to provide watershed landowners with the tools they need to make wise landuse decisions. An extensive and innovative public education program will be developed to inform watershed residents of the issues facing each lake and their roles in addressing these issues and to engage them in taking action. The following actions will be undertaken: Watershed Newsletters and News Releases; Public Meetings/Seminars Targeting Critical Groups, such as lake associations, county boards, and others; Support of Youth Education Activities; and Support of and Participation in information fairs/community events. The public education program will promote a community-to-community awareness and clearly identify the contributions that all communities, such as urban dwellers, waterfront property owners, agricultural producers, and industry must make to reduce nutrient loading. The educational program will integrate public relations advertising, marketing, civic engagement, public involvement, technical assistance, and training to optimize nutrient reductions from all phosphorus loading sectors within the overall watershed.

1). Watershed Newsletters / News Releases: Printed materials will be developed and distributed to reach all landowners in the Big Sandy/Minnewawa Lakes Watershed. Both watershed wide newsletters and lake association newsletters will be supported. Local newspapers will be used to distribute information through periodic news releases. Information fliers will be either developed and printed, or purchased. These materials will be used to inform landowners about BMPs for water quality, and available funding programs for implementation of BMPs.

Implementation Priority: High
Estimated Cost: $ 7,000/yr annual newsletter x 20 yrs
$ 4,000/yr Lk Assns & other print x 20 yrs = total = $ 220,000
Responsible Parties: BSALWMP, Lake Assns , Aitkin SWCD
Timeline: Ongoing

2). Public Meetings / Seminars: Education targeting critical groups such as county boards, lake association, sportsman's clubs, local civic groups, agricultural producers, and more, has been identified as a priority. Educating these groups about water quality issues and BMPs helps to insure that wise land use decisions are made. Education efforts of lake associations in the watershed will be supported and expanded.

Implementation Priority: High

Estimated Cost: $ 2,000/yr x 20 yrs = $ 40,000

Responsible Parties: BSALWMP, Lake Assns, Aitkin SWCD

Timeline: Ongoing

3). Support of Youth Education Activities: Education of elementary and high school students has been a high priority in the watershed. Existing, positive efforts such as the Big Sandy Water Institute, activities at the Cromwell-Wright School Forest, and the Area III Envirothon will be supported. New opportunities will be explored. Watershed management partners will be actively involved in promoting school projects related to protecting the health of Big Sandy and Minnewawa Lakes and their watersheds.

Implementation Priority: High

Estimated Cost: $ 6,000/yr x 20 yrs = $ 120,000

Responsible Parties: BSALWMP, Area School Districts, TRW

Timeline: Ongoing.

4). Support of and Participation in Information Fairs / Community Events: Several information fairs are held locally, providing an opportunity to reach several thousand people annually. Participation in these events will serve as an educational and community outreach project. Information shared will include the TMDL goals, BMPs, successes of the project, how landowners may become involved and strategies for reducing nutrient loading to surface waters. Events include the Aitkin County Rivers and Lakes Fair, Cromwell Harvest Festival, McGregor Wild Rice Days, and more.

Implementation Priority: High

Estimated Cost: $ 1,000/yr x 20 yrs = $ 20,000

Responsible Parties: BSALWMP, BSLA, TRW, Aitkin SWCD

Timeline: Ongoing

5.2.4 Monitoring

Baseline water quality monitoring will be conducted throughout the watershed. A long term monitoring plan has been implemented in the watershed. It has been designed to detect water quality trends, and allow examination of year-to-year variations in water quality, as well as watershed runoff responses to BMP implementation. Data has been and will be used to track long term water quality trends, and will dictate future watershed and in-lake management efforts. Citizen based monitoring will be encouraged whenever possible.

1). Baseline Lake Monitoring: Nine lake sites within the Big Sandy Lake Watershed will be monitored each year to gather background water quality data as described above.

Implementation Priority: High
Estimated Cost: $ 16,000/yr x 20 yrs = $ 320,000
Responsible Parties: Lake Assns, DNR, SWCDs
Timeline: Ongoing

2). Baseline Tributary Monitoring: Five tributary sites in the Big Sandy Lake Watershed have been identified as long term monitoring sites. Baseline water quality data will continue to be collected at these sites.

Implementation Priority: High
Estimated Cost: $ 1,500/yr x 20 yrs = $ 30,000
Responsible Parties: Aitkin SWCD
Timeline: Ongoing

5.2.5 Implementation Coordination

Locally driven coordination of the implementation actions outlined here will be provided by the Big Sandy Area Lakes Watershed Management Project. The BSALWMP Executive Council will continue to provide guidance regarding policies, approve procedures for implementation of action steps, review plans and budgets, approve project priorities and strategies, and expenditures. Sub-Watershed committees will identify areas in need of improvement within their areas, submit project request forms, and set priorities and strategies. They are the critical interface with the local landowners. The Technical Committee will provide sound technical recommendations and advice to volunteers involved in the project. Staff support of the volunteer efforts will be critical to the implementation efforts. Watershed Coordinator services will be provided by employees of the Soil and Water Conservation Districts. The primary focus of the position is to coordinate the efforts of the watershed Task Forces and Executive Council, while carrying out the TMDL Implementation Plan.

1). Support of Coordinator Position:
Implementation Priority: High
Estimated Cost: $ 20,000/yr x 20 yrs = $ 400,000
Responsible Parties: SWCDs
Timeline: Ongoing

2). Administration Support:
Implementation Priority: High
Estimated Cost: $ 5,000/yr x 20 yrs = $ 100,000
Responsible Parties: SWCDs
Timeline: Ongoing

5.3. Stakeholders

Implementation of the proposed actions will be conducted in partnership by the stakeholders in the Big Sandy Lake watershed. Each stakeholder has different mechanisms for ensuring that practices are implemented throughout the watershed. Combined efforts have proven successful in the past, and this is anticipated to continue.

The Big Sandy Areas Lakes Watershed Management Project (BSALWMP) is committed to providing a local mechanism to encourage equal partnership among all stakeholders and governmental agencies, in protecting and enhancing the esthetic, ecological, economic, agricultural, and recreational value of lakes, streams, shoreland, and wetland resources in the watershed. Implementation of this TMDL Implementation Plan requires continued cooperative efforts of the watershed residents, local decision makers, governmental units, and agencies. It is believed that this informal planning is the best way to sustain our valuable water and shoreland resources. The BSALWMP was structured to include a Volunteer

Citizen's Committee, 5 subwatershed groups, an Executive Council, and Technical Committee. Each of these groups plays a specific role in carrying out the goals of the watershed project.

Partners involved with the BSALWMP and the TMDL implementation efforts include:

Aitkin County
Aitkin County Soil and Water Conservation District
Big Sandy Lake Association
Carlton County
Carlton County Soil and Water Conservation District
City of Cromwell
City of McGregor
Clark Township
Horseshoe Lake Association
Lake Minnewawa Association
McGregor Township
Minnesota Board of Water and Soil Resources
Minnesota Department of Natural Resources
Minnesota Pollution Control Agency
Natural Resources Conservation Service
Prairie Lake Improvement Association
Shamrock Township
St. Louis County
St. Louis County Soil and Water Conservation District
Tamarack River Watershed Committee
United States Army Corps of Engineers

Table 5-1: Summary & Costs

Implementation Activity	Estimated Cost (20 year plan)	Estimated TP Reduction (lbs/yr)	Responsible Parties
Watershed Activities			
WS-1 Stormwater Treatment/Runoff Mgt	$ 200,000	1–3 lbs/phos. per project	BSALWMP, SWCDs, Lake Associations
WS-2 Lakeshore Erosion Mgt	$ 202,000	1-4 lbs/phos. per project	BSALWMP, SWCDs, Lake Associations
WS-3 Sewage/Septic Treatment/Water Usage	$ 50,000	3 lbs/phos.	Aitkin County, Cities of Cromwell, McGregor, Tamarack
WS-4 Environmental Planning	$ 700,000	4 lbs/phos.	Aitkin, Carlton, & St. Louis Counties
WS-5 Stream Channel Erosion	$ 200,000	2–5 lbs/phos. per project	BSALWMP, SWCDs
WS-6 Ditch Monitoring & Maintenance	$ 74,000	1 lb/phos.	SWCDs, Counties, Townships
WS-7 Ag BMPs & Mgt	$ 60,000	4-25 lbs/phos. per project	SWCDs, NRCS
WS-8 Silviculture	$ 20,000	5 lbs.phos.	SWCDs, Counties, NRCS, DNR
WS-9 Turf Nutrient Mgt Plans	$ 10,000	1 lb/phos.	SWCDs, Counties
In-Lake Activities			
IL-1 Int. Load Feasibility Study	$ 30,000	N/A	BSLA, Aitkin SWCD, DNR
IL-2 Imp. Feasibility Study	$ 500,000	400 lbs./phos.	BSLA, Aitkin SWCD, DNR
IL-3 Imp. Lake Management Plans	$ 10,000	2-5 lbs/phos. per project	Lake Associations
Education Activities			
ED-1 Newsletters	$ 220,000	N/A	BSALWMP, Lake Assns, Aitkin SWCD
ED-2 Public	$ 40,000	N/A	BSALWMP, Lake

Mtgs/Seminars			Assns, Aitkin SWCD
ED-3 Youth Education	$ 120,000	N/A	BSALWMP, School Districts, TRW
ED-4 Info. Fairs	$ 20,000	N/A	BSALWMP, BSLA, TRW, Aitkin SWCD
Monitoring			
MON-1 Baseline Lake Monitoring	$ 320,000	N/A	Lake Assns, DNR, SWCDs
MON-2 Baseline Tributary Monitoring	$ 30,000	N/A	Aitkin SWCD
Implementation Coordination			
COORD-1 Support Coordinator	$ 400,000	N/A	SWCDs
COORD-2 Administration	$ 100,000	N/A	SWCDs
	$ 3,336,000 TOTAL		

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