Stormwater Pond Project

2013 Report

February 2014

Riley
Purgatory
Bluff Creek
Watershed District

STORMWATER PONDS

Riley Purgatory Bluff Creek Watershed District

Quick Facts

No. Municipalitites Sampled	5
No. Subwatersheds Represented	13
No. Ponds Sampled in 2012	61
No. Ponds Sampled in 2013	98
No. Sampling Rounds Conducted	5
No. Total Phosphorus Samples Collected	686
No. Dissolved Phosphorus Samples Collected	110

Highest Total Phosphorus Concentration Sampled

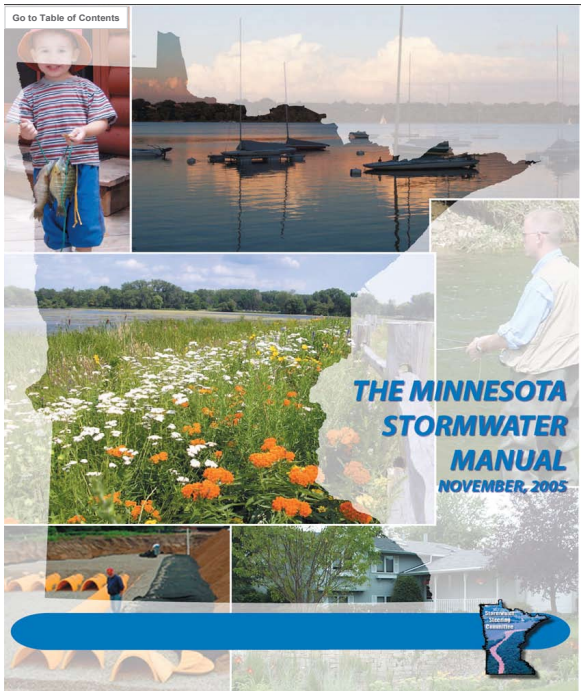
8.1 mg/L at Pond 849_w in Minnetonka (Round 3, 2013)

Lowest Total Phosphorus Concentration Sampled

0.025 mg/L at 17-13-A in Eden Prairie (Round 3, 2012)

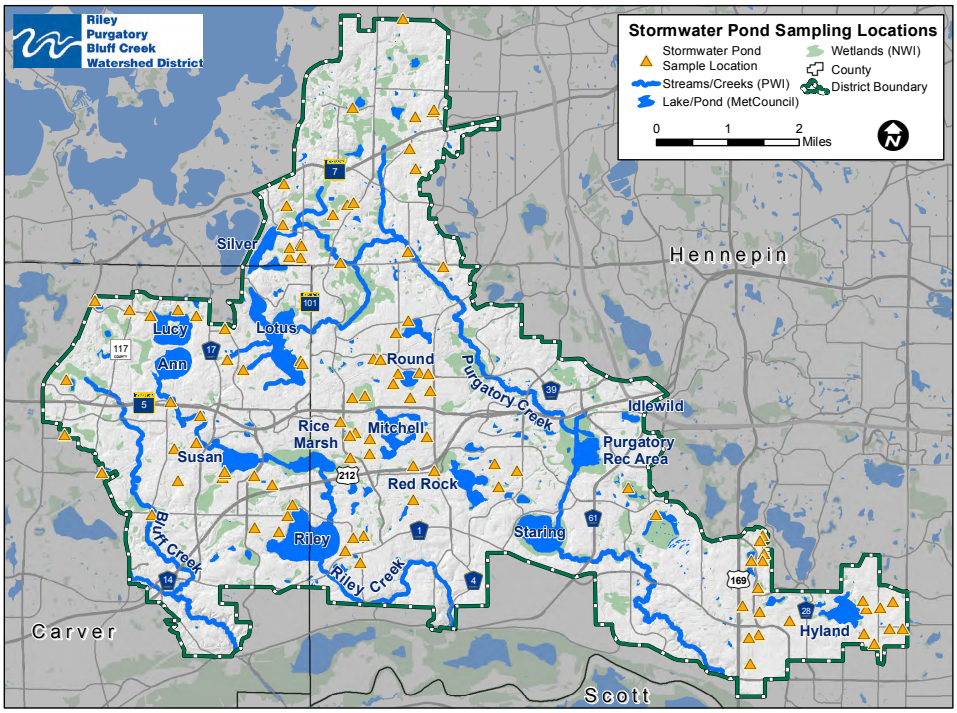
MPCA Stormwater Standard - Effluent Water

Low: 0.1 mg/L	High: 0.25 mg/L



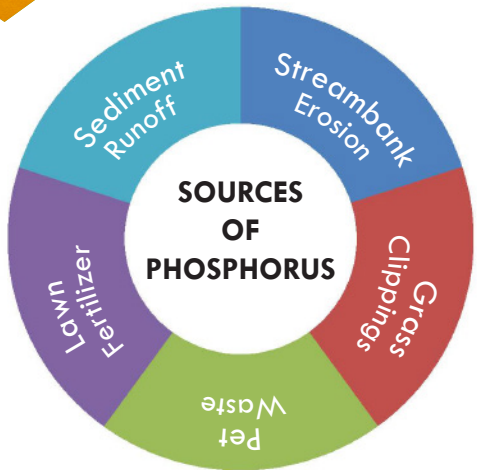
PROJECT BACKGROUND

Stormwater ponds were added to the landscape in order to "intercept, store, and treat" pollutants that move through a watershed. As part of this multiyear study, stormwater ponds were sampled in an effort to better understand if stormwater ponds are working efficiently as 'pollution sinks' or if they have become sources of pollution within the Riley-Purgatory-Bluff Creek Watershed.

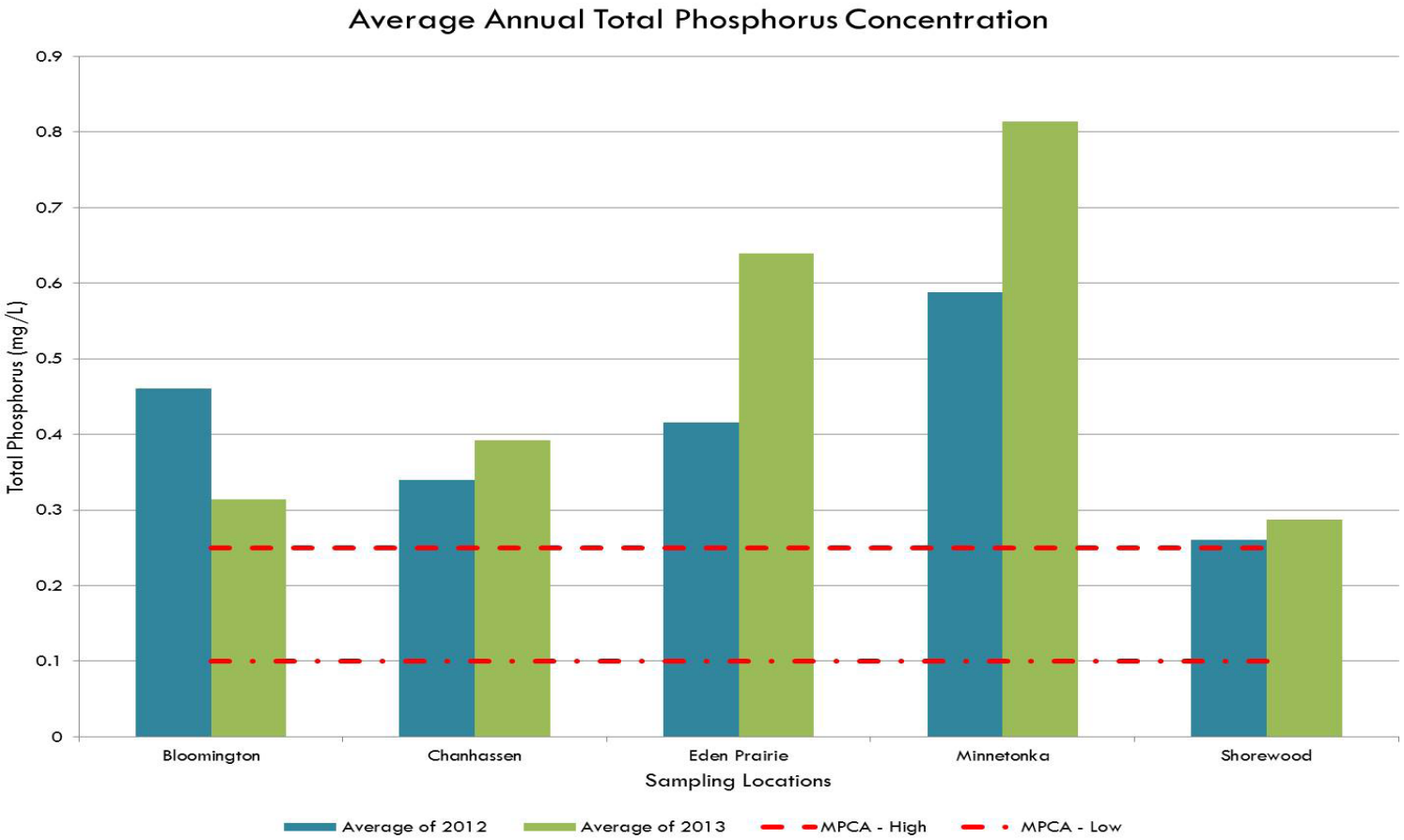


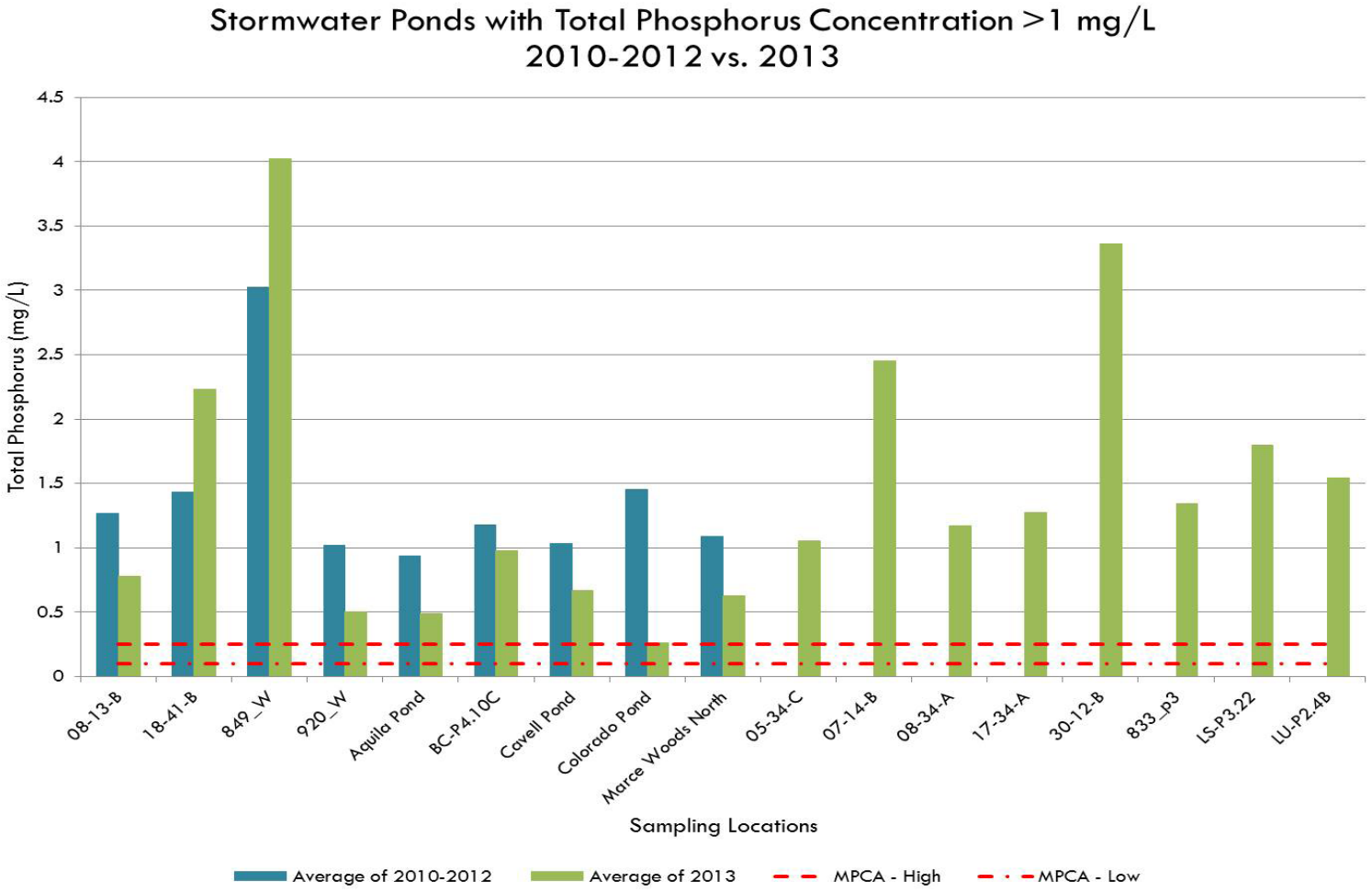
Did you know?

- Stormwater ponds are the most commonly used method for controlling pollutants, such as phosphorus and nitrogen
- Phosphorus pollution is the primary component influencing eutrophication in freshwater resources
- Excess phosphorus can lead to increased algal growth, turbid water, and loss of biodiversity and desirable aquatic habitat



STORMWATER POND PROJECT RESULTS





WATER QUALITY

Data Analysis

- Do total phosphorus concentrations vary annually?
- Do total phosphorus concentrations in a stormwater pond vary seasonally? If so, how frequently should the ponds be sampled? When should the sampling season begin and end?
- Do the ponds that had an average total phosphorus concentration >1mg/L in 2012 maintain that high concentration in 2013? After the second sampling season, do more ponds fall in this category?
- Does the origin state of the pond influence the average total phosphorus concentration?
- Which test paints a more representative picture of the state of phosphorus in the pond – dissolved phosphorus or total phosphorus?
- Do stormwater ponds work together to remove excess nutrients or do they behave independently?
- Is there a relationship between the presence/absence of macrophytes and high phosphorus levels in a stormwater pond?

How can you help?

Here are few tips to help control stormwater pollutants:

- **KEEP OUR STREET CLEAN.** Sweep up leaves, grass clippings and excess fertilizer from driveways and streets.
- **TRASH MATTERS.** Dispose of trash appropriately.
- **KEEP IT LOCAL.** Use native plants in gardens. Native plants have long roots that are more efficient in soaking up water and excess nutrients.
- **GARDEN WITH PURPOSE.** Build a raingarden. To learn more about raingardens, please visit our partner website at www.bluethumb.org.

FIELD WORK SUMMARY

The District Stormwater Pond Project was conducted by District staff in conjunction with city staff from Bloomington, Chanhassen, Eden Prairie, Minnetonka, and Shorewood. The field season started in early July and ran through the middle of September. Four rounds were completed for Bloomington and Eden Prairie (Round 5 was not conducted due to time contraints), but all five sampling rounds were completed for Chanhassen, Minnetonka, and Shorewood.

Field work included collecting water samples by integrating three water samples collected at or near the surface using a 500 mL bottle attached to a 10 ft pole or sampling stick at each sampling location and then screened with a 1.5 mm mesh in order to remove any excess plant matter or debris. In addition to gathering samples for water quality testing, climate data and pond attribute information was collected at each pond during each sampling round. Climatic data included: precipitation, temperature, wind, and cloud cover. The pond attribute data collected at each pond included: general pond and sediment smell, type of vegetation surrounding the pond (prairie grass, deciduous tree, mowed grass) or lack thereof (impervious cover), macrophyte coverage in the pond (type and percent), pond water and sediment color, and the presence or absence of bubble release from the sediment.

The pond attribute data was obtained unobtrusively by visual inspection, except for the sediment smell and color data, and when performing the bubble release test. Sediment smell and color information was collected by using a garden rake to collect a sample of the bottom substrate for staff to analyze while at the stormwater pond. The bubble test was performed by using a garden rake to disturb the bottom substrate in five separate locations along the side of the pond and then staff watched to see how many bubbles were released from the sediment following the disturbance.

District in Action

The third year of the District's stormwater assessment project will be completed in the summer of 2014. Because the previous sampling efforts took place during years with unusual and varied climactic conditions, conducting a third year of field sampling will hopefully produce a dataset that is more representative of total phosphorus levels in a stormwater pond. A third year of data will also allow District staff to highlight poorly performing stormwater ponds and begin to identify potential remediation activities that could be undertaken.

The sampling plan for the 2014 field season will differ from the previous two years in several ways. First off, the fifth sampling round in September will be forgone in favor of adding an early sampling round in late June. Incorporating a sampling round earlier in the growing season will hopefully reveal a fuller picture of total phosphorus concentrations in stormwater ponds.

In order to get a better understanding of what is happening in these ponds in real-time, the District plans to install ISCO units (automatic sampling system) at the outlet structures of two stormwater ponds in the District. The ISCO unit monitors the environmental conditions at a sampling site and collects water samples at a predetermined water level in the stormwater pond (i.e. during heavy rain event). The data provided will help ascertain the total phosphorus concentration of effluent stormwater during a heavy rain event.

The District hopes to further analyze the field data by utilizing available land use data to determine if there is a relationship between surrounding vegetation and total phosphorus levels. This analysis will be performed by quantifying the landuse types in each stormwater pond's tributary area (specifically amount impervious and vegetated) and comparing it against the total phosphorus concentration measured in each round.

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- **CITY OF SHOREWOOD** James Landini and Meredith Moore
- **CH2M HILL** Jason Carroll and Roger Scharf

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Riley Purgatory Bluff Creek Watershed District

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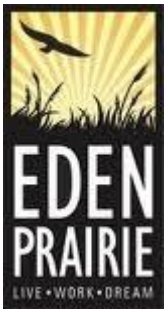

1. Project Background

The Riley-Purgatory-Bluff Creek Watershed District stormwater pond project began in 2010, with initial data collection conducted in the summers of 2010 and 2011 and the second phase beginning in 2012. The purpose of the project is to ascertain if stormwater ponds are possible sources of pollution within the District and identify the 'bad' ponds with exceptionally high total phosphorus concentrations that could be targeted for remediation projects. Stormwater ponds are the most commonly used method for controlling pollutants, such as phosphorus and nitrogen, which are found in stormwater runoff (Borden et al. 2001). Phosphorus pollution is the primary component influencing eutrophication in freshwater resources. Excess phosphorus can lead to increased algal growth, turbid water, and loss of biodiversity and desirable aquatic habitat.

In the 21st Century, most urban lakes will receive more phosphorus than necessary and the phosphorus levels are projected to be even higher in the future (Schueler 2001). Urban watersheds, like the Riley-Purgatory-Bluff Creek Watershed, typically export 5 to 20 times the amount of phosphorus than less developed watersheds due to an increase in the amount of impervious cover (streets, sidewalks, and driveways) and surface runoff for a watershed (Athayde et al. 1983, Dennis 1985). Potential sources of phosphorus pollution in the Riley-Purgatory-Bluff Creek Watershed District include: stormwater runoff, sediment erosion, grass clippings, lawn fertilizer, and pet waste.

1.1 Project History

During the first year of field monitoring in 2010, five stormwater ponds were selected for sampling in Chanhassen and Eden Prairie. The number of sampling locations increased to 61 sites in 2012 in five municipalities within the District boundaries (Bloomington, Chanhassen, Eden Prairie, Minnetonka, and Shorewood). In 2013, the District brought the program in-house and expanded the number of sampling locations to 98 stormwater ponds (Figure 1). No ponds were sampled in Chaska or Deephaven during the 2013 sampling season.

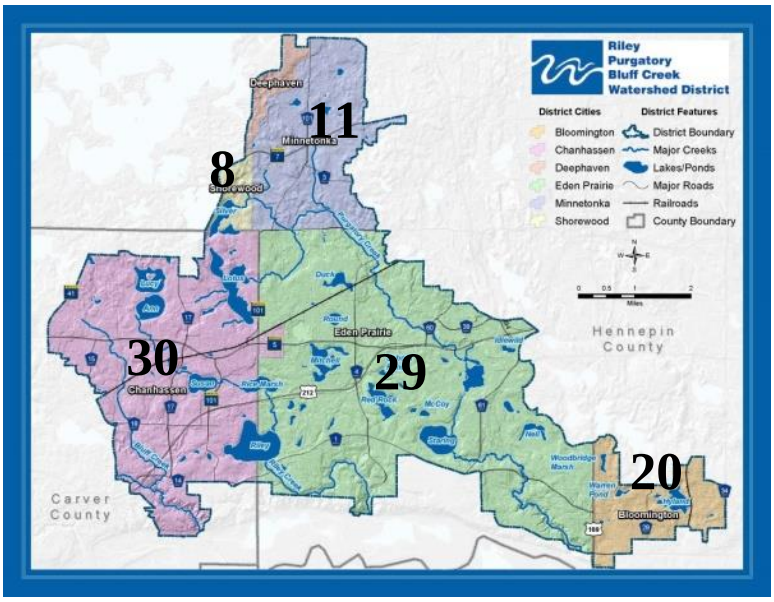

Figure 1. 2013 Stormwater Pond Sampling Locations by Municipality

Sampling locations for the 2013 field season included all of the stormwater ponds that were sampled in previous years (2010, 2011, and 2012), as well as several additional ponds that were identified following a review of the District's Use Attainability Analyses (UAA) for several of the lakes within the watershed and as part of conversations with city staff from Chanhassen and Eden Prairie (Table 1).

Table 1. No. of Stormwater Ponds and Municipalities Represented in 2013

Year	No. of SWP	Municipalities Represented
2010	5	Chanhassen and Eden Prairie
2011	7	Bloomington, Chanhassen, Eden Prairie, Minnetonka, Shorewood
2012	61	Bloomington, Chanhassen, Eden Prairie, Minnetonka, Shorewood
2013	98	Bloomington, Chanhassen, Eden Prairie, Minnetonka, Shorewood

The expansion of District's stormwater pond project took place in an effort to verify past results and begin to track the seasonal and annual changes in total phosphorous levels in stormwater ponds throughout the District. Figure 2 (next page) shows the locations of the stormwater ponds that were sampled in 2013.

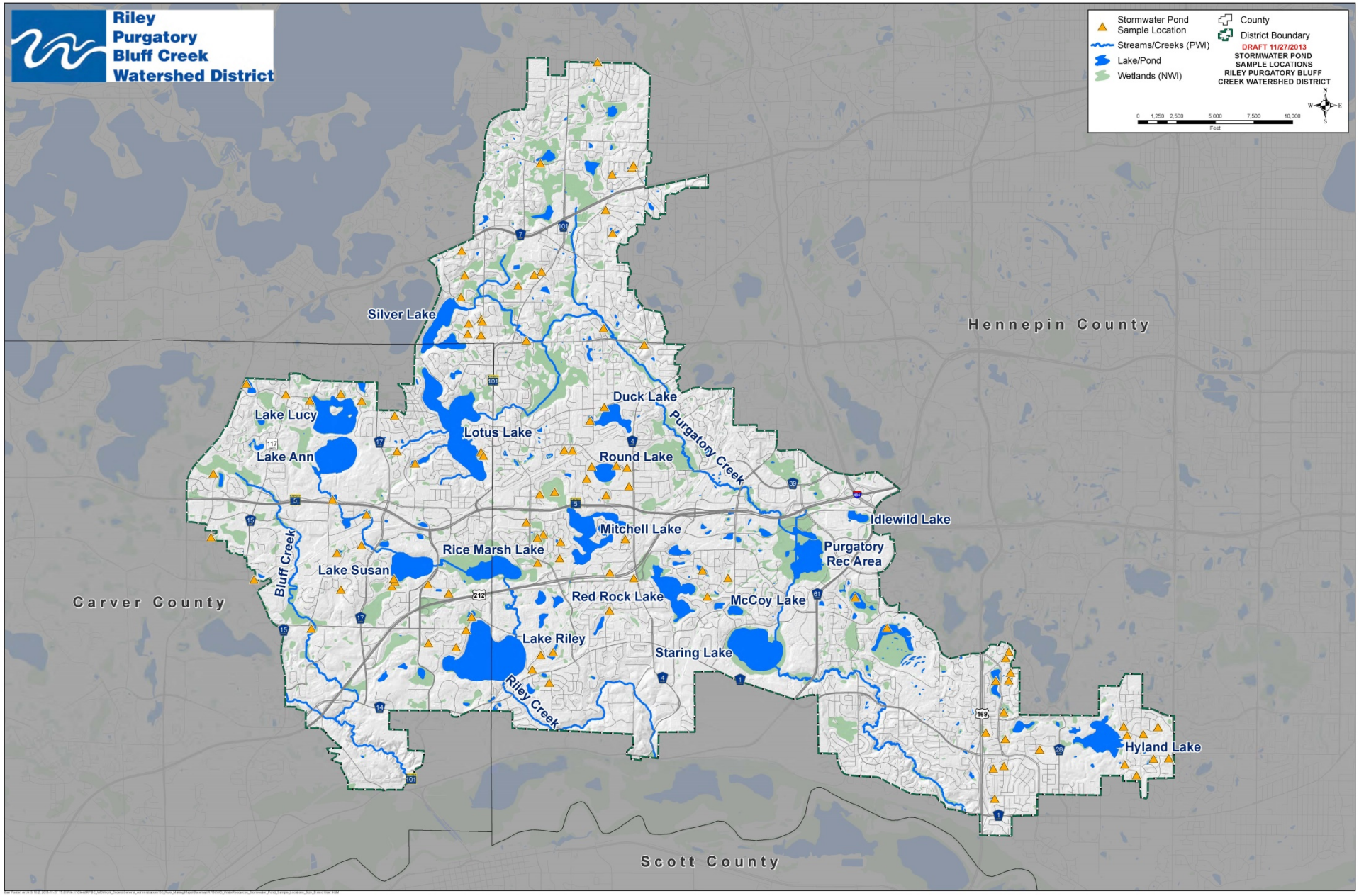

Figure 2. 2013 Stormwater Pond Sampling Locations

1.2 Background Data Collection

Before beginning the 2013 stormwater pond sampling session, the District partnered with the cities of Bloomington, Chanhassen, Eden Prairie, Minnetonka, and Shorewood. City staff was asked to provide the District with background information regarding the sampling sites located within their respective cities. The background information requested included information regarding the pond's maintenance schedule and surrounding environment such as: the location of the pond (physical address and/or latitude/longitude), the type of pond (Nationwide Urban Runoff Program (NURP) pond or wetland), the year the pond was built and the year(s) of major modifications, the size of the pond (surface area and volume) and of the catchment (the landscape from which water drains into a particular body of water), and general landuse information for the catchment area (residential, industrial, park area). All of these were incorporated into a database for data analysis. The District also requested that the cities provide staff members to help with the data collection process, as was done during previous sampling seasons, but was especially important in 2013 due to the increased number of stormwater ponds being monitored..

1.3 2013 Field Sampling Effort

The 2013 stormwater pond sampling season consisted of five rounds starting in early July and ending in mid-September. Each round lasted approximately two weeks and water samples from each site needed to be collected within the timeframe of the round. The schedule for the stormwater pond sampling rounds during the 2013 field season is shown below in Table 2.

Table 2. 2013 Sampling Rounds Schedule

Sampling Rounds	**Start Date**	**End Date**
1	July 1st	July 17th
2	July 18th	August 2nd
3	August 5th	August 20th
4*	August 21st	September 5th
5	September 6th	September 20th

* Only four sampling rounds were conducted for Bloomington and Eden Prairie due to time limitations. The fifth round was optional.

In late June, District staff held a training session for staff from the cities of Bloomington, Chanhassen, Eden Prairie and Minnetonka. At the training session, District staff explained the project background and the importance of the data that is being collected. City staff was taught the pond sampling methodology at a mock field sampling session performed at the stormwater pond in front of the Eden Prairie Water Treatment Plant (14100 Technology Drive)

Following the training session, city staff was responsible for collecting data within their respective jurisdiction. District staff communicated with city staff members on a regular basis to organize the delivery of sample bottles and to complete the data input process.

2. Field Methodology

The field sampling methodology used during the 2012 and 2013 stormwater pond assessment was developed during preliminary stormwater pond evaluations conducted by CH2M Hill in both 2010 and 2011. Following this methodology, the sampling location along the edge of the pond was selected using the background data provided by the cities. Field data was then collected in two parts: collecting the water sample and recording the pond attribute data.

2.1 Sampling Site Selection

Stormwater pond sampling locations were determined after a review of the pond infrastructure and the location of the stormwater inlets and outlets were identified. In order to ensure sampling consistency between samples rounds, water samples were always collected from the downstream one-third of the pond, closest to the outlet (Figure 3).

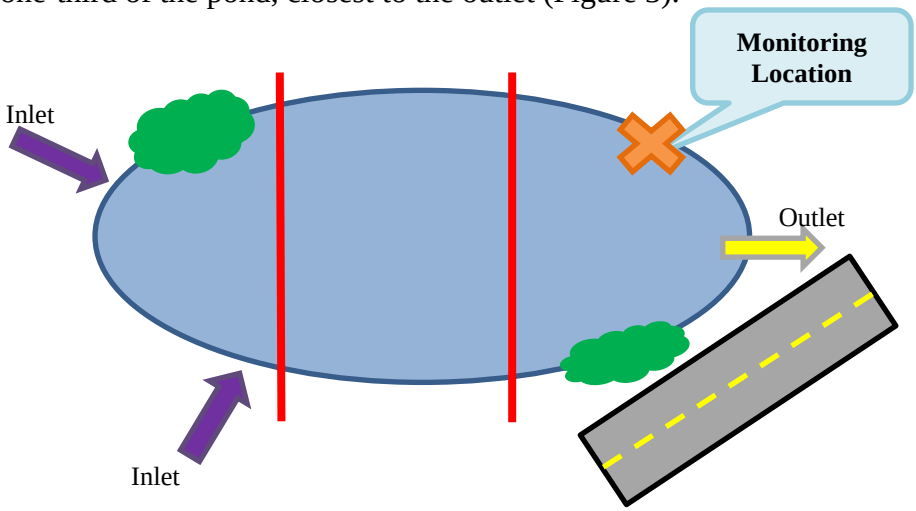

Figure 3. Site Specific Monitoring Location for Individual Stormwater Ponds

Collecting the samples from the downstream one-third of the pond was done to ensure that total phosphorus levels in the pond would not be influenced by incoming water from the pond's inlet and any associated flushing activities that could occur. Prohibited access or safety concerns were the only reasons to collect water samples from a location upstream of the down third of the pond.

Stormwater pond accessibility was a major consideration during this project. When appropriate, District and city staff used city easements to gain access to stormwater ponds. In cases where access to a pond was limited due to safety concerns, vegetation, or parking issues, staff was allowed to exercise personal judgment and could choose not to collect a water sample or fill out a data sheet for a particular pond. All assigned stormwater ponds were visited during each round even if a pond had been dry during the previous round.

As part of the sampling protocol, sampling activities were postponed if there had been more than ½ inch of precipitation within the 48 hours prior to sampling. This precaution was undertaken to allow for solubilization of phosphorus to occur and to avoid having the phosphorus flushed out from the pond. This activion could result in a less representative sample of phosphorus levels in the pond being collected.

2.2 Field Data Collection

The main objective of the District's stormwater project is to gain a better understanding of total phosphorus levels in the stormwater ponds. Water samples used for phosphorus sampling were collected by integrating three water samples collected at or near the surface using a 500 mL bottle attached to a 10 ft pole or sampling stick (Figure 4).

Figure 4. Using the sampling stick to collect the composite water sample.

The water samples were then screened with a 1.5mm mesh prior to undergoing lab analysis in order to remove any plant matter or debris that was inadvertently collected during the sampling process (Figure 5).

Figure 5. Filtering the water samples through the 1.5mm mesh filter.

In addition to testing the water samples from each pond for total phosphorus, 15 samples in both Chanhassen and Eden Prairie, and eight samples in Shorewood were also tested for dissolved

phosphorus (DP). The sites selected for dissolved phosphorus testing were chosen based on ease of access and represented an equal number of wetland and NURP ponds in Chanhassen and Eden Prairie while the ponds in Shorewood included one wetland and seven NURP ponds.

In addition to gathering samples for water quality testing, climate data and pond attribute information was collected at each pond during each sampling round. Climatic data included: precipitation, temperature, wind, and cloud cover. The pond attribute data collected at each pond included: general pond and sediment smell, type of vegetation surrounding the pond (prairie grass, deciduous tree, mowed grass) or lack thereof (impervious cover), macrophyte coverage in the pond (type and percent), pond water and sediment color, and the presence or absence of bubble release from the sediment.

The pond attribute data was obtained unobtrusively by visual inspection except for the sediment smell and color, and the bubble release test. Sediment smell and color information was collected by using a garden rake to collect a sample of the bottom substrate for staff to analyze. The bubble test was performed by using a garden rake to disturb the bottom substrate in five separate locations along the side of the pond and then staff watched to see how many bubbles were released from the sediment following the disturbance.

Water samples were delivered to the analysis lab at the conclusion of each sampling event. Samples could be collected on different days within the same round, but needed to be analyzed within 48 hours after the water was collected (per analysis laboratory standards). The pond attribute data collected in the field was used in conjunction with the testing results from the water quality samples to assess the health of stormwater ponds found in the District.

3. District Stormwater Project

Stormwater ponds were added to the landscape in order to "intercept, store, and treat" pollutants that move through a watershed. The placement of these ponds thereby mitigates possible negative impacts to downstream water bodies that could be brought on by stormwater runoff or streambank erosion (Athayde et al., 1983). As part of this multiyear study, stormwater ponds were monitored in an effort to better understand if the ponds are working efficiently as 'pollution sinks' or if they have become sources of pollution within the watershed.

3.1 Results Overview

In furtherance of this goal, the number of ponds sampled during the 2012 field season increased from 61 ponds to 98 ponds in 2013 (61 replicates and 37 new ponds). The number of ponds sampled increased in Chanhassen, Eden Prairie, and Minnetonka using information provided in District UAAs and identified in conversation with staff from Chanhassen and Eden Prairie. The number of ponds sampled in Shorewood decreased (due to accessibility issues for Wetland 2) and the number of ponds in Bloomington stayed the same from 2012 to 2013 (Table 3).

Table 3. Stormwater Pond Project Results Overview

Categories	Bloomington	Chanhassen	Eden Prairie	Minnetonka	Shorewood
# 2012 Locations	20	10	12	10	9
Ave. TP mg/L	0.46	0.3397	0.415	0.59	0.35
Max TP mg/L	3.3	3.1	2.2	4.2	3.2
Max TP Location	Colorado Pond	BC-P4.10C	18-41-B	849_w	Wetland_2
Min TP mg/L	0.042	0.067	0.025	0.038	0.038
Min TP Location	Tealwood Pond	BC-P1.10B	17-13-A	850_p1	20
# 2013 Locations	20	30	29	11	8
Ave. TP mg/L	0.31	0.5956	0.7156	0.77	0.28
Max TP mg/L	1.1	5.7	7.7	8.1	1.2
Max TP Location	Cavell Pond	LS-P2.12N	30-12-B	849_w	42
Min TP mg/L	0.056	0.034	0.044	0.04	0.07
Min TP Location	West Hills Park 2	LU-A5.6f	17-13-A	804_w	20

A couple of ponds to note from the aforementioned table include: 17-13-A, located east of Mitchell Lake in Eden Prairie, had the lowest total phosphorus concentration of all Eden Prairie ponds sampled in 2012 (0.025 mg/L) and in 2013 (0.044 mg/L). Pond 20, located south of Highway 7 west of Vine Hill Road in Shorewood, had the lowest total phosphorus concentration of the Shorewood ponds sampled in 2012 (0.038 mg/L) and in 2013 (0.07 mg/L). Contrary to the aforementioned ponds, 849_w, located off Hanus Road west of Clear Springs Elementary School in Minnetonka, had the highest total phosphorus concentration for all samples collected in 2012 (4.2 mg/L) and in 2013 (8.1 mg/L).

3.1.1 Minnesota Pollution Control Agency (MPCA) Stormwater Standard

The Minnesota Pollution Control Agency (MPCA) estimates that the typical total phosphorus concentrations found in waters leaving stormwater ponds ranges from 0.1 mg/L at the low end to

0.25 mg/L on the high end (MPCA Minnesota Stormwater Manual). The MPCA also estimates the median total phosphorus concentration for water leaving a wetland to be at 0.2 mg/L. For the purposes of this study, the District will use the stormwater standards set forth by the MPCA when evaluating stormwater pond productivity and total phosphorus levels in District stormwater ponds. For both 17-13-A and Pond 20, the minimum concentrations were lower than 0.10 mg/L whereas the maximum concentration measured for 849_w was much higher than the 0.25 mg/L standard.

3.2 General Analysis

As part of this multiyear study, the District collected water quality samples from stormwater ponds in an effort to better understand if the ponds are working efficiently as 'pollution sinks' or if they have become sources of pollution within the watershed. To better elucidate the findings from this project, the data was analyzed in a variety of ways to answer these key questions:

1. Do total phosphorus concentrations in a stormwater pond vary annually?
2. Do total phosphorus concentrations in a stormwater pond vary seasonally?
    a. If so, how frequently should the ponds be sampled? When should the sampling season begin and end?
3. Do the ponds that had and average total phosphorus concentration >1mg/L in 2012 maintain that high concentration in 2013?
    a. After the second sampling season, do more ponds fall in this category?
4. Does the origin state of the pond influence the average total phosphorus concentration?
5. Which test paints a more representative picture of the state of phosphorus in the pond – dissolved phosphorus or total phosphorus?
6. Do stormwater ponds work together to remove excess nutrients or do they behave independently?
7. Is there a relationship between the presence or absence of macrophytes and high phosphorus levels in a stormwater pond?

3.2.1 Annual Variation of Total Phosphorus Concentration

Figure 6 shows the average total phosphorus levels for samples collected in both 2012 and 2013 in all five cities (the new locations added in 2013 were excluded from this analysis). Chanhassen, Eden Prairie, Minnetonka, and Shorewood all showed an increase in the average total phosphorus levels, whereas Bloomington showed a noticeable decrease from 2012 to 2013. Something to consider when looking at Figure 6 is that the average total phosphorus levels for all five cities from both 2012 and 2013 were above the 0.25 mg/L 'high' concentration level identified by the MPCA.

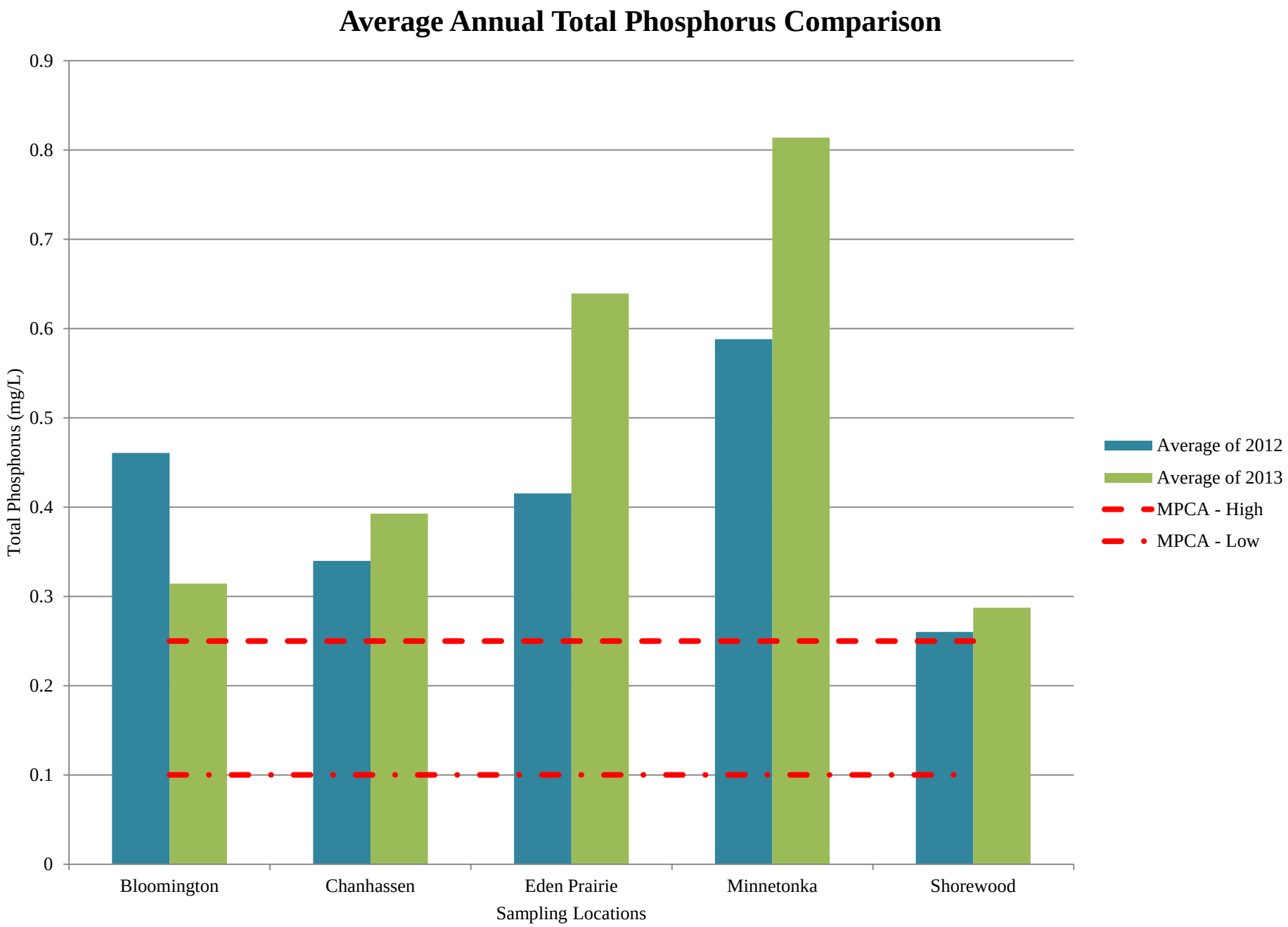

Figure 6. Average annual total phosphorus levels for sites sampled in 2012 and 2013

3.2.2 Seasonal Influence and Sampling frequency

In 2012, four sampling rounds were conducted, starting in early July and ending in late August. Additional quality control (QC) samples were collected between Rounds 2 and 3, and after Round 4 (Figure 7). These additional samples were collected at sites that were selected at random by the District Engineer and other staff. In 2013, five rounds of water samples were collected starting in early July and going until mid-September. The five rounds were completed for Chanhassen, Minnetonka, and Shorewood, but due to time constraints, only four rounds were conducted in Bloomington and Eden Prairie (Table 2). No QC rounds were conducted in 2013.

As part of this study, the data was analyzed to determine how many sampling rounds should be conducted within a field season in order to get a dataset that would be most representative of total phosphorus levels at the sampling locations. In addition, because of the quality control samples that were collected in 2012, the data was also evaluated to determine if increasing the sampling frequency would result in a more representative dataset.

The Shorewood stormwater ponds were used to evaluate these two questions because quality control rounds were collected in 2012 and Round 5 was completed in 2013. Data analysis comparing Round 1-5 against Rounds 1-4 in 2013 found that the average total phosphorus levels for most of the ponds showed minimal changes when the samples from Round 5 were excluded. Evaluation of the quality control data from 2012 did not produce any significant difference from data collected following the 2013 sampling methodology (sampling every two weeks). With this information, it was decided that completing four rounds of pond sampling every two weeks is sufficient in order to gain a good understanding of total phosphorus levels in stormwater ponds.

3.3 Stormwater Ponds with Average Total Phosphorus Concentration >1 mg/L

At the beginning of the season, historical data collected during sampling efforts from 2010, 2011, and 2012 were evaluated and 10 ponds with an average total phosphorus concentration of greater than 1 mg/L were highlighted because of their exceptionally high total phosphorus levels. Figure 8 shows the results from that analysis (the ten sampling locations on the left) along with ponds newly sampled in 2013 that had total phosphorus levels that averaged greater than 1 mg/L (eight ponds on the right). All, but two of the ponds identified as top offenders sampled from 2010-2012, had a decrease in the average total phosphorus concentration in 2013 (18-41-B in Eden Prairie and 849_w in Minnetonka). Following the 2013 sampling season, data analysis identified eight more stormwater ponds that had an average total phosphorus level greater than 1 mg/L in addition to the ponds identified before the sampling season began. These ponds were either new in 2013 or had an increased average total phosphorus concentration from what was measured in 2012.

Because there is so much annual variation between the ponds with average total phosphorus concentrations greater than 1 mg/L, collecting a third year of water samples from District stormwater ponds will help staff to identify the truly problematic ponds from those that may be more heavily influenced by climatic variations from one year to the next. This information is key when targeting the ‘bad’ ponds and developing remediation strategies for them.

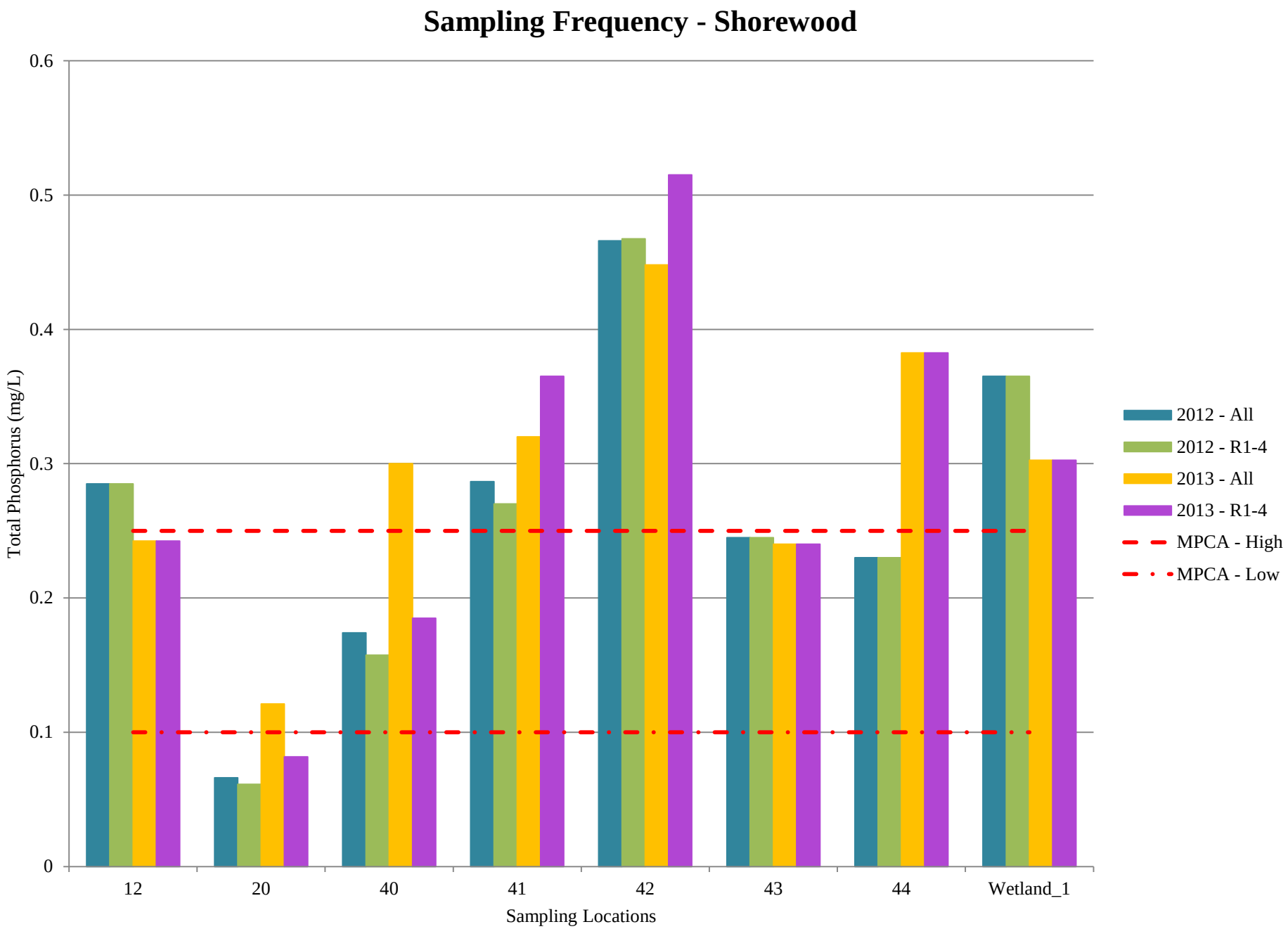

Figure 7. Sampling frequency for Shorewood stormwater ponds in 2012 and 2013

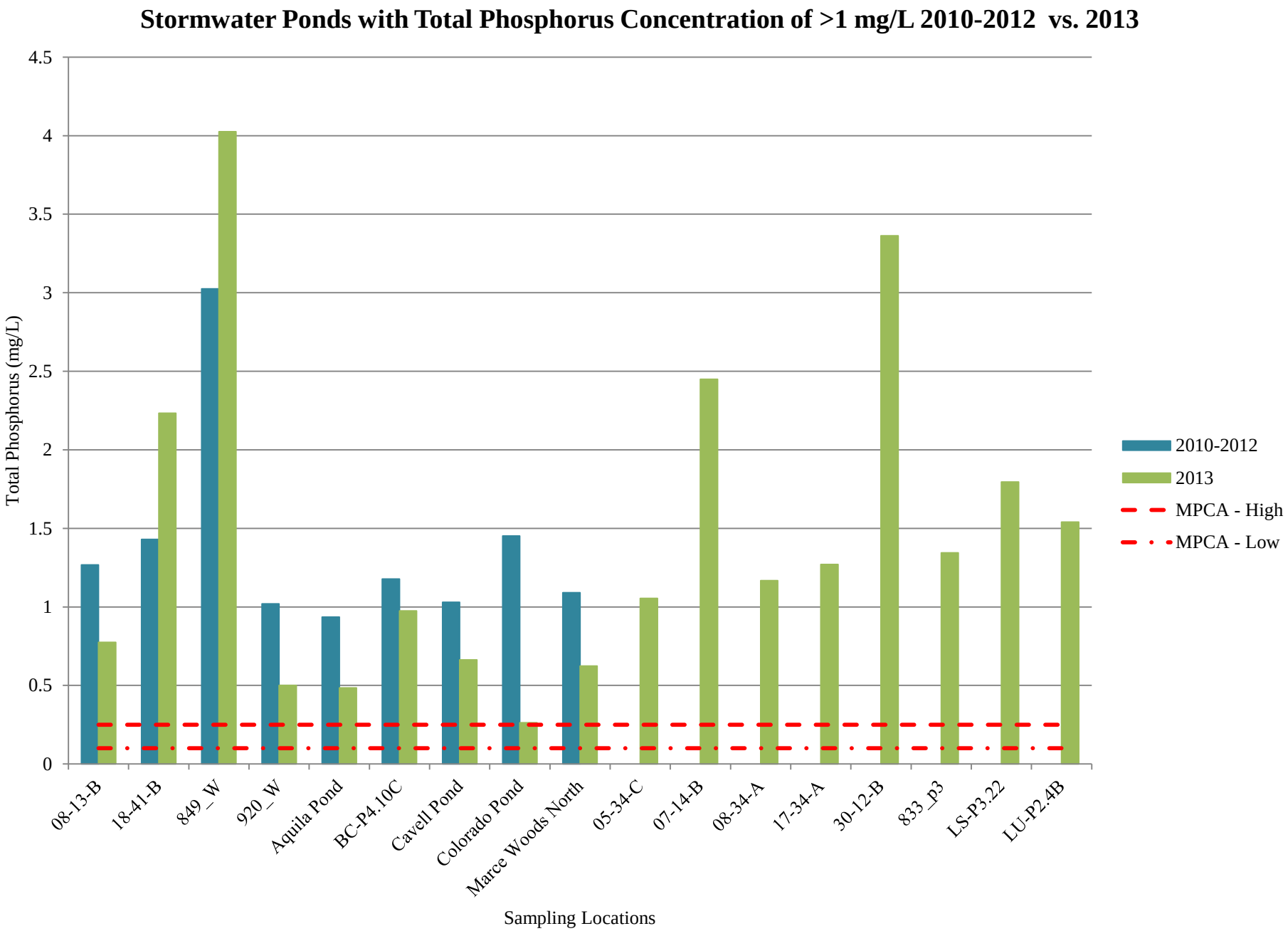

Figure 8. Stormwater Ponds with Total Phosphorus Concentration of >1 mg/L from 2010-2013

3.4 Does the origin state of a pond influence the total phosphorus concentration?

Within this study, the term 'stormwater pond' is generally used to describe two kinds of stormwater detention basins, NURP ponds and wetlands. NURP ponds are stormwater ponds that were constructed following guidelines set forth in the National Urban Runoff Program (NURP) pond study completed in 1983.These guidelines lay out the construction parameters that should be followed in order to build a pond that will effectively capture excess nutrients and sediment and remove them from effluent stormwater. Stormwater ponds that are categorized as wetlands are former wetlands that were converted into wet ponds by flooding them, a practice that occurred in the 1960s and 1970s.

This analysis was performed to determine if the origin state of a stormwater pond had any impact on the total phosphorus levels for a particular pond. Figure 9 shows that the average total phosphorus levels vary across the graph (wetlands on the left, NURP ponds on the right), showing no distinct pattern or grouping of the total phosphorus levels. From this, it has been determined that the total phosphorus levels of a stormwater pond are not influenced by the pond's original state, be it a constructed pond or a wetland. Because constructed ponds were constructed more recently than stormwater ponds that were converted from wetlands, it can be inferred that there is no relationship between the age of a stormwater pond and the total phosphorus levels measured during sampling events.

3.5 Which is a better indicator – total or dissolved phosphorus?

Total phosphorus encompasses all forms of phosphorus available in the water samples, whereas dissolved phosphorus is present only in solution and is more readily available to be taken up and used by plants. The particulate component of total phosphorus is where the majority of sampling efforts have focused in the past because it is easiest to remove/treat during a modification or treatment of a stormwater pond. In 2013, it was decided that some of the stormwater ponds should be sampled for dissolved phosphorus, in addition to collecting the traditional total phosphorus sample. This was done to determine if total phosphorus was the appropriate parameter to be testing for when evaluating the health of a stormwater pond.

Water samples to be tested for dissolved phosphorus were collected from 15 ponds in Chanhassen and Eden Prairie and 8 ponds in Shorewood (equal number wetland and NURP ponds). Figure 10 shows the difference in the phosphorus particulates in the water sample. A high average total phosphorus concentration and a low average dissolved phosphorus concentration means that there was a high amount of phosphorus particulates in the sample. These findings indicate that there are higher levels of particulates in the stormwater ponds that were sampled for dissolved phosphorus. All future stormwater pond modification/remediation projects undertaken by the District should focus on removing the phosphorus in the particulate form, not the dissolved form.

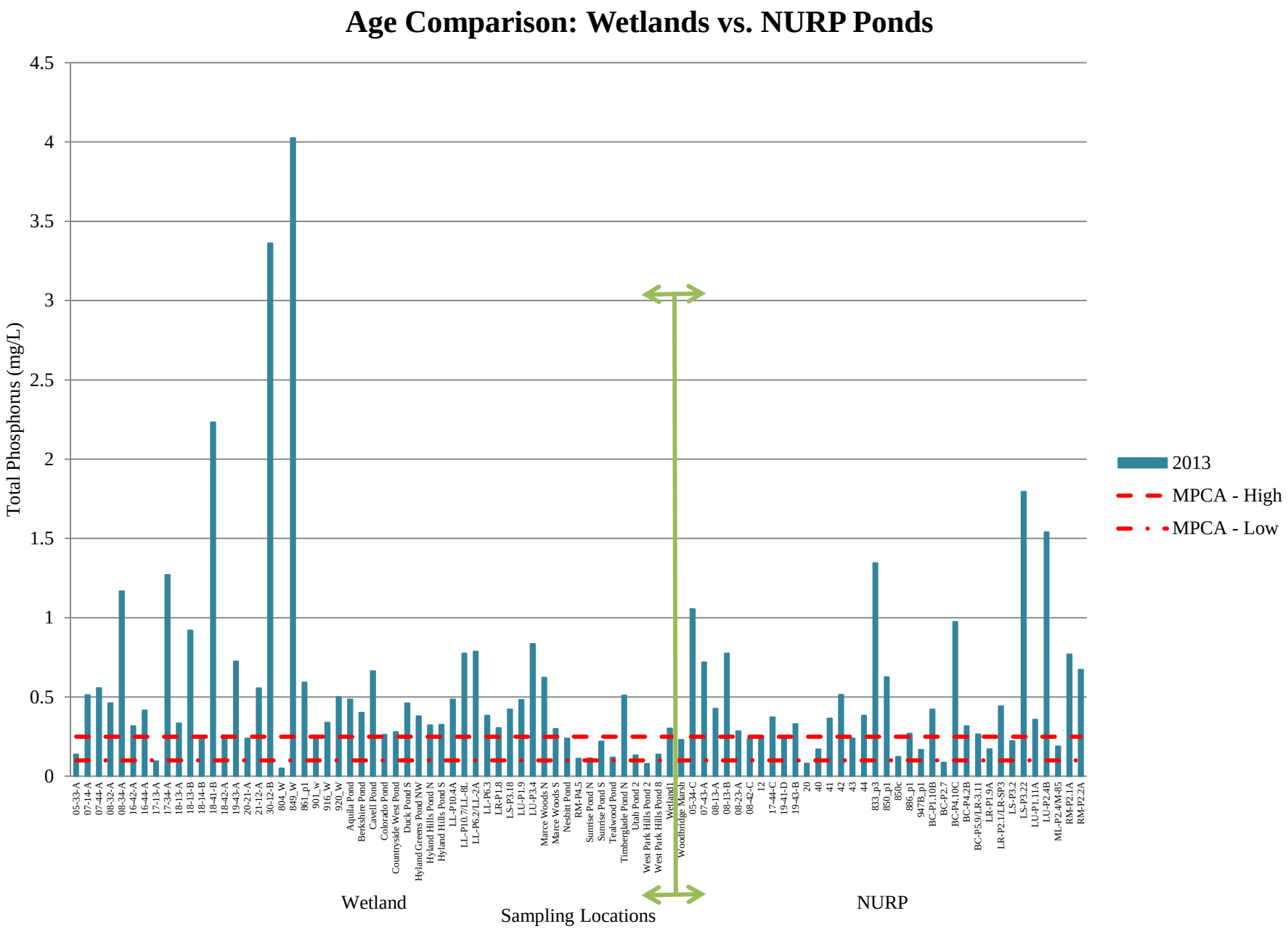

Figure 9. Average Total Phosphorus Concentration for Wetland (older) and NURP Ponds (newer) Sampled in 2013

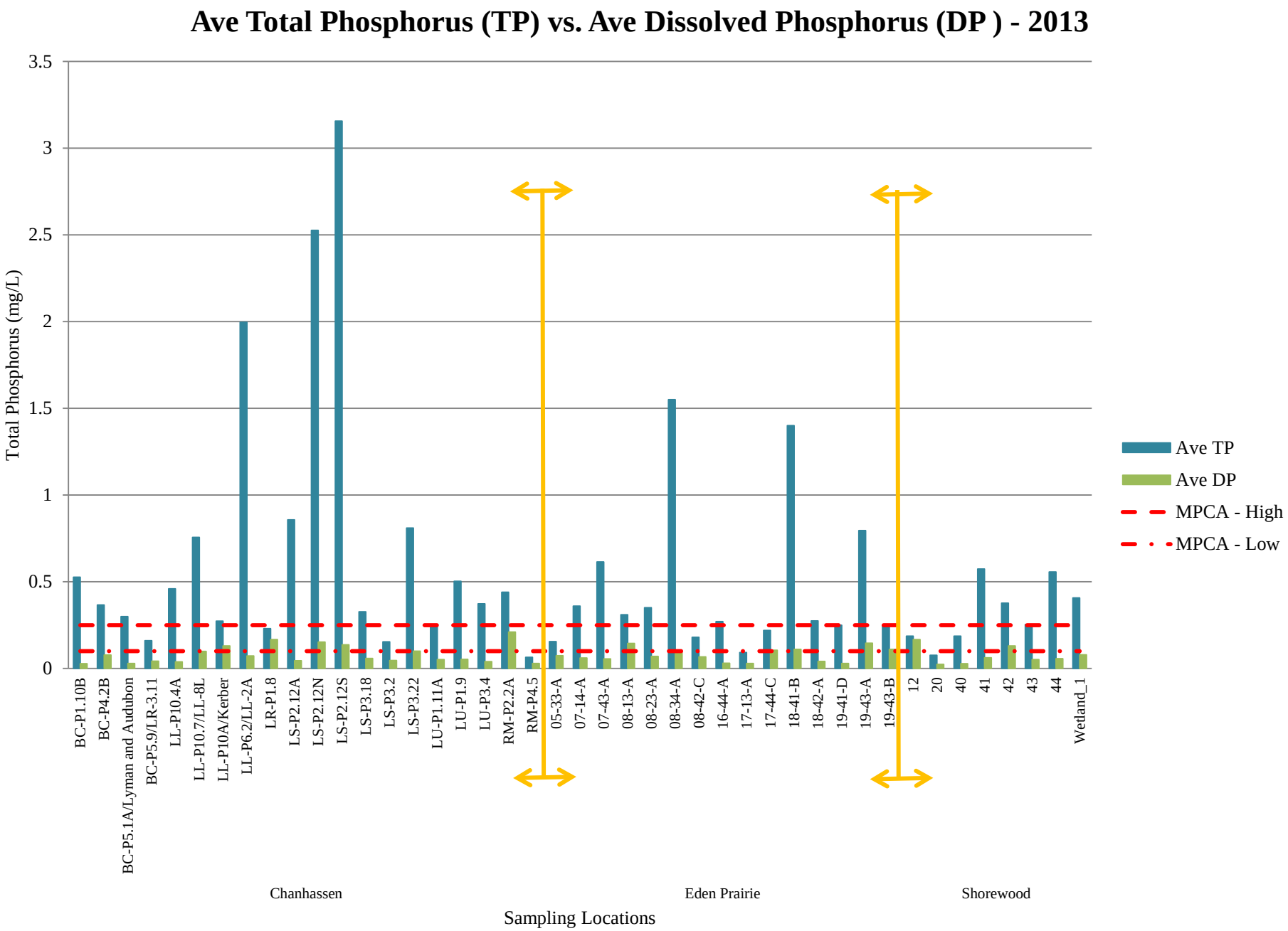

Figure 10. Average Total Phosphorus vs. Average Dissolved Phosphorus in 2013

3.6 Do total phosphorus levels vary along a chain of stormwater ponds?

Stormwater ponds are designed to treat the nutrient-rich runoff by interrupting the movement of coarse sediment and other pollutants and allowing them time to settle out of the water and into the bottom substrate. A chain of stormwater ponds (two or more) working together should result in a decrease in the downstream total phosphorus concentration as the water moves through the system and towards a main water body. In essence, the upstream ponds remove the majority of the phosphorus through settling and the water becomes cleaner as it moves down the chain.

To test this hypothesis, two stormwater pond chains were identified around Mitchell Lake in Eden Prairie: M-3 and M-56 (Figure 11). M-3 is located northwest of Mitchell Lake and consists of three stormwater ponds (upstream to downstream): ML-P2.4 (located in Chanhassen), 07-43-A, and 07-44-A. The M-56 stormwater networks drains into Mitchell Lake from the west and consists of three stormwater ponds (upstream to downstream): 18-13-B, 18-13-A, and 18-14-B.

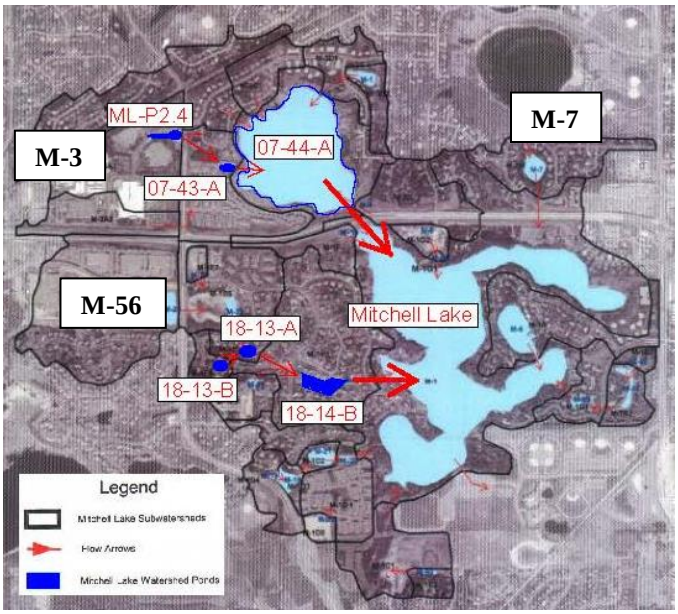

Figure 11. Mitchell Lake Stormwater Pond Chains (Barr 2005)

A third chain, M-7, was also considered, but because the M-7 chain consists primarily of stormwater ponds in the Round Lake Subwatershed and Round Lake itself (which the District did not sample in 2013), this chain was excluded from analysis due to lack of sampling data. All told, these three chains contribute over ¾ of the external phosphorus load to the lake (the Mitchell Lake subwatershed is primarily parkland and low-density residential).

Figure 12 shows the average total phosphorus concentration for each stormwater pond sampled. For the M-3 chain, the total phosphorus concentration in ML-P2.4 is considerably lower than what was sampled in 07-43-A (immediately downstream). This highlights the possibility that an external phosphorus source exists between ML-P2.4 and 07-43-A which could cause a spike in the total phosphorus concentration. Continuing downstream, 07-44-A behaves more accordingly with a lower average total phosphorus concentration than what was sampled upstream. In contrast, the M-56 stormwater chain behaves in a more expected manner with the total phosphorus concentration decreasing down the chain towards the main water body.

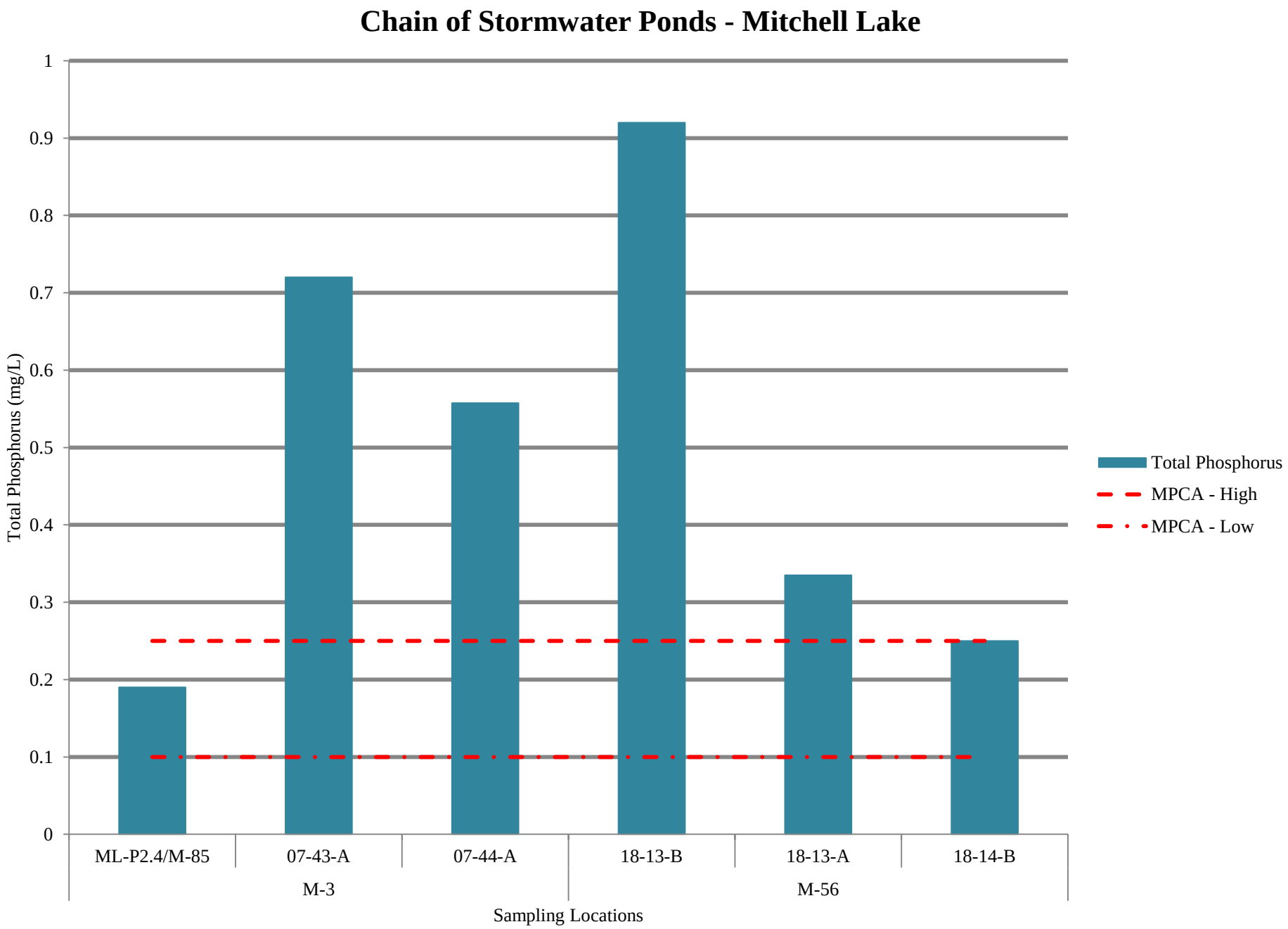

Figure 12. Average Total Phosphorus Concentration for Mitchell Lake Stormwater Pond Chains

3.7 Percent Macrophyte Coverage of Stormwater Ponds

A ‘macrophyte’ is an aquatic plant that grows in or near water and is partially submerged, fully submerged, or floating at the surface. As part of the methodology for pond attribute data collection, the percent macrophyte coverage was recorded following a visual inspection of the pond to determine the extent of the macrophyte coverage. Percent cover was broken down into four categories: <25%, 25-50%, 50-75%, and >75%.

This analysis was done to determine if the presence and quantity of macrophytes was at all indicative of high phosphorus levels in a stormwater pond. Figure 13 shows the total phosphorus concentrations by percent macrophyte coverage from the 20 stormwater ponds sampled in Bloomington in 2013. Total phosphorus concentrations are shown as total values by sampling round, not as an average across the sampling season (as done as part of other analyses). From this graph, there does not appear to be a relationship between macrophyte coverage and total phosphorus concentration. For example, a small macrophyte cover percent (<25%) was identified at several ponds with total phosphorus concentrations that ranged between 0.056 mg/L (West Park Hills Pond 2) up to 0.78 mg/L (Duck Pond S). In addition to the ponds with low macrophyte cover, stormwater ponds identified as having high percentage of macrophyte cover (>75%) were also found to have total phosphorus concentrations that fell within the aforementioned range. These findings indicate that there is no relationship between the presence of macrophytes and the extent of their cover over the surface of the stormwater pond and the total phosphorus concentration in the pond.

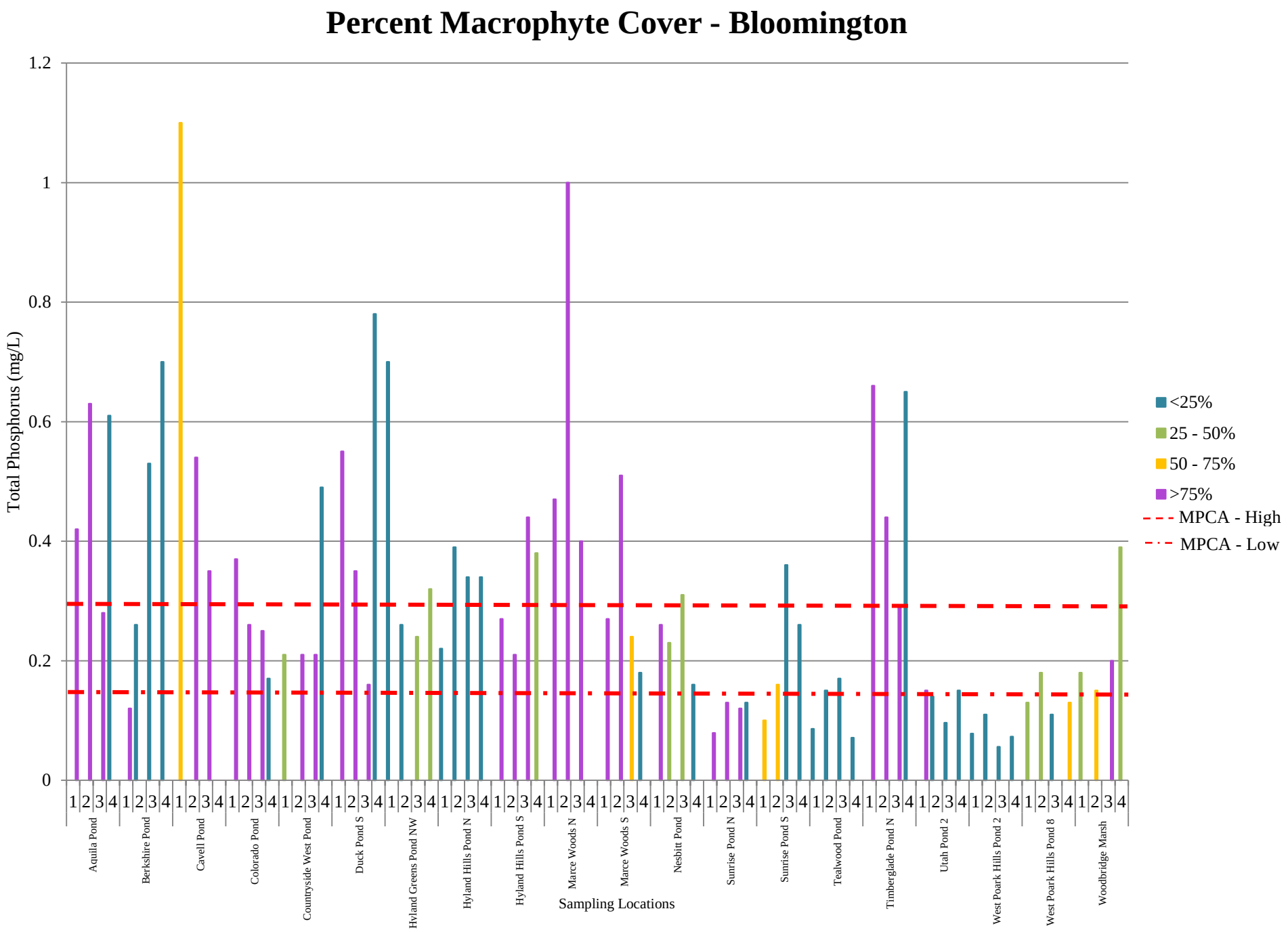

Figure 13. Percent Macrophyte Cover by Round for Bloomington Stormwater Ponds

4. Stormwater Pond Project Results by City

The 2013 stormwater pond project concentrated on ponds within five municipalities: Bloomington, Chanhassen, Eden Prairie, Minnetonka, and Shorewood. The ponds are also a part of the stormwater conveyance networks in 13 subwatersheds (Table 4). The results discussed below are communicated following the municipal boundaries represented by the sampling effort.

4.1 Bloomington

Eight of the ponds sampled are a part of the stormwater network that feeds into Hyland Lake (Figure 14) while the other 12 stormwater ponds are landlocked. All of the stormwater ponds are categorized as 'wetlands', and many have been used as stormwater management best management practices (BMPs) since the late 1960s and into the 1970s.

4.1.1 Average Annual Total Phosphorus Concentration

The same 20 ponds that were sampled in 2012 where replicated during the 2013 field season. 13 out of 20 ponds showed a decrease in the average total phosphorus concentration between 2012 and 2013. Most noticeably, the four ponds with the highest total phosphorus concentrations in 2012, Aquila Pond, Cavell Pond, Marce Woods N, and Colorado Pond, showed a marked decrease in 2013 (Figure 15).

For example, in 2012, Colorado Pond had an average concentration of 1.4525 mg/L, but in 2013, the total phosphorus concentration decreased by over 80%. The average total phosphorus concentration in 2013 was 0.2625 mg/L, only 0.0125 mg/L above the typical total phosphorus level for effluent stormwater estimated by the MPCA. Because 2012 was an inordinately wet year and 2013 was very dry, continuing the study in 2014 will hopefully provide more consistent data points that better represent the total phosphorus concentration in the stormwater ponds.

4.1.2 Seasonal Total Phosphorus Variation

As was mentioned previously, stormwater sampling began in early July and continued until mid-September with each round lasting approximately two weeks (see Table 2). Figure 16 shows the seasonal total phosphorus concentrations for the ponds sampled in Bloomington in 2013, divided by round. There was high variability in the total phosphorus concentrations between the rounds, meaning (for example) that the samples collected in a Round 2 did not have consistently higher or lower total phosphorus concentrations in comparison to the concentrations found in the samples collected during the other rounds (1, 3, and 4). These findings indicate that seasonality (ie which round the samples were collected in) is not a good indicator of the concentration of total phosphorus in the pond and no one round/time period should be considered representative of concentrations during the whole growing period.

Of all the ponds sampled in Bloomington in 2013, only five ponds, including Sunrise Pond N, Tealwood Pond, Utah Pond 2, West Park Hills Pond 2, and West Park Hills Pond 8, had total phophsorus concentrations that were consistently below the MPCA estimate of 0.25mg/L for effluent waters. West Park Hills Pond 2 was below the low end of the MPCA range (0.1mg/L) for three of the four sampling rounds (and was only slightly higher in Round 2).

Table 4. 2013 Stormwater pond locations organized by subwatershed. Municipalities are color coded.

Hyland Lake	Bluff Creek	Lake Lucy/ Lake Ann	Lake Susan	Lotus Lake	Rice Marsh Lake	Lake Riley	Duck Lake	Round Lake	Mitchell Lake	Red Rock Lake	Purgatory Creek	Silver Lake
Aquila Pond	BC-P4.2B	LU-A5.6f/ Brendon Pond	LS-P3.18	LL-P10A/ Kerber	RM-P2.1A	LR-P1.8	05-33-A	08-13-A	ML-P2.4/ M-85	16-42-A	804_W	12
Berkshire Pond	BC-P5.1A/ Lyman and Audubon	LU-P1.11A	LS-P3.2	LL-P10.4A	RM-P2.2A	LR-P1.9A	05-34-C	08-13-B	18-13-A	16-44-A	833_p3	20
Cavell Pond	BC-P1.10B	LU-P1.8	LS-P3.21	LL-P10.7/ LL-8L	RM-P4.5	LR-P2.1/ LR-SP3		08-32-A	18-13-B	17-34-A	849_W	40
Colorado Pond	BC-P2.7	LU-P1.9	LS-P3.22	LL-P6.2/ LL-2A		BC-P5.9/ LR-3.11		08-42-C	18-14-B	20-21-A	850_p1	41
Countryside West Pond	BC-P4.10C	LU-P2.4B	LS-P2.12A	LL-P6.3		19-41-D		07-14-A	18-41-B	21-12-A	850c	42
Duck Pond S		LU-P3.4	LS-P2.12N			19-43-A		08-23-A	18-42-A	17-44-C	861_p1	43
Hyland Greens Pond NW			LS-P2.12S			19-43-B		07-14-B	17-13-A		886_p1	44
Hyland Hills Pond N						30-12-B			07-43-A		901_w	Wetland_1
Hyland Hills Pond S									07-44-A		916_W	Wetland_2
Marce Woods N									08-34-A		920_W	
Marce Woods S											947B_p1	
Nesbitt Pond											05-11-A	
Sunrise Pond N												
Sunrise Pond S												
Tealwood Pond												
Timberglade Pond N												
Utah Pond 2												
West Park Hills Pond 2												
West Park Hills Pond 8												
Woodbridge Marsh												

Municipalities Represented

Bloomington
Chanhassen
Eden Prairie
Minnetonka
Shorewood

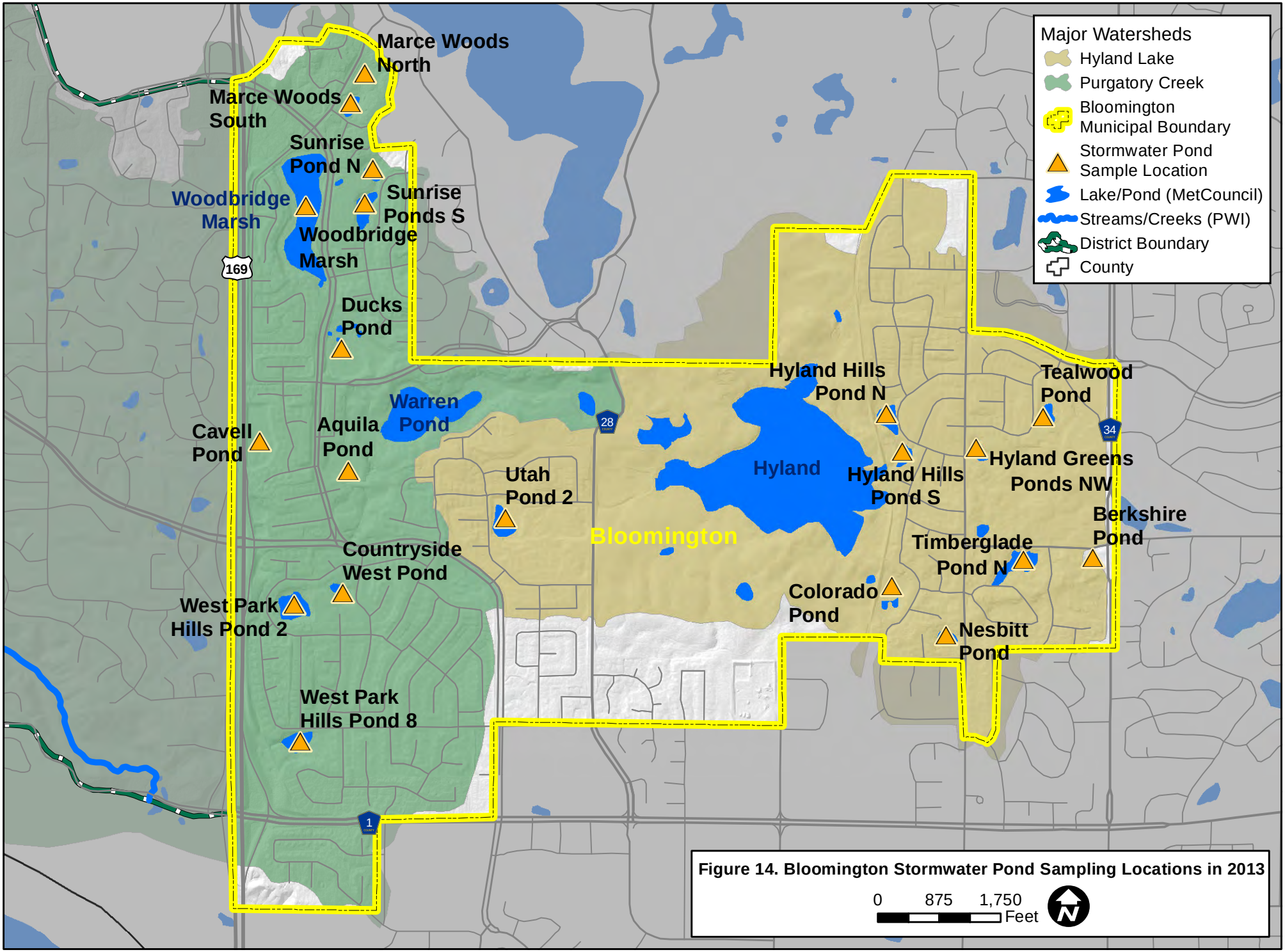

Figure 14. Bloomington Stormwater Pond Sampling Locations in 2013

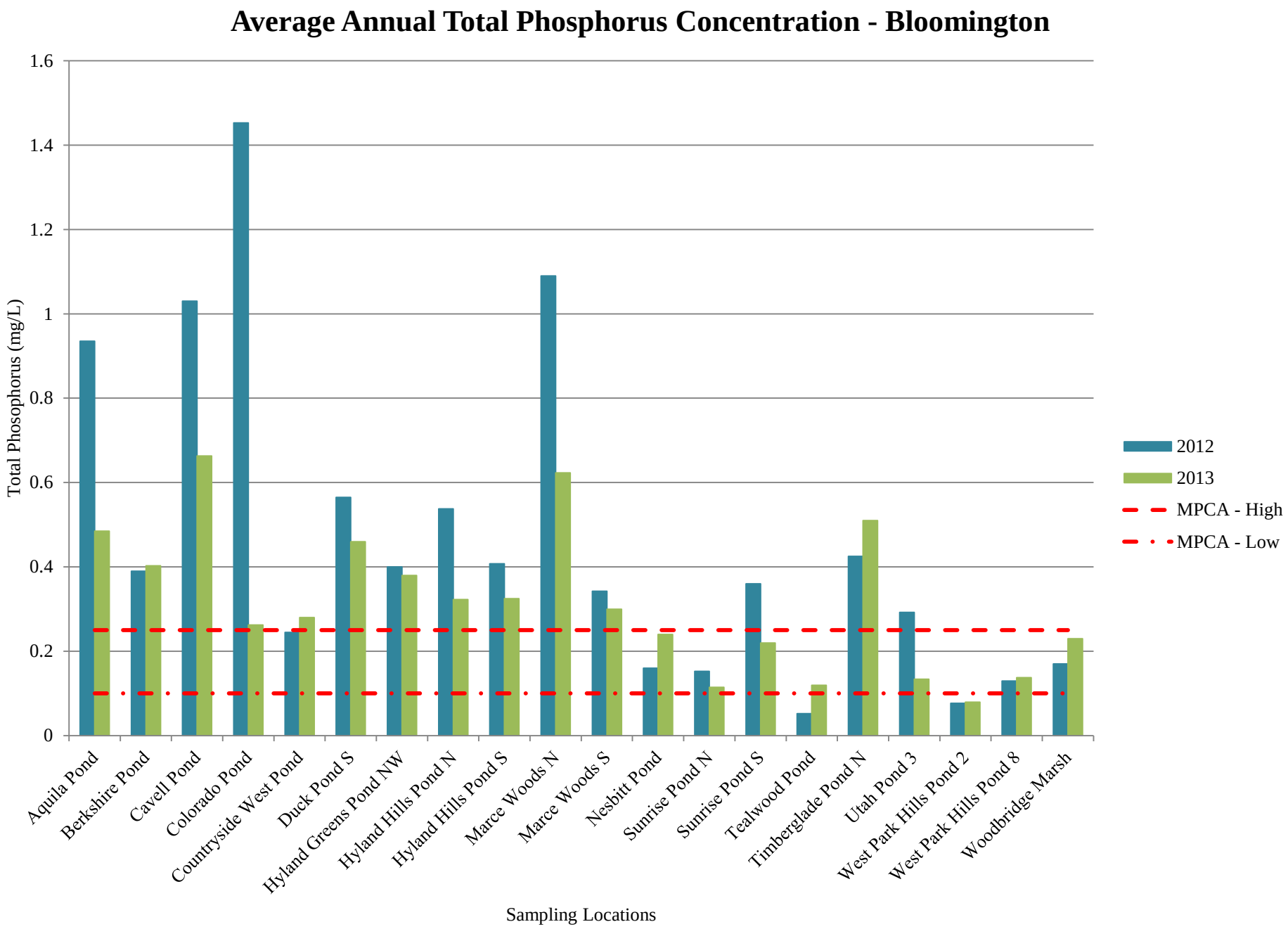

Figure 15. Average Annual Total Phosphorus Concentration for Bloomington Stormwater Ponds

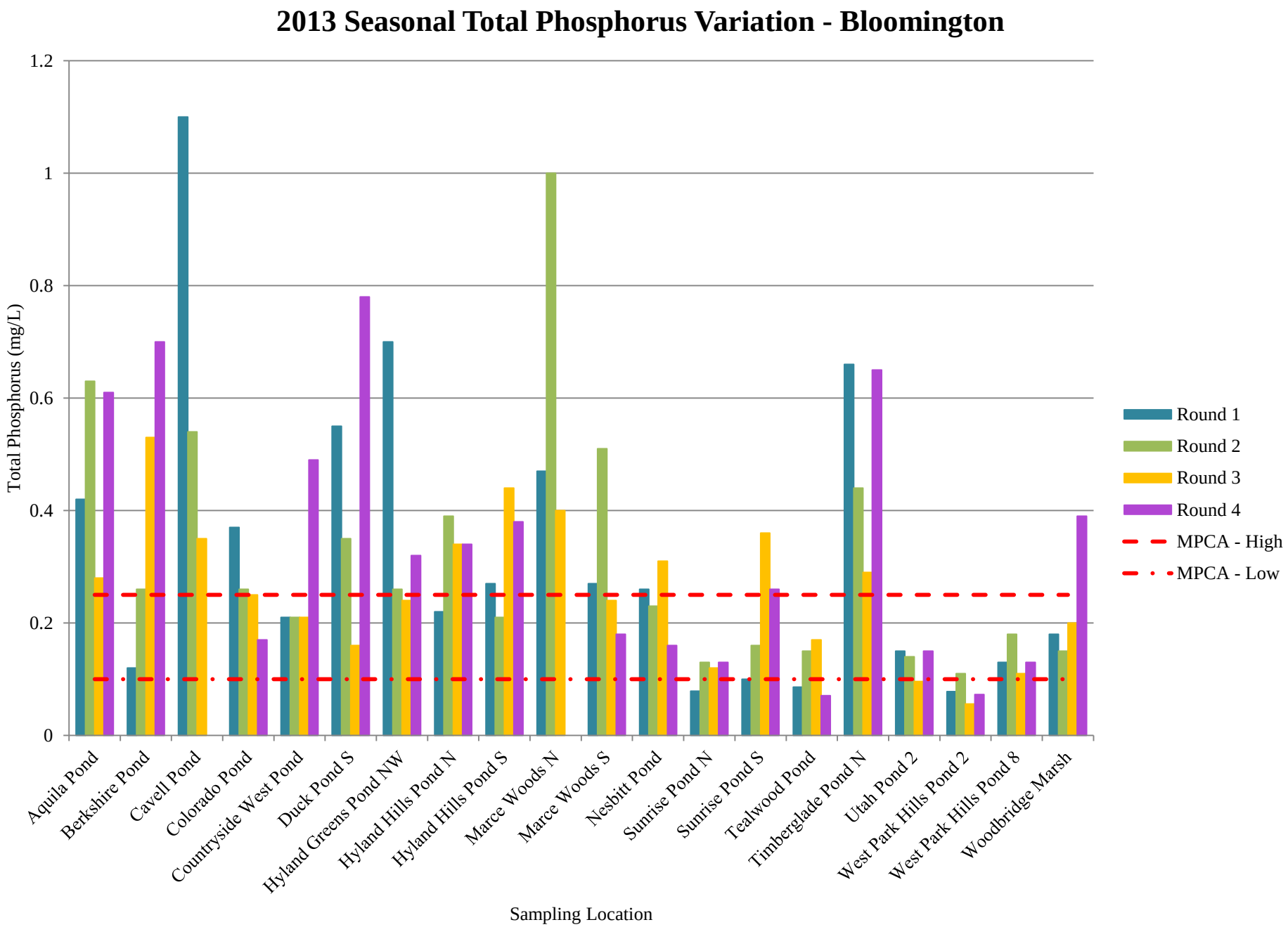

Figure 16. Seasonal Total Phosphorus Concentrations for Bloomington Stormwater Ponds in 2013

4.2 Chanhassen

The stormwater ponds that were sampled in Chanhassen operate as part of the stormwater conveyance networks found within seven different subwatersheds: Lake Riley, Lake Lucy and Lake Ann, Lake Susan, Mitchell Lake, Lotus Lake, Rice Marsh Lake, and Bluff Creek (Figure 17). Ten stormwater ponds were sampled in 2012 and those same ponds were sampled again in 2013, along with 20 other stormwater ponds added through review of District UAAs.

4.2.1 Average Annual Total Phosphorus Concentration

The ten stormwater ponds sampled in 2012 were replicated in 2013 in order to better understand annual fluctuation of total phosphorus levels from one year to the next (Figure 18). Six of the ten ponds sampled, including ponds BC-P1.10B, BC-P2.7, LL-P10.4A, LR-P1.8, LU-P1.11A, and LU-P1.9, showed an increase in the average total phosphorus concentration from 2012 to 2013, while the other four sampling locations showed a decrease by an average of 18%.

In 2012, BC-P1.10B and LU-P1.11A had average total phosphorus concentrations that fell at or just below the lower extent of the typical total phosphorus concentration (0.1 mg/L). In 2013, both ponds showed an increase in the average total phosphorus concentration from 0.11 mg/L to 0.42 mg/L (74%) and from 0.097 mg/L to 0.36 mg/L (73%) respectively, putting them above the upper extent (0.25 mg/L).

Of the ten ponds that were replicated from 2012 to 2013, two ponds had average total phosphorus concentrations that consistently fell within the typical total phosphorus concentration range estimated by the MPCA for effluent water (0.1 mg/L – 0.25 mg/L). In both years, BC-P2.7 had average total phosphorus concentrations below the lower extent of the standard (0.083 and 0.087 mg/L respectively) and RM-P4.5 had results that were within the lower end of the range (0.13 and 0.11 mg/L respectively).

4.2.2 Seasonal Total Phosphorus Variation

Stormwater sampling began in early July and continued until mid-September with each round lasting approximately two weeks (see Table 2). Figure 19 shows the seasonal total phosphorus concentrations for the ponds sampled in Chanhassen in 2013, divided by round. As shown in the figure, there was high variability in the total phosphorus concentrations between the rounds for all but three of the ponds sampled, BC-P2.7, RM-P4.5, and LU-A5.6f/Brendon Pond. Pond BC-P2.7 had a total phosphorus concentration that fell below the lower extent of the MPCA range in all but one of the rounds (Round 2 – 0.13 mg/L), same as what was analyzed for RM-P4.5 (Round 2 – 0.2 mg/L). Total phosphorus levels collected for Pond LU-A5.6f/Brendon Pond were consistently below the lower extent of the MPCA in all four rounds (0.034 – 0.044 mg/L).

Ponds BC-P1.10B, BC-P4.10C, LL-P10.7/LL-8L, LL-P6.2/LL-2A, LS-P2.12A, LS-P2.12N, LS-P2.12S, LS-P3.21, LS-P3.22, LU-P2.4B, LU-P3.4, and RM-P2.1A all had one or more rounds where the total phosphorus concentration was measured above 1 mg/L. LS-P2.12N, LS-P3.22, and LU-P2.4B were measured above that concentration during three rounds.

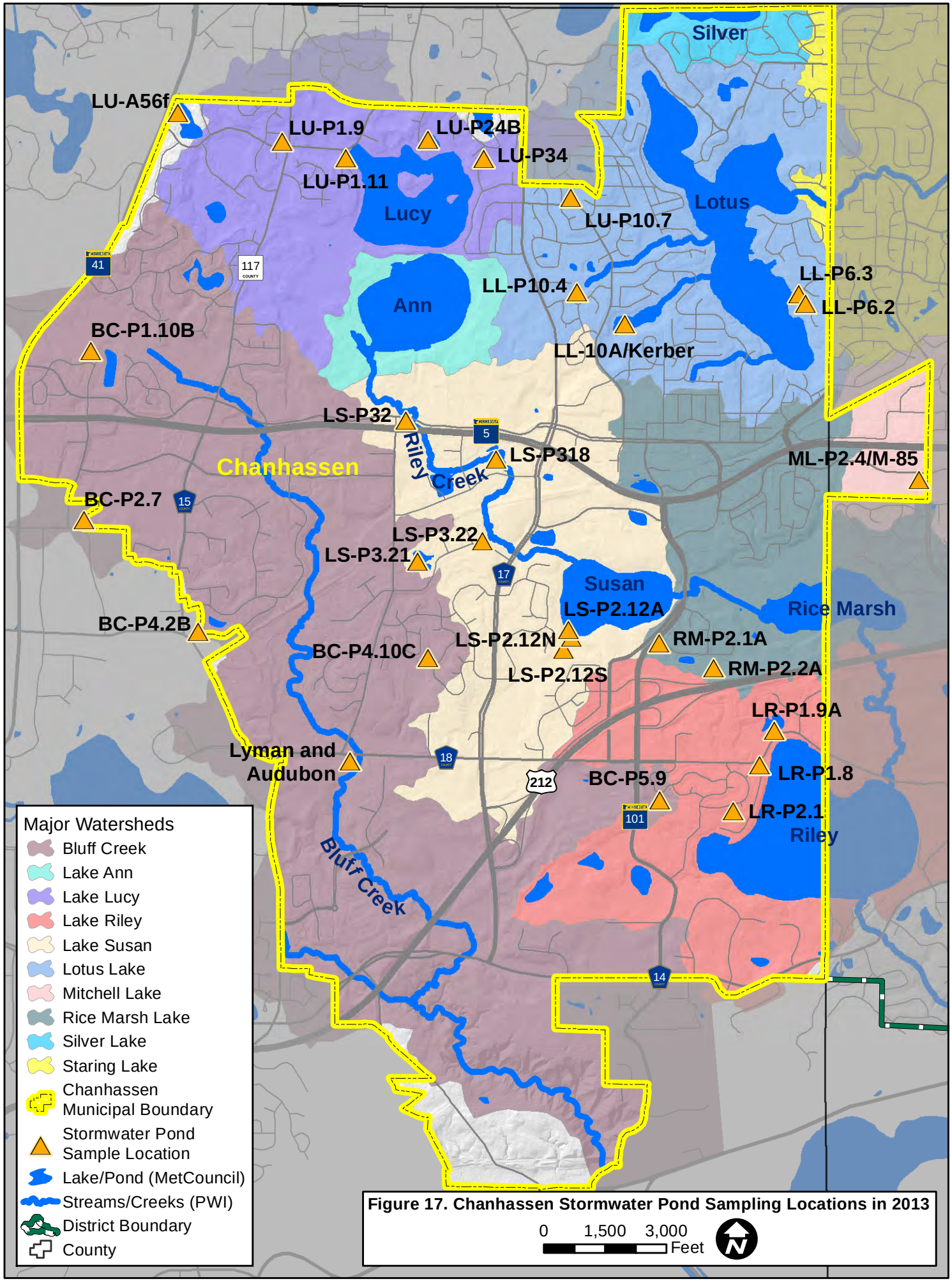

Figure 17. Chanhassen Stormwater Pond Sampling Locations in 2013

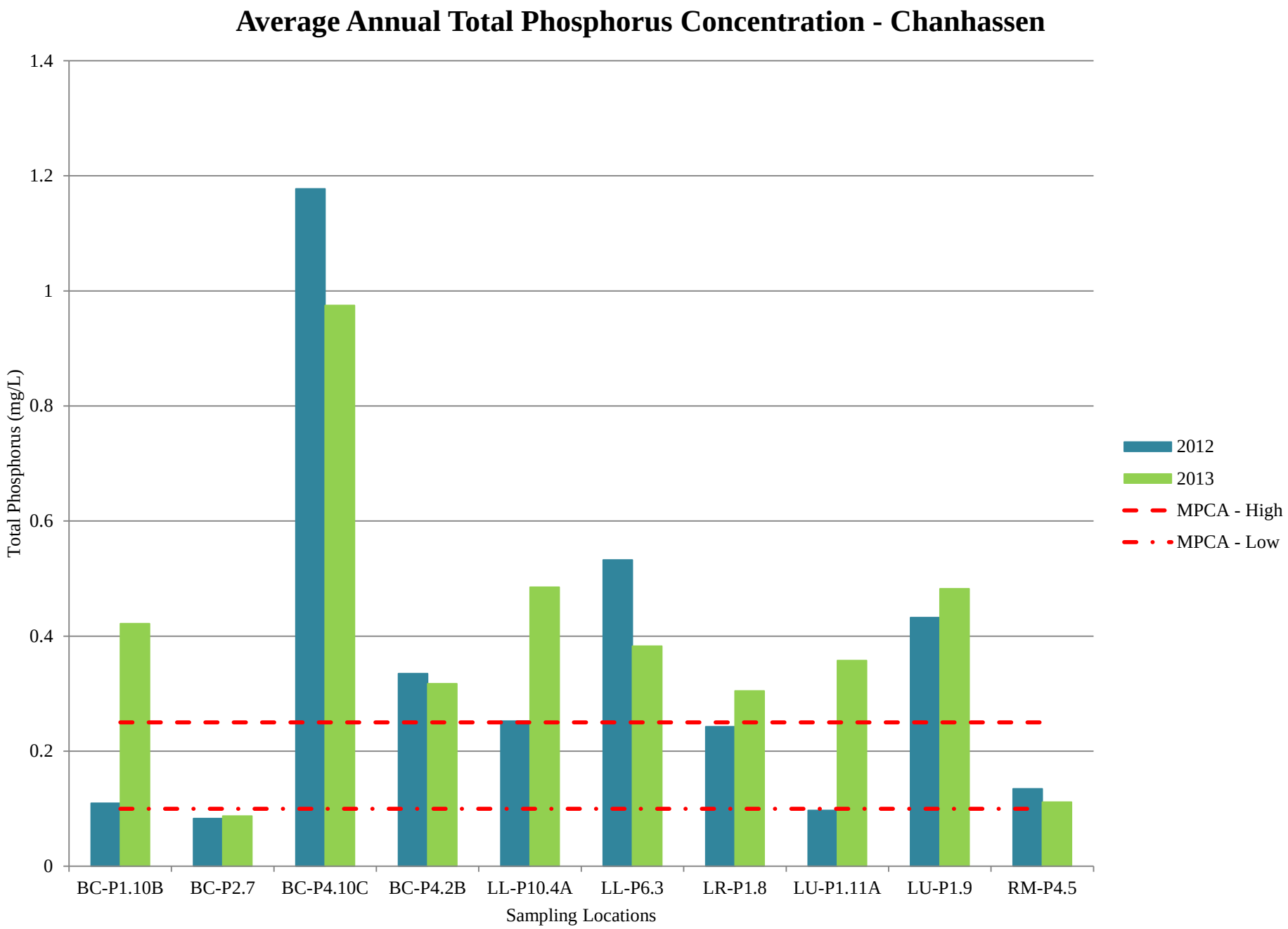

Figure 18. Average Annual Total Phosphorus Concentrations for Chanhassen Stormwater Ponds in 2012 and 2013

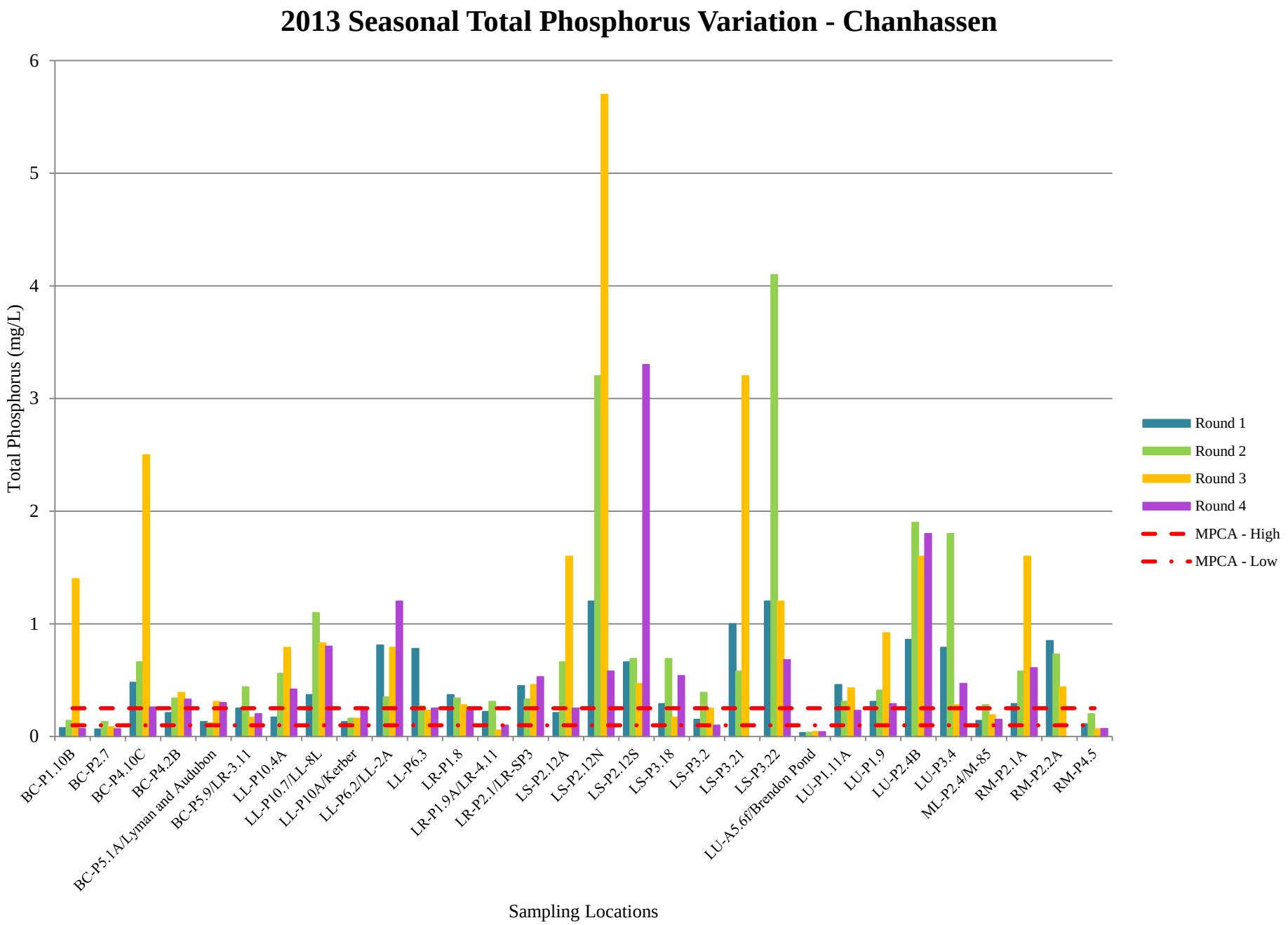

Figure 19. Seasonal Total Phosphorus Concentrations for Chanhassen Stormwater Ponds in 2013

4.3 Eden Prairie

The Eden Prairie stormwater pond group was comprised of sampling locations that operate as part of the stormwater conveyance networks found within six different subwatersheds: Lake Riley, Round Lake, Duck Lake, Mitchell Lake, Red Rock Lake, and Purgatory Creek (Figure 20). 12 stormwater ponds were sampled in 2012 and those same ponds were sampled again in 2013, along with 17 other stormwater ponds added after a review of District UAAs.

4.3.1 Average Annual Total Phosphorus Concentration

12 ponds sampled as part of the 2012 field season were replicated during the 2013 field season. Of those replicated, only three ponds, 08-13-B, 18-14-B, and 18-42-A, showed a decrease in average total phosphorus concentration between 2012 and 2013 (Figure 21). All other ponds had an increase in the annual average total phosphorus concentration from one year to the next.

Of the three ponds that had a decrease in the average total phosphorus concentration, water samples for Pond 18-13-B showed a decrease by almost 40% (from 1.2675 mg/L in 2012 to 0.775 mg/L in 2013). Ponds 18-14-B and 18-42-A had much smaller decreases in the average total phosphorus concentration (3% and 23% respectively) that brought their levels down into the MPCA's typical concentration range. In contrast, both ponds 07-14-B and 18-41-B showed a sharp increase in the average total phosphorus concentration. Pond 07-14-B increased from 0.69 mg/L in 2012 to 2.45 mg/L, while 18-41-B increased from 1.43 mg/L to 2.23 mg/L. All four rounds were completed for 07-14-B in both years, whereas only two rounds were completed for Pond 18-41-B in 2012 and three rounds in 2013.

4.3.2 Seasonal Total Phosphorus Variation

Stormwater pond sampling began in early July and continued until mid-September with each round lasting approximately two weeks (see Table 2). Figure 22 shows the seasonal total phosphorus concentrations for the ponds sampled in Eden Prairie in 2013 (29 ponds), divided by round. This variability in total phosphorus concentration between rounds is highly visible for Ponds 05-34-C, 07-14-B, 08-34-A, 17-34-A, 18-41-B, 19-43-A, and 30-12-B. For almost all of these ponds, samples collected during Round 1 were generally the highest, followed by Rounds 3 and 4. Samples collected during the Round 2 samples period generally had the lowest total phosphorus concentration out of the four water samples.

Of all the ponds sampled in Eden Prairie in 2013, only five ponds, including 05-11-A, 05-33-A, 17-13-A, 19-41-D, and 20-21-A (dry for three out of four rounds) had total phosphorus concentrations that were consistently within the MPCA range for effluent waters. Ponds 05-11-A, 05-33-A, and 17-13-A all had total phosphorus concentrations that fell below the typical total phosphorus concentration range (<0.1 mg/L) for the majority of the sampling rounds.

The discrepancy between the total phosphorus concentrations sampled during each round for each stormwater pond is indicative of the fact that seasonality (i.e. which round the samples were collected in) should not be used as a reliable indicator of total phosphorus concentration in pond. No one round/time period should be considered representative of concentrations for the whole growing period.

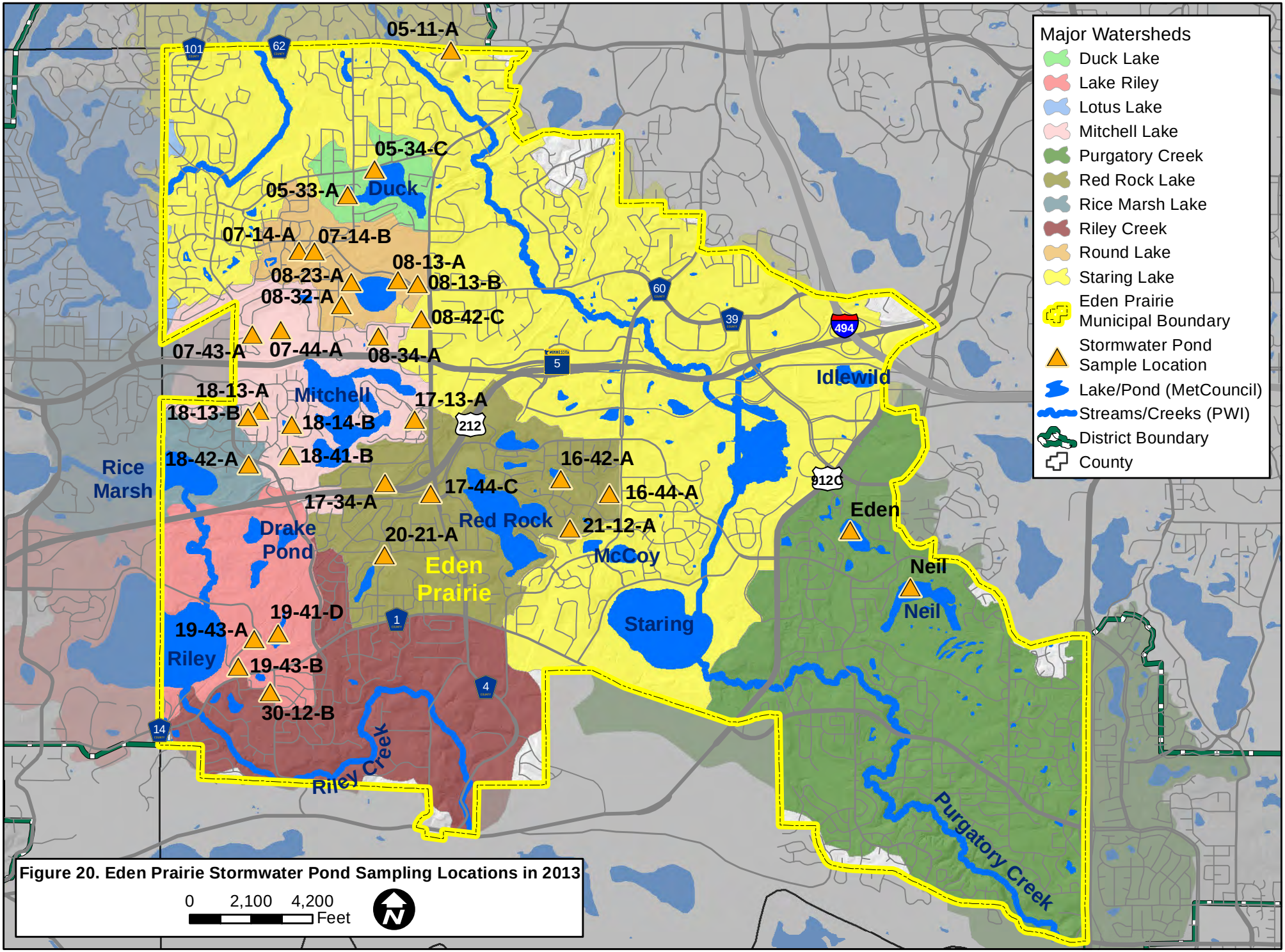

Figure 20. Eden Prairie Stormwater Pond Sampling Locations in 2013

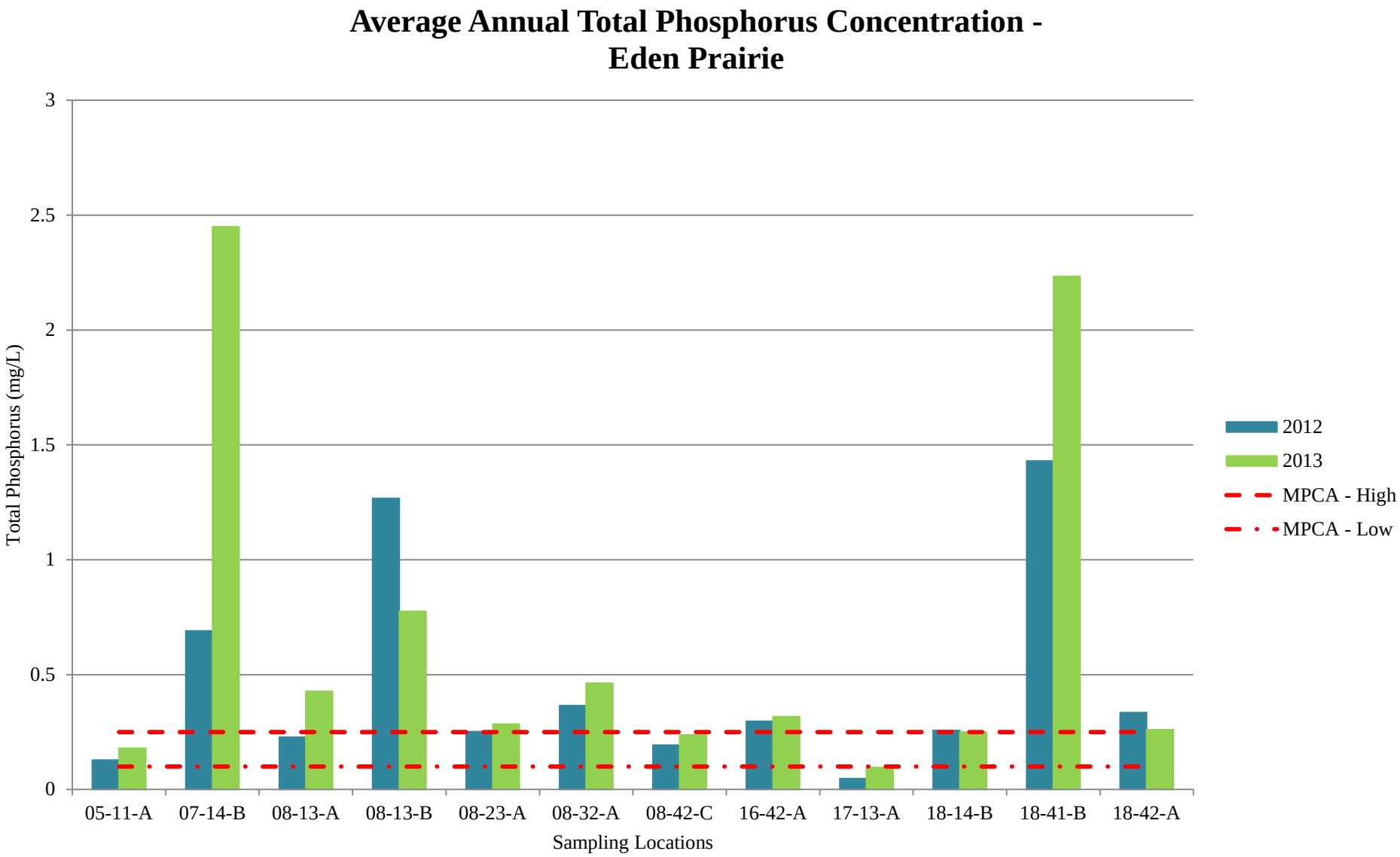

Figure 21. Average Annual Total Phosphorus Concentrations for Eden Prairie Stormwater Ponds in 2012 and 2013

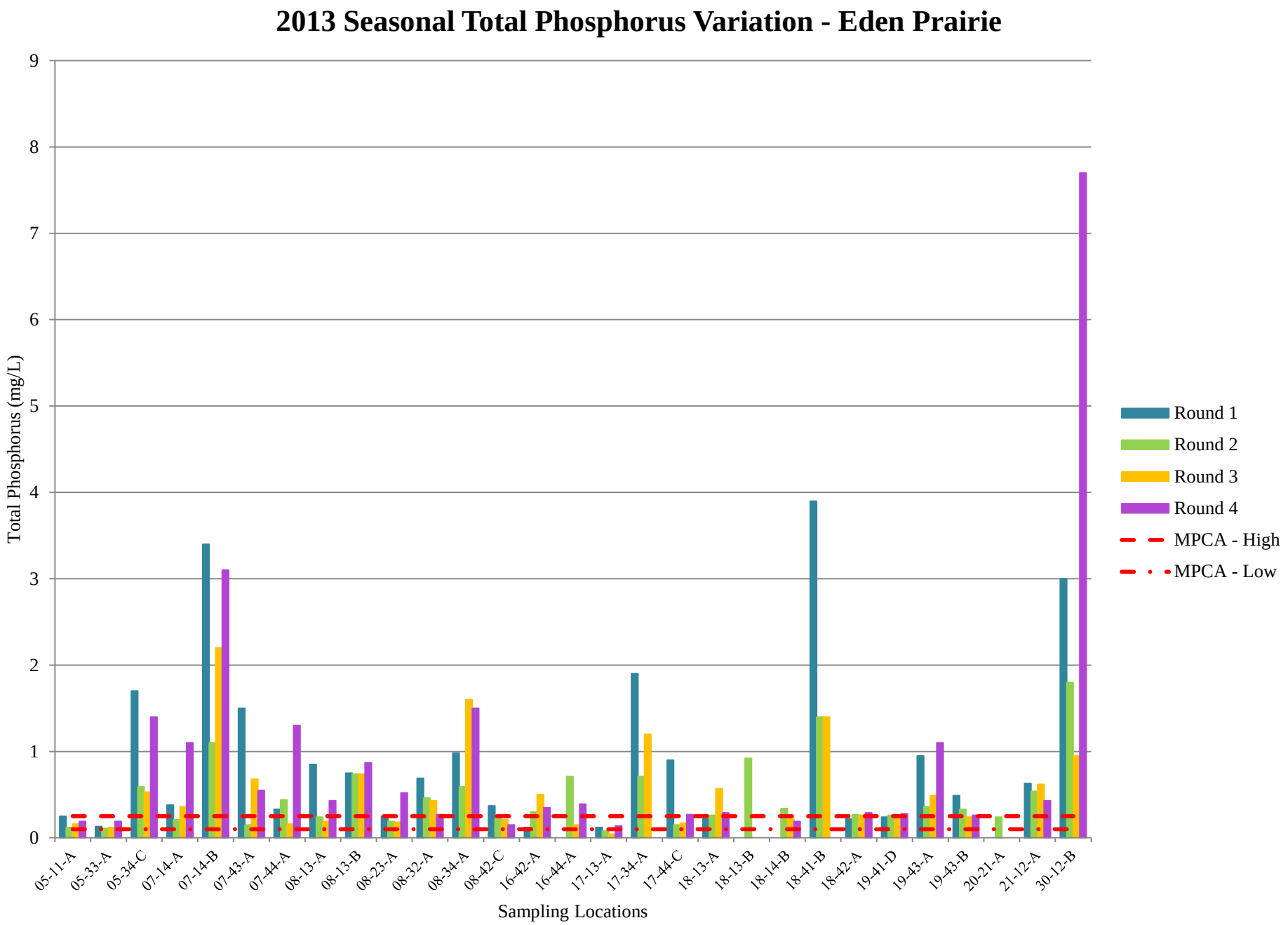

Figure 22. Seasonal Total Phosphorus Concentrations for Eden Prairie Stormwater Ponds in 2013

4.4 Minnetonka

Purgatory Creek flows from three distinct headwater sources: Lotus Lake in Chanhassen, Silver Lake in Shorewood, and several small wetland complexes in Minnetonka. All 11 of the stormwater ponds sampled in 2013 are a part of the stormwater conveyance network that flows through the wetland complexes that ultimately feeds into Purgatory Creek (Figure 23).

4.4.1 Average Annual Total Phosphorus Concentration

10 of the 11 ponds sampled in 2013 were replicated from the 2012 stormwater pond sampling effort (916_w excluded). Three of the ponds that were sampled in 2012 and 2013 (804_W, 920_W, and 947B_W) showed a decrease in the average total phosphorus concentration sampled from 2012 to 2013 (Figure 24). Because of this decrease, both 804_W and 947B_W fell within the typical total phosphorus concentration range found in stormwater estimated by the MPCA (0.1 mg/L to 0.25 mg/L). 804_W had an average total phosphorus concentration below the MPCA minimum value of 0.1 mg/L in 2013.

In 2012, six ponds had an average total phosphorus concentration that fell within the typical stormwater range set forth by the MPCA. These ponds include: 850_c, 850_p1, 861_p1, 886_p1, 901_w, and 947B_p1. In 2013, all but one of the ponds sampled (947_p1) showed an increase in the average total phosphorus concentration. Both ponds 850_p1 and 886_p1 showed an increase in the total phosphorus levels above the MPCA range (other three stayed within the range).

One pond to point out is Pond 849_W (Hanus Road, west of Clear Springs Elementary School). In 2012, 849_W had an average total phosphorus concentration of 3.025 mg/L and a maximum value of 4.2 mg/L in Round 4. In 2013, the average total phosphorus concentration increased to 4.025 mg/L, 16% higher than the MPCA's estimated range for effluent stormwater. Continuing the stormwater pond assessment for a third sampling season will provide District staff with information pertaining to the total phosphorus concentration of Minnetonka stormwater ponds, particularly 849_W, which will be of assistance when undertaking future remediation projects.

4.4.2 Seasonal Total Phosphorus Variation

The stormwater pond field season began in early July and continued until mid-September with each round lasting approximately two weeks (see Table 2). Figure 25 shows the seasonal total phosphorus concentrations for the ponds sampled in Minnetonka in 2013, divided by round (Rounds 1-4 only). The majority of the ponds had one round which showed extremely high or extremely low total phosphorus values in comparison to the rest of the samples (849_W and 916_W had two extremely high rounds and two lower rounds), whereas only three ponds (804_W, 850_c, and 947B_p1) had very consistent total phosphorus concentrations across all four sampling rounds. The discrepancy between ponds with high variability between the rounds and those with little variability of the total phosphorus concentrations is indicative of the fact that seasonality (i.e. which round the samples were collected in) should not be used as a reliable indicator of total phosphorus concentration in pond. No one round/time period should be considered representative of concentrations for the whole growing period.

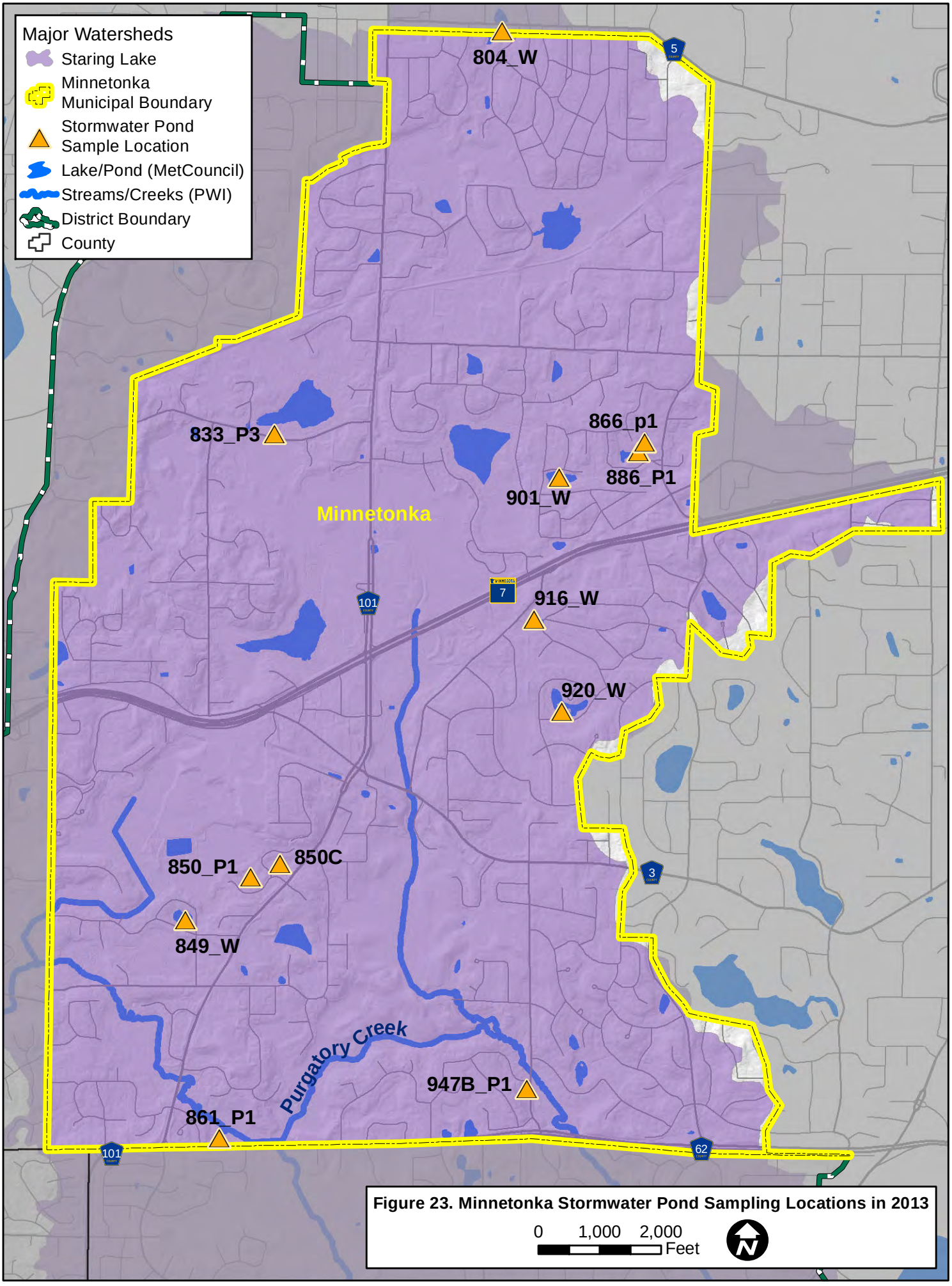

Figure 23. Minnetonka Stormwater Pond Sampling Locations in 2013

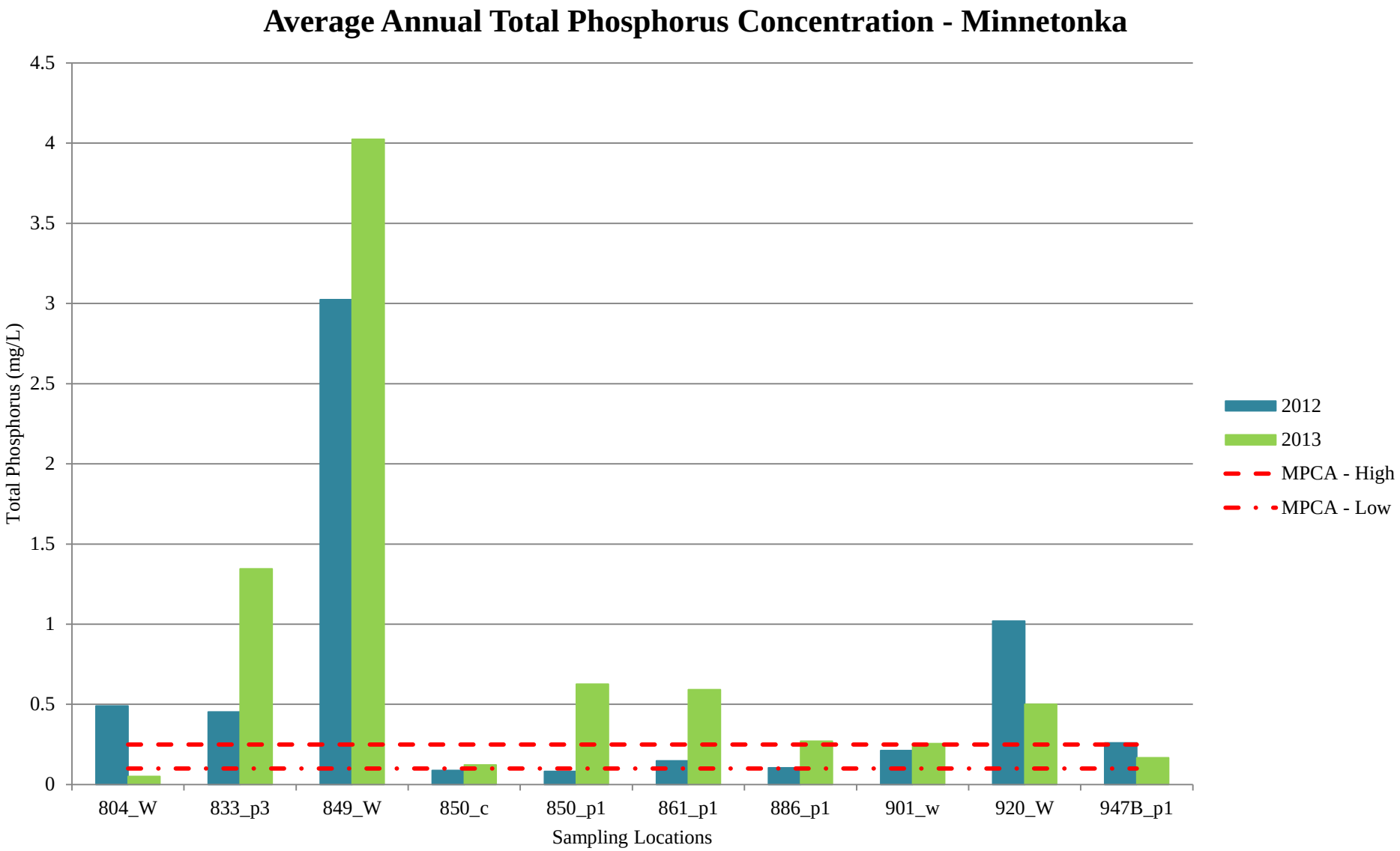

Figure 24. Average Annual Total Phosphorus Concentrations for Minnetonka Stormwater Ponds in 2012 and 2013

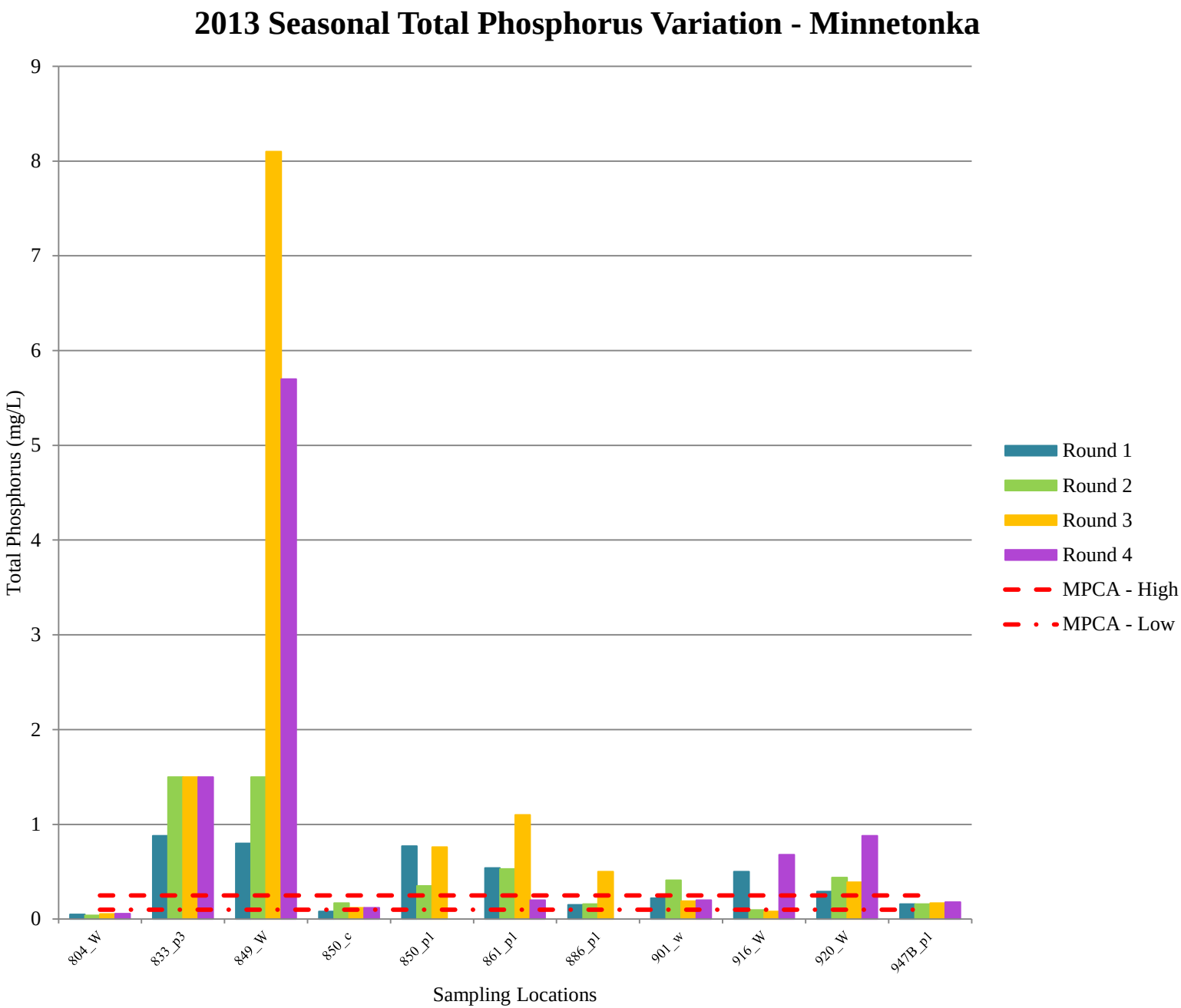

Figure 25. Seasonal Total Phosphorus Concentrations for Minnetonka Stormwater Ponds in 2013

4.5 Shorewood

Silver Lake is fed by a stormwater network that is made up of a combination of wet treatment ponds and a storm sewer network (Figure 26). The Silver Lake subwatershed is over 250 acres in size, 11 acres of which consists of stormwater ponds and 67 acres is Silver Lake itself. This subwatershed is fully developed and consists of low-density residential housing (Barr 2003).

4.5.1 Average Annual Total Phosphorus Concentration

Eight of the stormwater ponds that were sampled in 2012 were replicated during the 2013 field season (Wetland_2 was not sampled in 2013 due to accessibility issues). Seven out of the eight ponds were constructed stormwater ponds, while Wetland_1 is categorized as a wetland. Three of the ponds showed a decrease in the average total phosphorus concentration between 2012 and 2013 (Pond 12, Pond 43, and Wetland 1), whereas Pond 41 and Pond 44 showed a significant increase in the average total phosphorus concentration from 2012 to 2013 (Figure 27). During the 2014 field season, Ponds 41 and 44 will be studied closely to see what changes in total phosphorus concentration are presented. Ponds 20 and 40 also exhibited an increase in total phosphorus concentration from the 2012 effort to the 2013 effort, but with a much less drastic change.

This data shows that for the most part, the ponds that were ‘bad’ (had high total phosphorus concentrations) in 2012, continued to perform poorly in 2013. This was also true for the stormwater ponds that performed well or ‘good’ during the sampling efforts in both 2012 and 2013. Because 2012 was an inordinately wet year and 2013 was very dry, continuing the study in 2014 will hopefully provide District staff with more consistent data points that better represent the total phosphorus concentration in the stormwater ponds.

4.5.2 Seasonal Total Phosphorus Variation

Stormwater pond sampling began in early July and continued until mid-September with each round lasting approximately two weeks (see Table 2). Figure 28 shows the seasonal total phosphorus concentrations for the ponds sampled in Shorewood in 2013, divided by round (Rounds 1-4 only). There was high variability in the total phosphorus concentrations between the rounds, meaning that seasonality (i.e. which round the samples were collected in) is not a good indicator of the concentration of total phosphorus in the pond and no one round or time period should be considered representative of concentrations during the whole growing period. Oddly enough, for eight out of the nine stormwater ponds sampled, the samples collected in Round 2 (mid to late-July) were much higher than the total phosphorus concentrations collected during the other three rounds. This will be something to watch in 2014.

Of all the ponds sampled in Shorewood in 2013, only three ponds, including Pond 20 had a total phosphorus concentration that was consistently below the low end of the MPCA range (0.1mg/L) for three of the four sampling rounds (and only slightly higher in Round 2). Ponds 40 and 43 had average total phosphorus concentrations that fell below the 0.25 mg/L MPCA standard, but there was a lot of variation between the rounds.

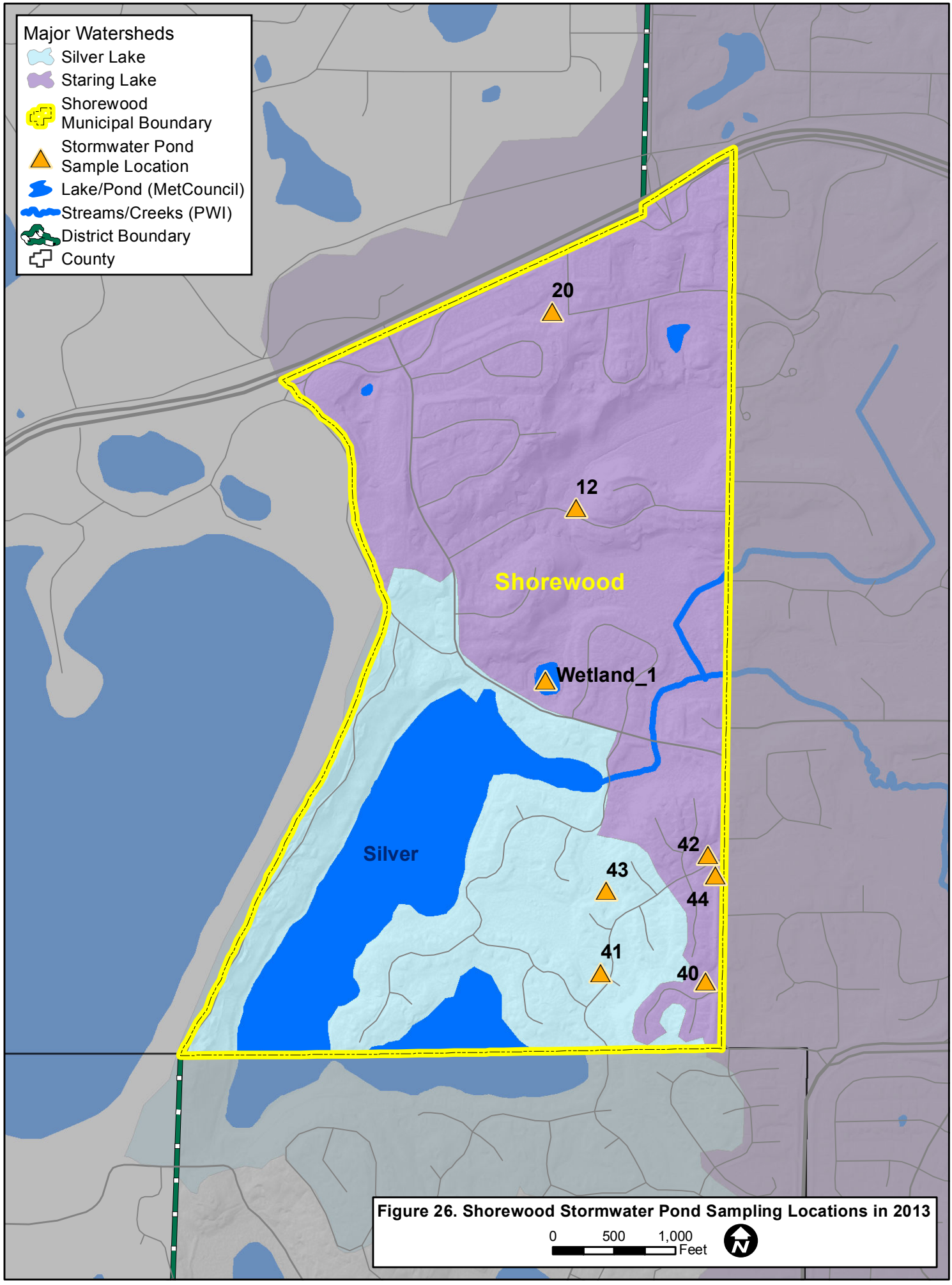

Figure 26. Shorewood Stormwater Pond Sampling Locations in 2013

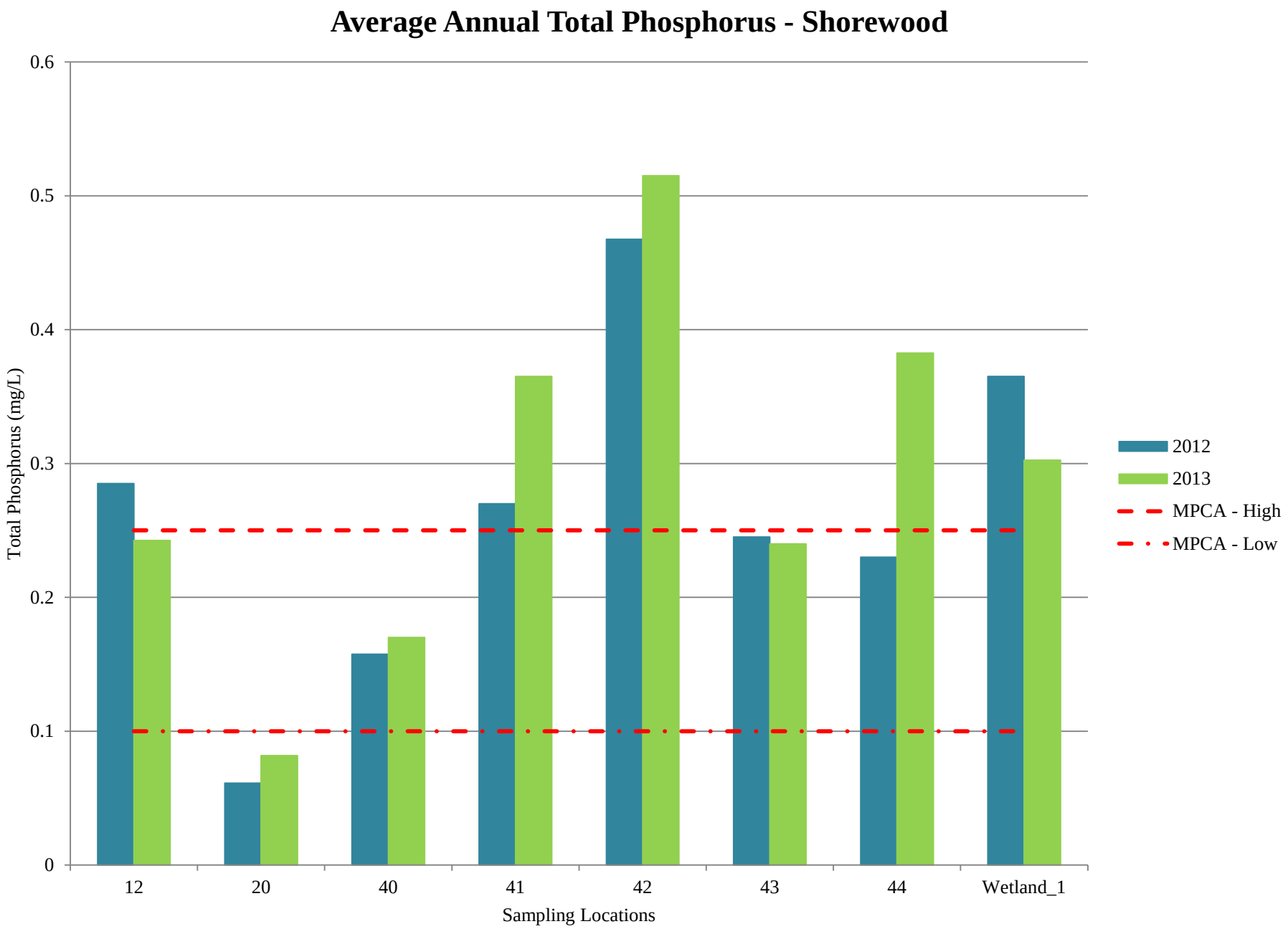

Figure 27. Average Annual Total Phosphorus Concentrations for Shorewood Stormwater Ponds in 2012 and 2013

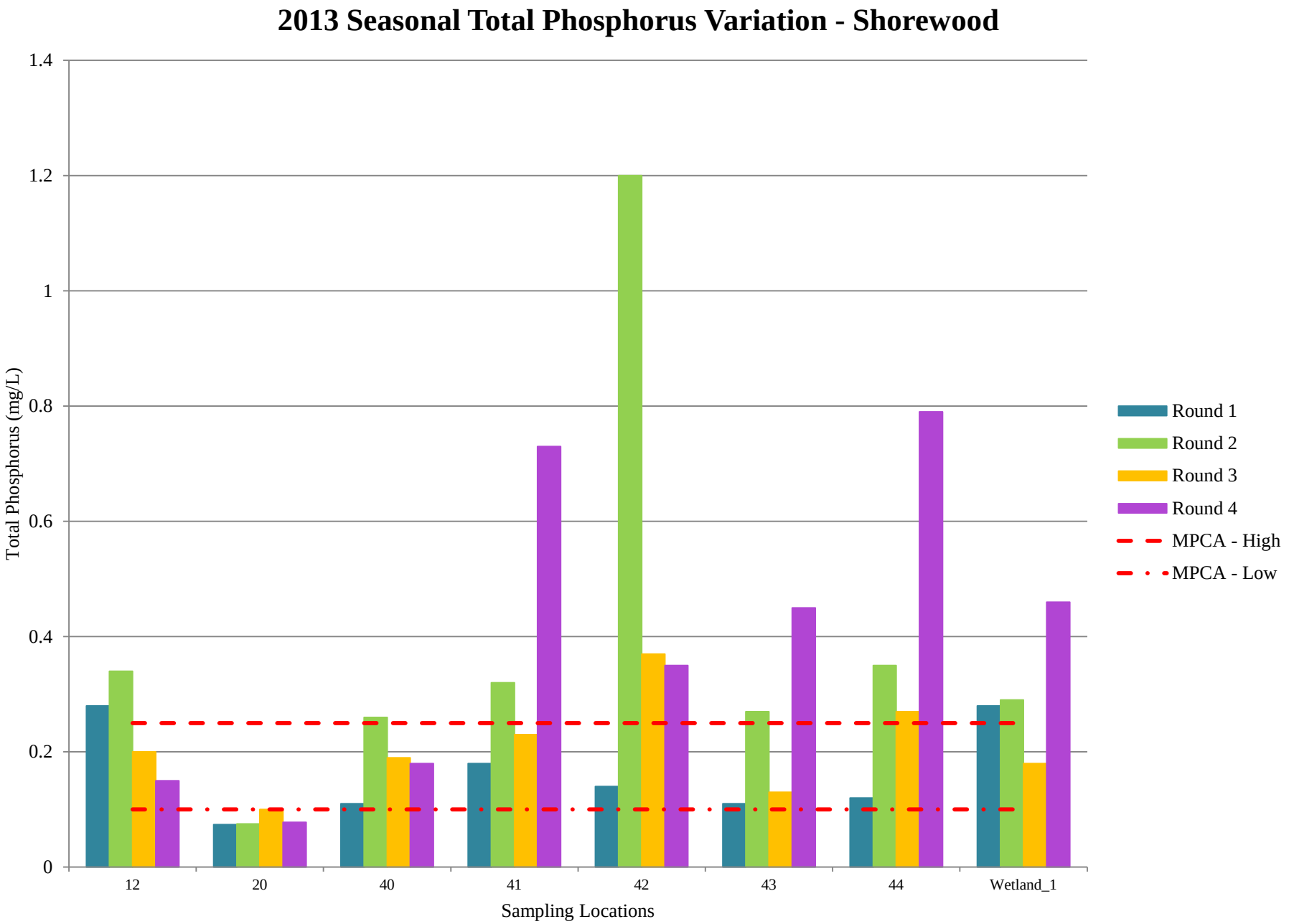

Figure 28. Seasonal Total Phosphorus Concentrations for Shorewood Stormwater Ponds in 2013

5. Conclusion

The District Stormwater Project was undertaken by District staff in conjunction with city staff from Bloomington, Chanhassen, Eden Prairie, Minnetonka, and Shorewood. In 2013, field sampling in Shorewood was conducted by District staff. Field work included collecting water samples at each sampling location, as well as recording climate data and pond attribute information during each sampling round.

5.1 Sampling Effort Review

At the conclusion of the 2012 field sampling season, 272 water samples were collected from 61 stormwater ponds to be tested for total phosphorus. The field season started in early July and ran through the end of August allowing for four sampling rounds to be completed. Water samples were collected approximately every two weeks, with the addition of some quality control samples collected. The quality control sampling events were conducted at a select number of ponds and were interspersed into the regular sampling schedule between Rounds 2 and 3 and between Rounds 3 and 4.

During the 2013 field sampling season, 420 water samples were collected from 98 stormwater ponds to be tested for total phosphorus and 110 samples from 38 stormwater ponds that were tested for dissolved phosphorus. The field season started in early July and ran through the middle of September. No quality control rounds were conducted in 2013. Four rounds were completed for both Bloomington and Eden Prairie, but all five sampling rounds were completed in Chanhassen, Minnetonka, and Shorewood.

5.2 Project Conclusions

The purpose of this project was to gain a better understanding of the role of stormwater ponds in the District. This was done by identifying which ponds are working well as ‘pollution sinks’ and which ponds are performing poorly and have become sources of pollution within the watershed.

In both 2012 and 2013, average total phosphorus levels were higher than the MPCA estimated typical total phosphorus range (0.1 mg/L to 0.25 mg/L) for effluent (outgoing) stormwater in all five of the cities sampled. Of the five cities sampled, only the ponds in Bloomington showed a decrease in the average total phosphorus concentration from 2012 to 2013.

Evaluation of the data found that increasing the frequency at which the water samples were collected was not necessary. Continuing to collect the samples following a two to three week sampling schedule resulted in a dataset that was equally representative of the total phosphorus levels in a stormwater pond that was sampled at a weekly interval. A fifth sampling round was completed in September for stormwater ponds in Chanhassen, Minnetonka, and Shorewood. Analysis of the data showed minimal variation in total phosphorus concentration between the cities when comparing the total phosphorus concentrations from Rounds 1-4 against Rounds 1-5.

Before the beginning of the sampling season, historical data was reviewed to distinguish ponds with extremely high total phosphorus concentrations (>1 mg/L). Through this analysis, ten ponds were identified and the historical total phosphorus concentrations were then compared with the

results from the 2013 field effort. Following replication, only two of the ponds had total phosphorus concentrations that stayed above 1 mg/L. This analysis also identified eight additional ponds that showed elevated total phosphorus levels following the 2013 season which were either recently added to the sampling plan or had historical levels that were below 1 mg/L.

This project tested an original hypothesis pertaining to the impact that the age of the pond could have on total phosphorus levels. This means that older ponds (wetlands converted to stormwater ponds) were expected to have higher levels of total phosphorus than the NURP ponds that were constructed more recently. Subsequent data analysis found no relationship between the age of the pond and the total phosphorus concentration measured in the pond. From this, it can be assumed that the original state of the pond (converted wetland vs. man-made) does not impact the total phosphorus concentration.

Dissolved phosphorus samples were collected at 38 of the 98 stormwater ponds sampled in 2013. The average dissolved phosphorus concentration in each of these ponds was significantly lower than the average total phosphorus concentration. These findings indicate that the majority of the phosphorus found in stormwater is in the particulate form, not the soluble form. Collecting water samples to be tested for total phosphorus, not dissolved phosphorus, will continue to be the primary tool used by the District when identifying problematic stormwater ponds.

Analysis of the two stormwater pond chains around Mitchell Lake, M-3 and M-56 showed varied results. The total phosphorus concentrations measure in M-56 were consistent with a chain that was behaving appropriately in that the concentrations were highest at the most upstream pond and slowly decreased as stormwater moved down the chain towards the main water body. In contrast, the M-3 chain exhibited an influx of total phosphorus from an unknown source that elevated the total phosphorus concentration mid-chain. These findings highlight why it is important to study stormwater ponds not just as individual units, but as a network of ponds working together. Concentrating sampling efforts on pond chains will provide more descriptive data looking at the impact of upstream stormwater ponds on downstream water bodies and how pollutants move through the watershed.

Preliminary studies conducted on stormwater ponds in the District hypothesized that a relationship existed between the presence and /or amount of mactrophytes (aquatic vegetation) and the total phosphorus concentration of a stormwater pond (CH2M Hill 2012). Analysis of the total phosphorus data collected in 2013 has found that no such relationship exists. Stormwater ponds observed with low (<25%) to medium macrophyte cover (50-75%) had similar total phosphorus concentrations to what was measured in ponds with high macrophyte cover. Water samples from Bloomington stormwater ponds with greater than 75% macrophyte cover had total phosphorus concentrations that fell below, within, and outside of the MPCA range for total phosphorus. With these findings it has been concluded that the presence and/or amount of macrophytes in a stormwater pond is not a reliable indicator of poor overall health.

5.3 Looking forward into 2014

The third year of the District's stormwater assessment project will be completed in the summer of 2014. Because both of the previous sampling events took place during years with unusual and varied climactic conditions (2012 was an exceptionally wet year and 2013 was an exceptionally

dry year), conducting a third year of field sampling will hopefully produce a dataset that is more representative of traditional or average total phosphorus levels in a stormwater pond. A third year of data will also allow District staff to highlight poorly performing stormwater ponds and begin to identify potential remediation activities that could be undertaken.

The sampling plan for the 2014 field season will differ from the previous two years in several ways. First off, following the findings of this report, the 5th sampling round in September will be forgone in favor of adding a sampling round in late June. The data collected in September did not prove to be highly influential on the total phosphorus concentrations in the stormwater ponds, in addition to difficulties brought on by staffing limitations due to the start of the school year. Incorporating a sampling round earlier in the growing season will hopefully reveal a fuller picture of total phosphorus concentrations in District stormwater ponds.

Secondly, the District hopes to further analyze the data collected in all three years of this study by utilizing the available land use data provided by the cities to determine if there is a relationship between the surrounding vegetation and total phosphorus levels in the pond. This analysis will be performed by quantifying the landuse types in each stormwater pond's tributary area (specifically the amount of impervious and vegetated area) and comparing it against the total phosphorus concentrations measured during each round. Other possibilities for further study include conducting temperature stratification studies using a multi-parameter sonde and using current and historical pond volume data to assess storage capacity in order to highlight potentially problematic ponds.

71% of stormwater ponds sampled in 2013 had total phosphorus levels that were greater than the typical total phosphorus concentration range for effluent water estimated by the MPCA (0.1 mg/L to 0.25 mg/L). In order to get a better understanding of what is happening in these ponds in real-time, the District plans to install ISCO units (automatic sampling system) at the outlet structures of two stormwater ponds (one with low total phosphorus concentration and one with high) in the District. The ISCO unit can monitor the environmental conditions at a sampling site and will collect water samples when a predetermined water level is reached (i.e. during heavy rain event). The data provided by an ISCO unit will help to ascertain the total phosphorus concentration of effluent stormwater during a heavy rain event, a circumstance that is currently undocumented as part of this study since pond sampling occurs 48 hours after a rain event.

District staff also plans to increase the number of ponds sampled to 130 in 2014. The additional stormwater ponds will include sampling sites identified in the Purgatory Creek Use Attainability Analysis and those identified in further conversation with city staff. In furtherance of the primary goal of this project, stormwater pond chains will also be a major focus during the 2014 sampling season, as there is a need to better understand the impact of upstream stormwater ponds on downstream water bodies (both lakes and creeks).

At the conclusion of the 2014 field season, 61 stormwater ponds will have been monitored for three years in a row. With this robust dataset, the stormwater ponds with excessive total phosphorus concentrations will be prioritized and potential remediation plans can begin to be strategized. By improving the water quality of these 'bad' ponds, the many lakes and creeks within the District will ultimately benefit from reduced total phosphorus levels in stormwater.

6. References

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Stream or lake water quality depend not only on the extent of sediment or nutrient sources within a landscape, but also on the extent of landscape sinks or transformers of nutrients and pollutants

- Detenbeck 1993