Apple Valley

Vermillion River Watershed Joint Powers Organization

Long and Farquar Lakes Nutrient TMDL

Prepared for
City of Apple Valley and MPCA
by Bonestroo

in partnership with
Vermillion River Joint Powers Organization and Wenck

Final Report

City of Apple Valley

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<tr><th colspan="5">TMDL Summary Table</th></tr>
<tr><th>EPA/MPCA Required Elements</th><th colspan="3">Summary</th><th>TMDL Page #</th></tr>
<tr><td>Location</td><td colspan="3">Long and Farquar Lakes are located in the Vermillion River Watershed, Lower Mississippi River Basin, Dakota County, and the City of Apple Valley, Minnesota which is in the southern part of the Minneapolis and St. Paul Metropolitan area.</td><td>9</td></tr>
<tr><td>303(d) Listing Information</td><td colspan="3">Lake Names (ID Number): Long Lake (19-0022-00) and Farquar Lake (19-0023-00)
Impaired Beneficial Use: Aquatic Life and Recreation (Minnesota Rules, part 7050.0222)
Impairment/Pollutant: Excess Nutrients (Total Phosphorus)
Proposed TMDL Start//Completion Dates: 2007//2011
Original Listing Year: 2002</td><td>10</td></tr>
<tr><td>Applicable Water Quality Standards/ Numeric Targets</td><td colspan="3">The Western Corn Belt Plains (WCBP) Ecoregion water quality standards for shallow lakes are Total Phosphorus $\leq$ 90 µg/L, Secchi Depth $\geq$ 0.7 m, and Chlorophyll-a $\leq$ 30 µg/L (Minnesota Rules 7050).</td><td>28</td></tr>
<tr><td>Loading Capacity (expressed as daily load)</td><td colspan="3">The loading capacities for Long Lake and Farquar Lake are provided in Tables 6.1 and 6.2. Long Lake's (Wasteload and Load) Allocation for Phosphorus = 0.33 lbs/day. Farquar Lake's (Wasteload and Load) Allocation for Phosphorus = 0.72 lbs/day.

Critical conditions are addressed in this TMDL because the load allocations were developed for the summer growing season when lake water quality is worst and most sensitive to loads. Consequently, the TMDL will be protective of all seasons.</td><td>38</td></tr>
<tr><td rowspan="6">Wasteload Allocation</td><td colspan="3"></td><td>38</td></tr>
<tr><td>Source</td><td>Permit #</td><td>Individual WLA (Total Phosphorus)</td><td></td></tr>
<tr><td>City of Apple Valley (permitted stormwater)</td><td>MS400074</td><td>Long Lake = 0.13 lbs/day
Farquar Lake = 0.17 lbs/day</td><td></td></tr>
<tr><td>City of Rosemount (permitted stormwater)</td><td>MS400117</td><td>Long Lake = NA
Farquar Lake = 0.005 lbs/day</td><td></td></tr>
<tr><td>Dakota County (permitted stormwater)</td><td>MS400132</td><td>Long Lake = 0.03 lbs/day
Farquar Lake = 0.08 lbs/day</td><td></td></tr>
<tr><td>Reserve Capacity</td><td>NA</td><td>Future growth is discussed in Section 6.2.</td><td></td></tr>
<tr><td rowspan="4">Load Allocation</td><td colspan="3"></td><td>38</td></tr>
<tr><td>Source</td><td colspan="2">LA</td><td></td></tr>
<tr><td>Internal Loading</td><td colspan="2">Long Lake = 0.15 lbs/day
Farquar Lake = 0.41 lbs/day</td><td></td></tr>
<tr><td>Direct Atmospheric Loading</td><td colspan="2">Long Lake = 0.02 lbs/day
Farquar Lake = 0.05 lbs/day</td><td></td></tr>
<tr><td>Margin of Safety</td><td colspan="3">The Margin of Safety is discussed in Section 6.1.5. It is provided in part by not including in the waste load allocation estimated reductions of 0.12 lbs/ac/yr in the direct drainage of Farquar Lake and by using conservative assumptions and proposing an adaptive management approach based on monitoring results.</td><td>39</td></tr>
<tr><td>Seasonal Variation</td><td colspan="3">Seasonal Variation is discussed in Section 6.1.4. Total Phosphorus loadings to Long and Farquar Lakes were estimated for dry (2003), normal (2005), and wet (2002) years.</td><td>38</td></tr>
<tr><td>Reasonable Assurance</td><td colspan="3">Reasonable Assurance is covered in Section 8.2. To maximize effectiveness, an</td><td>43</td></tr>
</table>

	Implementation Plan will be developed with an adaptive management strategy to reduce nutrient loading to Long and Farquar Lakes. In addition, there are three primary mechanisms assuring the implementation of improvements: the Vermillion River Watershed Joint Powers Organization (VRWJPO) and its Management Plan; the City of Apple Valley and its Local Water Management Plan; and the City of Apple Valley and its NPDES Phase II Stormwater Permit.	
Monitoring	A follow up Monitoring Plan is included in Section 8.3. The City of Apple Valley's NPDES Phase II MS4 Annual Report will be the mechanism by which the City will evaluate and report on progress toward implementing the BMPs detailed in the TMDL Implementation Plan. For those actions identified in this Plan for implementation by other parties, the City will request an annual progress report from that party for incorporation into the Annual Report.	45
Implementation	An Implementation Strategy is provided in Section 8. A separate, more detailed Implementation Plan will be developed within a year from the EPA approval date of this TMDL Report. Implementation activities will focus on reducing the movement of phosphorus from the watershed area into both Long and Farquar Lakes as well as working within the lakes themselves to reduce internal phosphorus recycling, decrease algal production as defined by chlorophyll-a, and improve water clarity to meet the WCBP Ecoregion criteria for shallow lakes as adopted by MPCA.	42
Public Participation	Public Participation is discussed in Section 7. Between June 2006 and June 2007, five meetings were held with a stakeholder group and a technical advisory group. The following groups were represented in the TMDL stakeholder process for this project: Long Lake Association, Farquar Lake Association, City of Apple Valley, Vermillion River Watershed Joint Powers Organization, Dakota County Soil and Water Conservation District, Metropolitan Council, Minnesota Pollution Control Agency, Minnesota Department of Natural Resources, and "At large" citizens. The Public Comment Period for this TMDL was from November 24, 2008 to December 24, 2008. Two comments were received on the Draft TMDL Report.	41

Executive Summary

In 2002, the Minnesota Pollution Control Agency (MPCA) listed Long and Farquar Lakes, located within the City of Apple Valley, MN, as impaired for aquatic recreation under Section 303(d) of the Clean Water Act. The main cause for these impairments is excessive nutrients in the lakes. The 303(d) list proposed start date for a Total Maximum Daily Load (TMDL) study was 2007 with a target completion date of 2011. This TMDL document assesses the nutrient load reductions needed for Long and Farquar Lakes to comply with Minnesota water quality standards. The specific sources of nutrients, target reductions from each source, strategies to achieve the reductions, and the approach to meeting the applicable water quality standards for each lake are discussed in the document.

Long and Farquar Lakes (MnDNR Lake ID #s 19-0022-00 and 19-0023-00, respectively) are 34 acres and 67 acres, respectively. Both lakes and their watersheds are located within the Vermillion River Watershed Joint Powers Organization in the southern part of the Minneapolis and St. Paul Metropolitan area. Long Lake is a shallow lake and is primarily used for non-motorized boating, aesthetic enjoyment by local residents, as well as for wildlife habitat. Farquar Lake, to which Long Lake discharges, is also a shallow lake, used for limited motorized and non-motorized boating, swimming, fishing, and aesthetic enjoyment, as well as for wildlife habitat. Long Lake has public access provided through a City Park located on the west side of the lake. However, the shoreline is not developed and cannot be reached by vehicular traffic. The only access to the park is by pedestrian traffic. Farquar Lake has public access provided through a City Park (Farquar Park) located along the southwest shoreline of the Lake. A fishing pier is present at the Park but there is no developed landing for trailer-mounted boats. The City of Apple Valley currently classifies Farquar Lake as Class II – Indirect Contact Recreation and Long Lake as Class III – Aesthetic/Wildlife, based on the City's own classification system as outlined in its Surface Water Management Plan (City of Apple Valley, 2007).

Both Lakes' drainage basins are predominantly urbanized, and comprised mainly of low and medium density residential development. A small part of the drainage (~10%) is Dakota County park land (Lebanon Hills Regional Park) and Dakota County highway right-of-way and a very small part (< 1%) is located within the City of Rosemount. Nearly half of Farquar Lake's 2,100-acre watershed is routed through Long Lake before entering Farquar Lake. Discharge from Farquar Lake is controlled by a 6-cubic foot per second (cfs) capacity lift station pump. Overall, the watershed to the lakes is comprised of approximately 23% impervious surfaces.

Water quality in Long and Farquar Lakes has declined substantially since the mid-1990s. Algal blooms now occur throughout much of the summer season, negatively impacting recreational use and aesthetic enjoyment. In-lake water quality data from 2002 through 2005 show June-September mean Total Phosphorus (TP) concentrations of almost 300 μg/L for Long Lake and just over 200 μg/L for Farquar Lake. Both concentrations significantly exceed the MPCA Western Corn Belt Plains (WCBP) ecoregion shallow lake TP standard of 90 μg/L for Class 2B recreational waters. A recent MPCA trend analysis revealed a significant decrease in water clarity over the last 10 years on Farquar Lake. The non-native curly-leaf pondweed grows at nuisance levels in both lakes.

P8 Urban Catchment Model results calibrated to satellite stormwater pond TP concentrations and average annual pumped lake discharges showed that the watershed contributes 311 pounds of phosphorus annually to Long Lake. Using the Canfield-Bachmann (C-B) lake response model calibrated to monitored in-lake TP concentrations, internal loading of TP within Long Lake was found to be 188 pounds annually. Total watershed loads to Farquar Lake were estimated at 265 pounds annually. Watershed TP loads to Farquar Lake are dominated by discharges from Long Lake, which comprise 70% of the total external phosphorus load to Farquar. Using the C-B lake response model calibrated to in-lake TP concentrations, internal loading of TP within Farquar Lake was found to be 510 pounds annually. Atmospheric deposition of phosphorus is a relatively small portion of the load compared to the other components and is estimated to be about 9 pounds and 17 pounds annually for Long and Farquar Lakes, respectively.

To address the issues effecting water quality in Long and Farquar Lakes, the City of Apple Valley teamed up with the Vermillion River Watershed Joint Powers Organization (VRWJPO) along with an experienced Technical Advisory Committee (TAC) and Lake Association members from each lake to develop a strategy to improve water quality and biological habitat within the lakes to reach the State standards for WCBP ecoregion shallow lakes.

The WCBP ecoregion shallow lake standards, as outlined by the MPCA (2005), include June-September mean TP concentration $\leq$ 90 μg/L, Secchi Disk Transparency (water clarity) $\geq$ 0.7 m, and Chlorophyll-*a* $\leq$ 30 μg/L. Guidance provided by MPCA indicates that in order to provide adequate basis for de-listing the lakes, one of the two following conditions relative to these standards must be met.

1. The monitored in-lake TP concentration and at least one of the other two parameters, chlorophyll-*a* or water clarity, must be equal to or better than the applicable standards.

2. The monitored values for both chlorophyll-*a* and water clarity must be equal to or better than the standard, even if the in-lake TP concentration does not meet the standard.

Since shallow lakes present many challenges and operate on different principles than deep lakes, an innovative approach of decreasing watershed loads, and manipulating in-lake aquatic biology will be used to return the lake to a clear-water, macrophyte dominated state. The numerical TMDL for Long and Farquar Lakes necessary to achieve the desired goal is calculated as follows:

Long Lake

TMDL	=	WLA	+	LA	+	MOS
123 lbs/year	=	60 lbs/year	+	63 lbs/year	+	MOS

Farquar Lake

TMDL	=	WLA	+	LA	+	MOS
263 lbs/year	=	96 lbs/year	+	167 lbs/year	+	MOS

Where WLA is the waste load allocation derived from permitted sources, LA is the load allocation derived from non-permitted sources (primarily internal loading), and MOS is the margin of safety. For this case, the MOS is implicit in each TMDL due to conservative assumptions used in the modeling and a proposed adaptive management approach based on monitoring results.

The existing phosphorus load to Long Lake is 508 pounds annually. Achieving the TMDL would require a loading reduction of 385 pounds per year, (508 lbs/year – 123 lbs/year), resulting in a reduction of the in-lake phosphorus concentration to near 90 μg/L. Biomanipulation management techniques would be employed within the Lake itself to reach the WCBP standards for chlorophyll-*a* and/or water clarity.

The existing phosphorus load to Farquar Lake is 792 pounds annually. Achieving the TMDL would require a loading reduction of 529 pounds per year, (792 lbs/year – 263 lbs/year), resulting in a reduction of in-lake phosphorus concentration to near 90 μg/L. As with Long Lake, biomanipulation management techniques would be employed within the Lake itself to reach the WCBP standards for chlorophyll-*a* and/or water clarity.

The City of Apple Valley, VRWJPO, TAC, and Lake Associations determined that the total required reductions in phosphorus loading for both lakes would come from the following sources:

- Urban stormwater 459 lbs/year
- Internal loading 455 lbs/year

Because the City of Apple Valley is an MS4 municipality and approximately 92% of the urban stormwater load is derived from within the City's system, the nutrient reduction strategies will be planned for and managed by Apple Valley and incorporated into its Storm Water Pollution Prevention Program (SWPPP).

1 Introduction

1.1 PURPOSE AND BACKGROUND

The goal of this Total Maximum Daily Load (TMDL) analysis is to quantify the phosphorus reduction that will be required to meet the water quality standards established for Long and Farquar Lakes and identify phosphorus reduction strategies for source areas in accordance with Section 303(d) of the Clean Water Act.

Long and Farquar Lakes are located within the City of Apple Valley, which is in the southeastern portion of the Twin Cities Metropolitan Area. The location of the City of Apple Valley within Minnesota is shown in Figure 1.1.

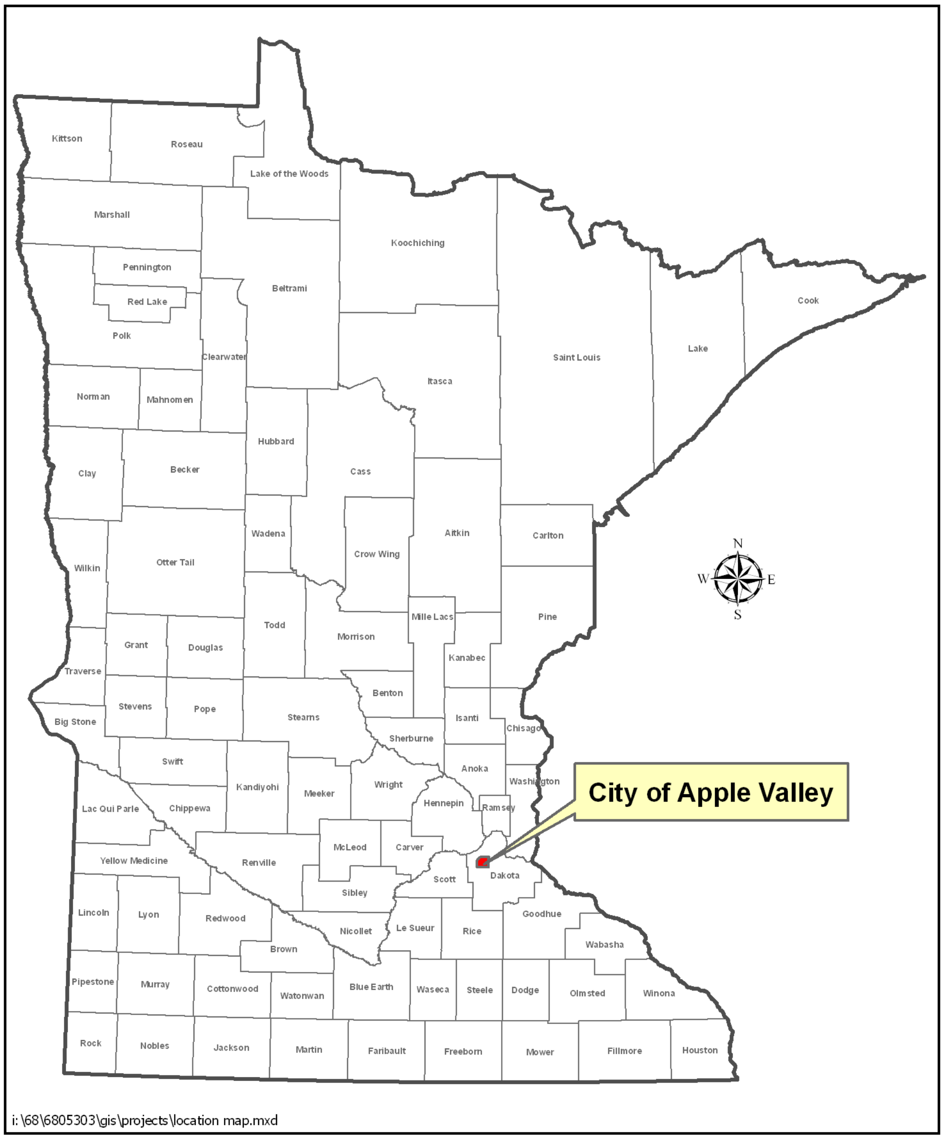


Figure 1.1 – Location of City of Apple Valley within Minnesota

Long and Farquar Lakes are identified as priority resources in the City of Apple Valley's Surface Water Management Plan (June 2007) and the Vermillion River Watershed Joint Powers Organization Watershed Plan (November 2005). Current in-lake data, collected as part of the Citizen Assisted Monitoring Program (CAMP), indicate these lakes are nutrient enriched, which poses management challenges typical of many shallow urban lakes – frequent and intense algae blooms, poor water clarity, and low oxygen in the deeper portions of the lake. The City initiated the development of a Lake Management Plan for the lakes in 2005 that would combine work on both lakes into a single project. From a technical standpoint this made sense because Long Lake discharges to Farquar Lake, and the watershed area draining to Long Lake is about half the total watershed area of Farquar. Thus, it was considered likely that phosphorus and water loads from Long Lake would constitute a significant proportion of the loading to Farquar Lake. The development of the Lake Management Plan was later expanded to meet the need of developing a formal TMDL to address the listing of the lakes as impaired waters due to excess nutrients.

1.2 PROBLEM STATEMENT

Long and Farquar Lakes, Hydrologic Unit Code: 07040001 (MnDNR Lake ID #s 19-0022-00 and 19-0023-00, respectively), are 34 acres and 67 acres, respectively, located in the City of Apple Valley, Minnesota. Long and Farquar Lakes and their surrounding drainage areas are located within the Vermillion River Watershed, and largely within the jurisdictional boundaries of the City of Apple Valley, with a small amount of the watershed extending into Dakota County's Lebanon Hills Regional Park and the City of Rosemount. Long and Farquar Lakes and their contributing watersheds are both located within the Western Corn Belt Plains (WCBP) ecoregion. The Twin Cities metropolitan lakes are heavily used. Long Lake is primarily used for non-motorized boating and aesthetic enjoyment by local residents, as well as for wildlife habitat. Farquar Lake, to which Long Lake discharges, is also used for non-motorized and motorized boating, some swimming, fishing, aesthetic enjoyment, and wildlife habitat. Long Lake does not have a public access. Farquar Lake has public access provided through a City Park (Farquar Park) located along the southwest shoreline of the Lake. A fishing pier is present at the Park, but there is no developed landing for trailer-mounted boats.

Since the mid-1990s, the lakes have experienced degraded water quality that has reduced the lakes' recreational and aesthetic value. In 2002, the lakes were added to the Minnesota 303(d) impaired waters list for impaired aquatic recreation as a result of mean summer phosphorus values that exceeded the standard for Class 2B recreational waters. According to the 303(d) list the proposed start date for this TMDL was 2007 with completion proposed for 2011.

2 Watershed and Lake Characterization

2.1 HISTORY OF THE LAKES AND THEIR WATERSHEDS

Before European settlement of the area, the watershed surrounding Long and Farquar Lakes were predominately forest and wetland until the late 1800s. In 1881 Farquar Lake was described as "the largest sheet of water lying entirely within [the boundaries of Lebanon Township]. The shore is partly a clean sandy beach, and the water pure and clear, containing good fish," *History of Dakota County, Including the Explorers and Pioneers of Minnesota*, Rev. Edward D. Neill (available in the Dakota County Library).

During the late 1800s and early 1900s the area surrounding the lake was steadily converted from forest to agricultural use. Conversion to agricultural use included construction of numerous drainage channels to drain fields and wetlands, which likely increased the drainage area and hydrologic and nutrient flux to the lake. During the modern era, the City of Apple Valley grew from a population of 585 people in 1960 to 45,527 in 2000. The City incorporated in 1969. As agricultural and forested land in the northeast area of the City was developed into residential suburban neighborhoods, the contributing watershed to Farquar Lake grew from an estimated pre-urban development area of 353 acres to a fully developed urban watershed area of about 2,100 acres.

2.2 SOILS AND GEOLOGY

The soils in the northern part of Apple Valley are from the Kingsley-Mahtomedi association that are characterized as gently sloping to very steep, loamy and silty textured soils. These well drained to excessively well drained soils are extensively intermingled.

The topographic elevations vary from a high of about 1,060 feet Mean Sea Level (MSL) in the northwest edge of the watershed to a low of 900 feet MSL near Farquar Lake. The rugged terrain in the north is characterized by steep slopes with many hills and depressions. These many depressions and natural ponds are ideal for long term storage of stormwater runoff.

The surficial geology of the watershed is a moraine topography caused by relatively recent geologic process. The advance and retreat of glacial lobes approximately 10,000 years ago deposited the rock material that characterizes the topography.

The watershed is within the Eastern St. Croix Moraine geomorphic area. The area consists of relatively steep hills, rolling topography, and some deep depressions that are either filled with small lakes or peat. The area consists of a mixture of red and grey till and is composed of silt, clay, sand, pebbles, cobbles and boulders. Water tables may be at or near the surface in the depressions, but are 10 feet or deeper in the hills.

2.3 CLIMATOLOGICAL SUMMARY

Annual normal precipitation in this part of the Twin Cities Metropolitan Area, as measured at the Rosemount Agricultural Experiment Center, is about 34.6 inches (1971 - 2000), of which about two-thirds occurs during the summer months of May - September. The annual snowfall in Apple Valley averages approximately 50 inches of snow; with the most severe melt runoff conditions usually occurring in March and early April. Twin Cities mean annual lake evaporation is about 30.5 inches per year. On average, lakes in the area experience about 132 days of ice cover a year, with the average freeze and thaw dates occurring the last week of November and the first week of April respectively. The average date of the last below freezing temperature (32°F) in the spring is April 27 while the average date of the first below freezing temperature in the fall is October 2. Thus, the normal growing season is about 157 days.

2.4 WATERSHED CHARACTERISTICS

The 2,100-acre watershed for both Long and Farquar Lakes is generally bounded by Lebanon Hills Regional Park, the Minnesota Zoo, and Valleywood Golf Course on the northern edge, the Apple Valley-Rosemount border on the eastern edge and 144th Street on the south. The western edge of the watershed generally follows Pilot Knob north to County Road 42, along Johnny Cake Ridge Road north of Co. Rd. 42 to 140th Street, and extends to just north of McAndrews Road (Figure 2.1).

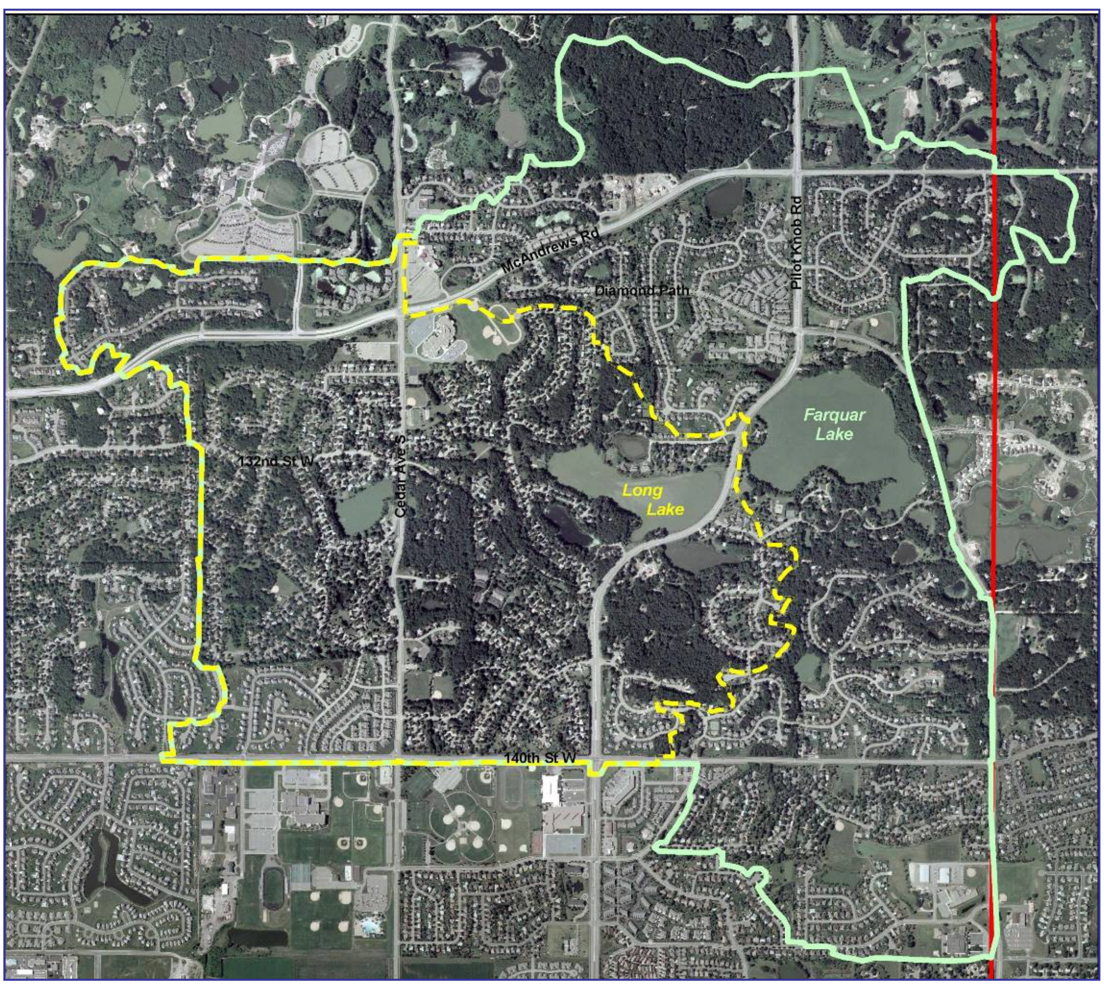


Figure 2.1 – Watersheds to Long and Farquar Lakes

The watershed is mostly developed. Low and medium density single family residential development is the predominant land use in the watershed, but there are also limited commercial, institutional, and park land uses as well as a golf course. Approximately 23% of the watershed surface is impervious. There are no industrial sites in the watershed. The residential area was predominately serviced by Individual Sewage Treatment Systems (ISTSs) until the Twin Cities Metropolitan Sewer Board (now the Metropolitan Council) provided sewage treatment service in the 1970s. Almost all sanitary waste generated within the watershed is now conveyed outside the watershed and treated. However, there are currently about 20 ISTSs remaining in the watershed, but this number is steadily decreasing each year.

Stormwater management for the developed areas of the watershed is provided by the City's storm sewer system. Much of the stormwater is routed through one or more natural or man-made ponds prior to discharge to either of the lakes. Long Lake captures about half of the drainage area contributing to Farquar Lake. Long Lake discharges directly to Farquar Lake through a 12-inch diameter pipe. The rest of the watershed drains through ponds and then to Farquar Lake. There are a total of 52 constructed and natural ponding areas within the watershed that are incorporated into the City's storm drainage system. The discharge from Farquar Lake is through a 6 cfs capacity lift station pump. There are high quality flow data for the lift station discharges out of the watershed. As will be mentioned later, this information was used to calibrate the hydrology in the watershed model.

Long and Farquar Lakes and their watersheds lie within the East Vermillion River (EVR) drainage district as defined in the City's Surface Water Management Plan (2007). Discharge from the Long and Farquar system is retained within the City of Apple Valley due to infiltration losses, within stormwater ponds, that occur as the water moves south toward the City's boundary with Lakeville. The final surface water feature, Cobblestone Lake, captures any excess runoff from the City's East Vermillion River drainage district. Cobblestone Lake has a lift station which has never been used since its installation in 2000. Therefore, none of the discharged water currently reaches the Vermillion River or its tributaries as surface runoff.

2.5 LAKE MORPHOMETRY AND HYDROLOGY

Long and Farquar Lakes are both shallow lakes, with surface areas of 33 acres and 67 acres respectively. Figure 2.2 shows a rough bathymetric map for Long Lake based on field measurements taken by City staff during the winter of 2004 and Figure 2.3 shows the bathymetry available from MnDNR (Minnesota Department of Natural Resources) for Farquar Lake. Table 2.1 summarizes key morphometric characteristics for both lakes. Nearly all the water entering the lakes is routed overland through the City's storm sewer system. There are significant system-wide water losses due to infiltration partly in the lakes and in upstream ponds. The excess water is pumped out of the system via the Farquar lift station.

Figure 2.2 – Long Lake Bathymetry (based on measurements taken by City of Apple Valley staff)

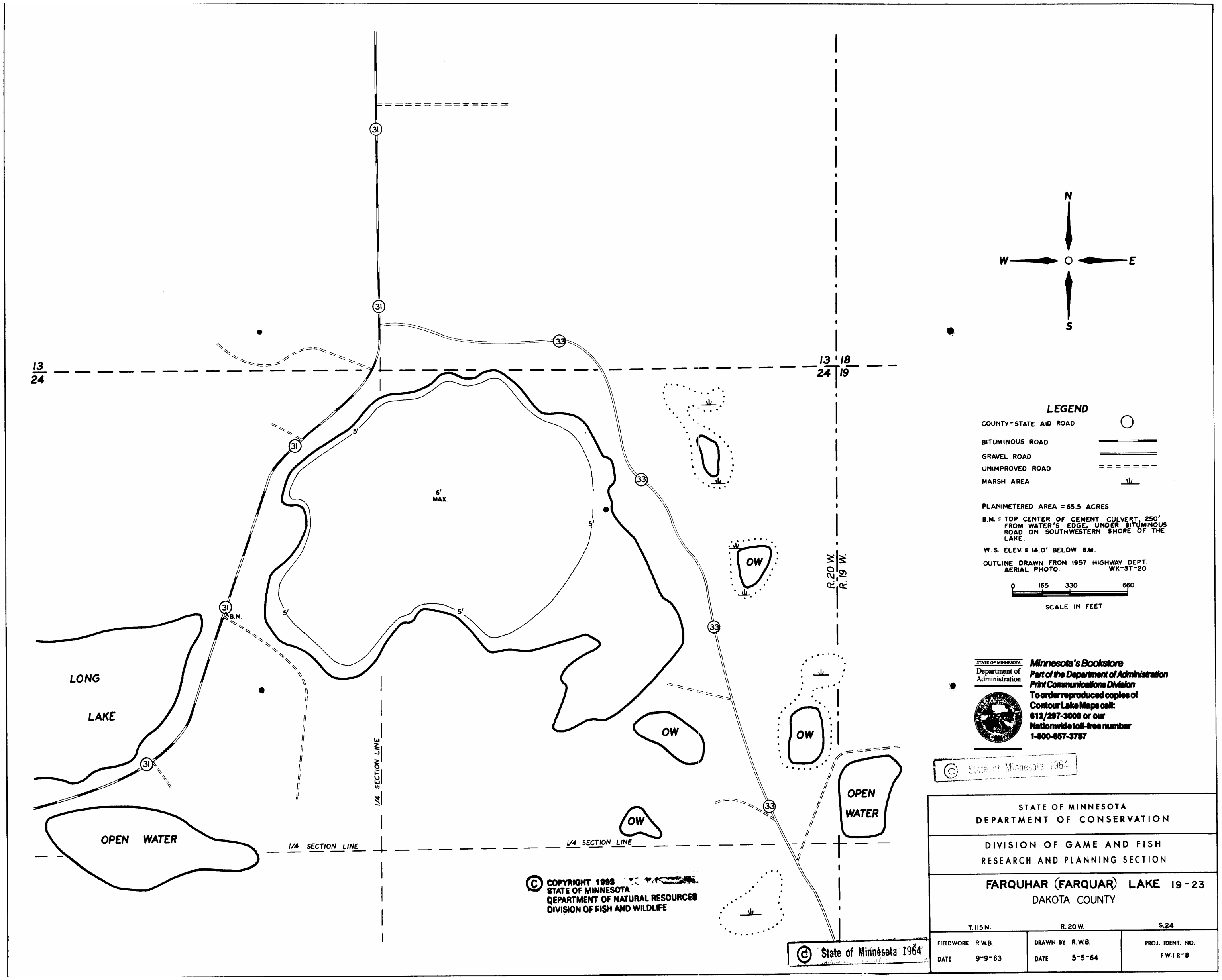


Figure 2.3 – Farquar Lake Bathymetry (MnDNR Lake Finder ID: 19-0023)

Table 2.1 – Long and Farquar Lakes Characteristics

	Long Lake	Farquar Lake
DNR ID	19-0022	19-0023
Surface Area (Ac)	34[2]	67[2]
Volume (Ac-ft)	77[3]	290[1]
Maximum Depth (Ft)	5[3]	10[1]
Mean Depth (Ft)	2.4	4.4
Watershed Area^ (Ac)	963	2,035
Direct Drainage (Ac)	51	75
Indirect Drainage (Ac)	913	1,960
Watershed: Lake Ratio	28:1	30:1
Residence Time (years)	0.26	0.64

^Watershed area does not include landlocked sub-districts or lake surface area.
<u>Data Sources:</u>
1. Metropolitan Council CAMP report
2. Obtained from aerial photo using GIS
3. City of Apple Valley: lake depth survey

Figure 2.4 and Figure 2.5 show individual sub-watersheds delineated by major discharge inlets to the lakes and are labeled in accordance with the satellite ponds discharging directly to the lakes. The cross-hatched areas in both figures show land-locked areas within each watershed that do not generate runoff for up to the 100-year precipitation event. Figure 2.6 shows how much of the total watershed each sub-watershed comprises for each lake. For example, the largest sub-watershed, EVR-12, comprises 47% of the total watershed area draining to Long Lake.

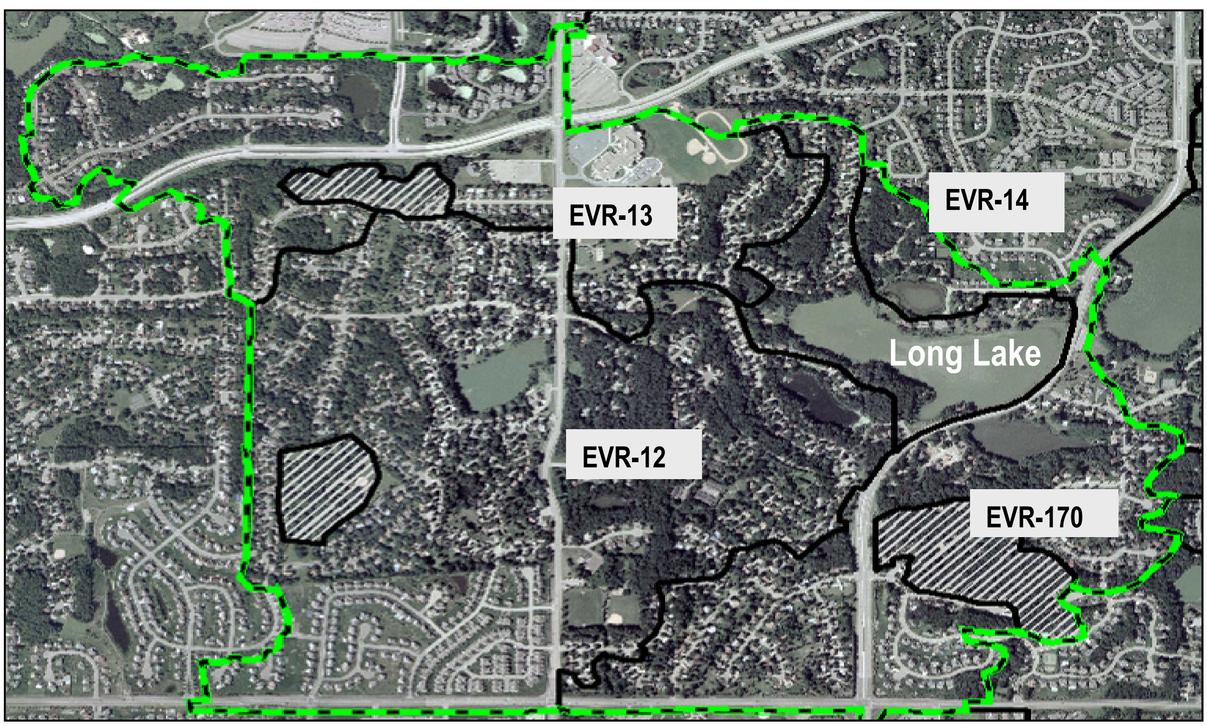


Figure 2.4 – Sub-watersheds to Long Lake (Cross-hatched areas represent land-locked areas)

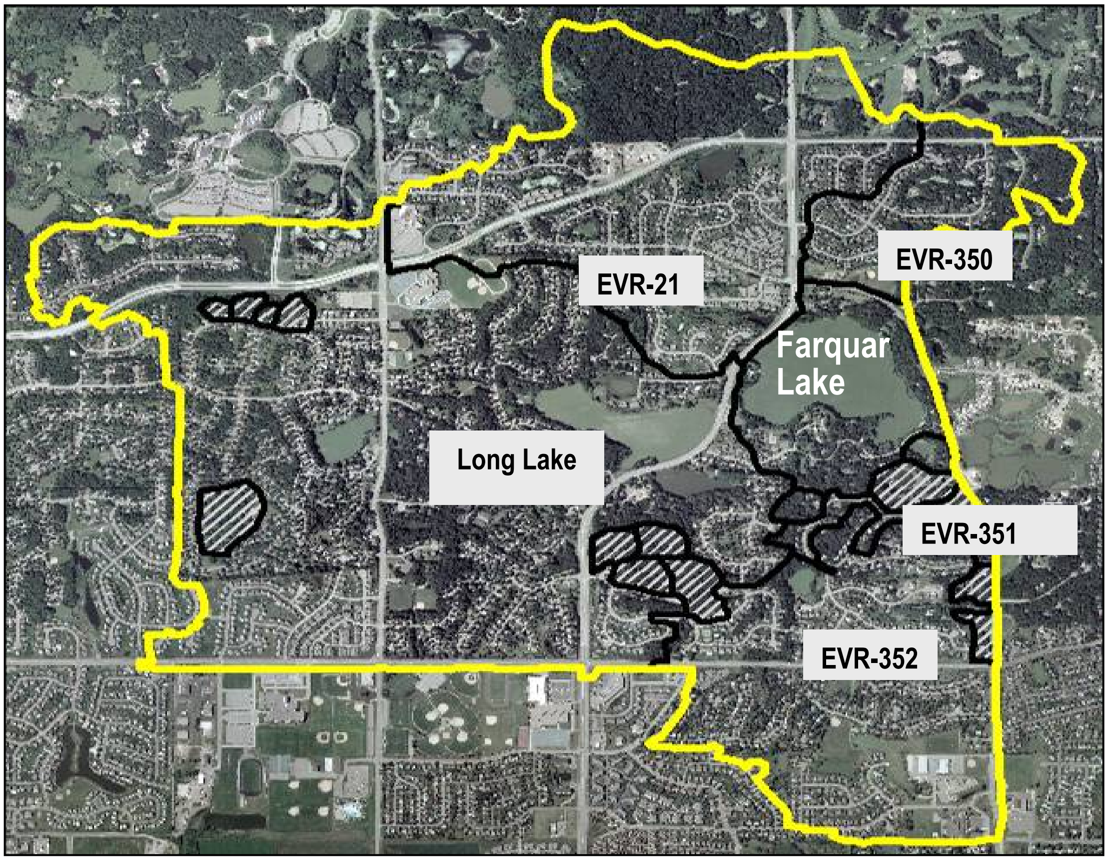


Figure 2.5 – Sub-watersheds to Farquar Lake (Cross-hatched areas represent land-locked areas)

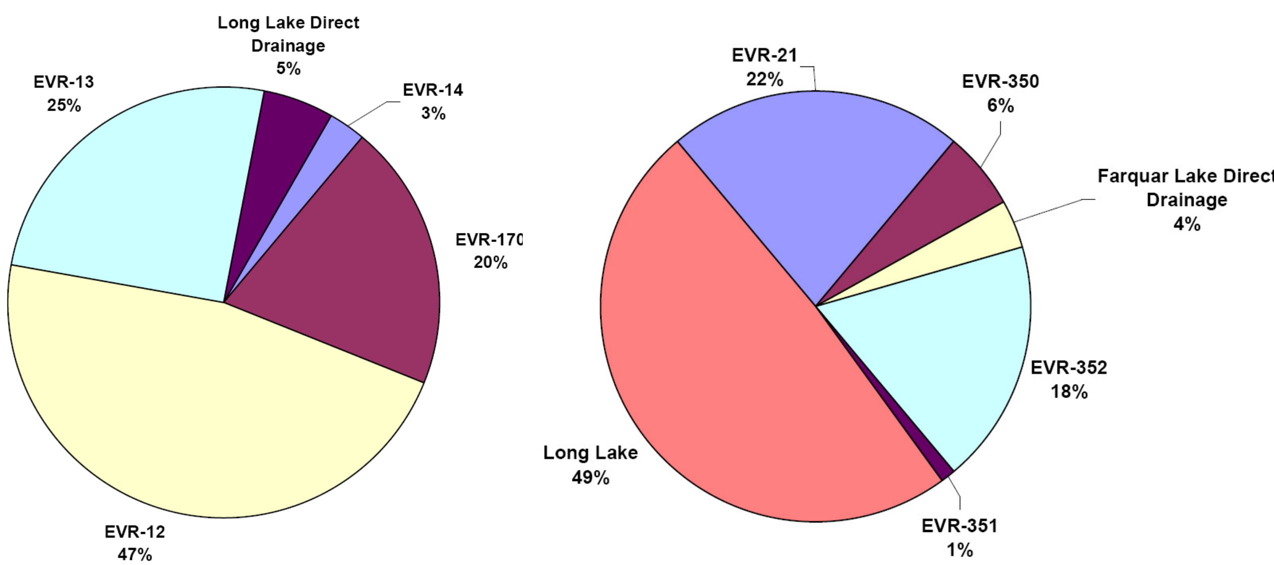


Figure 2.6 - Composition of watershed drainage area to - Left: Long Lake, Right: Farquar Lake

Table 2.2 presents tabular data for the area of all sub-watersheds draining to Long and Farquar Lakes.

Table 2.2 – Summary of the direct and indirect drainage areas for each lake (labeled by Sub-watershed)

Sub-watershed	Area (acres)
Long Lake	
EVR-P12	450
EVR-P170	193
EVR-P13	244
EVR-P14	26
Direct drainage to Long Lake (EVR-17)	50
Total	**963**
Farquar Lake	
Drainage from Long Lake	996
EVR-P21	454
EVR-P350	116
EVR-P351	21
EVR-P352	373
Direct drainage to Farquar Lake (EVR-35)	75
Total	**2,035**

2.6 WATER QUALITY

In-lake water quality data from 2002 through 2005 show June - September mean Total Phosphorus (TP) concentrations of almost 300 μg/L for Long Lake and just over 200 μg/L for Farquar Lake. Both significantly exceed the MPCA WCBP ecoregion shallow lake standard of 90 μg/L for Class 2B recreational waters. These data were supplemented in 2005 and 2006 with dissolved oxygen and temperature profiles as well as pH measurements. Dissolved oxygen was found to decrease with depth, with little or no dissolved oxygen near the bottom of the lakes.

Water quality conditions in Long Lake are extremely degraded. In fact, the average clarity for Long Lake in 2004 was one foot, the lowest out of 140 lakes evaluated by the Metropolitan Council in the Twin Cities area for that year. Long Lake has been monitored through the Citizen Assisted Monitoring Program (CAMP) for 1997 and 2002 - present. A major factor in the water quality management for Long Lake is the large ratio of watershed area to lake surface area (28:1). The large ratio indicates that Long Lake is vulnerable to stress from watershed inputs. Based on the incoming average annual volume of stormwater runoff, the lake is flushed about four times per year. Therefore, the lake water quality is strongly linked to the quality of stormwater runoff entering the lake, as well as in-lake biological processes. As is common with many degraded urban shallow lakes, internal recycling of phosphorus appears high for Long Lake.

The high internal phosphorus loads are likely caused in part by high phosphorus loads delivered to the lake from its urban watersheds over the last decade or more. Much of this load has likely been retained in the lake sediment and a portion of that load is available for release into the water column, affecting growing season water quality. Low dissolved oxygen at the sediment/water interface create conditions that cause release of iron-bound phosphorus. In addition, growth and subsequent die-off and decay of heavy curly-leaf pondweed infestations also move phosphorus from the sediment to the overlying water column. Finally, high populations of roughfish like bullheads and minnows can cause re-suspension of nutrient enriched sediments, which can also result in the release of phosphorus to the overlying water column.

Water quality conditions in Farquar Lake have declined substantially since the mid-1990s. Farquar Lake has been monitored through the CAMP program for the period 1994 - present. A recent MPCA trend analysis revealed a significant decrease in water clarity over the last 10 years. Because Long Lake discharges directly to Farquar, the influence of Long Lake phosphorus loadings on water quality in Farquar Lake has critical implications for Farquar Lake's management. Therefore, any actions taken to improve the Farquar Lake system, whether in the watershed or in the lake, are unlikely to be successful unless upstream improvements are made to Long Lake and its watershed system. In addition, Farquar Lake appears subject to internal loading of phosphorus for reasons similar to those outlined above for Long Lake.

Figure 2.7 shows seasonal variation in the water quality variables of phosphorus, chlorophyll-*a* and water clarity measured as secchi depth, for the 2005 growing season in Long Lake and Farquar Lake. Long and Farquar Lakes show trends of degrading water quality throughout the growing season, with improvement toward fall. Since Long Lake is much smaller than Farquar Lake it is more susceptible to rapid changes in water quality due to runoff events. For example, the first spike in phosphorus concentration in Long Lake in late May coincides with a 2.23 inch rainfall event which was the first substantial rainfall event of the season and likely washed off much of the built-up phosphorus from the watershed.

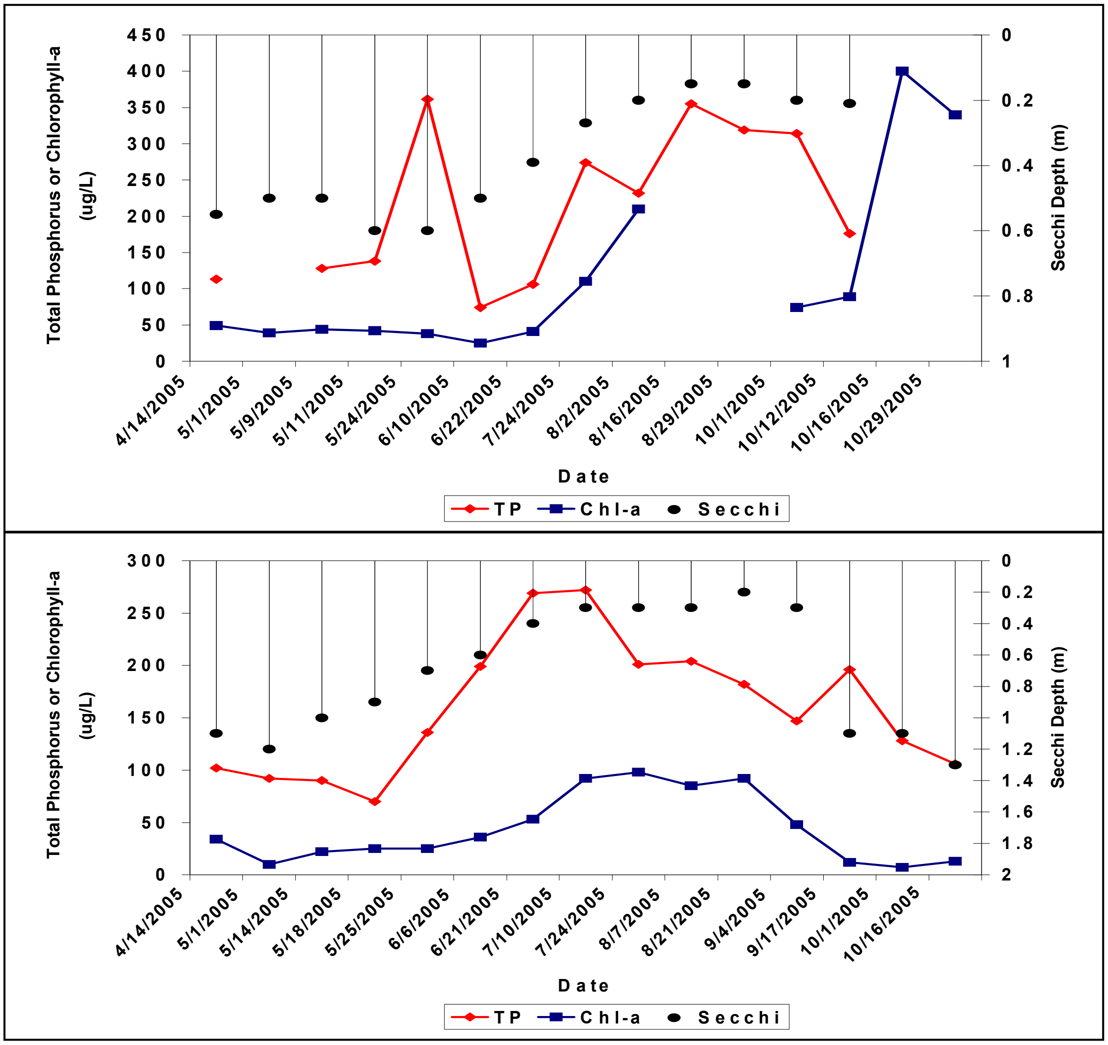


Figure 2.7 – Graph showing variation in Total Phosphorus, Chl-*a*, and Secchi depth during the 2005 monitoring season for. Top: Long Lake, Bottom: Farquar Lake. (Note: MPCA Eutrophication Standards TP ≤ 90 µg/l, Chl-*a* ≤ 30 µg/l and Secchi ≥ 0.7m)

Figure 2.8 shows dissolved oxygen and temperature profiles measured from Long and Farquar Lakes in July 2006. Low dissolved oxygen levels (below 2 mg/L), measured about one foot above the sediment water interface, indicate anoxia and the potential release of excess stored phosphorus from the sediments into the water column.

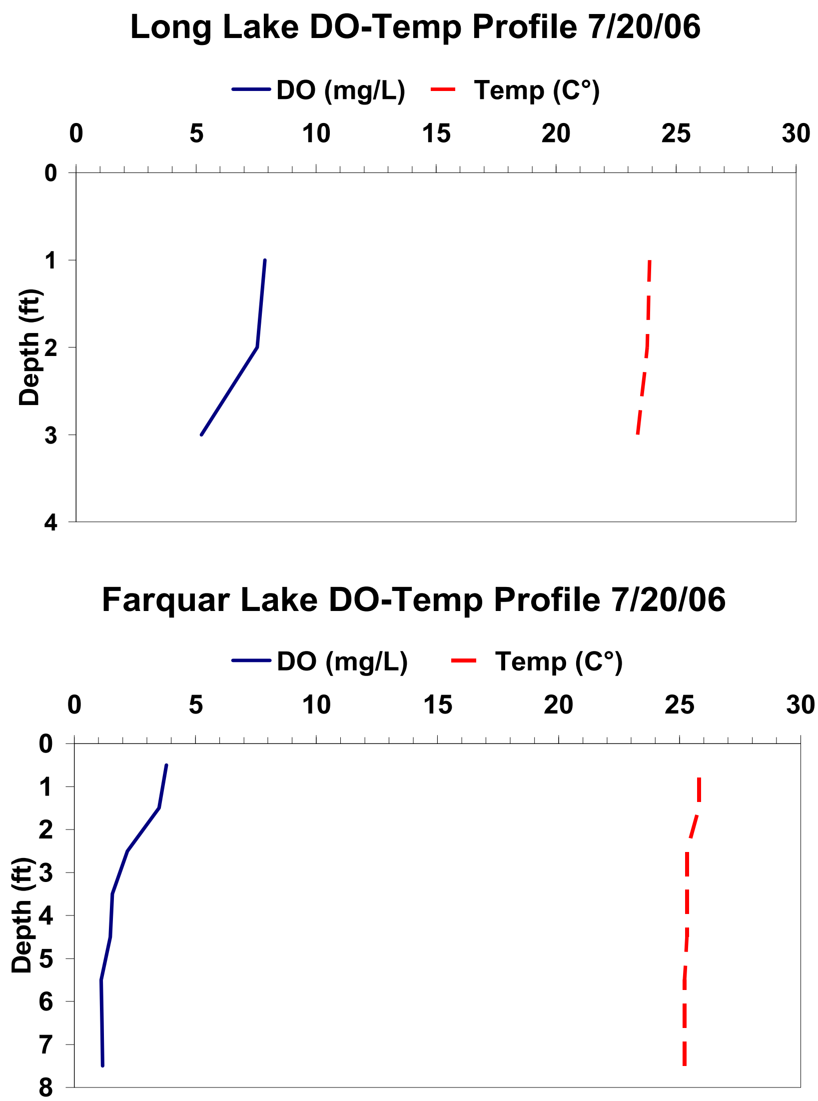
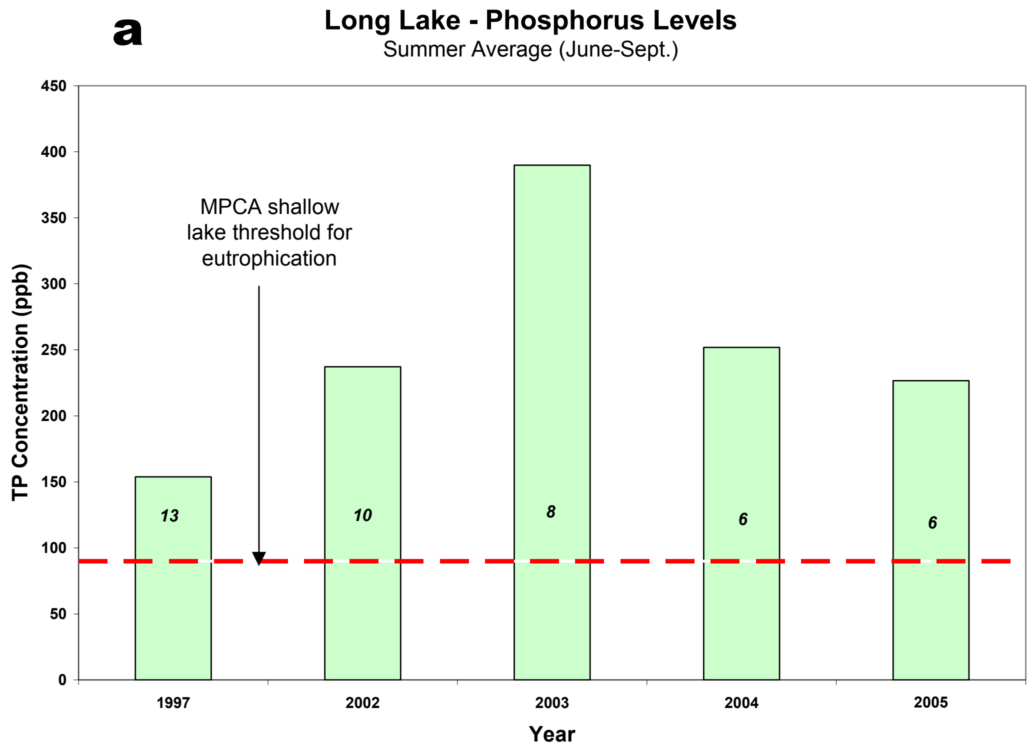
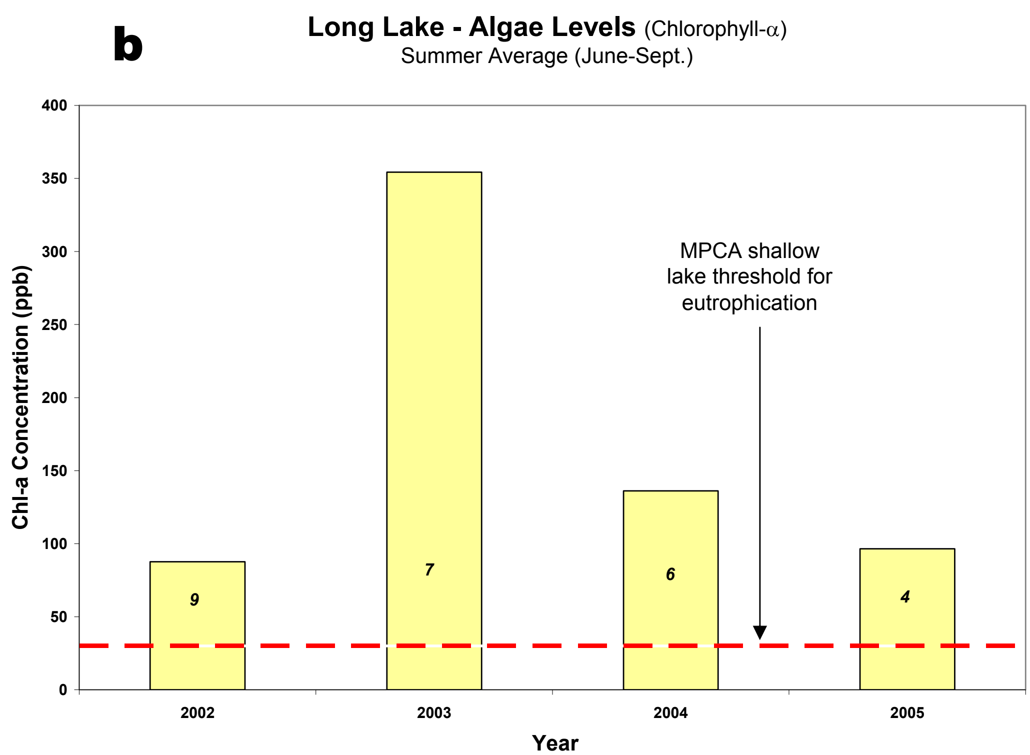


Figure 2.8 – Dissolved oxygen and temperature profiles measured in July 2006. Top: Long Lake, Bottom: Farquar Lake.

Figure 2.9 and Figure 2.10 show June - September summer mean lake water quality for the total CAMP monitoring period for Long and Farquar Lakes. The number annotations on the bars indicate the number of data points included in each seasonal average value. This data can be used to detect variations and trends in lake water quality and was the basis for the lakes 303(d) listing.


a
Long Lake - Phosphorus Levels
Summer Average (June-Sept.)
TP Concentration (ppb)
MPCA shallow
lake threshold for
eutrophication
13
10
8
6
6
1997
2002
2003
2004
2005
Year
0
50
100
150
200
250
300
350
400
450


b
Long Lake - Algae Levels (Chlorophyll-α)
Summer Average (June-Sept.)
Chl-a Concentration (ppb)
MPCA shallow
lake threshold for
eutrophication
9
7
6
4
2002
2003
2004
2005
Year
0
50
100
150
200
250
300
350
400

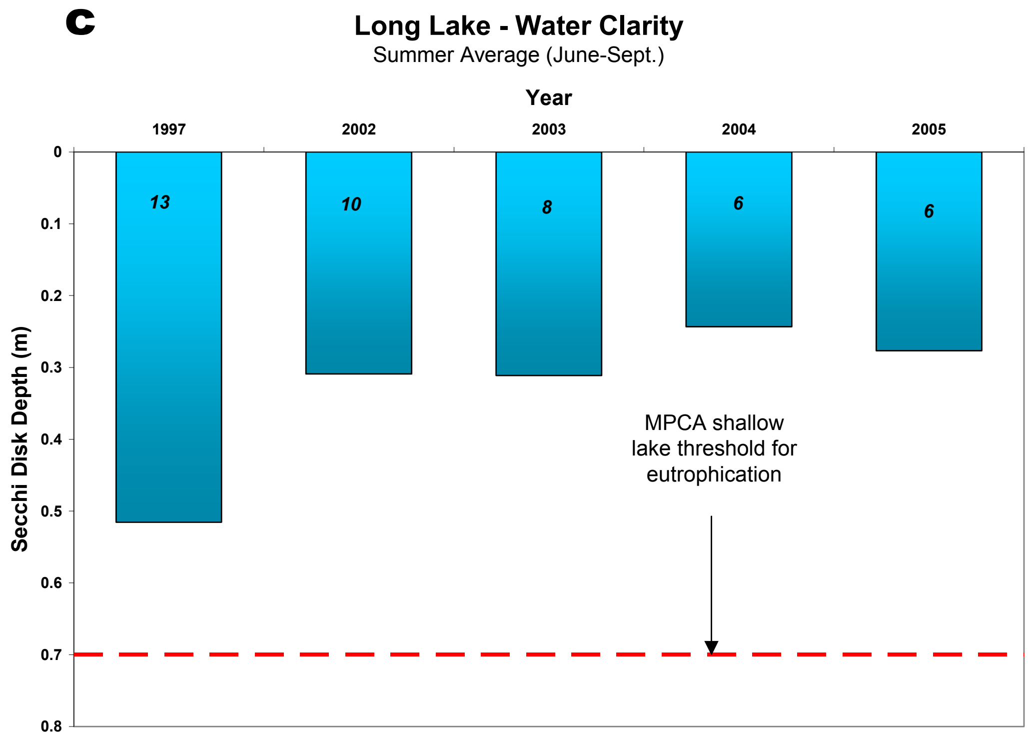
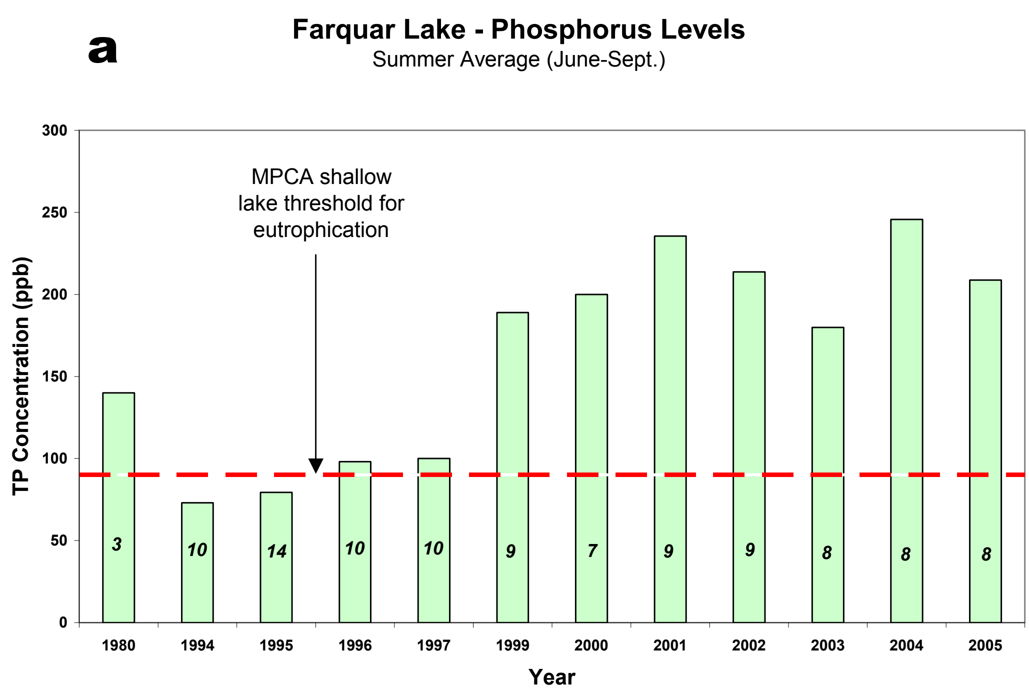


Figure 2.9 – Graphs of average annual summer water quality conditions for Long Lake. Numbers on the bars indicate the number of samples included in the average value. Dashed line indicates threshold for impairment. **a.** Total Phosphorus, **b.** Chlorophyll-*a*, **c.** Secchi Disk



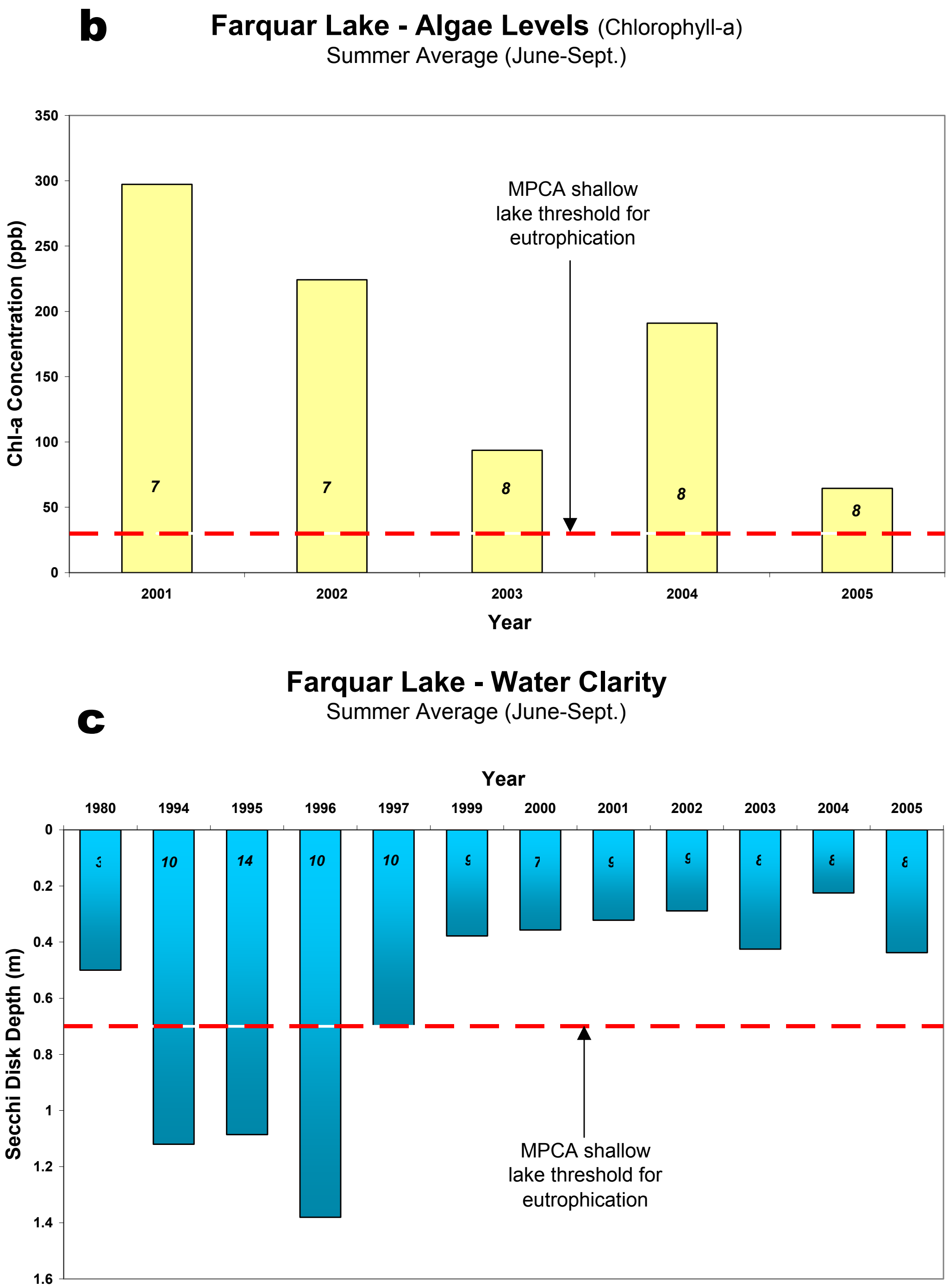


Figure 2.10 – Graphs of average annual summer water quality conditions for Farquar Lake. Numbers on the bars indicate the number of samples included in the average value. Dashed line indicates threshold for impairment. **a.** Total Phosphorus, **b.** Chlorophyll-*a*, **c.** Secchi Disk

2.7 HISTORICAL WATER QUALITY AND EVIDENCE OF IMPACTS FROM DEVELOPMENT

Historical (pre-development) water quality data are not available for Long and Farquar Lakes. However, studies on lake sediment cores, using diatom records as a measure of nutrient abundance, taken from area lakes (Lake Calhoun, Lake Harriet, Sweeney Lake, and Twin Lake) show a two to three fold increase in Total Phosphorus (MPCA, 2002). These increases are correlated directly to watershed development. It is likely watershed development within the Long and Farquar Lakes basin had similar effects on lake water quality from the 1960s to the late 1990s.

Another means of analyzing historical water quality is by utilizing the MINLEAP computer model (Wilson and Walker, 1989). The model was used to identify the expected water quality of Long and Farquar Lakes for "typical" nutrient inflows similar to minimally impacted reference lakes within the WCBP ecoregion. The model shows current in-lake water quality for both lakes is significantly degraded compared with reference lakes having similar basin morphometric characteristics. The degradation to a large extent is due to the expansion and development of the contributing watershed. Model runs using the current contributing watershed areas instead of pre-development areas generate predictions of water quality for both lakes that are closer to the observed values. Table 2.3 shows a comparison between current observed in-lake water quality and MINLEAP modeled water quality based on the current size of each lake's watershed but assuming nutrient inflows to the lakes similar to those characteristic of minimally impacted lakes in the WCBP ecoregion. As recommended by MPCA (2007), this analysis was done only to help frame the eutrophication issue and is not the basis for the load capacity work presented later in this report.

Table 2.3 – Summary of observed average summer water quality from 2005 and predicted values using MINLEAP for Long and Farquar Lakes based on pre-development watershed characteristics. (Note: MPCA Eutrophication Standards are TP ≤ 90ppb, Chl-*a* ≤ 30ppb and water clarity (Secchi Depth) ≥ 0.7m)

Water Quality Parameters	Observed (2005)	Predicted *(MINLEAP)*
Long Lake		
TP (µg/L)	227	131
Chlorophyll-*a* (µg/L)	97	81
Water Clarity (m)	0.28	0.6
Farquar Lake		
TP (µg/L)	209	111
Chlorophyll-*a* (µg/L)	65	64
Water Clarity (m)	0.44	0.7

2.8 FISHERIES STATUS

There is no fish population survey data available from MnDNR for Long Lake. For Farquar Lake, the most recent fish population survey was conducted in 2002. MnDNR noted that black bullhead were abundant, as were green sunfish (most under 5 inches in length) and goldfish. Pumpkinseed sunfish and black crappie were rare. Largemouth bass, though stocked in 1999 and 2000, were not present in the survey.

In order to supplement the available fish population information, a fish survey was conducted for both lakes by Bluewater Science of St. Paul Minnesota in July 2006. The methods and results of that survey are summarized in a report by McComas (2007). Based on sampling with trap nets, Farquar Lake survey results showed exceptionally high numbers of black bullheads (602 per net) and young-of-the-year panfish (120 per net). Largemouth bass, ranging in length from 8 to 14 inches were present as well, though in limited numbers (3 per net). In Long Lake, fathead and shiner minnows along with bullheads (7 per net) were the dominant fish. No game fish were sampled in Long Lake.

The high numbers of rough fish (e.g. bottom level feeders, commonly carp and bullhead, which spend a majority of the time rooting around in the sediments searching for food), stunted panfish and extremely high minnow populations compared to the low numbers of game fish strongly suggest that the structure of the fishery may be contributing to poor water quality in the lakes. Bullheads, for example, often feed off bottom sediments, which can result in re-suspension of those sediments and contribute to internal loading if the sediments are phosphorus enriched, as they are in this lake system. They also ingest sediment along with food particles and excrete most of the sediment, which again can introduce phosphorus from the sediments to the water column. Equally important, stunted panfish and minnows, in degraded systems, show similar feeding behavior which can lead to these same impacts, namely increased internal TP loading (McComas 2004, McComas 2005). Finally, stunted panfish and minnows are heavy planktivores and can exert considerable grazing pressure on the zooplankton (algae eaters) community (Zimmer et al. 2003). Reducing this grazing pressure is an important component of re-establishing grazer controls on nuisance algae populations.

It should also be noted that qualitative observations by City staff suggest high populations of goldfish and minnows in Pond EVR-P12, located at the bottom of Sub-watershed EVR-12 just south of Long Lake. No quantitative fish population surveys have yet been conducted for any of the satellite ponds upstream of Long Lake.

Figure 2.11 qualitatively illustrates the amount of rough fish and minnows that are occurring in Long and Farquar Lakes.

Figure 2.11 - Left: Photo of a catch of minnows at Long Lake. The goldfish held above the bucket is from one of many observed in upstream ponds. Right: Photo of a single net of bullheads caught at Farquar Lake. Source: S. McComas at Bluewater Science of St. Paul, MN

2.9 AQUATIC VEGETATION

Aquatic plant surveys were conducted for both lakes by Bluewater Science of St. Paul, Minnesota in June and September 2005. Each survey used the point-intercept method. The methods and results of that survey are summarized in a report by McComas (2007). The survey showed that aquatic plant diversity in both lakes is low. Curly-leaf pondweed, a non-native invasive species, is the dominant plant in both lakes in early summer. In late summer, elodea is present in each lake, but its density is low. All plants were found in water depths of 3.5 feet or less. Plant distribution is very limited, most likely because of very low water clarity in both lakes. Excessive numbers of rough fish and stunted panfish may also be limiting native plant distribution and abundance.

Curly-leaf pondweed appears to have a particularly detrimental impact on water quality in the lakes. This invasive plant grows under the ice and usually forms dense growths by late spring, then dies off naturally by mid-July. The die-off causes the release of a substantial mass of phosphorus when plant densities are at nuisance levels, as they are in much of Long and Farquar Lakes during the early summer. This introduction of nutrients to the water column can fuel algal blooms.

If water clarity improves to meet the WCBP ecoregion standard of ≥ 0.7 meters, it is likely light intensities adequate to support rooted aquatic plant growth would be sufficient for all of Long Lake and most of Farquar Lake. The management challenge will be to assure that any increase in aquatic plant distribution is dominated by native species comprised of a combination of submergent species (including some floating leaf macrophytes) as well as emergent species. Based on the aquatic plant survey report for both lakes, there may be a seed bank of native plants that could help the plant community move in this direction if adequate water clarity can be achieved.

2.10 WATER LEVEL

The water level in Long and Farquar Lakes is managed by structural controls. Long Lake outlets to Farquar Lake through a 12-inch reinforced concrete pipe with an invert elevation of 900.8 ft. MSL. The outlet was installed in the 1990s. Before this time Long Lake overflowed to Farquar via a path crossing constructed under Pilot Knob Road. Farquar Lake's level is controlled by a lift station located between Farquar and the connected pond, EVR-P352. The control water elevation for Farquar is set at 898.1 ft. MSL. Therefore, there is about 2.7 ft. of vertical separation between the two lakes when at their normal water levels. However, large rain events cause significant changes in lake water levels that can last for up to a few weeks while the lift station pumps work to draw down Farquar Lake.

A record for historical water level in Long Lake does not exist. Water level records for Farquar Lake exist at the lift station for 1999 - present. Most of the time the level hovers around 898 ft. MSL, but on occasion there are fluctuations as high as five feet. The water level dropped to 897.9 ft. MSL in 1999 and spiked up to 902.8 ft. MSL in 2000 during a rare return period storm event of about 7.5 inches of rain in two days.

It is important to note that the additional runoff directed to the lake system due to development of the area, the expansion of man-made drainage systems to accommodate that development, and the installation of a system to control water levels in the lakes has eliminated the natural drawdowns that likely occurred during extended dry periods under pre-settlement conditions. In shallow lakes, this can be an important part of re-establishing and maintaining a healthy submergent and emergent aquatic plant community (Scheffer 1998).

3 Water Quality Standards and Numeric Phosphorus Target

3.1 WATER QUALITY STANDARDS FOR DESIGNATED USES

Long and Farquar Lakes are primarily used by local residents. Long Lake has limited public access through a pedestrian accessed City Park on the west side of the lake. The Lake is primarily used by shoreline residents for fishing and aesthetic viewing of wildlife. Farquar Lake is primarily used by shoreline residents for fishing and aesthetic viewing of wildlife, as well as for limited boating and swimming. City residents use the lake primarily for fishing as there is a fishing pier in Farquar City Park located on the southwest shore. There is no public boat access to either lake.

Both Long Lake and Farquar Lakes are designated as Class 2B waters of the state. Both lakes and their watersheds are located in the Western Corn Belt Plains (WCBP) ecoregion, and both lakes are considered shallow lakes as well. The MPCA defines a shallow lake as an enclosed basin with a maximum depth of 15 feet or less or with 80 percent or more of the lake area shallow enough to support emergent and submerged rooted aquatic plants (littoral zone). MPCA recently revised some of the water quality standards presented in Minn. R. Chap. 7050 to include numeric targets for shallow lakes. The numeric phosphorus, chlorophyll-*a*, and water clarity standards for Class 2B shallow lakes in the WCBP ecoregion are ≤ 90 μg/l, ≤ 30 μg/l, and ≥ 0.7 meters, respectively.

Minnesota's standards include narrative criteria for nutrients which limits the quantity of nutrients that may enter the waters. The State's standards (Minn. R. Chap 7050. Subp 3 and Subp 5) state that all Class 2 waters of the state shall be free from any material increase in undesirable slime growths or aquatic plants including algae. The MPCA numeric standards for these parameters are designed to meet the current applicable narrative water quality standards for the designated uses of shallow lakes and therefore will be used as the basis for the numeric target for the Long and Farquar Lakes TMDL.

Meeting the above State standards will also meet the City's standards for these lakes based on the classification of Long Lake as a Class III water body and Farquar Lake as a Class II water body, as presented in the City's Surface Water Management Plan (2007). These classifications are explained below:

- Class II – These water bodies are intended to support indirect contact recreation activities that involve incidental contact with lake water. Examples include fishing, canoeing, and perhaps limited use of motor-driven water-craft. They also have depth characteristics (maximum depth > 6.6 feet and mean depth > 3 feet) that allow these uses for the vast majority of the summertime recreation season in almost all years.

- Class III – These water bodies are intended for passive recreation, primarily aesthetic/wildlife activities. The water bodies will have the potential for diverse wildlife habitat and/or wetland vegetation communities. They are accessible to the public for educational, interpretive or scenic benefits. They generally will have depth characteristics (maximum depth < 6.6 feet and mean < 3 feet) that severely limit opportunities for sustained high quality warm-water fishing, use of motor-driven watercraft, etc.

3.2 ANALYSIS OF IMPAIRMENT

During the periods of 1997, 2002 and 2003, the average summer (June - September) mean values for total phosphorus, chlorophyll-*a*, and water clarity in Long Lake were 260 μg/L, 221 μg/l, and 0.38 meters, respectively. These values exceeded the criteria of ≤ 90 μg/l total phosphorus, ≤ 30 μg/l chlorophyll-*a*, and ≥ 0.7 meters of water clarity. The mean seasonal concentrations were based on a minimum of eight samples in each year.

From 1999 to 2003 (five years), the average summer (June - September) mean values for total phosphorus, chlorophyll-*a*, and water clarity in Farquar Lake were 204 μg/L, 205 μg/l, and 0.35 meters, respectively. As with Long Lake, these values exceeded the MPCA criteria of ≤ 90 μg/l total phosphorus, ≤ 30 μg/l chlorophyll-*a*, and ≥ 0.7 meters of water clarity. The mean seasonal concentrations were based on a minimum of seven samples in each year. The data showed that the lakes had nutrient concentrations that did not meet standards for full support of their designated recreational uses. Consequently, the lakes were placed, and have remained, on the 303(d) list as impaired waterbodies.

4 Phosphorus Source Assessment

4.1 PHOSPHORUS SOURCE ASSESSMENT

The watershed modeling and lake response modeling as well as analysis of the in-lake water quality data indicated that stormwater runoff and internal loading were the primary sources of nutrients to both Long and Farquar Lakes. The models also showed that the majority of external loading to the lakes can be attributed to urban runoff. Analysis of lake water quality data as well as modeling for both lakes also showed that there is likely a large internal phosphorus load from a combination of curly-leaf pondweed senescence, sediment release of phosphorus due to high pH and/or low dissolved oxygen, and rough fish activity.

4.2 ANALYSIS OF PHOSPHORUS CONTRIBUTIONS

4.2.1 URBAN STORMWATER

The urban watershed model P-8 was used to estimate the load contribution of the major sub-watersheds draining to Long Lake based on land use characteristics, local climate, soils information, and any ponding Best Management Practices (BMPs) in the watersheds. The P-8 model was selected based on guidance provided by MPCA (2007) for estimating runoff volume and nutrient loads from urban watersheds in Minnesota. The watershed model was calibrated to growing season mean phosphorus concentration data monitored for Ponds EVR-P12 and EVR-P170. Pumping records for the Farquar Lake lift station, which serves as the outlet for the project watershed, was used to calibrate the hydrology in the P-8 model.

The vast majority of runoff reaching Long Lake enters the Lake via the City of Apple Valley's stormwater drainage system. The boundaries of the major sub-watersheds for which loads to Long Lake are summarized are shown in Figure 2.4 and the phosphorus loads from those sub-watersheds for an average precipitation year are shown in Figure 4.1.

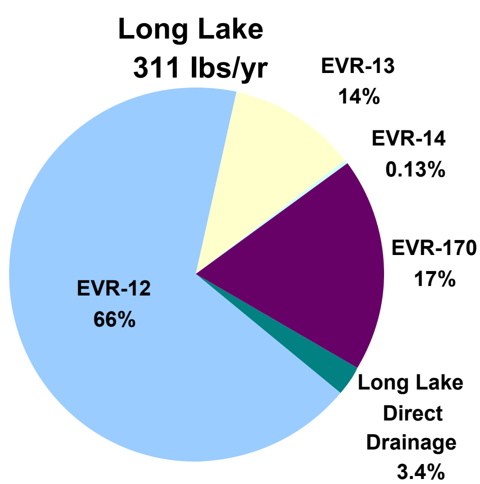


Figure 4.1 – Percent of average annual phosphorus load to Long Lake watershed by contributing sub-watershed

The majority of phosphorus load entering Farquar Lake comes from Long Lake, with the remaining external phosphorus load coming from runoff entering Farquar Lake from the City of Apple Valley's storm drainage system. The load of phosphorus entering Farquar Lake from Long Lake was derived based on the outflow volume estimated by P-8 for the Long Lake sub-watershed and the concentration of phosphorus provided by a calibrated lake response model for Long Lake. Loads from the remainder of the Farquar Lake drainage were estimated by using the P-8 model developed as described above. The boundaries of the major sub-watersheds (excluding that for Long Lake, which is shown in Figure 2.4) draining to Farquar Lake are shown in Figure 2.5 and the loads from those sub-watersheds for an average precipitation year are shown in Figure 4.2.

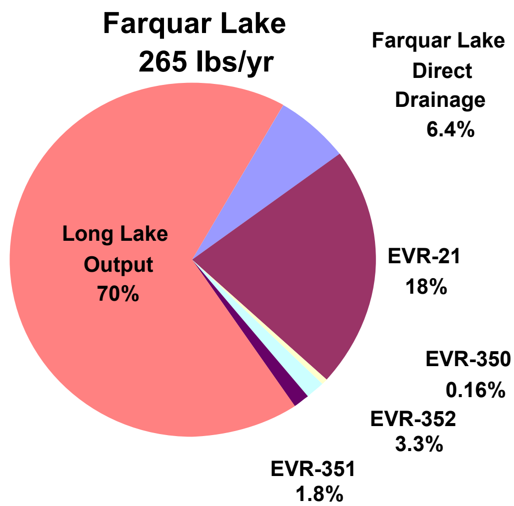


Figure 4.2 – Percent of average annual phosphorus load to Farquar Lake watershed by contributing sub-watershed

4.2.2 Internal Phosphorus Release

Long and Farquar Lakes have been exposed to nutrient loading that is much higher then their assimilative capacities. Much of this excess phosphorus has found its way into the bottom sediments. This excess phosphorus is now available to be released into the water column when conditions are favorable for nutrient release. This occurs when sediment is resuspended by wind mixing and rough fish activity as well as when DO (dissolved oxygen) levels near the sediment water interface drop below 2 mg/L. Phosphorus is also released when the heavy growths of curly-leaf pondweed, characteristic of each lake, die back in early to mid summer. All of these mechanisms for internal loading of phosphorus occur in Long and Farquar Lakes and lead to conditions that promote algae growth, especially in mid to late summer.

Employing a "weight of evidence approach," a number of techniques were considered to determine to what level internal loading is affecting Long and Farquar Lakes. Nürnberg's Anoxic Factor (Nurnberg, 1984) approach, as well as a reverse Canfield-Bachmann lake response model was employed. Also attempts were made to directly measure internal loading through a mass balance approach during periods of little to no precipitation. The mass balance method was especially helpful at estimating internal loading rates during curly-leaf pondweed senescence and nutrient release.

The Nürnberg method provided a reasonable range of seasonal internal phosphorus release rates based on the amount of time and area of anoxic sediment. The results of the analysis estimated internal load between 104 - 269 lbs/year for Long Lake and 204 - 531 lbs/year for Farquar Lake.

The mass balance method was used to determine the phosphorus accumulation in the lakes during dry periods where runoff from the watershed was absent. During the 2003 summer season, only about 13.5 inches of rain fell allowing for the dry season analysis for Long Lake. Analysis was completed based on TP samples collected on a bi-weekly basis, where runoff was absent. A total of three bi-weekly periods from 2002 and 2003 were analyzed for Long Lake and five periods from 2003 - 2005 were analyzed for Farquar Lake. The increase in TP concentrations in each lake was converted to a mass over the period and accumulation of TP was converted to an average summertime loading rate. Figure 4.3 shows examples of periods when TP concentrations increased and no runoff occurred. The average calculated estimate for internal loading was 256 lbs/year for Long Lake and 604 lbs/year for Farquar Lake.

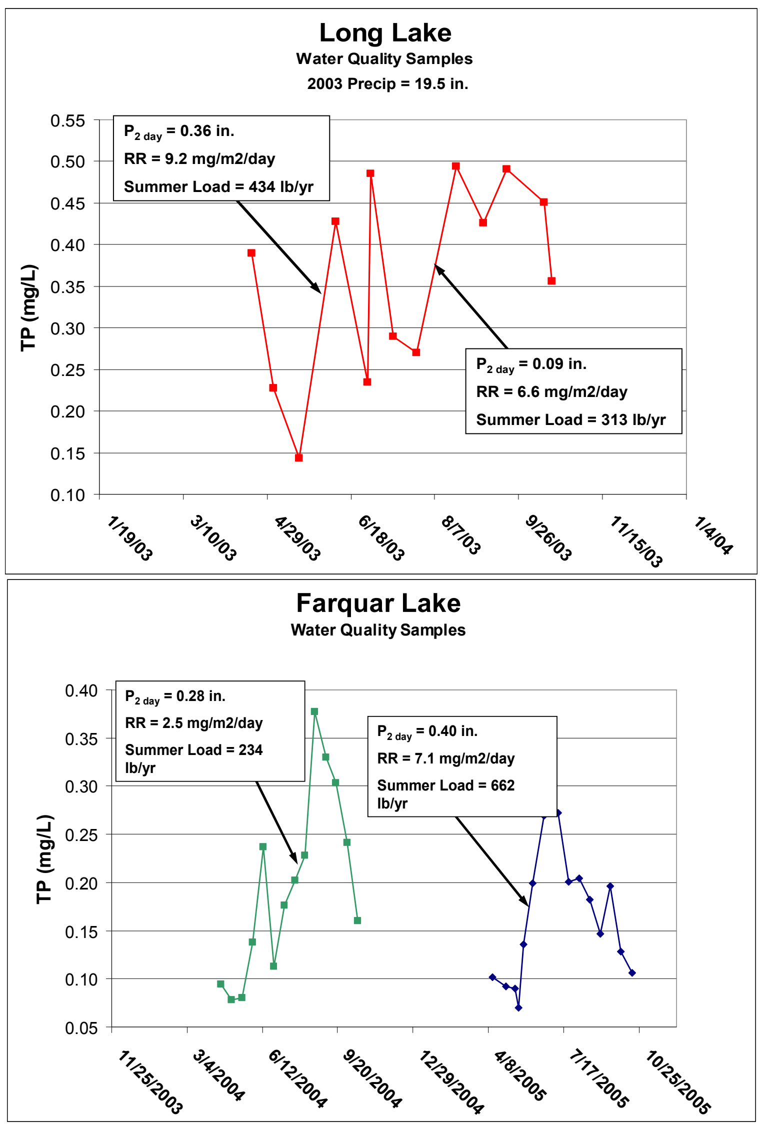


Figure 4.3 – Periods of internal loading for – Top: Long Lake, Bottom: Farquar Lake ($P_{2\,day}$ is the maximum 48-hour precipitation within the 2-week period and "RR" is the calculated internal release rate of TP)

Using the Canfield-Bachmann lake response model, the seasonal average phosphorus concentration and the modeled external loads were used to estimate the internal component of the load based on the total load required to achieve the seasonal monitored concentrations. From this analysis, for 2005, the internal loading to Long Lake was 188 lbs/year and the internal load to Farquar was 510 lbs/year.

Each of these methods provided an approximation of internal loading within Long and Farquar Lakes. The method presented by Nürnberg is well established and provides a range of reasonable values. The mass balance approach also provides a fair estimate for internal loading by direct measurement, but due to the small sample size it does not necessarily represent the average loading rate for the years sampled. The Canfield-Bachmann model used to back calculate internal loading, knowing the in-lake concentration and calibrated model watershed loading and atmospheric loading, provided a reasonable estimate for internal loading that was similar to the mass balance loads and fell within the range provided by Nürnberg. Therefore this approach was used for calculating internal loads for the dry, average and wet scenarios.

4.2.3 LAKE EXCHANGE

The transfer of nutrients between Long and Farquar Lakes is essentially one directional. Due to the size of the watersheds and the volume and area of the lakes and due to the elevation difference of the lakes, the flow of water and nutrients is virtually always from Long to Farquar under average annual precipitation conditions. No backflow occurs from Farquar Lake to Long Lake unless runoff from precipitation events exceeding a 10-year recurrence interval occurs. Therefore, the phosphorus load from the Long Lake watershed to Farquar Lake can be estimated as the seasonal in-lake phosphorus concentration multiplied by the discharge to Farquar.
On average this load is about 186 lbs/year.

4.2.4 ATMOSPHERIC DEPOSITION

The deposition of phosphorus from the atmosphere over the surface of the lakes is accounted for in the modeling but is small in comparison to calculated external loads and internal phosphorus recycling. An estimate based on average depositional rates in the area was used for both Long and Farquar Lakes. The rate is estimated to be 0.27 lbs/acre/year; this corresponds to the average value suggested in the BATHTUB model (Walker, 1996), yielding an average annual mass load of 9 lbs/year for Long Lake and 17 lbs/year for Farquar Lake.

4.2.5 OTHER

The vast majority of dwellings in the watersheds of Long and Farquar Lakes are served by sanitary sewer owned and operated by the City of Apple Valley. As of 2004, however, there were still a number of properties in the project area served by individual on-site wastewater disposal facilities (City of Apple Valley 2004). Eight of these were in the Long Lake sub-watershed, though none served lakeshore property. Nineteen were located in the Farquar Lake sub-watershed, and seven of these served lakeshore property.

The city has adopted and enforces a rigorous program of inspections and mandatory pump outs of these systems at least every three years. There are no records of failing systems in this area of the city. Thus, there was no phosphorus load from these systems assigned to either lake.

5 Linking Water Quality Targets to Source Loads

5.1 INTRODUCTION

Detailed water balance and nutrient balance models were developed for the Long and Farquar Lakes system. The models were calibrated and validated based on three years of detailed lift station discharge and in-lake water quality data. Also, water quality monitoring in satellite ponds (EVR-P12 and EVR-P170) provided data for calibrating the watershed loads. The models were used to analyze a range of precipitation including representative, wet (2002), dry (2003), and average (2005) years.

5.2 SELECTION OF MODEL AND TOOLS

Models used to analyze phosphorus loading in the Long and Farquar system included a calibrated urban watershed water quality model, P8 (Walker 1990), using the sediment size distribution based on the median NURP (National Urban Runoff Program) particle size range. The Canfield-Bachmann lake response model as found in the BATHTUB model (Walker, 1996) was used to help estimate internal loading as well as lake phosphorus concentrations for load allocation scenarios. Additionally, the BATHTUB model (Walker, 1996) was used to model the Chlorophyll-*a* and Secchi Disk Transparency response based on phosphorus concentration and lake characteristics. Both the watershed model (P-8) and the lake response model (BATHTUB) were selected based in large part on guidance provided by the MPCA (2007).

5.3 PHOSPHORUS BUDGETS AND RECEIVING WATER RESPONSE

A P8 urban watershed model was developed for the Long and Farquar Lakes watersheds based on readily available data for sub-watershed areas, land use, and stormwater treatment ponds within the watersheds. The model was then run using hourly rainfall data from the Seneca WWTP located approximately six miles north in Eagan, MN. The hydrologic balance for the model was adjusted using lake level and lift station pumping data for Farquar Lake from 2005, a year with near-normal precipitation. For example, data analyzed for a number of storms indicated that lift station discharge volume was often significantly less than the change in storage in Farquar Lake due to a given runoff event, suggesting that there were water losses within the Lake itself. In addition, soils data along with City staff knowledge regarding seepage characteristics of specific ponds in the system was used to reduce the discharge of those ponds where consistent and significant seepage losses were known to occur. This information was used to make minor adjustments to change default watershed runoff coefficients as well as assign small loss rates to the lake itself in order to bring the modeled water budget for the system into better agreement with the actual water budget derived from the lake stage and pumping monitoring data for 2005. The watershed model was then run for validation purposes using temperature and precipitation information for a representative dry year (2003) and wet year (2002).

The pumped volume in 2005, used for calibration, was 444 acre-feet. The 2003 pumped volume was 286 acre-feet compared to a model discharge of 220 acre-feet, and for 2002 the pumped volume was 865 acre-feet compared to a model discharge of 744 acre-feet.

The P8 model, with the median NURP particle size distribution, was used to estimate the TP loads to the lakes for the three scenarios. Nearly 70% of the watershed area draining to Long Lake is routed through ponds EVR-P12 and EVR-P170. These ponds were monitored for the 2006 summer season to determine how the water quality within the ponds compared to model estimates. The watershed model estimated loads of 38 lbs/year and 15 lbs/year from the EVR-P12 and EVR-P170, respectively. This is based on an approximate in-pond concentration of 100 μg/L total phosphorus. The loads to Long Lake from these satellite ponds were calibrated, based on the modeled volume discharged from the ponds and average in-pond phosphorus concentration, to be 205 lbs/year and 53 lbs/year, respectively. Qualitative observations, by Steve McComas of Bluewater Science in St. Paul, MN and City staff, provided evidence that invasive aquatic plants and abundant rough fish populations may be driving the poor water quality in these ponds. Table 5.1 shows the calibrated model loads entering through each satellite pond's sub-watershed.

Similarly, loads to Farquar Lake were estimated using the P8 Urban Watershed Model calibrated for loads entering through Long Lake and EVR-P352. The loads entering through Long Lake and EVR-P352 were based on calibrated discharge and monitored in-lake phosphorus concentrations. Table 5.1 shows the loads entering Farquar Lake. Additional monitoring will continue in these satellite ponds, and will be expanded to other ponds, to provide further data to refine estimated loads entering the lakes from the sub-watersheds.

Table 5.1 – Modeled TP loads to Long and Farquar Lakes (calibrated for 2005)

Sub-watershed	TP Load (lbs/year)
Long Lake	
EVR-12	205
EVR-170	53
EVR-13	42
EVR-14	0.4
Direct drainage to Long Lake (EVR-17)	11
Total	**311**
Farquar Lake	
Drainage from Long Lake	186
EVR-21	48
EVR-350	0.4
EVR-351	5
EVR-352	9
Direct drainage to Farquar Lake (EVR-35)	17
Total	**265**

The Canfield-Bachmann lake response model was used to estimate in-lake phosphorus concentration.
The model estimates in-lake TP concentrations based on the Total Phosphorus load delivered to the lake from watershed, atmospheric, and internal sources on an average annual basis and based on mean lake depth and lake flushing rate. The model was calibrated to monitor in-lake phosphorus, in part to help estimate internal TP loading for the average year of 2005 (results shown below in Figure 5.2) as well as for dry (2003) and wet (2002) years.

Table 5.2 – Observed and Predicted In-Lake Water Quality for Long and Farquar Lakes for 2005

Year	Variable	Long Lake		Farquar Lake	
		Observed[1] Mean	Predicted Mean	Observed[1] Mean	Predicted Mean
2005	Total P (μg/l)	252	252	186	186
	Chlorophyll-a (μg/l)	96.5	96	64.5	65
	Secchi Depth (meters)	0.28	0.19	0.44	0.38

[1] Based on approximately bi-weekly samples for summer growing season (May 1 – September 30)

The model was then used to determine the phosphorus load reduction required to reach the target TP goal of 90 μg/L. Using the BATHTUB model (Walker, 1996), estimates for Chlorophyll-*a* and water clarity were determined for both lakes based on a TP concentration of 90 μg/L, lake morphometry and hydrology. Table 5.3 shows the results from the BATHTUB model (Walker, 1996) for both lakes.

Table 5.3 – BATHTUB model for Chl-*a* and water clarity based on TP target of 90 μg/L

Long Lake	Farquar Lake
TP = 90 μg/L	TP = 90 μg/L
Chl-*a* = 55 μg/L	Chl-*a* = 45 μg/L
Secchi disk = 0.3 m – 0.4 m	Secchi disk = 0.5 m – 0.6 m

As shown above, even after reaching the target TP goal of 90 μg/L, the lakes will likely remain in a turbid algal dominated state, with chlorophyll-*a* predicted to be above the MPCA eutrophication standard of 30 μg/l and water clarity predicted to be below the standard of 0.7 meters. To address this issue, combined with the nutrient reduction effort, a biomanipulation approach will be employed to reduce chlorophyll-*a* and improve water clarity.

5.4 CONCLUSIONS

The current estimated phosphorus load to Long Lake based on field monitoring and computer modeling results is 508 lbs/year (311 lbs/year external, 188 lbs/year internal, and 9 lbs/year atmospheric) assuming normal annual precipitation. This is equivalent to 1.39 lbs/day (0.85 lbs/day external, 0.52 lbs/day internal, and 0.02 lbs/day atmospheric). To reach the goal of 90 μg/L for in-lake phosphorus concentration, the Canfield-Bachmann (1979) lake response model predicts that the annual phosphorus load to Long Lake would need to be reduced to 123 lbs/year (0.34 lbs/day). This translates to a total reduction of 385 lbs/year, or a 76% reduction from the current annual phosphorus load estimate of 508 lbs/year.

The current estimated phosphorus load to Farquar Lake based on field monitoring and computer modeling results is 792 lbs/year (265 lbs/year external, 510 lbs/year internal, and 17 lbs/year atmospheric) assuming normal annual precipitation. This is equivalent to 2.18 lbs/day (0.73 lbs/day external, 1.40 lbs/day internal, and 0.05 lbs/day atmospheric). To reach the goal of 90 μg/L for in-lake phosphorus concentration, the Canfield-Bachmann (1979) lake response model predicts that the annual phosphorus load to Farquar Lake would need to be reduced to 263 lbs/year (0.72 lbs/day). This translates to a total reduction of 529 lbs/year, or a 67% reduction from the current annual phosphorus load estimate of 792 lbs/year.

6 TMDL Allocations

6.1 TOTAL MAXIMUM DAILY LOAD CALCULATIONS

The numerical TMDL for Long and Farquar Lakes was calculated as the sum of the Waste Load Allocation (WLA), the Load Allocation (LA), and the Margin of Safety (MOS), expressed as phosphorus mass per unit time according to the following formula:

TMDL = WLA + LA + MOS

6.1.1 WASTE LOAD ALLOCATIONS (WLAS)

The City of Apple Valley, City of Rosemount, and Dakota County have been designated as Mandatory Small Municipal Separate Storm Sewer Systems (MS4s) by the MPCA. As a result, the allowable discharge associated with these MS4s has been designated as Waste Load Allocation (WLA). Long Lake's target phosphorus reductions necessary to comply with the allowable WLA total 251 lbs/year from storm sewer systems. Farquar Lake's target phosphorus reductions necessary to comply with the allowable WLA total 208 lbs/year from storm sewer systems. Table 6.1 and Table 6.2 summarize the Waste Load Allocations for Long and Farquar Lakes, respectively, as they refer to the appropriate MS4s.

Mn/DOT currently does not have right of way in the watershed for these lakes. If they do build a road in the future in the watershed, they will work with one of the existing MS4s (i.e. Apple Valley) to purchase the land for the road and then the WLA will be adjusted as needed (i.e. Apple Valley WLA would decrease and Mn/DOT would be added for some portion of the WLA). This would result in no change in the overall WLA for the lakes.

There are no current or planned industrial discharges in the watershed. Therefore industrial stormwater activities are not given a categorical or individual WLA. Construction stormwater is included in the WLA and is considered in compliance with provisions of the TMDL if a Construction General Permit is obtained under the National Pollutant Discharge Elimination system (NPDES) program and BMPs required under the permit are properly selected, installed, and maintained.

6.1.2 LOAD ALLOCATIONS (LAS)

Internal loading of phosphorus, resulting from aquatic plant senescence and entrainment of phosphorus-rich benthic sediment and pore water by periodic mixing events and rough fish disturbance, has been designated as a Load Allocation. The loading of phosphorus from atmospheric deposition onto the lake is also included as a Load Allocation. Long Lake's internal loading of phosphorus is predicted to decrease by 134 lbs/year as external load is reduced and in-lake plant and fish management activities are conducted. Farquar Lake's internal loading of phosphorus is predicted to decrease by 321 lbs/year as external load is reduced and in-lake plant and fish management activities are conducted. Table 6.1 and Table 6.2 summarize the Load Allocations for Long and Farquar Lakes, respectively, as they refer to both internal loading and direct atmospheric loading.

6.1.3 SUMMARY OF TMDL ALLOCATIONS

Tables 6.1 and 6.2 summarize the TMDL allocations for Long and Farquar Lakes.

Table 6.1 – Summary of assigned source Waste Load and Load Allocations for Long Lake

Assigned Source	Existing Phosphorus Loading		Phosphorus Allocations (WLA & LA)		Load Reduction
	(lbs/year)	(lbs/day)	(lbs/year)	(lbs/day)	(lbs/year)
City of Apple Valley (WLA)	299	0.82	48	0.13	251
Dakota County (WLA)	12	0.03	12	0.03	0
Internal Loading (LA)	188	0.52	54	0.15	134
Direct Atmospheric Loading	9	0.02	9	0.02	0
Total	**508**	**1.39**	**123**	**0.33**	**385**

Table 6.2 – Summary of assigned source Waste Load and Load Allocations for Farquar Lake

Assigned Source	Existing Phosphorus Loading		Phosphorus Allocations (WLA & LA)		Load Reduction
	(lbs/year)	(lbs/day)	(lbs/year)	(lbs/day)	(lbs/year)
City of Apple Valley (WLA)	232	0.64	63	0.17	169
City of Rosemount (WLA)	2	0.005	2	0.005	0
Dakota County (WLA)	31	0.08	31	0.08	0
Internal Loading (LA)	510	1.40	150	0.41	360
Direct Atmospheric Loading	17	0.05	17	0.05	0
Total	**792**	**2.18**	**263**	**0.72**	**529**

As additional data becomes available, after U.S. Environmental Protection Agency (EPA) approval of the TMDL, WLAs for individual permitted sources may be modified, provided the overall WLA does not change. Modifications of individual WLAs will be public noticed.

6.1.4 Seasonal and Annual Variation

Nutrient loads and therefore in-lake phosphorus concentrations for Long and Farquar Lakes are strongly influenced by annual precipitation patterns, which can be highly variable. TP loadings to the Lakes were estimated for dry (2003), normal (2005), and wet (2002) years. The annual precipitation for the dry, normal, and wet years were, 19.5 inches, 33.1 inches, and 41.1 inches, respectively. The Canfield-Bachmann lake response models along with modeled watershed loads from P8 were used to determine the total loads and the external and internal components of the loads for each scenario for both lakes. Figure 6.1 shows the seasonal variations for TP loads to Long and Farquar Lakes with the standard load required to meet the phosphorus target. The annotated percentages indicate the reduction of TP load to meet the standard.

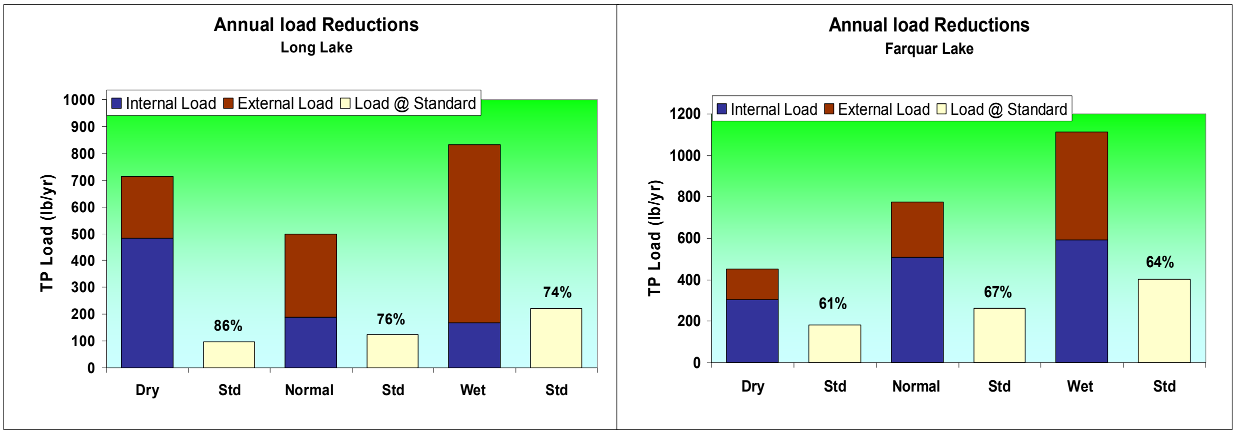


Figure 6.1 – Modeled annual loads for dry, normal and wet scenarios with associated load reductions needed to meet the standard for Long and Farquar Lakes

6.1.5 Margin of Safety (MOS)

A margin of safety has been provided in part by not including in the waste load allocation estimated reductions of 0.12 lbs/ac/yr in the direct drainage of Farquar Lake (direct drainage means that part of the drainage discharging to the lake without first traveling through a pond or other structural BMP). This reduction is attributed to:

- Enhanced street sweeping by the City of Apple Valley
- A cooperative education/information effort focused on keeping vegetative and other debris off paved surfaces, compliance with the state law to use no-phosphorus fertilizer on lawns, and disconnection of downspouts from connected impervious areas
- Installation of rainwater gardens and other bioretention features as opportunities arise

This amounts to a load reduction of 9 lbs/year of phosphorus to Farquar Lake.

In addition, a margin of safety is implicit in each TMDL due to the conservative assumptions of the modeling and proposing an adaptive management approach based on monitoring results. These were used to account for an inherently imperfect understanding of this highly dynamic shallow lake system and to ultimately ensure that the nutrient reduction strategy is protective of the water quality standard. Conservative assumptions included:

1. Developing load allocations for the summer growing season when lake water quality is worst and most sensitive to loads. Consequently, the TMDL will be protective of all seasons.

2. Utilizing data from three years to account for inter-annual variability.

TMDL implementation will be carried out on an iterative basis under an adaptive management strategy (Freeman, et. al. 2004) so that course corrections based on periodic monitoring and evaluation of the data can be used to adjust the strategy to meet the standard. After the first 5-year phase of nutrient reduction efforts, a re-evaluation will occur based on the monitored response of the system to those changes, and activities will be identified that need to be modified, removed, or added to reach the standards.

Since both Long Lake and Farquar Lake demonstrate significant internal loading characteristics typical of very degraded urban shallow lakes, internal load controls need to be implemented early in the process to overcome strong negative feedback nutrient cycles. Ultimately, a significant positive lake response will be tied to effectively controlling internal loading along with external loading.

6.2 FUTURE GROWTH AND NONDEGRADATION

The Apple Valley Surface Water Management Plan (City of Apple Valley 2007) includes a nondegradation policy (Policy 5.2) for future land development. The policy requires that any proposed development within the watershed that creates over 0.2 acres of new impervious surface achieve no-net-increase in average annual runoff volume as well as total phosphorus and total suspended solids loading compared to the condition of the site that existed immediately prior to the proposed alteration. In addition, Apple Valley has been designated as an MS4 community, and nutrient loading from future developments is included in the Waste Load Allocation covered under NPDES regulations in the Apple Valley Storm Water Pollution Prevention Program (SWPPP).

7 Public Participation

7.1 SUMMARY OF PUBLIC PARTICIPATION

The determination of a target goal, the waste load and load allocations discussed below, and the implementation plan for achieving those goals were completed with the help of a large group of stakeholders representing a range of interests and responsibilities in managing and/or using the lake and its watershed. The following groups were represented in the TMDL stakeholder process for this project:

Long Lake Association
Farquar Lake Association
City of Apple Valley
Vermillion River Watershed Joint Powers Organization
Dakota County Soil and Water Conservation District
Metropolitan Council
Minnesota Pollution Control Agency
Minnesota Department of Natural Resources
At large citizens

Between June 2006 and June 2007, five meetings were held. The first and fifth meetings were held with the stakeholder group comprised of members of all of the groups listed above. The first meeting was held on August 2, 2006 with the stakeholder group comprised of any interested members of all of the groups listed above. At this meeting, the TMDL process was explained, information was presented on general concepts of shallow lakes ecology and restoration, the current conditions of the lakes compared with recommended ecoregion-based eutrophication criteria was discussed, the concept of adaptive management was introduced, and a proposed public participation process and schedule for the remainder of the project was presented.

The second, third, and fourth meetings were held with the Technical Advisory Group, a smaller working group comprised of 1 - 2 members of the above groups. The second meeting was held on November 28, 2006 and covered the results of the diagnostic study for both lakes, including external and internal loading estimates, load sources, lake response and options for TMDL endpoints and allocations. The third meeting was held on February 1, 2007 and presented the TMDL equations for each lake as well as a suite of implementation options to achieve targeted reductions. The fourth meeting was held on March 7, 2007 and presented the final recommended TMDL allocations and implementation cost estimates for review, comment, and endorsement to the Technical Advisory Group as well as the Mayor and several City Council Members from the City of Apple Valley.

The final meeting in the TMDL process for Long and Farquar Lakes was held on June 21, 2007. The draft TMDL document and a supporting implementation plan were presented to the entire stakeholders group to receive final comments and for endorsement. The draft document was presented for review by the stakeholders group two weeks prior to the meeting.

This TMDL went through a formal public noticing process of the Minnesota Pollution Control Agency and the MPCA responded to all comments received during the Public Notice process.

8 Implementation Strategy

8.1 RECOMMENDED PHOSPHORUS MANAGEMENT STRATEGIES

The TMDL Implementation Plan will focus on reducing the movement of phosphorus from the watershed area into both Long and Farquar Lakes as well as working within the lakes themselves to reduce internal phosphorus recycling, decrease algal production as defined by chlorophyll-*a*, and improve water clarity to meet the WCBP ecoregion shallow lake criteria adopted by MPCA. Shallow lake restoration is a young science, and some of the actions proposed here should be considered experimental. Consistent with the philosophy of adaptive management outlined in Section 6.1, there will be an emphasis on assessing the impacts of the management actions to a reasonable extent and applying lessons learned to guide future actions as progress is made toward the goals.

Potential actions to achieve the phosphorus load reductions required to achieve in-lake standards include the following:

1. *Modification of an existing stormwater basin in the Long Lake watershed to enhance phosphorus removal efficiencies.* This action would be conducted within the first two years of the project implementation time period and is estimated to cost $100,000 - $150,000.

2. *Retro-fitting of infiltration practices to treat runoff from impervious cover at high priority locations in the watershed*. This action would be taken within the first five years of the project implementation time period and is estimated to cost $50,000 - $150,000.

3. *Reducing average annual phosphorus outflow loads from key satellite ponds to Long and Farquar Lakes* through a combination of actions emphasizing pre-treatment of stormwater entering the ponds, physical modifications to the ponds themselves, and management of biology in the ponds to try to achieve a clear water, native-plant dominated system. These improvements are anticipated to take place within the first three to five years of the project implementation time period and are estimated to cost $500,000 - $1,000,000.

4. *Enhanced street sweeping and public education*, emphasizing areas in the direct drainage of each lake as well as key satellite ponds. These actions would be undertaken throughout the project implementation time period and are estimated to cost up to $10,000 per year.

5. *Reduction of internal loading sources in both Long Lake and Farquar Lake* by supplementing reductions in phosphorus loadings to both lakes from the watershed with measures such as water level drawdown to control undesirable invasive aquatic plant and roughfish/stunted panfish populations, and, if needed, chemical inactivation of phosphorus in the lake sediments with iron and aluminum compounds. These elements are anticipated to take place in the first five years of the project implementation time period and are estimated to cost up to $285,000.

8.2 REASONABLE ASSURANCE

When establishing a TMDL, reasonable assurances must be provided demonstrating the ability to reach and maintain water quality standards. Several factors control reasonable assurances including: a thorough knowledge of the overall effectiveness of Best Management Practices (BMPs) and the ability to implement based on available resources, and state and local authority and regulatory controls. This TMDL establishes aggressive goals for the reduction of phosphorus loads to Long and Farquar Lakes. There are few examples where these levels of reductions have been achieved where the sources were primarily nonpoint and from both internal and external sources.

To maximize effectiveness, an adaptive management strategy will guide the development of the Implementation Plan. This Plan will identify specific BMPs that will be undertaken to reduce nutrient loading to the lakes. However, because lakes are dynamic systems, it is not known whether these BMPs will fully achieve the intended lake response. Mid-course corrections may be necessary to adapt to interim conditions. In addition, as research and technology continue to advance, and as knowledge of and experience with new BMPs increases, actions and management plans may need to be changed to incorporate these advances.

The lakes are located in the City of Apple Valley and in the Vermillion River watershed. There are three primary mechanisms assuring the implementation of improvements: the Vermillion River Watershed Joint Powers Organization (VRWJPO) and its Management Plan (2005); the City of Apple Valley and its Local Water Management Plan; and the City of Apple Valley and its NPDES Phase II Stormwater Permit. Existing and future regulation, programs and capital projects will be directed to the improvement of Long and Farquar Lakes as described below.

8.2.1 THE VERMILLION RIVER WATERSHED JPO

The Vermillion River Watershed JPO includes all or part of 20 communities in Dakota and Scott Counties, including that part of Apple Valley that drains to Long and Farquar Lakes. Management of the watershed was initially provided by the Vermillion River Watershed Management Commission, formed in 1984 by a joint powers agreement between the 20 communities in the watershed. In August 2000, the original watershed management organization dissolved and Dakota and Scott Counties became statutorily responsible for managing the watershed. The VRWJPO is now administered by a three-member Joint Powers Board of county commissioners through a joint powers agreement signed by Dakota and Scott Counties in September 2002. A nine-member citizen advisory Watershed Planning Commission supports the Joint Powers Board.

The Metropolitan Surface Water Management Act requires watersheds in the Twin Cities Metropolitan Area to be managed by watershed management organizations through the development and implementation of watershed management plans, and states that the purposes of watershed management organizations and water management programs are (Minn. Stat. Chapter 103B.201) to:

(1) protect, preserve, and use natural surface and groundwater storage and retention systems;
(2) minimize public capital expenditures needed to correct flooding and water quality problems;
(3) identify and plan for means to effectively protect and improve surface and groundwater quality;
(4) establish more uniform local policies and official controls for surface and groundwater management;
(5) prevent erosion of soil into surface water systems;
(6) promote groundwater recharge;
(7) protect and enhance fish and wildlife habitat and water recreational facilities; and
(8) secure the other benefits associated with the proper management of surface and ground water.

One of the goals of the VRWJPO's Management Plan (2005) is to protect and enhance surface water quality in the Vermillion River Watershed. To achieve this goal, the Plan establishes objectives and actions defining the JPO's role in developing and implementing TMDLs for Impaired Waters within the watershed. The JPO has been an active participant in all aspects of the Long and Farquar Lakes TMDL process, including funding and participating in the development of the TMDLs and Implementation Plans and identifying the appropriate roles and responsibilities of various stakeholders in implementing wasteload allocations and other load reduction measures. The VRWJPO has included actions and associated costs for the completion of TMDLs across the watershed and improvement project feasibility studies in its Management Plan.

The Management Plan also identifies the possibility of JPO funding to help implement load reduction measures. The Management Plan adopts a Cost Sharing Policy that describes "Achieving required pollutant load reductions identified in approved TMDLs" as among the highest priority for improvements within the watershed and making those actions eligible for JPO cost-sharing. The Capital Improvement Program includes $125,000 annually for such projects across the watershed.

8.2.2 The City of Apple Valley Surface Water Management Plan

The City of Apple Valley, as required by Minnesota Statute, has developed a Surface Water Management Plan that meets the requirements of State Statute and Administrative Rule and the requirements of the watershed management organizations having land within the city. This plan includes Goals and Policies, Watershed Requirements, Agency Requirements, Best Management Practices, watershed descriptions, stormwater quality, and infrastructure improvement planning. This Surface Water Management Plan is a component of the City's Comprehensive Plan, and is periodically updated to reflect changing conditions, new requirements, and VRWJPO Watershed Management Plan revisions. This Surface Water Management Plan sets forth the specific actions the City will undertake to achieve Watershed and local goals for stormwater management. The City also has enacted ordinances requiring stormwater quantity and quality management on development and redevelopment; regulating erosion control; and prescribing shoreland management standards.

This Surface Water Management Plan and regulatory controls will be amended as necessary to incorporate City activities identified in the TMDL Implementation Plan.

8.2.3 NPDES MS4 Stormwater Permits

The City of Apple Valley is a Municipal Separate Storm Sewer System (MS4) regulated under the State of Minnesota NPDES Phase II General Stormwater Permit. Under the General Permit, MS4s are required to develop and implement a Stormwater Pollution Prevention Program (SWPPP). The SWPPP must cover six minimum control measures:

- Public education and outreach;
- Public participation/involvement;
- Illicit discharge, detection and elimination;
- Construction site runoff control;
- Post-construction site runoff control; and
- Pollution prevention/good housekeeping.

The permit holder must identify BMPs and measurable goals associated with each minimum control measure.

According to federal regulations, NPDES permit requirements must be consistent with the assumptions and requirements of an approved TMDL and associated Waste Load Allocations. To meet this regulation, Minnesota's General Permit requires the following:

> "If your **MS4** discharges to a **Water of the State** that appears on the current **USEPA** approved list of impaired waters under Section 303(d) of the Clean Water Act (33 U.S.C. § 303 (d)), **You** must review whether changes may be warranted in your **Storm Water Pollution Prevention Program** to **Reduce** the impact of your discharge. If a **USEPA**-approved **TMDL(s)** has been developed, **you** must review the adequacy of your **Storm Water Pollution Prevention Program** to meet the **TMDL's** Waste Load Allocation set for **Storm Water** sources. If the **Storm Water Pollution Prevention Program** is not meeting the applicable requirements, schedules and objectives of the **TMDL**, **You** must modify your **Storm Water Pollution Prevention Program**, as appropriate, within **18 months** after the **TMDL** Waste Load Allocation is approved."

The TMDL Implementation Plan developed as a separate document, will identify specific BMPs and activities the City will undertake within the first five-year NPDES permit cycle following approval, as well as longer-term BMPs and activities that will be considered for implementation to achieve the required wasteload allocations. The City's SWPPP will be amended as necessary to incorporate City activities identified in the TMDL Implementation Plan.

8.3 FOLLOW-UP MONITORING PLAN

The City's NPDES Phase II MS4 Annual Report will be the mechanism by which the City will evaluate and report on progress toward implementing the BMPs detailed in the TMDL Implementation Plan. For those actions identified in this Plan for implementation by other parties, the City will request an annual progress report from that party for incorporation into the Annual Report. For this TMDL, the only parties other than the City that have implementation responsibilities are the respective Lake Associations, who will take the lead in specified public education and outreach activities with residents in the direct drainage of each Lake. The City will work with the Associations to help assure they can carry out their responsibilities.

8.3.1 FOLLOW-UP MONITORING

Adaptive Management requires ongoing monitoring to evaluate the effectiveness and impact of BMPs on water quality. Current plans are to continue the existing water quality monitoring program by Lake Association members for both Lakes through the Metropolitan Council's CAMP (Citizen Assisted Lake Monitoring Program) effort. This includes bi-weekly collection of surface water temperature and water clarity data as well as collection of discrete surface water sample collection between April 15 and October 15. Water samples will be analyzed for total phosphorus and chlorophyll-*a*. Supplemental monitoring will also be conducted by the City monthly between May 1 and September 30 on both lakes as well as on Ponds EVR-P12 and EVR-P170. This will include temperature and dissolved oxygen profiles as well as pH and conductivity for each water body.

Water samples will also be collected on EVR-P12 and -P170 and analyzed for total phosphorus, total nitrogen, and chlorophyll-*a*. Monitoring of aquatic plant and fish community species composition and abundance in both Lakes as well as in Ponds EVR-P12 and EVR-P170 will also be conducted by the City for each year of the initial 5-year project implementation period, with a more intensive effort undertaken during the first three years. Inflow quantity and quality monitoring will also be carried out during and after implementation of this TMDL to quantify actual external load reductions. The City will analyze and summarize all data. The City will fund all monitoring efforts.

8.3.2 Adaptive Management

The City will reconvene the Technical Advisory Committee (TAC) near the beginning of the fourth year of initial 5-year implementation period to review the monitoring data and evaluate project progress as well as determine if the Implementation Plan should be amended. The City of Apple Valley will act as the lead agency in this effort. If the Implementation Plan should be amended, those changes will be reflected in the next five-year NPDES Phase II General Permit covering the period 2012 to 2017. The City will work with the TAC and the MPCA to amend the Implementation Plan, obtain agency and stakeholder review and input on those amendments, and achieve final agency review and approval.

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