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Technical memorandum

To: John Loomis, Water Resources Program Manager, South Washington Watershed District
From: Charlie Hinds, Erin Andersen Wenz, and John Hanson
Subject: Northern SWWD stormwater best management practices feasibility study
Date: March 12, 2019
Project: 23/82-1196.00

1.0 Introduction

Barr Engineering Co. completed a feasibility study to evaluate the potential of implementing retrofit best management practices (BMPs) at four sites in the northern portion of the South Washington Watershed District (SWWD). The purpose of the study is to assess the ability of projects to reduce the phosphorus load to four different SWWD lakes (Powers, Armstrong, North Wilmes, and South Wilmes). The current total-phosphorus (TP) reduction goal and the project location targeting each lake are shown in table 1.

Table 1: Northern SWWD TP reduction goals

lake	watershed TP reduction goal (lbs/year)	project location targeting the lake	TP reduction goal source
Armstrong Lake	83	Armstrong Lake wetland	lake management plan by Wenck Associates, Inc. (December 2018)
North Wilmes Lake	153	Kargel Park	lake management plan by Wenck Associates, Inc. (December 2018)
South Wilmes Lake	27	Seasons Park	lake management plan by Wenck Associates, Inc. (December 2018)
Powers Lake	none	east of Powers Lake	lake management plan by Wenck Associates, Inc. (December 2018)

This memo summarizes the conceptual design, planning-level cost estimates, and water quality benefits for BMPs at each of the four potential project sites. The location of each site is shown in figure 1.

2.0 Summary

Barr developed a conceptual design, planning-level cost estimate, water-quality benefit estimates, and an annualized cost per pound of TP removed for 13 BMPs across four sites. This information is summarized in table 2. Water quality benefits are reported as both annual TP removal and TP removal within the growing season. The growing season was assumed as June 1 to September 30. More information on each BMP is provided in section 3.0 of the feasibility study.

Table 2: Feasibility study summary table

Armstrong Lake wetland	Armstrong Lake removal goal: 83 lbs/year				
BMP description	**planning-level opinion of cost[1]**	**annual operations and maintenance cost**	**TP removal (lbs/growing season)**	**TP removal (lbs/year)**	**annual cost per pound of TP removed ($/lb)[2]**
cattail harvesting—growing season	$ 75,000	$ 20,000	350	350	$ 70*
cattail harvesting—winter	$ 75,000	$ 20,000	0	40	$ 640*
CC17 filter berm—in channel	$ 35,000	$ 5,000	1.6	2.8	$ 2,700
CC17 filter berm—across wetland	$ 360,000	$ 20,000	7.9	14	$ 3,400
Kargel Park	**North Wilmes removal goal: 153 lbs/year**				
BMP description	**planning-level opinion of cost[1]**	**annual operations and maintenance cost**	**TP removal (lbs/growing season)**	**TP removal (lbs/year)**	**annual cost per pound of TP removed ($/lb)[2]**
Kargel Park infiltration—surface	$960,000	$10,000	8.5	15	$5,400
Kargel Park infiltration—underground[3]	$4,200,000	$10,000	23	40	$8,100
Kargel Park alum treatment	$2,700,000	$90,000	48	84	$3,600
wet basin CC17 filtration	$290,000	$35,000	8.6	15	$3,800
Seasons Park	**South Wilmes removal goal: 27 lbs/year**				
BMP description	**planning-level opinion of cost[1]**	**annual operations and maintenance cost**	**TP removal (lbs/growing season)**	**TP removal (lbs/year)**	**annual cost per pound of TP removed ($/lb)[2]**
west spent lime filter	$630,000	$10,000	17	30	$1,900
filter boxes (each)	$40,000	$7,000	1.6	2.8	$3,600
water reuse[3]	$430,000	$1,000	3.1	3.1	$10,500
east of Powers Lake					
BMP description	**planning-level opinion of cost[1]**	**annual operations and maintenance cost**	**TP removal (lbs/growing season)**	**TP removal (lbs/year)**	**annual cost per pound of TP removed ($/lb)[2]**
underground infiltration/filtration from Fish Lake[3]	$3,200,000 to $16,400,000	$15,000 to $25,000	19 to 38	33 to 67	$7,500 to $18,400
underground infiltration/filtration from area north of Fish Lake	$1,800,000 to $10,100,000	$10,000 to $20,000	15 to 22	45 to 70	$3,200 to $10,900

[1]Costs are represented as a feasibility-level class 5 cost estimate as defined by the Association for the Advancement of Cost Engineering (AACE) with a +50-percent/-30-percent uncertainty. Costs include engineering and design and construction observation.

[2]Range represents the annualized cost based on a 20-year BMP lifespan at an interest rate of 4 percent. Costs include construction and engineering and design.

[3]This option was removed from consideration during the December 18, 2018 meeting with Barr, the SWWD, and the City of Woodbury because of the high cost relative to TP removal.

**This cost per pound of TP removed assumes that all of the phosphorus removed during cattail harvesting would have been released into water as it passed through the wetland, which is not likely.*

3.0 Locations

Armstrong Lake wetland

Barr analyzed two BMP options to remove phosphorus in the wetland directly west of Armstrong Lake. The locations of the two BMPs are shown in figure 2. The cost estimate and phosphorus removal information for the four investigated BMPs are shown in table 3.

Table 3: Armstrong Lake cost estimate and phosphorus removal information

Armstrong Lake wetland	Armstrong Lake removal goal: 83 lbs/year				
BMP description	**planning-level opinion of cost[1]**	**annual operations and maintenance cost**	**TP removal (lbs/growing season)**	**TP removal (lbs/year)**	**annual cost per pound of TP removed ($/lb) [2]**
cattail harvesting—growing season	$ 75,000	$ 20,000	350	350	$ 70*
cattail harvesting—winter	$ 75,000	$ 20,000	0	40	$ 640*
CC17 filter berm—in channel	$ 35,000	$ 5,000	1.6	2.8	$ 2,700
CC17 filter berm—across wetland	$ 360,000	$ 20,000	7.9	13.8	$ 3,400

[1]Costs are represented as a feasibility-level class 5 cost estimate as defined by the AACE with a +50-percent/-30-percent uncertainty. Costs include engineering and design and construction observation.

[2]Range represents the annualized cost based on a 20-year BMP lifespan at an interest rate of 4 percent. Costs include construction and engineering and design.

**This cost per pound of TP removed assumes that all of the phosphorus removed during cattail harvesting would have been released into water as it passed through the wetland, which is not likely.*

Barr completed a brief review of the wetland west of Armstrong Lake. The wetland has had a constructed ditch running through it since before 1936 to allow some agricultural uses in the area – likely hay and pasture. The wetland is currently a shallow marsh with the water level anticipated to be just below the ground surface for much of the season, but the water level likely rises and floods periodically after heavy rain. The current ground elevation in the wetland is higher than the ordinary high water level in Armstrong Lake, which means the wetland is likely not a public water permitted by the Minnesota Department of Natural Resources.

Cattail harvesting

The SWWD estimated TP removals from cattail harvesting in the wetland west of Armstrong Lake in the *Armstrong Lake Subwatershed Retrofit Analysis Report* (September 2018). This document reported a potential TP removal of 40 to 350 pounds per year from cattail harvesting in the wetland west of Armstrong Lake. The significant range is due to differences in phosphorus removal depending on the season when the cattails are harvested. Another important consideration about cattail harvesting is that although the reported removals of 40 to 350 pounds per year account for the TP that would be physically removed from the wetland, they do not account for the fact that not all of that phosphorus in the removed cattails would have been released into Armstrong Lake, affecting its water quality. Monitoring would be recommended to complement cattail harvesting to assess the actual impact of cattail removal, which could be significantly lower than the theoretical removals from the SWWD report.

A cattail removal machine at work in a Ramsey-Washington Metro Watershed District wetland. Photo Credit: Ramsey-Washington Metro Watershed District

Crushed limestone filter berms

Barr investigated the use of crushed limestone as a filter berm in the wetland west of Armstrong Lake. Two berm layouts were investigated. Potential filter berm locations are shown in figure 2. Using crushed limestone is not an established method to remove phosphorus; however, preliminary monitoring data from a test cell in the Ramsey-Washington Metro Watershed District's Kohlman Basin permeable weir system shows that the material can remove 40 to 50 percent of phosphorus from water. While this removal efficiency is lower than alternative materials, crushed limestone shows potential because it does not need to dry out between filtering sessions to retain its removal efficiency. This makes it a good option to treat continuous low flows through the wetland at Armstrong Lake. The material does plug and would likely need to be replaced every three to five years, which adds a high maintenance cost to the relatively low construction cost.

Kohlman Basin permeable weir system with CC17 test cells. Photo Credit: Keith Pilgrim

Cross-wetland berms

The first option is to construct a crushed limestone filter berm across the length of the wetland. Based on experimental data from the Ramsey-Washington Metro Watershed District test cell at Kohlman Basin, the predicted TP removal of a single 500-foot-long berm is 14 pounds per year (7.9 pounds per growing season) assuming a baseflow of 0.5 cubic feet per second through the wetland. Cross-wetland berms could be added in series in the wetland to increase the phosphorus removal if desired. The cross-wetland berm could also be paired with a wetland restoration effort. The wetland is currently channelized, but the berm would be able to spread out flows and restore a more natural wetland habitat. Based on the City of Oakdale's HydroCAD model results in the city's December 2018 stormwater management plan, there are flooding concerns in the wetland area. The plan recommends a minimum building elevation of 1023.5 feet. Figure 2 shows that there are already buildings within that footprint. Restoring the wetland and raising the normal water level in the wetland could increase flooding. Before proceeding with design and construction of cross-wetland berms, the flood impacts of the design should be more thoroughly assessed.

Cross-channel berms

The second option is to construct a shorter crushed-limestone berm that only runs across the existing channel. This option allows the low flows to be treated in the channel, while higher-flow situations will bypass the filter. Very little of the storage area in the wetland is in the channel, so raising the water surface elevation in the channel would have little impact on flooding near the wetland. The predicted TP removal of a single cross-channel berm is 2.8 pounds per year (1.6 pounds per growing season).

Kargel Park

Four alternatives were investigated at two locations near Kargel Park. Locations of the BMP retrofits are shown in figure 3. The removals for each of the four alternatives cannot be combined. Constructing the items in series or parallel with each other is either not possible, or would significantly reduce the phosphorus removal from one of the combined options. The cost estimate and phosphorus removal information for the four investigated BMPs is shown in table 2. Removals for each option compared to the TP reduction goal in North Wilmes Lake are shown in figure 4.

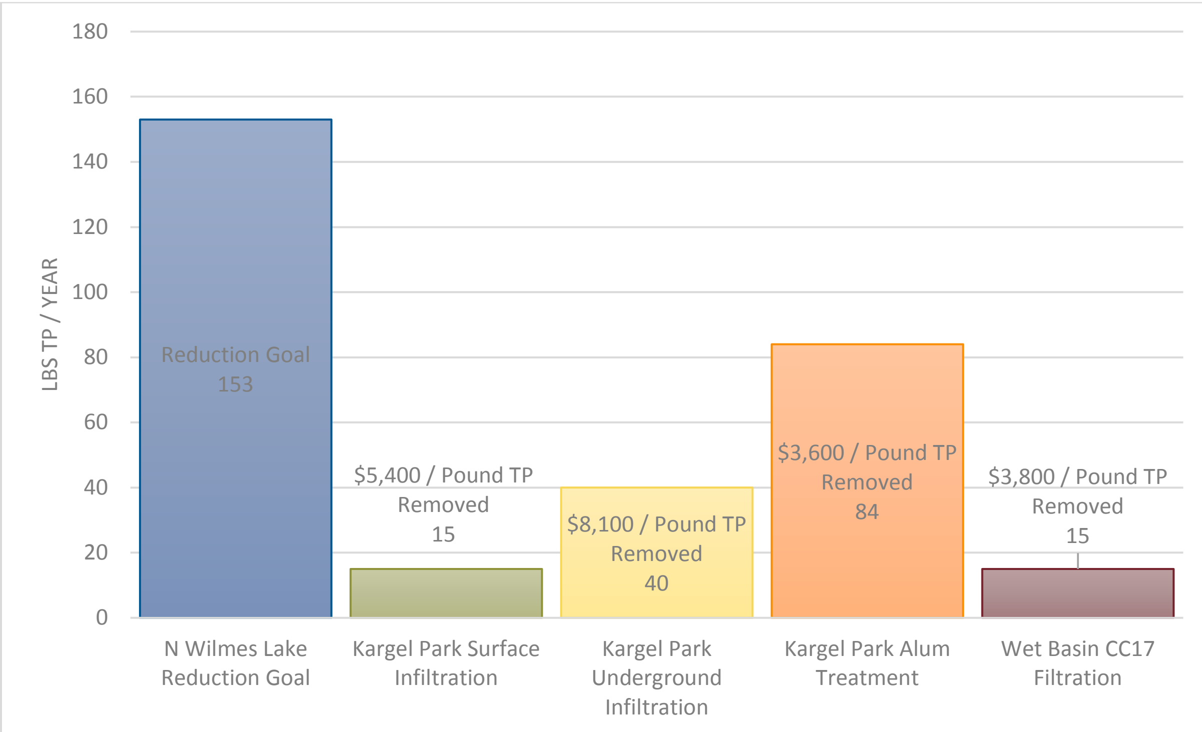


Figure 4: Kargel Park TP removal options compared to the North Wilmes Lake reduction goal

Alum treatment facility

An alum treatment facility could be constructed on the west end of Kargel Park. This facility would include a submersible pump that would convey water from its current flow path to the treatment basin. Aluminum sulfate (known as alum) would be injected into stormwater. The alum would bind to phosphorus in the water and form floc, a thick sludge that settles to the bottom of the basin. Stormwater that drains out of the pond would contain 70 to 80 percent less phosphorus than it did before treatment. This facility has high construction and maintenance costs, but also has high phosphorus removal. The predicted TP removal, assuming 3 cubic feet per second of baseflow, is 84 pounds per year (48 pounds per growing season). Prior to design of the alum treatment facility, the baseflow should be monitored to confirm that a flow of at least 3 cubic feet per second is present during normal low-flow conditions. Monitoring the TP conditions would also be helpful to more accurately predict the phosphorus removal at the alum treatment facility.

Underground infiltration/filtration

An underground infiltration or filtration chamber could be constructed under the west end of Kargel Park. Soil borings and/or infiltration testing is necessary to assess whether infiltration or filtration is a better option in the area. The predicted TP removal, assuming infiltration at 1.6 inches per hour, is 40 pounds per year (23 pounds per growing season). At the December 18, 2018 meeting with Barr, the SWWD, and the

City of Woodbury, the group removed this option from consideration because of the high cost relative to TP removal, which is due to the need for a pump station to convey water from the storm sewer to the infiltration/filtration area.

Surface infiltration/filtration

A surface infiltration or filtration chamber could be constructed at the west end of Kargel Park. Soil borings and/or infiltration testing is necessary to assess whether infiltration or filtration is a better option in the area. The predicted TP removal, assuming infiltration at 1.6 inches per hour, is 15 pounds per year (8.5 pounds per growing season). The SWWD, the City of Woodbury, and Barr removed this option from consideration at the December 18, 2018 meeting because of the high cost relative to TP removal. This cost is higher than usual because of the need for a pump station to convey water from the storm sewer to the infiltration/filtration area.

Crushed limestone retrofit in wet basins

Crushed limestone (CC17) could be added to the existing wet basins just west of Kargel Park. Using crushed limestone is not an established method to remove phosphorus; however, experimental data from the Ramsey-Washington Metro Watershed District test cell at Kohlman Basin shows that the material can remove 40 to 50 percent of phosphorus from water. While this removal efficiency is lower than alternative materials, crushed limestone shows high potential because it does not need to dry out between filtering sessions to retain its removal efficiency. This project would have a relatively low construction cost because a previously constructed project to limit channel erosion included a diversion structure that can be used to route low flows through the wet basins. The predicted TP removal is 15 pounds per year (8.6 pounds per growing season).

Seasons Park

Barr investigated three alternatives in Seasons Park, all of which could be constructed and would have little diminishing impact on the phosphorus removals from downstream alternatives. These projects in Seasons Park could be combined with a larger City of Woodbury project to reduce maintenance by restoring natural vegetation near the stream running through the park. Each project's contributing watershed is shown in figure 5, The BMP locations are shown in figure 6. The cost estimate and phosphorus removal information for the three investigated BMPs are shown in table 2. Figure 7 compares the combined estimated TP removal for all projects with the South Wilmes Lake TP removal goal.

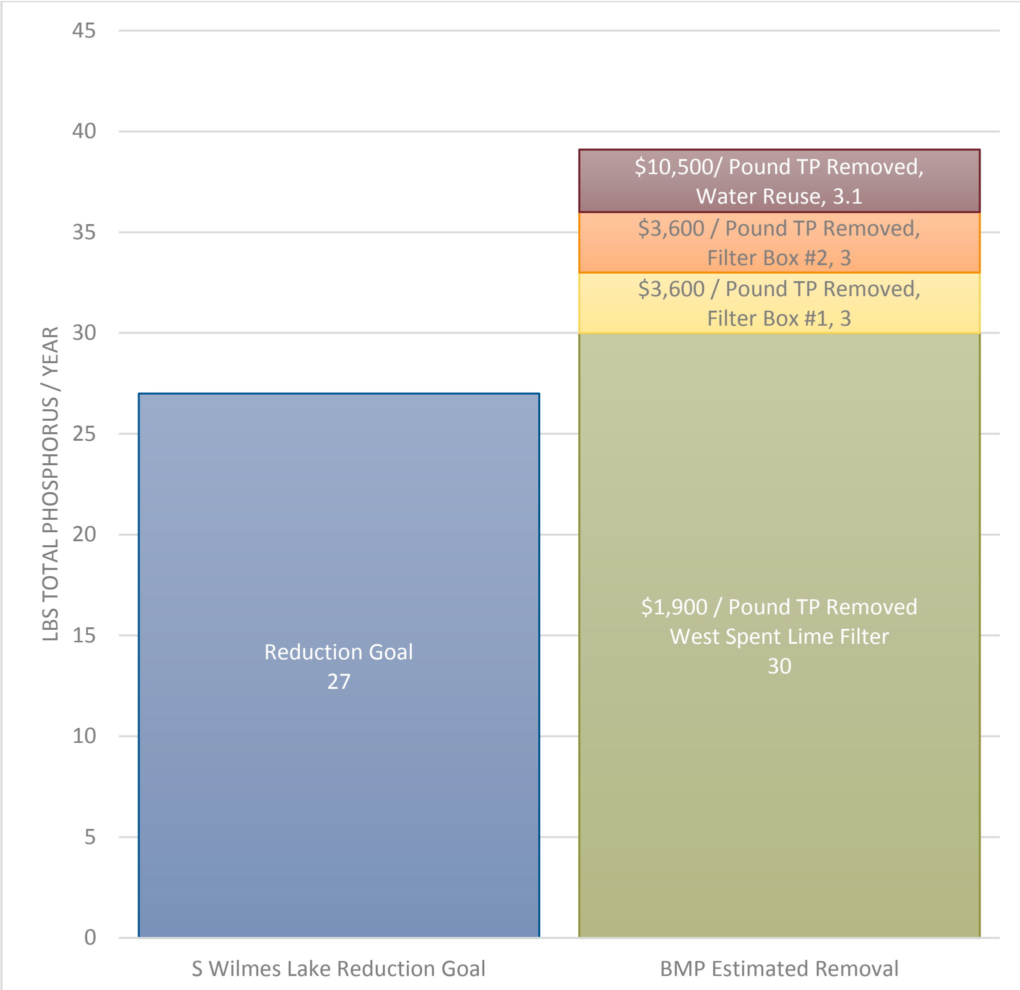


Figure 7: Seasons Park TP removal options compared to the South Wilmes Lake reduction goal

Spent-lime filter in western Seasons Park

A spent-lime filter proposed at the west end of Seasons Park could draw water off of the pond just east of Radio Drive, filter the water, and discharge flows back into the stream via passive flow (without the use of pumps). The predicted TP removal from the spent-lime filter is 30 pounds per year (17 pounds per growing season). The project could utilize a continuous monitoring and adaptive control (CMAC) valve to draw down the pond between storm events and reduce flooding in the area.

Filter boxes in central Seasons Park

Filter boxes are proposed at two locations in central Seasons Park. These boxes would be used to treat low flow and would use the head that is built up at the two ponds in central Seasons Park to filter flow using gravity. These boxes would have a low construction cost, but their small filter surface areas could plug more often and need routine maintenance. The boxes would be designed for ease of maintenance, including replacement of filtration media, and therefore could be used to test different media. The predicted TP removal from each individual filter box is 2.8 pounds per year (1.6 pounds per growing season), although actual removals depend on the type of media placed within each filter box.

Water reuse on Seasons Park baseball field

Water reuse on the south baseball field at Seasons Park was investigated. The predicted TP removal from the water reuse is 3 pounds per year based on results from the minimal impact design standards (MIDS) best management practice calculator. Due to the high cost relative to the estimated TP removal, the SWWD and the City of Woodbury asked Barr to remove this option from further consideration. Water reuse tends to be a good option in areas where irrigation infrastructure already exists. There is no irrigation system in the area; therefore, the construction of an irrigation system raised the cost relative to TP removal.

East of Powers Lake

Barr investigated two alternatives to remove phosphorus upstream of Powers Lake. The locations of the BMPs as well as their contributing areas are shown in figure 8. The BMPs were originally viewed as infiltration basins based on promising soil data; however, the City of Woodbury reported that many infiltration basins in the area are not infiltrating as expected, so filtration may be a better alternative than infiltration. Cost-estimate and phosphorus-removal information for the two investigated BMPs is shown in table 2. Removals for each option compared to the TP reduction goal in Powers Lake are shown in figure 9. The percentage of treatment in the figure 9 and table 4 references the percent of volume that the BMP can capture compared to the Minnesota Stormwater Manual’s recommendation of 1.1 inches of stormwater captured off all impervious surfaces.

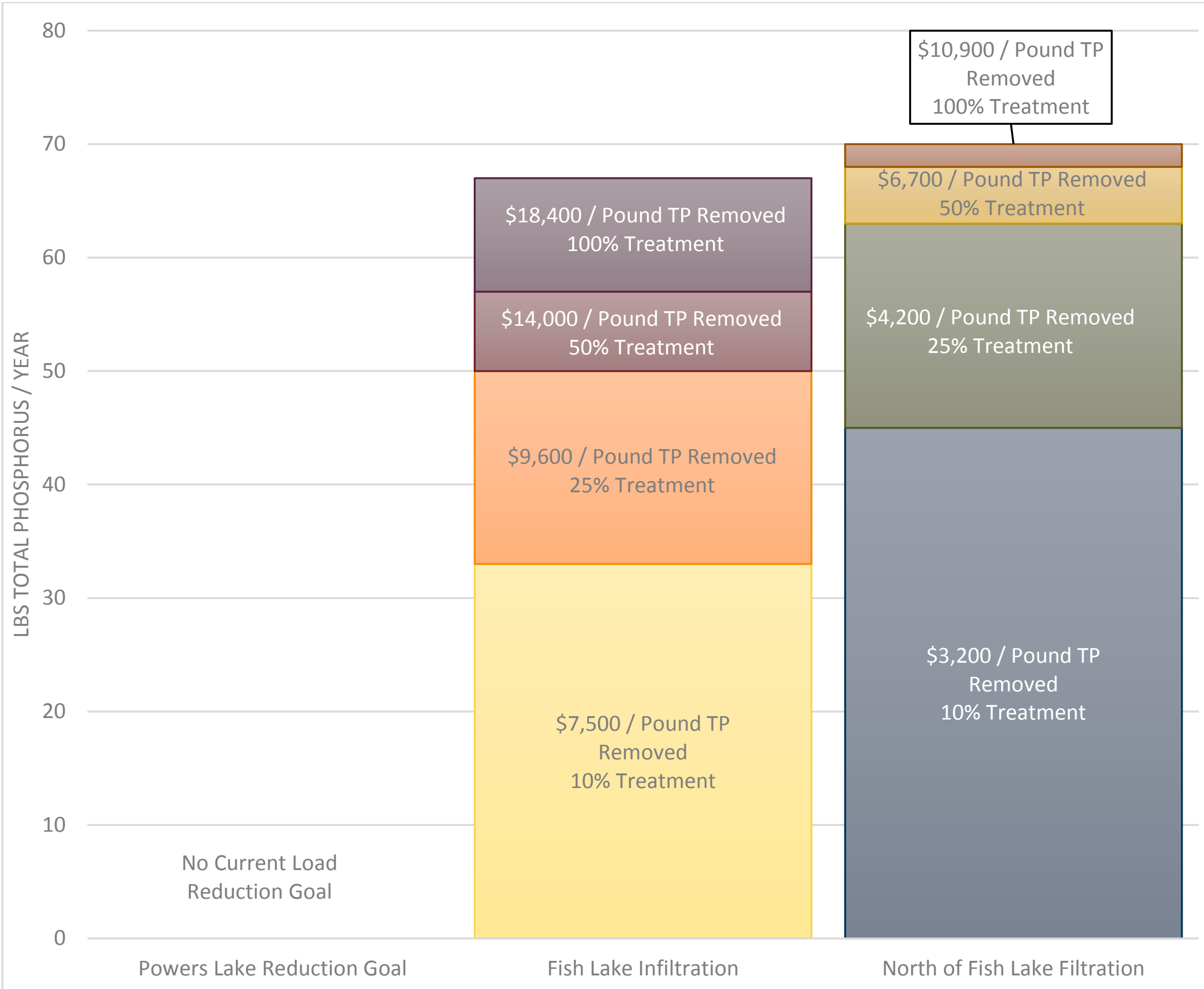


Figure 9: East of Powers Lake TP removal options compared to Powers Lake reduction goal

Underground infiltration/filtration from Fish Lake

An underground infiltration chamber in the open space just east of Powers Lake was assessed to estimate potential phosphorus removals from water leaving Fish Lake. The predicted removals of the system vary from 33 pounds per year (19 pounds per growing season) to 67 pounds per year (38 pounds per growing season) depending on the size of the underground chamber. At the December 18, 2018 meeting with Barr, the SWWD, and the City of Woodbury, this option was removed from consideration because of the high cost relative to TP removal. The storm sewer leaving Fish Lake is approximately 20 feet deep at the open space east of Powers Lake. Due to the depth of the storm sewer, the underground chamber would either have to be buried very deep, or a pump station would need to be constructed—resulting in a high cost relative to TP removal.

Underground infiltration/filtration from the area north of Fish Lake

An underground filtration chamber in the open space east of Powers Lake was assessed to estimate potential phosphorus removals from water leaving a series of stormwater ponds north of Fish Lake. The underground filtration chambers assessed varied in size from a 0.2-acre footprint to a 2.1-acre footprint. The estimated TP removal for the range of filter size options was between 46 pounds per year and 70 pounds per year (15 to 22 pounds per growing season). The cost estimate and phosphorus removal information for the four different filtration chamber sizes are shown in table 4. The increase in cost per pound of total phosphorus removed as filter size increases is caused by the cost of additional storage space that will be used significantly less frequently to treat stormwater than the space in a smaller filter. Based on this analysis, if the regional filter is selected for design, we recommend further optimization of the filter size to balance stormwater treatment goals and TP removal efficiency. The use of underground filtration is beneficial in this area because it would allow the area to be developed for community use in the future.

Table 4: Filtration from north of Fish Lake cost estimate and phosphorus removal information

east of Powers Lake	Powers Lake removal goal: none				
BMP description	**planning-level opinion of cost[1]**	**annual operations and maintenance cost**	**TP removal (lbs/growing season)**	**TP removal (lbs/year)**	**annual cost per pound of TP removed ($/lb)[2]**
full size underground filtration – 2.1 acres	$10,100,000	$20,000	22	70	$10,900
half size underground filtration – 1.0 acres	$6,000,000	$15,000	22	68	$6,700
quarter size underground filtration – 0.5 acres	$3,500,000	$10,000	21	63	$4,200
tenth size underground filtration – 0.2 acres	$1,800,000	$10,000	15	45	$3,200

[1]Costs are represented as a feasibility-level class 5 cost estimate as defined by the AACE with a +50-percent/-30-percent uncertainty. Costs include engineering and design and construction observation.

[2]Range represents the annualized cost based on a 20-year BMP lifespan at an interest rate of 4 percent. Costs include construction and engineering and design.

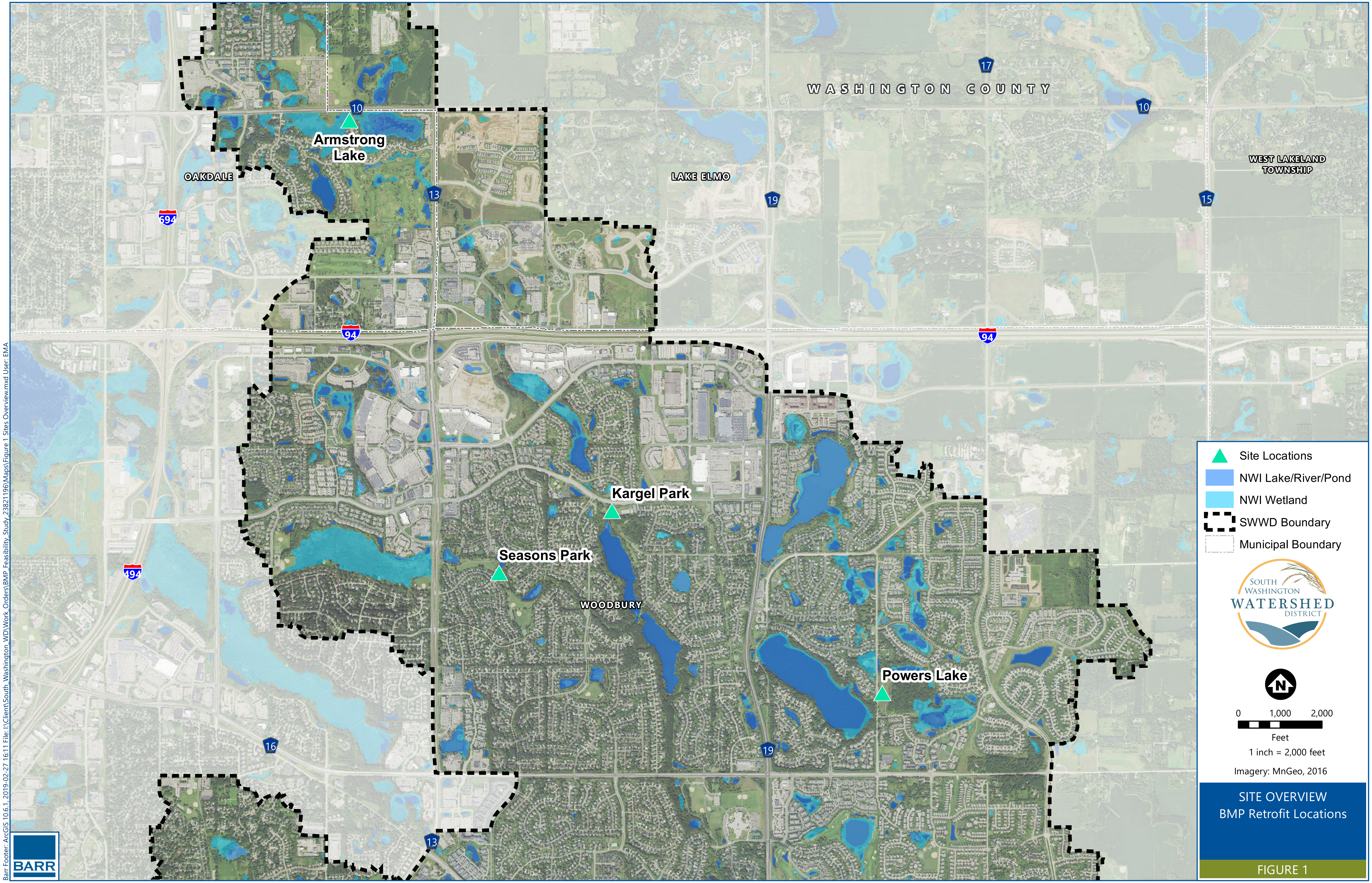
4.0 Monitoring recommendations

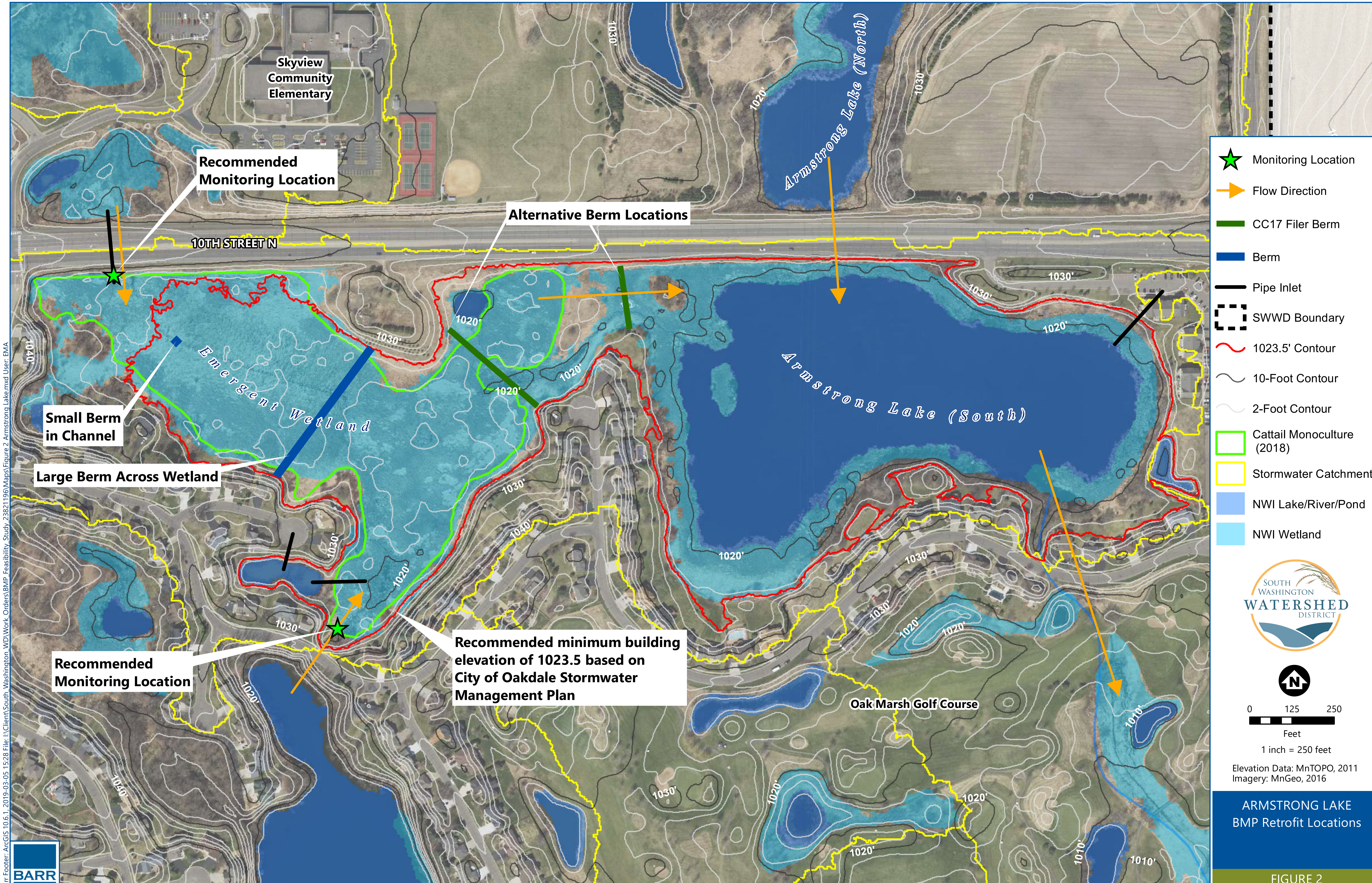
- Armstrong Lake
  - Recommended monitoring locations – see figure 2 for locations
    - Northwest inlet into the wetland west of Armstrong Lake
    - South inlet into the wetland west of Armstrong Lake
- Kargel Park
  - Recommended monitoring location – see figure 3 for location
    - At the diversion structure just south of the 60-inch storm sewer crossing under Tamarack Road
- Seasons Park
  - Recommended monitoring location – see figure 6 for location
    - At the outlet of the pond just east of Radio Drive
  - Potential additional monitoring location – see figure 6 for locations
    - At the outlet of each pond in seasons park where a filter box is called out
- Powers Lake
  - Potential monitoring location – see figure 8 for location
    - At the outlet of the pond just northwest of the open space along St. John's Drive.

5.0 References

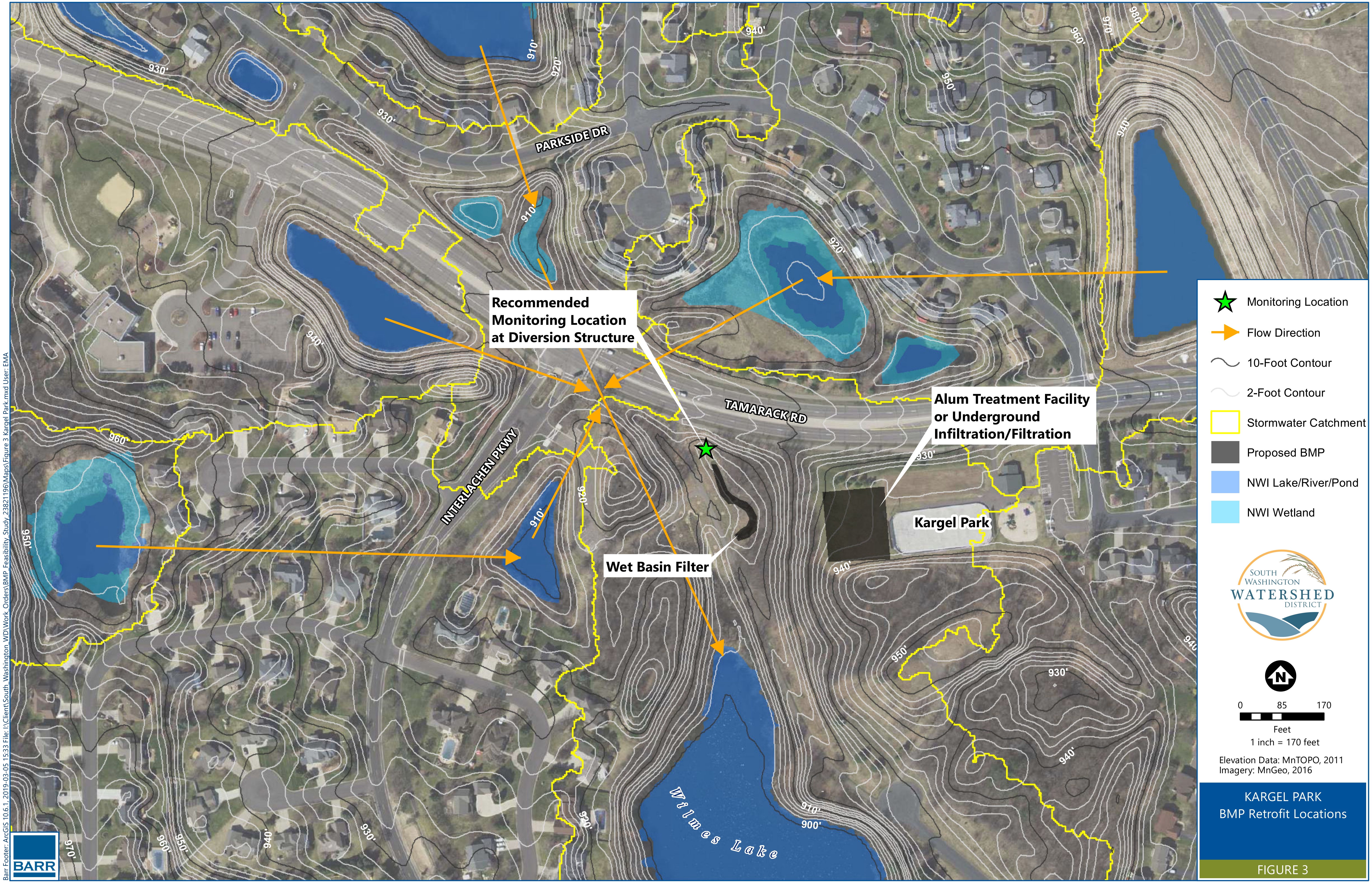
1. **South Washington Watershed District**. *Armstrong Lake Subwatershed Retrofit Analysis*. South Washington Watershed District, September 2018.
2. **Wenck Associates, Inc.** *South Washington Watershed District Lake Management Plan*. South Washington Watershed District, December 2018.

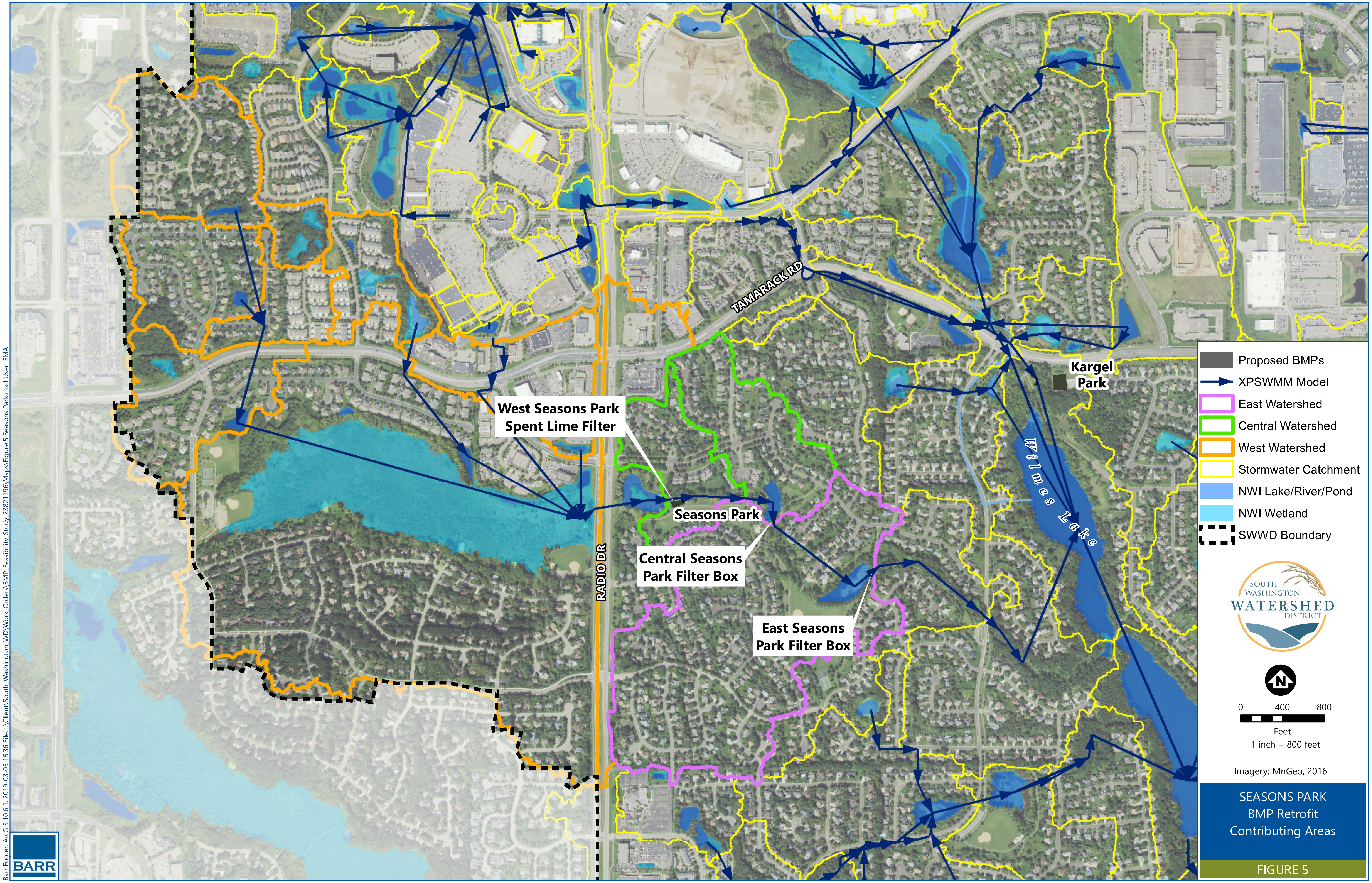
6.0 Large figures


WASHINGTON COUNTY
WEST LAKELAND TOWNSHIP
OAKDALE
LAKE ELMO
WOODBURY
Armstrong Lake
Kargel Park
Seasons Park
Powers Lake
10
17
13
19
15
694
94
494
16
Site Locations
NWI Lake/River/Pond
NWI Wetland
SWWD Boundary
Municipal Boundary
SOUTH WASHINGTON WATERSHED DISTRICT
N
0
1,000
2,000
Feet
1 inch = 2,000 feet
Imagery: MnGeo, 2016
SITE OVERVIEW
BMP Retrofit Locations
FIGURE 1
BARR



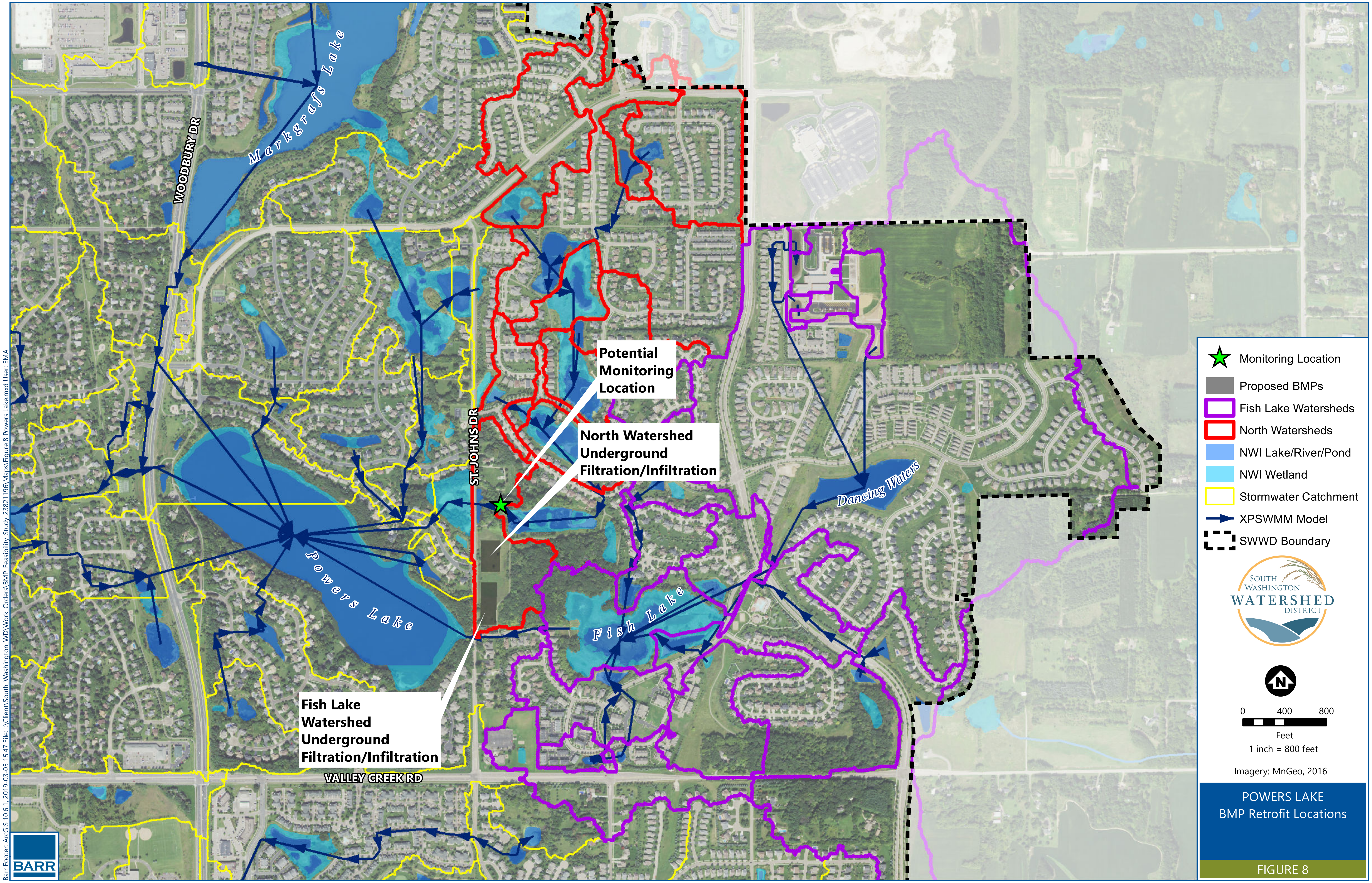
Barr Footer: ArcGIS 10.6.1, 2019-03-05 15:28 File: I:\Client\South_Washington_WD\Work_Orders\BMP_Feasibility_Study_23821196\Maps\Figure 2 Armstrong Lake.mxd User: EMA


PARKSIDE DR
TAMARACK RD
INTERLACHEN PKWY
Recommended Monitoring Location at Diversion Structure
Alum Treatment Facility or Underground Infiltration/Filtration
Wet Basin Filter
Kargel Park
Wilmes Lake
910'
920'
930'
940'
950'
960'
970'
980'
900'
Monitoring Location
Flow Direction
10-Foot Contour
2-Foot Contour
Stormwater Catchment
Proposed BMP
NWI Lake/River/Pond
NWI Wetland
SOUTH WASHINGTON WATERSHED DISTRICT
N
0 85 170
Feet
1 inch = 170 feet
Elevation Data: MnTOPO, 2011
Imagery: MnGeo, 2016
KARGEL PARK
BMP Retrofit Locations
FIGURE 3
BARR



Barr Footer: ArcGIS 10.6.1, 2019-03-05 15:36 File: I:\Client\South_Washington_WD\Work_Orders\BMP_Feasibility_Study_23821196\Maps\Figure 5 Seasons Park.mxd User: EMA


Recommended Monitoring Location
West Seasons Park Spent Lime Filter
Seasons Park
Potential Monitoring Location
Central Seasons Park Filter box
Potential Monitoring Location
East Seasons Park Filter box
Existing Pond Storage Used for Water Reuse
Location of Water Reuse
RADIO DR
SILVERWOOD DR
AUTUMN DR
PINEHURST RD
DUCKWOOD TRAIL
980'
970'
960'
950'
940'
930'
990'
1000'
1010'
1020'
1030'
Monitoring Location
Flow Direction
Water Reuse Area
Proposed BMP
Atlas 14 Ponds
10-Foot Contour
2-Foot Contour
Stormwater Catchment
NWI Lake/River/Pond
NWI Wetland
SOUTH WASHINGTON WATERSHED DISTRICT
N
0 125 250
Feet
1 inch = 250 feet
Elevation Data: MnTOPO, 2011
Imagery: MnGeo, 2016
SEASONS PARK
BMP Retrofit Locations
FIGURE 6
BARR


Markgrafs Lake
WOODBURY DR
ST. JOHNS DR
Potential Monitoring Location
North Watershed Underground Filtration/Infiltration
Dancing Waters
Powers Lake
Fish Lake
Fish Lake Watershed Underground Filtration/Infiltration
VALLEY CREEK RD
Monitoring Location
Proposed BMPs
Fish Lake Watersheds
North Watersheds
NWI Lake/River/Pond
NWI Wetland
Stormwater Catchment
XPSWMM Model
SWWD Boundary
SOUTH WASHINGTON WATERSHED DISTRICT
N
0 400 800
Feet
1 inch = 800 feet
Imagery: MnGeo, 2016
POWERS LAKE
BMP Retrofit Locations
FIGURE 8
BARR