

## Technical Memorandum

**To:** Michael Schroeder, Tyler Pederson, & Rachael Crabb, MPRB  
**From:** Jennifer Koehler, PE, Kurt Leuthold, PE, & Fritz Doster  
**Subject:** Hiawatha Golf Course Pumping and Water Quality Summary Update  
**Date:** 8/15/2022  
**Project:** 23/27-1935

### 1 Executive Summary

Barr Engineering Company (Barr) assisted the Minneapolis Park and Recreation Board (MPRB) and the City of Minneapolis (City) on the evaluation of the surface, storm, and groundwater management issues related to the Hiawatha Golf Course area and performed an alternatives assessment for the golf course area which was completed in July 2017. As part of that study, available data related to pumping, lake levels and creek flows, groundwater levels and quality, and pond and lake water quality were compiled and summarized as part of that assessment. The 2017 assessment is summarized in a variety of documents available [here](#).

Additionally, building off this assessment, Barr and its team helped develop the [MPRB Hiawatha Golf Course Area Master Plan](#) which was completed in February 2021.

Since the completion of the 2017 assessment and through the master planning process, the MPRB has been collecting additional data on Lake Hiawatha water levels, pumping rates and volumes at the Hiawatha Golf Course, and golf course pond and Lake Hiawatha water quality. The MPRB asked Barr to update past assessments to incorporate and summarize the new data, which is further discussed in the sections below. The following are the main take aways from the update to the assessment:

- In general, Lake Hiawatha water levels are showing similar trends as seen in data collected since the dam at Gray's Bay on Lake Minnetonka was replaced. However, it is worth noting that in 2019 (one of the wettest years on record), the lake was at elevations corresponding to sustained high flow conditions (814+ ft MSL) all season (spring through fall). The berm overtopped in May 2019. This was not captured in the lake level data (due to the timing of the data collection), but this event was documented in a news story.
- From a pumping standpoint, annual pumping has been higher the past several years than originally estimated during the 2017 assessment summary (100 – 200 MG per year higher). The highest pumping was observed in 2019, an extremely wet year.

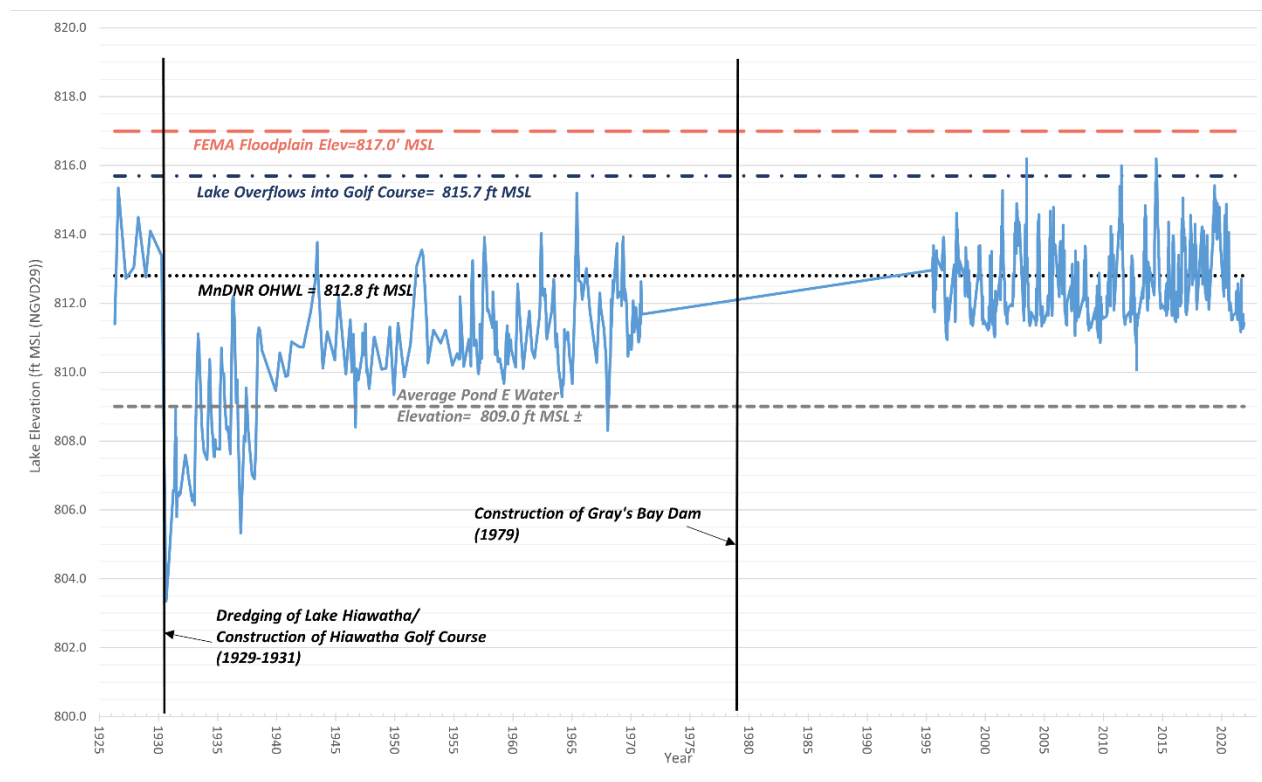
- The data suggests there were some modifications made to the operations of the Pond E pumps in 2017 that more equally runs the two pumps (and potentially increased the total pumping) that continues to present.
- Based on the data from 2020-2021, the Pond E pumping system is currently the primary pumping system for the golf course (pumping ~99% of the volume per year). The other 4 pumps in the golf course only pump ~1% of the total volume from the golf course.
- Lake Hiawatha water quality (total phosphorus) has shown some improvement in overall growing season water quality when compared to the TMDL assessment period and other historic data. However, the average over of the most recent 10-year indicates that the lake is still impaired.
- The golf course pond total phosphorus levels generally fall in the range of stormwater ponds. However, the growing season total phosphorus concentration averages are 2-3 times higher than the water quality in Lake Hiawatha.
- The estimated growing season total phosphorus loads from the estimated pumping from 2016-2021 when compared to the TMDL load assessment could represent 2.0% of the seasonal load to Lake Hiawatha (on average) but ranges from 0.5% during wet/high flow conditions to as much as 28% of the load during dry/low flow conditions.

## 2 Lake Level Summary

Lake levels on Lake Hiawatha are significantly influenced by the flows on Minnehaha Creek. The flows on Minnehaha Creek are impacted by precipitation/runoff events as well as the operations at Gray's Bay dam on Lake Minnetonka. The discharge from Gray's Bay dam can vary throughout the year; however, highest flows are typically discharged from the dam during wet climatic periods when levels on Lake Minnetonka are high or in the fall when Lake Minnetonka is being drawn down to develop flood storage for the spring snowmelt.

Past evaluations of lake level data are summarized in Section 4.0. of the [Hiawatha Golf Course – Stormwater, Surface Water, and Groundwater Analysis Summary \(February 2017\)](#) and Section 4.2 of the [Hiawatha Golf Course Area – Water Management Alternatives \(June 2017\)](#).

MPRB staff provided additional Lake Hiawatha level monitoring data from 2017 through 2021. Figure 1 is a summary of lake level data for Lake Hiawatha including the data previously summarized and the addition of the more current data provided by the MPRB from 2017 through 2021. The figure also includes key elevations including, Average Pond E Water Elevation, the Minnesota Department of Natural Resources (MnDNR) Ordinary High-Water Level (OHWL), the berm overflow elevation where water spills from Lake Hiawatha into the Golf Course, and the FEMA floodplain elevation on Lake Hiawatha and the Hiawatha Golf Course.



**Figure 1 - Lake Hiawatha Water Levels through 2021**

Review of this historic data as well as the data collected following the replacement of the Gray's Bay Dam on Lake Minnetonka, suggests the following:

- Installation of utilities under Minnehaha Creek downstream of Lake Hiawatha have created high points in the downstream Minnehaha Creek channel that ultimately control the water levels in the lake (with the existing outlet weir being submerged). Additionally, the replacement of the dam at Lake Minnetonka in 1979 has modified the flow regime in the creek, resulting in more constant flows throughout the year when historically flows would stop in Minnehaha Creek during dry periods. During extremely low flow conditions, Lake Hiawatha is typically sitting around elevation +/-811.0 ft MSL.
- Average water levels in the lake since the replacement of the Gray's Bay Dam are similar to the established OHWL (812.8 ft MSL).
- With rain events, water levels in Lake Hiawatha are highly variable, being impacted by both the discharges from Gray's Bay and upstream water bodies as well as the runoff from the more local watershed to the lake and Minnehaha Creek. This bounce in water levels typically range from 1-4 feet.
- Additionally, there are periods of sustained high flows (~250-300 cfs) along Minnehaha Creek that result in sustained high water elevations in Lake Hiawatha. This condition can occur when Lake

Minnetonka is being drawn down in the fall or when there have been long periods of above average precipitation. For example, there were recently high sustained lake levels observed in Lake Hiawatha throughout 2019.

- There are several times in the record since 1995 where the recorded lake levels are above the minimum berm elevation between Lake Hiawatha and the Hiawatha Golf Course (approximately 815.7 ft MSL), indicating water overtops the berm and spills into the golf course, temporarily flooding portions of the course. This occurred in 2003, 2011, 2014. There were also [observed berm overflows on May 27, 2019](#); however, due to the overtopping occurring on a holiday weekend and the frequency of the MPRB lake level monitoring (typically weekly readings), the resolution of the lake level monitoring data did not capture the peak lake elevation on the date of the occurrence.

### 3 Pumping Summary

As part of the 2017 assessment, Barr monitored groundwater levels, Lake Hiawatha and pond levels, pumping rates and total pumped volumes at the Hiawatha Golf Course from the December 2015 through June 2016, in order to understand the magnitude of pumping at the course and the groundwater impacts and inform the groundwater modeling used to evaluate pumping alternatives. During the original assessment, focus was only on the pump station located at Pond E in the golf course, based on direction by the MPRB, as that lift station is the primary pumping system for the golf course. Past pumping evaluations are summarized in Section 3.0. of the [Hiawatha Golf Course – Stormwater, Surface Water, and Groundwater Analysis Summary \(February 2017\)](#) and Section 3.0 of the [Hiawatha Golf Course Area – Water Management Alternatives \(June 2017\)](#).

Because the monitoring equipment from the 2017 assessment was still installed and collecting data on the Pond E pumps in 2019, Barr downloaded the available detailed Pond E pumping data which was available for April and May 2019.

Since the completion of the original assessment and the master plan, the MPRB identified and provided information on four additional pumps within the golf course. These pumps were installed on various dates over the past 20 years to maintain playability of the course and to keep it dry. In 2020 and 2021, the MPRB worked with Young Environmental Consulting Group to collect additional data on the pumping occurring at all pump locations. These pump locations are shown in Figure 2 and are summarized below:

- Pump 1 – Located at Pond E, primary pumping location for the golf course pumping surface runoff, regional groundwater, and seepage from lake
- Pump 2 – Located at Pond K, may be pumping surface runoff, regional groundwater, and seepage from lake/creek
- Pump 3 – Located at Pond H, may be pumping surface runoff, regional groundwater, and seepage from lake
- Pump 4 – Located behind berm at north end of Lake, likely pumping local runoff

- Pump 5 – Located behind berm south of Minnehaha Creek, likely pumping local runoff

During the more recent study, flow meters were installed on previously nonmetered pumps to estimate the flow rate of the pump when operating. Additionally, monthly pump totalizer readings were read at each pump to record the hours the pumps ran. The hours in combination with the flow rates were used to determine a total pumped volume from each pump. Additional details of each pump location are included in the Hiawatha Golf Course Pumps—Volume Calculation and Operations and Maintenance Plan (December 2020).

Table 1 summarizes the annual total pumped volume from the Hiawatha Golf Course based on the Pond E pump totalizer readings and estimates based on the flow rates and pumping frequency from 2015-2021, as provided by the MPRB. Also included is the monitored pumping data available for the additional pumping locations within the golf course area. Included in this table is the corresponding summary of the annual precipitation from Minneapolis-St. Paul International Airport (MSP).

In general, the primary pumping location for the golf course is the lift station at Pond E, which is estimated to pump approximately 99% of the total volume (including a combination of surface runoff, regional groundwater inflows, and seepage from the lake/creek) from the golf course while the other four pump locations pump the other 1% of the volume. Annual pumping has ranged from 261.9 to 501.3 million gallons per year from 2015 through 2021. Pumped volumes during recent years have typically been higher than estimated during the original 2017 assessment.

In addition to the annual total pumped volumes, the available monitoring data was used to estimate the approximate monthly pumping volume from Hiawatha Golf Course to Lake Hiawatha for each year from 2016 – 2021. Pump location 1 at Pond E is the primary pump location and had the most comprehensive data (both annually and monthly). The data suggests there were some modifications made to the operations of the Pond E pumps in 2017 that more equally runs the two pumps (and potentially increased the total pumping) that continues to present. For Pump locations 2-5, data was limited to monthly data collected for a portion of 2020 and 2021. This monthly pumping summary also includes the estimated pumped volume per growing season and per year and is included as Attachment A.



**To:** Michael Schroeder, Tyler Pederson, & Rachael Crabb, MPRB  
**From:** Jennifer Koehler, PE, Kurt Leufhold, PE, & Fritz Doster  
**Subject:** Hiawatha Golf Course Pumping and Water Quality Summary Update  
**Date:** 8/15/2022  
**Page:** 7

**Table 1 – Total Annual Pumping Estimates for Hiawatha Golf Course**

Year	Annual Precip (MSP Airport) (in)	Pond E / Location 1			% of Total Pumped Volume	Pond K / Location 2 <sup>2</sup>	Pond H / Location 3 <sup>3</sup>	North Fairway / Location 4 <sup>4</sup>	South Fairway / Location 5 <sup>4</sup>	Total Pumping From Hiawatha Golf Course
		Left	Right	Total						
		(gallons)	(gallons)	(gallons)						
2015 <sup>3,5</sup>	36.1	45,192,429	216,718,203	261,910,632	99.0	0	322,936	34,834	264,529,738	
2016 <sup>5</sup>	40.4	10,865,089	289,279,214	300,144,303	99.0	0	370,078	39,919	303,145,746	
2017 <sup>5</sup>	32.4	252,659,494	213,988,123	466,647,617	99.0	0	575,377	62,064	471,314,093	
2018 <sup>5</sup>	33.6	261,716,276	209,646,010	471,362,286	99.0	0	581,190	62,691	476,075,908	
2019 <sup>5</sup>	43.2	230,985,181	270,333,635	501,318,816	99.0	0	618,126	66,675	506,332,004	
2020	29.9	202,114,177	194,129,945	396,244,121	98.9	0	223,377	131,668	400,741,182	
2021	26.0	227,723,364	135,404,977	363,128,341	98.8	0	612,520	16,117	367,378,794	
1 – 2015 annual pumped volume for Pond E/Location 1 estimated by extrapolating the Dec 2015 pumping volume to the entire year.										
2 – Pond K / Location 2 pump is documented to have issues with backflow due to a broken check valve as documented in the Hiawatha Golf Course Pumps—Volume Calculation and Operations and Maintenance Plan (December 2020). This results in an over-estimation of total pumped volume in 2020 & 2021 since hour meter readings include pumping of backflow water as well as groundwater / stormwater.										
3 – Pond H / Location 3 pumps are indicated as out of service & needing repair in the Hiawatha Golf Course Pumps—Volume Calculation and Operations and Maintenance Plan (December 2020). Therefore, no pumping data was collected.										
4 – Pump locations 4 & 5 are small sump pumps. They typically operate spring through fall during rain events and are removed in the winter to protect them from freezing.										
5 – Pumped Volume for pump locations 2, 4, & 5 are estimated as 1% of the Pond E / Location 1 pumped volume for years 2015 – 2019 based on the 2020 – 2021 monitoring data as there is no available data during these years.										

## 4 Water Quality Summary

### 4.1 Lake Hiawatha Total Maximum Daily Load Summary

Lake Hiawatha is listed as impaired for excess nutrients (total phosphorus (TP)) by the Minnesota Pollution Control Agency (MPCA). A [Total Maximum Daily Load \(TMDL\)](#) study (Tetra Tech, 2013) was completed and approved on February 24, 2014. Site-specific standards were established for Lake Hiawatha including the following water quality goals for the growing season (June-September):

- Total Phosphorus < 50ug/L (0.05 mg/L)
- Chlorophyll a < 14 ug/L
- Secchi Depth > 1.4 m

Through the TMDL process, the seasonal (June – September) flow volumes, phosphorus loads, and lake residence time were summarized from 2001 through 2011 (11 years). The average seasonal inflow to the lake is 1,053 million cubic feet with 77% of the inflow from Minnehaha Creek and 23% coming from stormflow. The seasonal total phosphorus load to Lake Hiawatha is 6,463 pounds. A 30-percent reduction in the total phosphorus load would be needed to achieve the TMDL. For the City of Minneapolis, a load reduction of 400.4 pounds total phosphorus per growing season is required.

The estimated average water residence time for Lake Hiawatha is 4.4 days (ranging from 1.8 to 47.4 days). The TMDL indicates that internal loading may be a source of phosphorus to the lake during low flow conditions/years when the residence time is longer and the lake may become stratified. However, under normal and high flow conditions, stratification typically does not occur and residence times are short, minimizing the impact of internal loading on lake water quality.

#### 4.1.1 Local Watershed Contribution Estimate

The TMDL assessment focused on the flows and loads from Minnehaha Creek, which is the main source of load to Lake Hiawatha. However, there is a local watershed that drains to the lake that is not directly accounted for in the Minnehaha Creek flow and load assessment. The MPCA Minimal Impact Design Standards (MIDS) calculator was used to estimate the total phosphorus load from the local Lake Hiawatha watersheds to the north and west of the lake. Based on this assessment, the local watershed contributes on average approximately 330 pounds of total phosphorus to the lake during the growing season and represents approximately five (5) percent of the seasonal phosphorus load to Lake Hiawatha (6,463 pounds), as estimated in the TMDL study. For more information, see Section 5.2 of the [Hiawatha Golf Course Area – Water Management Alternatives \(June 2017\)](#).

### 4.2 Lake Hiawatha Water Quality

MPRB staff collect water quality data on Lake Hiawatha, including data through 2021. Barr downloaded the available water quality data from the MPCA website, including all data from the MPRB through 2021, and summarized the average growing season (June – September) total phosphorus concentrations for all surface sample (0-2 m) data available. Table 2 summarizes the Lake Hiawatha growing season average

**To:** Michael Schroeder, Tyler Pederson, & Rachael Crabb, MPRB  
**From:** Jennifer Koehler, PE, Kurt Leuthold, PE, & Fritz Doster  
**Subject:** Hiawatha Golf Course Pumping and Water Quality Summary Update  
**Date:** 8/15/2022  
**Page:** 9

---

total phosphorus concentrations by year for all available data. Values in red represent values that exceed the site water quality standard for the Lake.

In general, Lake Hiawatha water quality (total phosphorus) has improved from historic conditions and even shown some improvements since the completion of the TMDL study in 2011. However, even with the most recent data (past 10-years), the lake water quality does not consistently meet the MPCA water quality standard and is still considered impaired.

**Table 2 – Lake Hiawatha Growing Season Total Phosphorus Concentrations**

Year	Sample Count	Growing Season Avg TP (mg/L)
1988	2	0.105
1989	2	0.110
1990	2	0.190
1991	2	0.115
1992	7	0.074
1993	5	0.058
1994	11	0.051
1995	8	0.064
1996	17	0.068
1997	10	0.071
1998	9	0.068
1999	7	0.048
2000	8	0.098
2001	15	0.062
2002	13	0.070
2003	8	0.071
2004	8	0.060
2005	8	0.066
2006	9	0.064
2007	8	0.096
2008	9	0.072
2009	9	0.096
2010	9	0.062
2011	9	0.059
2012	9	0.090
2013	8	0.062
2014	9	0.050
2015	9	0.064
2016	10	0.052
2017	8	0.045
2018	9	0.045
2019	9	0.053
2020	10	0.048
2021	10	0.081
<b>Growing Season Average (2001-2011)<sup>1</sup></b>		<b>0.071</b>
<b>Growing Season Average (2012-2021)<sup>2</sup></b>		<b>0.059</b>
1 - Represents evaluation period from the TMDL study		
2 – Represents most recent 10-year period		
0.0XX - Red TP concentration indicates value exceeds the MPCA site specific standard (0.050 mg/L)		

### 4.3 Hiawatha Golf Course Water Quality

During the original assessments, Barr staff collected water quality grab samples from the Hiawatha Golf Course Ponds in January 2016. These grab samples were tested for a variety of parameters. MPRB staff also collected additional water quality grab samples from Lake Hiawatha and the Hiawatha Golf Course Ponds (collected at Pond E, in pump vault, or at pump discharge pipe, depending on accessibility) in January, April, and May 2017. These samples were tested for total phosphorus and soluble reactive phosphorus (dissolved phosphorus). Water quality data collected as part of past studies was originally summarized in Section 3.2. of the [Hiawatha Golf Course – Stormwater, Surface Water, and Groundwater Analysis Summary \(February 2017\)](#) and Section 5.0 of the [Hiawatha Golf Course Area – Water Management Alternatives \(June 2017\)](#).

MPRB staff recently provided annual water quality data for four (4) of the ponds in the Hiawatha Golf Course that are typically collected during the growing season (June through September) as part of environmental certification that the golf course has for the Audubon Cooperative Sanctuary Program. This typically includes collection of one sample per pond per year and includes data from 2009 through 2022. Figure 3 shows the location of the ponds where this water quality data has been collected.

There are several naming conventions for the ponds in the Hiawatha Golf Course (See different naming conventions in Figure 2 and Figure 3). The following provides a connection between the naming conventions:

- Pond 1 = Pond A
- Pond 2 = Pond D
- Pond 3 = Pond F
- Pond 4 = Pond G

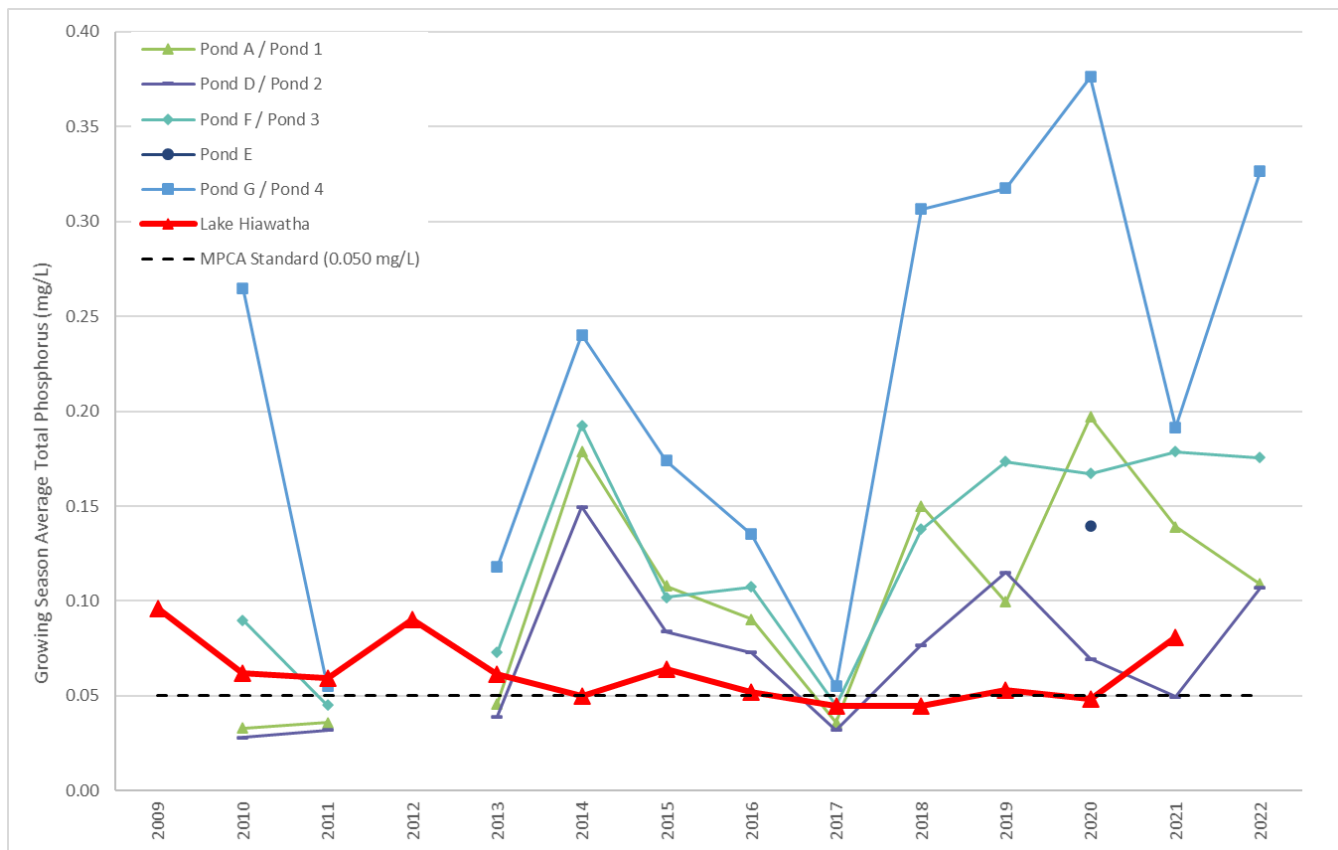


Source: MPRB

### Figure 3 – Hiawatha Golf Course Pond Water Quality Monitoring Summary

Additionally, in 2020, MPRB staff conducted stormwater pond investigations for ponds throughout the MPRB system as part of the MPRB Pond Screening and Monitoring Program. This program included survey and sampling of Pond E (at the primary pumped outlet) in the Hiawatha Golf Course. Additional details about this program and complete data collected are outlined in the [MPRB 2020 Water Resources Report](#).

Water quality data, specifically total phosphorus, collected as part of the original assessment and the more recent efforts were compiled and summarized. Total phosphorus growing season (June through September) averages were calculated for each monitored ponds in the Hiawatha Golf Course. Figure 4 includes a plot of the average growing season total phosphorus concentrations for Lake Hiawatha, the MPCA site-specific total phosphorus standard, and the corresponding growing season total phosphorus concentrations in the monitored ponds in the Hiawatha Golf Course from 2009-2022.



**Figure 3 – Growing Season Average Total Phosphorus Concentration Summary**

Total phosphorus levels in the golf course ponds varies, both in time as well as spatially. Ponds 1/A, 2/D, 3/F and Pond E are ponds located in series from west to east across the course, conveying both stormwater runoff from the golf course as well as the watershed west of the golf course and are likely influenced by groundwater as well. These ponds generally show similar phosphorus levels and trends. Pond 4/G primarily collects runoff from the golf course only and may also be influenced by groundwater. Pond 4/G has total phosphorus concentrations that track significantly higher (on average double) than the other monitored ponds in the golf course; however, no pumping occurs at Pond 4/G and discharges from this pond are ultimately reflected in the pumping at Pond E.

The growing season average total phosphorus concentrations in the various golf course ponds ranged from 0.028 mg/L to 0.376 mg/L, with an average of 0.128 mg/L across all ponds based on all available data. These levels are typical of total phosphorus concentrations observed in urban stormwater ponds.

Based on the water quality data for the golf course ponds as compared to Lake Hiawatha, the growing season total phosphorus concentrations in the Hiawatha Golf Course ponds are 2-3 times the concentrations observed in corresponding Lake Hiawatha samples.

#### 4.4 Golf Course Total Phosphorus Loading Summary

The TMDL study provided a summary of the estimated growing season flows and volumes into Lake Hiawatha and determined that the seasonal variation in flows has a strong influence on the estimated total phosphorus loads to Lake Hiawatha. Based on the TMDL assessment period (2001-2011), Table 2 summarizes the Lake Hiawatha growing season inflow volumes and phosphorus loads, as presented in the TMDL report.

**Table 3 – Lake Hiawatha Growing Season Flow and Total Phosphorus Loads from TMDL Report**

	Flow (MG/Growing Season)	Total Phosphorus Load (lbs/Growing Season)
<b>Minimum (Low Flow, per Figure 5-11 of TMDL)</b>	733 MG (2009)	700 lbs
<b>Average (per Figure 5-11 of TMDL)</b>	7,568 MG (2001-2011)	5,061 lbs
<b>Average (per Table 5-3 and 5-6 of TMDL)</b>	7,876 MG (2001-2011)	6,463 lbs
<b>Maximum (High Flow, per Figure 5-11 of TMDL)</b>	19,201 MG (2002)	15,000 lbs

As outlined in Section 3 above, the estimated pumping data for the golf course pumping locations were summarized by month, growing season, and year and are included in Attachment A. This monthly pumping data was used in conjunction with the water quality monitoring data available for the golf course ponds in corresponding months to estimate month, growing season, and annual total phosphorus loads being pumped from the golf course to Lake Hiawatha.

Because golf course pond water quality data was not available for every month, Barr utilized the observed water quality data in the corresponding months/years. Typically, this data is only available in months falling in the growing season (June-September) although there are some samples that were collected outside the growing season (e.g. April, May, October, November). Additionally, there is only one data point collected in the winter (January 2016). This total phosphorus concentration was applied in January of every year and concentrations for months where no data were available were linearly interpolated between the months with observed data.

For the total phosphorus loading estimates, focus was primarily on Pond E. Pond E is the main pumping location for the golf course, accounting for approximately 99% of the pumped volume to the lake and has the most complete pumping estimates from 2016-2021. Additionally, there are water quality monitoring data available for Pond E and Pond F to provide good estimates of the actual total phosphorus concentrations that were being pumping in any given year. Because Pond E data was limited to a few dates in 2016, 2017, and 2020, Barr assumed that water quality data for Pond F would be representative of Pond E water quality on dates where data was not available as it is located immediately upstream of and discharges directly into Pond E.

There were no water quality data directly associated with the other four pumping locations in the golf course. As a result, Barr estimated that the total phosphorus load contribution from these other pumping locations was equivalent to the fraction of the total pumped volume (~1%) from the golf course, based on the 2020 and 2021 monitoring data.

Table 4 summarizes the annual and growing season pumped volumes and estimated total phosphorus loads from the Hiawatha Golf Course to Lake Hiawatha, by year from 2016 to 2021. Attachment A includes the more detailed summary of the monthly, growing season, and annual pumped volumes and estimated total phosphorus loads from the golf course.

Based on the estimated growing season volume pumped from the golf course to Lake Hiawatha using the monitoring data, the estimated pumped volume could range from 87.0 MG to 150.8 MG per growing season, with an average of 123.8 MG per growing season. This suggests that pumping from the golf course is approximately 1.6% of the total seasonal inflow volume to the lake on average but could range from approximately 0.5% (wet conditions) to 10.5% (dry conditions), based on the information summarized from the TMDL study.

Using the water quality data from the golf course ponds along with the estimated pumped volume, Barr estimates that growing season total phosphorus loads could range from 74.3 lbs to 199.5 lbs of total phosphorus per growing season, with an average of 125.8 lbs. This suggests that pumping from the golf course is approximately 2.0% of the total seasonal phosphorus load to the lake on average but could range approximately 0.5% (wet conditions) to 28% (dry conditions), based on the information summarized from the TMDL study.

**Table 4 – Hiawatha Golf Course Annual and Growing Season Pumping and Total Phosphorus Load Summary**

		Precip (MSP Airport) (in.)	Pond E (Location 1)			Other Pumps (Locations 2, 3, 4, & 5)		Total System	
			Pumped Volume (US Gal)	% Pumped Volume	Estimated TP Load to Lake Hiawatha From Pond E (lbs)	Pumped Volume (US Gal) <sup>1</sup>	Estimated TP Load to Lake Hiawatha (lbs) <sup>2</sup>	Pumped Volume (US Gal)	Estimated Total TP Load to Lake Hiawatha
<b>2016</b> <sup>1</sup>	Annual	40.4	300,144,303	99.0%	228.9	3,001,443	2.3	303,145,746	231.2
	<i>Growing Season</i>	22.9	98,430,900	32.5%	83.6	984,309	0.8	99,415,209	84.4
<b>2017</b> <sup>1</sup>	Annual	32.4	466,647,617	99.0%	331.8	4,666,476	3.3	471,314,093	335.1
	<i>Growing Season</i>	15.2	139,135,273	29.5%	73.6	1,391,353	0.7	140,526,626	74.3
<b>2018</b> <sup>1</sup>	Annual	33.6	471,362,286	99.0%	416.2	4,713,623	4.1	476,075,908	420.3
	<i>Growing Season</i>	17.9	140,540,995	29.5%	149.3	1,405,410	1.5	141,946,405	150.8
<b>2019</b> <sup>1</sup>	Annual	43.2	501,318,816	99.0%	514.2	5,013,188	5.1	506,332,004	519.3
	<i>Growing Season</i>	19.4	150,818,065	29.8%	197.5	1,508,181	2.0	152,326,245	199.5
<b>2020</b>	Annual	29.9	396,244,121	98.9%	346.0	4,497,061	3.9	400,741,182	349.9
	<i>Growing Season</i>	14.8	118,143,824	29.5%	127.2	2,884,662	1.4	121,028,486	128.7
<b>2021</b>	Annual	26.0	363,128,341	98.8%	350.1	4,250,453	4.1	367,378,794	354.2
	<i>Growing Season</i>	11.3	86,986,080	23.7%	115.9	907,698	1.3	87,893,778	117.2
<b>Average (2016-2021)</b>	<b>Annual</b>		<b>416,470,000</b>	<b>99.0%</b>	<b>364.5</b>	<b>4,357,041</b>	<b>3.8</b>	<b>420,831,288</b>	<b>368.3</b>
	<b><i>Growing Season</i></b>		<b>122,340,000</b>	<b>98.8%</b>	<b>124.5</b>	<b>1,513,602</b>	<b>1.3</b>	<b>123,856,125</b>	<b>125.8</b>
1 – Pumped Volume for pump locations 2, 4, & 5 are estimated as 1% of the Pond E / Location 1 pumped volume for years 2016 – 2019 based on the 2020 -2021 monitoring data as there is no available data during these years.									
2 - Due to lack of TP concentration data at sites other than Pond E/F, TP load from pump locations 2-5 is assumed to be 1% of the Pond E TP load estimate (similar concentration as Pond E).									

## **Attachment A: Hiawatha Golf Course Pumping Summary and Total Phosphorus Load Analysis**

	Annual Precip (MSP Airport) (in)	Pond E (Location 1)					TP Data				TP Load to Lake Hiawatha From Pond E (lbs)	Pond K (Location 2) <sup>1</sup>	Pond H (Location 3) <sup>2</sup>	North Fairway (Location 4) <sup>3</sup>	South Fairway (Location 5) <sup>3</sup>	Sum of Auxillary Pumps (Locations 2, 3, 4, & 5)			System Totals		
		Left Pump	Right Pump	Combined Pumped Volume (US Gal)	% Annual Pumped Volume	Pumped Volume Estimate Notes	Pond E Observed TP (mg/L)	Pond F Observed TP (mg/L)	TP - Used for Pond E Load Estimates (mg/L)	TP Load Estimate Notes		Pumped Vol (US Gal)	Pumped Vol (US Gal)	Pumped Vol (US Gal)	Pumped Vol (US Gal)	Pumped Vol (US Gal) <sup>5</sup>	% Total	Other Pump TP Loading (1%) <sup>6</sup>	Total Pumping Volume (US Gal)	Total TP Loading (lbs)	
<b>2016</b>	<b>40.4</b>	<b>10,865,089</b>	<b>289,279,214</b>	<b>300,144,303</b>	<b>99.0%</b>						<b>228.9</b>						<b>3,001,443</b>	<b>1.0%</b>	<b>2.3</b>	<b>303,145,746</b>	<b>231</b>
<b>Growing Season</b>	<b>22.9</b>			<b>98,430,900</b>	<b>32.5%</b>						<b>83.6</b>						<b>984,309</b>		<b>0.8</b>	<b>99,415,209</b>	<b>84</b>
Jan	0.3	2,206,883	18,454,525	20,661,408	6.9%	collected data	0.076		Pond E		13.1										
Feb	1.1	0	18,530,801	18,530,801	6.2%	collected data			Interpolated		12.6										
Mar	2.3	0	22,124,442	22,124,442	7.4%	collected data			Interpolated		15.9										
Apr	2.8	2,718,186	20,387,568	23,105,754	7.7%	collected data			Interpolated		17.6										
May	2.4	379	17,842,288	17,842,667	5.9%	collected data			Interpolated		14.4										
Jun	4.5	3,197,799	17,785,656	20,983,456	7.0%	trend data			Interpolated		17.9										
Jul	5.1			22,205,727	7.4%	adj. 2020 percentage		0.107	Pond F		19.9										
Aug	7.8			29,734,609	9.9%	adj. 2020 percentage			Interpolated		25.3										
Sep	5.5			25,507,108	8.5%	adj. 2020 percentage			Interpolated		20.6										
Oct	3.4			34,361,616	11.4%	adj. 2020 percentage			Interpolated		26.2										
Nov	3.0			33,266,269	11.1%	adj. 2020 percentage			Interpolated		23.9										
Dec	2.2			31,797,504	10.6%	adj. 2020 percentage			Interpolated		21.5										
<b>2017</b>	<b>32.4</b>	<b>252,659,494</b>	<b>213,988,123</b>	<b>466,647,617</b>	<b>99.0%</b>						<b>331.8</b>						<b>4,666,476</b>	<b>1.0%</b>	<b>3.3</b>	<b>471,314,093</b>	<b>335</b>
<b>Growing Season</b>	<b>15.2</b>			<b>139,135,273</b>	<b>29.5%</b>						<b>73.6</b>						<b>1,391,353</b>		<b>0.7</b>	<b>140,526,626</b>	<b>74</b>
Jan	1.0			39,070,951	8.4%	2020 percentage			0.076	Same as Jan 2016	24.7										
Feb	0.6			37,111,529	8.0%	2020 percentage			0.102	Interpolated	31.5										
Mar	0.7			41,884,873	9.0%	2020 percentage			0.125	Interpolated	43.8										
Apr	4.5			42,523,541	9.1%	2020 percentage	0.151		0.151	Pond E	53.6										
May	4.8			46,343,409	9.9%	2020 percentage	0.106		0.106	Pond E	40.9										
Jun	4.2			45,210,963	9.7%	2020 percentage			0.085	Interpolated	32.2										
Jul	3.1			26,929,973	5.8%	2020 percentage			0.066	Interpolated	14.7										
Aug	6.8			36,060,617	7.7%	2020 percentage		0.045	0.045	Pond F	13.5										
Sep	1.0			30,933,720	6.6%	2020 percentage			0.051	Interpolated	13.2										
Oct	4.5			41,672,015	8.9%	2020 percentage			0.057	Interpolated	19.9										
Nov	0.4			40,343,635	8.6%	2020 percentage			0.064	Interpolated	21.4										
Dec	0.8			38,562,390	8.3%	2020 percentage			0.070	Interpolated	22.4										
<b>2018</b>	<b>33.6</b>	<b>261,716,276</b>	<b>209,646,010</b>	<b>471,362,286</b>	<b>99.0%</b>						<b>416.2</b>						<b>4,713,623</b>	<b>1.0%</b>	<b>4.1</b>	<b>476,075,908</b>	<b>420</b>
<b>Growing Season</b>	<b>17.9</b>			<b>140,540,995</b>	<b>29.5%</b>						<b>149.3</b>						<b>1,405,410</b>		<b>1.5</b>	<b>141,946,405</b>	<b>151</b>
Jan	1.6			39,465,695	8.4%	2020 percentage			0.076	Same as Jan 2016	25.0										
Feb	1.3			37,486,477	8.0%	2020 percentage			0.085	Interpolated	26.6										
Mar	1.2			42,308,048	9.0%	2020 percentage			0.093	Interpolated	32.8										
Apr	2.2			42,953,168	9.1%	2020 percentage			0.102	Interpolated	36.6										
May	3.0			46,811,629	9.9%	2020 percentage			0.111	Interpolated	43.3										
Jun	3.8			45,667,742	9.7%	2020 percentage			0.120	Interpolated	45.7										
Jul	4.4			27,202,054	5.8%	2020 percentage			0.129	Interpolated	29.2										
Aug	2.8			36,424,947	7.7%	2020 percentage		0.138	0.138	Pond F	41.8										
Sep	6.9			31,246,252	6.6%	2020 percentage			0.125	Interpolated	32.6										
Oct	3.4			42,093,039	8.9%	2020 percentage			0.113	Interpolated	39.7										
Nov	1.5			40,751,237	8.6%	2020 percentage			0.101	Interpolated	34.2										
Dec	1.5			38,951,997	8.3%	2020 percentage			0.089	Interpolated	28.7										
<b>2019</b>	<b>43.2</b>	<b>230,985,181</b>	<b>270,333,635</b>	<b>501,318,816</b>	<b>99.0%</b>						<b>514.2</b>						<b>5,013,188</b>	<b>1.0%</b>	<b>5.1</b>	<b>506,332,004</b>	<b>519</b>
<b>Growing Season</b>	<b>19.4</b>			<b>150,818,065</b>	<b>29.8%</b>						<b>197.5</b>						<b>1,508,181</b>		<b>2.0</b>	<b>152,326,245</b>	<b>200</b>
Jan	0.5			42,351,627	8.4%	adj. 2020 percentage			0.076	Same as Jan 2016	26.8										
Feb	2.6			40,227,678	8.0%	adj. 2020 percentage			0.090	Interpolated	30.2										
Mar	2.0			45,401,826	9.1%	adj. 2020 percentage			0.103	Interpolated	39.0										
Apr	3.9			46,094,122	9.2%	adj. 2020 percentage			0.117	Interpolated	45.1										
May	6.7	25,814,011	19,683,037	45,497,048	9.1%	collected data			0.131	Interpolated	49.7										
Jun	2.7			49,007,198	9.8%	adj. 2020 percentage			0.145	Interpolated	59.4										
Jul	6.5			29,191,206	5.8%	adj. 2020 percentage			0.159	Interpolated	38.7										
Aug	6.3			39,088,524	7.8%	adj. 2020 percentage		0.174	0.174	Pond F	56.5										
Sep	3.9			33,531,136	6.7%	adj. 2020 percentage			0.154	Interpolated	42.9										
Oct	4.1			45,171,096	9.0%	adj. 2020 percentage			0.135	Interpolated	50.7										
Nov	2.3			43,731,175	8.7%	adj. 2020 percentage			0.115	Interpolated	41.8										
Dec	1.8			41,800,364	8.3%	adj. 2020 percentage			0.096	Interpolated	33.3										
<b>2020</b>	<b>29.9</b>	<b>202,114,177</b>	<b>194,129,945</b>	<b>396,244,121</b>	<b>98.9%</b>						<b>346.0</b>	<b>4,142,016</b>	<b>0</b>	<b>223,377</b>	<b>131,668</b>		<b>4,497,061</b>	<b>1.1%</b>	<b>3.9</b>	<b>400,741,182</b>	<b>350</b>
<b>Growing Season</b>	<b>14.8</b>	<b>81,764,792</b>	<b>36,379,032</b>	<b>118,143,824</b>	<b>29.5%</b>		<b>0.140</b>	<b>0.167</b>			<b>127.2</b>	<b>2,884,662</b>					<b>2,884,662</b>	<b>2.4%</b>	<b>1.4</b>	<b>121,028,486</b>	<b>129</b>
Jan	1.0	15,203,982	17,972,303	33,176,286	8.4%	collected data			0.076	Same as Jan 2016	21.0	-	-	-	-						
Feb	0.6	14,360,360	17,152,123	31,512,483	8.0%	collected data			0.083	Interpolated	21.8	-	-	-	-						
Mar	2.4	9,564,734	26,000,935	35,565,669	9.0%	collected data			0.090	Interpolated	26.6	-	-	-	-						
Apr	1.8	4,248,441	31,859,540	36,107,981	9.1%	collected data			0.097	Interpolated	29.2	-	-	-	-						
May	4.9	27,745,826	11,605,716	39,351,542	9.9%	collected data	0.104		0.104	Pond E	34.1	-	-	-	-						

	Annual Precip (MSP Airport) (in)	Pond E (Location 1)					TP Data				TP Load to Lake Hiawatha From Pond E (lbs)	Pond K (Location 2) <sup>1</sup> Pumped Vol (US Gal)	Pond H (Location 3) <sup>2</sup> Pumped Vol (US Gal)	North Fairway (Location 4) <sup>3</sup> Pumped Vol (US Gal)	South Fairway (Location 5) <sup>3</sup> Pumped Vol (US Gal)	Sum of Auxillary Pumps (Locations 2, 3, 4, & 5)			System Totals	
		Left Pump	Right Pump	Combined Pumped Volume (US Gal)	% Annual Pumped Volume	Pumped Volume Estimate Notes	Pond E Observed TP (mg/L)	Pond F Observed TP (mg/L)	TP - Used for Pond E Load Estimates (mg/L)	TP Load Estimate Notes						Pumped Vol (US Gal) <sup>5</sup>	% Total	Other Pump TP Loading (1%) <sup>6</sup>	Total Pumping Volume (US Gal)	Total TP Loading (lbs)
Jun	6.7	29,946,460	8,443,489	38,389,949	9.7%	collected data	0.108		0.108	Pond E	34.7	1,218,492	-	-	87,712	1,306,204	3.29%		39,696,153	
Jul	3.2	13,913,594	8,953,433	22,867,027	5.8%	collected data	0.166		0.166	Pond E	31.5	541,926	-	169,277	22,311	733,514	3.11%		23,600,541	
Aug	4.0	25,282,009	5,338,114	30,620,123	7.7%	collected data	0.138	0.167	0.138	Pond E	35.1	673,200	-	54,100	21,179	748,479	2.39%		31,368,602	
Sep	0.9	12,622,729	13,643,996	26,266,725	6.6%	collected data	0.119		0.119	Pond E	25.9	451,044	-	-	-	451,044	1.69%		26,717,769	
Oct	2.4	15,237,071	20,147,855	35,384,925	8.9%	collected data	0.113		0.113	Pond E	33.3	629,442	-	-	466	629,908	1.75%		36,014,834	
Nov	1.3	17,163,726	17,093,233	34,256,959	8.6%	collected data			0.101	Interpolated	28.7	282,744	-	-	-	282,744	0.82%		34,539,703	
Dec	0.8	16,825,245	15,919,207	32,744,452	8.3%	collected data			0.088	Interpolated	24.1	345,168	-	-	-	345,168	1.04%		33,089,620	
<b>2021</b>	<b>26.0</b>	<b>227,723,364</b>	<b>135,404,977</b>	<b>363,128,341</b>	<b>98.8%</b>	<b>0.0%</b>					<b>350.1</b>	<b>3,621,816</b>	<b>0</b>	<b>612,520</b>	<b>16,117</b>	<b>4,250,453</b>	<b>1.2%</b>	<b>4.1</b>	<b>367,378,794</b>	<b>354</b>
<b>Growing Season</b>	<b>11.3</b>			<b>86,986,080</b>	<b>23.7%</b>			<b>0.179</b>			<b>115.9</b>	<b>907,698</b>				<b>907,698</b>	<b>1.0%</b>	<b>1.3</b>	<b>87,893,778</b>	<b>117</b>
Jan	0.9			69,402,326	19.1%	trend data			0.076	Same as Jan 2016	43.9	461,142	-	-	-					
Feb	0.5			67,163,541	18.5%	trend data			0.091	Interpolated	50.9	461,142	-	-	-					
Mar	2.8	16,129,147	10,080,101	26,209,248	7.2%	collected data			0.105	Interpolated	22.8	690,030	-	-	-					
Apr	2.5			32,101,637	8.8%	trend data			0.120	Interpolated	32.0	338,844	-	-	-					
May	3.3			34,108,431	9.4%	trend data			0.134	Interpolated	38.1	338,844	-	-	-					
Jun	2.1			33,008,159	9.1%	trend data			0.149	Interpolated	41.0	338,844	-	281,866	10,456					
Jul	0.9	10,989,316	7,934,831	18,924,147	5.2%	collected data			0.164	Interpolated	25.8	131,274	-	50,820	-					
Aug	6.9	11,327,973	6,173,928	17,501,901	4.8%	collected data		0.179	0.179	Pond F	26.0	212,058	-	88,242	4,063					
Sep	1.5	9,471,047	8,080,827	17,551,874	4.8%	collected data			0.158	Interpolated	23.1	225,522	-	97,297	1,598					
Oct	1.9	8,583,660	8,282,384	16,866,044	4.6%	collected data			0.138	Interpolated	19.3	131,274	-	74,890	-					
Nov	0.9	8,212,685	8,250,530	16,463,215	4.5%	collected data			0.117	Interpolated	16.0	178,398	-	19,404	-					
Dec	2.0	6,435,405	7,392,414	13,827,819	3.8%	collected data			0.097	Interpolated	11.1	114,444	-	-	-					

1 - Pond K / Location 2 pump is documented to have issues with backflow due to a broken check valve as documented in the Hiawatha Golf Course Pumps - Volume Calculation and Operations and Maintenance plan (December 2020). This results in an over-estimation of pump volume since hour meter readings include pumping of backflow water as well as groundwater / stormwater.

2 - Pond H / Location 3 pumps are indicated as out of service & needing repair in the Hiawatha Golf Course Pumps - Volume Calculation and Operations and Maintenance plan (December 2020). Therefore no pumping data was collected.

3 - Pump locations 4 & 5 are small sump pumps. They operate spring through fall during rain events and are removed in the winter to protect them from freezing.

4 - June 2020 pumping data at Pond K / Location 2 pump is uncertain due to undocumented hour meter reading date before the second reading on 7/7/2020.

5 - Pumped Volume for pump locations 2, 4, & 5 are estimated as 1% of the Pond E / Location 1 pumped volume for years 2016 – 2019 based on the 2020 -2021 monitoring data as there is no available data during these years.

6 - Due to lack of TP concentration data at sites other than Pond E/F, TP load from pump locations 2-5 is assumed to be 1% of the Pond E TP load estimate (similar concentration as Pond E).