Lake Cornelia and Lake Edina Water Quality Study

Use Attainability Analyses for Lake Cornelia (updated from 2010) and Lake Edina (first version)

9 MILE CREEK WATERSHED DISTRICT

Prepared for
Nine Mile Creek Watershed District

July 2019

BARR

4300 MarketPointe Dr • Suite 200
Minneapolis, MN 55435
952.832.2600 • www.barr.com

List of Appendices, Attachments, or Exhibits

Appendices

Appendix A

Existing Pond Information—Lake Cornelia and Lake Edina

Table A-1 North Cornelia Existing Pond Information

Watershed	BMP Type	Normal Pool Area (acres)	Existing Dead Storage (acre-ft)	Existing Flood Pool Area (acres)	Existing Flood Pool Storage (acre-ft)	Existing Outlet	Comments
NC_130	Infiltration Basin	0.001	0	1.52	2.82	Overflow	
NC_135	Infiltration Basin	0.001	0	1.19	4.04	Overflow	
NC_6	Infiltration Basin	0.001	0	1.41	7.12	Overflow	
NC_2	Pond	3.72	6.1	4.92	12.96	42" Pipe	
NC_5	Pond	0.67	0.96	4.31	9.95	48" Pipe	
NC_72	Pond	0.31	0.9	0.41	0.41	10' Weir	
NC_88	Pond	0.39	0.86	0	0	6" Pipe	Normal outflow to NC_3; Overflow to NC_4
NC_4	Pond	3.58	12.62	5.11	34.76	65" Pipes	
NC_3	Pond	6.12	24.35	8.8	19.92	(3) 3/4" orifices	
NC_62	Lake	18.7	72.82	36.34	115.2	12" Pipe	North Cornelia
NC_78	Pond	1.75	5.26	1.92	1.09	12" Pipe	
NC_30	Pond	9.93	32.4	11.33	17.96	24" Pipe	
NC_4A_RG1	Infiltration Basin	0.07	0	0.16	0.17	12.5' Weir	
NC_4A_RG2	Infiltration Basin	0.06	0	0.13	0.14	12.5' Weir	
NC_4A_UG1	Underground Storage	0.0006	0.0013	0.025	0.084	15" Pipe	
NC_4A_UG2	Underground Storage	0.0006	0.0013	0.017	0.058	4" Pipe	

Table A-2 South Cornelia Existing Pond Information

Watershed	BMP Type	Normal Pool Area (acres)	Existing Dead Storage (acre-ft)	Existing Flood Pool Area (acres)	Existing Flood Pool Storage (acre-ft)	Existing Outlet	Comments
SC_1	Lake	33.15	162.74	49.46	353.54	54" Pipe	South Cornelia
SC_2	Pond	0	0	2.806	8.24	9" Pipe	
SC_3	Pond	0.57	1.62	4.9	13.74	18" Pipe	

Table A-3 Lake Edina Existing Pond Information

Watershed	BMP Type	Normal Pool Area (acres)	Existing Dead Storage (acre-ft)	Existing Flood Pool Area (acres)	Existing Flood Pool Storage (acre-ft)	Existing Outlet	Comments
LE_1	Lake	24.63	68.07	37.31	149.15	36" Pipe	Lake Edina
LE_38	Pond	0.24	0.32	1.6	8.25	36" Pipe	
LE_44	Infiltration Basin	0.001	0	1.47	5.48	Overflow	
LE_51	Infiltration Basin	0	0	8.21	42.09	Overflow	
LE_54	Infiltration Basin	0	0	1.58	5.21	Overflow	

Appendix B

Lake Cornelia System Fisheries Assessment (2018)

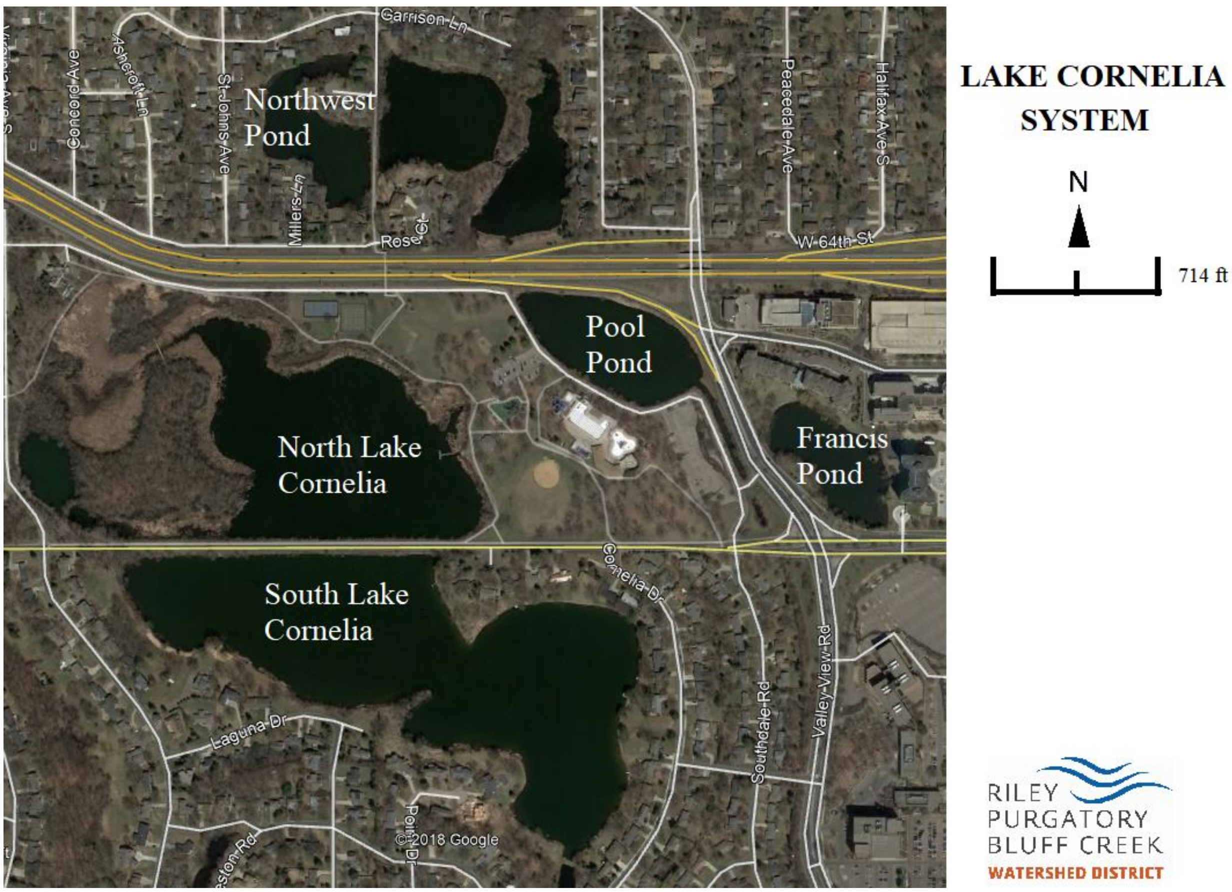
Lake Cornelia System Fisheries Assessment

Prepared By: Joshua Maxwell - Water Resources Coordinator,
Riley Purgatory Bluff Creek Watershed District

Prepared For: Nine Mile Creek Watershed District
October 9, 2018

Survey Details

During the summer of 2018, the Riley-Purgatory-Bluff Creek Watershed District (RPBCWD) assisted Nine Mile Creek Watershed District in conducting a fish assessment of Normandale Lake, Lake Cornelia, and ponds connected to Cornelia. The fish surveys were based on research and methodology established by the University of Minnesota (UMN) in the Riley Chain of Lakes Carp Management Plan drafted in 2014 (Bajer, 2014), and the Purgatory Creek Carp Management Plan drafted in 2015 (Sorensen, 2015). Common carp populations within both lakes were of specific concern due to the negative impacts large populations can cause within lakes in MN. Adult carp populations were monitored by conducting, three, 20-minute electrofishing transects per lake, three times between late July and October. If the total biomass estimate of carp is above 100kg/h in a lake, significant water quality degradation can occur. Young of the year (YOY) carp are monitored by placing five, 24-hour small mesh fyke net sets per lake between July and September. If YOY carp were captured during this event, it meant successful recruitment occurred, which can lead to a larger future carp population. Bluegill abundance was also important to assess because they can keep a carp population under control by consuming carp eggs during the spawn. In the case of both sampling techniques, all other fish species were enumerated and summarized. The following document is an overall summary of the fish assessment results on the Lake Cornelia system.



Fyke Netting

District staff completed fyke net surveys on Lake Cornelia and Pool Pond on July 27th, 2018 and July 24th respectively. In Lake Cornelia, three nets were set in both the upper and lower sections of the Lake. Due to the small size of Pool Pond, only four nets were set. The fyke net results for Cornelia can be seen in Table 2 and 3. Table 1 contains results for Pool Pond.

Figure 1 – Large snapping turtle from North Cornelia fyke nets.

Both Lake Cornelia and Pool Pond experienced a partial winter kill over the 2017-2018 winter season. Evidence of the winterkill was highlighted by the fyke net catch results, including limited year classes present of all fish species, specifically game fish, and lack of diversity of commonly found fish species for the region. Based on the results, it appears that South Cornelia had a more severe winterkill. Only black bullheads, golden shiners, goldfish, and three bluegill sunfish were found. More Centrarchid species were found in North Cornelia, including pumpkinseed sunfish, black crappie, green sunfish, and bluegills. The diversity of the Pool Pond fish population was similar to what was seen in North Cornelia, although the overall number of fish captured increased. Overall, 27 painted turtles and 21 snapping turtles were captured in the fyke nets on Cornelia. Goldfish were captured in low numbers on both North and South Cornelia. During the survey. One YOY carp was captured in North Cornelia and 14 were captured in Pool Pond which indicates that some recruitment occurred in the system in 2018.

Table 1: Pool Pond Lake Fyke Net Results

Species	Number of fish caught in each category (inches)									
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	Total	Fish/Net
black bullhead	115	20							135	33.8
bluegill sunfish	18								18	4.5
common carp	14								14	3.5
golden shiner	28	1							29	7.3
green sunfish	316	6							322	80.5
hybrid sunfish	31	2							33	8.3
pumpkinseed	246								246	61.5

Table 2: South Cornelia Lake Fyke Net Results

Species	Number of fish caught in each category (inches)									
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	Total	Fish/Net
black bullhead	75	82	1						159	53
bluegill sunfish	1	2							3	1
goldfish	16								16	5.3
golden shiner	16	1							17	5.7
painted turtle									11	3.7
snapping turtle									10	3.3

Table 3: North Cornelia Lake Fyke Net Results

Species	Number of fish caught in each category (inches)									
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	Total	Fish/Net
black bullhead	148	161	1						676	225.3
black crappie		2							2	0.67
bluegill sunfish	31								31	10.3
common carp	1								1	0.33
goldfish	9								9	3
golden shiner	63	23							90	30
green sunfish	20								20	6.7
hybrid sunfish	12								12	4
pumpkinseed	12								12	4
painted turtle									16	5.3
snapping turtle									11	3.7

Electrofishing

Boat electrofishing was conducted across three dates on Lake Cornelia. During two of the surveys all fish captured were identified and measured. The third survey targeted carp only. Each of the ponds were electrofished one time in which all species were identified and measured. The common carp population estimates were devloped based on research conducted on shallow and deep lakes within the RPBCWD and may not accurately reflect actual population estimates for stormwater ponds. Additionally, only one sampling event was conducted on each pond which is lower than the three sampling events recommended. Fish captured via electrofishing mirrored that which was captured within the fyke nets for each waterbody. No large fish were captured due to the recent winterkill. Below is a brief description of what native fish were found across the electrofishing surveys:

- Pool Pond - pumpkinseed sunfish, green sunfish, and golden shiners were the most abundant native fish (Exhibit 1).
- Lake Cornelia – black bullheads were the most abundant native species; very limited game species captured (Exhibit 2 - South; Exhibit 3 - North).
- Northwest Pond – black bullheads were the most abundant native fish captured with no gamefish captured (Exhibit 4).
- Francis (East) Pond – fathead minnows and golden shiners were the most abundant native fish with only four sunfish captured (Exhibit 5).

Non-native fish species captured during the electrofishing surveys included both goldish (*Carassius auratus*) and common carp. Similar to common carp, goldfish swim along the bottom of lakes and rivers, uprooting vegetation, disturbing sediment and releasing nutrients that trigger excess algal growth. They feed broadly, eating algae, small invertebrates, plant material, and fish eggs. Within the Lake Cornelia system goldfish were found in large numbers (989 fish captured; Table 4). They were the most abundant fish species captured and have an established breeding population. Most of the goldfish captured were YOY or one year old, however, fully-grown fish up to 365 mm (14.4 in) were captured. For a maximum potential size reference, the world's longest goldfish measured 474

Figure 2 – Goldfish from Northwest Pond.

mm (18.7in; Guinness Book of World Records). The Northwest pond had the highest catch rate of goldfish at 468 fish/hour which may be the main source for Lake Cornelia (combined 400 fish/hour).

Table 4: Lake Cornelia System Goldfish Electrofishing Results

Species	Number of goldfish caught in each category (inches)					
	0-5	6-8	9-11	12-14	Total	Fish/Hour
North Cornelia	227	2	52	2	310	221
Northwest Pond	155	92	3		250	468
Pool Pond	39	2			41	123
South Cornelia	283	3	90	12	388	194
Francis Pond					0	0
Total	704	99	145	14	989	198

Adult (>300 mm) common carp populations within the Lake Cornelia system were found in relatively low in numbers, which is likely a result of the recent winterkill (Table 5). That said, Francis (East) Pond had a very high concentration of carp at 23 fish, or a biomass estimate of 219.5 kg/h. The biomass estimate is significantly higher than the 100 kg/h threshold and can result in degraded water quality. No carp were captured in Northwest Pond or North Cornelia. Similar to migration patterns seen within the RPBCWD, fish in the Cornelia system appear to be migrating to the furthest waterbody upstream to spawn. Francis (East) Pond is one of the furthest upstream ponds along with the two ponds not surveyed north of Lake Cornelia and just east of Northwest Pond. Francis (East) Pond appeared to have depths which may allow carp to overwinter, however this was based on only a visual observation. Carp often spawn in the most upstream sections of a system and return to the larger and deeper waterbodies to overwinter.

Table 5: 2018 Common Carp Biomass Estimates for Normandale Lake

Lake	# of Fish	Fish per Hour	Density per Hectare	Average Weight (kg)	Carp Biomass (kg/h)	Threshold (kg/h)
Francis (East) Pond	23	60	285.64	0.77	219.50	100
Pool Pond	1	3	17.17	1.45	24.86	100
NW Pond	0	0	0	0	0	100
North Cornelia	0	0	0	0	0	100
South Cornelia	4	2	12.46	1.51	18.82	100

Summary

Overall the fish sampled in the Lake Cornelia system were small in size and species richness was limited. This is most likely a result of the 2017-2018 winterkill and past winterkills that have occurred. The low number of bluegill and other Centrarchid species captured from the surveys reflect a limited population that may not be able to control common carp and goldfish recruitment effectively. The frequency of winterkills and the availability of connected shallow waterbodies that winterkill which act as YOY nurseries, are most likely preventing bluegills from effectively controlling carp and goldfish within the system. This is highlighted by the number of yoy common carp captured in Pool Pond via fyke nets, the large number of carp captured in Francis (East) Pond, and the very large number of golfish captured in Northwest Pond. The 2018 survey suggests that Francis (East) Pond is currenlty the main source of carp for the Lake Cornelia system, however it is uncertain whether carp migrated to and were trapped in the pond, or if they are overwintering in the pond. The two ponds directly east of Northwest Pond may be another source carp population or be acting as a nursery, however they were not sampled in 2018. Due to the limited number of Cetrarchid species captured, carp will be able to freely reproduce in Francis (East) Pond and distribute throughout the Cornelia system.

It is apparent that goldfish have established breeding populations in most waterbodies within the Lake Cornelia system. The highest concentration of goldfish did occurr in the very shallow Northwest Pond. With the high numbers of goldfish in the system, along with their abiltiy to survive in extememly low oxygen conditions, goldfish maybe degrading water quality more than carp at this time. Winterkill frequency is most likely the main control of carp and golfish populations in the Cornelia system.

References:

Sorensen, P., P. Bajer, and M. Headrick. 2015. Development and implementation of a sustainable strategy to control common carp in the Purgatory Chain of Lakes. Prepared for Riley Purgatory Bluff Creek Watershed District. University of Minnesota, Saint Paul, MN. Accessed online from: http://rpbcwd.org/files/6414/9382/4422/SorensenBajerandHeadrick2015_Development_of_carp_control_in_the_Purgatory_Creek_Chain_of_Lakes.pdf

Bajer, P.G., M. Headrick, B.D. Miller, and P.W. Sorensen. 2014. Development and implementation of a sustainable strategy to control common carp in Riley Creek Chain of Lakes. Prepared for Riley Purgatory Bluff Creek Watershed District. University of Minnesota, Saint Paul, MN. Accessed online from: http://rpbcwd.org/files/3414/3561/7194/Carp_management_report_2014.pdf

EXHIBITS:

Exhibit 1: Pool Pond Boat Electrofishing Results

Species	Number of fish caught in each category (inches)									
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	Total	Fish/Hour
black bullhead	12	2							14	42
common carp				1					1	3
goldfish	39	2							41	123
golden shiner	53								53	159
green sunfish	47								47	141
pumpkinseed	75								75	225

Exhibit 2: South Lake Cornelia Boat Electrofishing Results

Species	Number of fish caught in each category (inches)									
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	Total	Fish/Hour
black bullhead	31	57							88	66
bluegill sunfish	1	1							2	2
common carp					3	1			4	2
mudminnow	1								1	0.75
goldfish	283	3	90	12					388	194
golden shiner	14								14	11
green sunfish	20								21	16
hybrid sunfish	1								1	0.75
pumpkinseed	13								13	10

Exhibit 3: North Lake Cornelia Boat Electrofishing Results

Species	Number of fish caught in each category (inches)									
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	Total	Fish/Hour
black bullhead	62	103	1						235	261
bluegill sunfish	1								1	1
goldfish	227	2	52	2					310	221
golden shiner	9	2							11	12
green sunfish	19								19	21
hybrid sunfish	1								1	1
pumpkinseed	14								14	16

Exhibit 4: Northwest Pond Boat Electrofishing Results

Species	Number of fish caught in each category (inches)									
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	Total	Fish/Hour
black bullhead	22	21							43	81
goldfish	155	92	3						250	469
mudminnow	1								1	2

Exhibit 5: Francis (East) Boat Electrofishing Results

Species	Number of fish caught in each category (inches)									
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	Total	Fish/Hour
bluegill sunfish	1								1	3
common carp			6	21	2				29	78
fathead minnow	71								71	185
golden shiner	22	2							24	60
pumpkinseed	3								3	8

Appendix C

In-Lake Model Water Balance Results

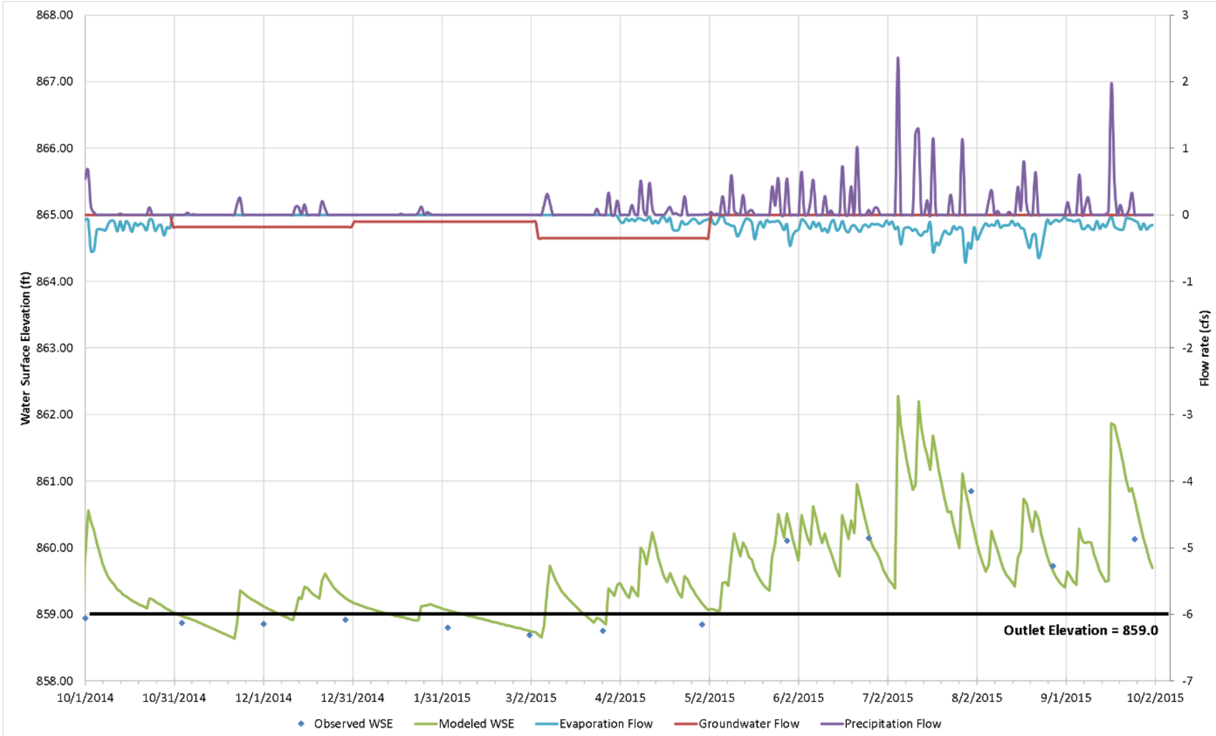


Figure C-1 North Cornelia (2015) Water Balance

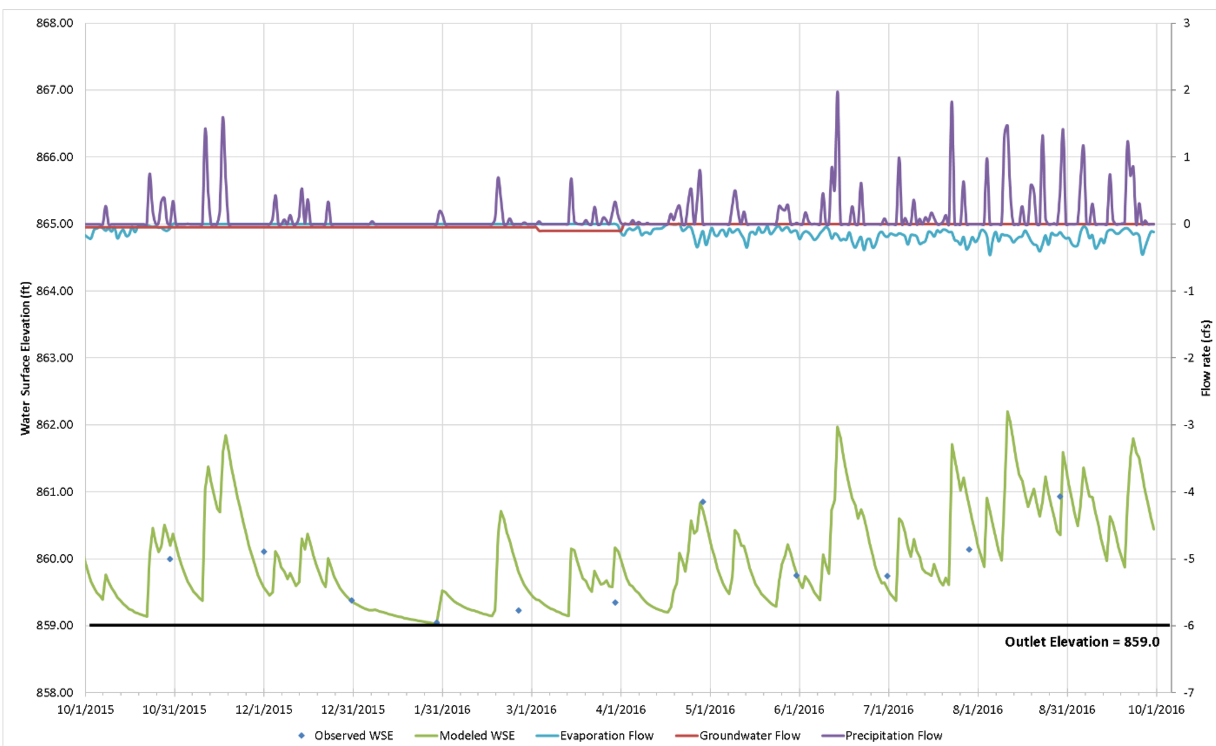


Figure C-2 North Cornelia (2016) Water Balance

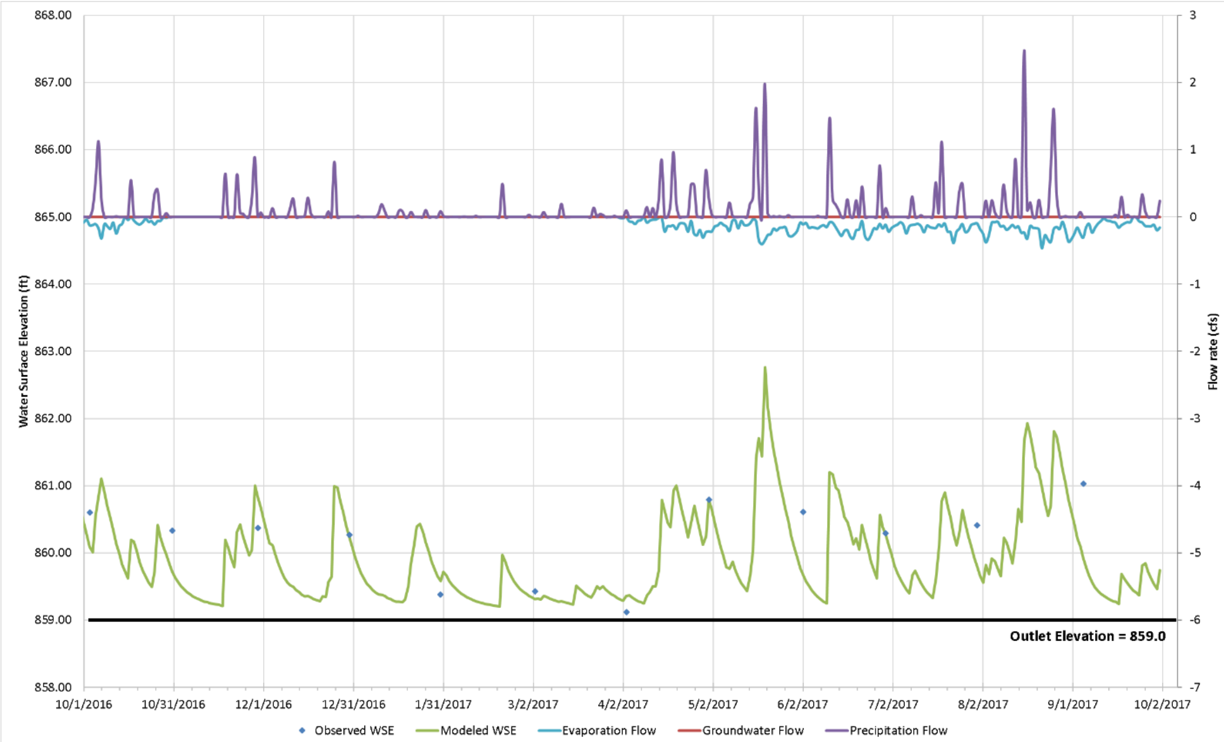


Figure C-3 North Cornelia (2017) Water Balance

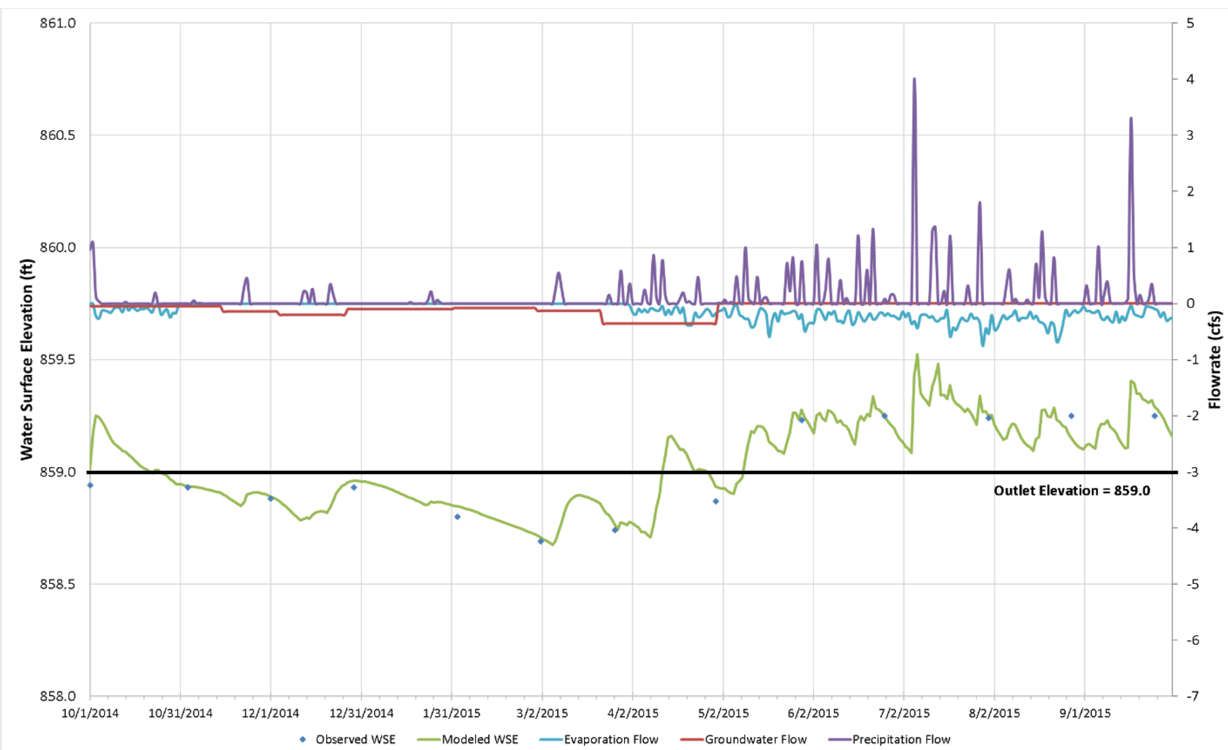


Figure C-4 South Cornelia (2015) Water Balance

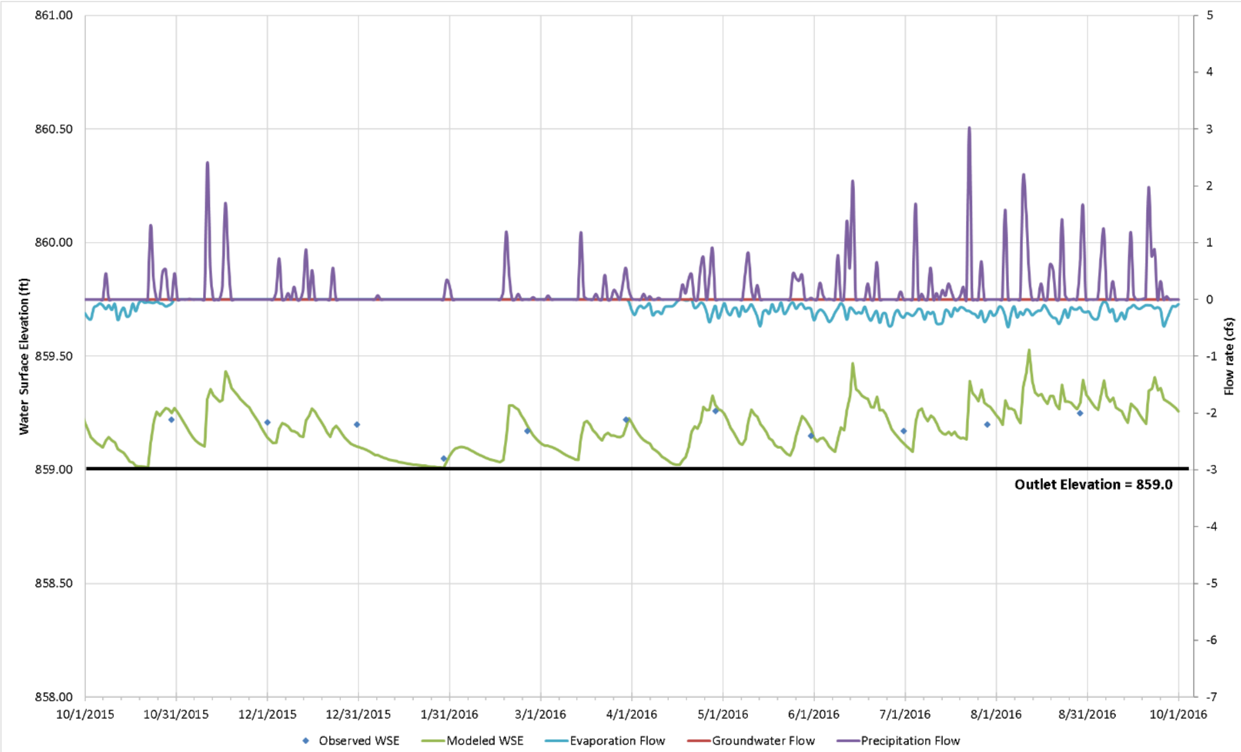


Figure C-5 South Cornelia (2016) Water Balance

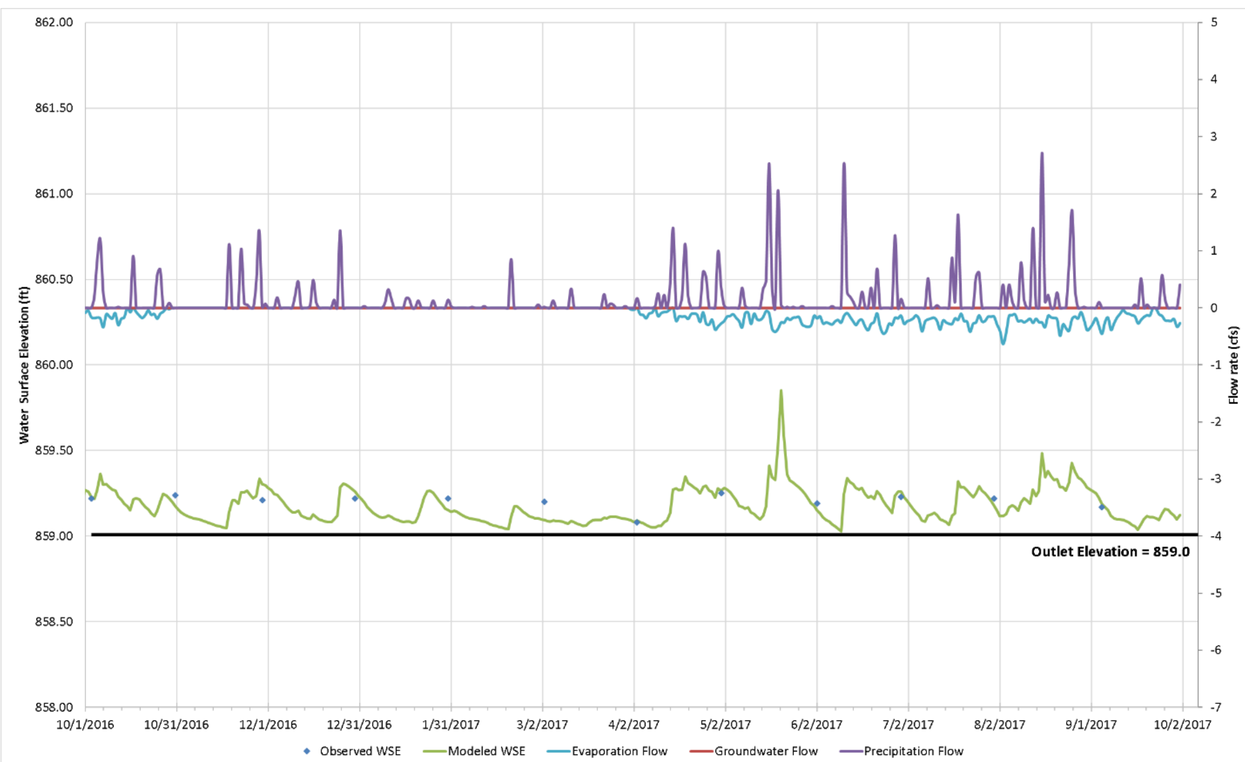


Figure C-6 South Cornelia (2017) Water Balance

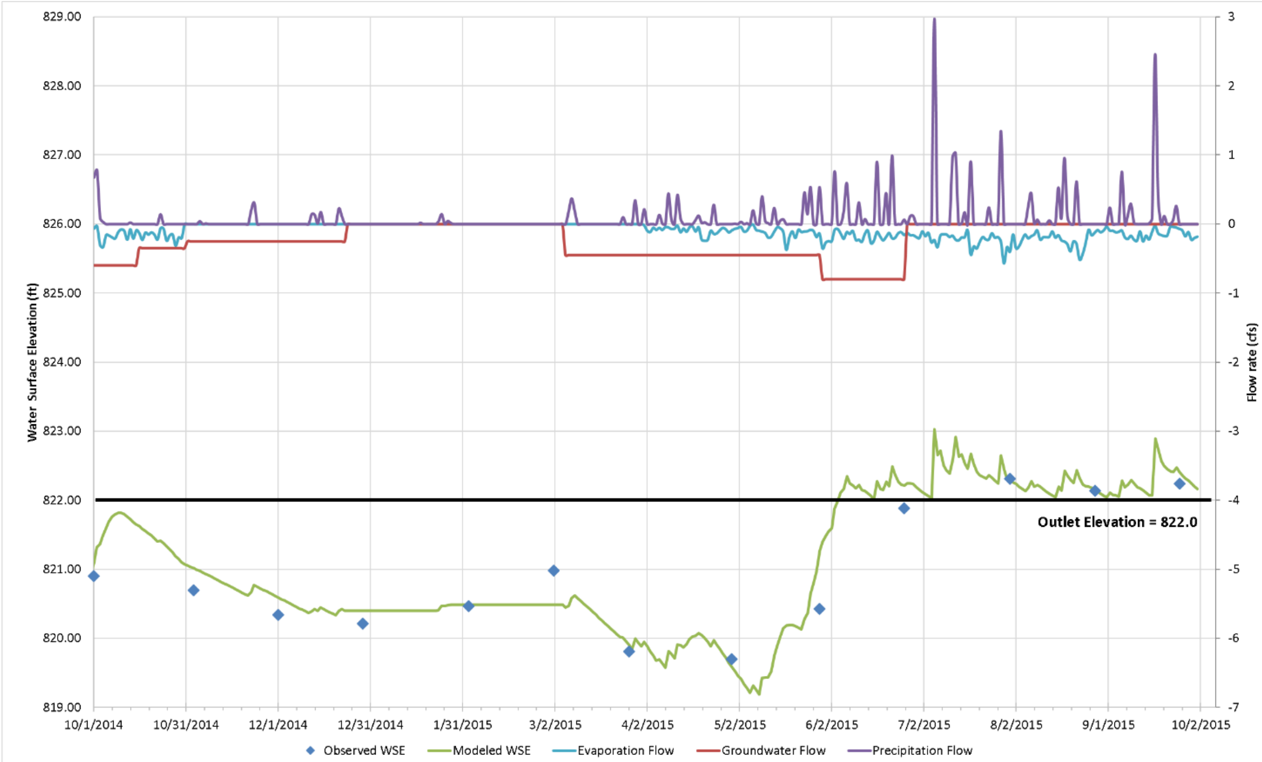


Figure C-7 Lake Edina (2015) Water Balance

Figure C-8 Lake Edina (2016) Water Balance

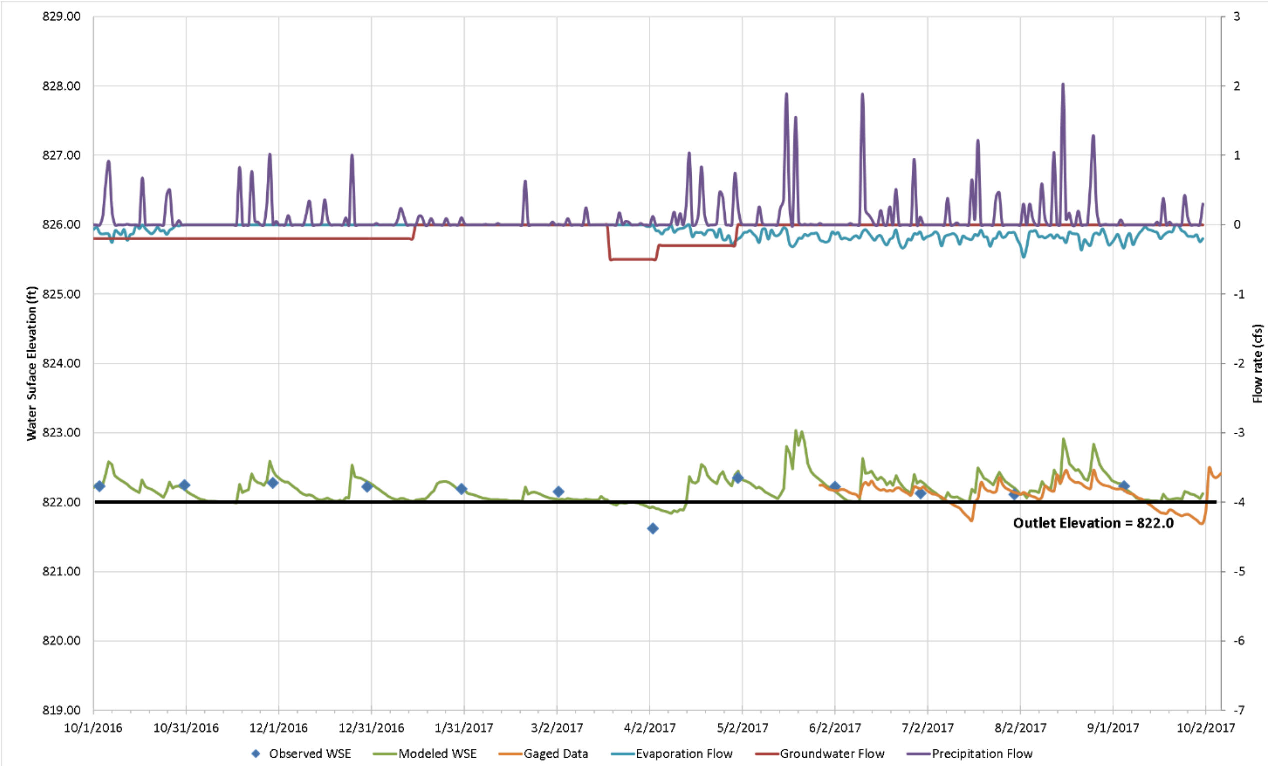


Figure C-9 Lake Edina (2017) Water Balance

Appendix D

External Loading Management Concentration Plots

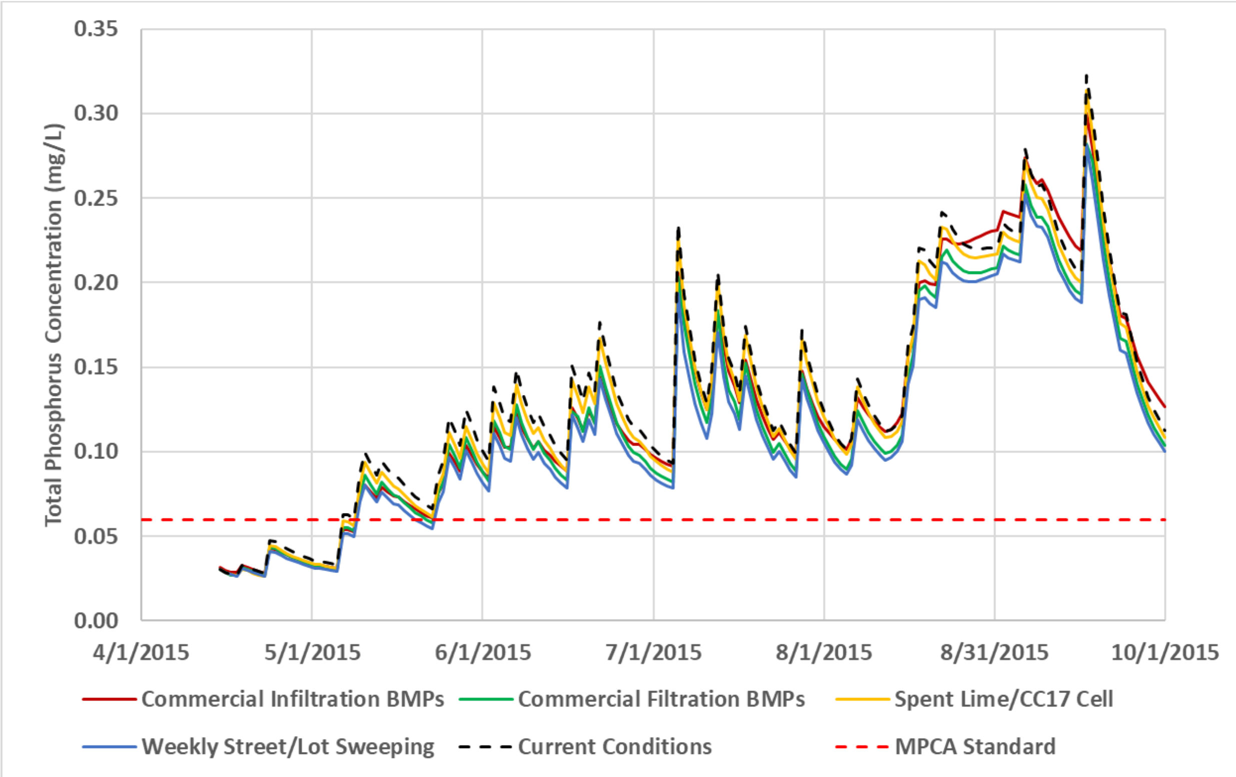


Figure D-1 In-lake phosphorus concentrations that resulted from external management efforts in North Cornelia in 2015

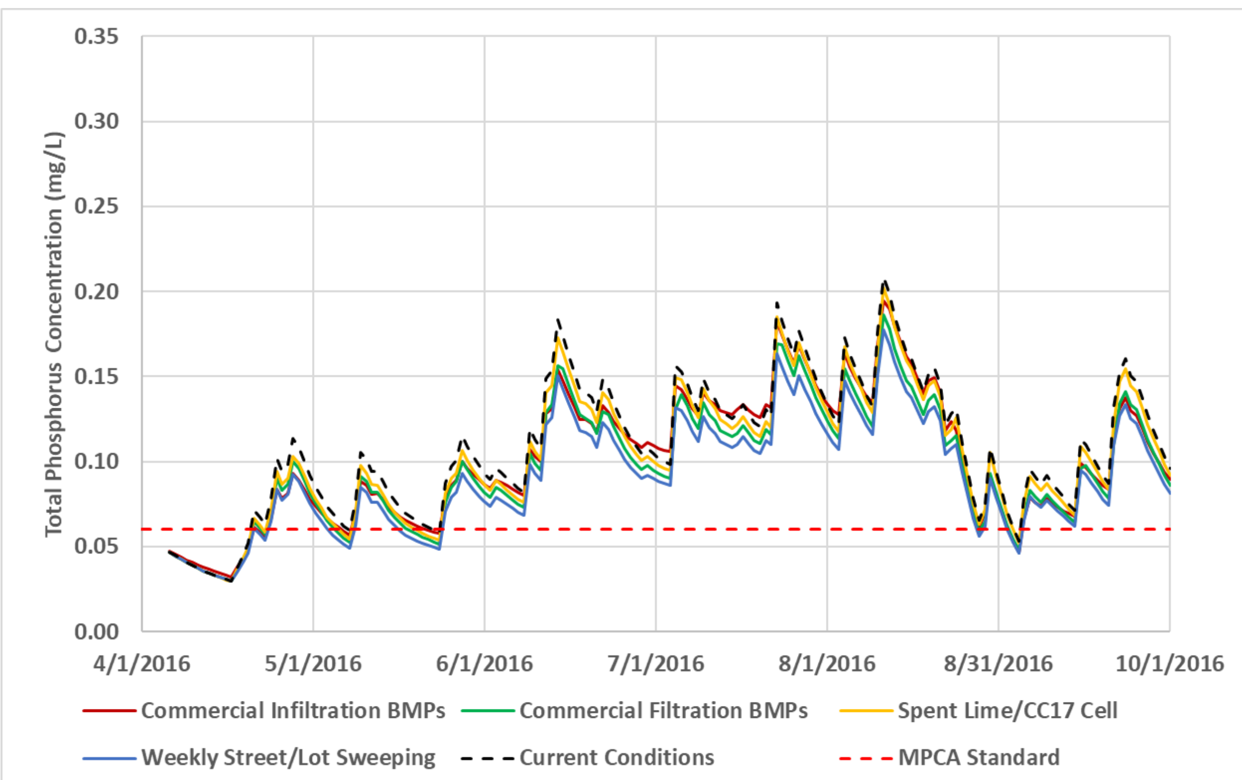


Figure D-2 In-lake phosphorus concentrations that resulted from external management efforts in North Cornelia in 2016

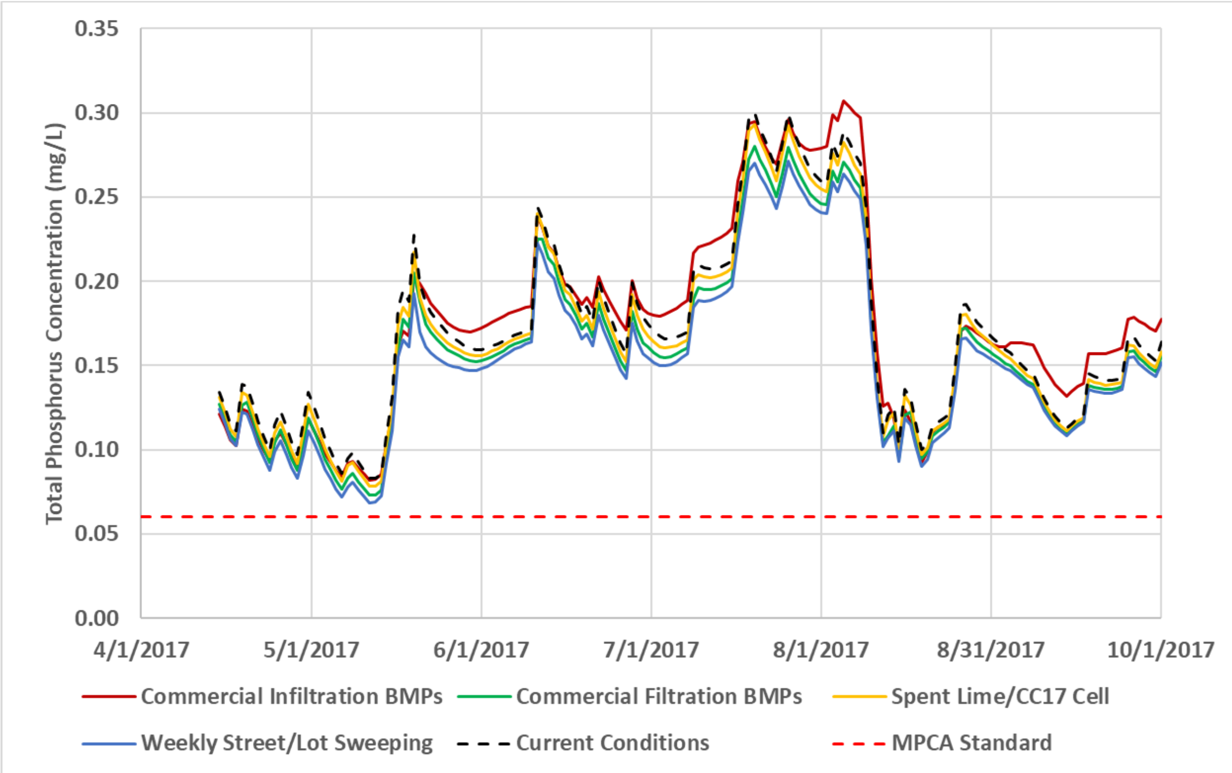


Figure D-3 **In-lake phosphorus concentrations that resulted from external management efforts in North Cornelia in 2017**

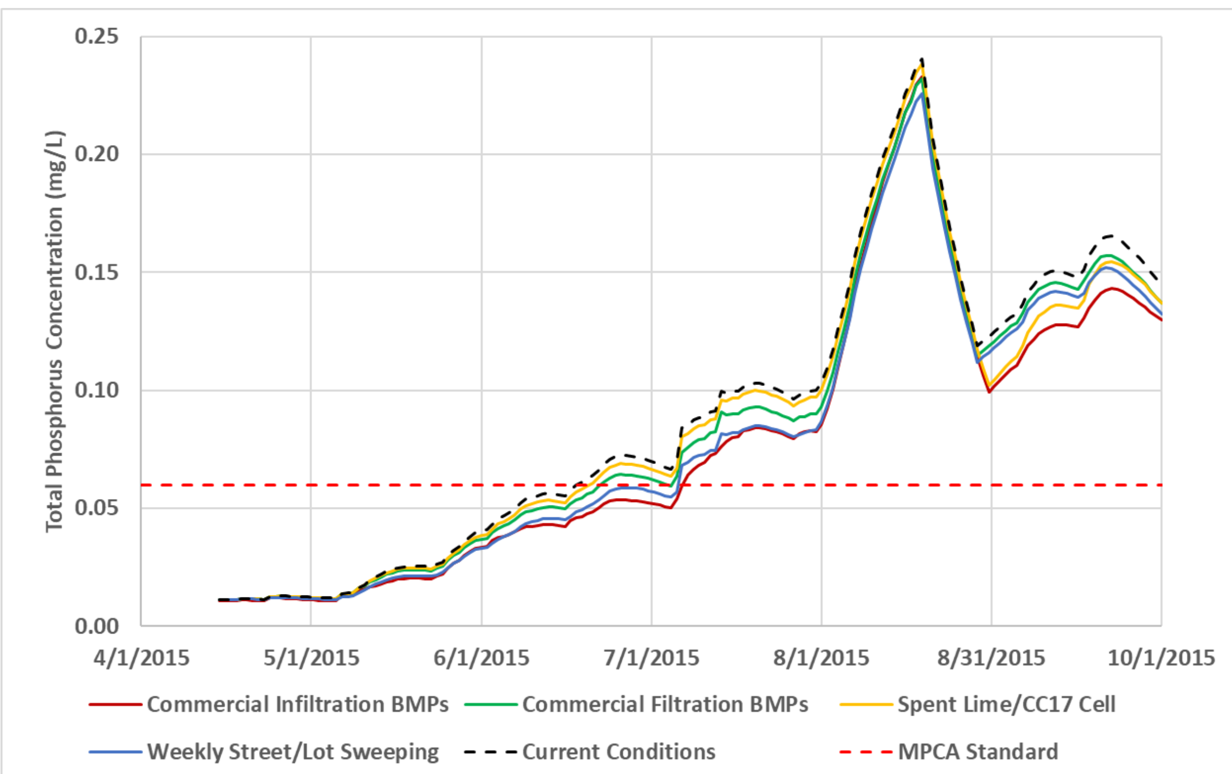


Figure D-4 **In-lake phosphorus concentrations that resulted from external management efforts in South Cornelia in 2015**

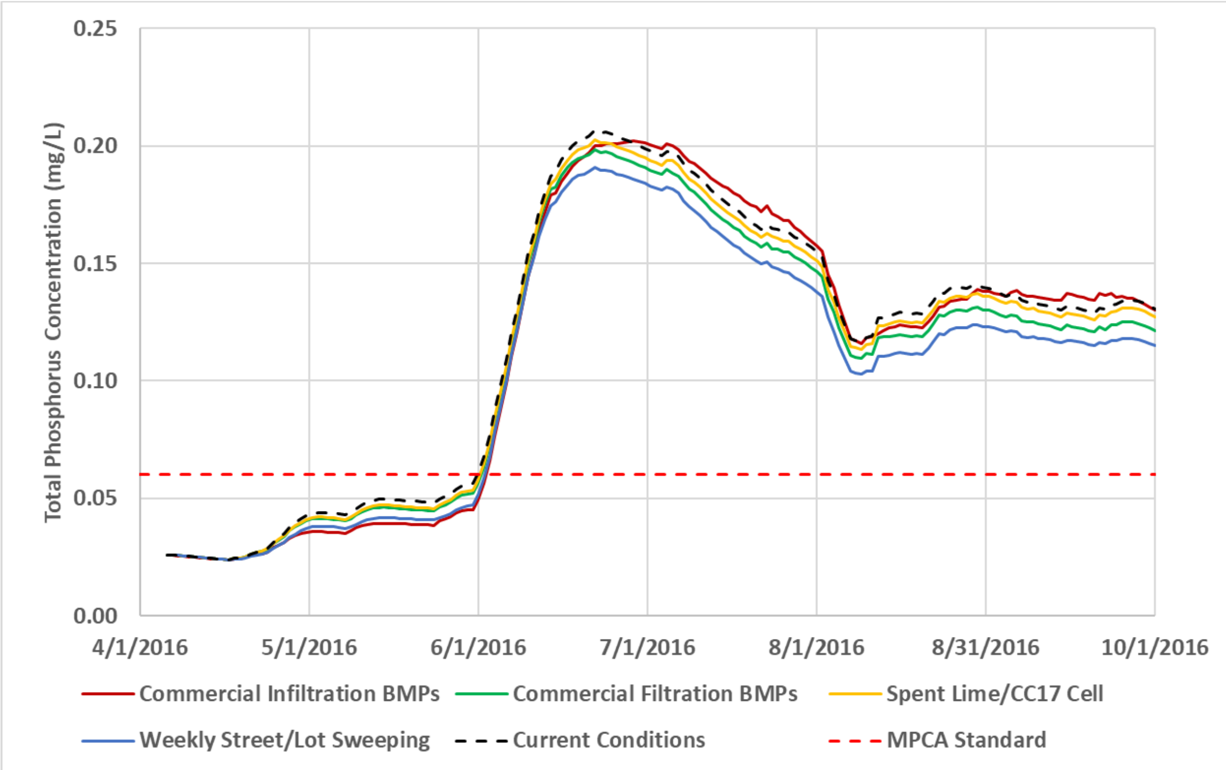


Figure D-5 In-lake phosphorus concentrations that resulted from external management efforts in South Cornelia in 2016

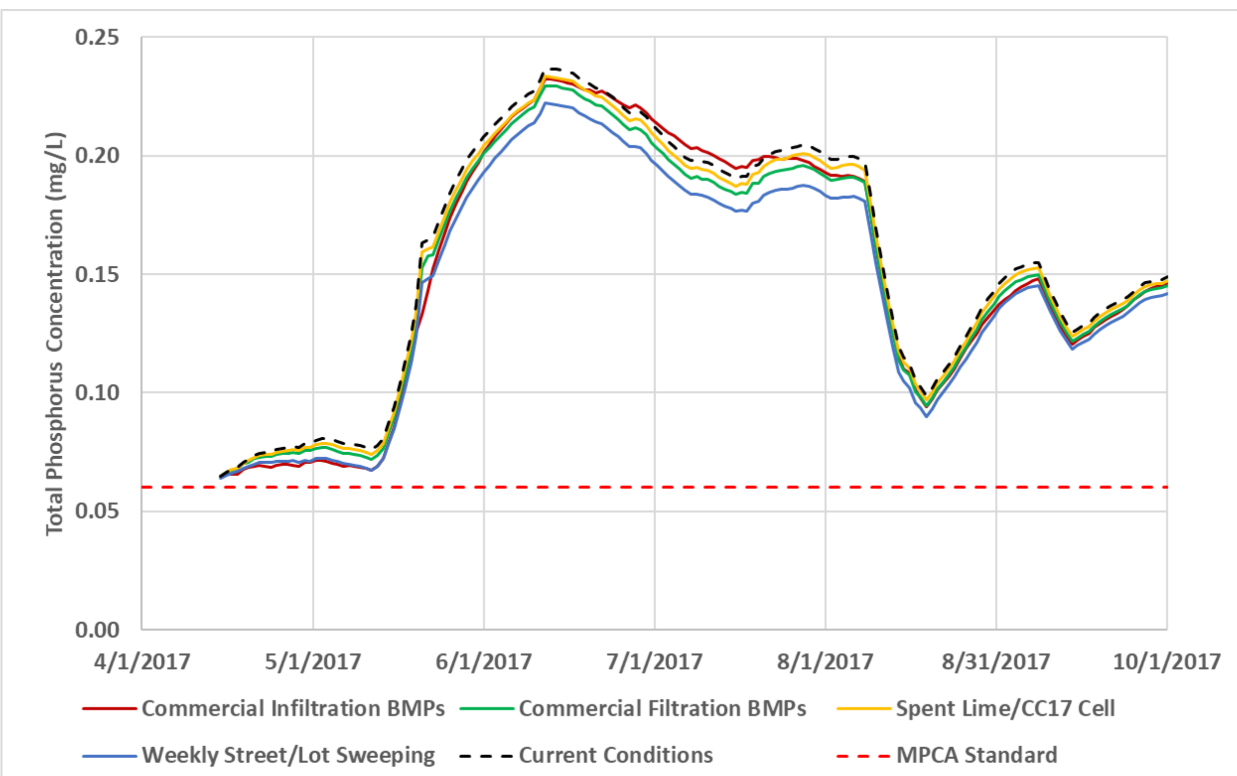


Figure D-6 In-lake phosphorus concentrations that resulted from external management efforts in South Cornelia in 2017

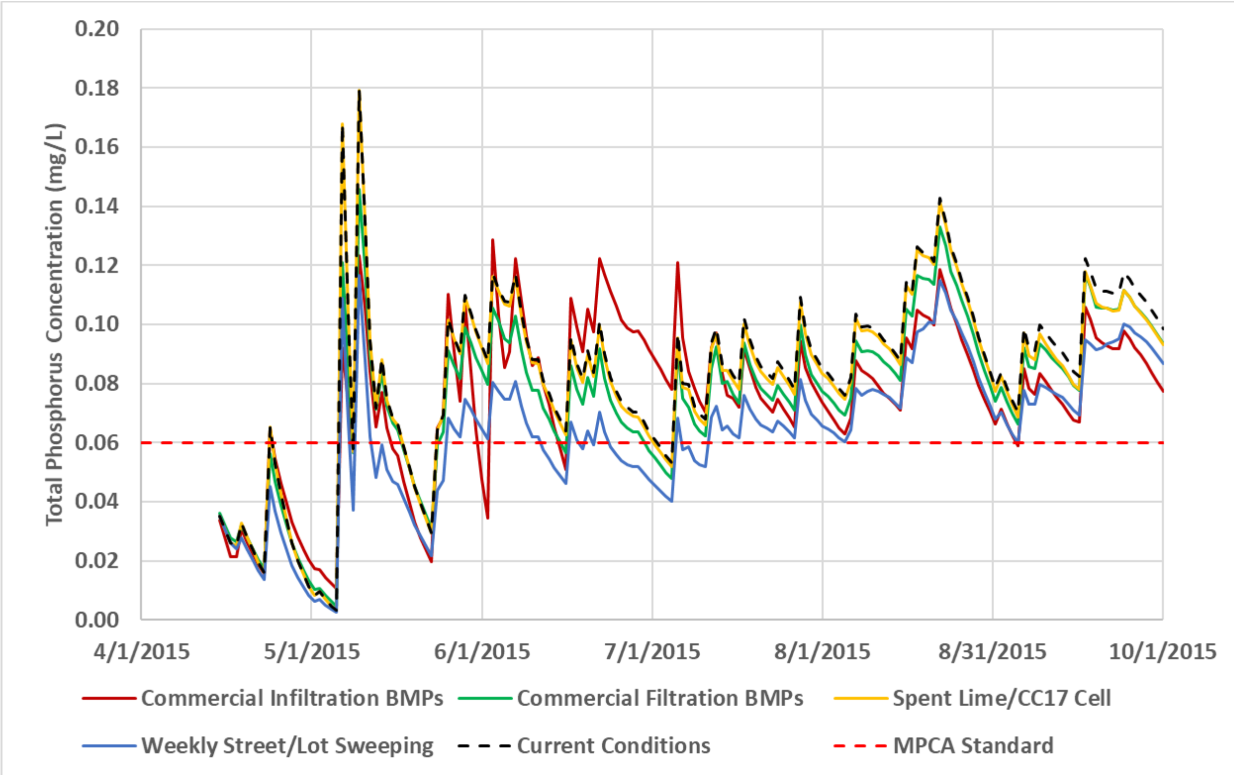


Figure D-7 **In-lake phosphorus concentrations that resulted from external management efforts in Lake Edina in 2015**

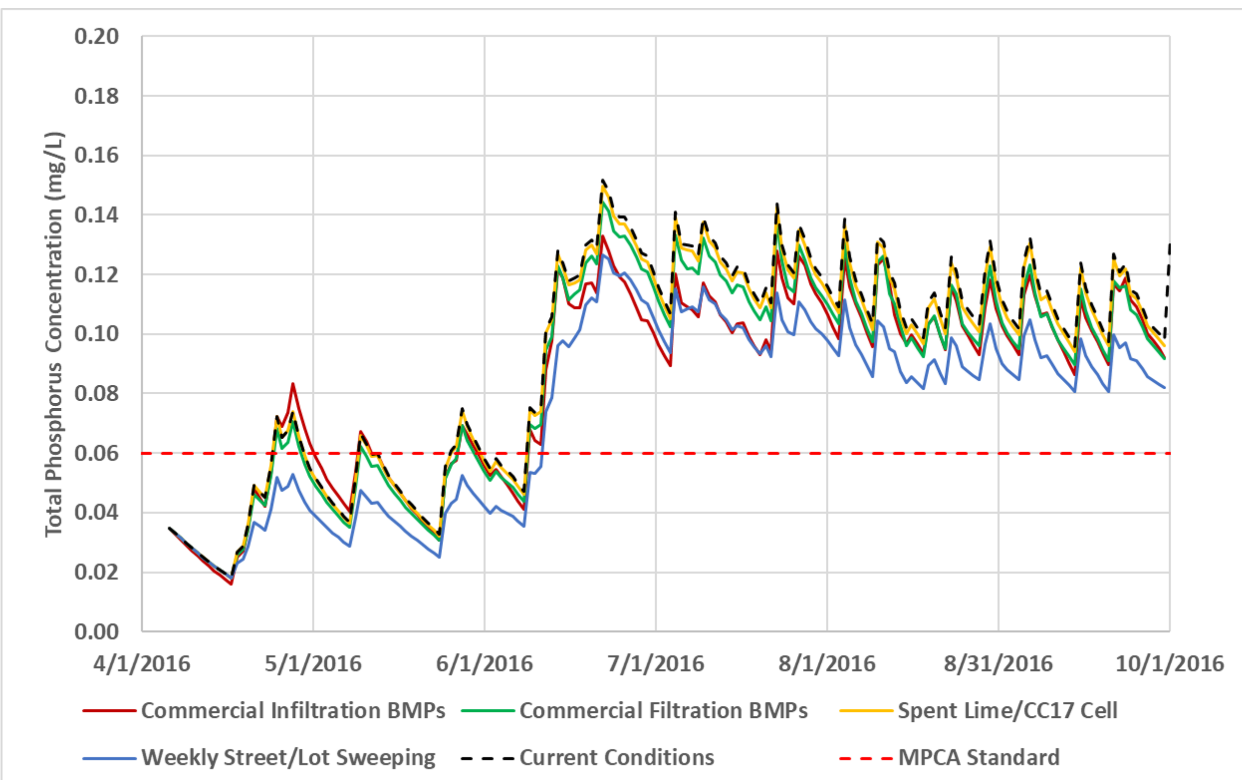


Figure D-8 **In-lake phosphorus concentrations that resulted from external management efforts in Lake Edina in 2016**

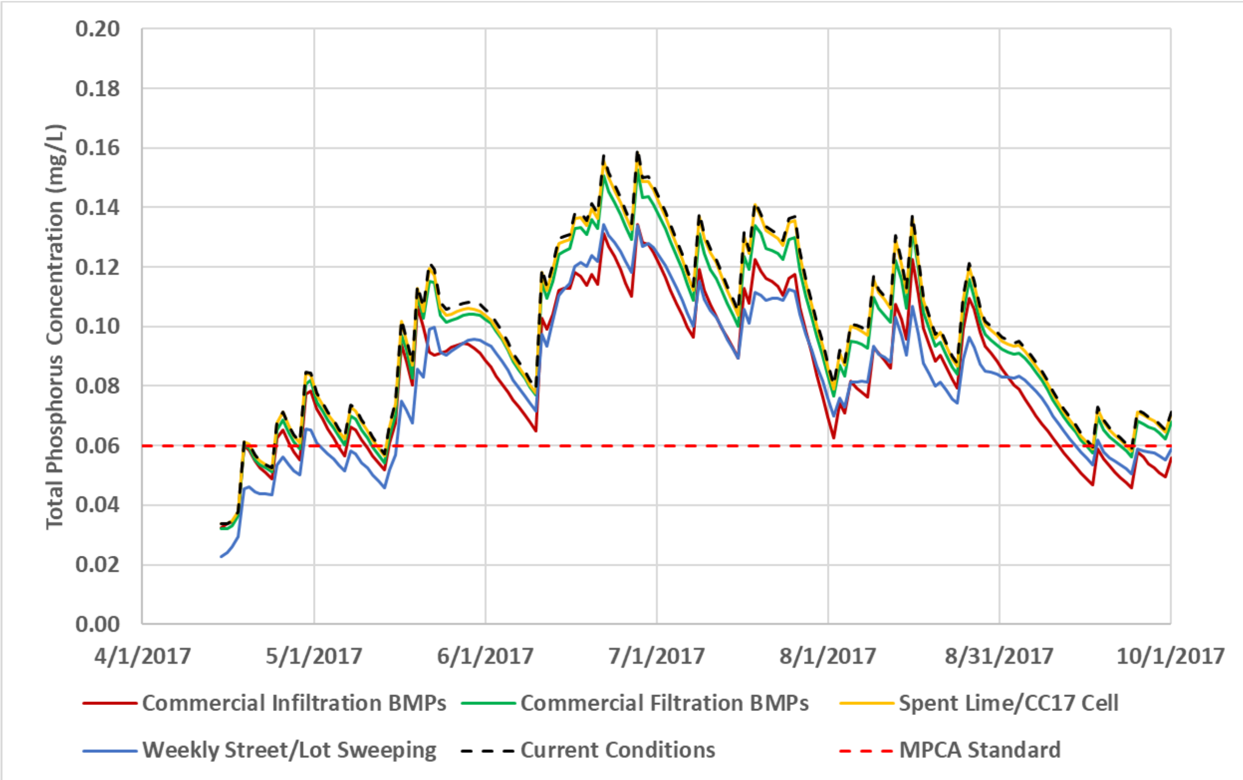


Figure D-9 In-lake phosphorus concentrations that resulted from external management efforts in Lake Edina in 2017

Appendix E

Internal Loading Management Concentration Plots

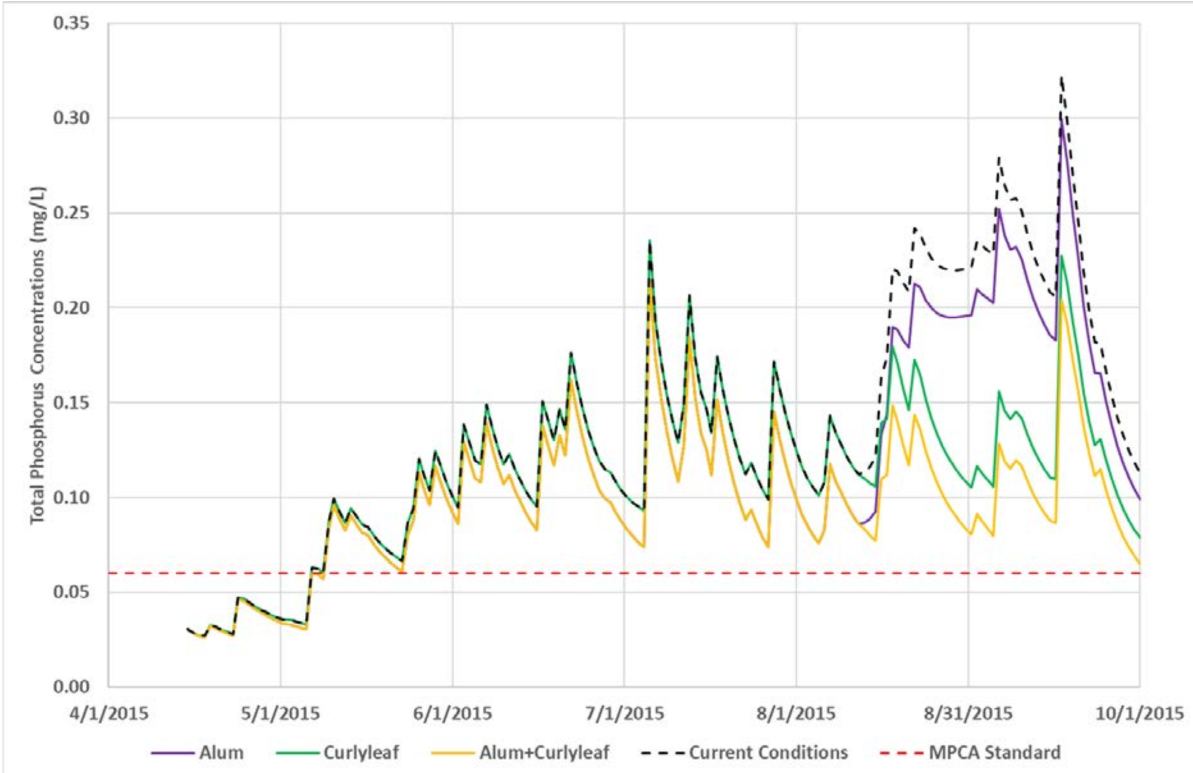


Figure E-1 In-Lake Phosphorus Concentration Changes that resulted from internal management efforts in North Cornelia in 2015

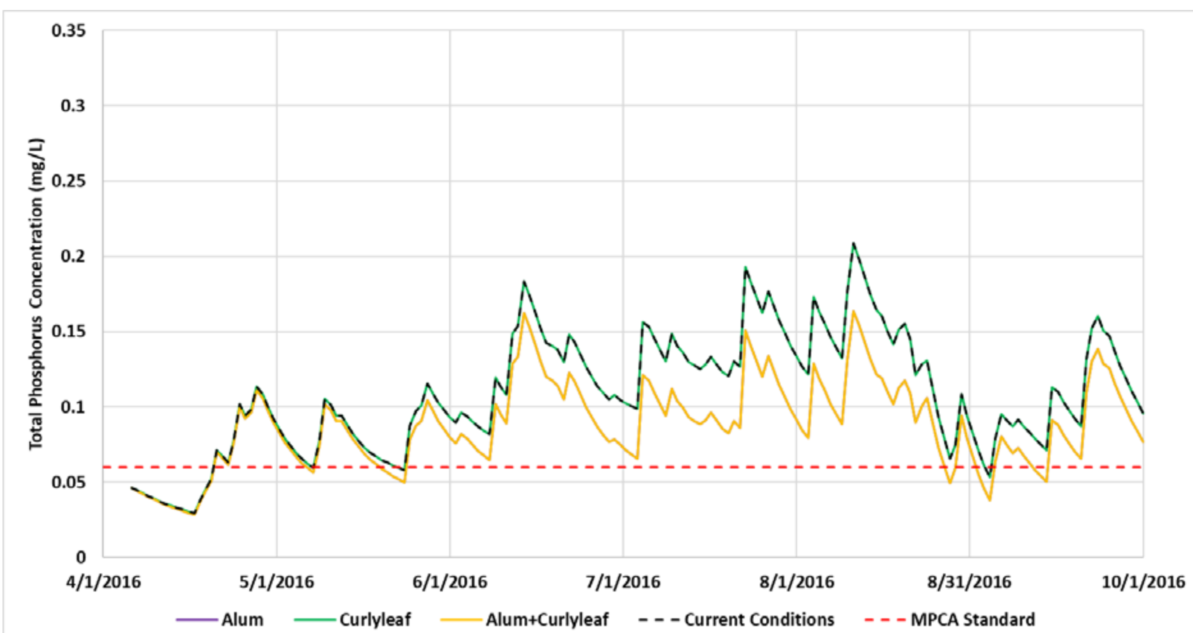


Figure E-2 In-Lake Phosphorus Concentration Changes that resulted from internal management efforts in North Cornelia in 2016

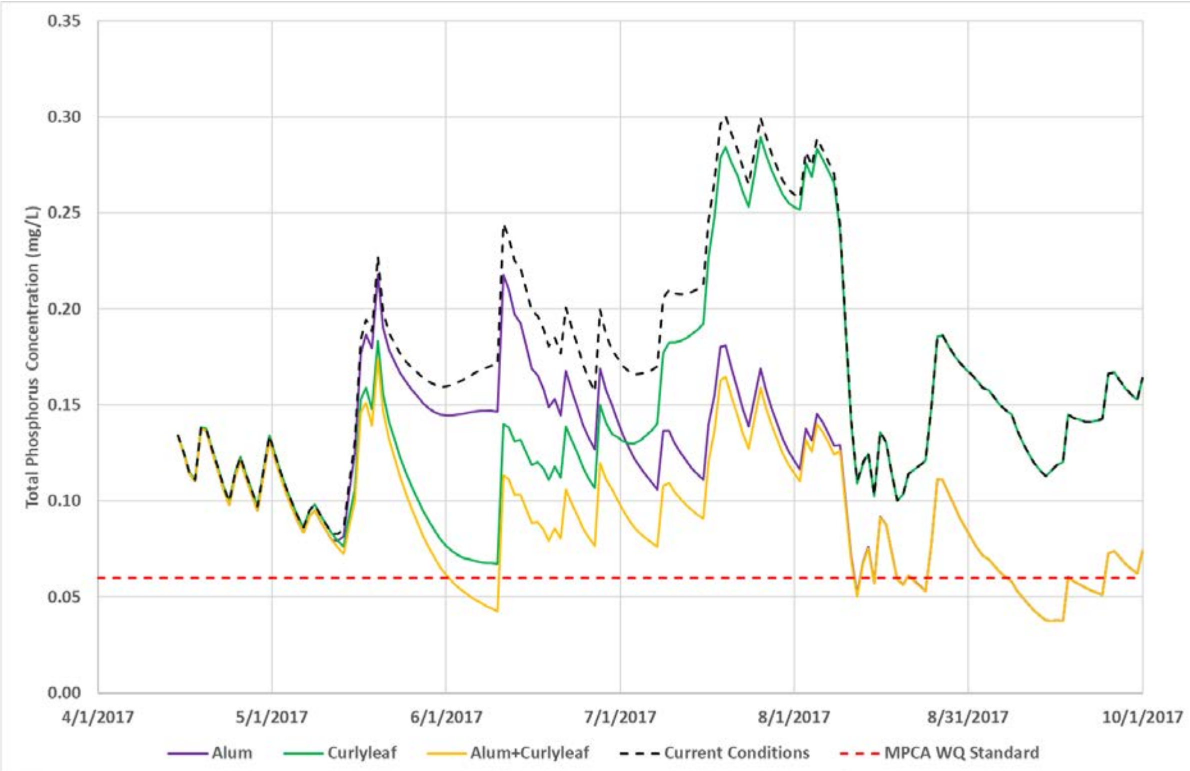


Figure E-3 In-Lake Phosphorus Concentration Changes that resulted from internal management efforts in North Cornelia in 2017

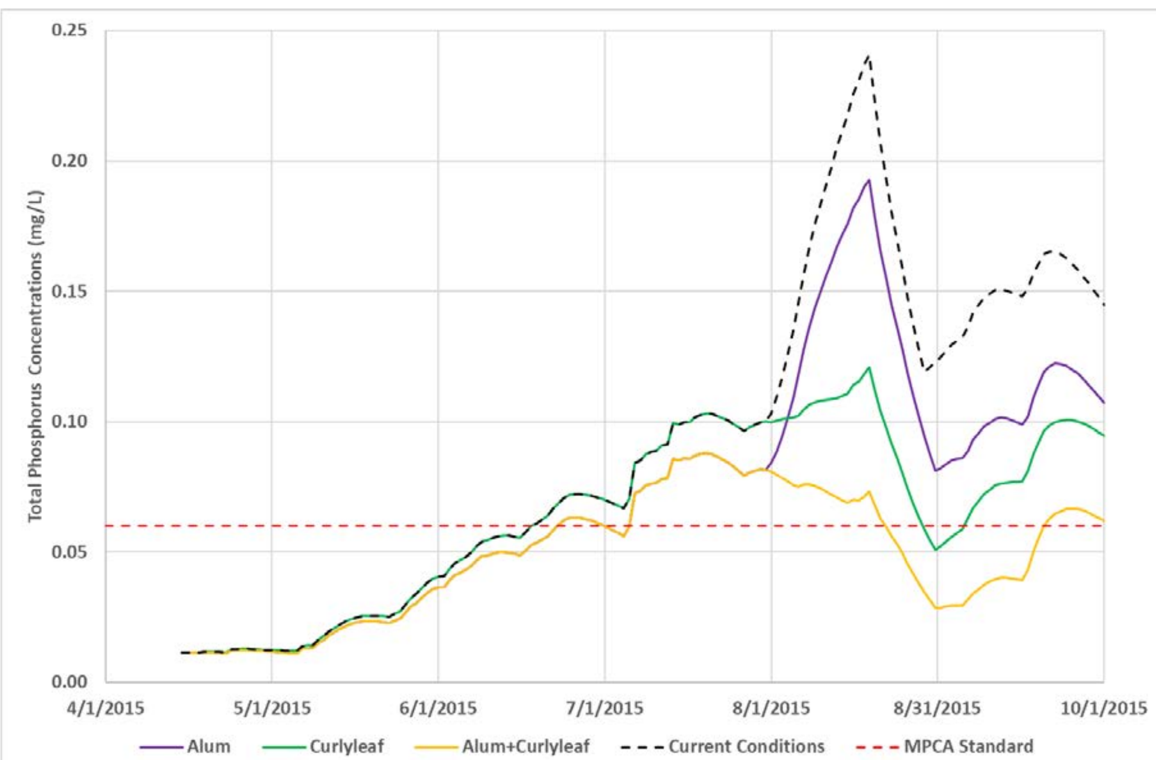


Figure E-4 In-Lake Phosphorus Concentration Changes that resulted from internal management efforts in South Cornelia in 2015

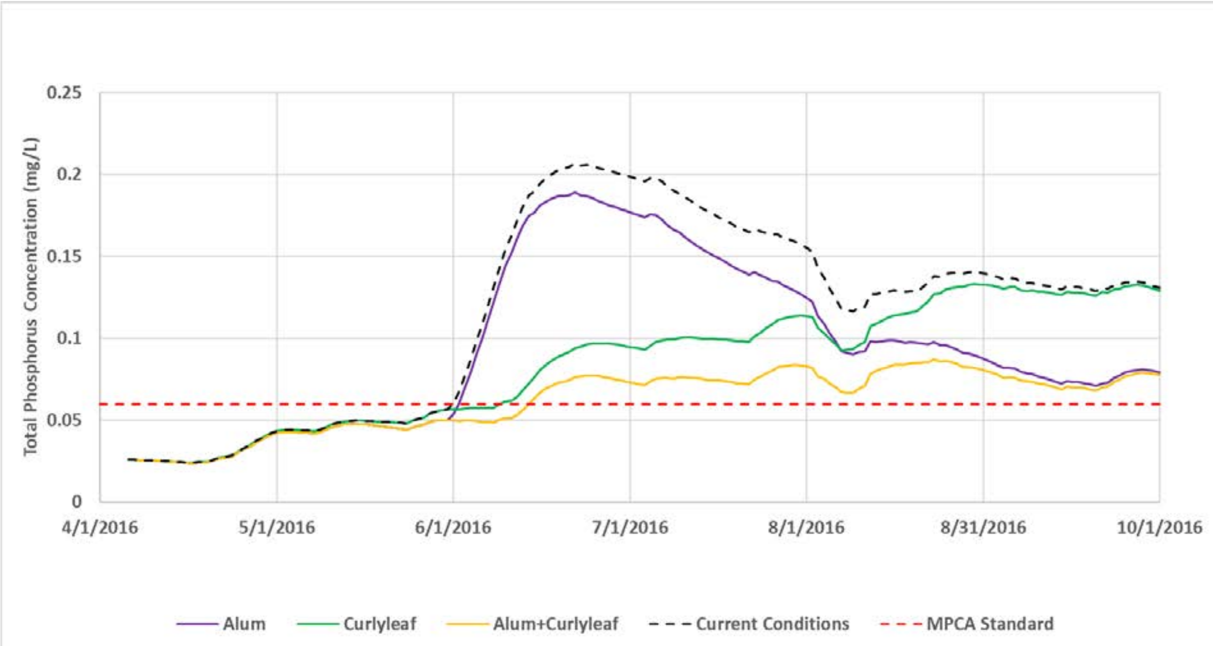


Figure E-5 In-Lake Phosphorus Concentration Changes that resulted from internal management efforts in South Cornelia in 2016

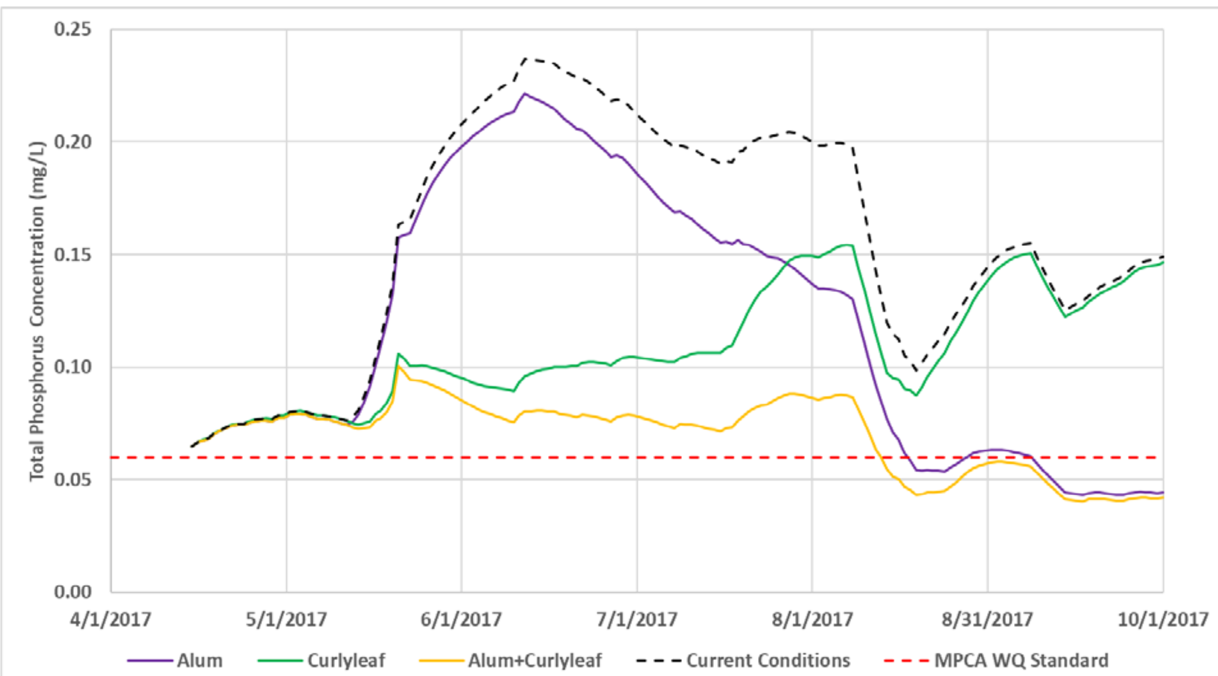


Figure E-6 In-Lake Phosphorus Concentration Changes that resulted from internal management efforts in South Cornelia in 2017

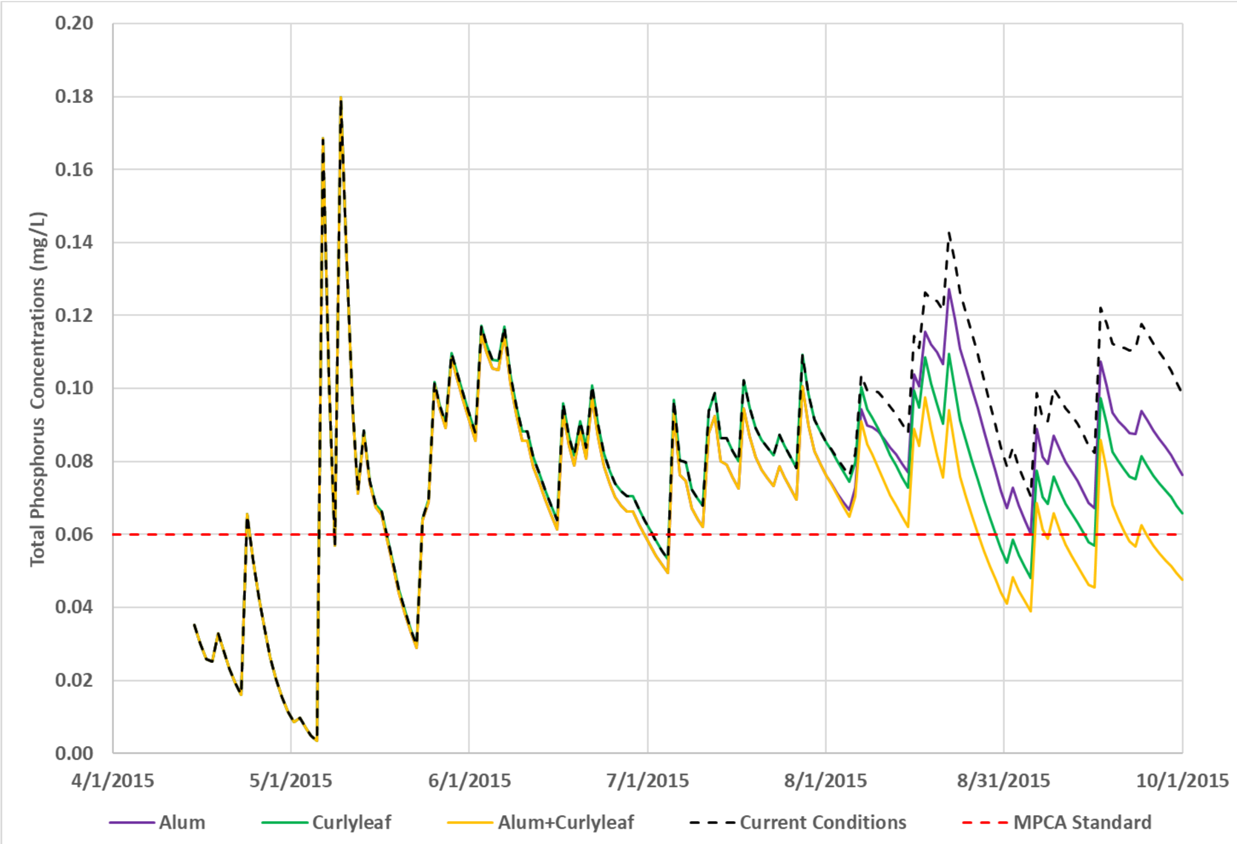


Figure E-7 In-Lake Phosphorus Concentration Changes that resulted from internal management efforts in Lake Edina in 2015

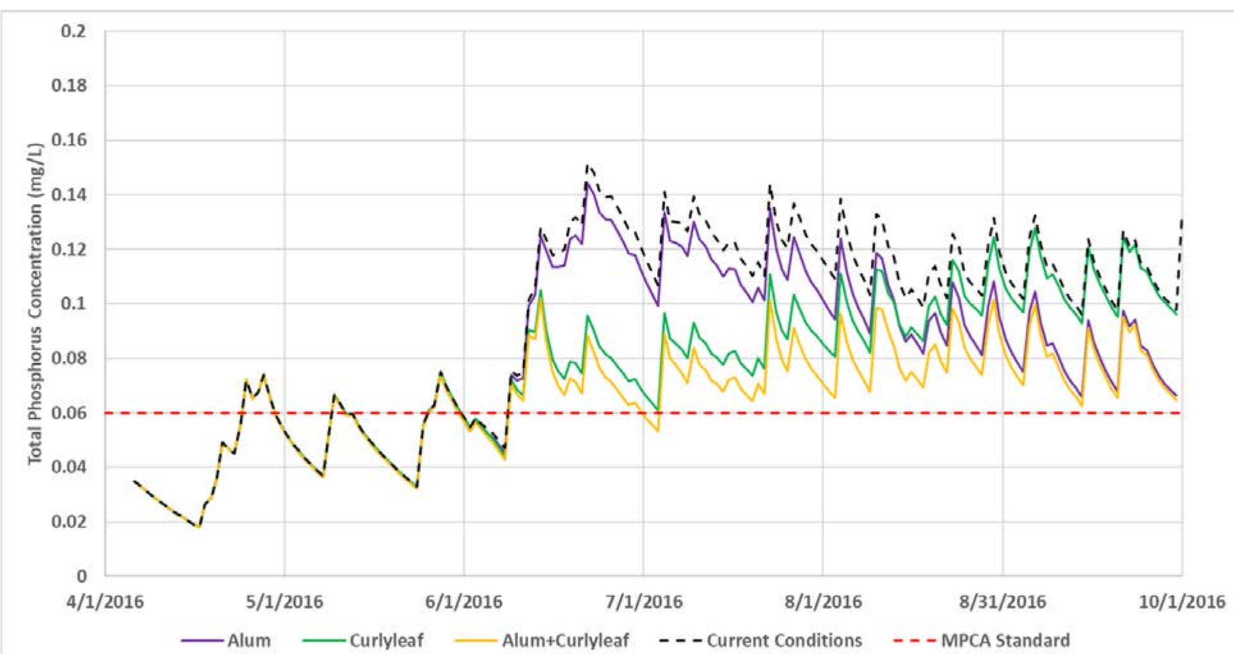


Figure E-8 In-Lake Phosphorus Concentration Changes that resulted from internal management efforts in Lake Edina in 2016

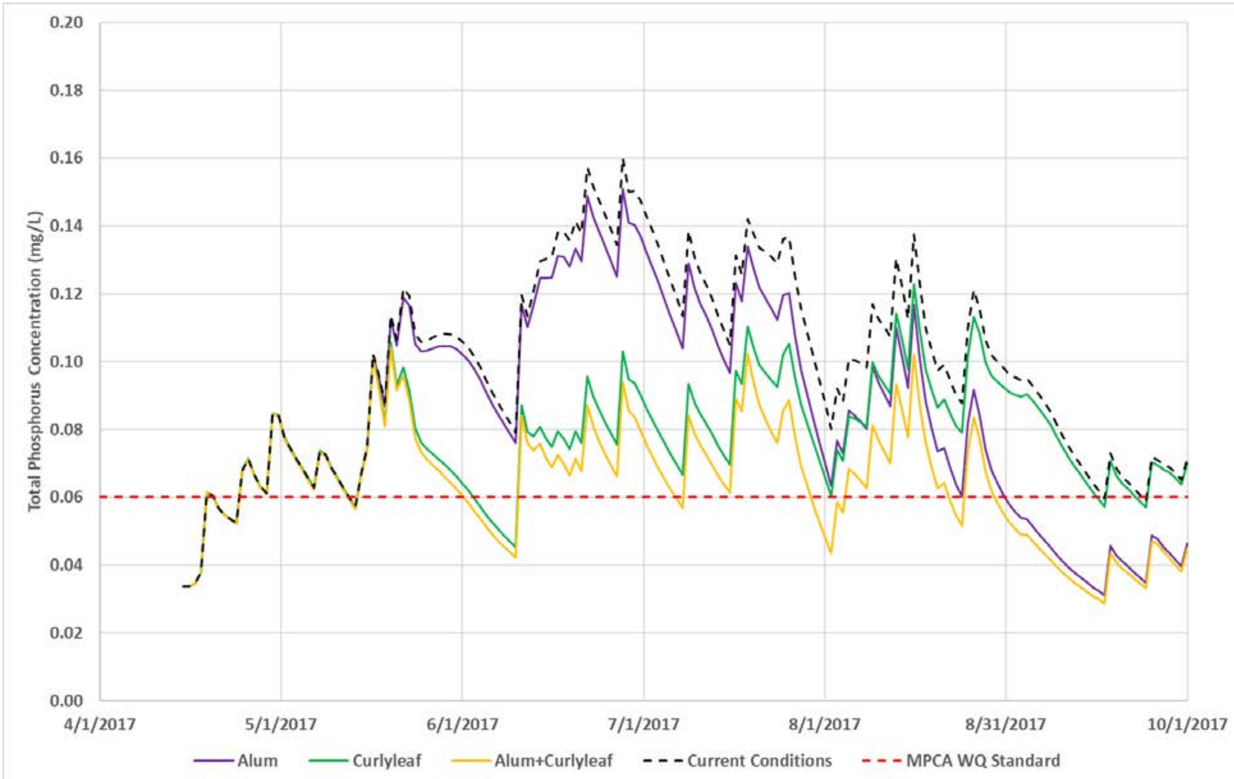


Figure E-9 **In-Lake Phosphorus Concentration Changes that resulted from internal management efforts in Lake Edina in 2017**

Appendix F

Combined (Internal + External) Management Concentration Plots

Appendix F

Combined (Internal + External) Management Concentration Plots

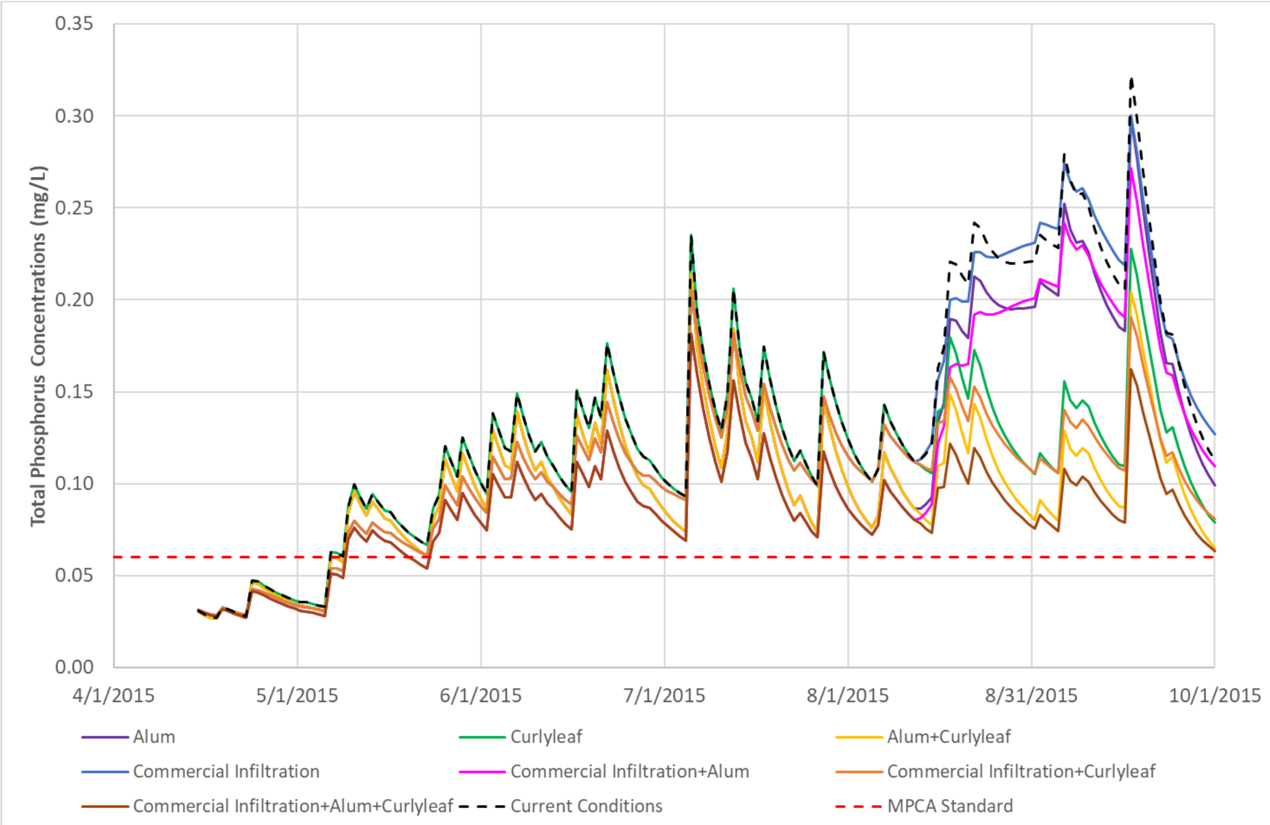


Figure F-1 **In-lake phosphorus concentrations in North Cornelia in 2015 under various combinations of internal and commercial infiltration management efforts**

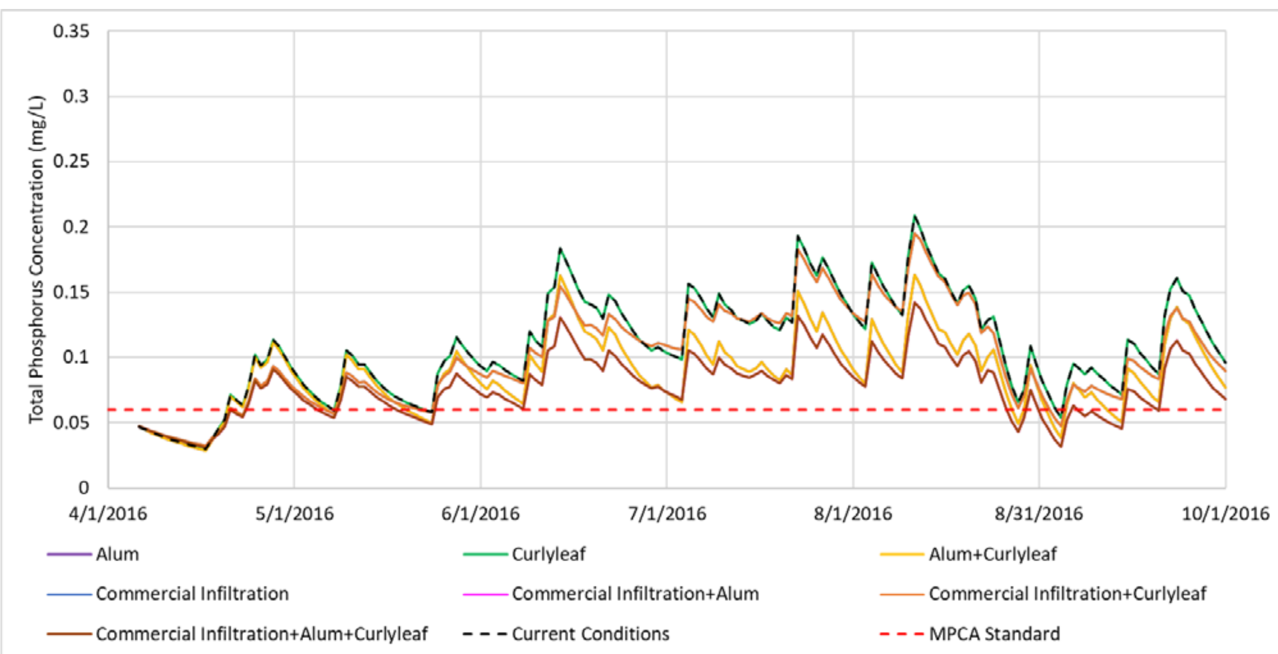


Figure F-2 **In-lake phosphorus concentrations in North Cornelia in 2016 under various combinations of internal and commercial infiltration management efforts**

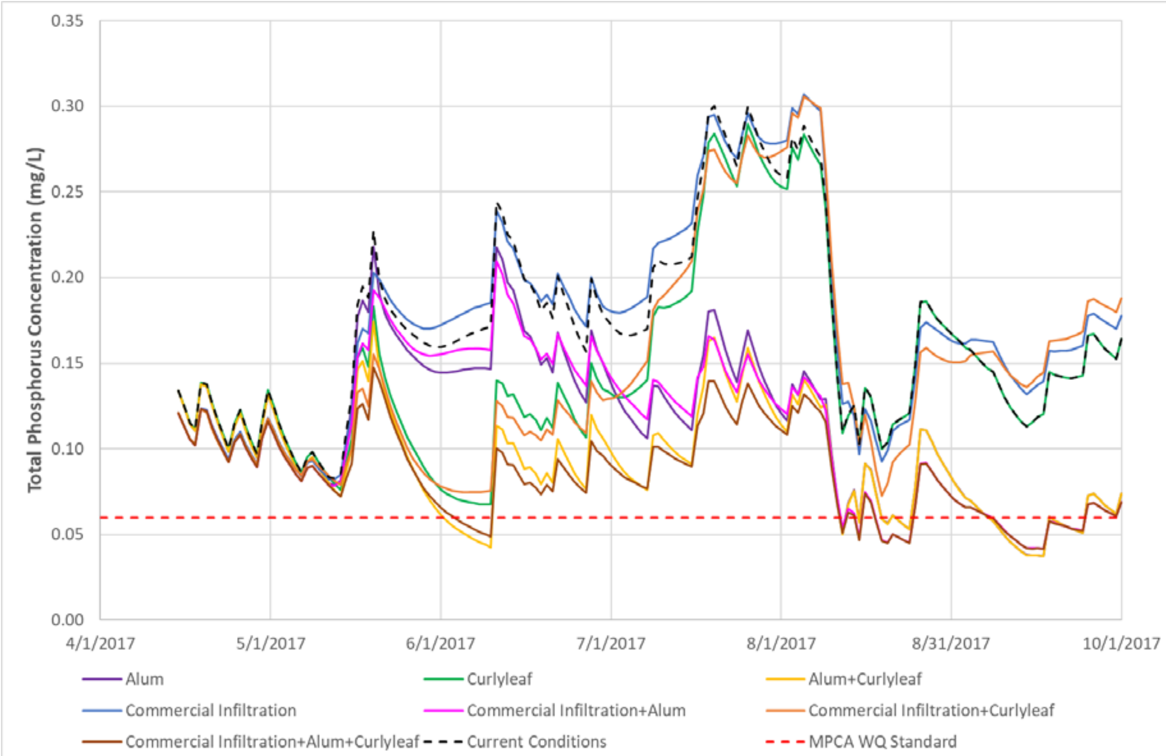


Figure F-3 In-lake phosphorus concentrations in North Cornelia in 2017 under various combinations of internal and commercial infiltration management efforts

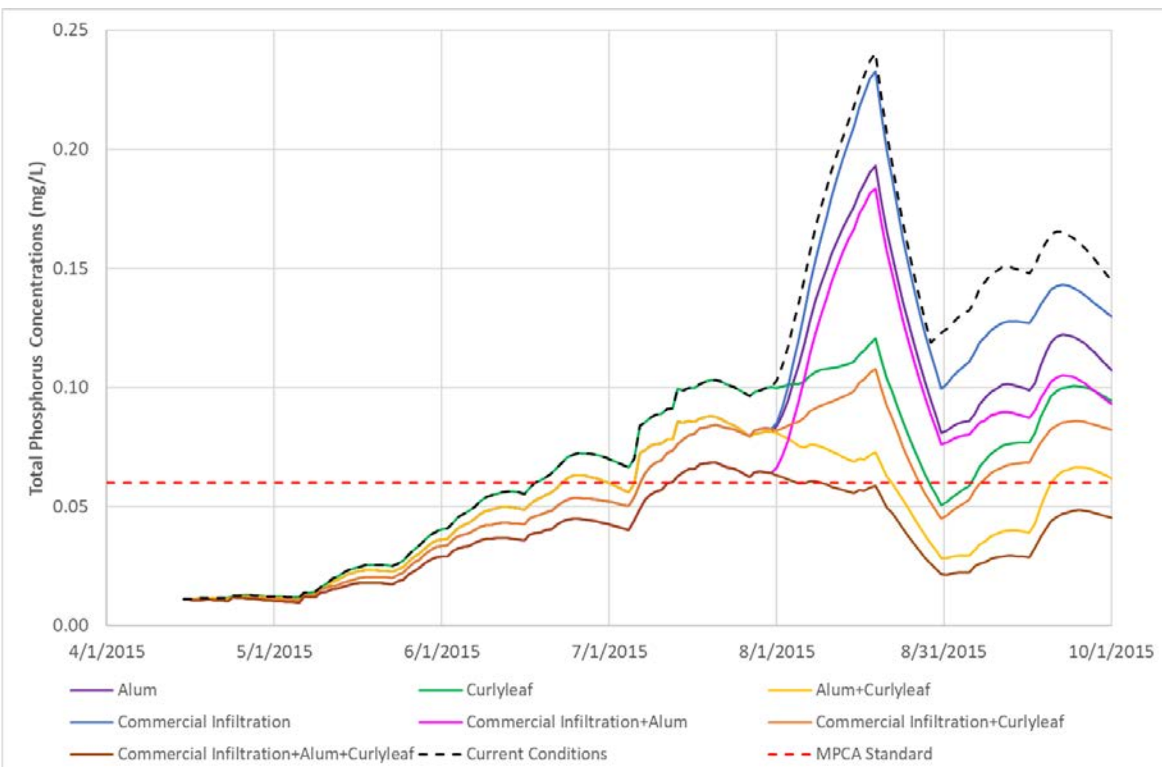


Figure F-4 In-lake phosphorus concentrations in South Cornelia in 2015 under various combinations of internal and commercial infiltration management efforts

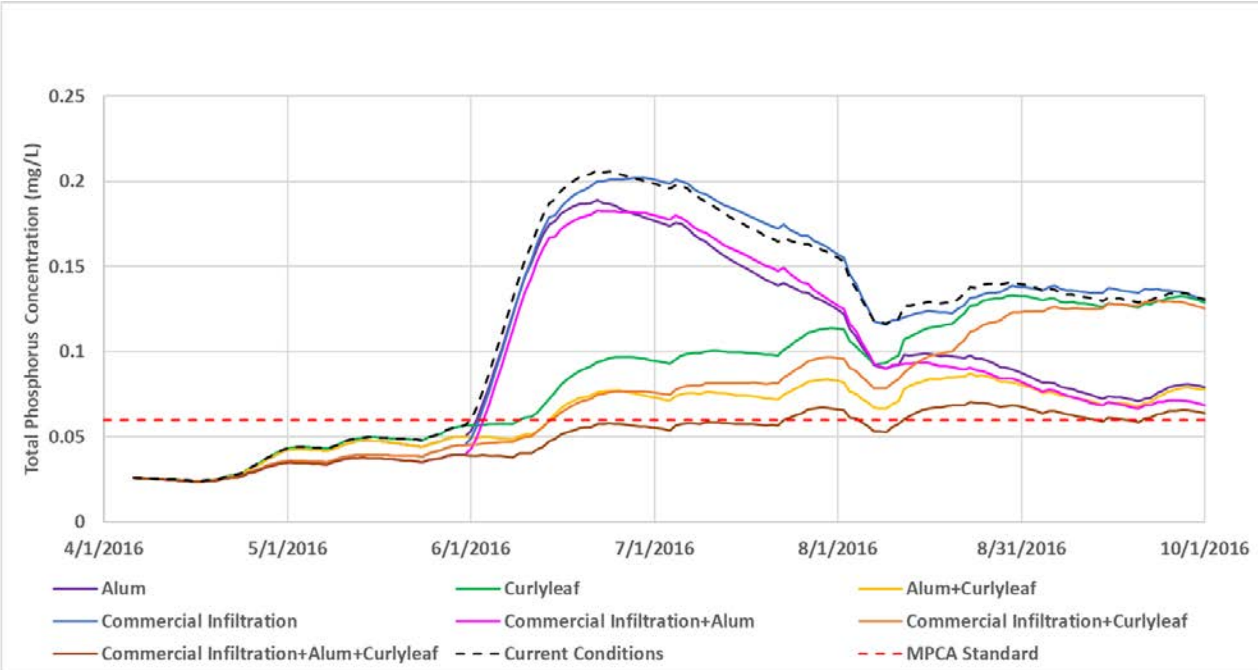


Figure F-5 In-lake phosphorus concentrations in South Cornelia in 2016 under various combinations of internal and commercial infiltration management efforts

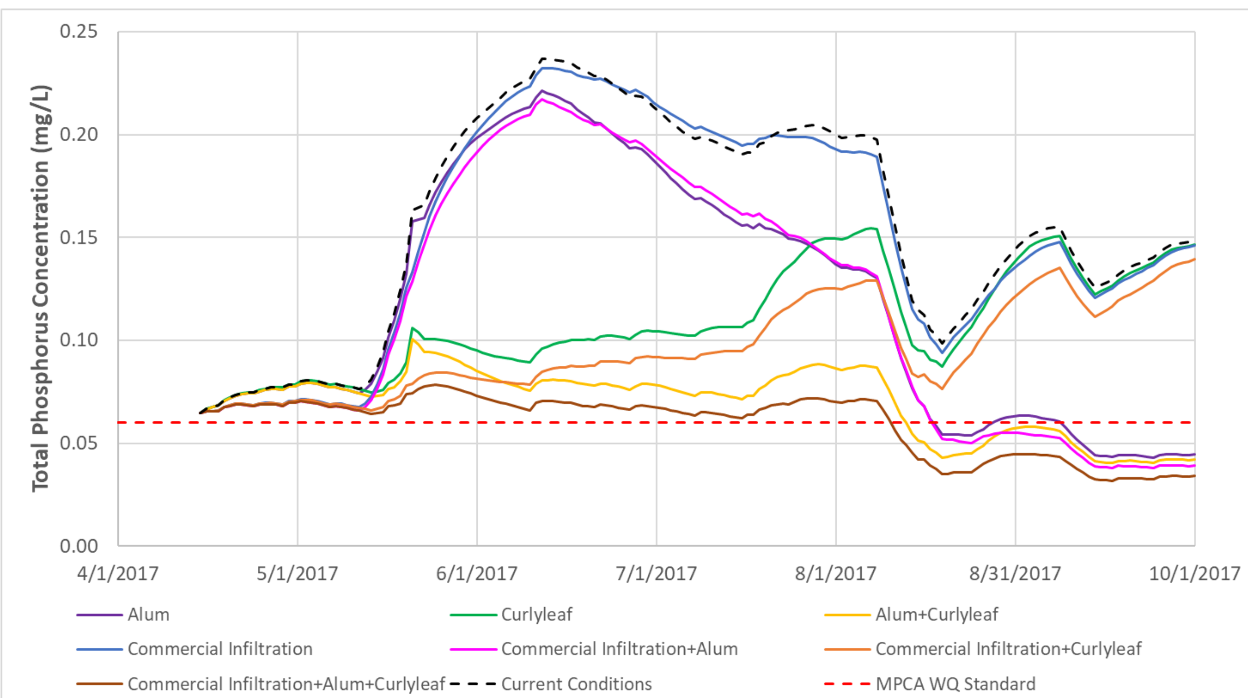


Figure F-6 In-lake phosphorus concentrations in South Cornelia in 2017 under various combinations of internal and commercial infiltration management efforts

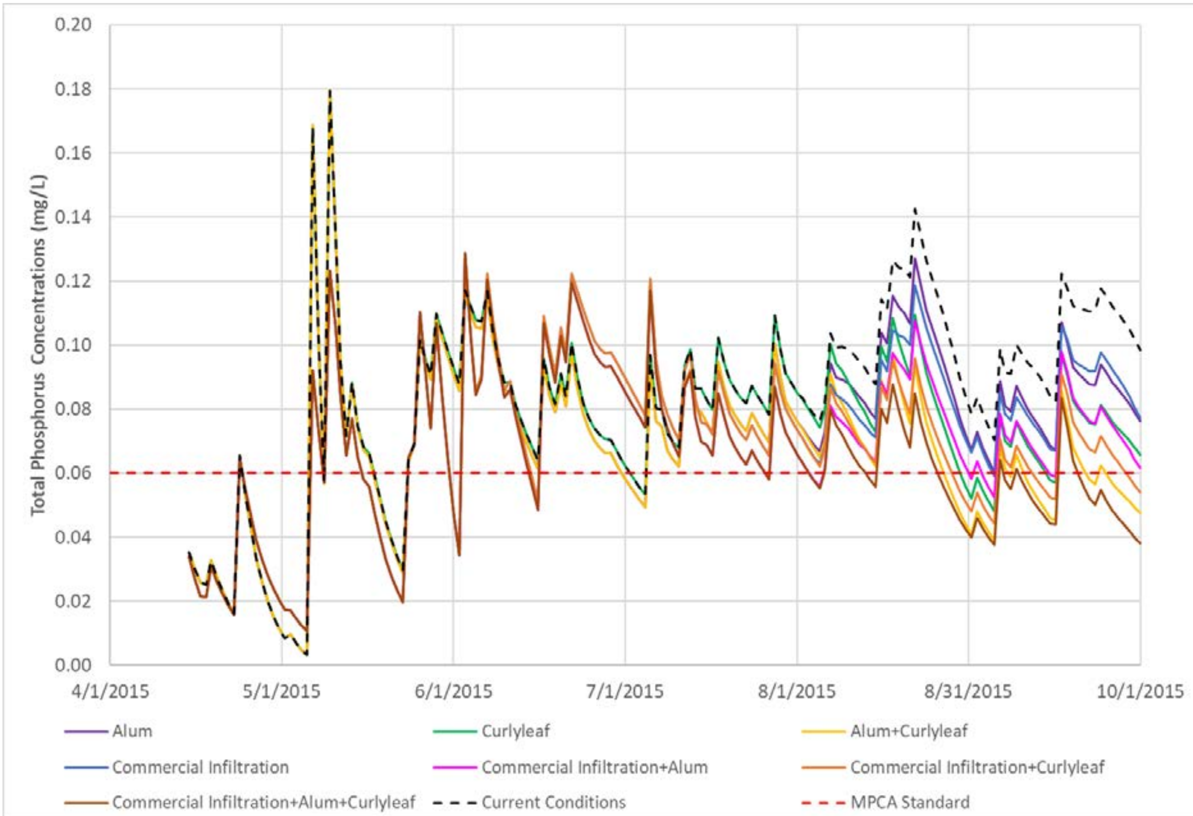


Figure F-7 **In-lake phosphorus concentrations in Lake Edina in 2015 under various combinations of internal and commercial infiltration management efforts**

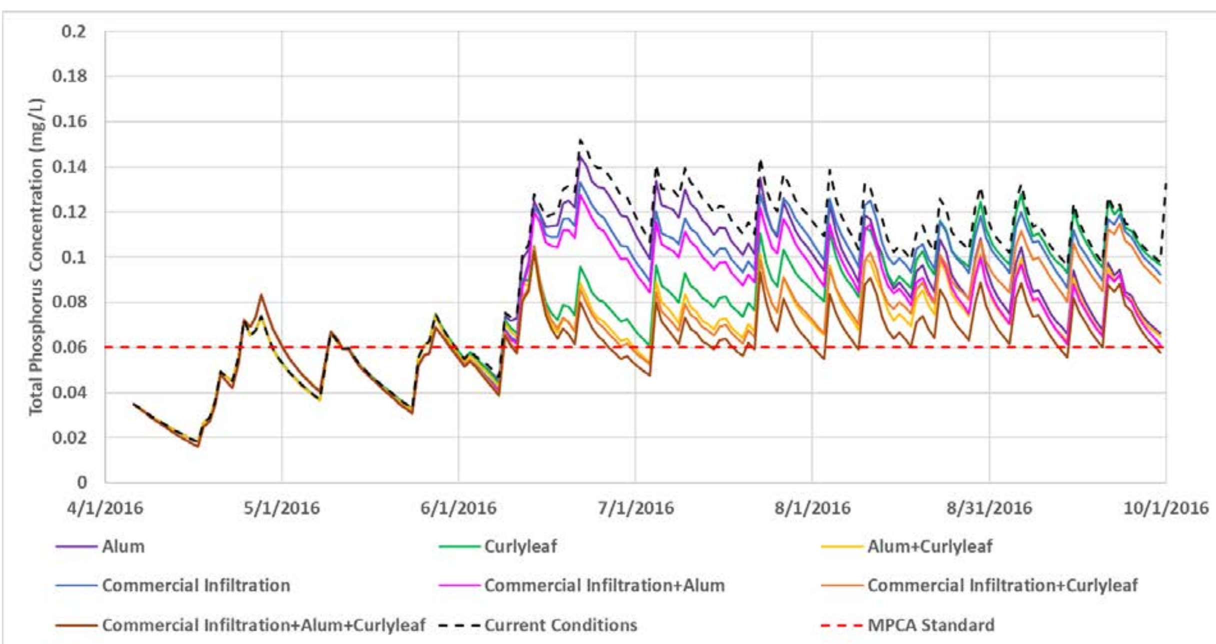


Figure F-8 **In-lake phosphorus concentrations in Lake Edina in 2016 under various combinations of internal and commercial infiltration management efforts**

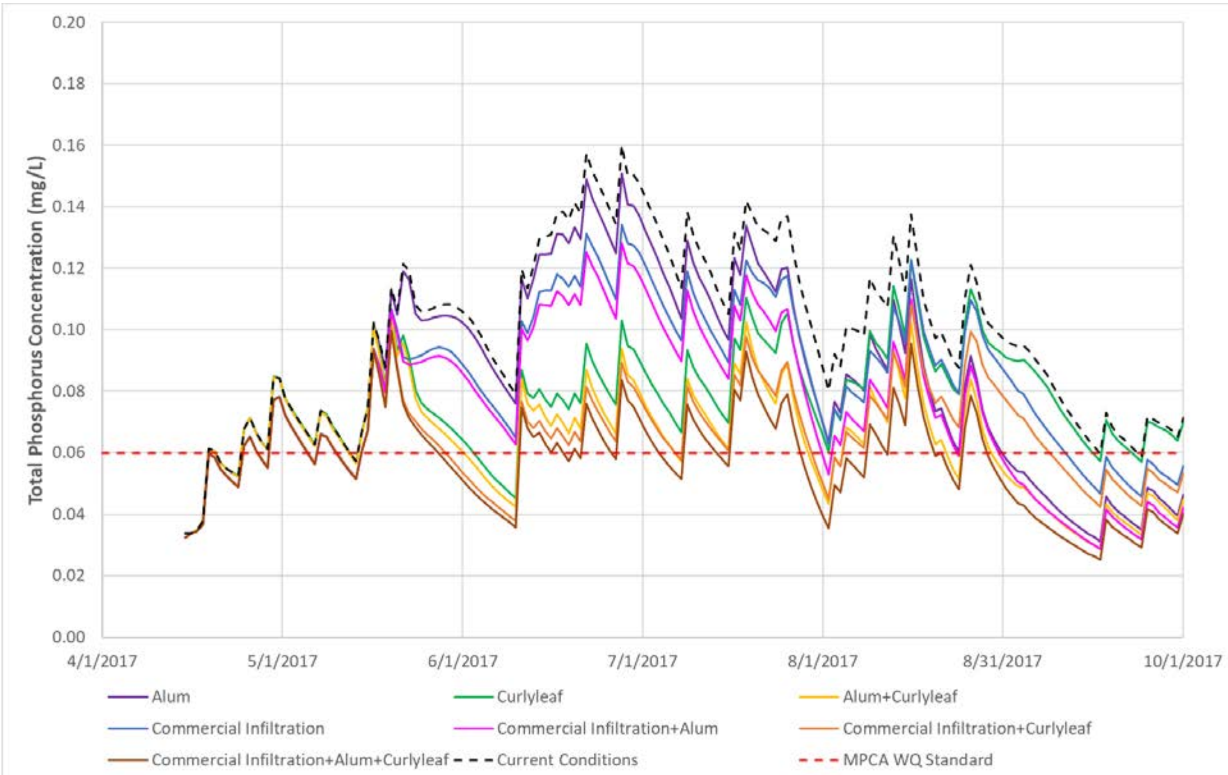


Figure F-9 In-lake phosphorus concentrations in Lake Edina in 2017 under various combinations of internal and commercial infiltration management efforts

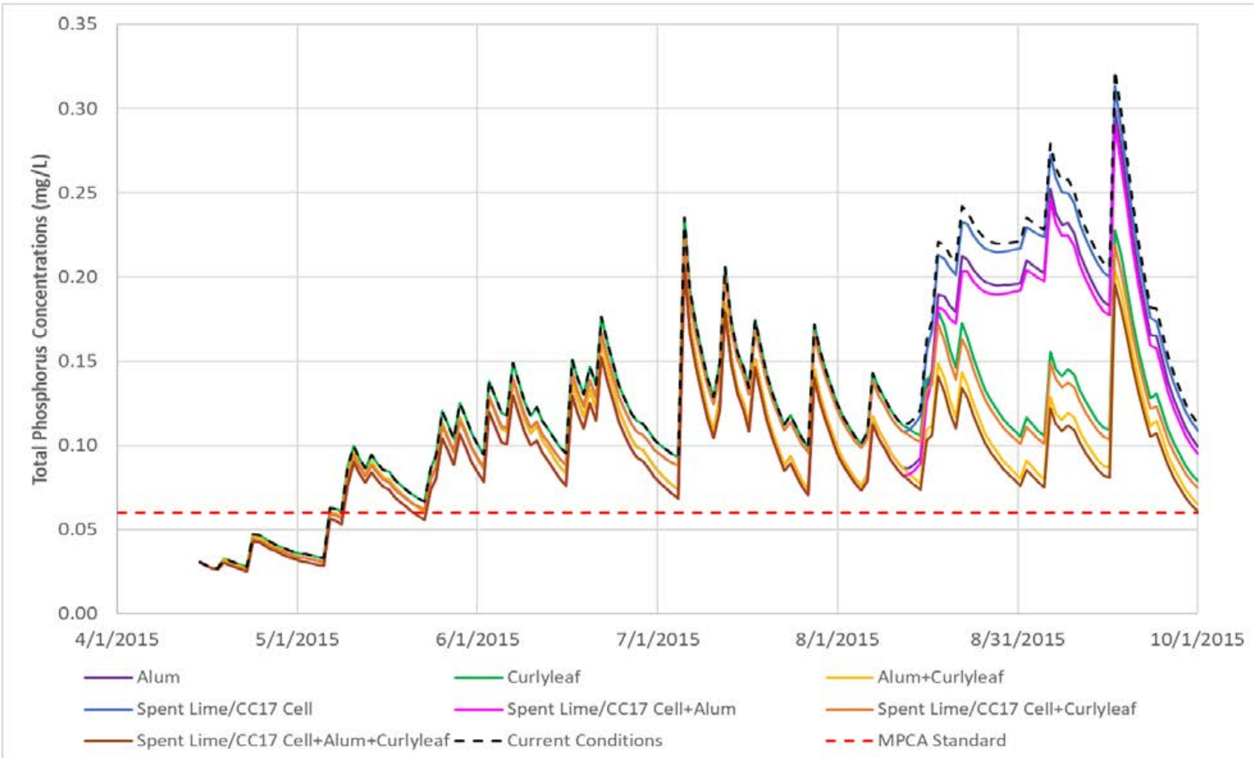


Figure F-10 In-lake phosphorus concentrations in North Cornelia in 2015 under various combinations of internal management efforts and a spent lime/CC17 treatment cell

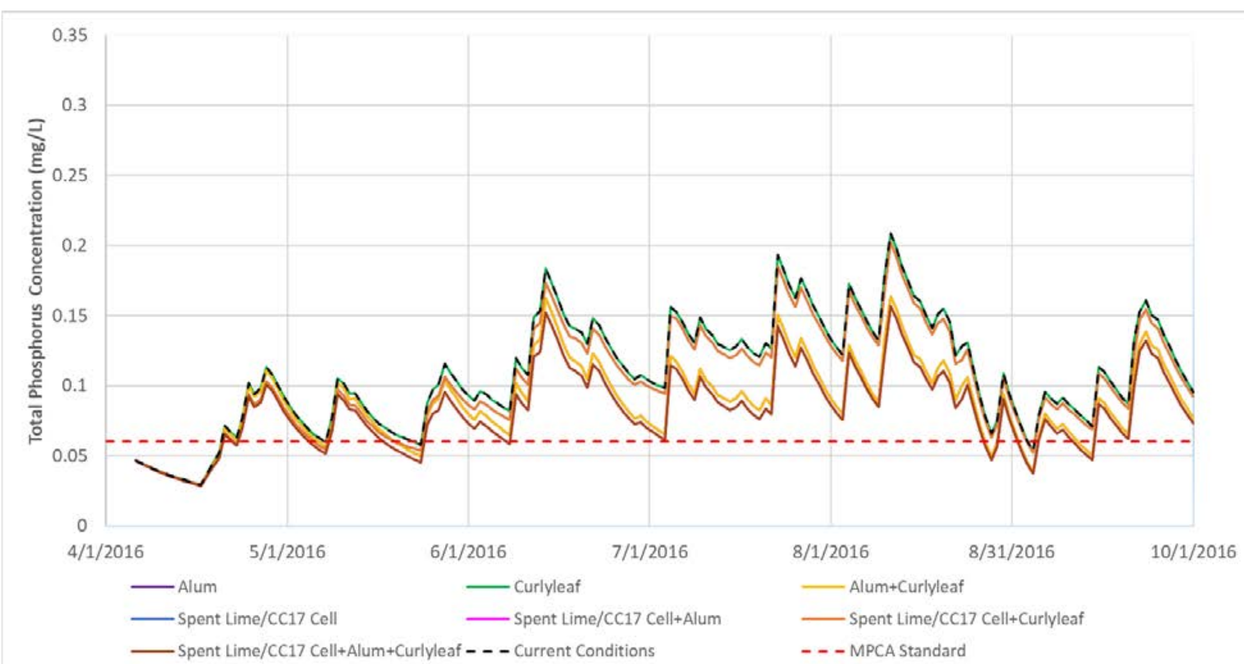


Figure F-11 In-lake phosphorus concentrations in North Cornelia in 2016 under various combinations of internal management efforts and a spent lime/CC17 treatment cell

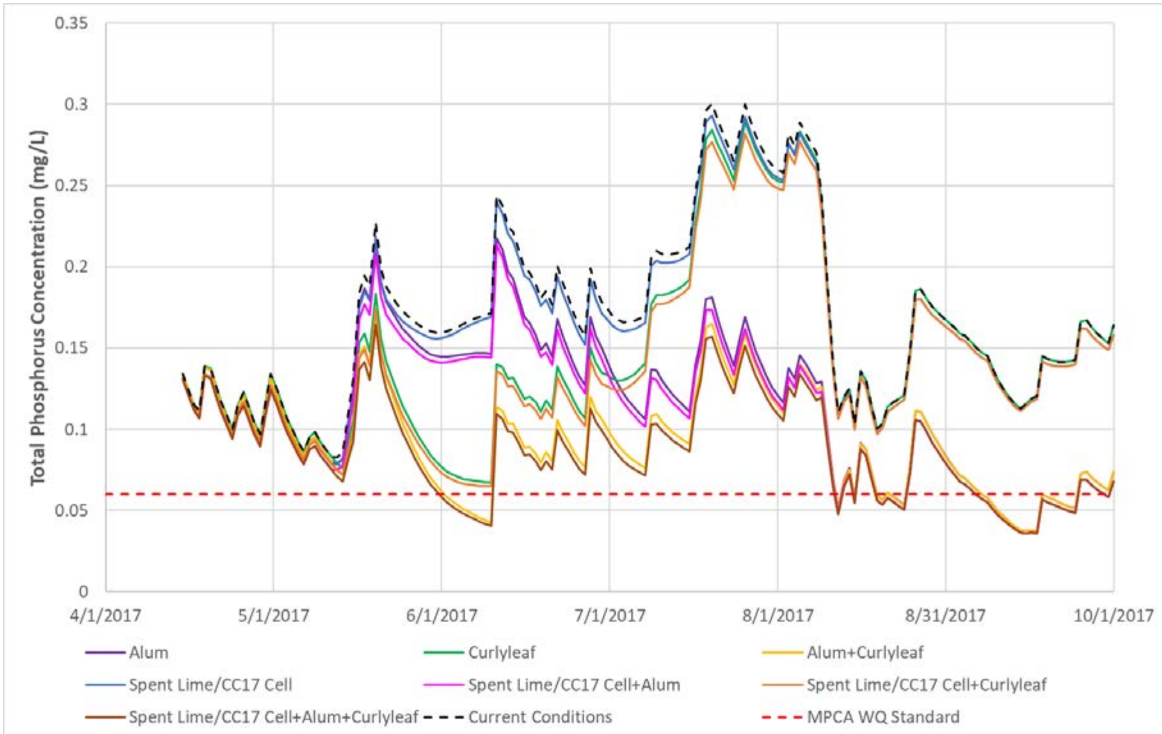


Figure F-12 **In-lake phosphorus concentrations in North Cornelia in 2017 under various combinations of internal management efforts and a spent lime/CC17 treatment cell**

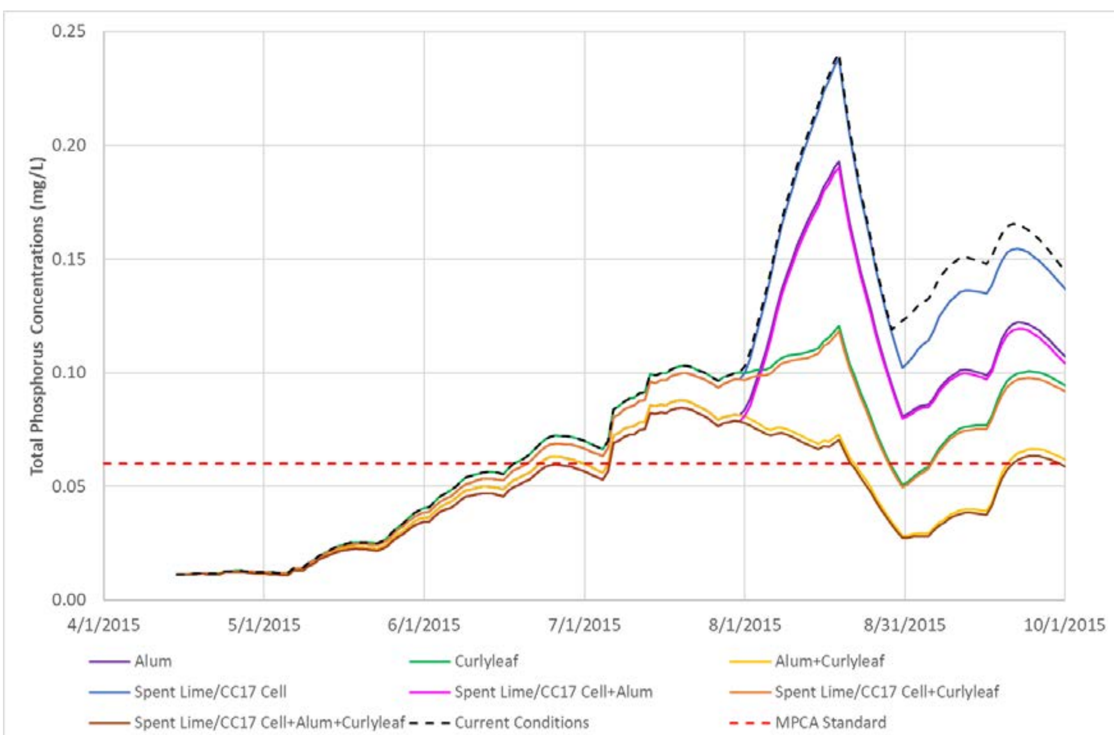


Figure F-13 **In-lake phosphorus concentrations in South Cornelia in 2015 under various combinations of internal management efforts and a spent lime/CC17 treatment cell**

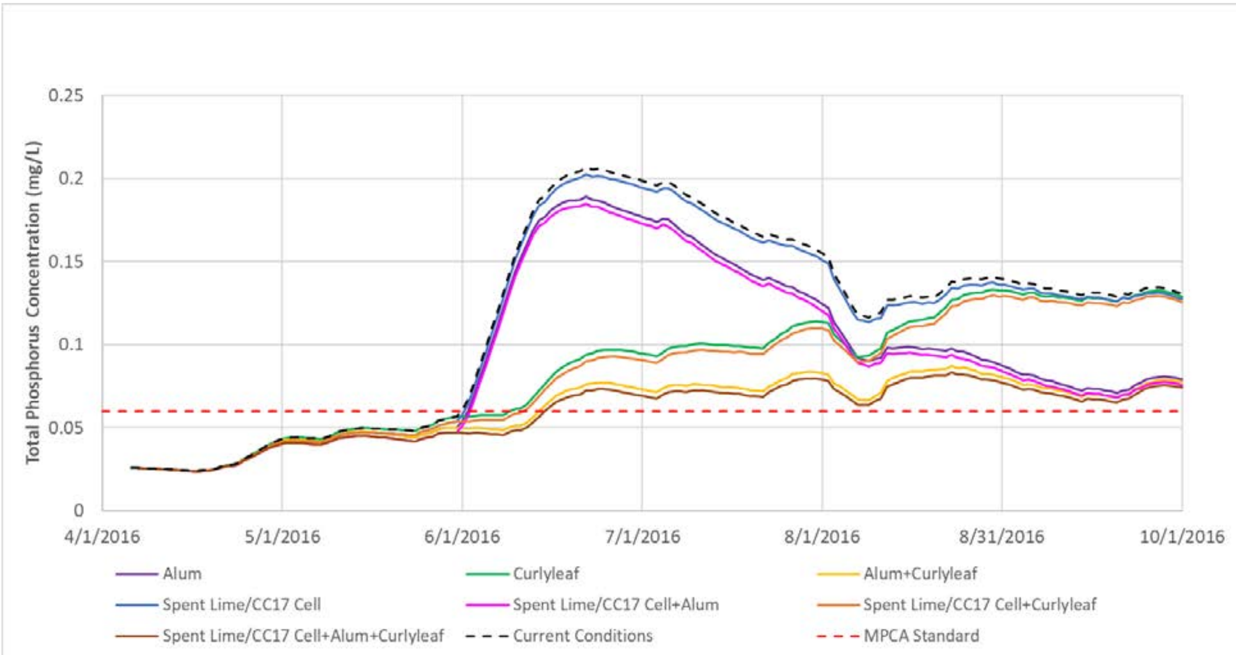


Figure F-14 **In-lake phosphorus concentrations in South Cornelia in 2016 under various combinations of internal management efforts and a spent lime/CC17 treatment cell**

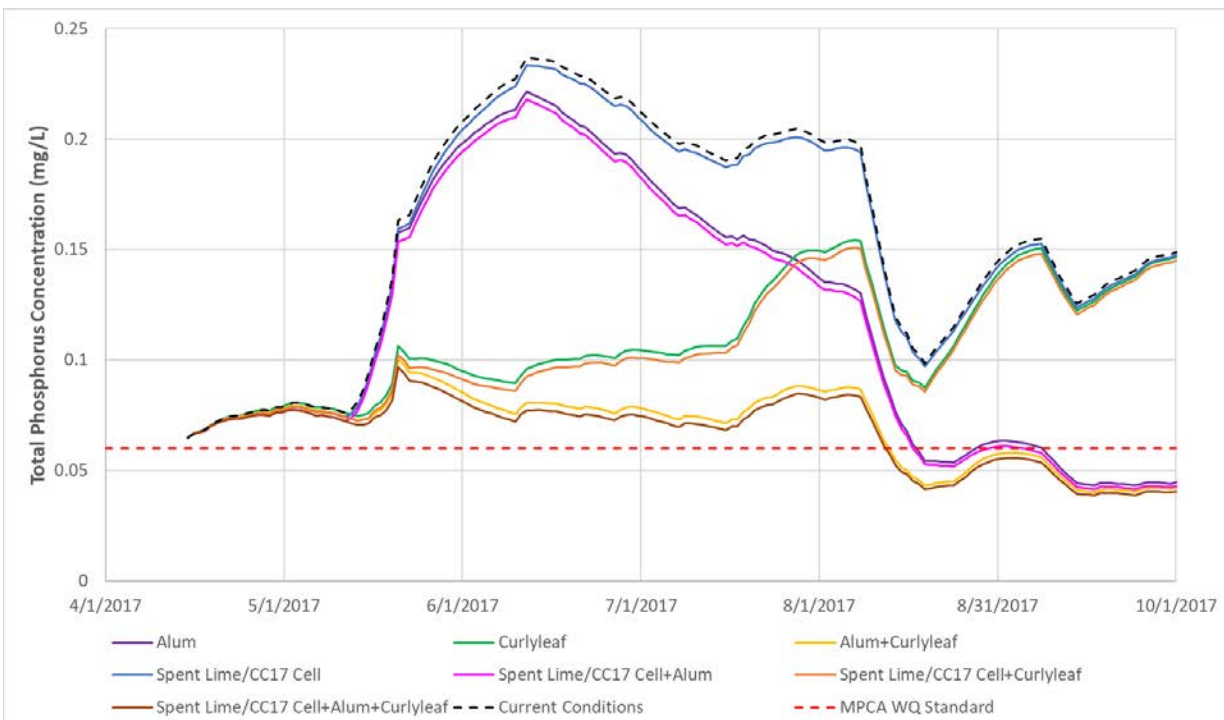


Figure F-15 **In-lake phosphorus concentrations in South Cornelia in 2017 under various combinations of internal management efforts and a spent lime/CC17 treatment cell**

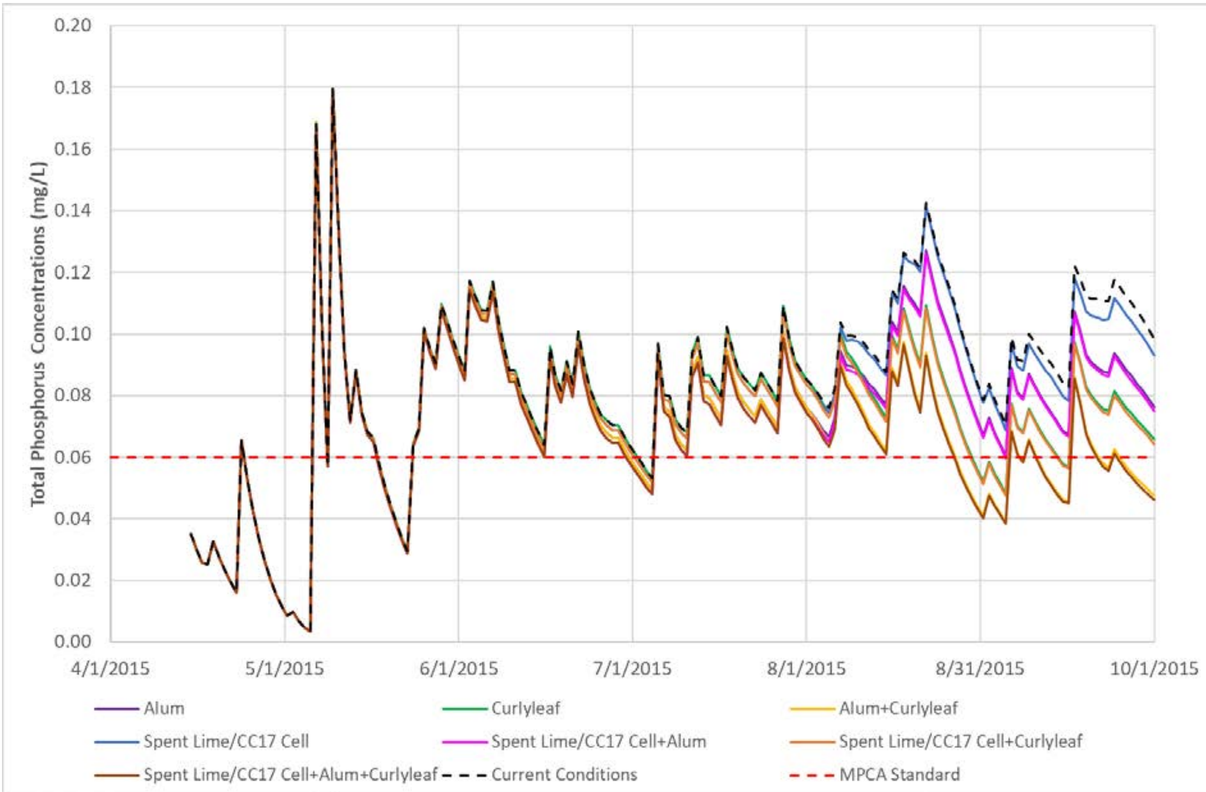


Figure F-16 In-lake phosphorus concentrations in Lake Edina in 2015 under various combinations of internal management efforts and a spent lime/CC17 treatment cell

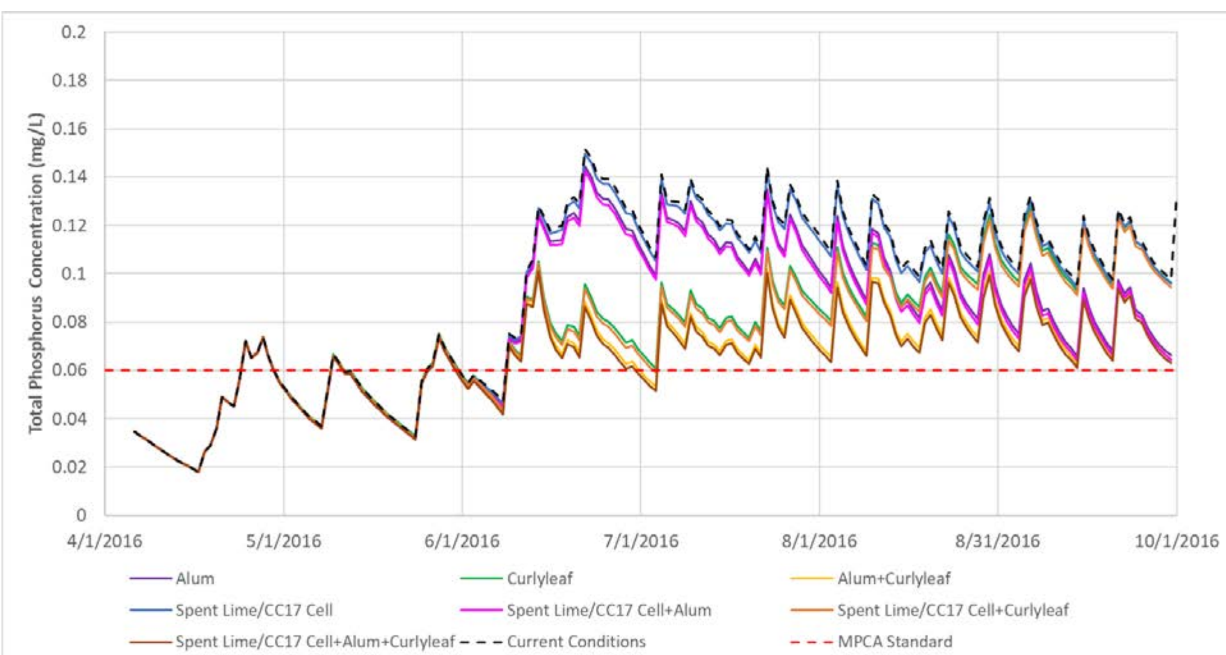


Figure F-17 In-lake phosphorus concentrations in Lake Edina in 2016 under various combinations of internal management efforts and a spent lime/CC17 treatment cell

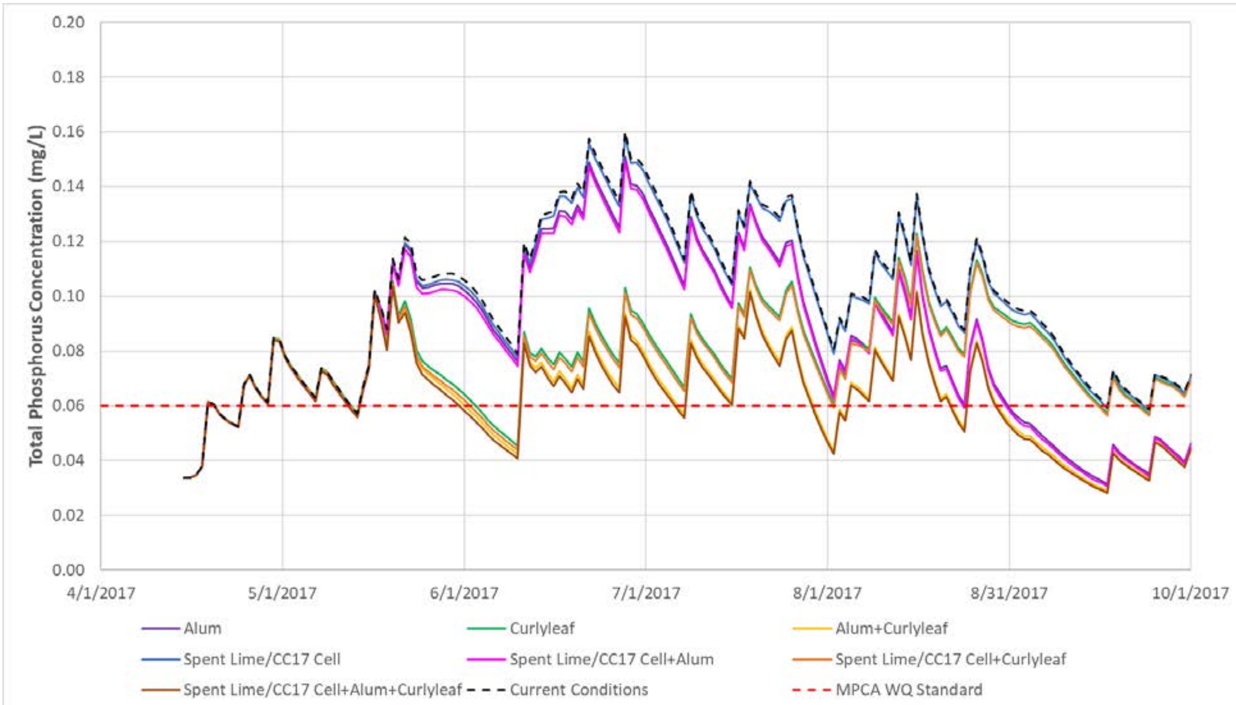


Figure F-18 In-lake phosphorus concentrations in Lake Edina in 2017 under various combinations of internal management efforts and a spent lime/CC17 treatment cell

Appendix G

Combined (Internal + External) Management Loading Bar Plots

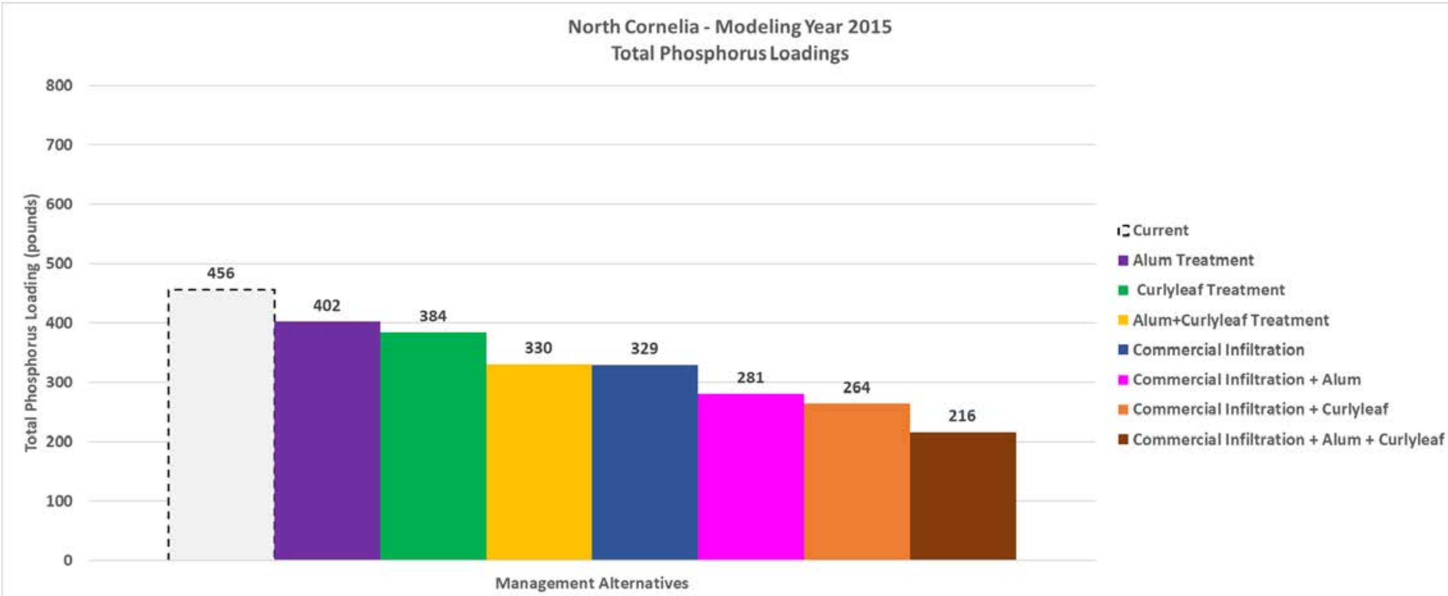


Figure G-1 **Remaining Total Phosphorus Load to North Cornelia in 2015 with various combinations of internal and external commercial infiltration management**

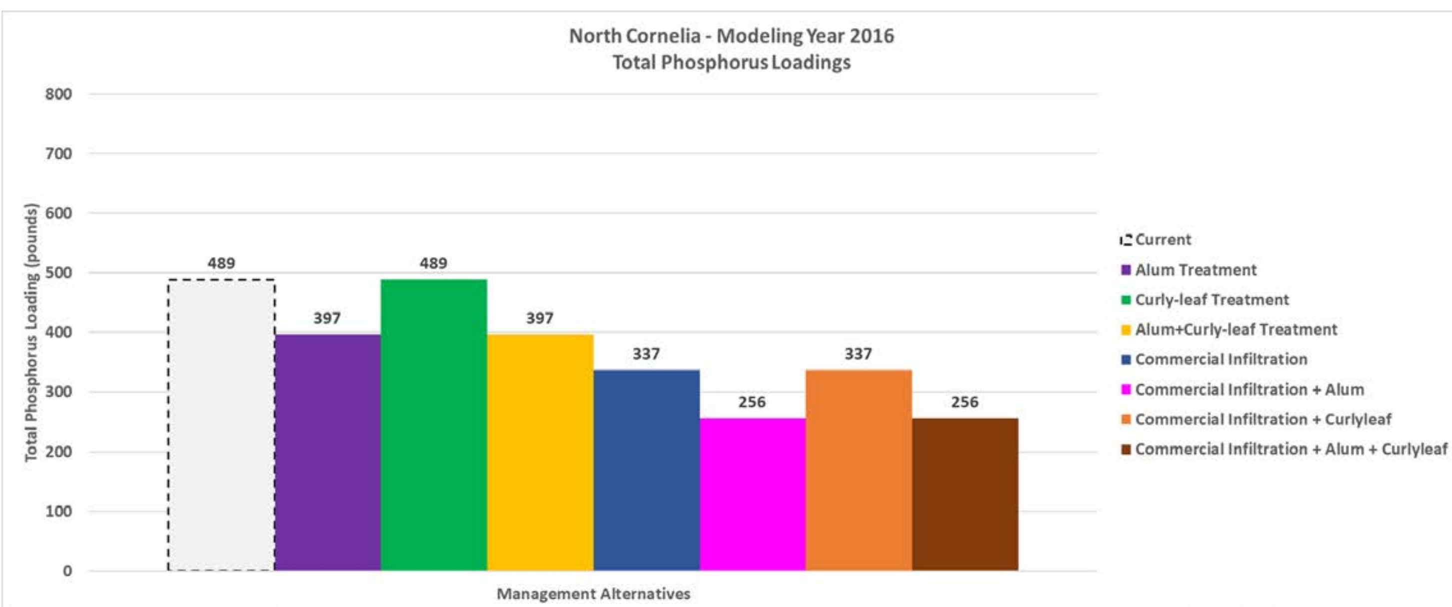


Figure G-2 **Remaining Total Phosphorus Load to North Cornelia in 2016 with various combinations of internal and external commercial infiltration management**

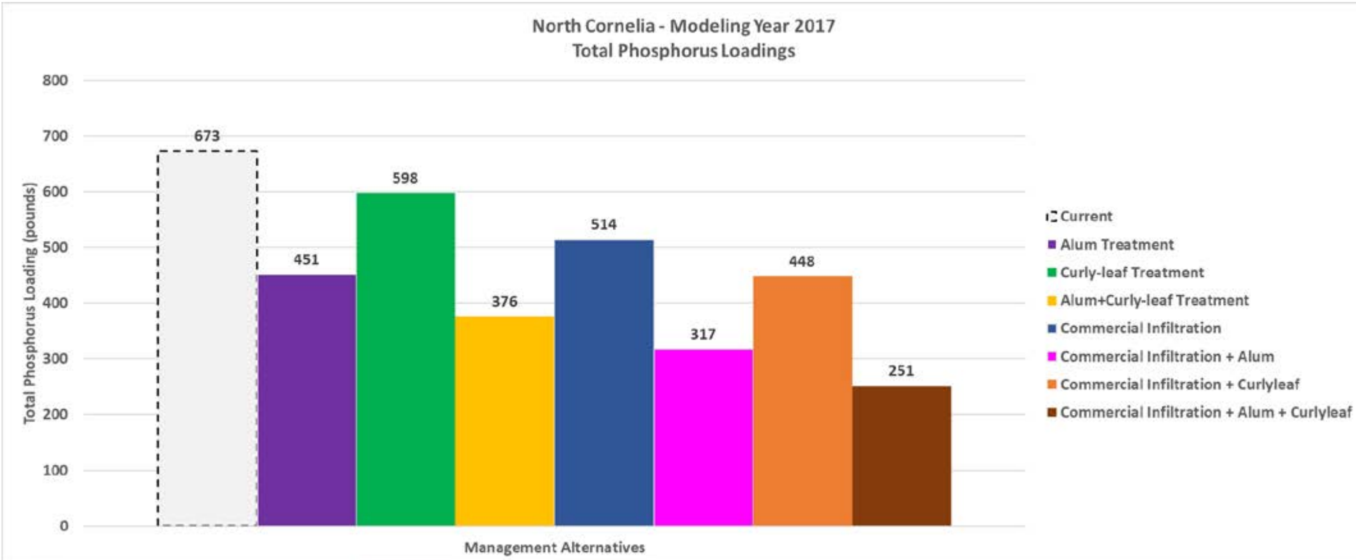


Figure G-3 **Remaining Total Phosphorus Load to North Cornelia in 2017 with various combinations of internal and external commercial infiltration management**

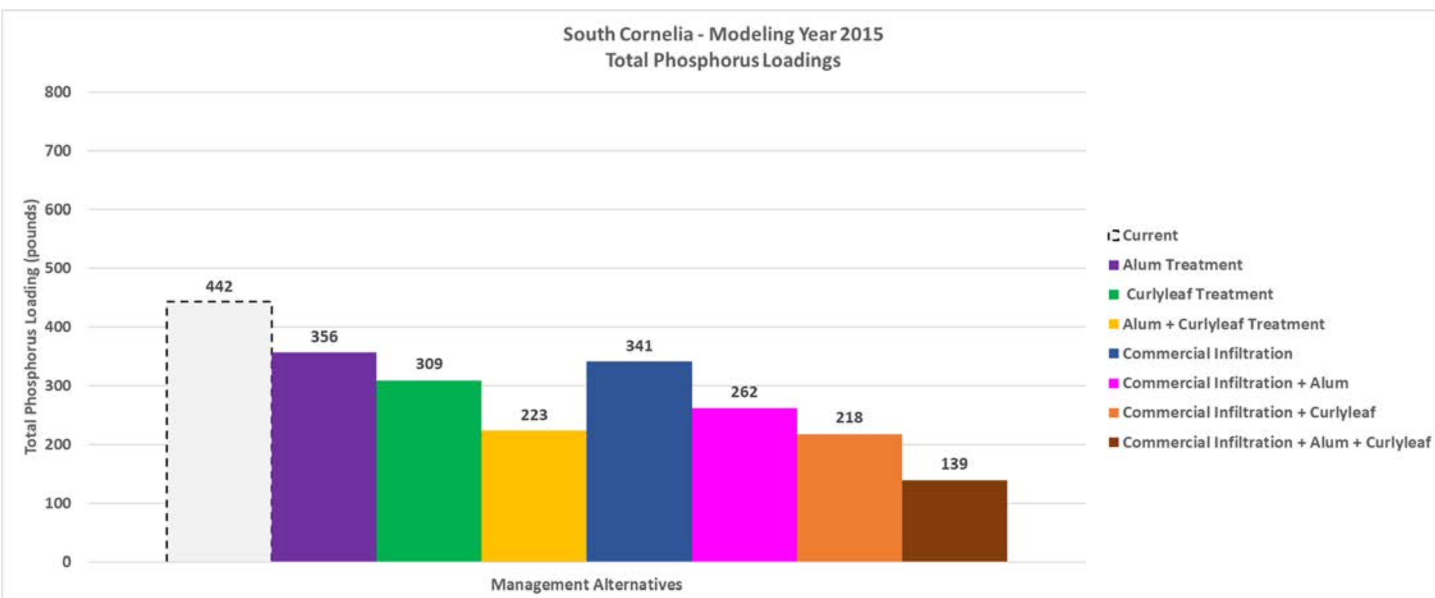


Figure G-4 **Remaining Total Phosphorus Load to South Cornelia in 2015 with various combinations of internal and external commercial infiltration management**

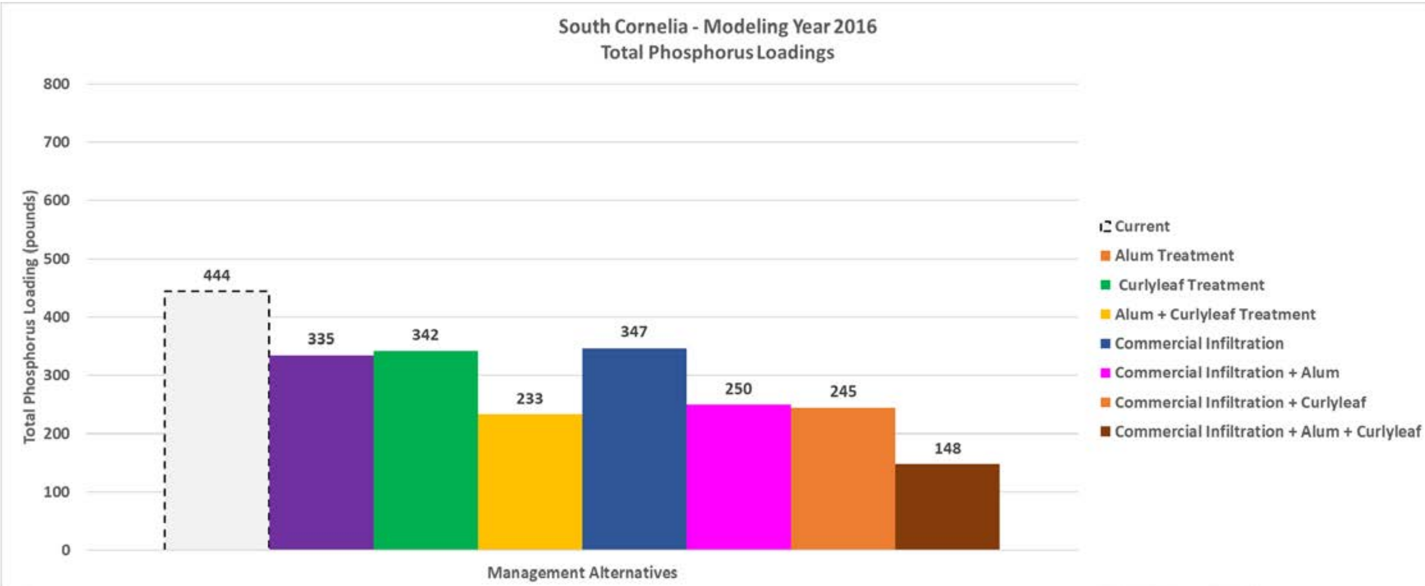


Figure G-5 **Remaining Total Phosphorus Load to South Cornelia in 2016 with various combinations of internal and external commercial infiltration management**

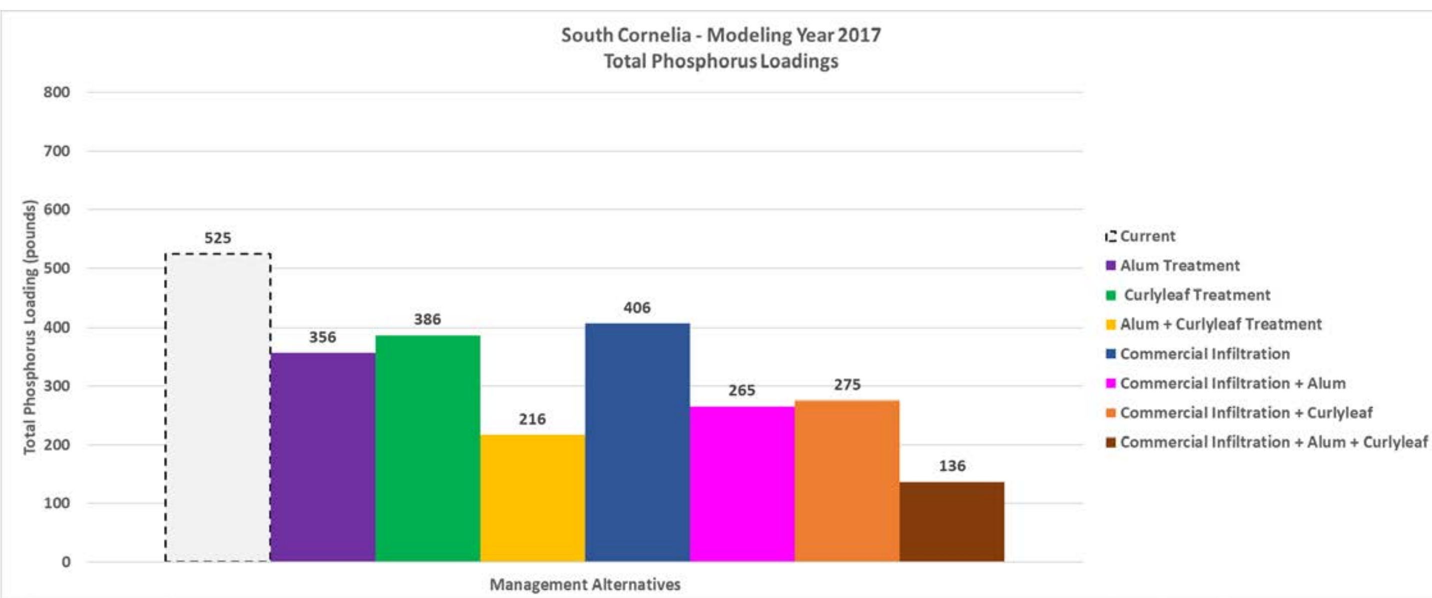


Figure G-6 **Remaining Total Phosphorus Load to South Cornelia in 2017 with various combinations of internal and external commercial infiltration management**

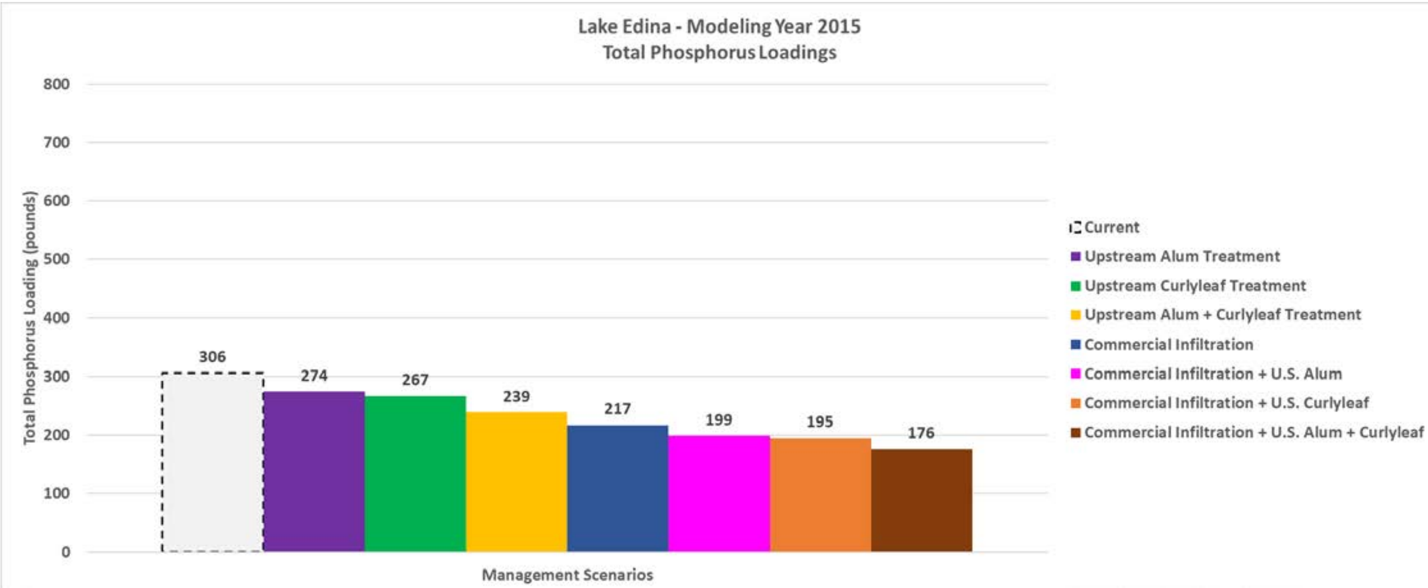


Figure G-7 Remaining Total Phosphorus Load to Lake Edina in 2015 with various combinations of internal and external commercial infiltration management

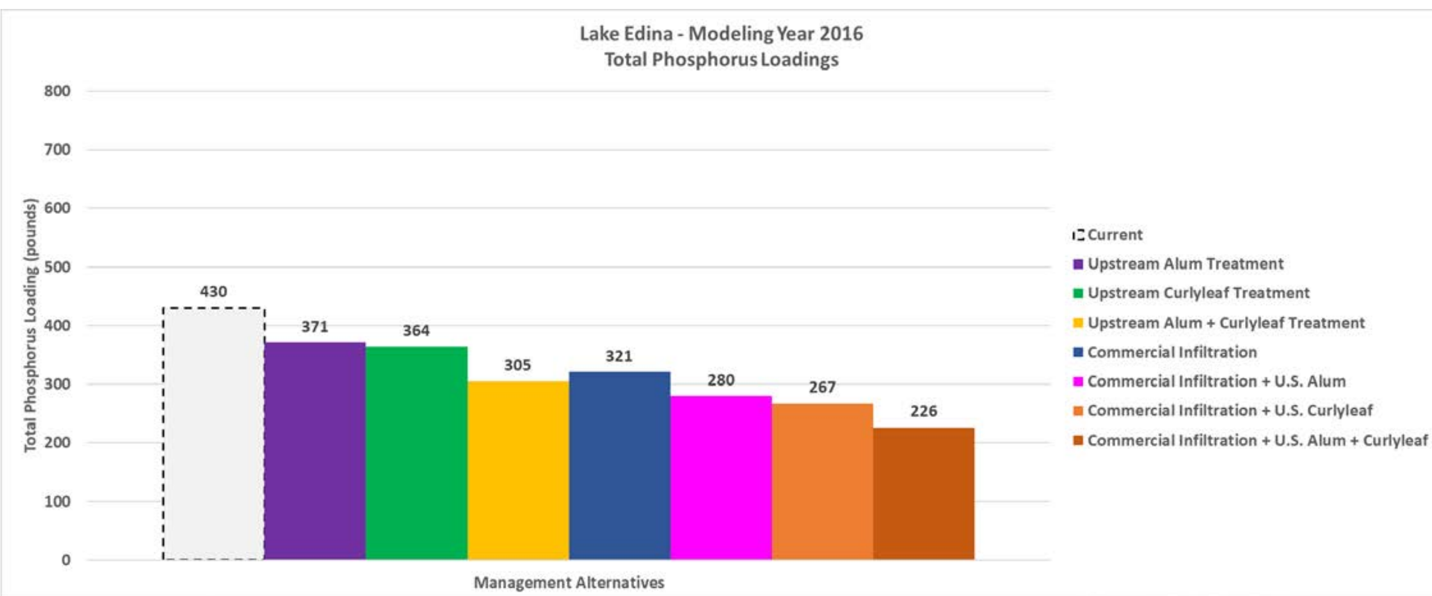


Figure G-8 Remaining Total Phosphorus Load to Lake Edina in 2016 with various combinations of internal and external commercial infiltration management

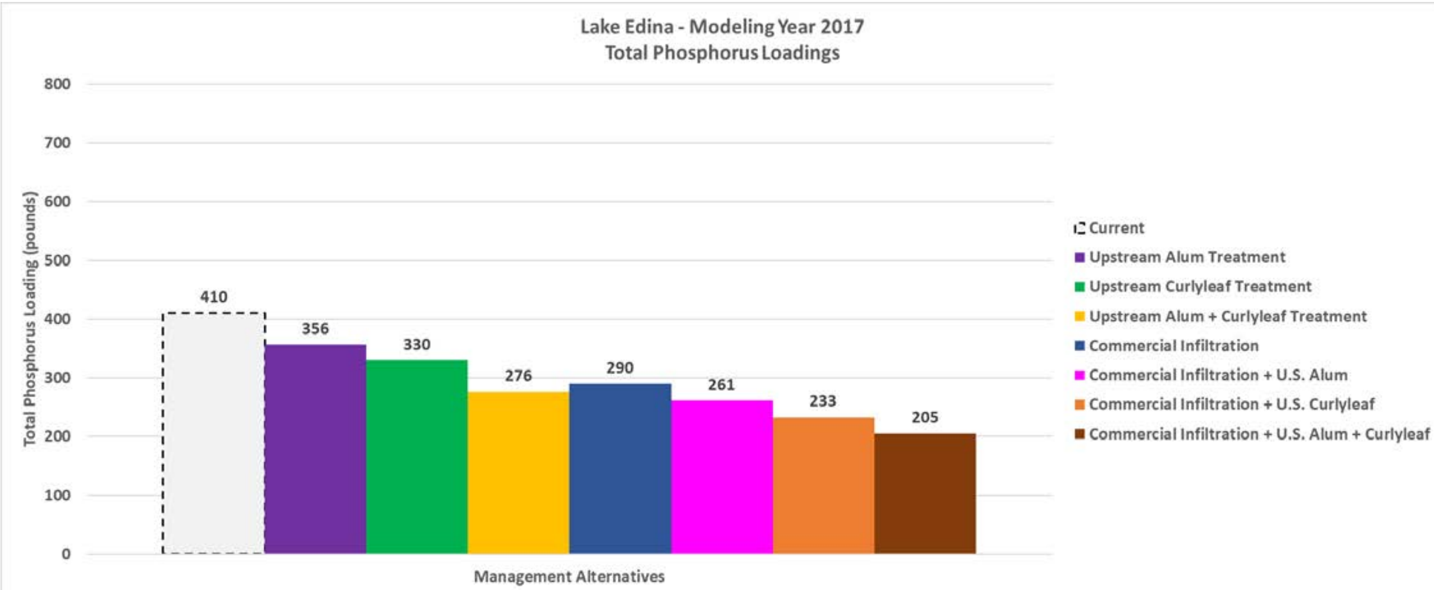


Figure G-9 Remaining Total Phosphorus Load to Lake Edina in 2017 with various combinations of internal and external commercial infiltration management

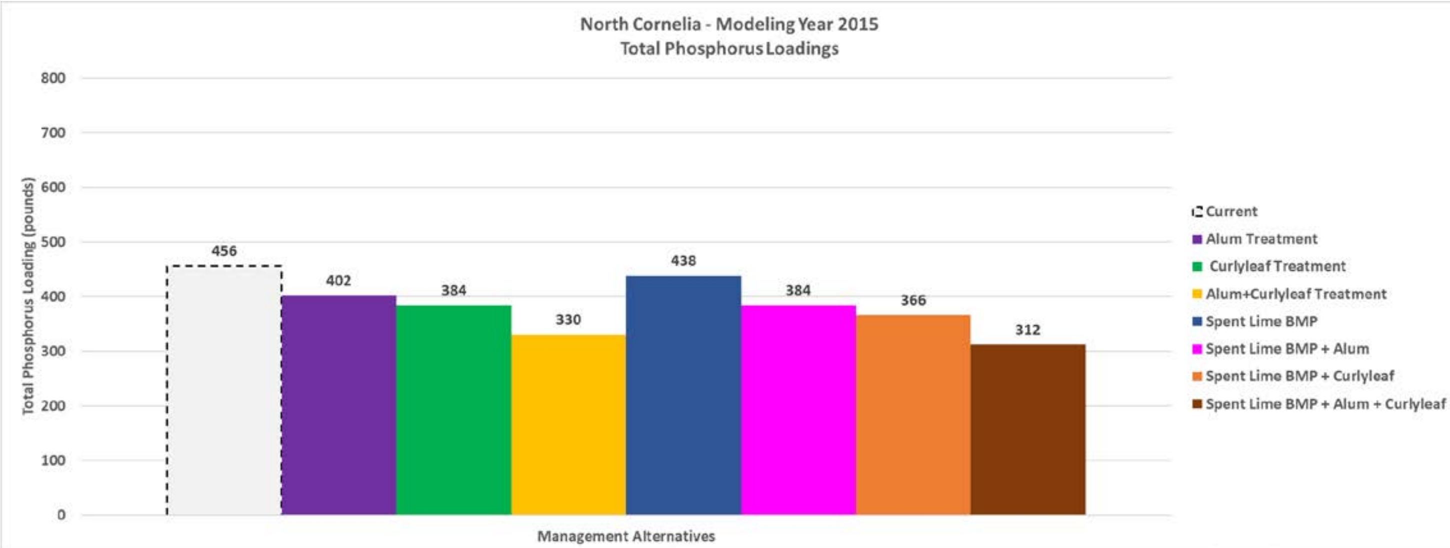


Figure G-10 **Remaining Total Phosphorus Load to North Cornelia in 2015 with various combinations of internal and external spent lime/CC17 management**

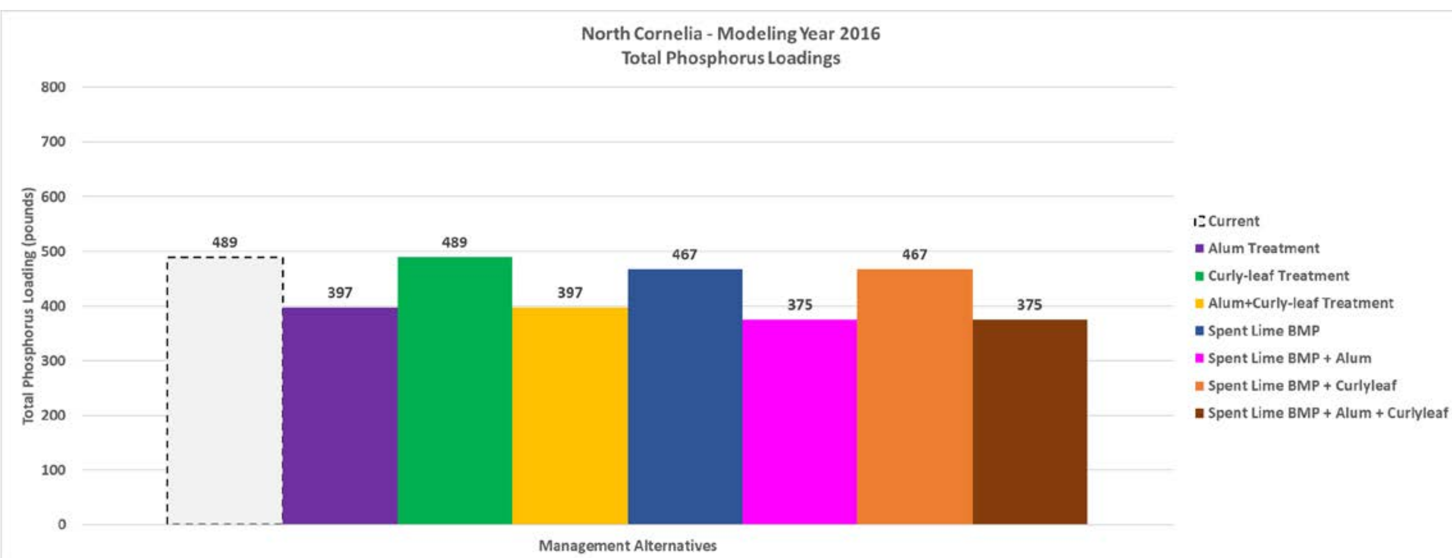


Figure G-11 **Remaining Total Phosphorus Load to North Cornelia in 2016 with various combinations of internal and external spent lime/CC17 management**

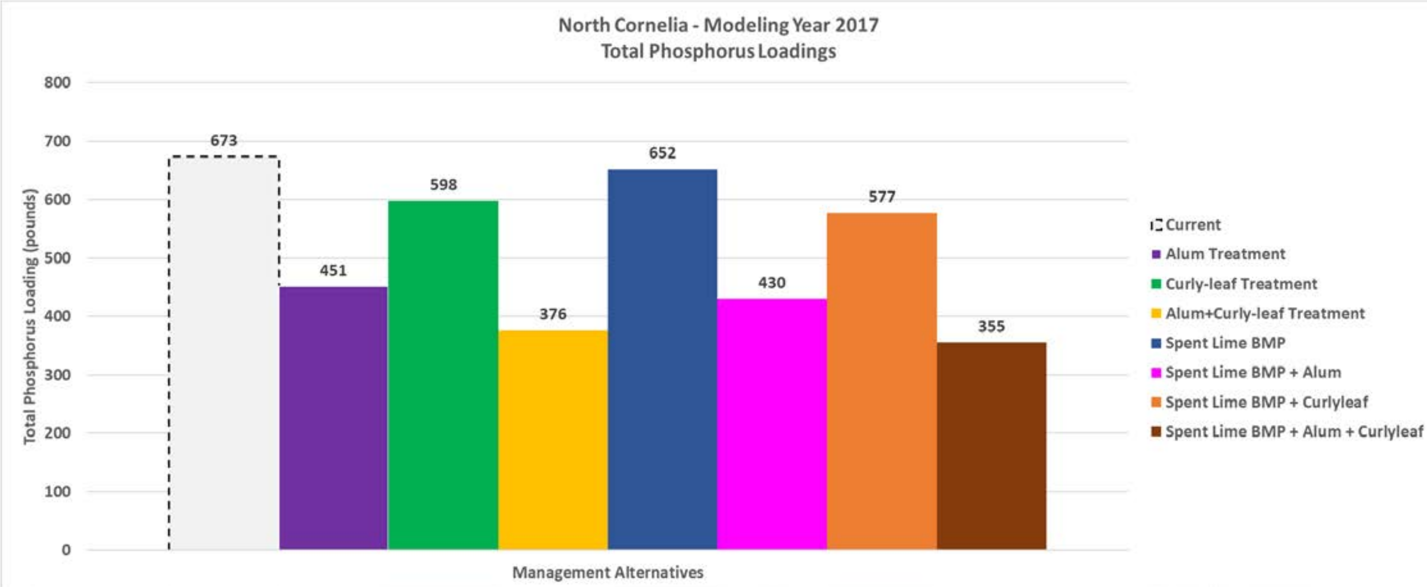


Figure G-12 Remaining Total Phosphorus Load to North Cornelia in 2017 with various combinations of internal and external spent lime/CC17 management

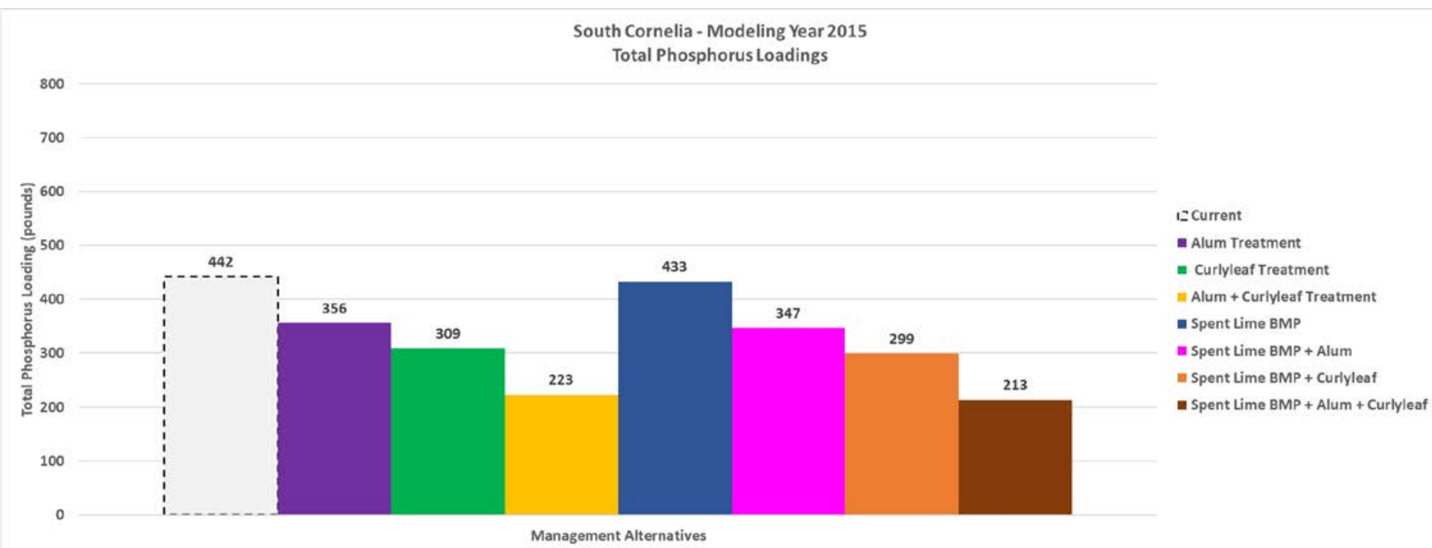


Figure G-13 Remaining Total Phosphorus Load to South Cornelia in 2015 with various combinations of internal and external spent lime/CC17 management

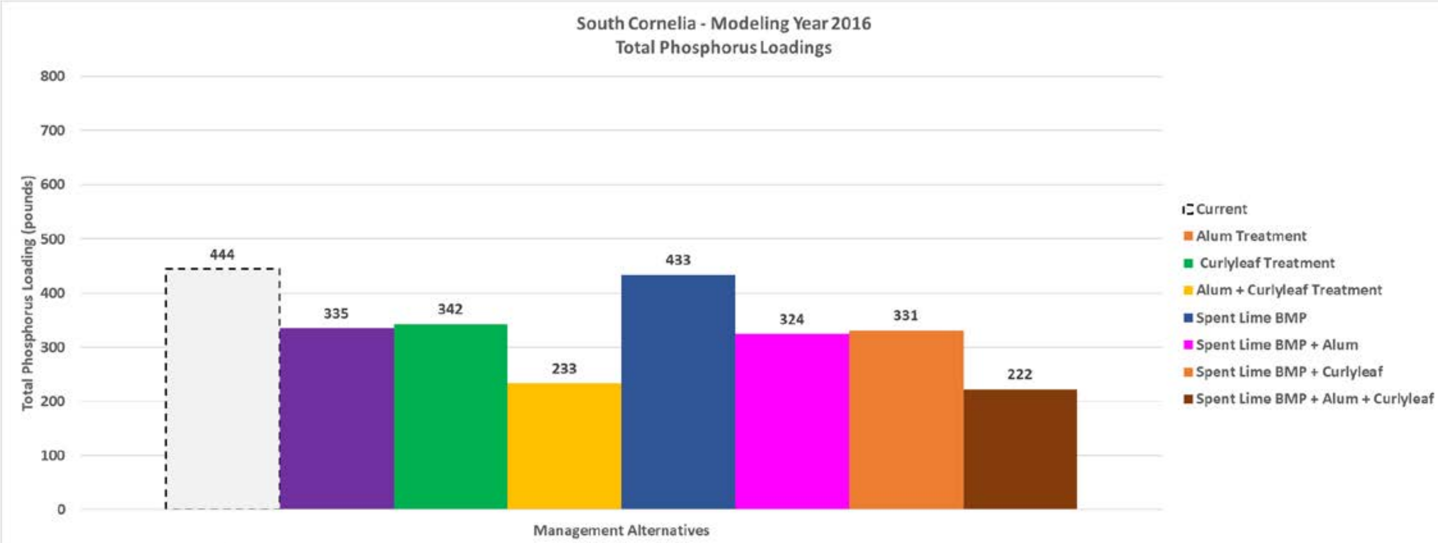


Figure G-14 **Remaining Total Phosphorus Load to South Cornelia in 2016 with various combinations of internal and external spent lime/CC17 management**

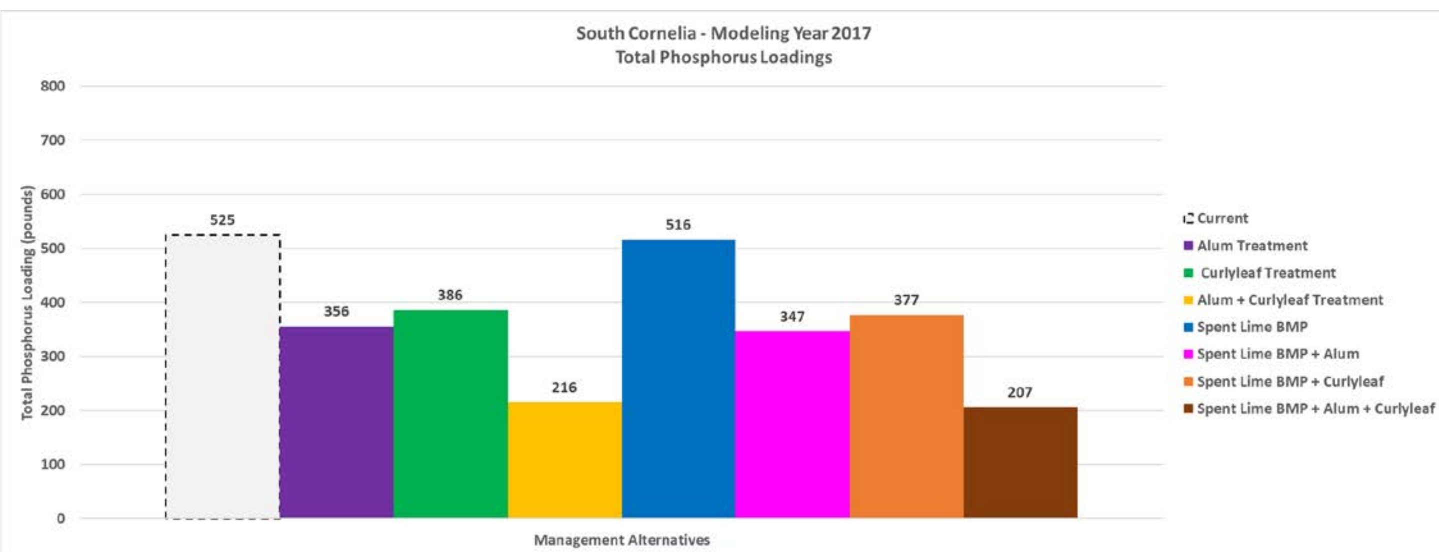


Figure G-15 **Remaining Total Phosphorus Load to South Cornelia in 2017 with various combinations of internal and external spent lime/CC17 management**

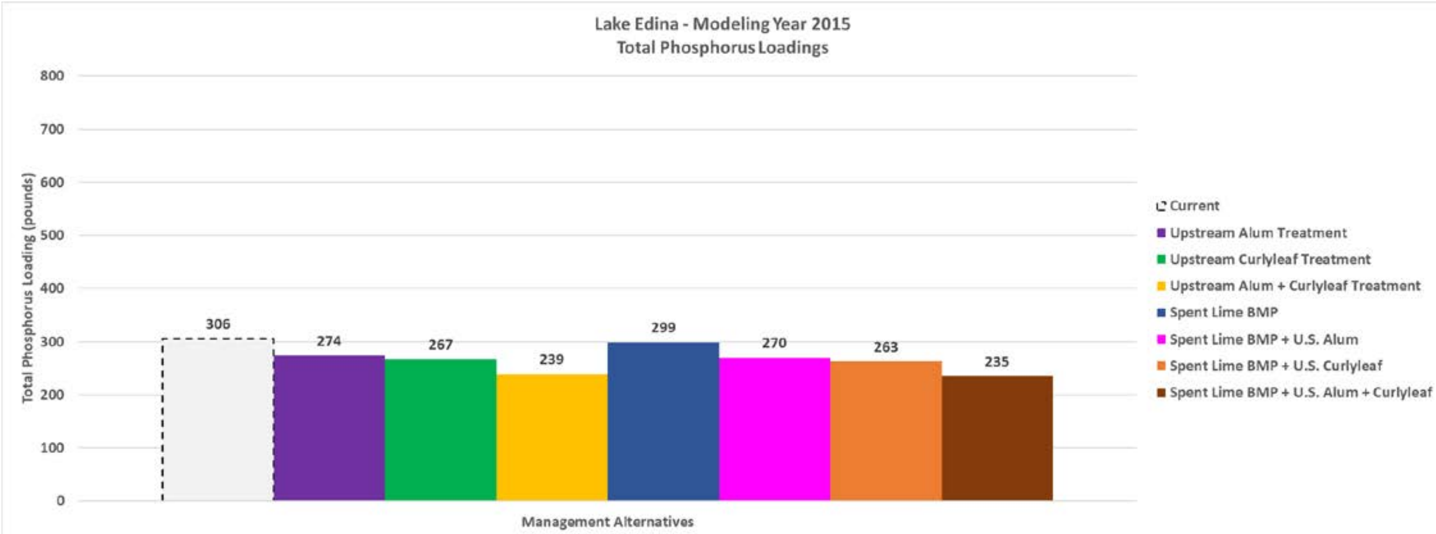


Figure G-16 Remaining Total Phosphorus Load to Lake Edina in 2015 with various combinations of internal and external spent lime/CC17 management

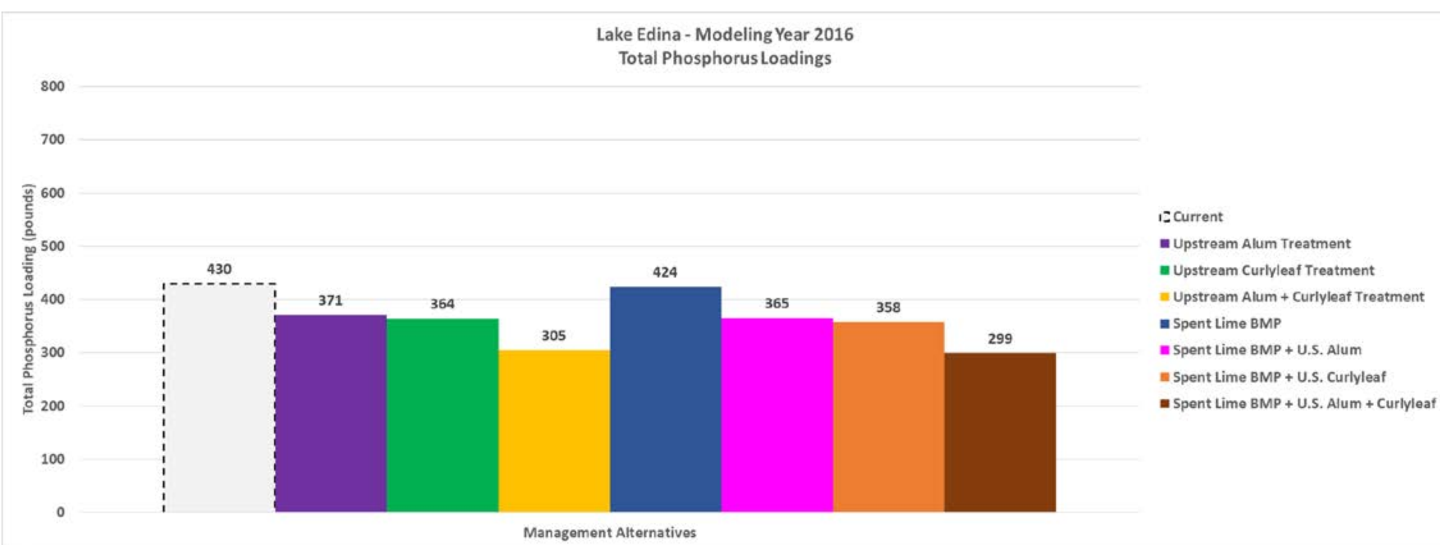


Figure G-17 Remaining Total Phosphorus Load to Lake Edina in 2016 with various combinations of internal and external spent lime/CC17 management

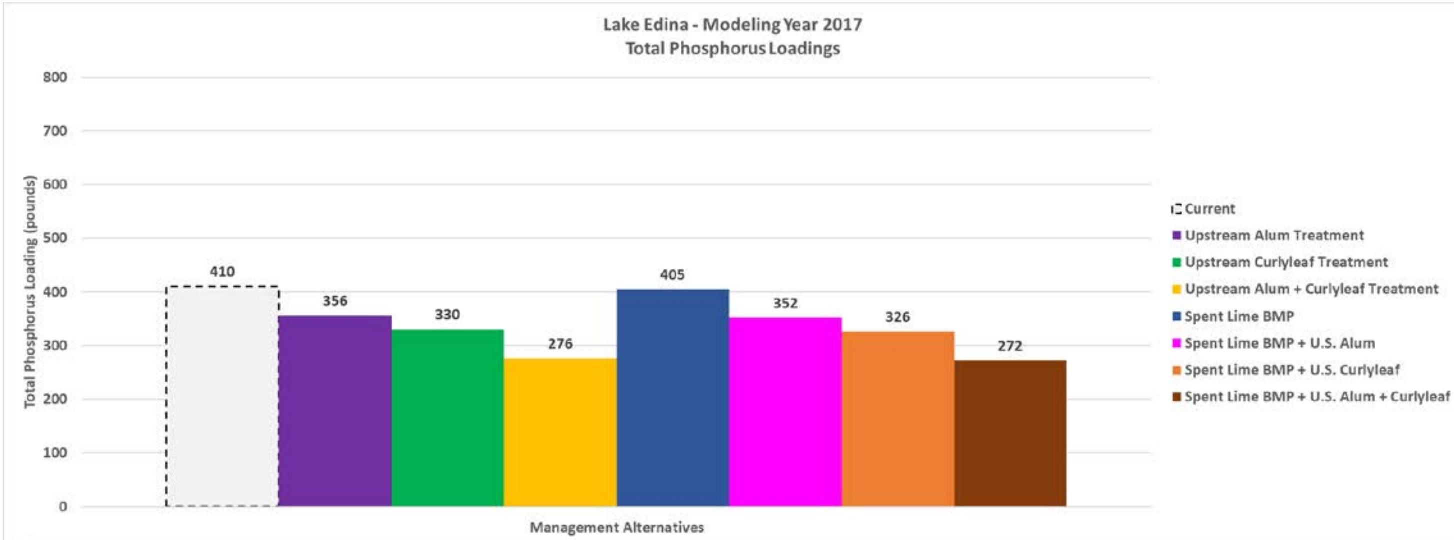


Figure G-18 Remaining Total Phosphorus Load to Lake Edina in 2017 with various combinations of internal and external spent lime/CC17 management

Appendix H

Opinions of Probable Costs

2019 UAA for Lake Cornelia and Lake Edina

ENGINEERS OPINION OF COST

ALUM SEDIMENT TREATMENT FOR LAKE CORNELIA				
ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	COST
MOBILIZATION/DEMOBILIZATION	LS	1	$ 15,000.00	$ 15,000.00
Alum + Sodium Aluminate	Gallon	45,669	$ 2.55	$ 116,358.00
			Subtotal =	$ 131,358.00
Bid and Contract Documents	LS	1	10,000.00	$ 10,000.00
pH Monitoring and Oversight	LS	1	5,000.00	$ 5,000.00
			Subtotal =	$ 146,358.00
			Contingency (10%)	$ 14,636.00
			Total =	$ 161,000.00
			-10%	$ 145,000.00
			+20%	$ 194,000.00

Assumptions

- Includes treatment of North and South Cornelia
- Dose equivalent to 29,238 gallons alum for North Cornelia and 16,431 gallons alum for South Cornelia
- Non-tax exempt unit rate for alum/sodium aluminate assuming 1:2 volume ratio
- Engineering assistance with bid administration and contract documents
- Two engineering staff members for 2 full days of observation of alum application and pH monitoring.
- Assuming Class 2 opinion of cost with accuracy range of -10% to +20% standards established by the Association for the Advancement of Cost Engineering (AACE).
- Estimated total cost is reported to the nearest thousand dollars

2019 UAA for Lake Cornelia and Lake Edina

ENGINEERS OPINION OF COST

COMMERCIAL FILTRATION BMPS (WATERSHED-WIDE)				
ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	COST
Subsurface Filtration BMPs	CF	625,432	$ 15.00	$ 9,381,480.00
Construction Contingency (30%)	EA	1	$ 2,814,444.00	$ 2,814,444.00
			Subtotal=	$ 12,195,924.00
Engineering and Design (30%)	EA	1	$ 3,658,780.00	$ 3,658,780.00
			Total =	$ 15,855,000.00
			-30%	$ 11,099,000.00
			+50%	$ 23,783,000.00

Assumptions
- Assume all filtration BMPs will be subsurface due to being located on commercial parcels.
- All commercial parcels located on soils with good infiltration capacity (HSG A and B soils) will have filtratior
- BMPs sized to capture 1.1" of runoff from impervious surfaces
- Assuming Class 5 opinion of cost with accuracy range of -30% to +50% standards established by the Association for the Advancement of Cost Engineering (AACE).
- Estimated total cost is reported to the nearest thousand dollars

2019 UAA for Lake Cornelia and Lake Edina

ENGINEERS OPINION OF COST

COMMERCIAL INFILTRATION BMPS (WATERSHED-WIDE)				
ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	COST
Subsurface Infiltration BMPs	CF	625,432	$ 15.00	$ 9,381,480.00
Construction Contingency (30%)	EA	1	$ 2,814,444.00	$ 2,814,444.00
			Subtotal=	$ 12,195,924.00
Engineering and Design (30%)	EA	1	$ 3,658,777.20	$ 3,658,777.20
			Total=	$ 15,855,000.00
			-30%	$ 11,099,000.00
			+50%	$ 23,783,000.00

<u>Assumptions</u>

- Assume all infiltration BMPs will be subsurface due to being located on commercial parcels.
- All commercial parcels located on soils with good infiltration capacity (HSG A and B soils) will have infiltratior
- BMPs sized to capture 1.1" of runoff from impervious surfaces
- Assuming Class 5 opinion of cost with accuracy range of -30% to +50% standards established by the Association for the Advancement of Cost Engineering (AACE).
- Estimated total cost is reported to the nearest thousand dollars

2019 UAA for Lake Cornelia and Lake Edina

ENGINEERS OPINION OF COST

DIRECT OXYGEN INJECTION SYSTEM FOR LAKE CORNELIA				
ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	COST
Aeration System and Materials	EA	2	$ 24,430.00	$ 48,860.00
Mobilization/Site Work	EA	1	$ 11,275.00	$ 11,275.00
Operations Support and Troubleshooting	EA	1	$ 4,900.00	$ 4,900.00
Electrical Install	EA	2	$ 10,000.00	$ 20,000.00
			Subtotal =	$ 85,035.00
			Construction Contingency (10%)	$ 8,510.00
			Subtotal =	$ 93,545.00
			Engineering and Design (30%)	$ 28,070.00
			Total =	$ 122,000.00
			-30%	$ 86,000.00
			+50%	$ 183,000.00

Direct Oxygen Injection System Design Assumptions

- Floating barge that can sustain frozen conditions
- Oxygen supply (qty 1 Topaz Ulta, 110VAC)
- Small air supply compressor
- One pair of 12" and 24" ADS rise and down tubes
- Housing, sound proofing, wiring, temperature control (fan, thermostat, heater), plumbing, mooring, and cable (8AWG3-1 submersible well cable)

Other Assumptions

- Sediment oxygen demand of 1.2 g m^{-2} d^{-1} and applying to 4 ft ad 6 ft contours in North and South respectively (50 kg O_2 consumed/d), and a minimum of 1.0 SCFM O_2 to each lake.
- Assuming Class 5 opinion of cost with accuracy range of -30% to +50% standards established by the Association for the Advancement of Cost Engineering (AACE).
- Estimated total cost is reported to the nearest thousand dollars

2019 UAA for Lake Cornelia and Lake Edina

ENGINEERS OPINION OF COST

CURLY-LEAF PONDWEED TREATMENT OF LAKE CORNELIA				
ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	COST
Macrophyte Surveys and Analyses	LS	2	$ 1,000.00	$ 2,000.00
Endothall Treatment	Gallons	114	$ 74.91	$ 8,539.60
			Subtotal =	$ 10,539.60
			Contingency (10%)	$ 1,054.00
			Total =	$ 12,000.00
			-10%	$ 11,000.00
			+20%	$ 15,000.00

<u>Assumptions</u>

-Includes treatment of North and South Cornelia

- Includes one pre-treatment and post-treatment plant survey

-Assumes the City of Edina conducts all coordination, including monitoring and reporting that may be required as part of permitting (e.g., temperature monitoring, herbicide residual monitoring, post-treatment aquatic plant surveys in August, water quality monitoring).

-Dose of 5 ppm active ingredient for 7.4 acres

-Total gallons applied is 114 gallons of Aquathol K (Endothall treatment)

- Class 2 opinion of cost with accuracy range of -10% to +20%

- Estimated total cost is reported to the nearest thousand dollars

PREPARED BY: BARR ENGINEERING COMPANY		SHEET:	1	OF	2
		BY:	KJN2	DATE:	2/15/2019
		CHECKED BY:	KMP	DATE:	3/13/2019
ENGINEER'S OPINION OF PROBABLE PROJECT COST		APPROVED BY:	JMK2	DATE:	5/7/2019
PROJECT:	2019 Lake Cornelia and Lake Edina UAA	ISSUED:		DATE:	
LOCATION:	Nine Mile Creek Watershed District	ISSUED:		DATE:	
PROJECT #:	23/27-0634.00	ISSUED:		DATE:	
OPINION OF COST - SUMMARY		ISSUED:		DATE:	

Engineer's Opinion of Probable Project Cost
Spent Lime/CC17 Treatment Chamber
Conceptual Design

Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST	NOTES
A	Mobilization/Demobilization (10%)	LS	1	$31,690.00	$31,690.00	1,2,3,4,5,6
B	Traffic Control	LS	1	$10,000.00	$10,000.00	1,2,3,4,5,6
C	Stabilized Rock Construction Entrance/Exit	Each	1	$2,500.00	$2,500.00	1,2,3,4,5,6
D	Inlet Protection	Each	4	$250.00	$1,000.00	1,2,3,4,5,6
E	Orange Construction Fencing	LF	450	$4.00	$1,800.00	1,2,3,4,5,6
F	Flotation Silt Curtain (Swimming Pool Pond, North Cornelia)	LF	200	$15.00	$3,000.00	1,2,3,4,5,6
G	Silt Fence	LF	200	$4.00	$800.00	1,2,3,4,5,6
H	Erosion Control Blanket	SY	233	$4.00	$933.33	1,2,3,4,5,6
I	Hydromulch	SY	233	$2.00	$466.67	1,2,3,4,5,6
J	Street Sweeping	HR	20	$175.00	$3,500.00	1,2,3,4,5,6
K	Utility Relocation	LS	1	$5,000.00	$5,000.00	1,2,3,4,5,6
L	Bituminous Pavement Removal (Parking Lot & Trail)	SY	656	$4.00	$2,622.22	1,2,3,4,5,6
M	Sawcut Bituminous Pavement (Full Depth)	LF	640	$3.00	$1,920.00	1,2,3,4,5,6
N	Clearing and Grubbing	AC	0.1	$50,000.00	$5,000.00	1,2,3,4,5,6
O	Remove and Salvage Topsoil	SY	233	$5.00	$1,166.67	1,2,3,4,5,6
P	Excavation & Disposal (for Spent Lime Structure)	CY	833	$15.00	$12,500.00	1,2,3,4,5,6
Q	Backfill and Compaction (for Spent Lime Structure)	CY	540	$10.00	$5,396.30	1,2,3,4,5,6
R	Grading	SY	233	$4.00	$933.33	1,2,3,4,5,6
S	Bituminous Pavement Installation (Parking Lot & Trail)	SY	479	$30.00	$14,380.00	1,2,3,4,5,6
T	Wetland Restoration	AC	0.1	$10,000.00	$1,000.00	1,2,3,4,5,6
U	Upland Native Restoration	AC	0.1	$3,000.00	$300.00	1,2,3,4,5,6
V	Turf Re-Establishment (Restoration)	AC	0.1	$2,000.00	$200.00	1,2,3,4,5,6
W	48" weir manhole (Swimming Pool Pond Control Mod.)	Each	1	$1,320.00	$1,320.00	1,2,3,4,5,6
X	72" pre-cast manhole with Casting	Each	2	$1,500.00	$3,000.00	1,2,3,4,5,6
Y	Manhole Filter	Each	1	$3,000.00	$3,000.00	1,2,3,4,5,6
Z	6" CPEP 90 Degree Elbow	Each	16	$25.00	$400.00	1,2,3,4,5,6,7
AA	6" CPEP Slotted Draintile (Smooth Interior)	LF	240	$10.00	$2,400.00	1,2,3,4,5,6,7
BB	6" CPEP Dual-Wall (Smooth Interior)	LF	240	$10.00	$2,400.00	1,2,3,4,5,6,7
CC	6" CPEP Cleanout Cap	Each	8	$10.00	$80.00	1,2,3,4,5,6,7
DD	15" RCP (Furnish and Install - wet meadow)	LF	300	$45.00	$13,500.00	1,2,3,4,5,6,7
EE	15" FES	Each	3	$550.00	$1,650.00	1,2,3,4,5,6,7
FF	15" FES Trach Rack	Each	2	$550.00	$1,100.00	1,2,3,4,5,6,7
GG	MnDOT Class III RipRap with Filter Fabric	TON	30	$80.00	$2,400.00	1,2,3,4,5,6
HH	Granular Filter Aggregate	TON	3	$56.00	$168.00	1,2,3,4,5,6
II	Remove Existing Storm Sewer	LF	16	$18.00	$288.00	1,2,3,4,5,6
JJ	Modify Existing Storm Sewer (Manhole Tie-In)	Each	1	$8,000.00	$8,000.00	1,2,3,4,5,6
KK	Spent Lime Material	CY	111	$26.00	$2,888.89	1,2,3,4,5,6
LL	CC17 Material	CY	111	$30.00	$3,333.33	1,2,3,4,5,6
MM	Spent Lime Grate	SY	312	$100.00	$31,177.78	1,2,3,4,5,6
NN	Reinforced Concrete - Slab	SY	312	$250.00	$77,944.44	1,2,3,4,5,6
OO	Reinforced Concrete - Wall	SY	203	$400.00	$81,333.33	1,2,3,4,5,6
PP	Steel Grating Support Beams	LB	1,000	$6.00	$6,000.00	1,2,3,4,5,6
	CONSTRUCTION SUBTOTAL				$348,000.00	
	CONSTRUCTION CONTINGENCY (30%)				$104,000.00	
	ENGINEERING AND DESIGN (30%)				$136,000.00	
	ESTIMATED TOTAL CONSTRUCTION COST				$588,000.00	1,2,3,4,5,6,7,8
	ESTIMATED ACCURACY RANGE	**-30%**			**$412,000.00**	5,8
		50%			**$882,000.00**	5,8

Notes

[1] Limited design work completed (conceptual level)

[2] Quantities Based on Design Work Completed.

[3] Unit Prices Based on Information Available at This Time.

[4] Minimal Soil and Field Investigations Completed.

	[5] This Design Level (Class 5, 0 - 2% design completion per ASTM E 2516-116) cost estimate is based on screening/conceptual discussion. Costs will change with further design. Time value-of-money escalation costs are not included. A construction schedule is not available at this time. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of the completion of design, but are not included at this level of project definition. The estimated accuracy range for the Total Project Construction Cost as the project is defined is -30% to +50%. The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. The contingency and the accuracy range are not intended to include costs for future scope changes that are not part of the project as currently scoped or costs for risk contingency. Operation and maintenance costs are not included.
	[6] Estimated costs are for construction and do not include maintenance, monitoring, or additional tasks following construction.
	[7] Furnish and Install pipe cost per linear foot includes all trenching, bedding, backfilling, compaction, and disposal of excess materials
	[8] Estimated costs are reported to nearest thousand dollars.

2019 UAA for Lake Cornelia and Lake Edina

ENGINEERS OPINION OF COST

WEEKLY STREET AND PARKING LOT SWEEPING (WATERSHED-WIDE)				
ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	COST
Crosswind 4 Wheel Regenerative Air Sweeper	EA	3	$ 210,000.00	$ 630,000.00
Annual Vehicle Maintenance	EA	4	$ 4,800.00	$ 19,200.00
Annual Labor (for four sweepers)	HRS	4070	$ 75.00	$ 305,250.00
Annual Fuel (for four sweepers)	GAL	2,660	$ 3.00	$ 7,980.00
			Subtotal =	$ 963,000.00
			Contingency (10%)	$ 96,300.00
			Total	$ 1,060,000.00
			-30%	$ 742,000.00
			+50%	$ 1,590,000.00

Assumptions
- Sweepable public street curb miles = 67.3 miles
- Sweepable parking lots = 80.4 miles
- Sweeper operation speed = 4.5 mph
- 1.5 hours of labor needed for every 4 hours of sweeping time
- Total transit (brush off) are about 3 times total swept miles
- Average fuel consumption is 5 mpg
- Sufficient staffing
- Sweeping occurs on a weekly basis May through November (~30 weeks)
- Maximum number of hours worked in one week by one worker = 40 hours
- Assuming Class 5 opinion of cost with accuracy range of -30% to +50% standards established by the Association for the Advancement of Cost Engineering (AACE).
- Estimated total cost is reported to the nearest thousand dollars

Lake Edina Eurasian Watermilfoil and Curly-lear Pondweed Management Cost Estimate*

Item Description	Unit Cost	Cost Per Year
Prepare Bids/Specs (1)	$5,000	$5,000
Treatment design (5 years)	$2,000	$2,000
MnDNR Permitting (5 years)	$1,000	$1,000
Temperature Measurements (5 years)	$3,000	$3,000
Aquatic Plant Monitoring (5 years)	$3,400	$3,400
Herbicide Residue Monitoring (5 years)	$2,300	$2,300
Data Processing/Reporting to Mn DNR (5 years)	$4,200	$4,200
Herbicide Application	$1,000 to $4,000	$1,000 to $4,000
Mobilization	$3,000	$3,000
Subtotal		$24,900 to $27,900
Contingency (10%)		$2,490 to $2,790
Total		**$27,930 to $30,690**

*Assumes post-treatment water quality monitoring is not required by MnDNR as a permit condition.

Assumptions:

Assume plans and specs similar to Normandale Lake Endothall treatment project are prepared for Lake Edina. Since Edina is a small lake and the treatment will be less than 15% of littoral area, less complicated plans and specs may suffice. Janna will decide the specifics required for Lake Edina Plans and Specs.

Assume temperature measurements will be required. Temperature measurements would not be required for a small scale ProcellaCOR treatment.

Assume 3 plant surveys per year - pre-treatment, June, and August. Assume plant surveys are subcontracted to Endangered Resource Services, LLC. Assume $500 of Barr costs for contracting, coordination, and data QA.

Assume herbicide residue monitoring required. Herbicide residue monitoring will not be required for ProcellaCOR or diquat. Hence this cost will not occur if ProcellaCOR or diquat are used for the treatment.

Assume water quality monitoring is not required. MnDNR may or may not require water quality monitoring. Likely not required if either ProcellaCOR or diquat are used. May not be required for 2,4-D or endothall when 15% of littoral area or less are treated.

Assume data reporting to MnDNR is required. MnDNR may not require reporting of data for treatments of 15% or less. If 2,4-D or endothall are used, we would ask to apply a dose that would attain a lake wide lethal effect. The MnDNR likely would require reporting for these treatments, but may not require reporting for diquat treatment.