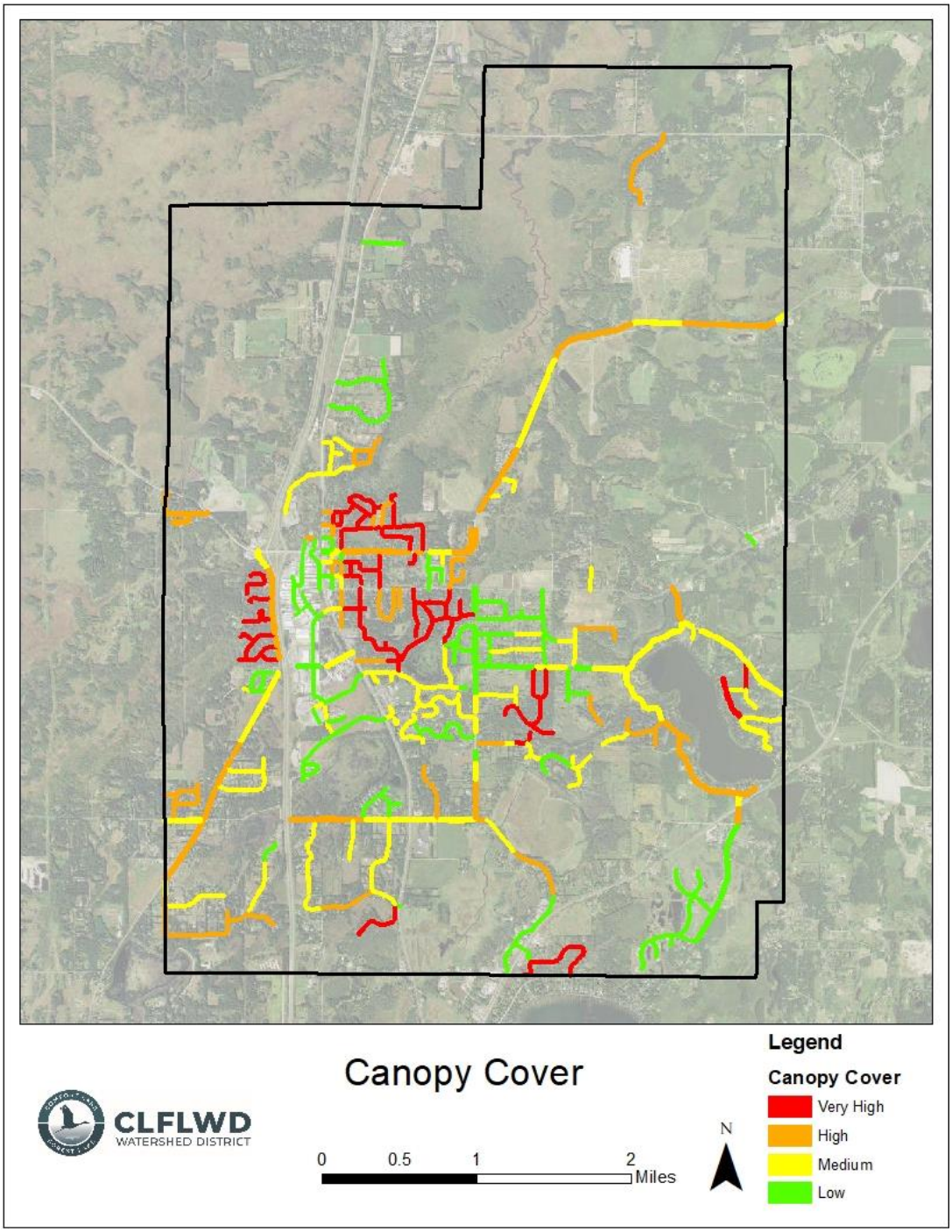
Enhanced Street Sweeping Plan

City of Wyoming



Report Prepared by the Comfort Lake-Forest Lake Watershed

1. Introduction and Purpose

In 2022, the St. Croix Watershed Partnership developed a grant program to provide incentive funding for enhanced street sweeping practices for municipalities within the Lower St. Croix Watershed. The goal of the grant program is to help cities adopt targeted street sweeping practices by providing funds for implementation. The grant application requirements include a tree canopy cover assessment and enhanced sweeping plan for the municipality of interest. This study was undertaken to fulfill these requirements.

More specifically the objectives of this study are to:

- Quantify right-of-way tree canopy cover for municipal streets within the City of Wyoming, MN.
- Characterize streets/storm drain watersheds by connectivity to downstream surface water resources.
- Prioritize municipal streets for enhanced street sweeping based on the tree canopy cover and drainage characteristics described above.

2. Current Street Sweeping Practices

The City of Wyoming currently sweeps all roads once in the spring with the goal of removing sand used for winter maintenance. All city roads are swept once, with total time taking seven to eight days. An additional fall sweeping is preferred by the City but does not always occur due to staffing issues.

Pollutant recovery (total solids, total nitrogen, and total phosphorus) associated with spring sweeping was estimated using the Planning Calculator for Estimating Nutrient Removal through Street Sweeping model developed by the University of Minnesota (Kalinosky, 2014). A default cost of $36 per curb mile provided in Kalinosky et al. (2015), however this report uses Lower St. Croix Watershed Partnership (LSCWP) cost estimate of $100 per curb mile. Actual costs may be lower, resulting in better cost-benefit. Based on the planning calculator model, this single spring sweeping resulted in an estimated 15.9 pounds of annual phosphorus reductions at a cost of $272.67 per pound [Table 1].

Table 1: Estimated annual pollutant recovery calculated using canopy cover and curb miles [Table 3] for priority areas identified later in the study [Figure 7].

Current Practice - Single Spring Sweep						
Route	Predicted Annual					
	Wet solids, lb	Dry solids, lb	Nitrogen, lb	Phosphorus, lb	Cost, $	Average $ Cost/ lb P
Sub-Totals	**25154.2**	**18643.9**	**183.6**	**15.9**	**$ 4,324.00**	**$ 272.67**
256th	760.6	595.8	3.1	0.5	$ 214.00	**$ 465.54**
Sunrise	8604.7	6348.9	61.3	5.4	$ 1,331.00	**$ 244.77**
Ashton N	4921.3	3447.8	56.2	3.2	$ 442.00	**$ 136.72**
Ashton S	2183.4	1717.1	8.7	1.3	$ 644.00	**$ 489.49**
Heims	2747.8	2109.9	13.6	1.7	$ 628.00	**$ 372.57**
Kettle	3946.0	2865.5	32.5	2.5	$ 507.00	**$ 200.90**
Comfort	1990.3	1559.0	8.2	1.2	$ 558.00	**$ 463.88**

3. Study Area

The street sweeping prioritization described in this report includes all municipal roads within the City of Wyoming, MN jurisdictional boundary. Within the study area there are a number of important hydrological features: the Sunrise River, Heims Lake, Ashton Lake, and Comfort Lake which is connected to Little Comfort Lake [Figure 1].

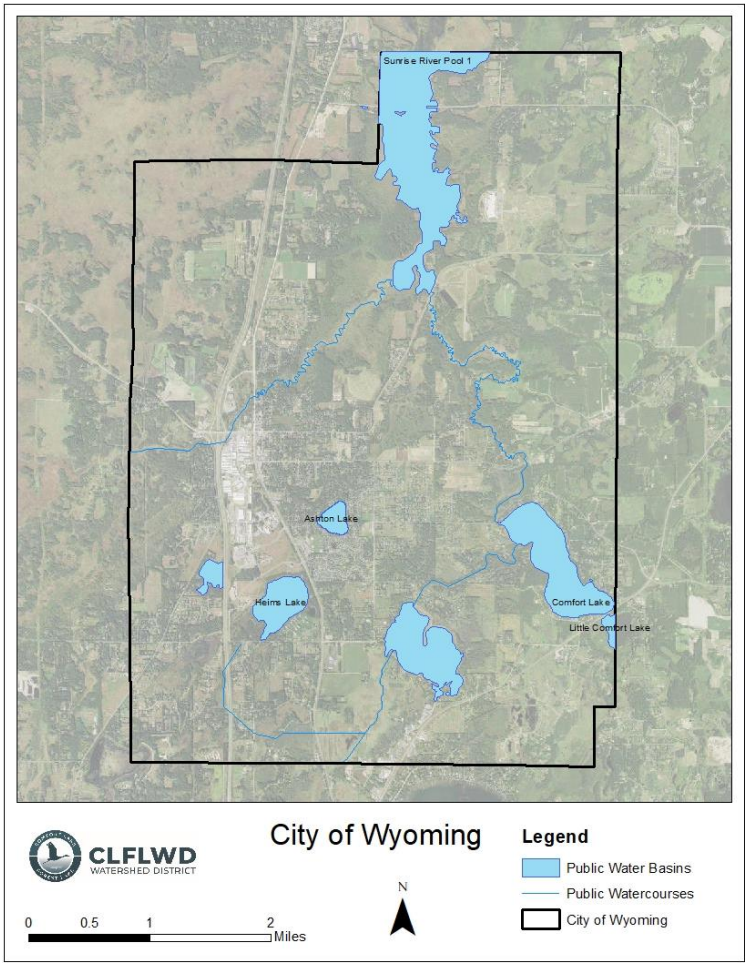


Figure 1: Wyoming city boundaries and the key surface water resources located within its borders.

4. Methods

This study follows the 2022 Tree Canopy Assessment Protocol for Enhanced Street Sweeping Prioritization developed for the Lower St. Croix Watershed Partnership (LSCWP) by Emmons & Olivier Resources (EOR).

This study had two main components:

1. Data Development and Evaluation: Data layers developed for this study include items (a) through (d) below. These data are described in greater detail in Section 4, City of Wyoming Street Characterization.
    a. Municipal Roads:

i. centerline miles and total lane miles
ii. right-of-way surface area layer following 2.1.3 section in LSCWP protocol.

b. Tree canopy cover layer - the City of Wyoming is located outside of the 7-County Twin Cities Metropolitan Area and therefore does not have mapped tree canopy cover data. Right of way tree canopy cover was estimated at the street segment scale following the Visual Assessment of Tree Canopy using aerial imagery summarized in Section 2.2 of the LSCWP's tree canopy assessment protocol.
c. Stormwater management considerations (see Stormwater System section).
d. Watershed assignment (see Watersheds section).

2. Sweeping Prioritization: Street segments were rated with respect to three categories: Right of way tree canopy, stormwater management, and water resources management priorities (watershed). Individual ratings were combined in a final score that was used to prioritize areas for sweeping. The scoring system is described in Section 5, Finding and Recommendations.

City of Wyoming Street Characterization

Centerline road data for the City of Wyoming was obtained from the Chisago County GIS website. A data layer representing road right-of-way surface areas was developed following the Lower St. Croix Watershed Partnership (LSCWP) assessment protocol. However, the road data did not include functional classification or right of way (ROW) width, so a proxy for functional class based on roadway names was assigned. For example, roads with names "boulevard" and "trail" were assigned as "arterial", while "street" and "avenue" were assigned as "collector". Three road types with set ROW widths were assigned in the study; arterial: 150 feet, collector: 100 feet, and service: 80 feet. Functional class assignments were verified through visual inspection of aerial imagery. Additionally, non-paved roads were removed by creating a selection based on surface type, which was included in the Chisago County dataset. Several main arterial roads were identified along with a small industrial area with service roads. However, most roads in the dataset were collector roads [Figure 2].

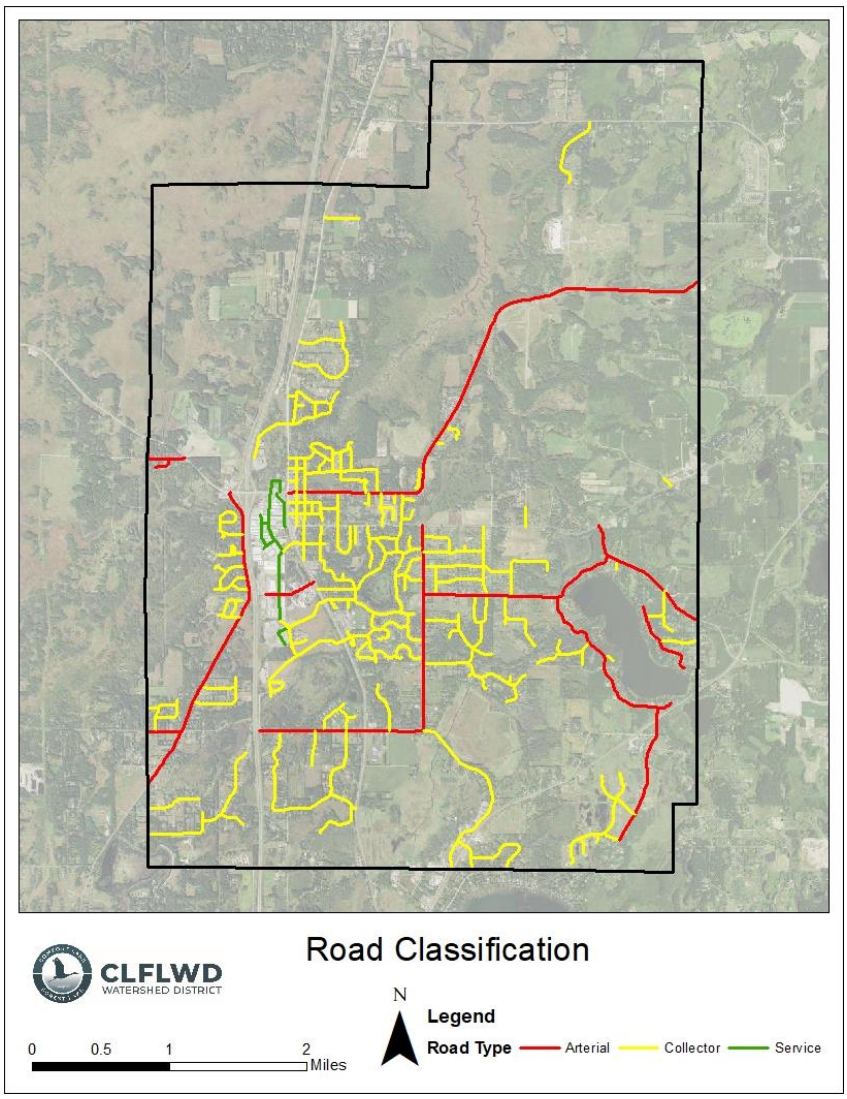


Figure 2: Road Classification in City of Wyoming, all paved roads maintained by the City of Wyoming are mapped with red showing arterial roadways, yellow collector, and green service.

Right of Way Tree Canopy Cover

Because the City of Wyoming is located outside of the Twin Cities Metro Area, the visual assessment protocol outlined in the Emmons & Olivier Resources (EOR) report was used to assign canopy cover density. However, instead of the five categories suggested by EOR (Low, Moderate, Medium, High, and Very High) four categories were used (Low, Medium, High, and Very High). The justification for this decision was the lack of an existing data set to use as a control; it would be difficult for the visual assessment to differentiate between five categories consistently. Overall, very high vegetative cover was concentrated in several older developments, and the lowest canopy cover was found in the industrial sections and new developments [Figure 3].

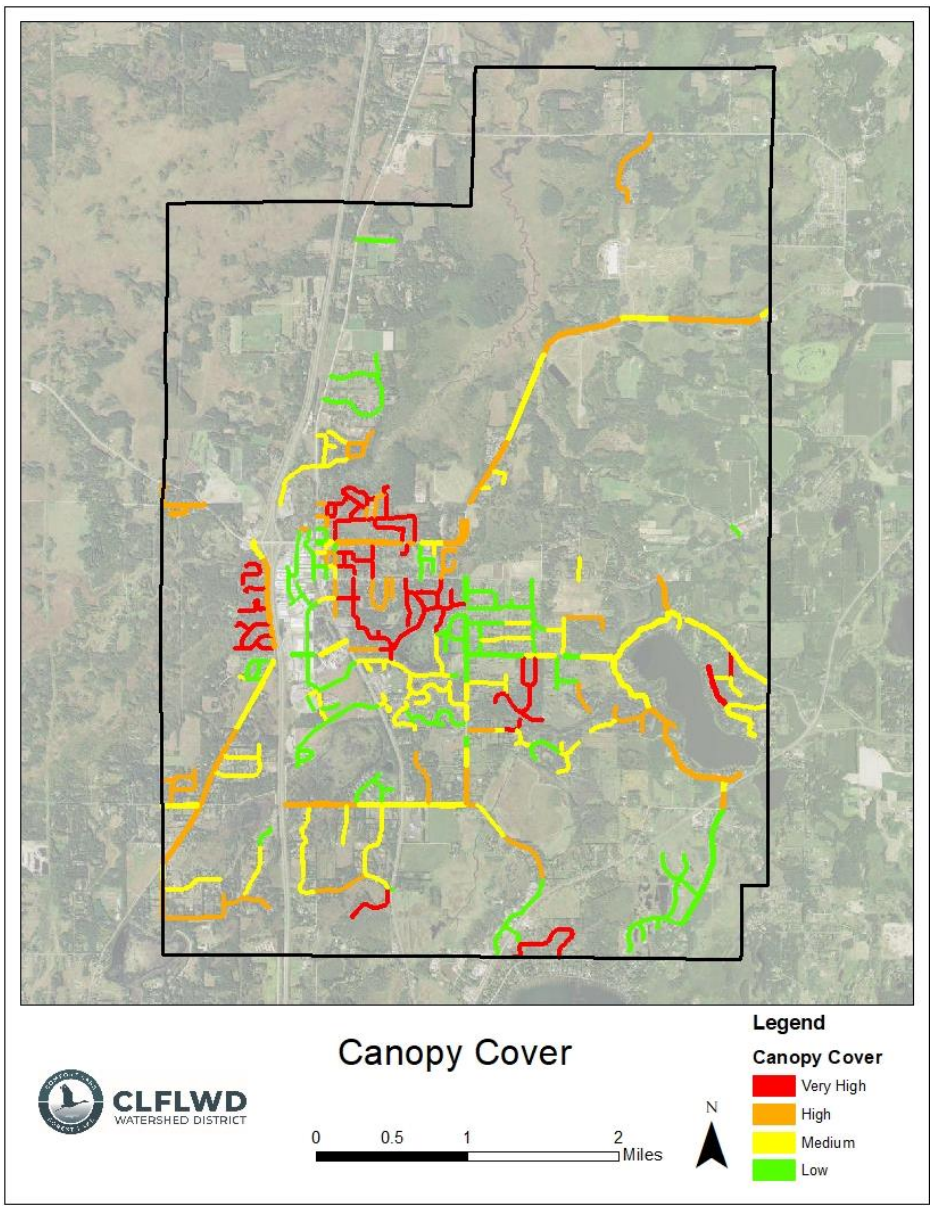


Figure 3: Right-of-way canopy cover ratings for municipal streets within the City of Wyoming; red represents very high, orange high, yellow medium, and green low.

Stormwater System

Streets located in developed areas where roads are connected to storm drains were prioritized for sweeping over those that drain overland to ditches or other surface water conveyances. Storm drains are intended to protect developed areas from flooding by moving water away from buildings and other infrastructure, but they can also transfer organic litter and other pollutants directly from road surfaces to surface waterbodies. Street sweeping can reduce pollutant loads to surface water bodies by removing pollutant before they enter the stormwater drainage network. Street sweeping can also reduce the mass of pollutant transferred from road surfaces to overland conveyances like ditches and swales; however, these conveyances are typically vegetated, which allows some of the runoff and pollutants to be retained on the landscape.

To rank streets for sweeping priority with respect to stormwater management, the location of storm drain inlets and discharge points were reviewed. Inlets are points where stormwater, organic litter, and other pollutants enter the stormwater drainage system from roadways or other surfaces. Discharges points are locations where the stormwater pipes daylight and discharge to land surfaces or surface waters. Clusters of these structures are most common in developed portions of the City and along the Comfort Lake shoreline [Figure 4]. Stormwater drainage system data for the City of Wyoming were provided by the city engineer, WSB.

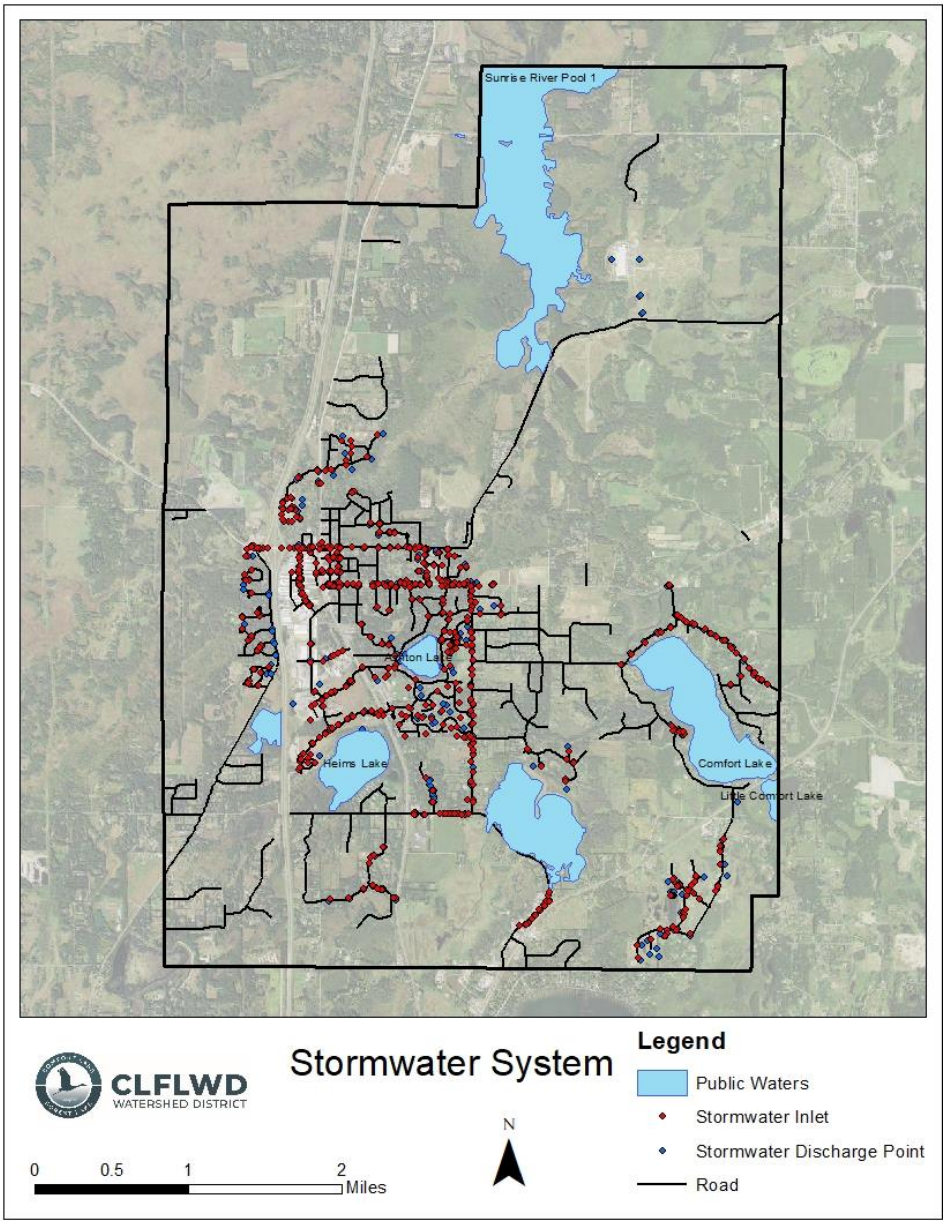


Figure 4: Stormwater Infrastructure in City of Wyoming; red dots represent stormwater inlets while blue represent stormwater discharge points.

Watersheds

The final criteria used to rank street sweeping priorities were hydrologic unit code (HUC) 8 watersheds derived from the Department of Natural Resources (DNR) watershed catchment layer. A total of 7 watersheds were in the target area, Comfort Lake, Forest Lake, Heims Lake, Higgins Lake, Sunrise-Comfort, Sunrise-Mud, and Sunrise-South. Of these, the majority of roads were located in three watersheds, Comfort Lake, Heims Lake, and Sunrise-South [Figure 5]. Comfort, Forest, and Heims Lake watersheds were given preference due to Comfort Lake-Forest Lake Watershed and the City of Wyoming's priorities.

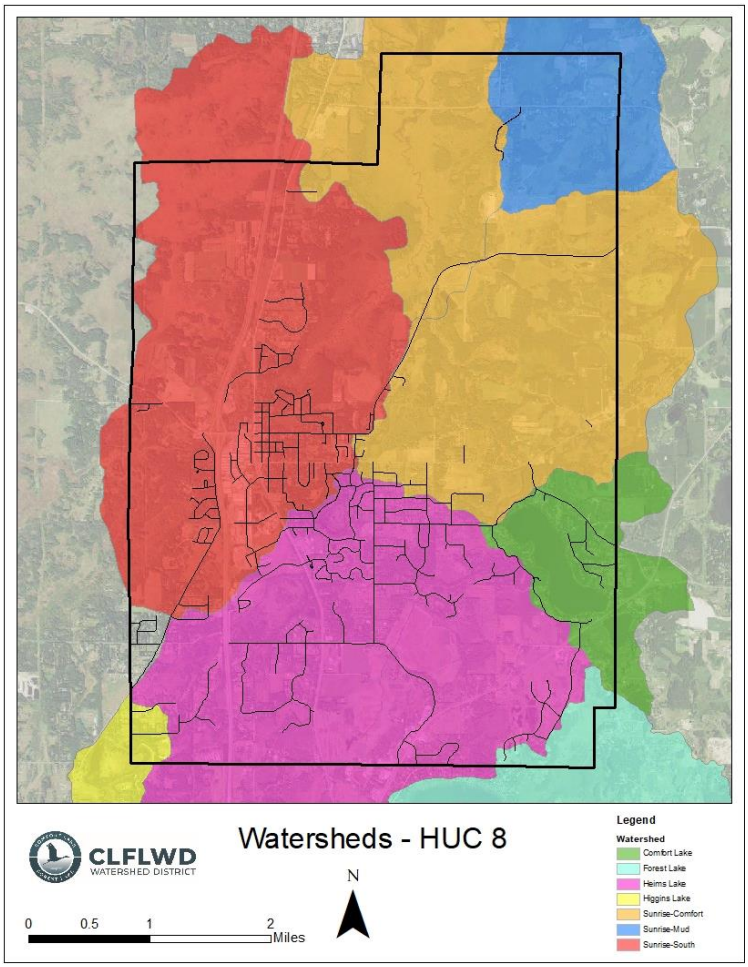


Figure 5: Watersheds located within the City of Wyoming and containing roads in the study.

5. Findings and Recommendations

Scoring and Identification of Priority Sweeping Areas

Through the characterization and assessment described in the previous section, priority ratings were assigned to street segment for each of the three scoring attributes (canopy cover, stormwater management, and watershed) using the ratings scales summarized in Table 2. A final prioritization score was then calculated for roadway segments by multiplying the three ratings to create a final ranking value with a range of 0 to 8, with 8 being the highest priority.

In the ranking system, existing storm water management (the presence of storm drains) was given the greatest weight since the absence will result in a value of 0 regardless of other variables. While roads without a stormwater system could have been removed from the road network entirely, they were included to account for street sweeping practices (i.e., continuation of a route).

Table 2: Three variables were considered for road prioritization: canopy cover, stormwater system, and watersheds. These variables were assigned numerical values allowing for prioritization.

Street Prioritization Variables					
Canopy Cover		**Stormwater System**		**Watersheds**	
Low	1	Absent	0	Comfort Lake	2
				Forest Lake	2
Medium	2			Heims Lake	2
		Present	1	Higgins Lake	1
High	3			Sunrise-Comfort	1
				Sunrise-Mud	1
Very High	4			Sunrise-South	1

Final prioritization scores are illustrated in Figure 6. High priority areas are shown as red with lower priority rankings shown in green. The lowest priority areas (rank =0) are shown in white. The figure shows high prioritization scores concentrated in three areas: east of Comfort Lake, the area surrounding Ashton Lake, and the area south of Heims Lake. Additionally, the residential area west of Kettle River Boulevard is an area with high values.

The large number of curb miles in the City of Wyoming necessitated the sub selection of priority sweeping routes. Six high priority sweeping routes were identified based on prioritization score, density of roads, and downstream water resources [Figure 6]. The total curb-miles and average right-of-way canopy cover for each priority sweeping route are summarized in [Table 3].

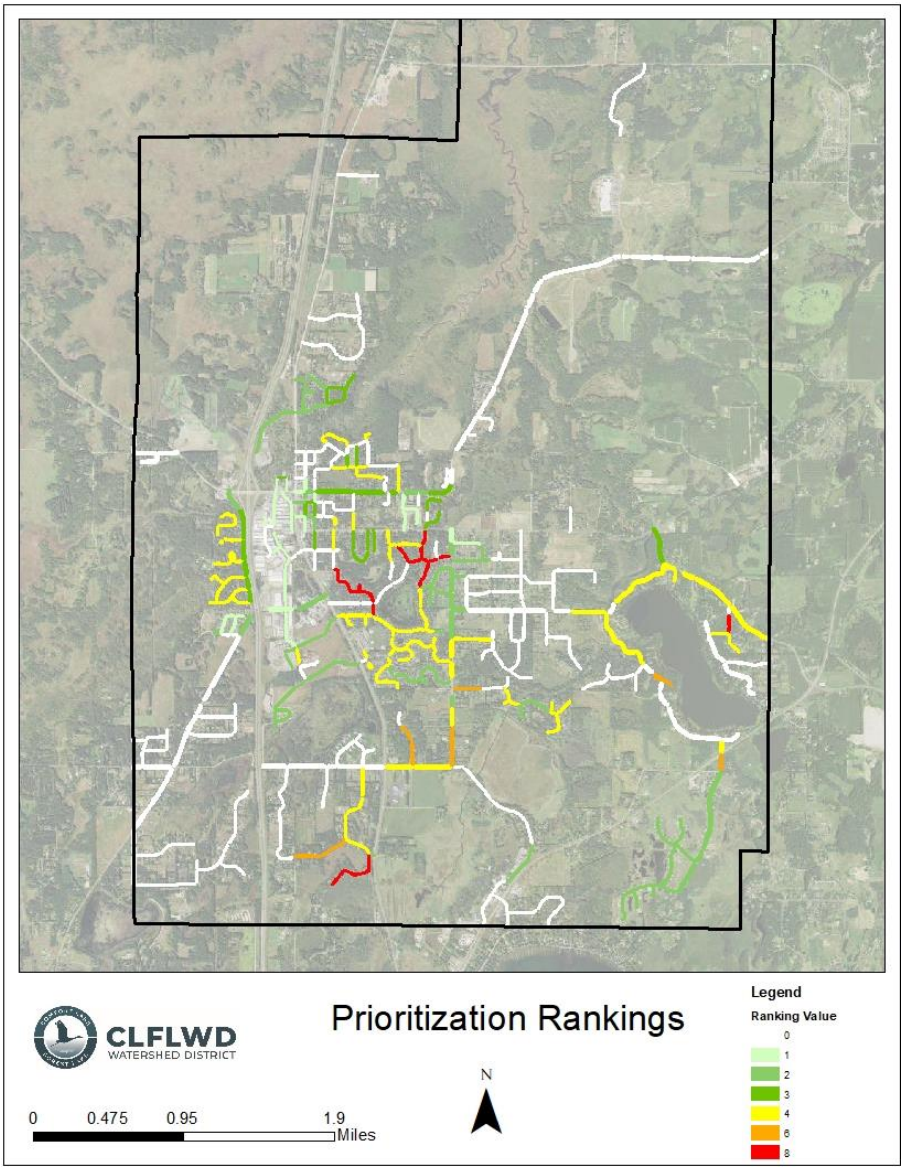


Figure 6: Street sweeping prioritization rankings for municipal street within the City of Wyoming. Prioritization ranking range from 0 (lowest priority) to 8 (highest priority).

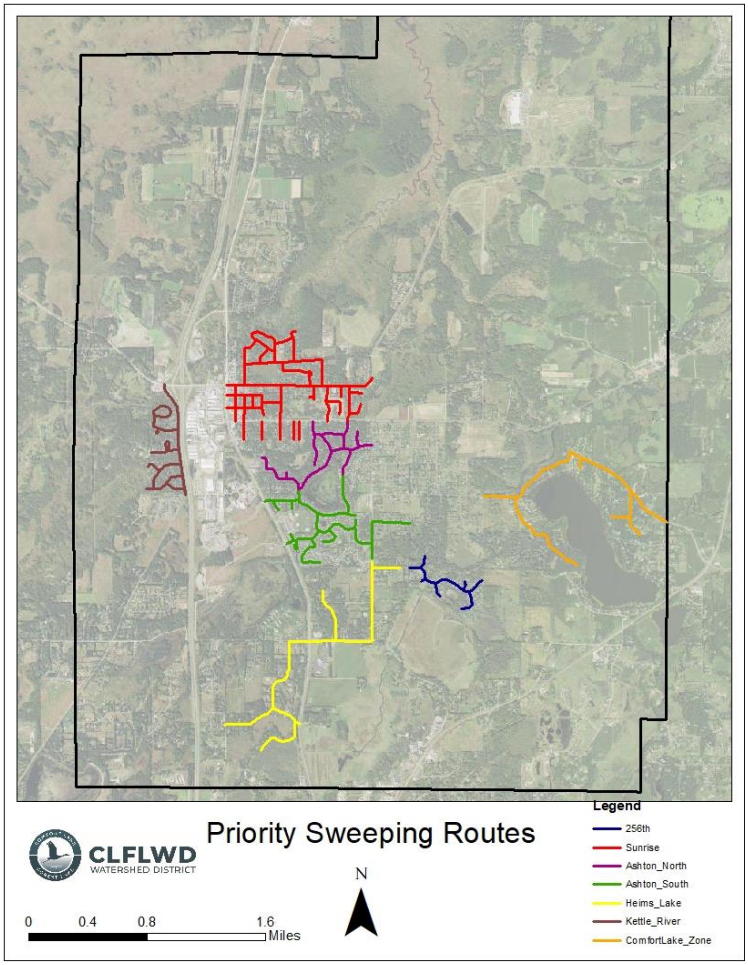


Figure 7: Seven sweeping routes were selected due to their score in the prioritization rankings.

Table 3: Stormwater pollutant reductions and estimated costs for street sweeping require the two variables listed in the table below: Total curb miles and average canopy cover.

Priority Areas		
Name	**Curb Miles**	**Average Canopy Cover**
256th	2.14	12%
Sunrise	13.31	27%
Ashton N.	4.42	40%
Ashton S.	6.44	11%
Heims Lake	6.28	17%
Kettle River	5.07	31%
Comfort Lake	5.58	12%
TOTAL	**43.24**	

Enhanced Sweeping Options

The priority sweeping routes discussed in the previous section include a total of 43.24 curb miles of roadway [Table 3]. The Lower St. Croix Watershed Partnership's Watershed Based Implementation Funding grant program offers street sweeping incentives for up to 50 curb miles, per community, for the three-year cycle. To determine how to best apply grant funds in priority sweeping routes, three enhanced sweeping plan options (plans A, B, and C) were modeled using the University of MN street sweeping planning calculator.

While the average cost per pound of phosphorus (P) increases with sweeping frequency, the average cost remains low at $200.55 per pound of P for the plan with the most sweeping, option 2. Due to this low practice cost, it is recommended for implemented.

Enhanced Sweeping Plan A requires a total of 4 sweeps throughout the year meaning a total of 12.5 curb miles can be covered by the grant in each cycle. The 43.24 curb miles were divided into 3 separate sweeping plans; A, B, and C [Figure 8]. Sweeping Enhanced Sweeping Plan A consists of Comfort Lake, Ashton N, and 2.5 miles of Ashton S. Enhanced Sweeping Plan B consists of the remaining portion of Ashton S, 256th, and Heims Lake. Enhanced Sweeping Plan C consists of 12.5 miles of the Sunrise. These groups were created mainly due to proximity; therefore, the Kettle River priority area was not covered in any of the plans. Each of the plans call for two spring sweepings and two fall sweepings on the identified 12.5 miles. However, It would be beneficial for the City of Wyoming to sweep all roads with a stormwater system even though they are not covered by the Lower St. Croix Watershed Partnership (LSCWP) grant; these streets are listed as low priority in Figures 9-11.

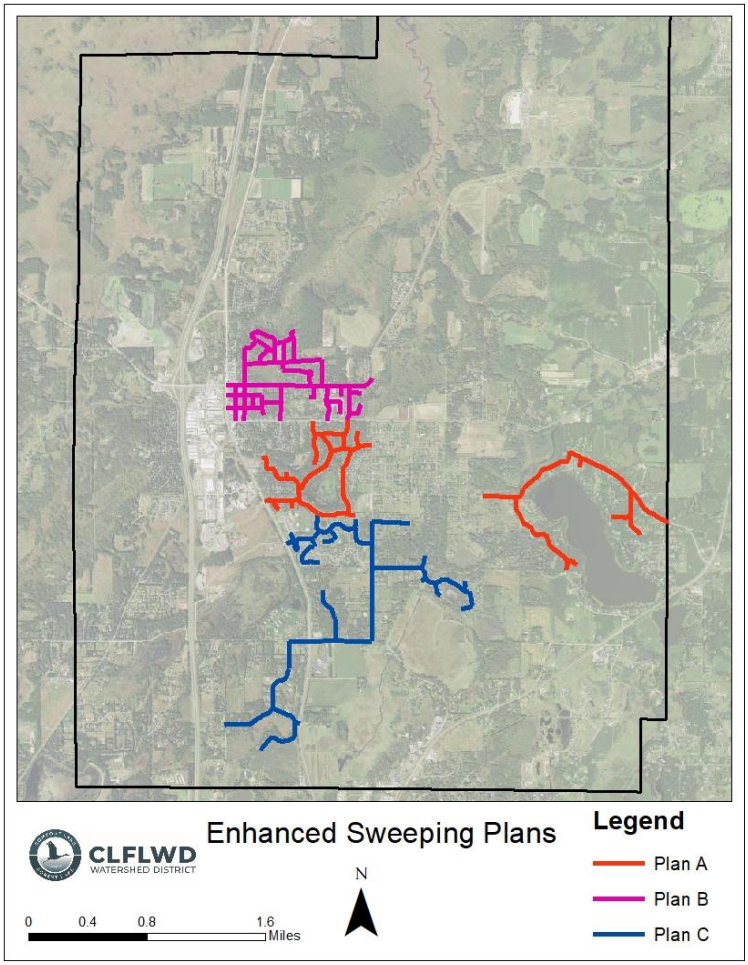


Figure 8: The final three enhanced sweeping plans are shown; plan A in red, plan B in purple, and plan C in blue. All routes have a total length of 12.5 curb miles.

Based on results from the Prior Lake, MN street sweeping study, sweeping is most cost-effective in the spring and fall. The current spring sweeping, which is estimated to remove 15.9 pounds of phosphorus annually at a cost of $272.67 per pound for priority routes [Table 1] should be maintained as a cost-effective practice. To optimized phosphorus recovery, enhanced sweeping plans should first target fall sweeping, especially fall leaf drop. Based on estimates from the U of MN planning calculator, adding one sweeping during fall leaf drop will increase removal of phosphorus to 58.9 pounds annually at an average cost of $146.92 per pound [Table 4].

Table 4: Maintaining the spring sweeping with an additional sweeping in fall results in an increased phosphorus removal (58.9 lb.) at a reduced average price per pound ($146.92).

Option 1 - Single Spring and Single Fall Sweep						
	Predicted Annual					
Route	Wet solids, lb	Dry solids, lb	Nitrogen, lb	Phosphorus, lb	Cost, $	Average $ Cost/ lb P
Sub-Totals	**102467**	**68823**	**508.7**	**58.9**	**$ 8,648.00**	**$ 146.92**
256th	3098	2199	8.7	1.7	$ 428.00	**$ 250.85**
Sunrise	35052	23437	169.7	20.2	$ 2,662.00	**$ 131.89**
Ashton N	20047	12728	155.8	12.0	$ 884.00	**$ 73.67**
Ashton S	8894	6338	24.1	4.9	$ 1,288.00	**$ 263.75**
Heims	11193	7788	37.7	6.3	$ 1,256.00	**$ 200.75**
Kettle	16074	10578	90.0	9.4	$ 1,014.00	**$ 108.25**
Comfort	8108	5755	22.7	4.5	$ 1,116.00	**$ 249.95**

Kalinosky et al. (2015) found that additional sweepings, especially spring, can result in increased nutrient removal. This was tested for the priority areas in the City of Wyoming by running a model for double spring and fall sweeping. The model resulted in a greater estimated nutrient removal, 86.2 lb. of phosphorus, but the overall estimated cost per pound of phosphorus increased to $200.55 per pound [Table 5].

Table 5: Double spring and fall sweepings result in a greater modeled removal of phosphorus but at an increased average cost.

Option 2 -Double Spring and Double Fall Sweep						
	Predicted Annual					
Route	Wet solids, lb	Dry solids, lb	Nitrogen, lb	Phosphorus, lb	Cost, $	Average $ Cost/ lb P
Sub-Totals	**144123**	**99922**	**864.0**	**86.2**	**$17,296.00**	**$ 200.55**
256th	4358	3193	14.8	2.5	$ 856.00	**$ 342.41**
Sunrise	49301	34027	288.2	29.6	$ 5,324.00	**$ 180.03**
Ashton N	28197	18479	264.6	17.6	$ 1,768.00	**$ 100.56**
Ashton S	12510	9203	40.9	7.2	$ 2,576.00	**$ 360.02**
Heims	15744	11308	64.0	9.2	$ 2,512.00	**$ 274.03**
Kettle	22609	15358	152.9	13.7	$ 2,028.00	**$ 147.76**
Comfort	11404	8355	38.6	6.5	$ 2,232.00	**$ 341.19**

A hybrid option of option 1 and 2 would be a double spring sweeping and a single fall sweeping [Table 6]. Kalinosky et al. (2015) found multiple spring passes can increase the amount of winter residual capture. Overall, Option 3 resulted in lower phosphorous removal, 78.6 lb., then option 2, 86.2 lb., but at a lower average price, $165.05 versus $200.55 per lb. of P.

Table 6: Option 3 has double spring sweeping and a single fall sweep; it has a similar average $ cost/lb. of P as Option 1 but results in lower overall P removal than option 2.

Option 3 -Double Spring and Single Fall Sweep						
Route	Predicted Annual					
	Wet solids, lb	Dry solids, lb	Nitrogen, lb	Phosphorus, lb	Cost, $	Average $ Cost/ lb P
Sub-Totals	**142254**	**98359**	**681.4**	**78.6**	**$12,972.00**	**$ 165.05**
256th	4301	3143	11.6	2.3	$ 642.00	**$ 281.81**
Sunrise	48662	33494	227.3	26.9	$ 3,993.00	**$ 148.16**
Ashton N	27832	18190	208.7	16.0	$ 1,326.00	**$ 82.76**
Ashton S	12348	9059	32.2	6.5	$ 1,932.00	**$ 296.30**
Heims	15540	11131	50.5	8.4	$ 1,884.00	**$ 225.53**
Kettle	22316	15117	120.6	12.5	$ 1,521.00	**$ 121.61**
Comfort	11256	8225	30.5	6.0	$ 1,674.00	**$ 280.80**

6. Final Plans

The identified priority areas had a total of 43.24 curb miles [Table 3]. The Lower St. Croix Watershed Partnership's Watershed Based Implementation Funding grant program offers street sweeping incentives for up to 50 curb miles, per community, for the three-year cycle. Three alternative sweeping plans [Table 4, 5 & 6] were modeled using the Kalinosky et al. 2014 estimator, a direct correlation was found between number of sweeps, amount of nutrient removal, and average cost per pound of phosphorus (P) removed [Table 7]. While the average cost per pound of P increases with sweeping frequency, the average cost remains low at $200.55 per lb. of P for the plan with the most sweeping, option 2. Due to this low cost, option 2 is recommended for implementation [Table 8].

Option 2 requires a total of 4 sweeps throughout the year meaning a total of 12.5 curb miles can be covered by the grant in each cycle. The 43.24 curb miles were divided into 3 separate enhanced sweeping plans; A, B, and C [Figure 8]. Enhanced Sweeping Plan A consists of Comfort Lake, Ashton N, and 2.5 miles of Ashton S. Enhanced Sweeping Plan B consists of 12.5 miles of the Sunrise. Enhanced Sweeping Plan C consists of the remaining portion of Ashton S, 256th, and Heims Lake. These groups were created mainly due to proximity; therefore, the Kettle River priority area was not covered in any of the plans. Each of the plans call for two spring sweepings and two fall sweepings on the identified 12.5 miles. However, It would be beneficial for the City of Wyoming to sweep all roads with a stormwater system even though they are not covered by the Lower St. Croix Watershed Partnership (LSCWP) grant; these streets are listed as low priority in Figure 9-11.

Table 7: Comparison of total phosphorous removal by pound per year based on different sweeping routes and sweeping scenarios.

	Total Phosphorus (TP) and Sediment (TS) Removal (lb/yr)					
	Sweeping Route					
	Plan A		Plan B		Plan C	
Sweeping Scenario*	TP	TS	TP	TS	TP	TS
Existing	4.9	13,440	5.1	14,041	2.9	10,547
Option 1	18.4	52,578	19	54,920	10.9	41,242
Option 2	26.9	74,903	27.8	78,245	16.0	58,762
Option 3	24.5	73,850	25.4	6,990	14.6	57,936

**Existing scenario is one spring sweep, Option 1 is one spring and fall sweep, Option 2 is two spring and two fall sweeps, Option 3 is two spring and one fall sweep. These load recovery estimates are based on material removed from the street surface and do not reflect total load reductions to the downstream lakes. The actual load reduction to downstream water resources achieved through street sweeping is less than the total load recovery (generally 50% or less) and depends on the number and type of BMPs along the treatment train.*

Table 8: Comparison of estimated cost per lb of P removed for Option 2 [Table 6] based on the plans shown in Figure 8.

Route Cost Comparison	
Plan	Estimated $ Cost Per lb of P
A	$185.78
B	$179.86
C	$311.88

7. Recommended Plan

Enhanced Sweeping Plan A, shown in Figure 9, is recommended for implementation during the first three-year grant cycle. Streets shown in green in the figure should be swept twice in spring and twice in fall. Roads shown in yellow are lower priority. Recommendations include adding a fall sweeping in these areas.

The Enhanced Sweeping Plan A area contains the Comfort Lake priority area which is adjacent to an important surface water resource, and the Ashton N area which has the densest right-of-way tree canopy [Figure 9] [Table 3]. Also, an additional 2.5 curb miles from Ashton S to create a total area of 12.5 curb miles, this section was added due to proximity. If possible, the City of Wyoming should also sweep all streets with a stormwater system not covered by sweeping Enhanced Sweeping Plan A. A cost of $100 was used in the model, resulting in an estimated annual cost of $5,000 for recommended roads and $7,651.11 low priority roads. Overall, the sweeping would remove a modeled 24.5 pounds of phosphorus each year for recommended roads.

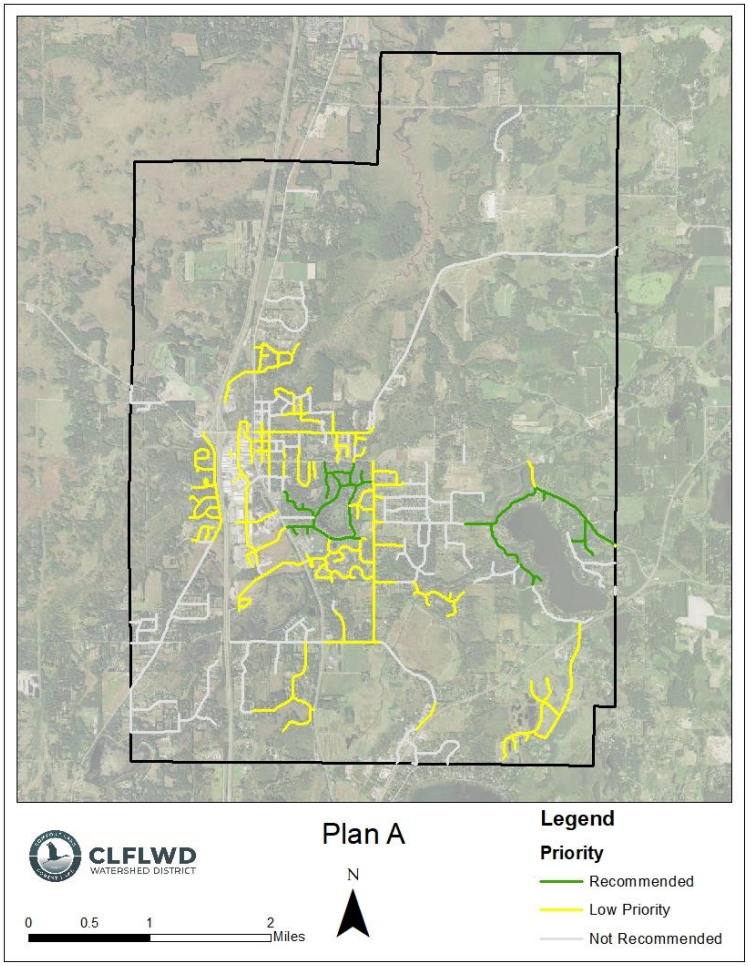


Figure 9: Enhanced Sweeping Plan A is the recommended street sweeping plan for implementation. Streets shown in green should be swept twice in spring and twice in fall. Yellow roads are low priority and, if possible, the City of Wyoming should sweep once in the spring and fall.

8. Future Plans

Future Goals for Enhanced Street Sweeping

Enhanced Sweeping Plan A covers about 30% of the roads identified in the priority areas creating opportunity for future sweeping plans. Two other options – Enhanced Sweeping Plans B, and C, were developed. These options cover the remaining municipal roads except those in the Kettle River drainage area [Figure 10 and 11]. Of the two options, Plan B should be implemented next due to the lower estimate cost of $179.86 per pound of phosphorus compared to ~$311.88 for Enhanced Sweeping Plan C. Low priority roads including the areas covered by Plan A should be swept at least once in the spring and fall. If a third round of funding is pursued, Enhanced Sweeping Plan C should be implemented.

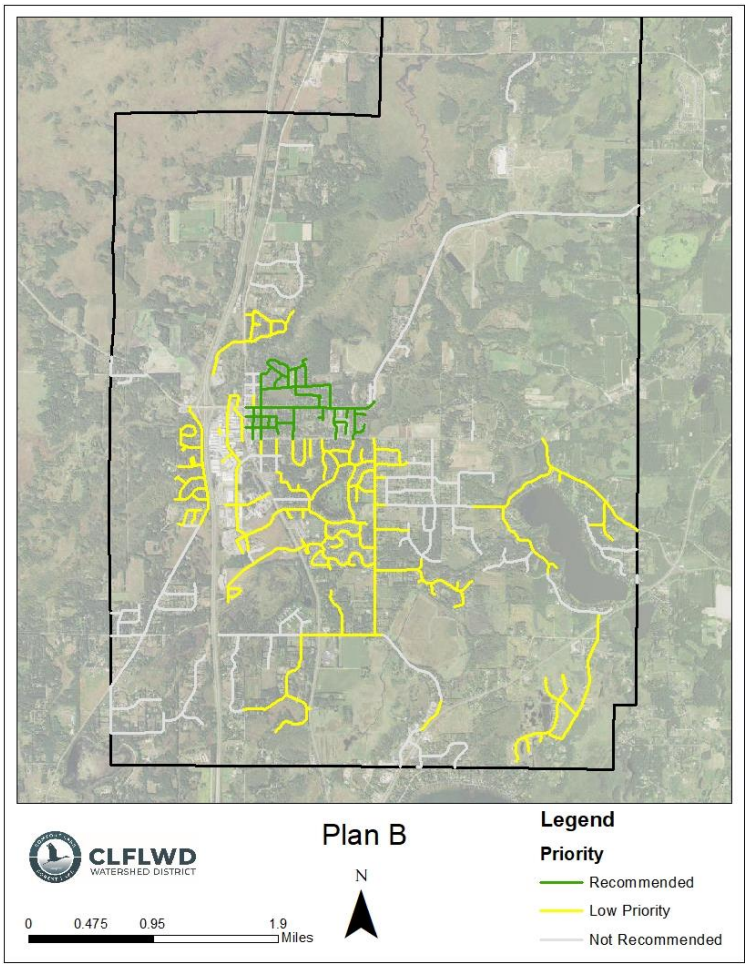


Figure 10: Enhanced Sweeping Plan B, streets in green should be swept twice in spring and twice in fall. Yellow roads are low priority and if possible, the City of Wyoming should sweep once in the spring and fall.

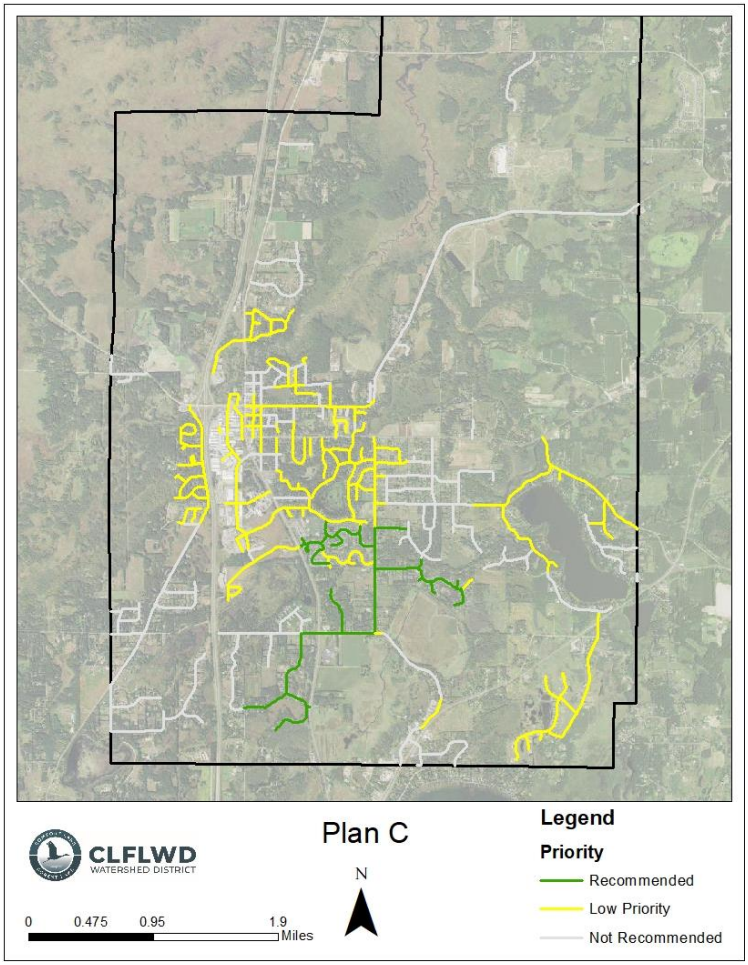


Figure 11: Enhanced Sweeping Plan C, streets in green should be swept twice in spring and twice in fall. Yellow roads are low priority and if possible, the City of Wyoming should sweep once in the spring and fall.

9. References

Lower St. Croix Watershed Partnership (LSCWP) and Emmons and Olivier Resources Inc. (EOR). Tree Canopy Assessment Protocol for Enhanced Street Sweeping Prioritization. 2022.

Kalinosky, P., L.A. Baker, S.E. Hobbie, R. Binter, and C. Buyarski. 2014. User Support Manual: Estimating Nutrient Removal by Enhanced Street Sweeping. Minneapolis, MN.

Kalinosky, P.M. 2015. Quantifying Solids and Nutrient Recovered Through Street Sweeping in a Suburb Watershed. A Thesis Submitted to the Faculty of University of Minnesota. Minneapolis, MN.

10. Appendix:

Right of Way Tree Canopy Cover Classification Categories

The following canopy cover classifications were used to rank streets for sweeping priority with respected to right-of-way tree canopy cover. Canopy cover was assessed visually using aerial imagery and the visual tree canopy assessment guide in Appendix A of the LSCWP Tree Canopy Assessment Protocol.

Table 9. Canopy cover classification scheme used prioritize streets for sweeping.

Right of Way Tree Canopy Characterization	
Canopy Cover Classification	**Average ROW Canopy Cover (%)**
Low	3
Medium	10
High	20
Very High	40