Prepared by: EOR

For the Comfort Lake Forest Lake Watershed District

Little Comfort Phosphorus Source Assessment

12.12.2018

EOR water ecology community

Cover Image

Bone-Birch-School-Little Comfort Tributary downstream of Manning Avenue [Mike Majeski, September 2015]

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. PHOSPHORUS ASSESSMENT STUDIES

Sequential monitoring on the Bone-Birch-School-Little Comfort Tributary (BBSLC Trib) is important for understanding flow and water quality dynamics within the system, as well as identifying potential phosphorus "hotspots" and sinks (areas where pollutants are deposited and stored). Hotspots are areas within the watershed that are predicted to contribute a disproportionally large amount of phosphorus or sediment relative to their size. In addition, this system is characterized by a low gradient, network of wetland complexes that may or may not be currently acting as phosphorus sinks. The identified hotspots, therefore, become the most cost-effective management targets for improvement of stream and downstream lake water quality. Sequential monitoring at several sites along the tributary facilitates identification of individual hotspots with relatively high level of spatial certainty.

The Little Comfort Phosphorus Source Assessment was a multi-year, adaptive assessment process. Several studies have been completed over the last 10 years that were used to inform the management alternatives recommendations in this report. In 2010, there was a Load Assessment Study based on stream monitoring data from 2008 and 2009 to refine the project recommendations included in the 2007 District-wide Capital Improvement Program report. In 2015, field reconnaissance completed as part of a near-stream bacteria source and biological monitoring study was used to identify additional tributary sites that were monitored in 2016 to further refine phosphorus sources throughout the Little Comfort Lake drainage area. In 2016, monitoring focused on the main Bone-Birch-School-Little Comfort tributary. In 2017, monitoring moved upstream in the July Avenue tributary to investigate the source of the high phosphorus load observed at July Avenue in 2016. In 2018, monitoring was focused on the Heath Avenue pipe outlet and the Bone-Birch-School-Little Comfort tributary to determine the relative contribution of phosphorus loads to Little Comfort Lake from its two major inlets.

A summary of each monitoring study is provided below, with Management Alternatives discussed in Section 2 of this report.

1.1. 2010 Tributary Load Assessment

1.1.1. Monitoring Locations

Phosphorus load monitoring since 2004 and the District-wide Capital Improvement Program (CIP) study identified increased phosphorus loading between the outlet of Bone Lake to the inlet of Little Comfort Lake. The CIP study recommended the need for further study to determine the prioritization and siting of projects in this watershed. In 2008 and 2009, three tributary sites between Bone Lake Outlet and Little Comfort Lake inlet (July Avenue, Manning Trail, and Itasca Avenue), as well as three lakes (Bone, School, and Little Comfort), were monitored as part of a load assessment study. The 2010 Little Comfort Lake Watershed Load Assessment Study is available on the District website at:

https://www.clflwd.org/documents/LittleComfortWatershedLoadAssessmentReport1July10.pdf

Continuous flow and water quality samples were collected at each stream site between April and October during base and storm events, as well as twice a month from June to September. Total phosphorus and total suspended solid loads were calculated for each site. The total drainage area to Manning Trail is 7,115 acres, to July Avenue is 7,902 acres, and to Itasca Avenue is 10,513 acres. The total precipitation in 2008 was 27 inches, and in 2009 was 26 inches.

1.1.2. Results

The 2010 load assessment study identified the area downstream of School Lake as a phosphorus load hotspot based on an increased load from the July Avenue to the Itasca Avenue monitoring sites. In particular, the study concluded that the stream channel downstream of School Lake contributed additional phosphorus load to Little Comfort Lake. However, when loads are normalized for increased flow along the tributary, the upper part of the drainage area discharges a disproportionately higher amount of phosphorus than the lower part of the drainage area. The measured phosphorus flow weighted mean concentrations at Manning Trail are slightly above the ecoregion stream standard of 100 µg/L, and decreases at the downstream sites. The phosphorus flow weighted mean concentration at Itasca Avenue is approximately equal to the School Lake summer average phosphorus concentration, which does not indicate that the stream channel downstream of this site contributes additional phosphorus load to Little Comfort Lake. In contrast, the lower part of the drainage area discharges a disproportionately higher amount of total suspended solids than the upper part of the drainage area. It should be noted that all of measured TSS flow weighted mean concentrations are well below the ecoregion stream standard of 65 mg/L, which is expected from a depressional, wetland-dominated drainage area.

The 2010 Load Assessment study included two monitoring recommendations:

- Conduct a series of synoptic surveys of the phosphorus concentration profile along the length of the stream to help identify phosphorus sources and sinks that may be worth treating. This was completed as part of the 2016-2018 load assessment studies.
- Conduct a geomorphic assessment between School and Little Comfort Lake to provide information necessary for properly restoring the reach to natural conditions. In subsequent load assessment studies, the load from this portion of the reach was not identified as a hotspot compared to other areas in the watershed.

In addition, the 2010 Load Assessment study identified several management alternatives that are described in Section 2 of this report.

Table 1. 2008 and 2009 Load Monitoring Results (Washington Conservation District)

Parameter	Monitoring Stations (Upstream to Downstream)					
	Manning Trail		July Ave		Itasca Ave	
	2008	2009	2008	2009	2008	2009
Flow (ac-ft)	1,452	258	1,859	623	8,273	2,325
Flow (in/yr)*	2.4	0.4	2.9	0.9	9.4	2.7
TP Load (lb)	508	104	431	151	1,127	418
TP FWMC (µg/L)**	129	148	85	89	50	66
TSS Load (lb)	7,421	3,718	14,137	9,112	94,344	34,444
TSS FWMC (mg/L)**	1.9	5.3	2.8	5.4	4.2	5.5

* Flow reported as inches of runoff over the total drainage area. This normalizes flow based on drainage area. That is to say, larger drainage areas are expected to have larger flows. Higher inches of runoff per year represents more runoff compared to precipitation than other lower inches of runoff per year. More runoff could be due to less infiltration or storage in the watershed, or greater imperviousness.

** The flow-weighted mean concentration (FWMC) is the total load divided by the total flow. The FWMC normalizes loads based on flow. That is to say, larger loads are expected with larger flows. Higher FWMCs represent loads larger than would be expected based on flow, which represents a loading hotspot.

1.2. 2016 Tributary Load Assessment

1.2.1. Monitoring Locations

Continuous flow and water quality monitoring data were collected at six locations along the main Bone-Birch-School-Little Comfort Tributary (BBSLC Trib) to Little Comfort Lake in 2016. Washington Conservation District staff collected data at Bone Lake Outlet, Manning Avenue, and Itasca Avenue; and EOR staff collected data at July Avenue (main), July Avenue Tributary, and 240th (Figure 1). The Manning Avenue, July Avenue, Itasca Avenue, and Bone Lake Outlet locations were selected for maintaining consistency with past biological and water quality monitoring. The July Avenue Tributary monitoring location is an intermittent stream that flows into the BBSLC Trib just west of July Avenue and School Lake. The July Avenue Tributary drains approximately 120 acres of mixed residential and agricultural land. The 240th monitoring location is an intermittent stream that enters the south-western wetland fringe of Birch Lake at 240th Avenue. This stream drains approximately 400 acres of rural residential and forest, including numerous large and small closed basin lakes and wetlands. Flowpaths to this outlet at 240th Avenue likely have a substantial subsurface component, and is not conducive to flow gaging but was sampled for WQ.

1.2.2. Results

Flow weighted mean phosphorus concentrations were low at the Bone Lake Outlet and July Avenue sites; moderate at the Manning Avenue, 240th Avenue, and Itasca Avenue sites; and very high at the July Avenue Tributary site. With the exception of the Manning Avenue site, total suspended solids loads were low at all monitoring stations. In addition, ortho-phosphorus concentrations were high at the 240th Avenue and July Avenue Tributary sites, and iron to total phosphorus (Fe:TP) ratios low at the Bone Lake Outlet and July Avenue Tributary sites. Based on the high total and ortho-phosphorus concentrations and low Fe:TP found at the July Avenue Tributary site which indicate degraded watershed conditions, we recommended additional monitoring at 3 locations upstream of and including the July Avenue Tributary monitoring site in 2017 to spatially refine this source of high phosphorus to School Lake.

Table 2. Little Comfort Lake 2016 continuous flow and water quality monitoring summary

Monitoring Site	Days of continuous flow	Water quality samples	Daily cfs	Flow (ac-ft)
Bone Lake Outlet	202	9	7.28	2,922
Manning Avenue	202	12	3.95	1,583
July Avenue	159	12	5.72	1,807
Itasca Avenue	202	12	4.93	1,977
240th Avenue	231	8	0.22	102
July Avenue Tributary	231	9	0.34	155

Table 3. Little Comfort Lake 2016 total phosphorus and total suspended solids load summary

Monitoring Site	Total Phosphorus			Total Suspended Solids		Ortho P (as %TP)	Fe: TP
	Load (lb)	FWMC* (µg/L)	CV	Load (tons)	CV		
Bone Lake Outlet	555	70	0.44	39	0.46	10%	2.9
Manning Avenue	715	166	0.3	3,897	0.93	17%	13.0
July Avenue	430	88	0.14	13.6	0.28	35%	7.1
Itasca Avenue	887	165	0.43	220	0.62	6%	6.7
240th Avenue	49	178	0.19	0.6	0.29	78%	5.9
July Avenue Tributary	426	1,014	0.16	2.4	0.21	80%	2.6

* The flow-weighted mean concentration (FWMC) is the total load divided by the total flow. The FWMC normalizes loads based on flow. That is to say, larger loads are expected with larger flows. Higher FWMCs represent loads larger than would be expected based on flow, which represents a loading hotspot.

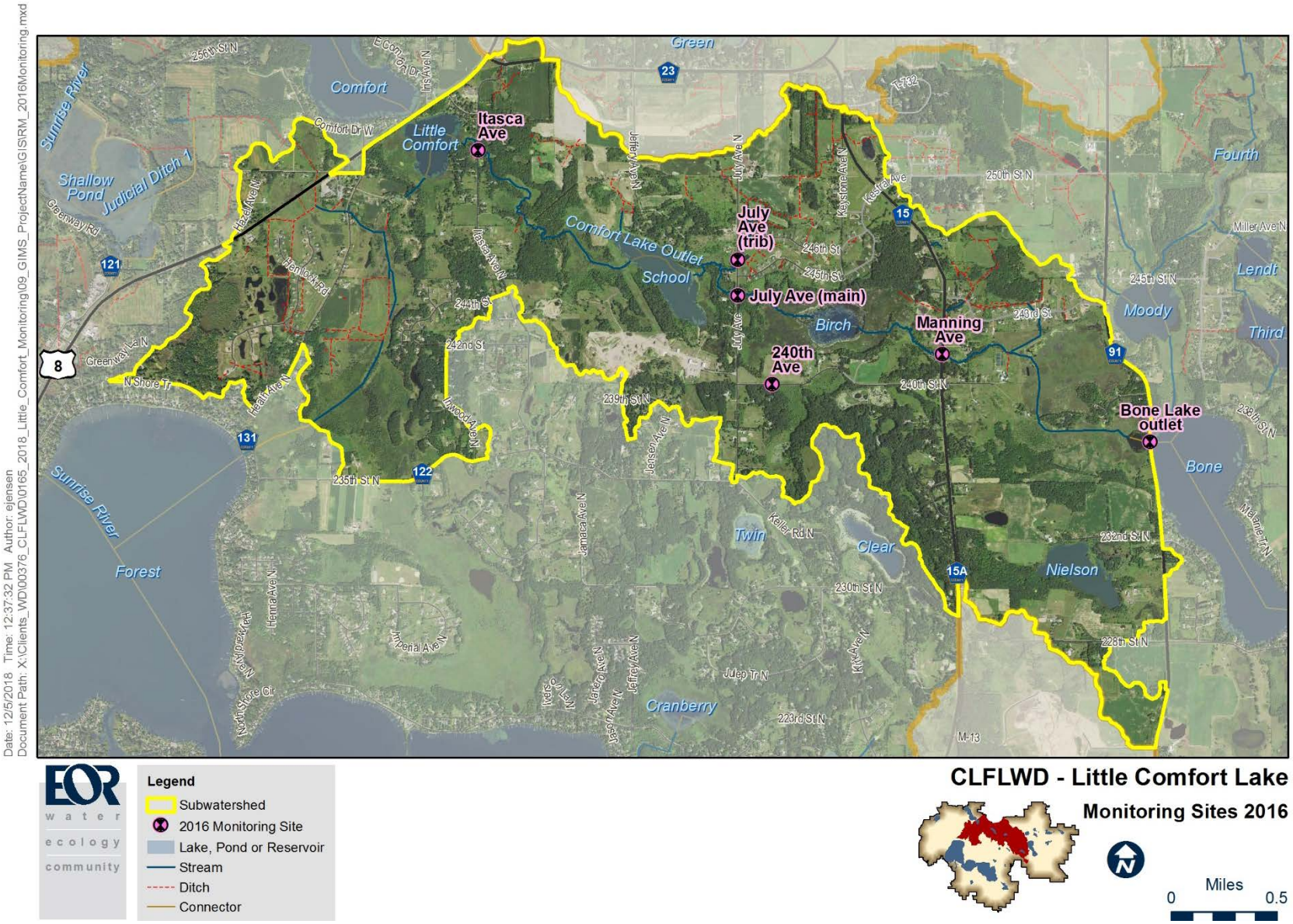

Figure 1. Little Comfort Lake 2016 Monitoring Site Water Quality Summary

Figure 2. Downstream of July Avenue (September 2015)

Figure 3. Upstream of Manning Avenue (September 2015)

Figure 4. Downstream of Manning Avenue (September 2015)

Figure 5. Upstream of Itasca Avenue (September 2015)

1.3. 2017 July Avenue Load Assessment

1.3.1. Monitoring Locations

Five water quality grab samples were collected at 3 locations upstream of and including the July Avenue Tributary monitoring site (Figure 7) to spatially refine the source of the high phosphorus identified from the 2016 monitoring. Continuous flow could not be collected at these sites due to intermittent flow conditions.

1.3.2. Results

The water quality monitoring results from 2017 in the July Avenue Tributary drainage area are summarized in Table 4. Overall, total phosphorus concentrations were high in 2017 at the July Avenue Tributary site, with even higher concentrations at the two upstream sites (245th and West Branch). Most of the phosphorus at these sites was comprised of ortho-phosphorus with low iron to phosphorus ratios, indicating degraded watershed conditions and low potential for soil adsorption of phosphorus. The West Branch site had the highest phosphorus concentrations, with consistently very turbid, muddy water (Figure 6) likely the result of an active cattle pasture and rotational agricultural fields just upstream of the monitoring site. The West Branch drainage area is 75 acres with approximately two-thirds in a corn-soybean rotation (Figure 8).

Assuming an area-weighted flow at the West Branch site compared to the July Avenue Tributary site in 2016 (or 36 acre-feet), and applying the 2017 average phosphorus concentration at the West Branch site (4,260 µg/L), the total load at the West Branch site in 2017 was approximately 417 lb/yr.

Phosphorus concentrations collected at the Heath Avenue pipe outlet were much lower than the July Avenue Tributary sites, but the overall load to Little Comfort Lake may be significant given the high flows observed discharging from this pipe. Additional monitoring in 2018 was recommended at the Heath Avenue pipe to determine the relative contribution of phosphorus loads from the pipe versus the Little Comfort tributary inlet at Itasca Avenue.

Table 4. 2017 Water Quality Monitoring Results

Parameter		July Avenue Tributary	246th Street	West Branch
Drainage Area		326 acres	307 acres	75 acres
Total Phosphorus (TP, µg/L)	Average	870	1,330	4,260
	Range	310 – 2,190	470 – 3,380	1,720 – 7,660
Total Suspended Solids (TSS, mg/L)	Average	18	50	99
	Range	6 – 39	10 – 123	61 - 133
Ortho-phosphorus (as %TP)	Average	81%	84%	81%
	Range	75-88%	76-94%	77-87%

Parameter		July Avenue Tributary	246th Street	West Branch
Iron to TP ratio	Average	2.8	3.0	2.4
	Range	1.4 – 3.9	1.1 – 5.5	0.5 – 8.4

Figure 6. West Branch monitoring site turbidity

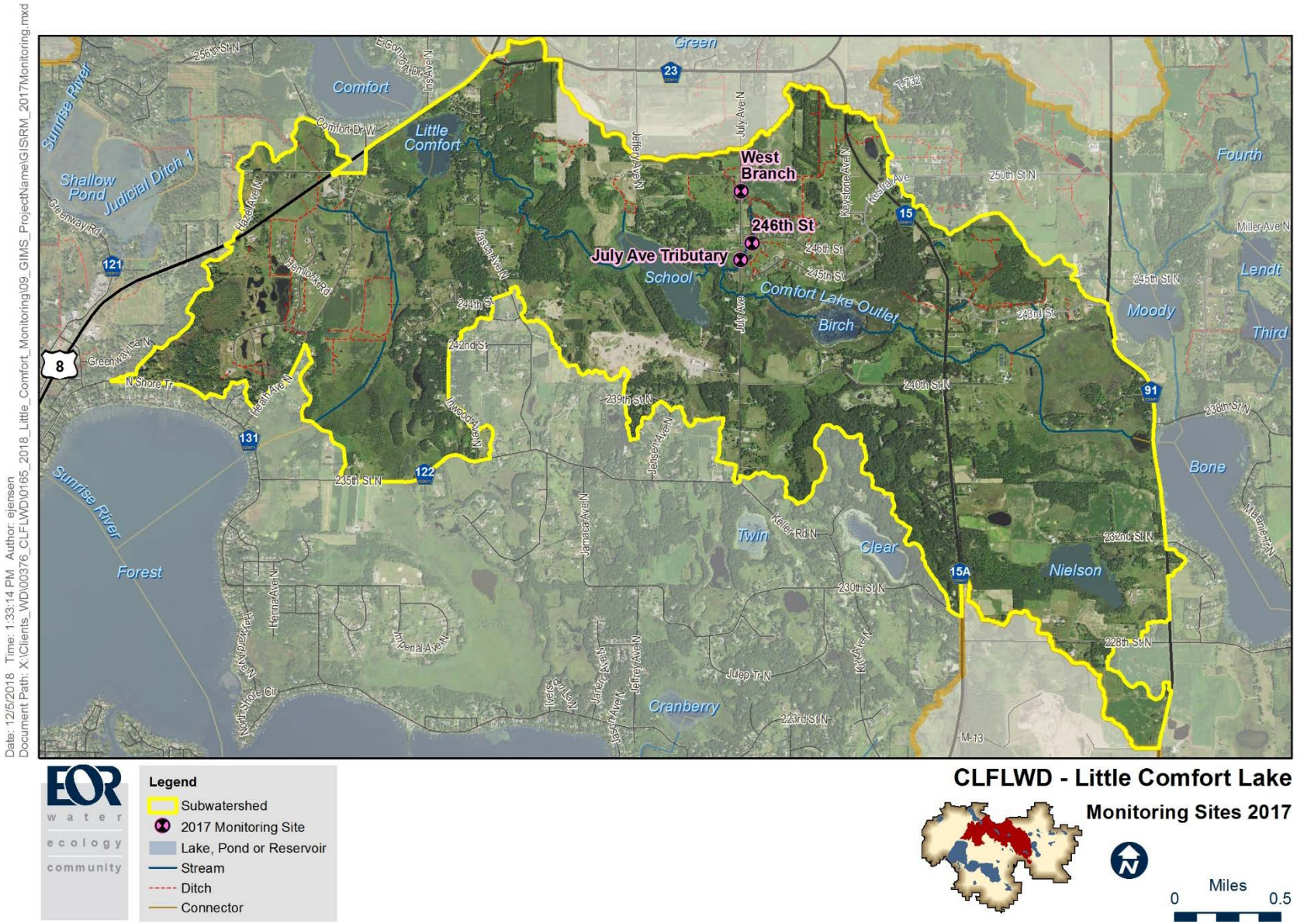

Figure 7. Little Comfort Lake 2017 Monitoring Locations Upstream of July Avenue

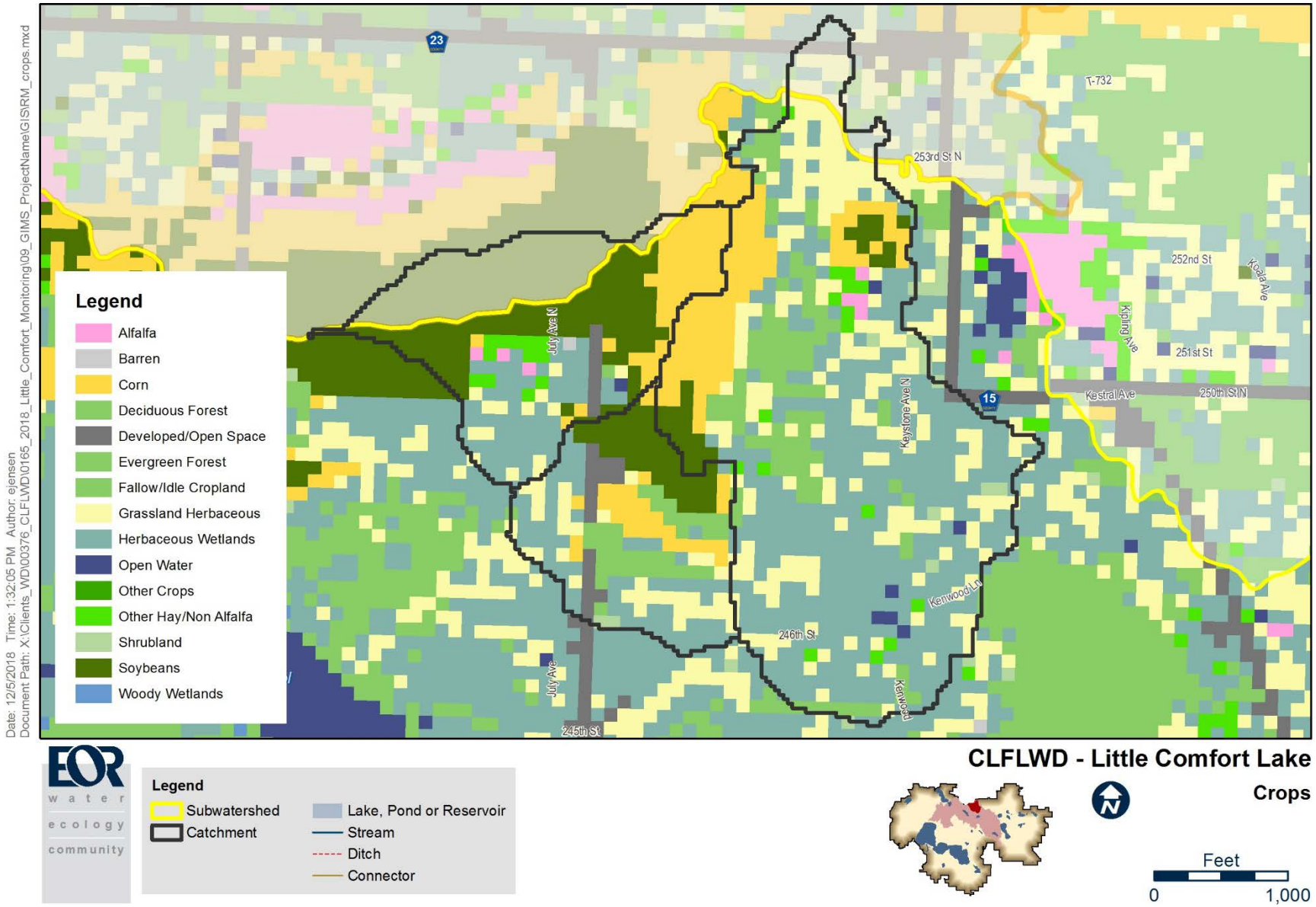

Figure 8. July Avenue Tributary Drainage Area Crops

1.4. 2018 Little Comfort Lake Inlets Load Assessment

1.4.1. Monitoring Locations

In 2018, EOR collected continuous stage and flow and 10 water quality grab samples (TP, Ortho-P, and TSS) following rainfall events between April 23 and October 10 at the Heath Avenue pipe (Figure 9) to determine the contribution of phosphorus and sediment load from this drainage area to Little Comfort Lake. The Washington Conservation District collection continuous stage and flow and 9 composite water quality samples (TP) under baseflow and rainfall events between April 30 and October 3. In addition, EOR collected several water quality grab samples on October 10 to investigate the spatial distribution of phosphorus concentrations from a residential neighborhood that discharges to the Heath Avenue pipe. All monitoring locations sampled in 2018 are shown in Figure 10.

1.4.2. Results

Continuous flow and water quality grab samples collected by EOR at the Heath Avenue pipe were used to estimate TP loads using FLUX (Table 5). The total flow discharged from the Heath Avenue pipe for the 2018 monitoring season was 314 acre-feet, the total phosphorus load was 286 lb/year at a flow-weighted mean phosphorus concentration of 337 µg/L, and the total suspended solids load was 9,590 lb/year at a flow-weighted mean TSS concentration of 11 mg/L. The

Continuous flow and water quality composite samples collected by WCD at Itasca Avenue were also used to estimate TP loads using FLUX. The FLUX results indicate that the Heath Avenue outlet discharges a similar amount of phosphorus to Little Comfort Lake compared to the inlet stream at Itasca Avenue. The load calculation for the full monitoring season (April 30 and October 10) indicated that the flow at Heath Avenue was 84% of the total flow at Itasca Avenue, with similar flow weighted mean phosphorus concentrations at these two sites. A preliminary load calculation completed for data collected between April 30 and July 30 also indicated similar phosphorus loads at Heath and Itasca Avenues, but the Heath Avenue flow mid-season was 50% (half) of the Itasca Avenue flow and the Heath Avenue flow weighted mean phosphorus concentration (348 µg/L) was much higher than Itasca Avenue (99 µg/L). In other words, the Heath Avenue outlet discharged phosphorus at a disproportionately high concentration compared to the volume discharged to the Lake. However, the partial Itasca Avenue load calculation was based on 2 water quality samples and the uncertainty in the FLUX load estimates for the full monitoring season at the Itasca Avenue site was fairly high (47%) compared to the Heath Avenue site (11%). EOR will review the final load calculation for Itasca Avenue in the WCD final monitoring report for the CLFLWD to verify these results. The WCD collects stream monitoring data using a protocol better suited for a different load calculation method than FLUX, and our FLUX load estimate may be a misrepresentation of the WCD Itasca Avenue data.

The Liberty Pond residential development discharges stormwater to the Heath Avenue outlet. Prior to the City taking of the maintenance of the Liberty Ponds stormwater ponds, EOR was directed by the District to conduct an investigation of the current volume capacity and phosphorus levels of the stormwater ponds within the development in 2018 to determine whether there is a need for

additional maintenance of the ponds to improve downstream water quality. Overall, our assessment indicates that the current storage capacity of the ponds exceeds or is near the design capacity. For the five largest stormwater ponds surveyed, the 2018 measured pond volumes exceeded the design volume, suggesting these ponds were possibly over-excavated and sediment has not substantially accumulated since construction. The two smaller pond 2018 measured volumes were below the design volume shown in the plans but the October 2018 water levels in the ponds were below normal water level, therefore the actual storage volumes are likely near design volume.

Moreover, the phosphorus (P) concentration measured at two discharge locations from the development on October 10, 2018 were both 42 µg P/L, significantly lower than the Heath Avenue outlet on that same date (217 µg P/L). Although this is only a single snapshot in time, the low phosphorus concentration of the ponds compared to the Heath Avenue outlet pipe suggests that the stormwater ponds are operating as intended and are unlikely to be the primary source of phosphorus to the Heath Avenue outlet.

Table 5. Little Comfort Lake Inlets 2018 total phosphorus load summary

Monitoring Site	Flow (ac-ft)	Total Phosphorus			Total Suspended Solids			Average Ortho-P (% of TP)
		Load (lb)	FWMC* (µg/L)	CV	Load (lb)	FWMC* (mg/L)	CV	
Heath Avenue	314	286	337	0.11	9,590	11	0.29	66%

* The flow-weighted mean concentration (FWMC) is the total load divided by the total flow. The FWMC normalizes loads based on flow. That is to say, larger loads are expected with larger flows. Higher FWMCs represent loads larger than would be expected based on flow, which represents a loading hotspot.

CV = the level uncertainty in the FLUX load estimate, values < 0.15 indicate low uncertainty

Figure 9. Heath Avenue Outlet pipe discharging to a wetland on the west side of Little Comfort Lake

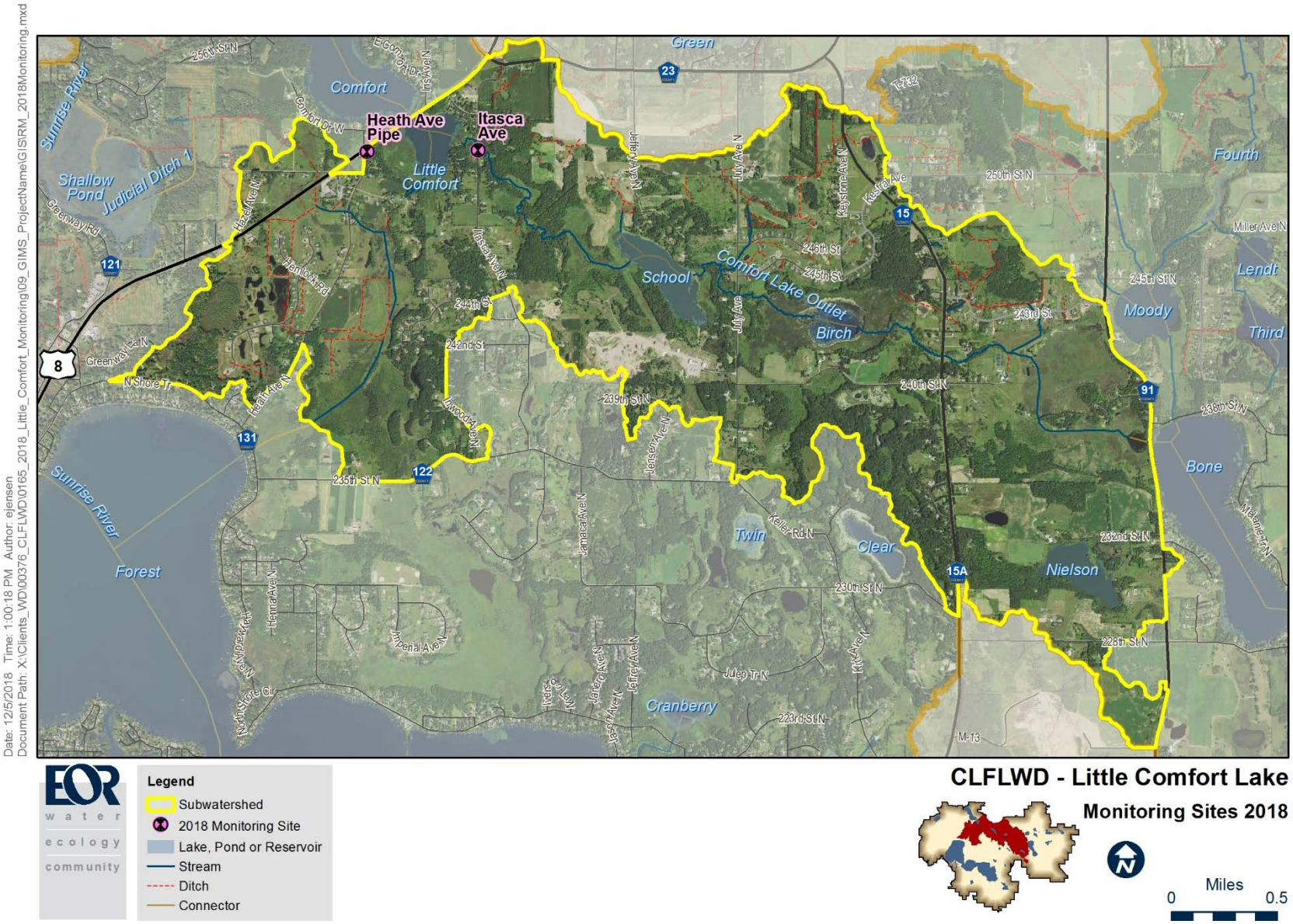

Figure 10. 2018 Little Comfort Lake Inlets Monitoring Sites

1.5. Load Summary

Flow-weighted mean phosphorus concentrations for 2008-2018 are summarized in order of downstream to upstream (left to right) for the Bone-Birch-School-Little Comfort tributary chain, including the summer average in-lake phosphorus concentrations for Bone, Birch, School, and Little Comfort Lakes (Table 6). All monitoring locations are shown in Figure 11. Based on monitoring data collected over the past 10 years in the Little Comfort Lake drainage area, the highest flow-weighted mean phosphorus concentrations were observed at the July Avenue Tributary and the Heath Avenue pipe inlet, moderate flow-weighted mean phosphorus concentrations were observed at Manning Trail, and low flow-weighted mean phosphorus concentrations were observed at July Avenue and Itasca Avenue. Projects should be prioritized in the areas with higher flow-weighted mean phosphorus concentrations.

Table 6. Little Comfort Lake Drainage Area Flow-weighted Mean Phosphorus Concentration Summary (2008-2018)

Year	Flow-weighted Mean Phosphorus Concentration (µg/L) Downstream ← Upstream									
	Little Comfort Lake	Heath Avenue inlet	Itasca Avenue	School Lake	July Avenue	July Ave Trib	Birch Lake	Manning Avenue	Bone Lake Outlet	Bone Lake
2008	28		50		85			129		39
2009	19		66	47	89			148		33
2016	68		52		88	1,014		166	55	39
2017	43		58	51			72		30	30
2018	*	339	*	*			*			*

Note that the blue shaded columns denote summer average in-lake phosphorus concentrations

* Monitoring data were collected at these locations in 2018 but final results were not available at the time of this report

2. MANAGEMENT ALTERNATIVES

Several management alternatives have been identified by the load assessment studies over the past 10 years. Based on the comprehensive review of these load assessments, and our ranking of phosphorus loads based on the flow weighted mean phosphorus concentrations in Section 0, these projects are described and listed below in order of higher priority to lower priority.

2.1. July Avenue Tributary Agricultural BMPs

The 2017 monitoring data indicated that the West Branch and 246th Street sites are phosphorus hotspots to School Lake, and priority in identifying water quality improvement projects should begin in the West Branch drainage area, followed by the 246th Street drainage area. The West Branch drainage area is 75 acres with approximately two-thirds in a corn-soybean rotation and an active cattle pasture, while the 246th Street direct drainage area is 232 acres with approximately 17% in a corn-soybean rotation (Figure 8). Depending on landowner willingness, some simple agricultural BMPs to reduce erosion of the agricultural fields and reduce erosion and manure runoff from the active cattle pasture could significantly reduce the phosphorus and sediments loads discharged from this drainage area to School Lake. School Lake is currently impaired for eutrophication due to excess nutrients, and as a primary source of phosphorus to Little Comfort Lake, improvement of water quality in School Lake will also benefit water quality in Little Comfort Lake.

Partnership with the Chisago SWCD to reach out to landowners in this drainage area is a high priority for the District in 2019.

2.2. Heath Avenue Subwatershed Investigation

The 2018 monitoring data indicated that the Heath Avenue pipe discharges an equivalent amount of phosphorus load to Little Comfort Lake as the stream inlet at Itasca Avenue, with a high flow-weighted mean concentration. However, the source of this high phosphorus load has not yet been determined. Preliminary investigation of the Liberty Pond neighborhood development suggests that this area is not a likely source. The Heath Avenue pipe drainage area is dominated by wetlands, but has been ditched for agriculture and development. A more comprehensive investigation of phosphorus concentrations throughout the ditch network, and a better understanding of the surface and subsurface flow paths, is needed to target cost-effective BMPs in this drainage area. This area would be part of the Comfort Lake Diagnostic Phase 2 project budgeted for 2019, which includes an update of the District original SWMM model and BMP scenario modeling. The District applied for an Accelerated Implementation Grant for 2019 to support BMP scenario modeling in this area of.

Completion of the SWMM model update and BMP scenario modeling in the Heath Avenue pipe drainage area is a high priority for the District to identify the most cost effective BMPs in this complex depressional network of ditches and wetlands.

2.3. Birch Lake Wetland Restoration

Flow-weighted mean phosphorus concentrations at Manning Trail, upstream of Birch Lake, are consistently above the ecoregion stream phosphorus standard of 100 µg/L. The 2010 Load Assessment study identified a potential Birch Lake Wetland Restoration project upstream of Manning Trail to improve the hydrology and water quality reduction functions of the Birch Lake wetland. Stream between Bone and Birch Lakes is almost entirely within channelized wetlands. Release of phosphorus in this 125 acre wetland may be due to fluctuating wetland water levels and subsequent wetting and drying of wetland soils, which accelerates dissolved phosphorus release. The 2010

project recommends a sheet pile weir to maintain wetted soils in this wetland. The project was expected to reduce phosphorus by 130 lb/yr at a total cost of $650,000 (in 2010 dollars) for a 20 year cost-benefit of $400 per pound of phosphorus removed.

Before pursuing this wetland restoration project, the District should determine the relative contribution of phosphorus load to Birch Lake from the upstream wetland versus internal sediment phosphorus loading within Birch Lake. Birch Lake is very shallow and its water quality may be dominated by in-lake phosphorus and plant dynamics. While important to understand, further study of Birch Lake should be prioritized after phosphorus reductions from the Heath Avenue pipe and July Avenue tributary drainage areas have been completed. Water quality improvements in Little Comfort and School Lakes from these higher priority projects should be assessed and then the contribution of loads from Birch Lake to the downstream system reevaluated before pursuing the Birch Lake wetland restoration project.

2.4. School Lake Outlet Structure and Wetland Restoration

Stream channel instability and beaver dam issues have been observed in the School Lake outlet channel. The 2010 Load Assessment study recommended installing a hydraulic control downstream of School Lake to maintain the present elevation of School Lake. In addition, the study recommended replacement of a culvert at the downstream service road with an oversized culvert to allow the culvert invert to be set below the streambed and to fill partly with sediment. Finally, the study recommended restoration of the stream channel between the new service road culvert and School Lake outlet structure. The project was expected to reduce phosphorus by 50 lb/yr at a total cost of $290,000 (in 2010 dollars) for a 20 year cost-benefit of $460 per pound of phosphorus removed. The 2010 study also noted that a geomorphic assessment between School and Little Comfort Lakes was needed to provide the necessary information for properly restoring the reach to natural conditions.

This project is likely a moderate priority for the District, but should also be deferred until the water quality improvements in Little Comfort and School Lakes from the high priority projects in the July Avenue Tributary and Heath Avenue pipe drainage area are assessed.

2.5. Other Recommendations

The District could consider other management recommendations from the 2010 Load Assessment study as opportunities arise, including increasing the width and quality of wetland buffers and pursuing partnerships to construct water quality BMPs for roadways and developed areas that discharge to Birch and School Lake wetlands with no current treatment. However the cost-benefit of wetland buffer and roadway treatment projects is likely small given the larger sources of phosphorus identified from the agricultural crop rotations upstream of the July Avenue Tributary monitoring site and from the Heath Avenue pipe drainage area. Wetland buffer and roadway treatment projects should be implemented based on landowner willingness and utilizing District cost-share programs.

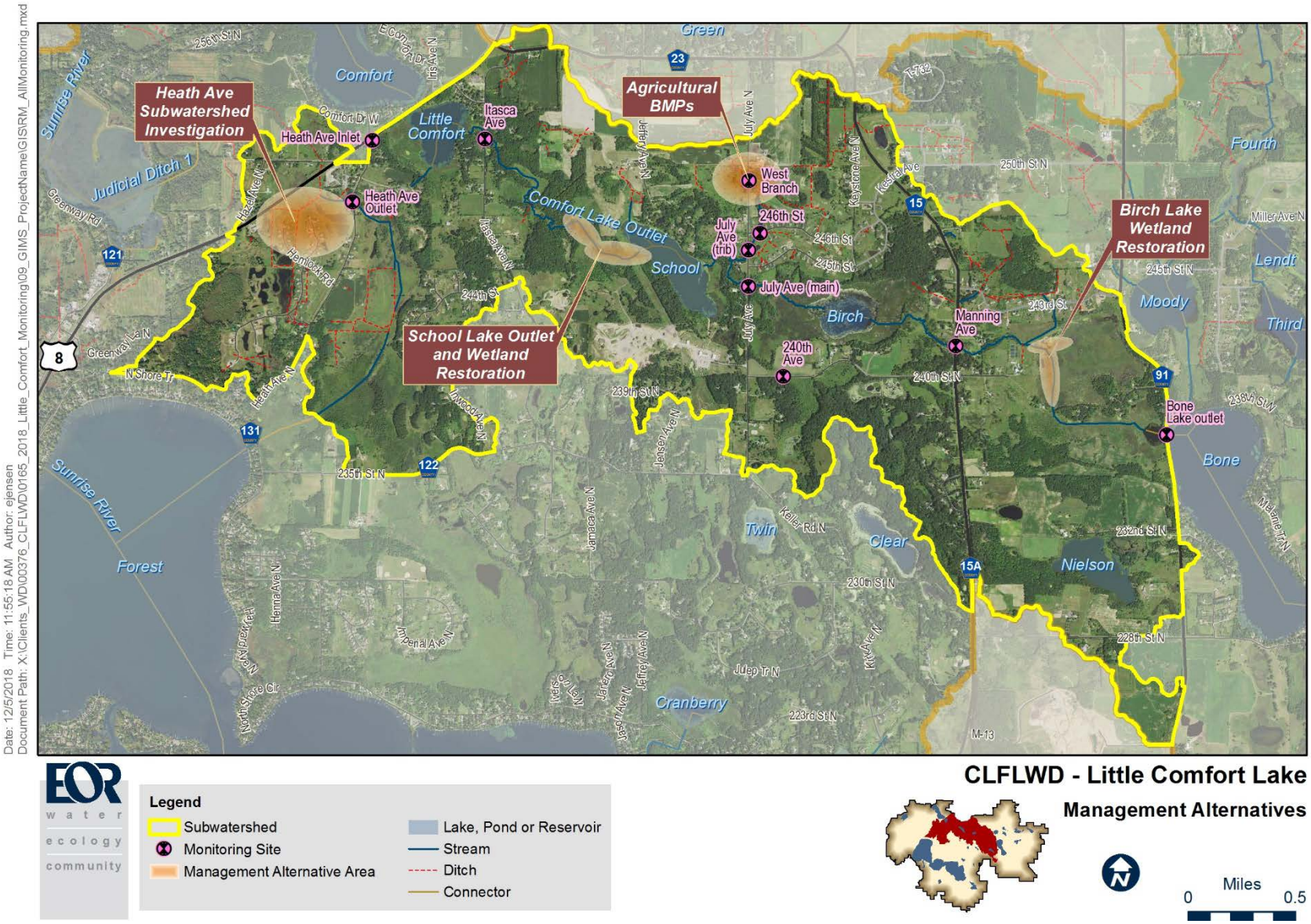

Figure 11. Management Alternatives in the Little Comfort Lake Drainage Area