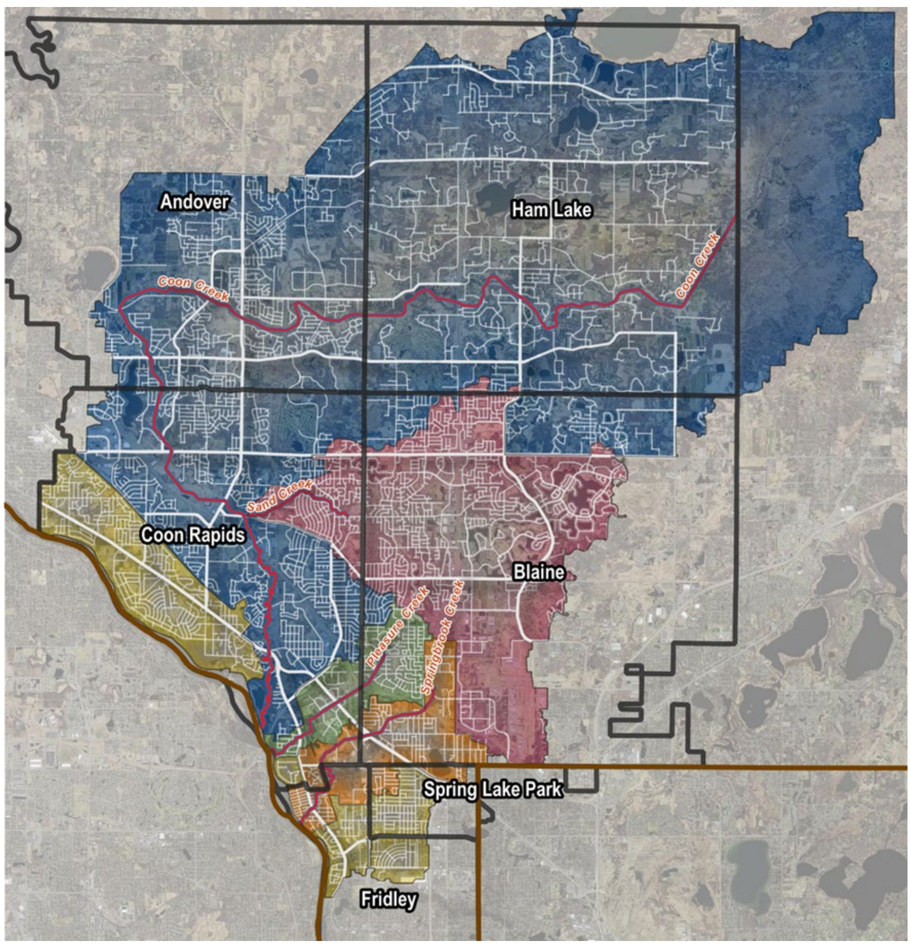
Prepared by: EOR

For the Coon Creek Watershed District

Coon Creek Watershed District Street Sweeping Crediting Study Phase II



EOR water ecology community

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1. INTRODUCTION

The Coon Creek Watershed District (CCWD) contracted Emmons & Olivier Resources, Inc. to complete a two-part study on street sweeping for water quality. The purpose of this study was to 1) inventory past and present sweeping practices to fulfil compliance tracking requirements as part of municipal stormwater general permit, MNR040000 (Phase 1) and 2) provide recommendations for enhanced sweeping practices to address water quality impairments (Phase 2). CCWD contains four streams impaired for both aquatic life and recreation including Coon Creek, Sand Creek, Pleasure Creek, and Springbrook Creek. Excess total phosphorus (TP) was identified as a primary stressor to aquatic biota for all four streams and total suspended solids (TSS) in all streams except Springbrook Creek. Required pollutant loading reduction targets known as Wasteload Allocations (WLAs) were established for TP and TSS as part of the 2016 Total Maximum Daily Loading (TMDL) study. It is the joint responsibility of all MS4s within the watershed (Andover, Anoka County, Blaine, CCWD, Coon Rapids, Fridley, Ham Lake, MnDOT, and Spring Lake Park) to achieve WLAs for each receiving water.

During Phase I of the CCWD Street Sweeping Study, data was collected and summarized from each participating MS4 about their existing street sweeping practices from 2009 through 2022 to represent the period since the TMDL baseline year. Pollutant load reductions and associated credits for TP and TSS were estimated using methods defined by the Minnesota Pollution Control Agency (MPCA) for the four impaired streams within the CCWD (Figure 1). A detailed summary of the Phase I methods and results are included as part of the project deliverable and a summary memo is included in Appendix B.

The purpose of the second phase of this study (this report) was to build off the work completed in Phase I to provide recommendations to each of the MS4s within the CCWD on how they can enhance their street sweeping programs to maximize water quality benefits to receiving waters and respective pollutant reduction credits. Recommendations include sweeping zone prioritization, road-specific street sweeping timing and frequency, predicted TP and TSS load reductions to each impaired stream, and itemized costs for the recommended sweeping strategies. The results of this study enable cost-benefit comparisons between street sweeping and other stormwater best management practices to inform implementation of targeted, cost-effective projects and practices. This phase of the study was partially funded by a Minnesota Clean Water Fund grant.

CLEAN WATER LAND & LEGACY AMENDMENT

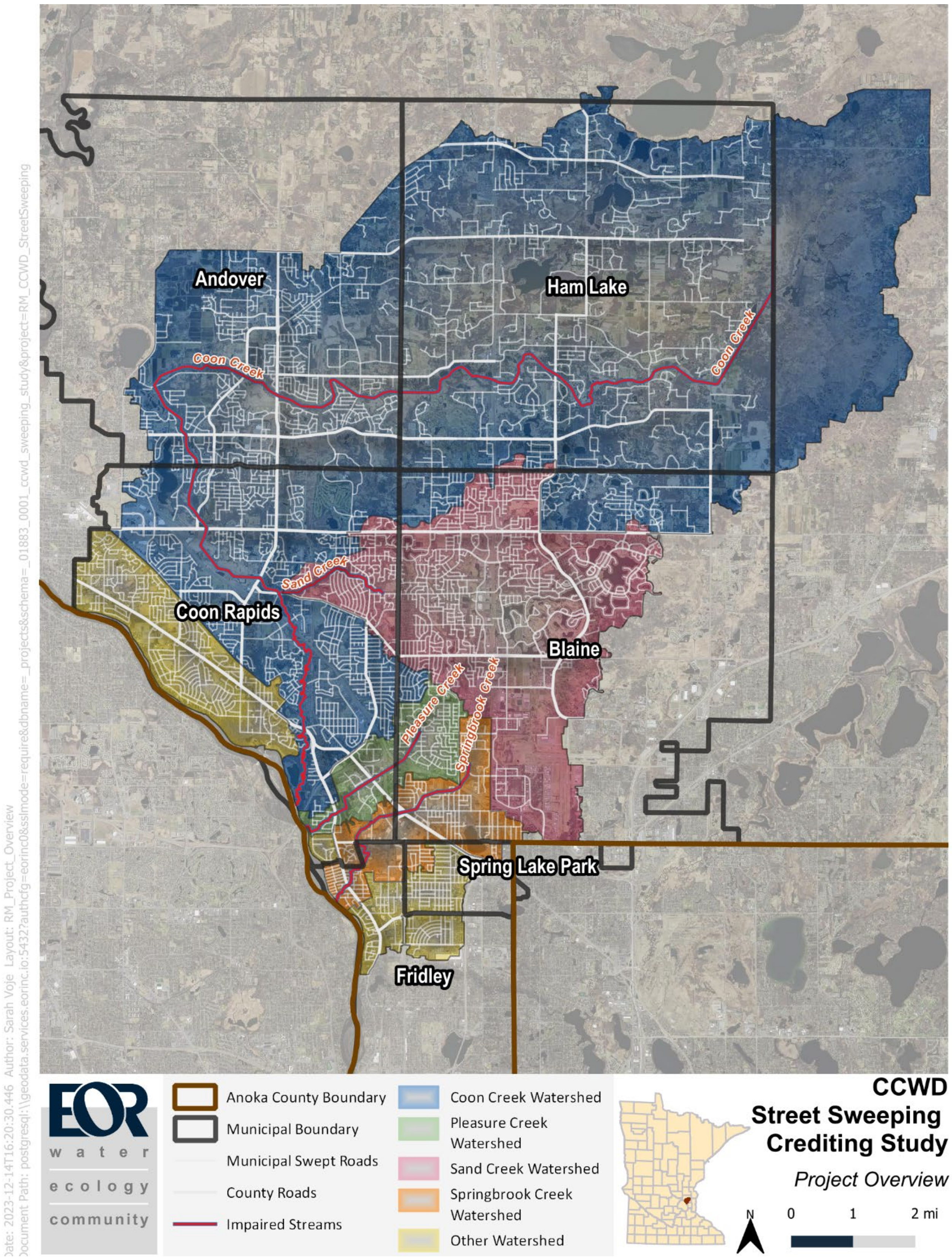

Figure 1 CCWD street sweeping MS4s, and impaired stream reaches and drainage areas. Other watershed represents direct drainage to Mississippi River.

2. METHODS

Information about each MS4's existing sweeping program was collected through two questionnaires sent out to each MS4 inquiring about equipment type and number, number of complete street sweepings per year, costs, and sweeper operation. Table 1 summarizes the existing sweeping each MS4 completes each year within the CCWD as of 2022, and the amount of associated pollutant reduction credits calculated using MPCA-approved methods. It should be noted that MS4s are only eligible to claim credits associated with sweeping activities above and beyond those implemented during the TMDL baseline year for each impaired reach (2009-2012); eligible credits for each MS4 are summarized in the Phase 1 Summary Memo (Appendix B). Sweeping length is reported in lane-miles which is typically twice the road length for a two-way street. All MS4s sweep their streets a minimum of once in the spring and once in the fall. Also, all MS4 sweeping programs extend to their entire MS4 boundary and not just within the CCWD. Table 2 summarizes the roads within each MS4 and within CCWD. The road length was used throughout Phase II to adjust MS4 totals to MS4 totals within CCWD. All costs and pollutant loads are estimated for each MS4 to the CCWD boundary and do not reflect the total for the entire MS4. Table 3 shows the total number of street sweepers in each MS4's fleet and the adjusted number of sweepers estimated for the area within CCWD. The type of street sweeper as either regenerative air or mechanical broom are included because the type of street sweeper has an impact on costs and potentially the pollutant pickup efficiency. Mechanical broom street sweepers are generally less expensive and better at picking up larger particles. Regenerative air street sweepers are more expensive but, they are better at picking up smaller particles and some studies suggest they remove more pollutants from the street (Law, DiBlasi, and Ghosh 2008). However, a recent study in the Twin Cities Metro Area did not find a noticeable difference between the two types of street sweepers in pollutant removal (Hobbie et al. 2023). Tandem sweeping is a sweeping strategy in which a mechanical broom and a regenerative air street sweeper follow each other along the same route. The combined use of different sweeper types increases the sweeping removal efficiency. Multiple passes of one street sweeper would be needed to have the same effect. Given conflicting research findings, the differences in sweeper type pickup efficiency was not accounted for in this study. However, MS4s that employ tandem sweeping or upgrade their existing equipment and can demonstrate increased pickup efficiency through volume or mass measurements can maximize eligible pollutant reduction credits without increasing sweeping effort. Spring Lake Park relies on contract street sweeping and does not own any street sweepers.

Table 1. Baseline Sweeping Effort (2022) and Associated Credits for each MS4 within the CCWD

MS4	Total Lane-miles	Swept Lane-Miles	Number of Sweepings per Year	TP Credits[1] (lbs/yr)	TSS Credits[1] (tons/yr)	Credit Calculation Method
Andover	216.1	576.3	2.67	369.5	1.33	Mass
Anoka County	263.0	364.7[2]	2	1,071.1	1.35	Volume
Blaine	425.8	1916.1	4.5	1,263.3	2.51	Volume
Coon Rapids	448.1	2464.6	5.5	2,232	3.41	Volume
Fridley	52.4	393	7.5	0.032	0.14	Miles Swept
Ham Lake	270.4	540.8	2	0.1318	1.61	Miles Swept
Spring Lake Park	43.5	87	2	0.004	0.08	Miles Swept

[1]TP and TSS Credits in Phase 1 do not include Mississippi River credits; not all credits reported here are eligible for TMDL compliance reporting (see Tables 2-3 in Appendix B for a summary of "eligible" credits for each MS4).
[2]Anoka County does not sweep all roads.

Table 2 Road Length (mi) within each MS4 and CCWD

MS4	Total Road Length (mi)	CCWD Road Length (mi)	Roads within CCWD (% of Total)
Andover	204.3	108.0	53%
Anoka County	519.1	131.5	25%
Blaine	275.9	212.9	77%
Coon Rapids	226.6	226.6	100%
Fridley	108.4	26.2	24%
Ham Lake	151.2	135.2	89%
Spring Lake Park	26.8	21.7	81%

Table 3. MS4 Street Sweeper Inventory

MS4	Number of Regenerative Air Street Sweepers	Number of Mechanical Broom Street Sweepers	Number of Street Sweepers Allocated to CCWD
Andover	2	1	1.6
Anoka County	0	2	0.5
Blaine	4	1	3.9
Coon Rapids	1	1	2.0
Fridley[1]	1	1	0.5
Ham Lake[1]	0	2	1.8
Spring Lake Park	0	0	0

[1]Fridley and Ham Lake use tandem sweeping where two street sweepers sweep the same street in combination.

2.1. Sweeping Zone Prioritization

The priority score for each sweeping zone is shown in Figure 2 and Figure 3 on a scale from four through twelve, with twelve being the highest priority for enhanced sweeping for water quality. The priority score considers metrics related to both the source and fate of pollutants in each zone including road tree canopy cover percentage, BMP density defined as the drainage area per BMP, and the percentage of each zone directly connected to the stream with little to no BMP treatment. The score classification for each category is shown in Table 4. The highest priority sweeping zones have dense road tree canopy, sparse BMP density, and are directly connected to the stream. Road tree canopy is estimated using the Twin Cities Metro Area high resolution land cover data set and Minnesota Department of Transportation (MN DOT) roads layer (Host, Knight, and Rampi 2016; MN DOT 2022). BMP density is estimated from the MS4 bmp layers provided as part of the project. The BMPs used to estimate the BMP density are shown in Figure 4 and Figure 5. The directly connected percentage is an estimate created from the CCWD subcatchment layer and through review of aerial imagery and the MS4 provided BMP layers. Moving downstream to upstream subcatchments were identified as directly connected to a stream until a BMP feature (e.g., in-line pond) was identified from either the BMP layers or aerial imagery. Any subcatchment further upstream of the identified BMP feature was assumed to be indirectly connected to the stream and some existing BMP treatment was assumed. The CCWD area assumed to be directly connected to a stream and the percentage of each zone that is assumed to be directly connected to the stream are shown in Figure 6 and Figure 7. All layers used to prioritize the street sweeping zones are included as part of the deliverable.

Equation 1 shows the calculation used to calculate the priority score. The road tree canopy cover score is multiplied by two because this metric directly reflects available litterfall in a catchment and is positively correlated with nutrient concentrations in stormwater runoff and sweepings (Hobbie et al. 2023). These scores can be refined as aerial imagery and BMP inventories are updated over time. Each zone's category value is shown in Table 30 in Appendix A and the zone layer is included as deliverable along with this report.

Table 4 Priority Score Classifications

Priority Classification	Category Score	Road Tree Canopy Cover (%)	BMP Density (acres/BMP)	Directly Connected (%)
Low	1	<20%	<40	<20%
Medium	2	20-30%	40-70	20-60%
High	3	≥30%	≥70	≥60%

Equation 1:

$$\text{Total Priority Score} = \text{Road Tree Canopy Score} \times 2 + \text{BMP Density Score} + \text{Directly Connected Score}$$

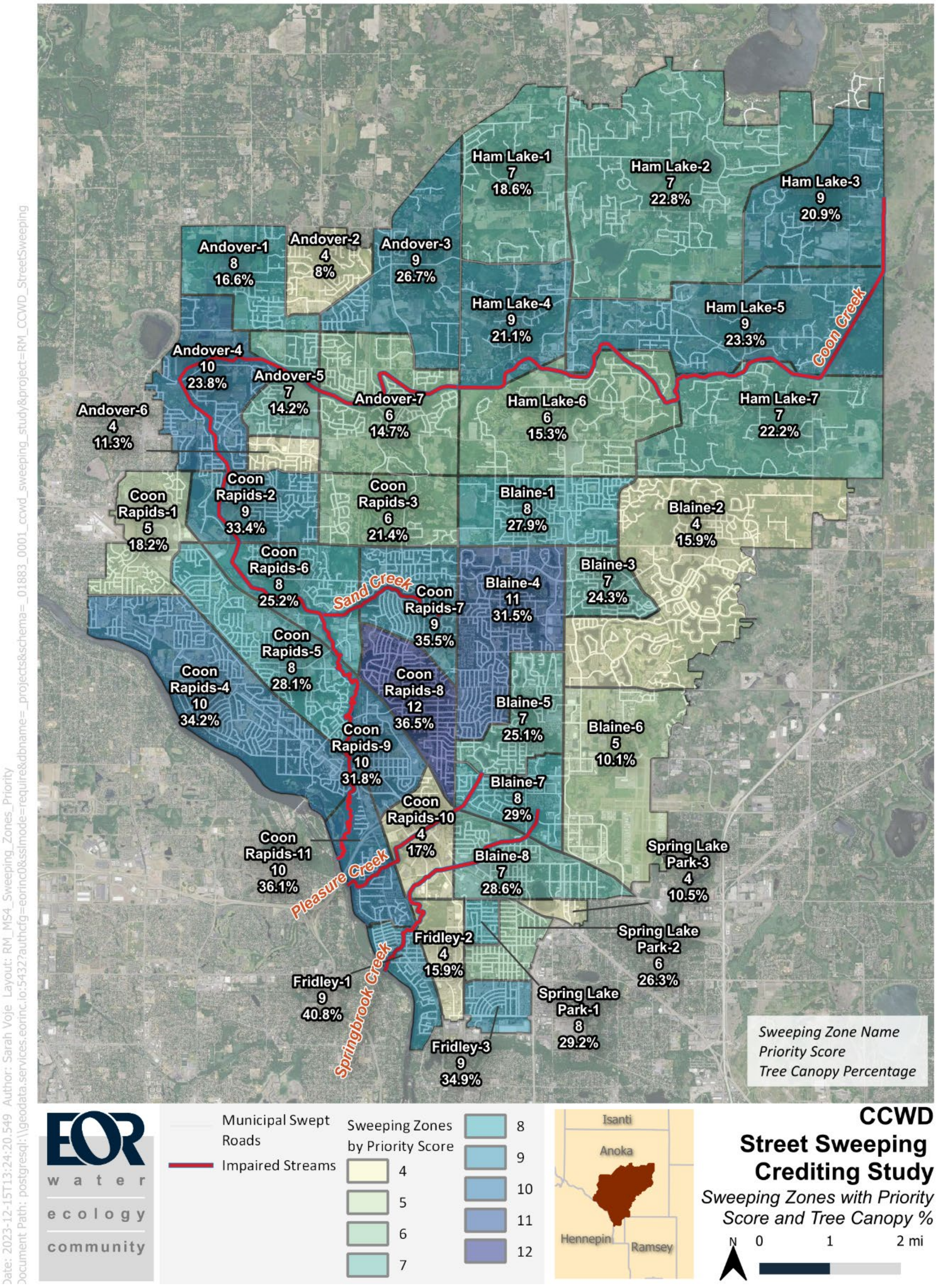

Figure 2 CCWD Municipal MS4 sweeping zones with priority score (4-12) and road tree canopy (%).

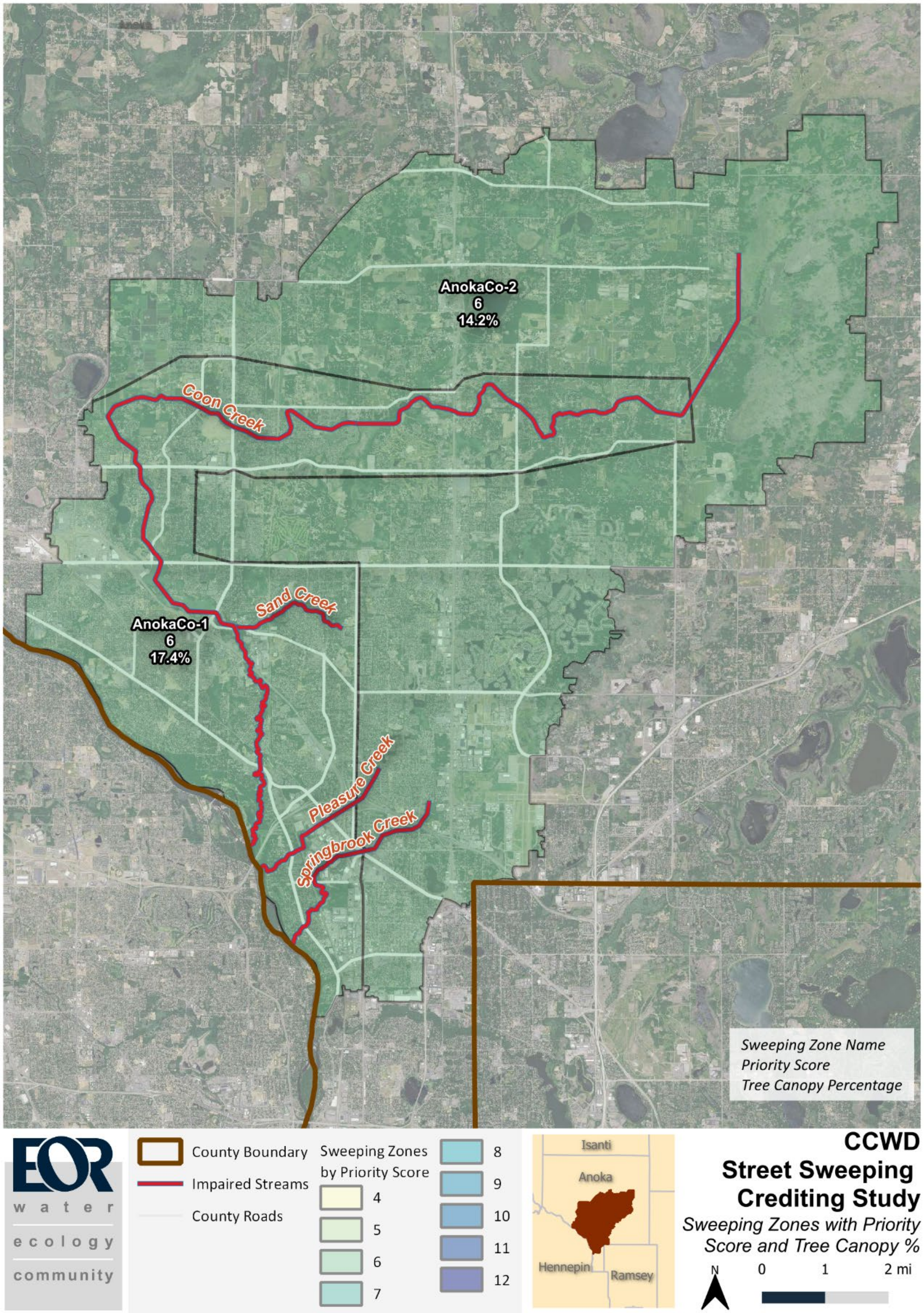

Figure 3 CCWD Anoka county sweeping zones with priority score (4-12) and road tree canopy (%).

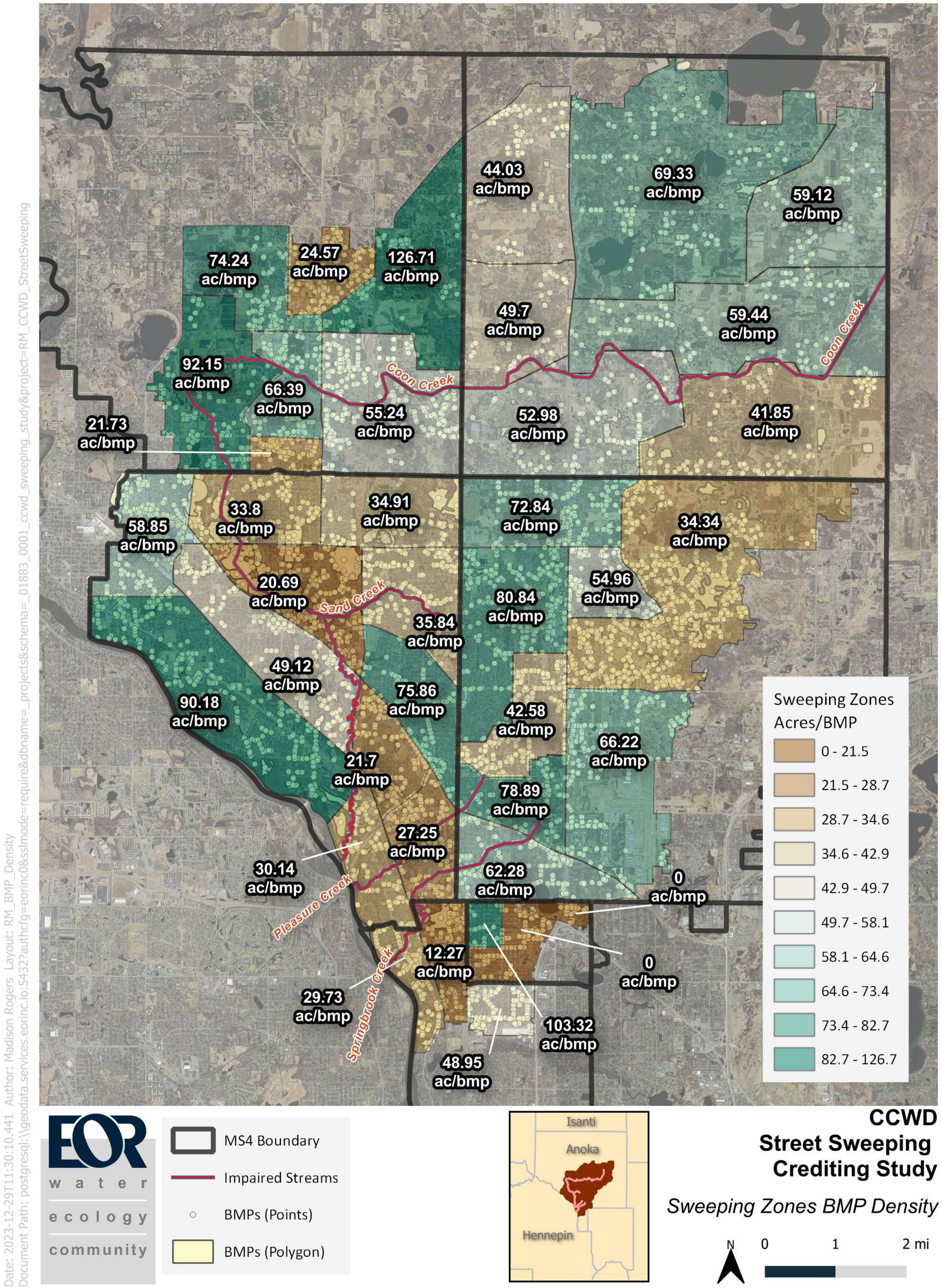

Figure 4 CCWD Municipal MS4 sweeping zones with BMP density (acres/BMP).

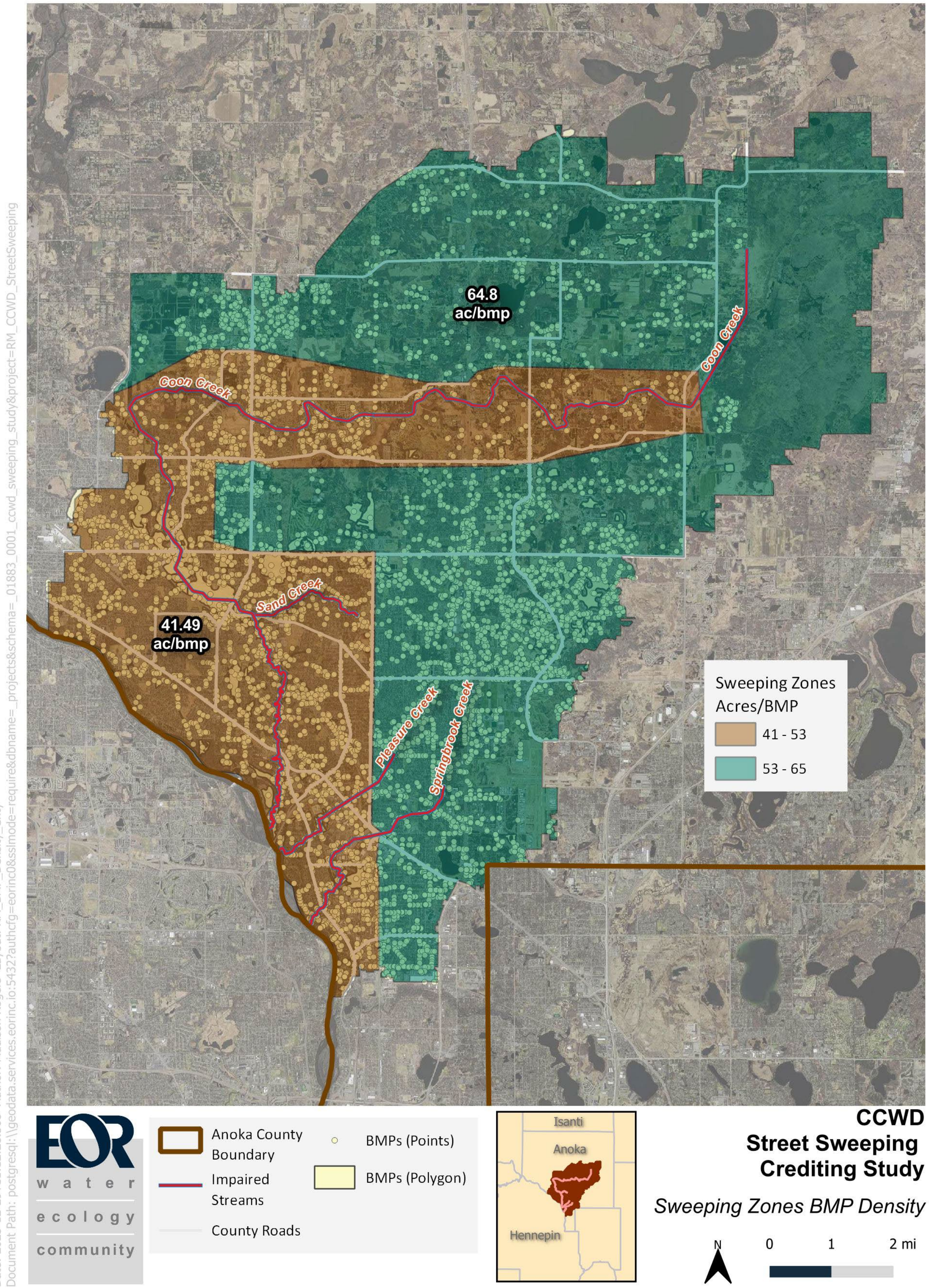

Figure 5 CCWD Anoka county sweeping zones with BMP density (acres/BMP).

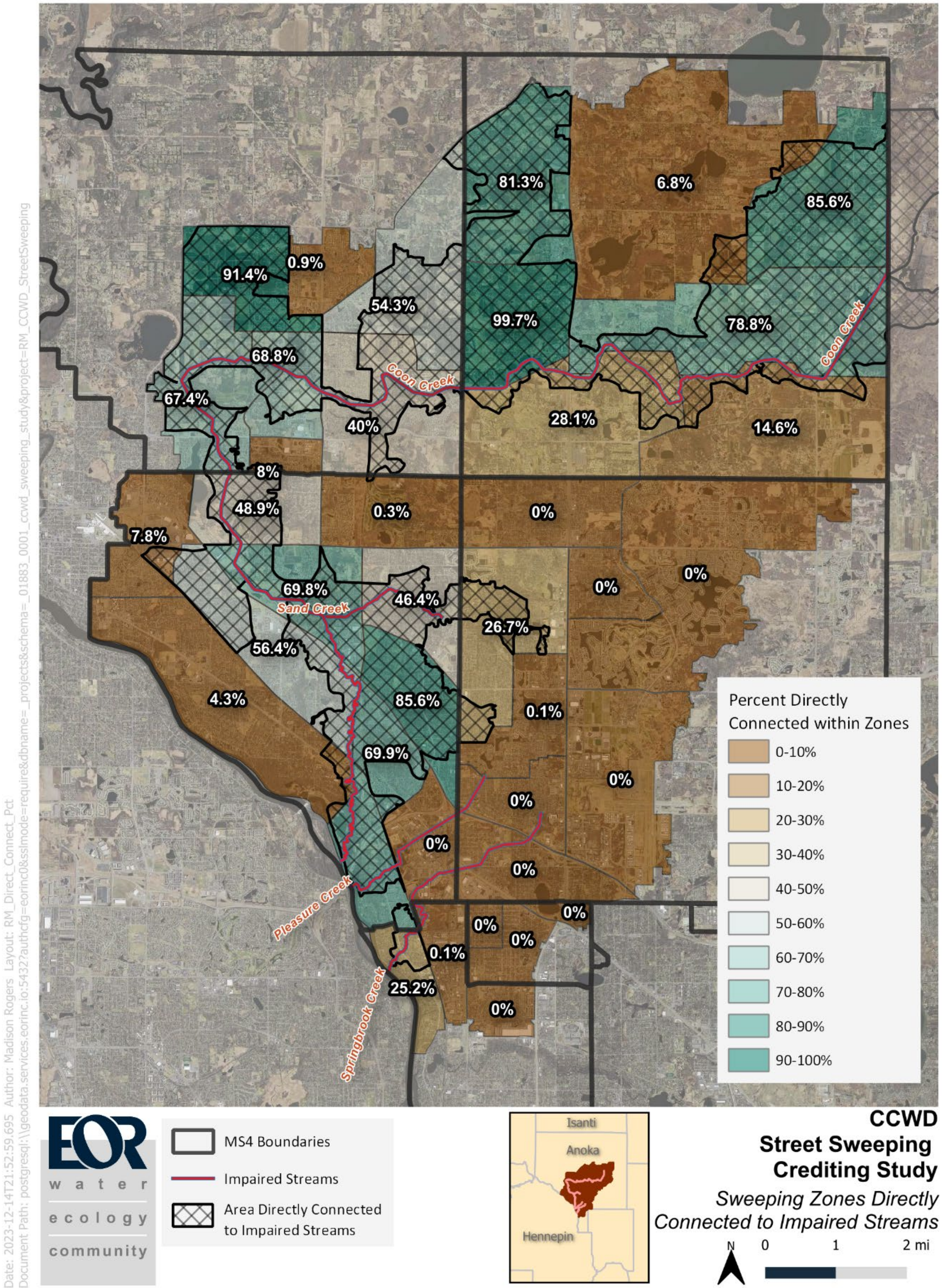

Figure 6. CCWD municipal street sweeping zones directly connected (%) to an impaired stream.

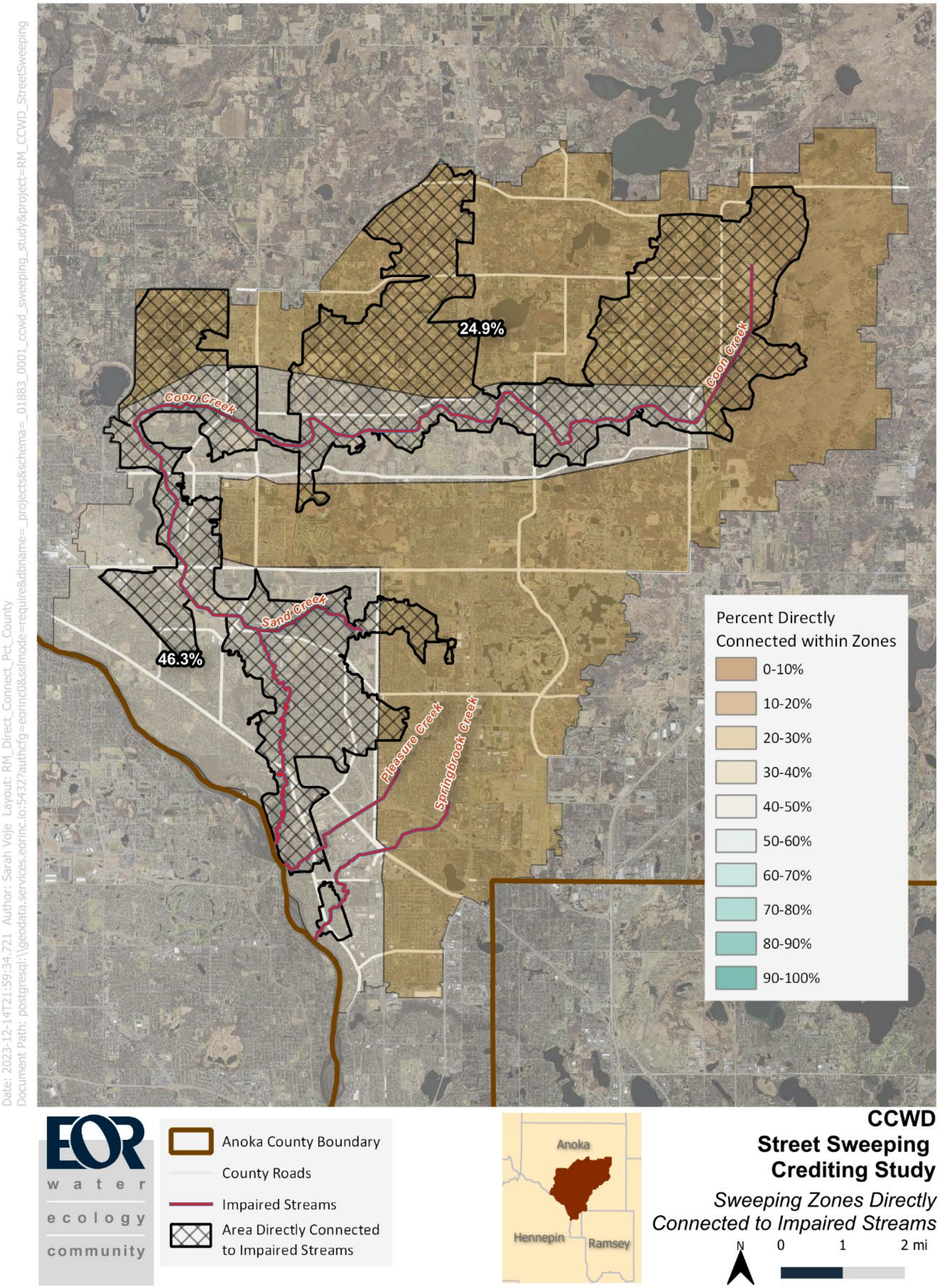

Figure 7. CCWD Anoka county street sweeping zones directly connected (%) to an impaired stream.

2.2. Pollutant Recovery

Pollutant recovery was estimated using a statistical model that relates the road tree canopy percentage to observed pollutant recovery from the roadway in the form of total solids (TS) and TP by month (Kalinosky 2015; Hobbie et al. 2020). The model requires splitting a community into sweeping zones and estimating the road tree canopy percentage and length of lane-miles within each zone. For this study the 1-meter resolution Twin Cities Metro Area land cover classification dataset was used to estimate the tree canopy percentage (Host, Knight, and Rampi 2016). The road tree canopy percentage ranged from 8% to 41%. Lane-miles are typically twice the road length within each zone except for narrow one-way roads. Different sweeping schedules (frequency and timing) can then be evaluated by adjusting the amount of sweeping in each month from April through October. The maximum sweeping available in the model is four times a month or 28 times a year. For this study, the maximum street sweeping evaluated was twelve times a year. A defined set of proposed sweeping schedules were used to simplify the analysis. Table 5 shows the set sweeping schedules evaluated and Figure 8 shows the predicted pollutant recovery across the range of sweeping effort for a representative sweeping zone with 20 lane-miles and 15% road tree canopy percentage. The gain in pollutant recovery for each additional street sweeping begins to decrease around seven or eight times per year or roughly monthly sweeping. The greatest increase in pollutant recovery is between sweeping twice per year which is referred to as baseline sweeping (once in the spring and fall) to sweeping four times per year which is referred to enhanced baseline sweeping (twice in the spring and fall). The timing of enhanced baseline sweeping is important. Sweeping twice in the spring and twice in the fall yields the most pollutant recovery compared to any other sweeping schedule with four complete sweeps. The high spring load is associated with the remaining winter material on the road after the snowmelt followed by tree bloom and bud drop later in the spring. The high fall load is associated with the fall leaf drop (Hobbie et al. 2023). The TS recovery is predicted to increase to 129% which is greater than the 100% increase in street sweeping effort. The TP recovery is predicted to increase 63% according to the statistical model. From a pollutant recovery and cost per effort perspective, enhanced baseline should be the minimum goal for all MS4s within CCWD.

While the model provides predicted pollutant recovery from the roadway, additional calculations were needed to approximate the pollutant reduction at the stream in an attempt to prevent double counting pollutant removal from existing stormwater BMPs and to maximize the actual benefit to the receiving water. A simplified method was developed to adjust the modeled load recovery to the load reduction at the stream using the directly connected percentages estimated during the sweeping zone prioritization process. For areas in the CCWD that were assumed to be directly connected to the stream, no adjustment was needed from the model. For areas that were not directly connected to the stream, it was assumed that runoff passed through at least one stormwater retention pond which already provides some pollutant treatment prior to the pollutants entering the ultimate receiving water. This idea is commonly called a treatment train. According to the Minnesota Stormwater Manual, a design level 1 stormwater retention pond provides 60% TSS removal and 34% TP removal (MPCA 2022). Therefore, for areas in the CCWD that were not directly connected to the stream, the additional street sweeping only removes what would have passed through a stormwater pond and the estimated load was reduced accordingly. Additionally, for TSS removal, the model calculates TS removal and not TSS removal. TSS is the suspended fraction of TS that is silt and clay sized which was assumed to be 5% of the TS based on discussions with the MPCA. In addition, a calibration factor is applied to the TSS calculation because there is much more uncertainty in the TSS removal effectiveness from street sweeping and the statistical model tends to overpredict TS recovery compared to past studies. Equation 2 is the calculation applied to the modeled pollutant recovery to approximate the stream load reduction:

Equation 2:

$$L_{stream} = (L_{road} * DC + L_{road} * (1 - DC) * (1 - R_{pond})) * P_{frac} * CF$$

Where:

- L_{stream} is the stream load reduction,
- L_{road} is the road load recovery,
- DC is the directly connected percentage.
- R_{pond} is the pond pollutant removal rate and,
- P_{frac} is the pollutant fraction from TS to TSS. The TP load was not reduced farther and the P_{frac} is 1.
- CF is the calibration factor for the statistical model and is only used for TSS. The TSS load calibration factor is 75% while the TP load calibration factor is 1.

Table 31 in Appendix A shows the percentage of the modeled road load that is predicted to contribute to the stream for each sweeping zone in the study. Lastly, the total pollutant recovery predicted for each zone was split to each impaired stream that the zone was shown to contribute to using the percentage of lane miles in each zone within each impaired streams watershed. The load reduction estimated by the method used in this study is approved by the MPCA on a pilot basis if the MS4s meet certain record-keeping criteria described in Section 4.8.

Table 5 Set Sweeping Schedules

Number of Sweepings	Number of Monthly Sweepings						
	April	May	June	July	August	September	October
2	1						1
3	1	1					1
4	1	1				1	1
5	1	1		1		1	1
6	1	1	1			1	2
7	1	1	1	1	1	1	1
8	1	1	1	1	1	1	2
9	2	1	1	1	1	1	2
10	2	2	1	1	1	1	2
11	2	2	1	1	1	2	2
12	2	2	2	1	1	2	2

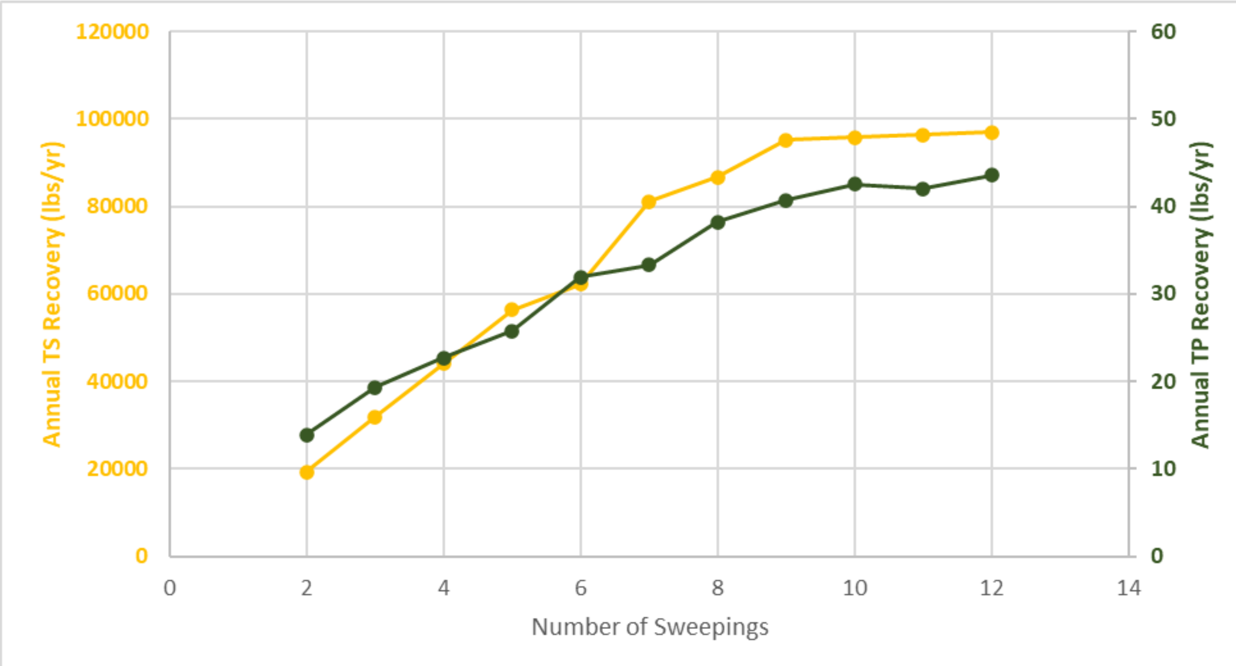

Figure 8 Annual pollutant recovery predicted for each sweeping schedule for a representative zone with 20 lane-miles and 15% tree canopy percentage.

2.3. Cost

Street sweeping costs include equipment purchase and depreciation, equipment maintenance, labor, and disposal. To estimate the total cost for each MS4 in CCWD, questionnaires were sent out to each MS4 about their sweeping operations and equipment costs. The questionnaires provided enough information to provide unique cost estimates for each sweeping program. The sweeping operations costs are an estimate of the existing sweeping capacity and hours spent on the street sweeping program. Equipment costs were split by the type of street sweeper with individual costs for regenerative air type street sweepers and mechanical broom street sweepers. Four of the seven MS4s responded to the questionnaires. For Fridley, Ham Lake, and Spring Lake Park default values from other Twin Cities metropolitan cities were used to estimate costs for their street sweeping programs. Table 6, Table 7, and Table 8 summarize the data received from each MS4 and the default values assumed for the other MS4s. From the sweeper operations information, an estimated maximum sweeping distance can be estimated for each MS4 sweeping program. The maximum sweeping distance is estimated to be between 21.6 lane-miles/day to 27 lane-miles/day for Andover which reported working 10-hour days (Table 6). Table 9 shows the resulting operation unit cost including labor and equipment costs, and annual depreciation cost. A weighted average based on the reported number of regenerative air street sweepers and mechanical broom street sweepers was used to simplify the costs independent of the type of street sweeper. In addition, for proposed scenarios, the annual depreciation cost was converted to a unit cost based on 2022 baseline lane-miles swept to account for additional equipment needs for enhanced sweeping beyond the base condition. The exact amount of street sweeping that would require an MS4 to purchase an additional street sweeper is difficult to assess when only looking at a portion of their jurisdictional area. For Spring Lake Park which only uses contract street sweeping, a median street sweeping unit cost was used to estimate the total street sweeping program cost (EOR 2022). The median contract street sweeping cost adjusted to 2023 dollars was assumed to be $107.23/lane-mile. Lastly, a consistent disposal unit cost assumed for all MS4s was added to each MS4s total cost. Each MS4 has different disposal methods with some reporting storing street sweeping material on public property which will eventually need to be disposed of in the long term. Therefore, the disposal cost was estimated based on information from Andover and Blaine who both reported properly disposing of street sweeping material. The disposal unit cost was estimated to be $18.41/ton of swept material based on the following assumptions:

- Cost to dump material in a landfill is $4 per ton plus $10 per load (Andover),
- Round trip to the landfill is 54 miles (Andover – 68 miles and Blaine – 40 miles),
- Average driving speed is 40 mph,
- Each load is approximately 11 tons (Andover),
- The unit cost for the truck, box, and labor needed to transport material to a landfill is $110 per hour (Blaine) and,
- To have a conservative cost estimate, all swept material is assumed to be landfilled even though most MS4s compost the fall sweeping material.

Table 6 Sweeper Operation Estimates

MS4	Workday (hr/day)	Sweeper Downtime[1] (hr/day)	Average Sweeper Operation Speed (mph)	Average Sweeper Driving Speed (mph)	Average Deadhead Distance[2] (mi)	Average Hauling Distance[3] (mi)	Sweeping Operation per Maintenance Day[4] (lane-mi)	Estimated Maximum Sweeping Distance (lane-mi/day)
Default[5]	8	1	4	40	5	10	1000	21.9
Andover	10[6]	2	4	40	3	3	1000	27.0
Anoka County	8	1	4	50	8	8	2500	22.3
Blaine	8	1.5	4	40	5	1.5	1000	21.6
Coon Rapids	8	2	5	35	2	2	1000	26.0

[1]Sweeper downtime is the time during a day where the street sweeper is not working and includes operator paid breaks, time spent refueling, dumping, weighing, cleaning, and record keeping.

[2]Dead-head distance is the distance between the vehicle garage and the route start.

[3]Hauling distance is the distance between the vehicle garage and the stockpile or dumpster.

[4]Sweeping operation per maintenance day is the average operation distance before a full maintenance day is needed for the street sweepers.

[5]Fridley, Ham Lake, and Spring Lake Park did not provide responses to the Phase 2 sweeper demand and cost information questionnaire. Default values were assumed for Fridley and Ham Lake. Spring Lake Park costs were estimated using median Contractor cost per lane-mi (EOR 2022).

[6]Andover reported working 10 hr days. 4-day work weeks were assumed.

Table 7 Regenerative Air Street Sweeper Costs

MS4	Vehicle Purchase Price ($)	Vehicle Useful Life (yrs)	Assumed Resale Value ($)	Fuel Cost ($/gal)	Average Fuel Efficiency (mpg)	Annualized Maintenance Cost ($/yr)	Average Labor Rate ($/hr)
Default[1]	$275,000	10	$25,000	$4.00	8	$9,190	$75.00
Andover	$275,000	16.5	$25,000	$3.77	8	$6,341	$125.00
Anoka County	NA	NA	NA	NA	NA	NA	NA
Blaine	$351,000	10	$10,000	$4.00	6	$10,000	$75.00
Coon Rapids	$267,000	8	$75,000	$3.30	7	$6,984	$85.00

[1]Fridley, Ham Lake, and Spring Lake Park did not provide responses to the Phase 2 sweeper demand and cost information questionnaire. Default values were assumed for these three MS4s. Spring Lake Park costs were estimated using median Contractor cost per lane-mi (EOR 2022).

Table 8. Mechanical Broom Street Sweeper Costs

MS4	Vehicle Purchase Price ($)	Vehicle Useful Life (yrs)	Assumed Resale Value ($)	Fuel Cost ($/gal)	Average Fuel Efficiency (mpg)	Annualized Maintenance Cost ($/yr)	Average Labor Rate ($/hr)
Default[1]	$209,000	10	$15,100	$4.00	7	$6,892	$75.00
Andover	$220,000	15	$15,000	$4.00	7	$4,044	$125.00
Anoka County	$266,500	7	$60,000	$3.35	3.5	$12,750	$28.70[2] ($46.59)
Blaine	NA	NA	NA	NA	NA	NA	NA
Coon Rapids	$300,000	8	$50,000	$3.30	6	$6,272	$85.00

[1]Fridley, Ham Lake, and Spring Lake Park did not provide responses to the Phase 2 sweeper demand and cost information questionnaire. Default values were assumed for these three MS4s. Spring Lake Park costs were estimated using median Contractor cost per lane-mi.

[2]No benefits calculated in the provided number. US Bureau of Labor Statistics estimates 61.6% of state and local government workers compensation is salary. Total pay is estimated to be $46.59.

Table 9. Sweeper Operation Cost Equation Estimates

MS4	Regenerative Air Sweeper Costs		Mechanical Broom Sweeper Costs		Average Sweeper Cost within CCWD		
	Operation Cost ($/lane-mi)	Depreciation Cost ($/yr)	Operation Cost ($/lane-mi)	Depreciation Cost ($/yr)	Operation Cost ($/lane-mi)	Depreciation Cost ($/yr)	Additional Deprecation Cost ($/lane-mi)
Default[1]	$32.20	$25,000	$31.16	$19,390.00	NA	NA	NA
Andover	$50.64	$15,151.52	$39.89	$13,667.67	$47.06	$23,250	$40.30
Anoka County	NA	NA	$25.29	$29,500	$25.29	$14,942	$40.98
Blaine	$33.03	$34,100	NA	NA	$33.03	$131,540	$68.66
Coon Rapids	$30.13	$24,000	$29.92	$31,250	$30.03	$54,635	$22.17
Fridley[2, 3]	NA	NA	NA	NA	$63.56	$10,721	$27.29
Ham Lake[3]	NA	NA	NA	NA	$62.32	$34,679	$64.14
Spring Lake Park[3]	NA	NA	NA	NA	$107.23	$0	$0

[1]Fridley, Ham Lake, and Spring Lake Park did not provide responses to the Phase 2 sweeper demand and cost information questionnaire. Default values were assumed for these three MS4s.

[2]Fridley and Ham Lake reported using tandem street sweeping which doubles the operation cost assumed but increases pickup efficiency.

[3] Spring Lake Park costs were estimated using median Contractor cost per lane-mi (EOR 2022).

2.4. Sweeping Scenarios

In total, five CCWD-wide scenarios and one optimized existing effort scenario for each MS4 were evaluated as part of this study. Two of the scenarios, "enhanced baseline" and "maximum", bracket the full range of pollutant recovery possible through enhanced street sweeping recommendations. Enhanced baseline assumes every MS4 reaches the minimum recommended enhanced street sweeping strategy which is sweeping twice in the spring and fall. Presently, only three of the seven MS4s within the District (i.e., Blaine, Coon Rapids, and Fridley) meet this threshold. The maximum sweeping scenario assumes every MS4 sweeps all streets twelve times per year; this is not practical but provides a realistic upper bound to pollutant reductions achievable through enhanced sweeping activities. The other three CCWD-wide scenarios are based on if there were additional street sweepers available within the Watershed District allocated to sweeping zones based on cost effectiveness and priority scores (regardless of MS4 boundaries). One, three, and five additional sweepers were modeled for these three scenarios. Each additional sweeper was assumed to be able to sweep approximately 2,769 lane-miles per year assuming a weighted average daily maximum sweeping distance of approximately 23 lane-miles/workday and 120 workdays of sweeping per year. Within an MS4s jurisdiction, the results of these CCWD-wide scenarios can also inform recommendations for each MS4 on where they should prioritize additional street sweeping if they have available capacity. The "optimized existing effort" MS4-specific scenarios are described in more detail in the Recommendations section, but generally either reallocate the current sweeping to maximize pollutant recovery within CCWD or assume the MS4 can sweep half of their streets another time each year with their current equipment and staffing levels. This scenario is meant to reflect optimizing existing capacity but is not necessarily the optimal strategy for maximizing pollutant removal per unit cost. Figure 9 through Figure 20 show the number of street sweeping used for each street sweeping zone in each scenario. All scenarios are compared to the 2022 baseline level of effort.

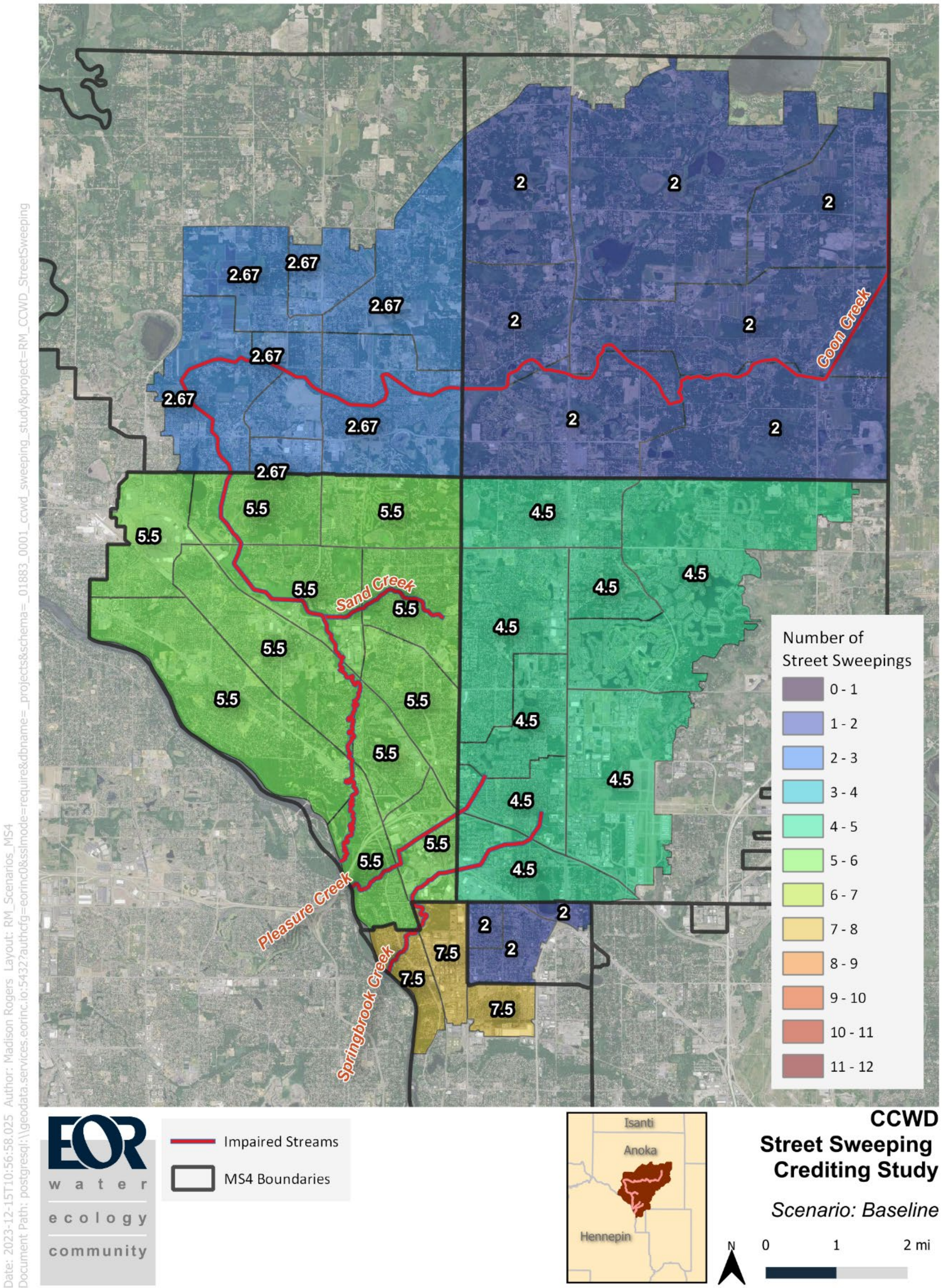

Figure 9 Municipal baseline street sweeping as of 2022.

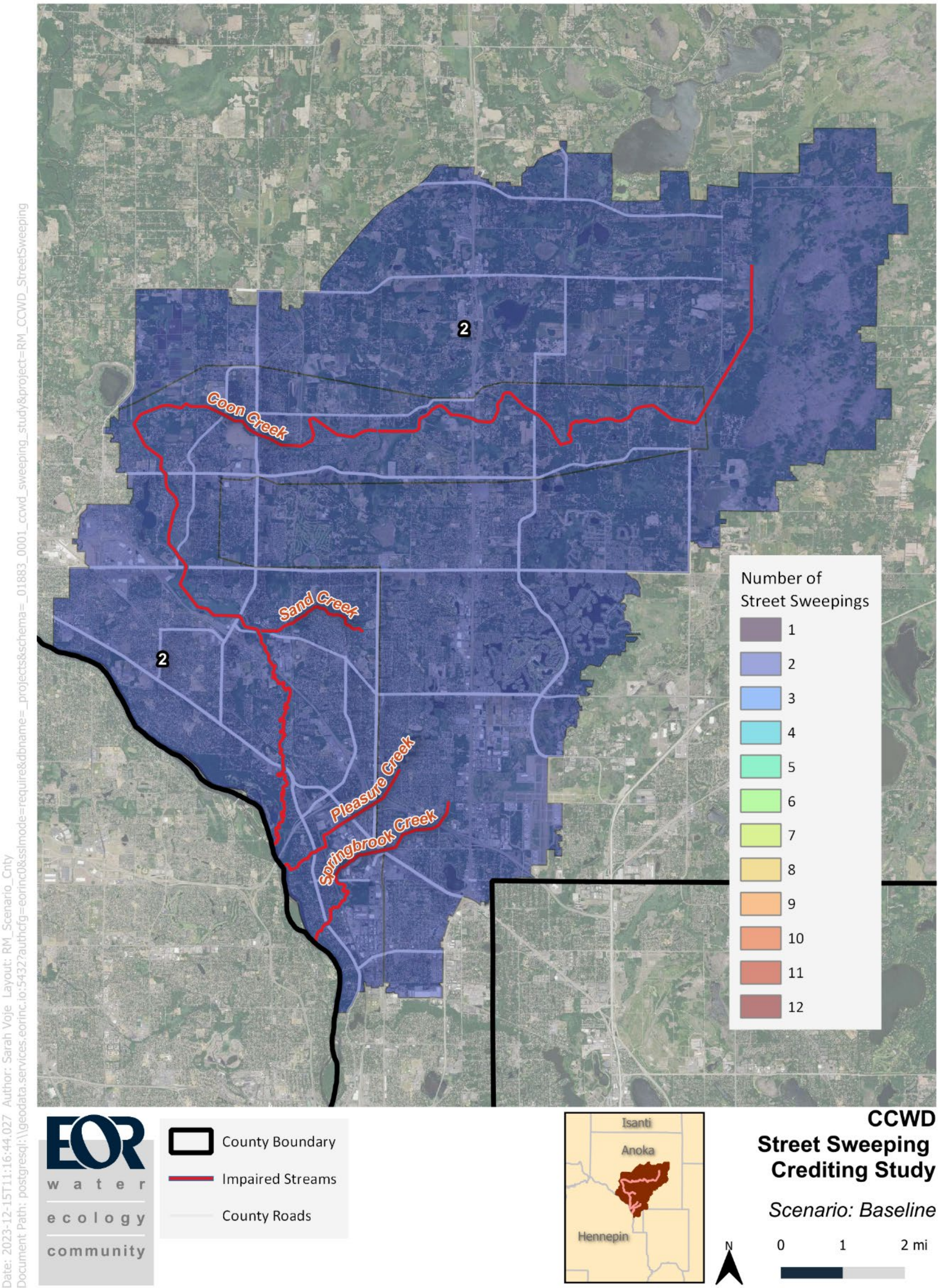

Figure 10 Anoka County baseline street sweeping as of 2022.

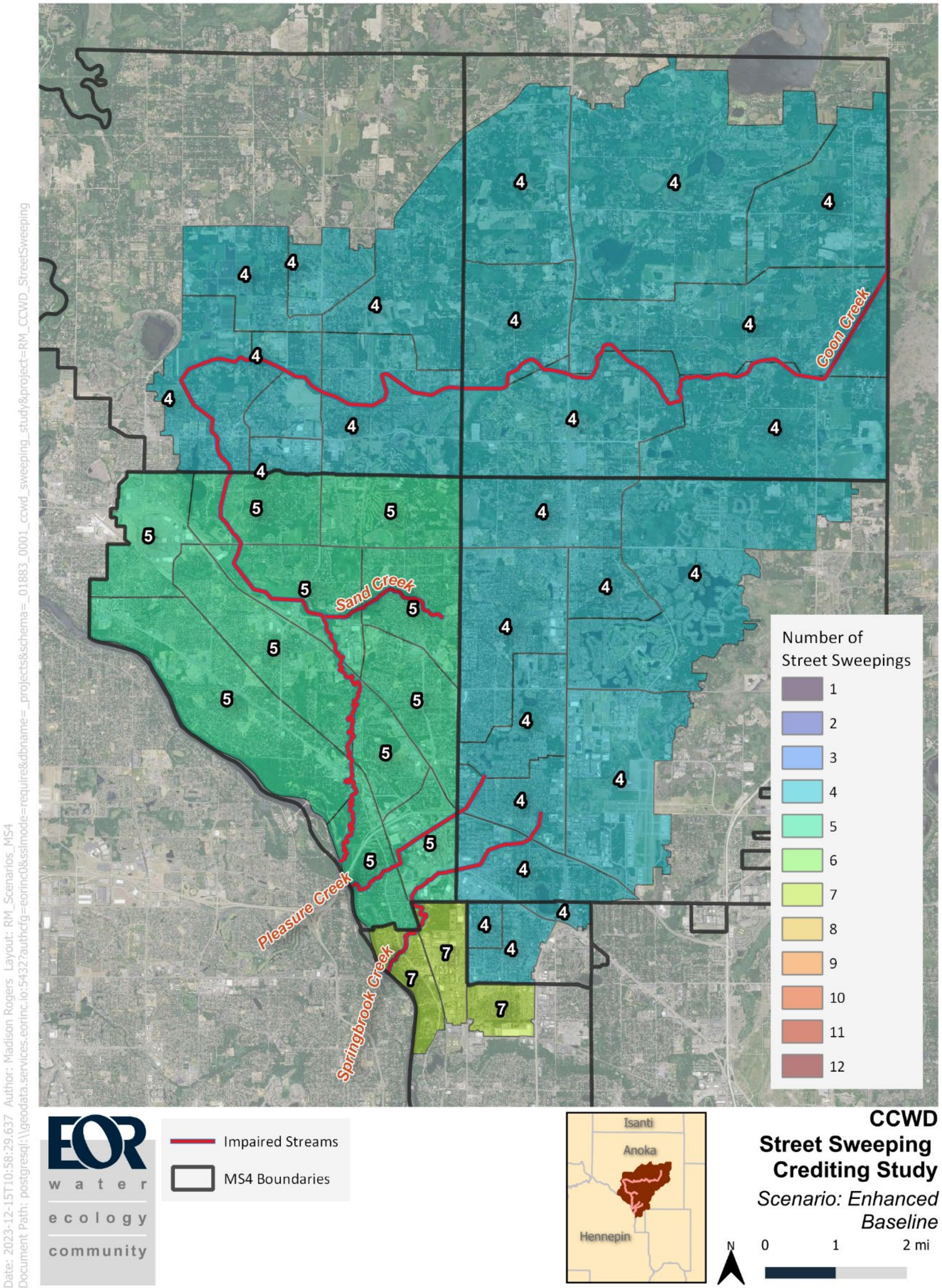

Figure 11 Municipal enhanced baseline street sweeping.

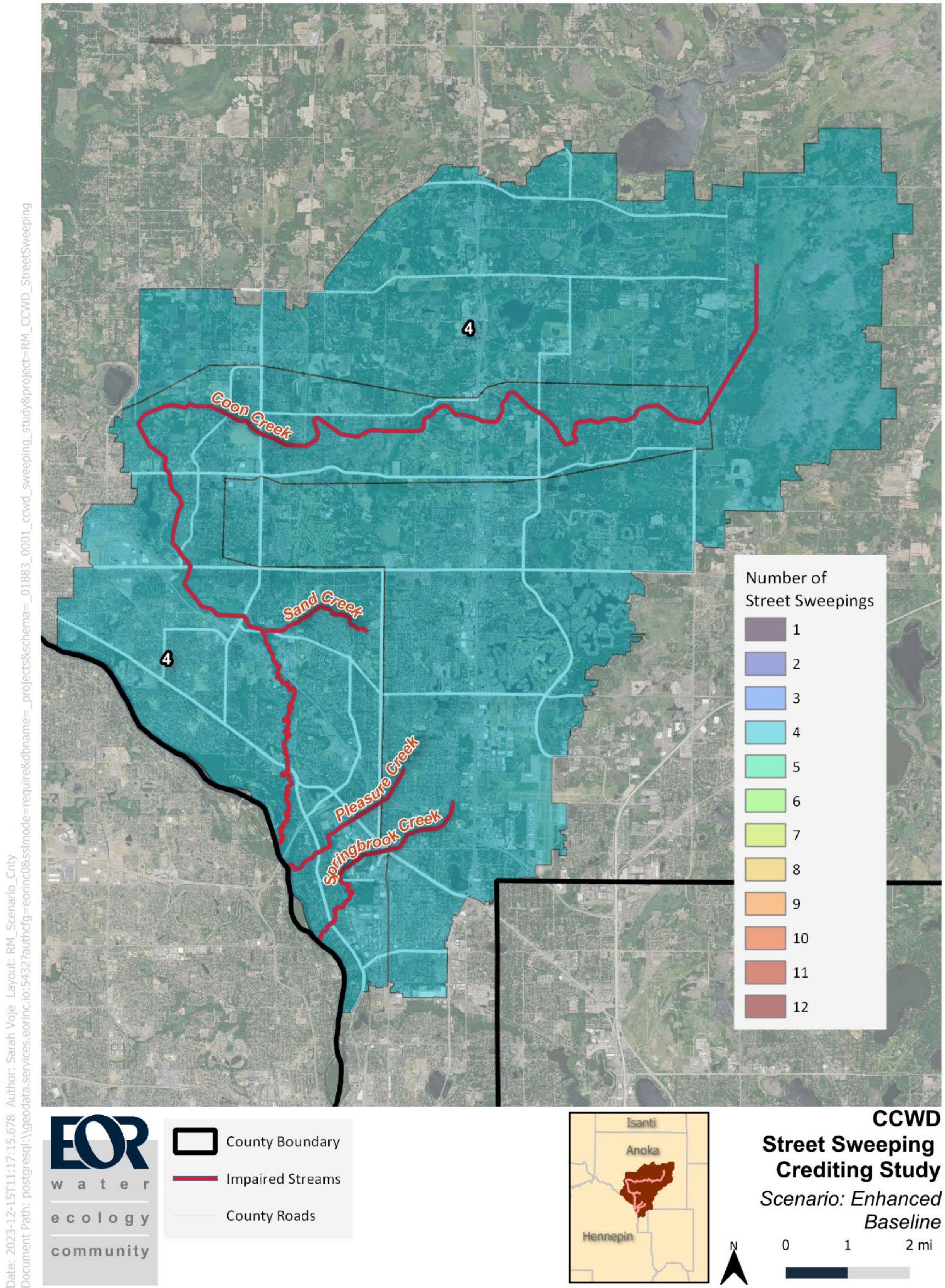

Figure 12. Anoka County enhanced baseline street sweeping.

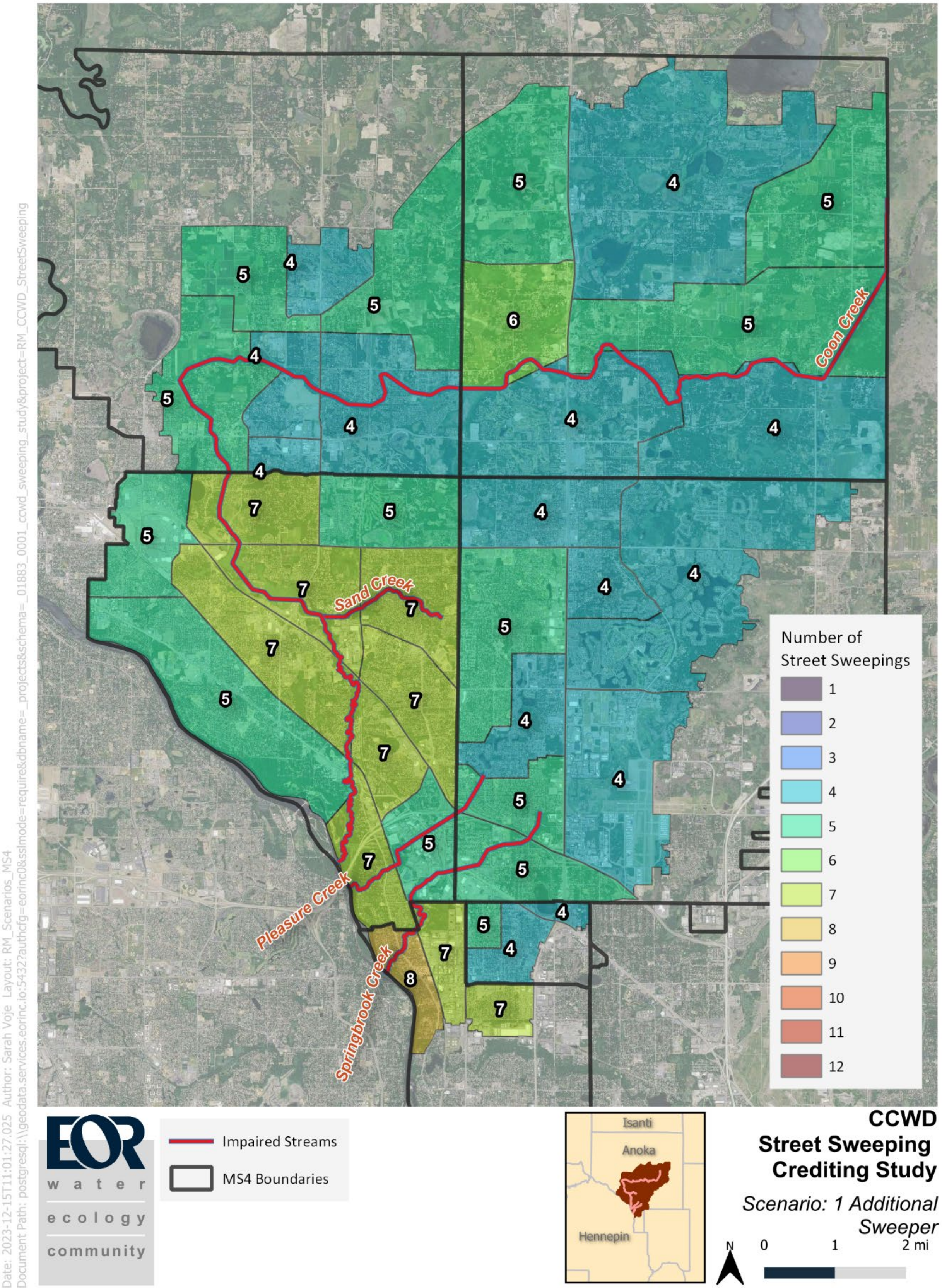

Figure 13. Municipal sweeping with one additional street sweeper spread across the CCWD.

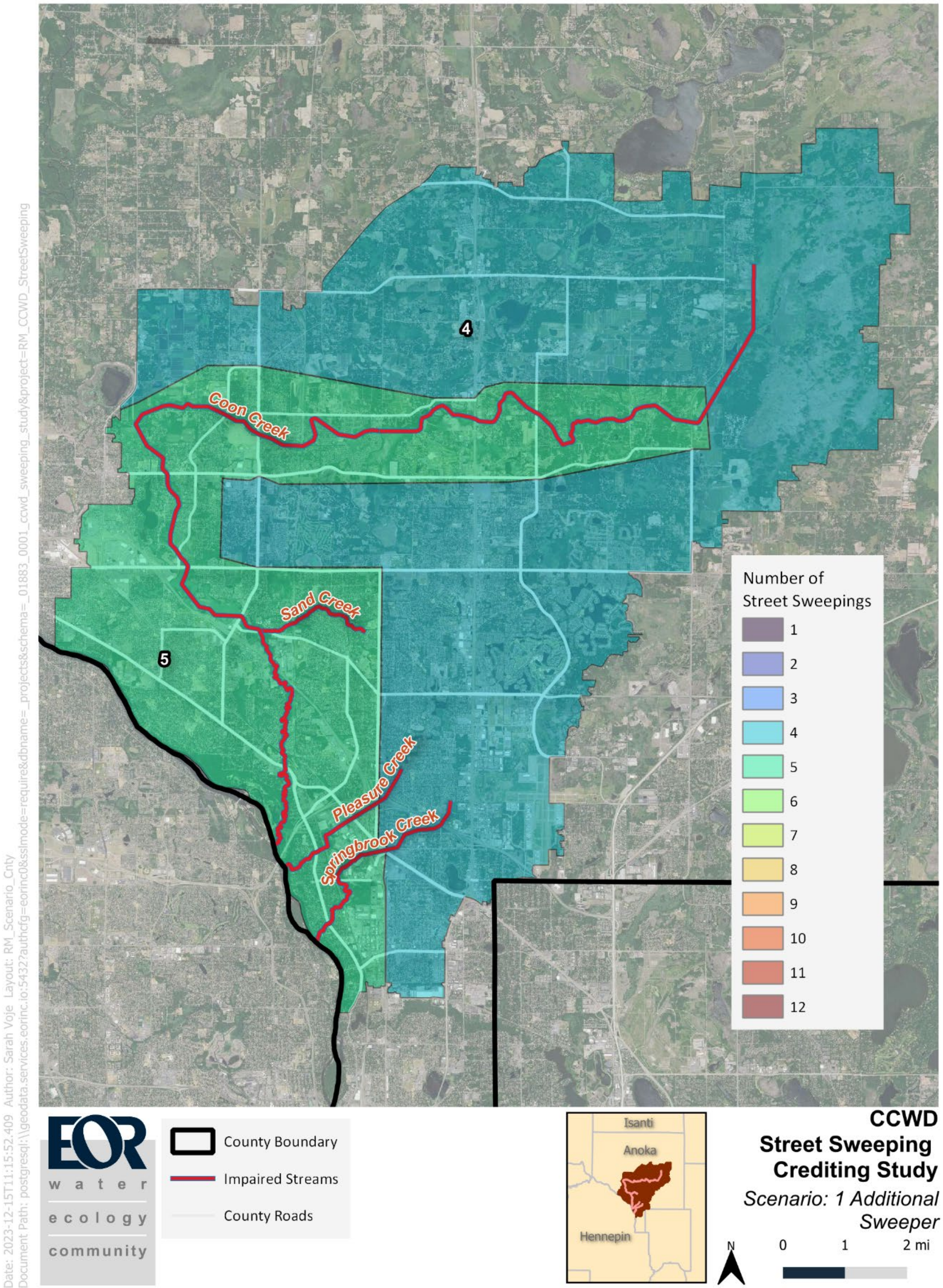

Figure 14. Anoka county sweeping with one additional street sweeper spread across the CCWD.

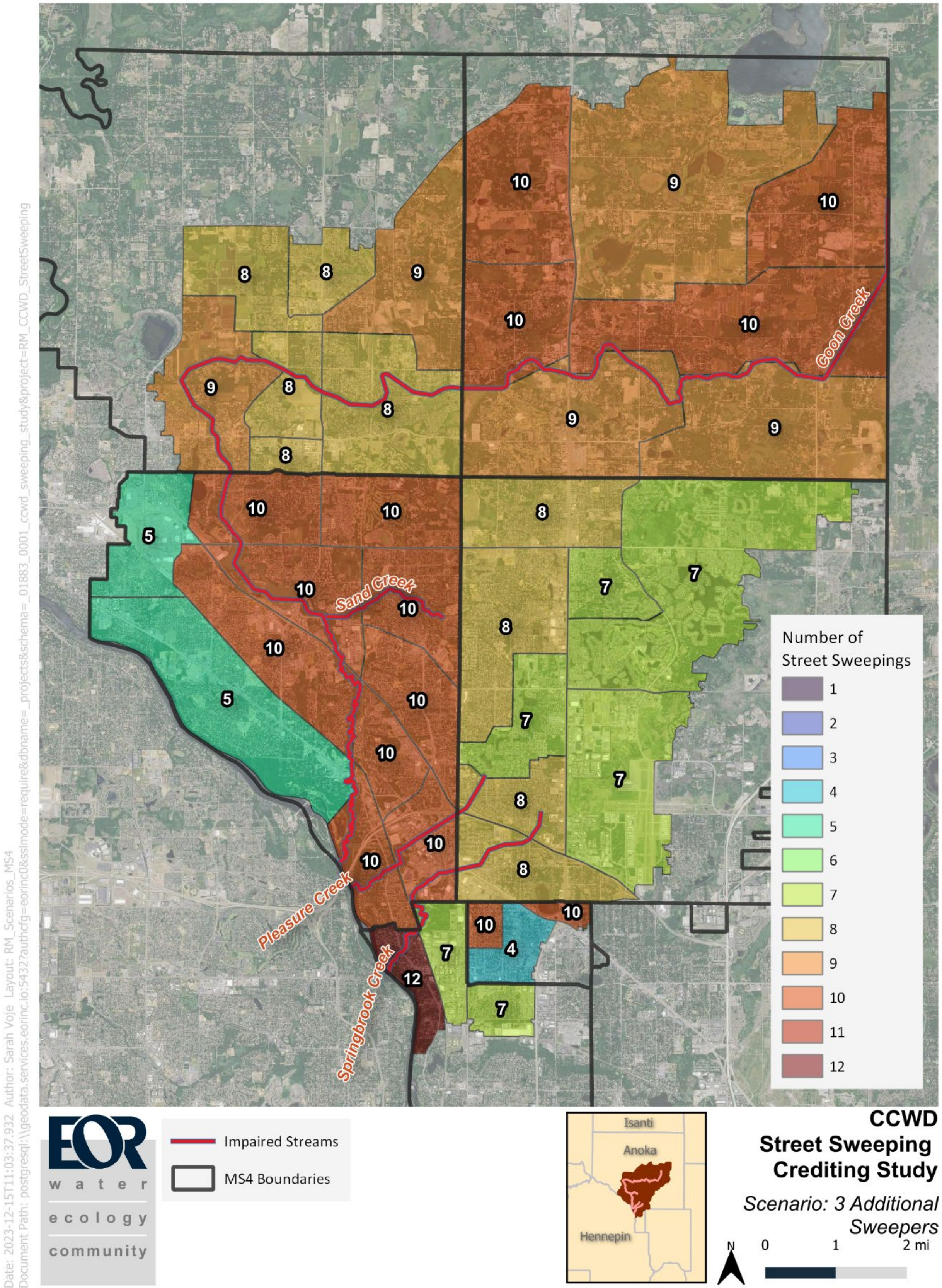

Figure 15. Municipal sweeping with three additional street sweepers spread across the CCWD.

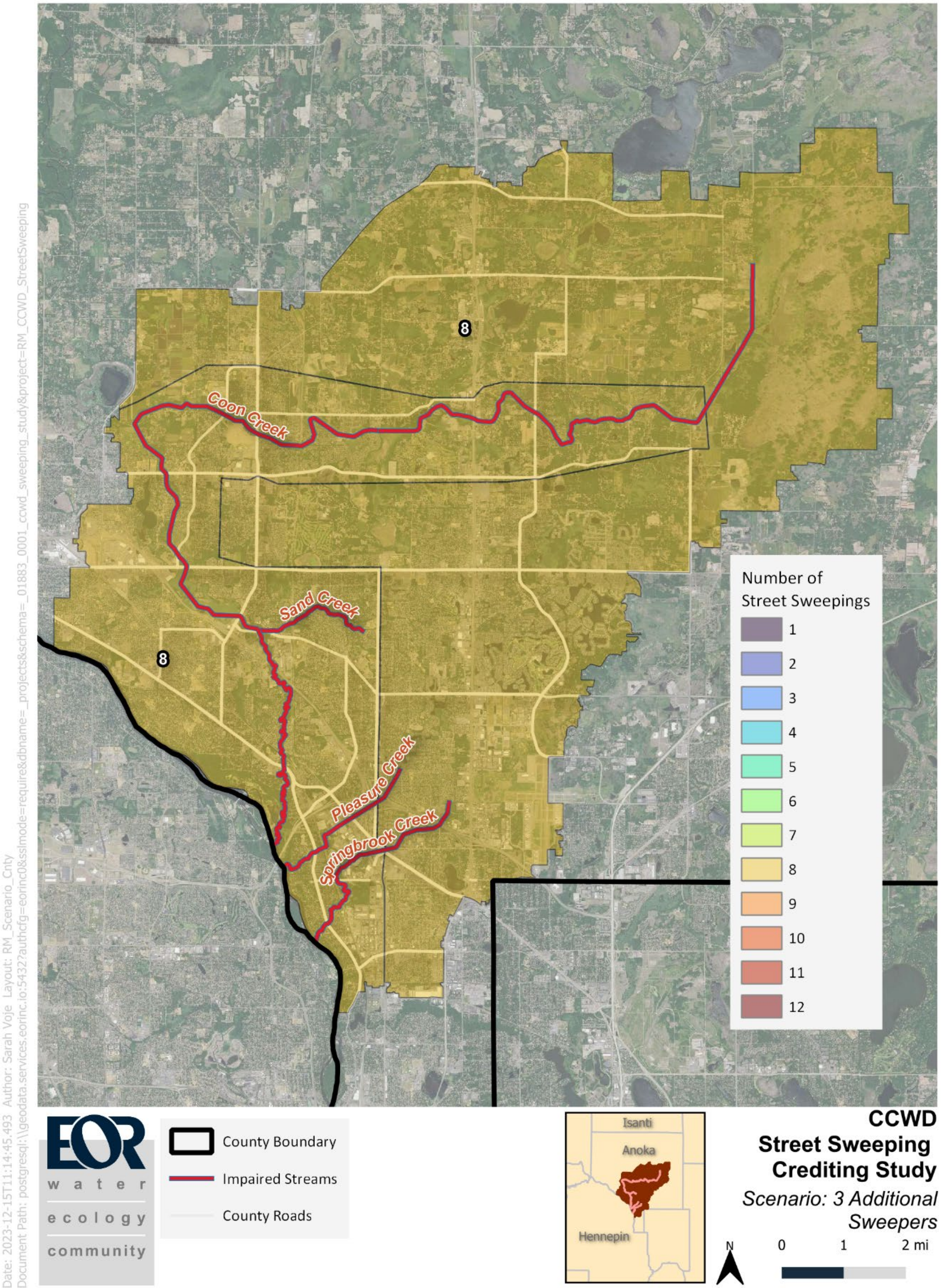

Figure 16. Anoka county sweeping with three additional street sweepers spread across the CCWD.

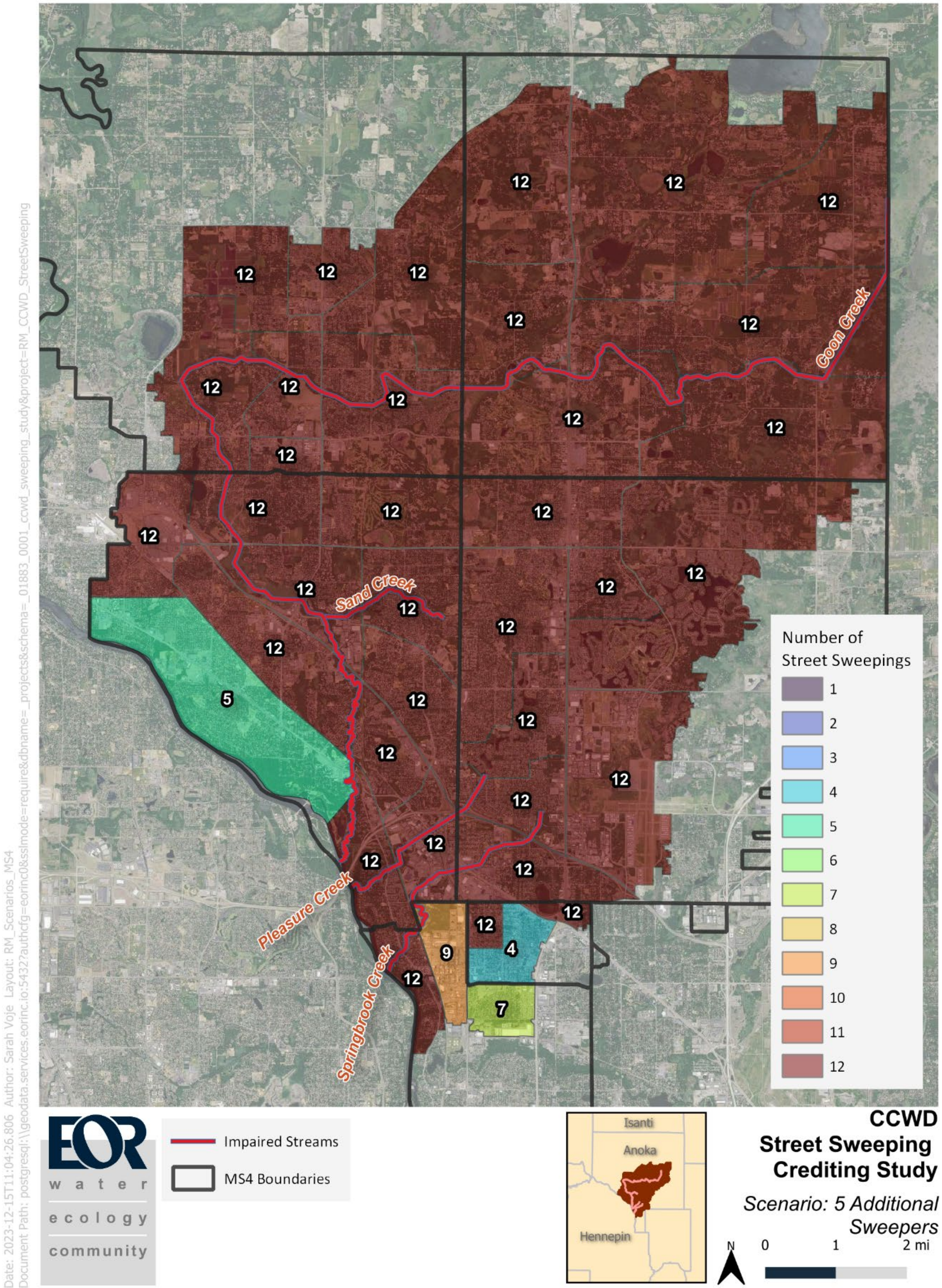

Figure 17. Municipal sweeping with five additional street sweepers spread across the CCWD.

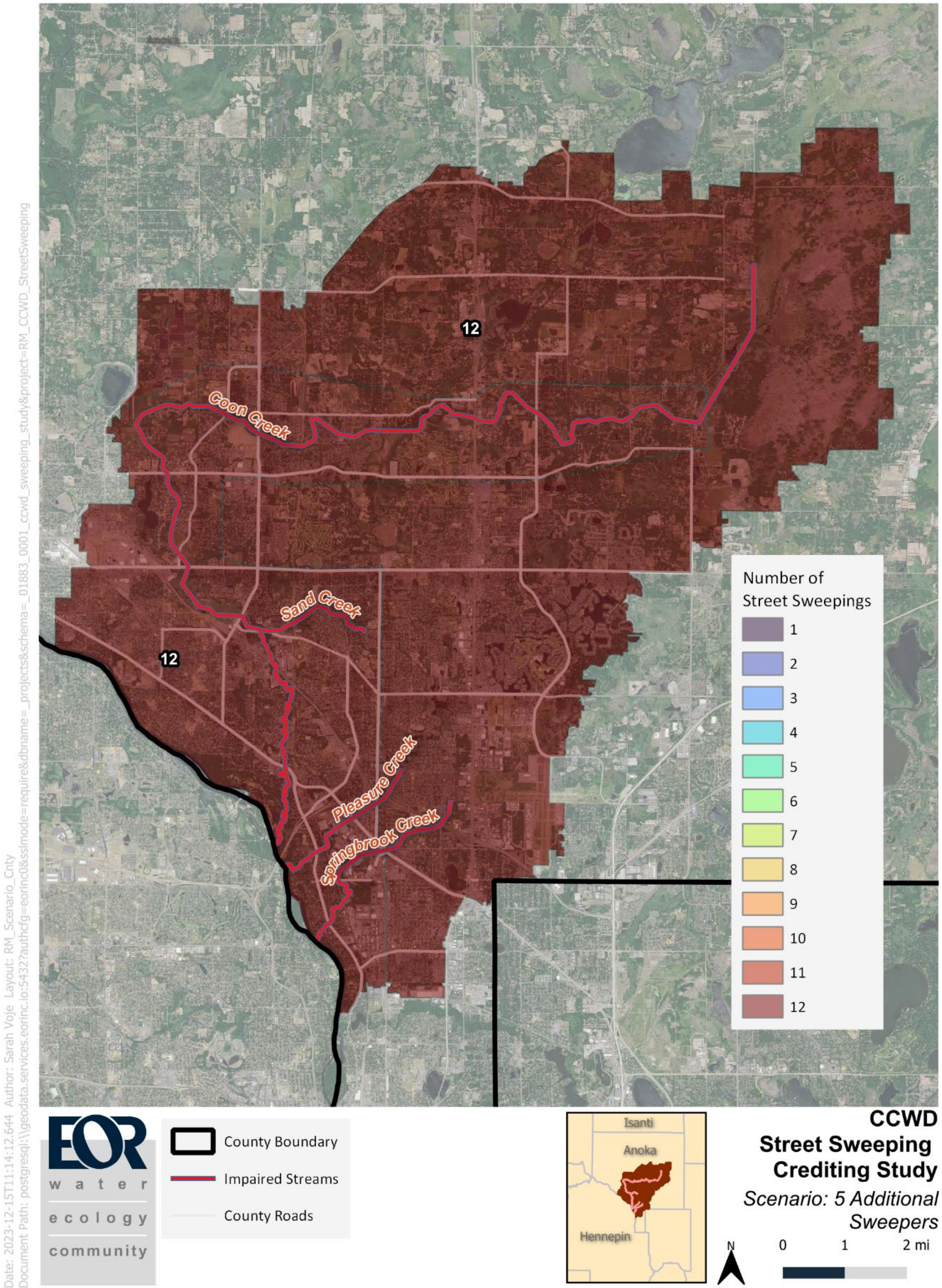

Figure 18. Anoka county sweeping with five additional street sweepers spread across the CCWD.

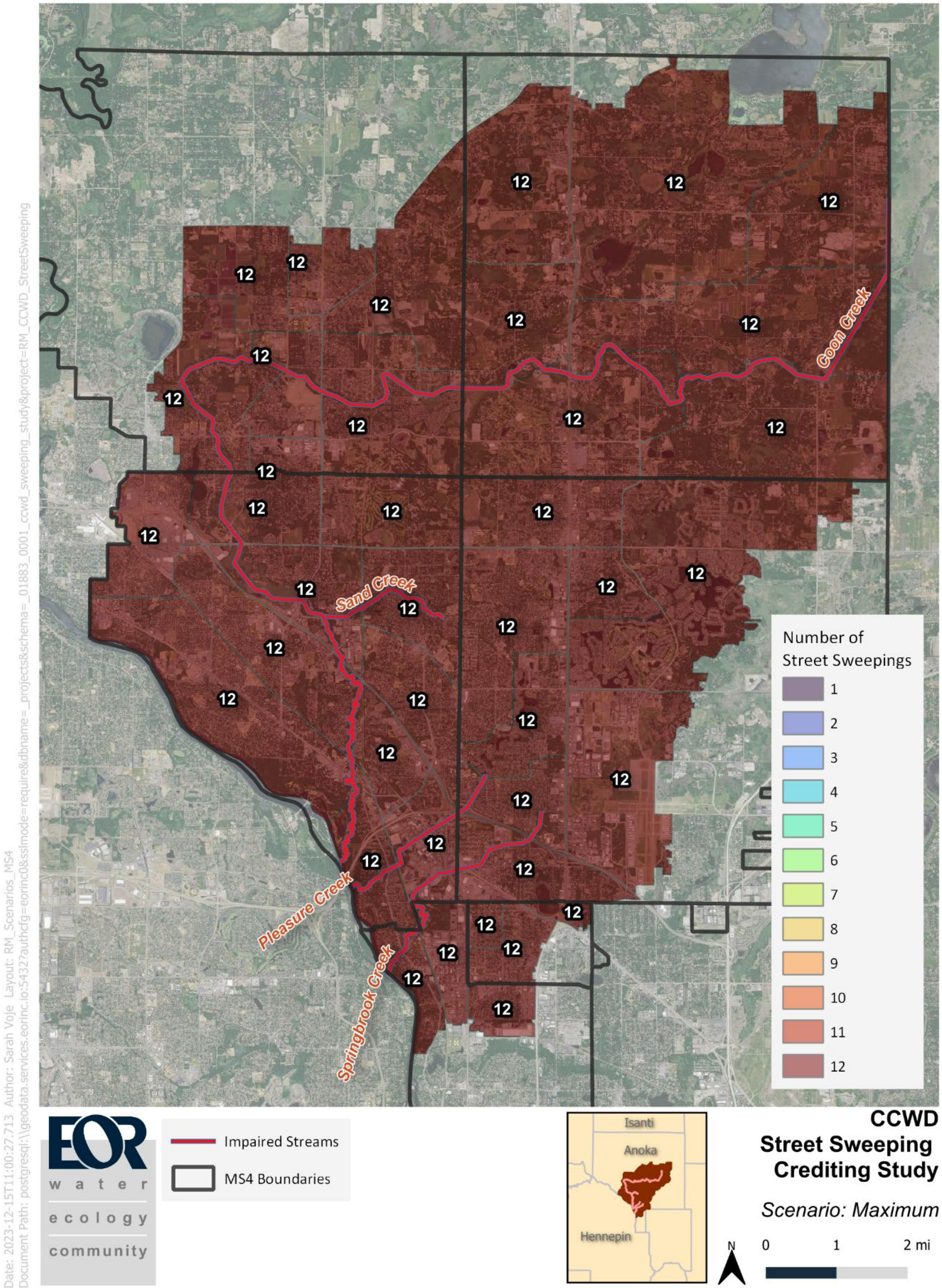

Figure 19. Municipal sweeping with maximum street sweeping throughout the CCWD.

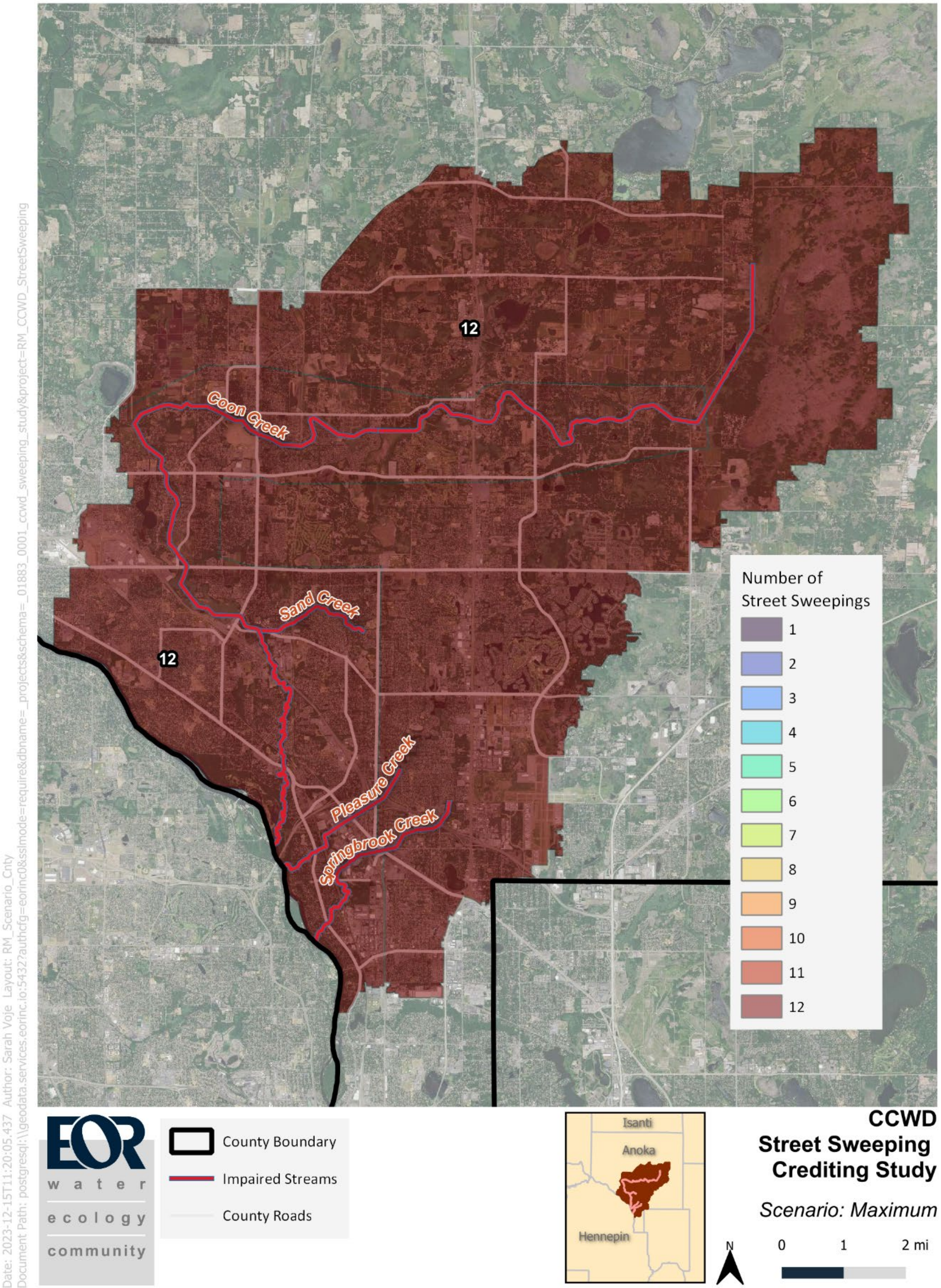

Figure 20. Anoka county maximum street sweeping throughout the CCWD.

3. RESULTS

The results of each scenario are included in this section. The result includes estimates for the pollutant reduction, change in sweeping effort and costs for each scenario. In addition, a brief review of the existing sweeping equipment is discussed with respect to the likelihood more equipment is needed by each MS4.

3.1. Existing Equipment Evaluation

Each MS4's monthly sweeping capacity was evaluated to help approximate if more equipment would be needed to implement the different sweeping scenarios. For MS4s working 5-day work weeks 20 days were assumed in a month. For Andover, assuming 4-day work weeks, 16 workdays were assumed in a month. Table 10 summarizes the monthly sweeping capacity and the assumptions used in the estimate. All MS4s are predicted to have the equipment capacity to sweep close to or greater than once per month which is enough equipment capacity to sweep as much as seven times per year. Andover, Blaine, Coon Rapids, and Fridley are predicted to have the equipment capacity to sweep multiple times per month. With monthly sweeping capacity greater than one, a MS4 is more likely to sweep all their streets during more advantageous times such as between leaf drop and an upcoming rain event. The monthly sweeping capacity estimates also suggest that for most MS4s staffing or disposal constraints is the limiting factor in the amount each MS4 sweeps.

Table 10 MS4 Estimated Sweeping Capacity

MS4	Estimated Total MS4 Lane-miles	Estimated Maximum Sweeping Distance (lane-mi/day)	Number of Sweepers	Sweeping Capacity per Month (Full Sweeps/Month)
Andover[1]	409	27.0	3	3.2
Anoka County[2]	1038	22.3	2	0.9
Blaine	552	21.6	5	3.9
Coon Rapids	453	26.0	2	2.3
Fridley[3]	217	21.9	1	2.0
Ham Lake[3]	306	21.9	1	1.4
Spring Lake Park	54	21.9	0	0

[1]Andover reported 10-hour workdays. A 4-day work week was assumed.
[2]All county roads were included in the estimate. The county's actual sweeping capacity is likely higher because they do not sweep all their roadways.
[3]Fridely and Ham Lake use tandem sweeping where two sweepers follow each other. The two sweepers function as one unit.

3.2. Increases in Pollutant Recovery and Associated Effort

Table 11 summarizes swept lane-miles and the modeled change in pollutant reduction from the stream load across the range of sweeping scenarios. MS4s that only sweep once in the spring and once in the fall can see the greatest benefit from enhanced baseline street sweeping. Anoka County, Ham Lake, and Spring Lake Park could more than double their pollutant recovery by doubling their effort. Andover could also see significant benefits from enhanced baseline sweeping. For all MS4s, except Fridley which already sweeps 7.5 times per year, the predicted increase in TSS recovery is predicted to exceed the associated increase in effort up to an MS4-averaged 8.1 sweepings per year. Figure 21 shows the percent increase in TSS from 2022 baseline versus the percent increase in effort measured as lane miles swept plotted against a one-to-one line. If the MS4 line is above the one-to-one line the scenario is predicted to have TSS recovery increases exceeding the increase in effort. The maximum street sweeping at the same or less cost-effectiveness is theoretically located where the MS4 line crosses the one-to-one line. The 8.1 sweepings per year is estimated by multiplying the percent increase in effort where each MS4 line crosses the one-to-one line by the 2022 baseline annual sweeping number. The predicted maximum street sweeping at the same or less TSS cost effectiveness is predicted to occur between 6.4 sweepings per year and 10.1 sweepings per year. Blaine, Coon Rapids, and Fridley may still see benefits from additional street sweeping; however, it will not be as significant as the MS4s sweeping twice per year because they are already close to sweeping once per month.

Table 11 MS4-specific Swept Lane-miles and Modeled Change in Pollutant Reduction across all Impaired Streams for each Sweeping Scenario. Bold values indicate scenarios discussed further in the Recommendations Section of this report.

MS4	Total Swept Lane-miles and Percent Increase in Effort						
	2022 Base[1]	Optimized Existing Effort	Enhanced Baseline	1 Additional Sweeper	3 Additional Sweepers	5 Additional Sweepers	Maximum
Andover	577	**566 (0%)**	**864 (50%)**	961 (67%)	1804 (213%)	2593 (349%)	2593 (349%)
Anoka County	365	**487 (34%)**	**729 (100%)**	852 (134%)	1459 (300%)	2188 (500%)	2188 (500%)
Blaine	1916	**1895 (0%)**	1916 (0%)	1861 (-3%)	**3194 (67%)**	5109 (167%)	5109 (167%)
Coon Rapids	2465	**2458 (0%)**	2465 (0%)	**2787 (13%)**	3798 (54%)	4646 (89%)	5377 (118%)
Fridley	393	**389 (0%)**	393 (0%)	389 (-1%)	**478 (22%)**	506 (29%)	629 (60%)
Ham Lake	541	**662 (22%)**	**1081 (100%)**	1224 (126%)	2554 (372%)	3244 (500%)	3244 (500%)
Spring Lake Park	87	**99 (13%)**	**174 (100%)**	186 (113%)	262 (201%)	291 (235%)	522 (500%)
	Modeled Change in TSS Load Reduction from Stream (%)						
Andover	31.1	**3%**	**59%**	86%	227%	249%	249%
Anoka County	15.3	**49%**	**129%**	176%	350%	403%	403%
Blaine	86.5	**2%**	0%	0%	**69%**	93%	93%
Coon Rapids	203.8	**12%**	0%	**27%**	48%	52%	64%
Fridley	27.7	**1%**	0%	1%	**8%**	10%	16%
Ham Lake	28.3	**40%**	**129%**	171%	396%	403%	403%
Spring Lake Park	3.3	**19%**	**129%**	148%	219%	221%	403%
	Modeled Change in TP Load Reduction from Stream (%)						
Andover	180.8	**1%**	**30%**	40%	125%	149%	149%
Anoka County	106.6	**28%**	**63%**	79%	175%	213%	213%
Blaine	502.6	**3%**	0%	2%	**54%**	84%	84%
Coon Rapids	992.8	**2%**	0%	**8%**	32%	37%	51%
Fridley	142.0	**1%**	0%	1%	**10%**	12%	22%
Ham Lake	194.5	**20%**	**63%**	79%	200%	213%	213%
Spring Lake Park	31.3	**12%**	**63%**	70%	111%	114%	213%

[1]The Base predicted TSS Recovery and TP Recovery is reported in tons/yr and lbs/yr, respectively. The load recovery for the other scenarios can be approximated by multiplying the modeled percent change in recovery in each cell to the respective base load.

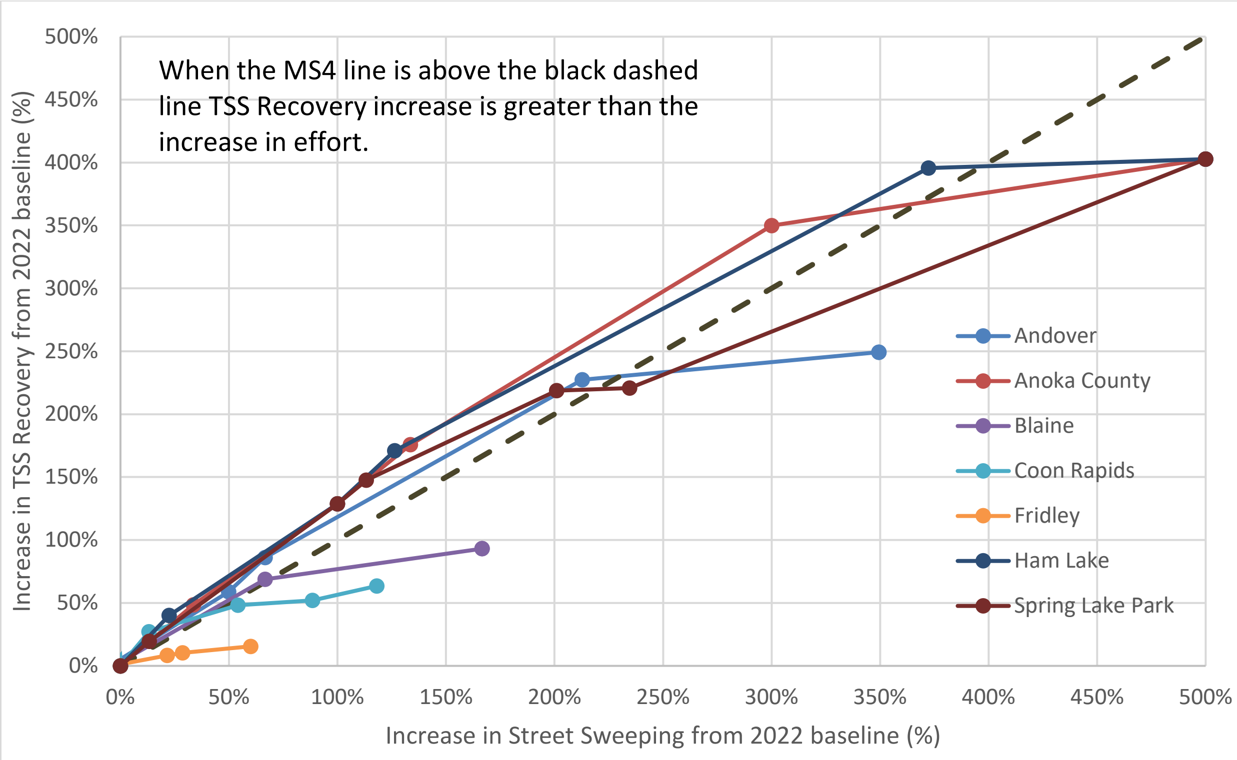

Figure 21 Increase in TSS recovery from street sweeping versus increased street sweeping effort for each MS4 and for each scenario.

3.3. Costs

Table 12 and Table 13 summarize the costs estimated for each scenario and for each MS4. The costs are only for street sweeping the portions of each MS4 within CCWD and are the best available estimates. Fridley’s estimated operation and disposal costs were 26% below their reported street sweeping budget adjusted to the lane-miles within CCWD. Possible reasons for the lower estimated costs include roads requiring additional passes before the road is visibly clean, expenses related to mobilization of the dump location around each MS4, dump truck operation and maintenance costs, and any costs associated with material screening completed prior to disposal. In all tables below, bold values indicate the scenarios discussed in the following recommendations section.

Table 12 Operation, Disposal, and Depreciation Costs for the portion of each MS4 within CCWD boundary across Sweeping Scenarios

MS4	Operation Cost ($/yr)						
	2022 Base	Optimized Existing Effort	Enhanced Baseline	1 Additional Sweeper	3 Additional Sweepers	5 Additional Sweepers	Maximum
Andover	$27,146	**$26,615**	**$40,668**	$45,238	$84,905	$122,005	$122,005
Anoka County	$9,222	**$17,770**	**$26,600**	$31,070	$53,200	$79,800	$79,800
Blaine	$63,283	**$62,581**	$63,283	$61,455	**$105,490**	$168,754	$168,754
Coon Rapids	$74,000	**$73,816**	$74,000	**$83,684**	$114,045	$139,491	$161,454
Fridley	$24,970	**$24,716**	$24,970	$24,716	**$30,360**	$32,131	$39,951
Ham Lake	$33,913	**$41,496**	**$67,825**	$76,747	$160,190	$203,476	$203,476
Spring Lake Park	$9,351	**$10,596**	**$18,702**	$19,947	$28,141	$31,287	$56,105
	Disposal Cost ($/yr)						
Andover	$3,116	**$3,140**	**$4,951**	$5,707	$10,169	$10,885	$10,885
Anoka County	$1,704	**$3,582**	**$5,619**	$6,713	$11,054	$12,355	$12,355
Blaine	$13,995	**$14,144**	$13,995	$13,863	**$23,565**	$27,026	$27,026
Coon Rapids	$22,400	**$23,659**	$22,400	**$27,300**	$31,685	$32,653	$36,630
Fridley	$4,104	**$4,116**	$4,104	$4,116	**$4,388**	$4,481	$4,741
Ham Lake	$2,996	**$3,888**	**$6,850**	$7,789	$14,830	$15,061	$15,061
Spring Lake Park	$587	**$701**	**$1,341**	$1,452	$1,869	$1,881	$2,948
	Depreciation Cost ($/yr)						
Andover	$23,250	$22,796	$34,832	$38,746	$72,720	$104,496	$104,496
Anoka County	$14,942	$19,964	$29,884	$34,906	$59,769	$89,653	$89,653
Blaine	$131,540	$130,080	$131,540	$127,740	$219,272	$350,773	$350,773
Coon Rapids	$54,635	$54,499	$54,635	$61,785	$84,201	$102,987	$119,203
Fridley	$10,721	$10,612	$10,721	$10,612	$13,036	$13,796	$17,154
Ham Lake	$34,679	$42,433	$69,358	$78,482	$163,810	$208,074	$208,074
Spring Lake Park	$0	$0	$0	$0	$0	$0	$0

Table 13 Total Cost for the portion of each MS4 within CCWD boundary across Sweeping Scenarios

MS4	Roads within CCWD (% of Total)	2022 Base	Optimized Existing Effort	Enhanced Baseline	1 Additional Sweeper	3 Additional Sweepers	5 Additional Sweepers	Maximum
Andover	53%	$53,513	$52,551	$80,451	$89,691	$167,794	$237,386	$237,386
Anoka County	25%	$25,868	$34,768	$52,223	$61,103	$104,319	$153,548	$153,548
Blaine	77%	$208,817	$206,804	$208,817	$203,057	$348,327	$546,553	$546,553
Coon Rapids	99%	$151,034	$151,973	$151,034	$172,769	$229,931	$275,131	$317,287
Fridley	24%	$39,795	$39,444	$39,795	$39,444	$47,784	$50,408	$61,846
Ham Lake	89%	$71,588	$87,817	$144,034	$163,018	$338,830	$426,611	$426,611
Spring Lake Park	81%	$9,937	$11,297	$20,043	$21,399	$30,010	$33,168	$59,053

3.4. Cost Effectiveness Estimates

In addition to the modeled range of pollutant recovery and cost estimates summarized for each MS4, zone-specific cost effectiveness estimates are shown in Figure 22 through Figure 29. The cost effectiveness estimates are for the maximum sweeping scenario with twelve sweepings per year which provide the highest cost estimates and for monthly street sweeping with seven sweepings per year which is close to the most cost-effective sweeping schedule based on TS recovery per unit effort and associated load reductions. The provided cost effectiveness estimates can be used as a planning tool to help identify the most cost-effective locations in CCWD for enhanced street sweeping. The TP cost effectiveness is predicted to be between $149 per modeled lb to $1,105 per modeled lb while the TSS cost effectiveness is predicted to be between $3,900 per modeled ton to $43,000 per modeled ton depending on the sweeping zone for the maximum sweeping scenario. Even the most expensive zones for implementing enhanced street sweeping at $1,105 per lb of TP are cost-effective compared to many structural stormwater BMPs which often exceed annualized costs of $1,000 per lb of TP. The predicted TSS cost effectiveness is also more cost effective for large portions of the CCWD compared to many structural BMPs which normally have cost effectiveness estimates exceeding $10,560 per ton of TSS (The Center for Watershed Protection 2013). The monthly street sweeping scenario is on average 78% and 72% of the maximum sweeping scenario cost effectiveness for TP reduction and TSS reduction respectively. Cost effectiveness is even more favorable at reduced levels of sweeping effort such as the enhanced baseline scenario of sweeping four times per year.

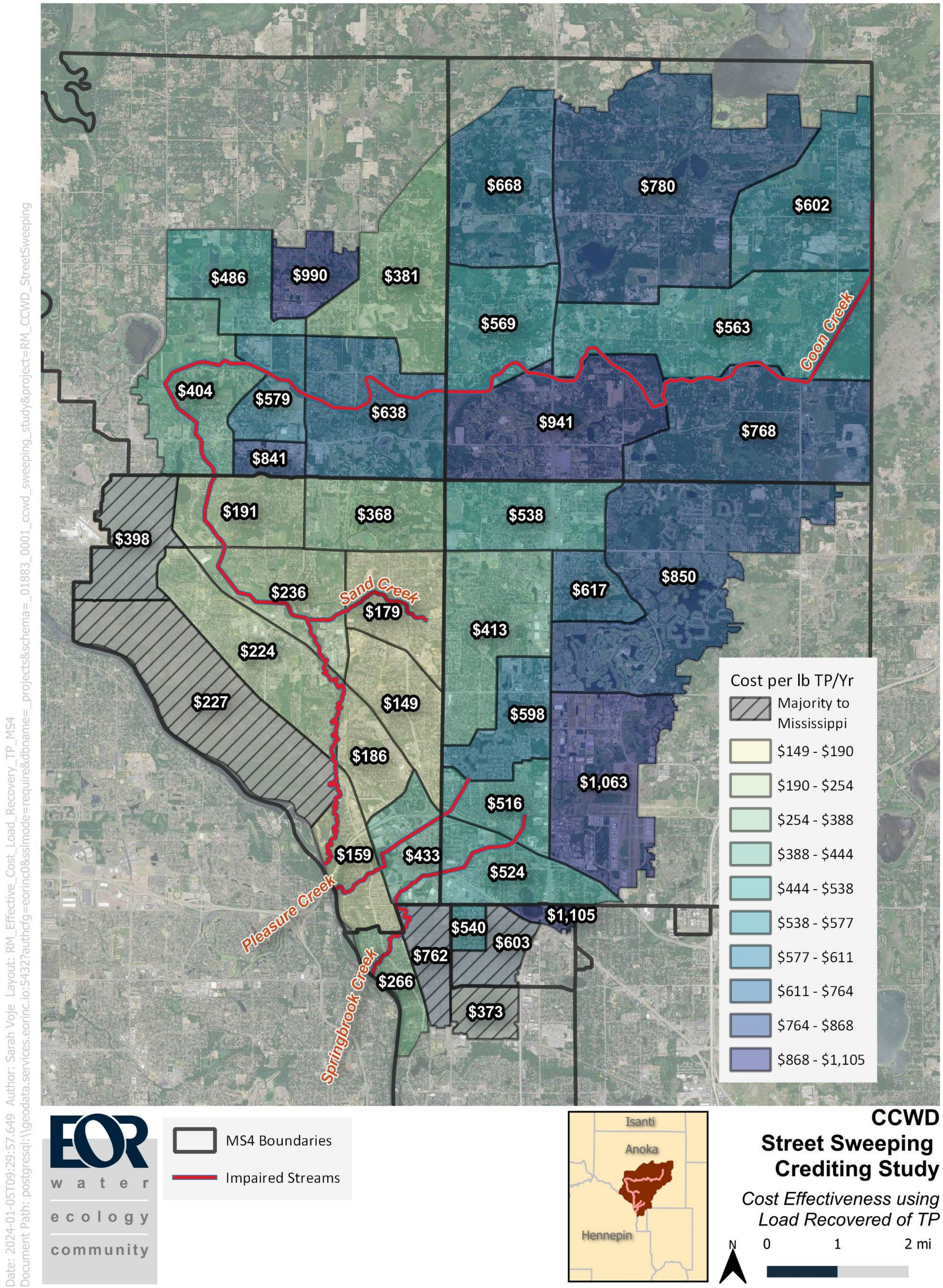

Figure 22. Municipal zone otal phosphorus cost-effectiveness ($/lbs/yr) for street sweeping 12 times/year.

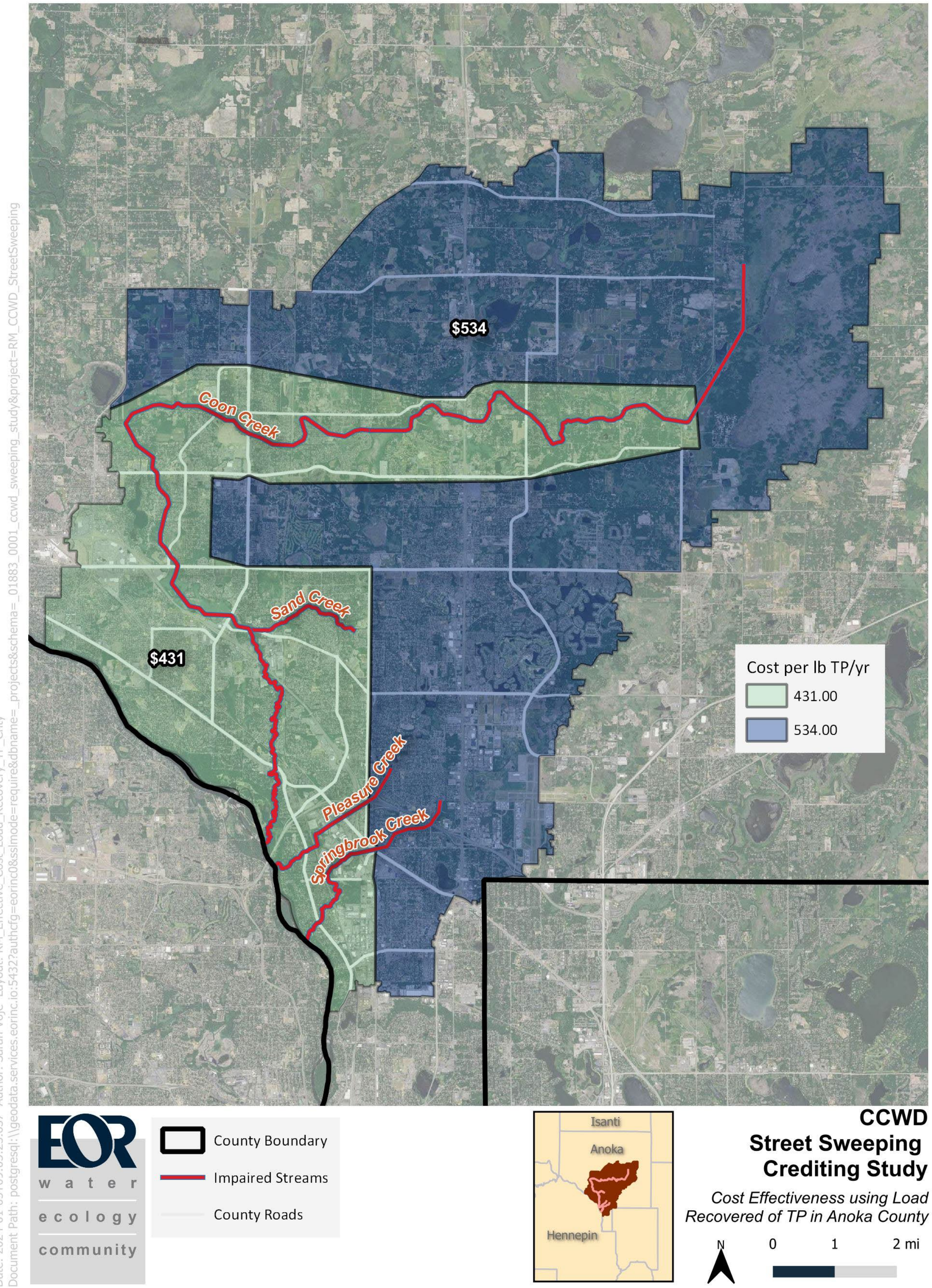

Figure 23. Anoka county zone total phosphorus cost-effectiveness ($/lb/yr) for street sweeping 12 times/year.

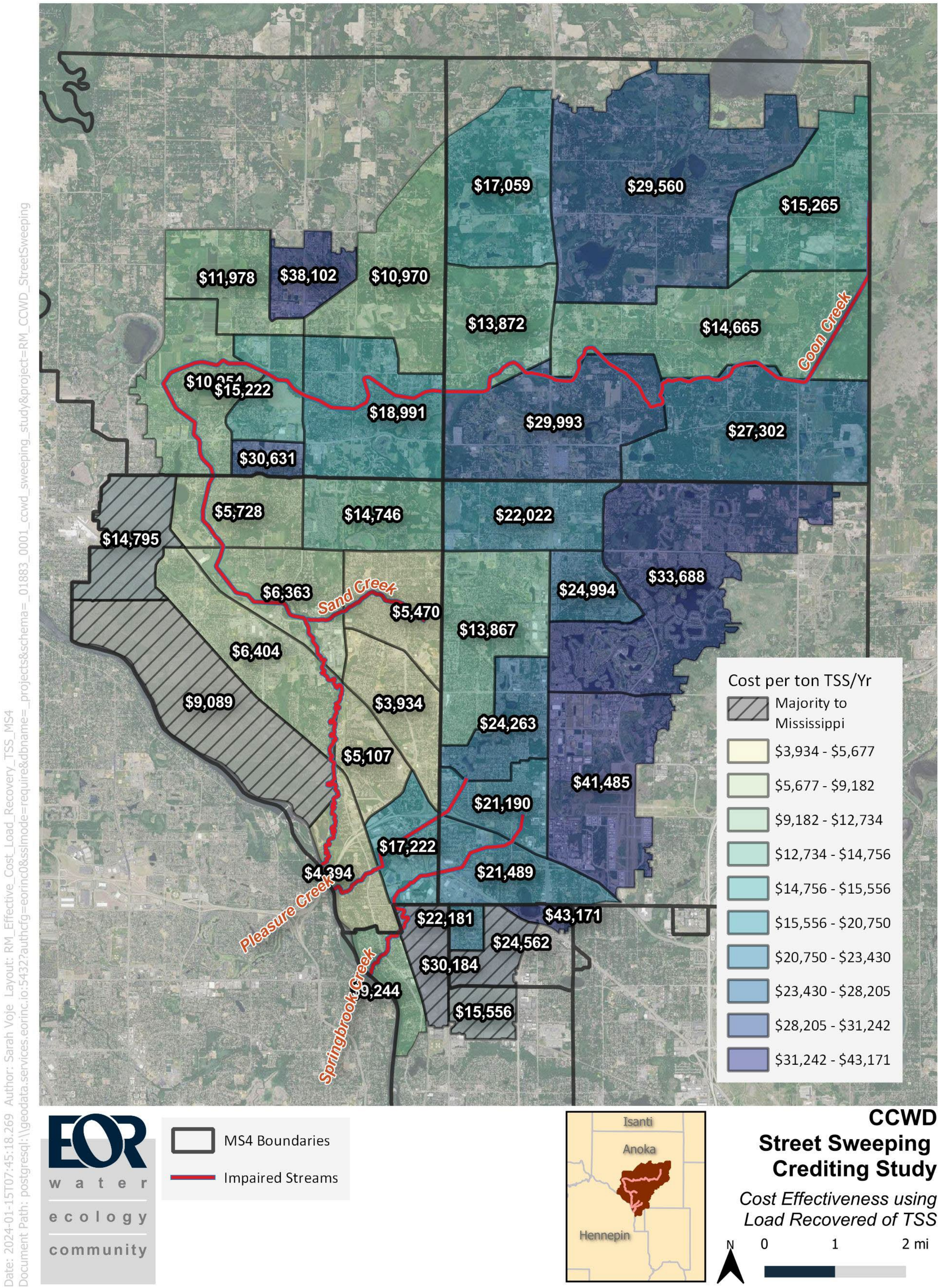

Figure 24. Municipal zone totally suspended solids cost-effectiveness ($/tons/yr) for street sweeping 12 times/yr.

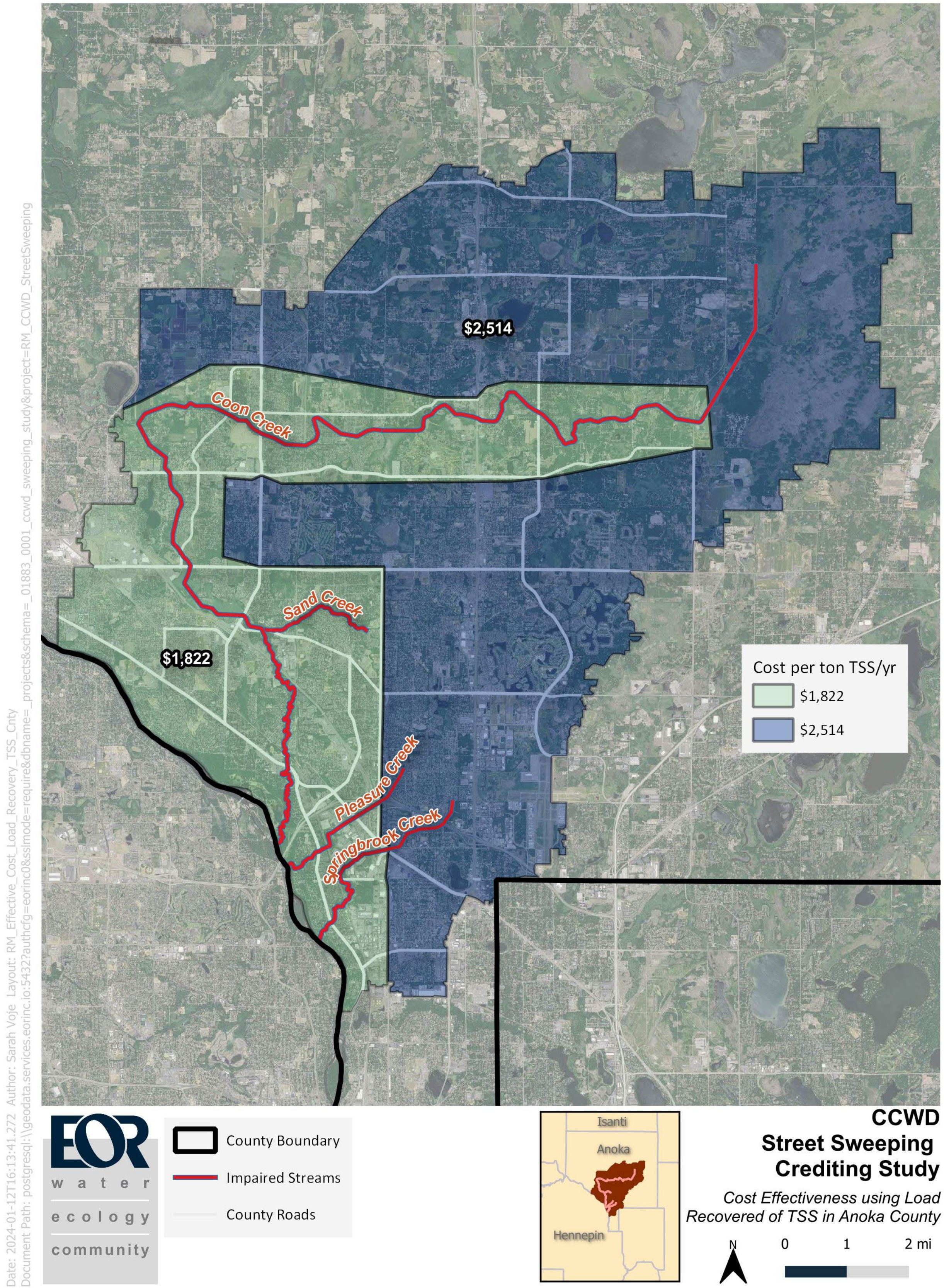

Figure 25. Anoka county zone total suspended solids cost-effectiveness ($/tons/yr) for sweeping 12 times/year.

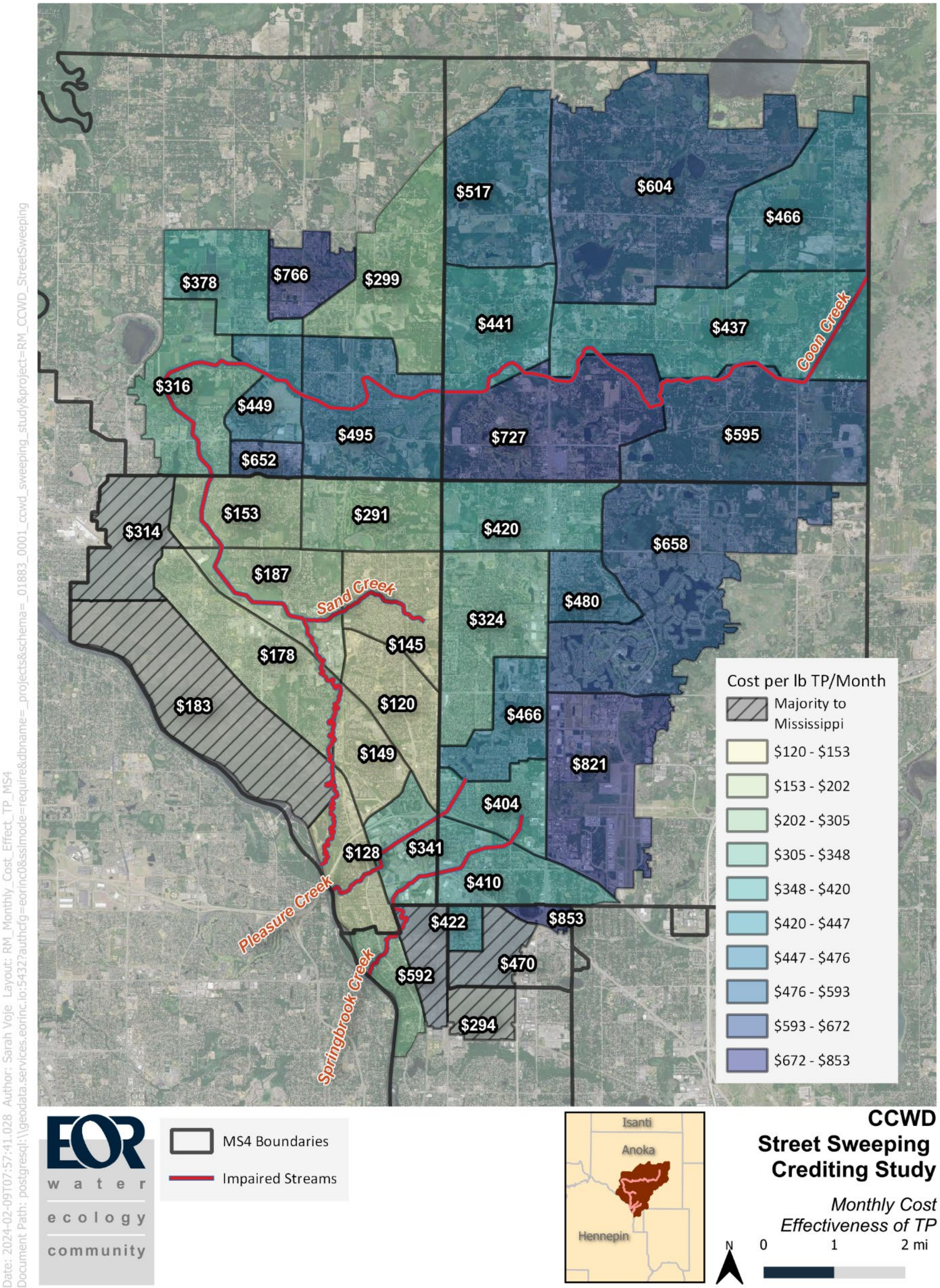

Figure 26. Municipal zone total phosphorus cost-effectiveness ($/lbs/yr) for monthly street sweeping.

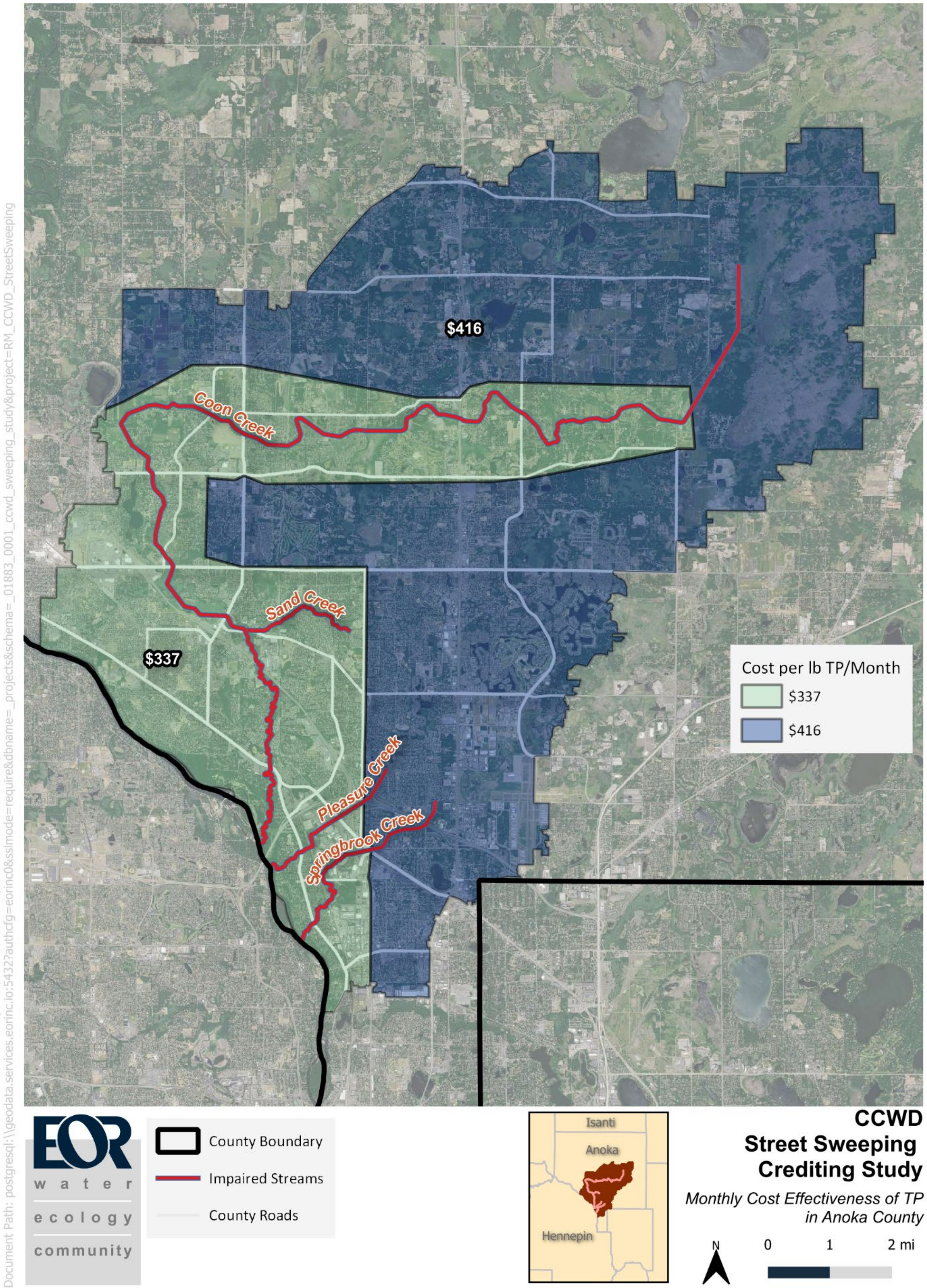

Figure 27. Anoka county zone total phosphorus cost-effectiveness ($/lb/yr) for monthly street sweeping.

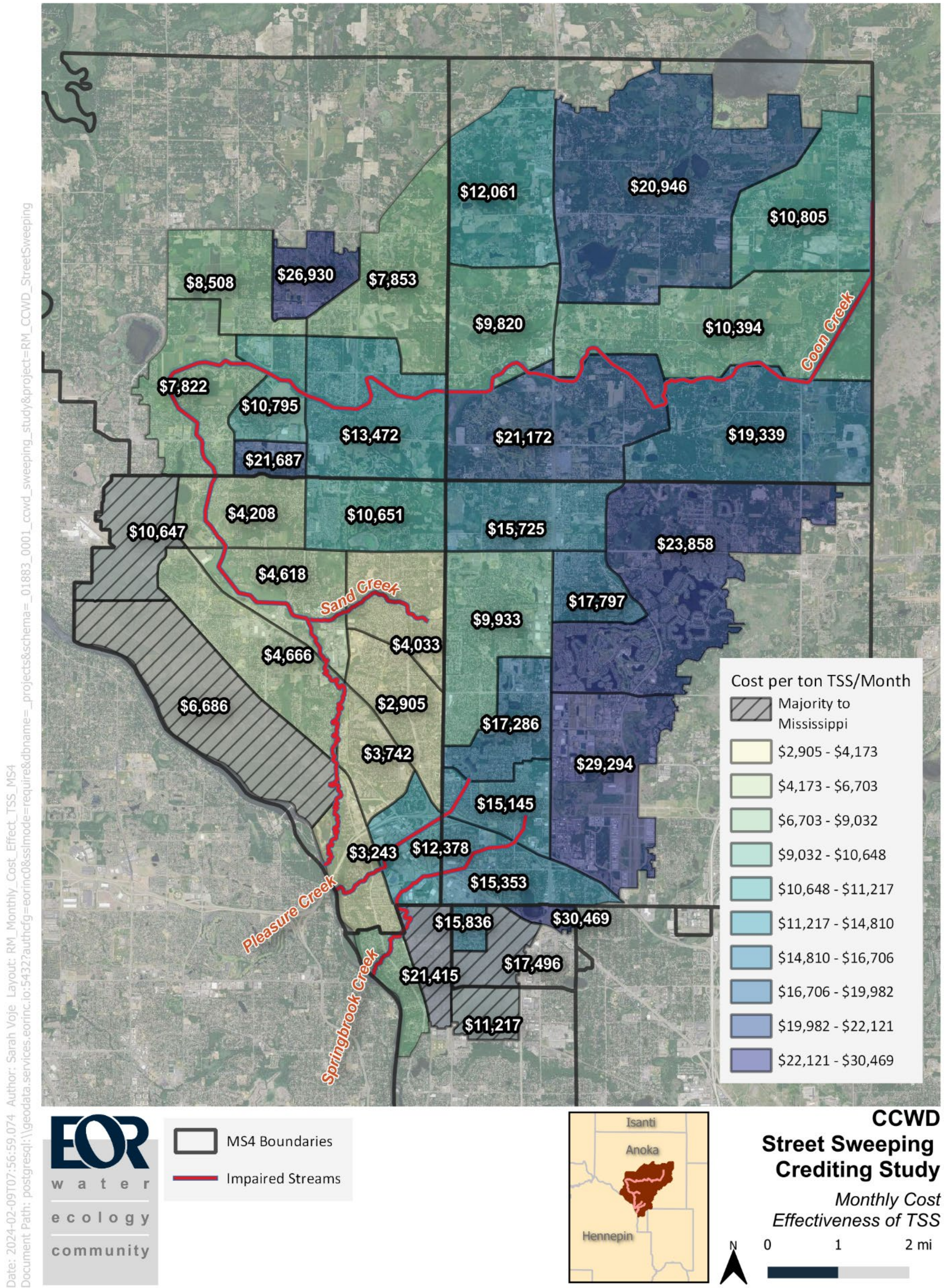

Figure 28. Municipal zone totally suspended solids cost-effectiveness ($/tons/yr) for monthly street sweeping.

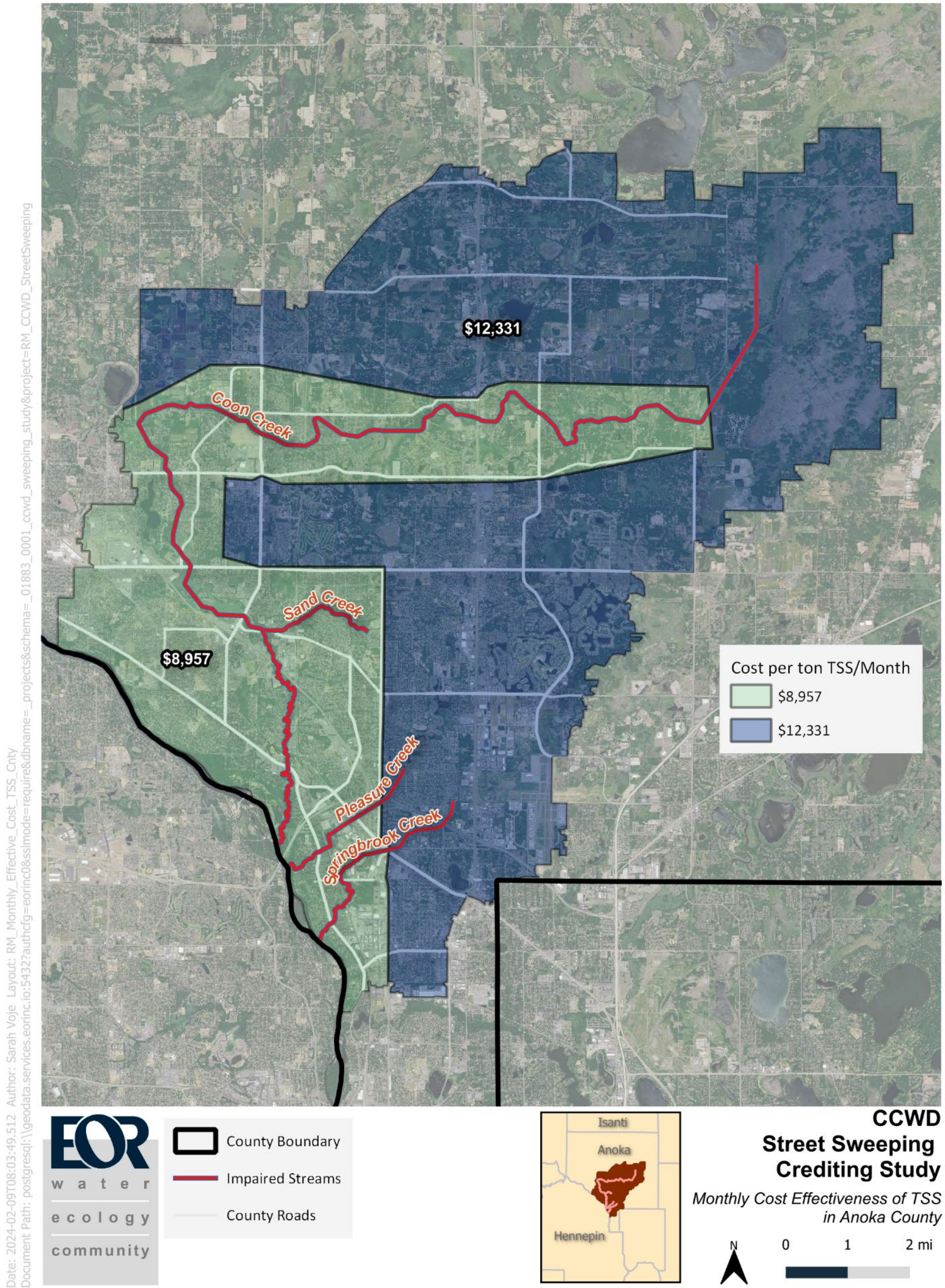

Figure 29. Anoka county zone total suspended solids cost-effectiveness ($/tons/yr) for monthly street sweeping.

4. RECOMMENDATIONS

Recommendations for each MS4 are provided below. In each case, two scenarios are presented: 1) the "optimized existing effort" scenario which reallocates existing effort or includes a modest increase in effort for those MS4s sweeping the minimum of twice per year and 2) the next best value scenario based on increased incremental pollutant recovery per unit cost. Further recommendations are included where applicable. In addition, modeled pollutant recovery estimates for enhanced sweeping scenarios are included as annual load reductions from each stream. The annual load reductions from each stream can be used as pollutant credits on a pilot basis if certain conditions are met. It should be noted that MS4s are only able to claim pollutant reduction credits for those that exceed credits earned in the TMDL baseline year for each receiving water and need to be adjusted accordingly. Therefore, the TMDL baseline load reductions were estimated using the street sweeping planning calculator for each MS4 in addition to scenarios included in Section 3. The major differences between the TMDL baseline year scenario and the 2022 base scenario are:

- Andover swept twice annually in 2009 instead of 2.67 times in 2022,
- Fridley swept five times annually in 2012 instead of 7.5 times in 2022, and
- Ham Lake swept once annually in 2009-10 instead of twice annually in 2022.

All other MS4s maintained the same number of complete sweeps from the TMDL baseline years (2009-2012 depending on stream) to 2022. Figure 40 and Figure 41 in Appendix A show the number of sweeping per year in each sweeping zone for the TMDL baseline scenario. All credits greater than those estimated for the TMDL baseline year and associated with implementing recommended enhanced sweeping strategies are eligible. In some instances, there is a predicted decrease in credits caused by rearranging sweeping actions to prioritize high load areas instead of assuming a constant sweeping rate throughout a MS4. It should be noted that all credits realized for Sand Creek can also be applied towards meeting Coon Creek's load reductions given that it is a tributary to Coon Creek. Due to the categorical nature of the CCWD TMDL WLA, all MS4s benefit from increased sweeping recoveries/load reductions regardless of where they occur in relation to MS4 boundaries. The recommendations provided to CCWD are generalized recommendations applicable to all MS4s.

4.1. Andover

Figure 30 shows Andover's current 2.67 sweepings per year optimized in the CCWD by reallocating more effort to five priority sweeping zones. The optimized existing effort scenario is predicted to increase Andover's TP load reduction for Coon Creek by 1% from the 2022 base scenario which will increase the eligible credits attributable to Andover by 3 lbs/yr (Table 14). Furthermore, the City's TSS load reduction from Coon Creek is predicted to increase by 3% from the 2022 base scenario which will provide an additional 0.2 tons of TSS credit per year. The optimized existing effort street sweeping scenario should not cost the city more than the existing street sweeping program aside from a modest increase in disposal costs (~3%) based on the predicted increase in sweepings mass recovery. If the city wants to increase their street sweeping effort, their minimum recommended target should be enhanced baseline sweeping which is sweeping twice in the spring and fall. The increase in TP and TSS load reductions is predicted to be 30% and 59% respectively. The cost to implement enhanced baseline street sweeping within the portion of Andover within CCWD is estimated to be approximately $27,000 or 50% more than the existing street sweeping cost for a total cost of approximately $80,000/yr.

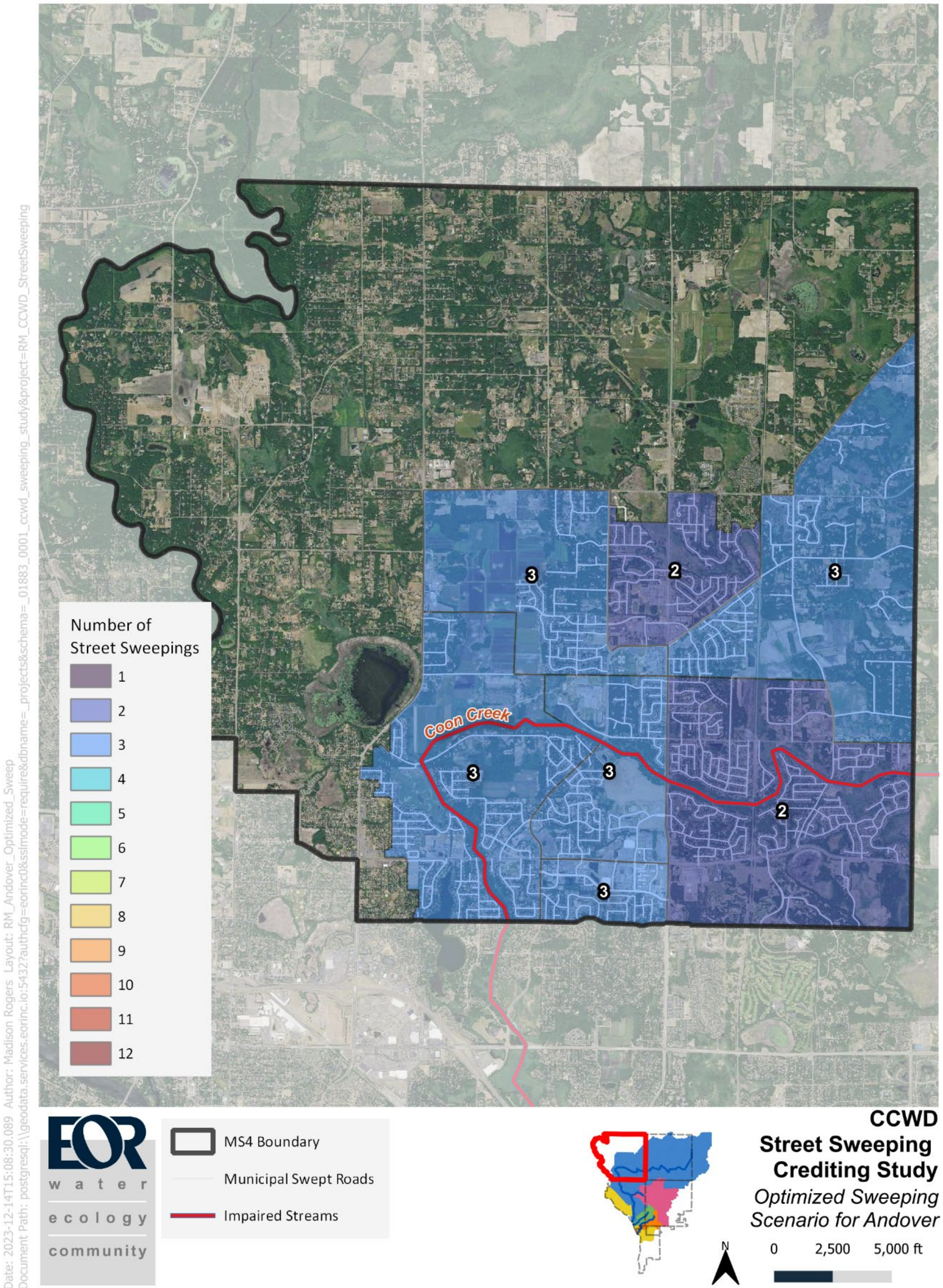

Figure 30. Andover optimized existing effort street sweeping.

Table 14 Andover Predicted Pollutant Load Reduction from the Stream across a range of Sweeping Scenarios

Stream	Predicted TP Load Reduction from the Stream (lbs/yr)							
	TMDL Baseline[1]	2022 Base	Optimized Existing Effort	Enhanced Baseline	1 Additional Sweeper	3 Additional Sweepers	5 Additional Sweepers	Maximum
Coon Creek	144	181	**184**	**235**	253	407	450	450
	Predicted TSS Load Reduction from the Stream (tons/yr)							
Coon Creek	3.1	4.5	**4.7**	**7.2**	8.4	14.8	15.8	15.8

[1]The TMDL Baseline predicted load reduction may differ from Phase 1 credits because of the method used to estimate the credits. If the MS4 currently tracks sweepings mass or volume they should continue to do so because they will receive more credits.

Bold values indicate the two best scenarios recommended for the MS4.

Table 15 Andover Scenario Swept Lane-miles and Cost Summary

MS4 Effort Summary	Scenario						
	2022 Base	Optimized Existing Effort	Enhanced Baseline	1 Additional Sweeper	3 Additional Sweepers	5 Additional Sweepers	Maximum
Total Swept Lane-miles	577	**566 (0%)**	**864 (50%)**	961 (67%)	1804 (213%)	2593 (349%)	2593 (349%)
Total Cost ($/yr)	$53,513	**$52,551**	**$80,451**	$89,691	$167,794	$237,386	$237,386

Bold values indicate the two best scenarios for the MS4.

4.2. Anoka County

Anoka county currently sweeps a portion of their streets twice per year, once in the spring and fall. County roads are less likely to have curb and gutter and are more likely to be rural where sweeping is more difficult and less applicable. Figure 27 shows Anoka County's optimized existing effort scenario which is sweeping approximately half of their streets within CCWD another time in the spring which is approximately 122 more lane-miles per year. The optimized existing effort scenario is predicted to increase Anoka County's eligible TP credits by a total of 29 lbs/yr and their TSS credits by a total of 1.1 tons/yr above their current 2022 base load reduction (Table 16). The optimized existing effort street sweeping scenario is predicted to increase the County's Street sweeping cost within CCWD by 34% (~$9,000) to a total cost of approximately $35,000/yr. The next best value scenario above the optimized existing effort scenario is enhanced baseline which is sweeping all County roads within CCWD twice in the spring and fall. The enhanced baseline sweeping schedule is predicted to increase the TP and TSS credits available to Anoka County by 63% and 129% respectively compared to their current 2022 base sweeping. The cost to implement enhanced baseline sweeping in Anoka County is estimated to be approximately $52,000/yr (~102% increase from existing).

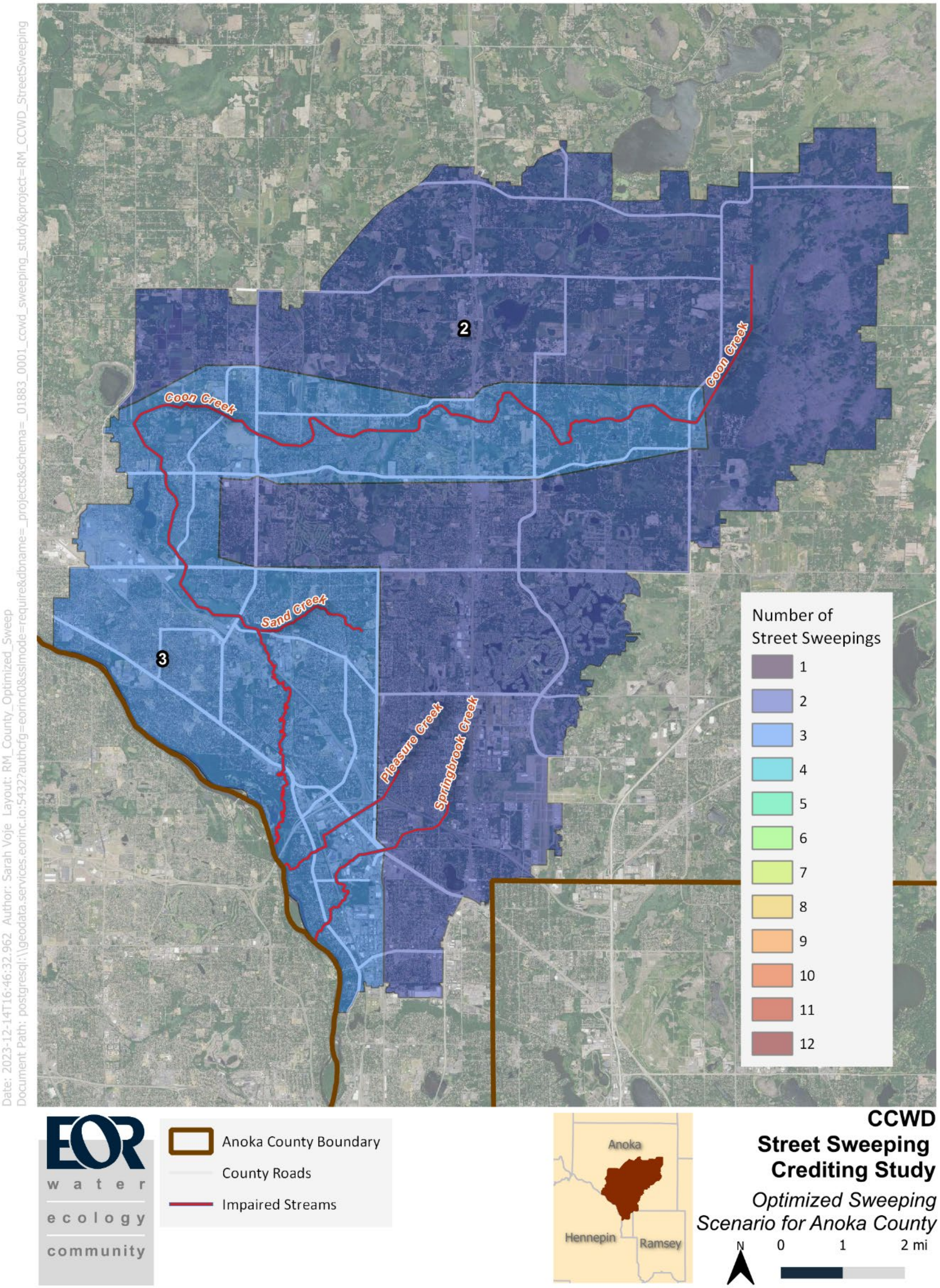

Figure 31. Anoka county optimized existing effort street sweeping.

Table 16 Anoka County Predicted Pollutant Load Reduction from the Stream across a range of Sweeping Scenarios.

Stream	Predicted TP Load Reduction from the Stream (lbs/yr)							
	TMDL Baseline[1]	2022 Base	Optimized Existing Effort	Enhanced Baseline	1 Additional Sweeper	3 Additional Sweepers	5 Additional Sweepers	Maximum
Coon Creek	60	60	**78**	**97**	108	164	187	187
Pleasure Creek	5	5	**7**	**8**	9	13	15	15
Sand Creek	22	22	**25**	**36**	38	61	70	70
Springbrook Creek	8	8	**10**	**13**	14	21	24	24
Other	12	12	**16**	**20**	22	34	38	38
Total	107	107	**136**	**174**	191	293	334	334
	Predicted TSS Load Reduction from the Stream (tons/yr)							
Coon Creek	1.3	1.3	**1.9**	**2.9**	3.5	5.6	6.3	6.3
Pleasure Creek	0.10	0.10	**0.17**	**0.23**	0.30	0.45	0.51	0.51
Sand Creek	0.45	0.45	**0.55**	**1.0**	1.1	2.0	2.2	2.2
Springbrook Creek	0.16	0.16	**0.25**	**0.37**	0.45	0.72	0.81	0.81
Other	0.26	0.26	**0.40**	**0.59**	0.73	1.2	1.3	1.3
Total	2.2	2.2	**3.3**	**5.1**	6.1	10.0	11.2	11.2

[1]The TMDL Baseline predicted load reduction may differ from Phase 1 credits because of the method used to estimate the credits. If the MS4 currently tracks sweepings mass or volume they should continue to do so because they will receive more credits.

Bold values indicate the two best scenarios for the MS4.

Table 17 Anoka County Scenario Swept Lane-miles and Cost Summary

MS4 Effort Summary	Scenario						
	2022 Base	Optimized Existing Effort	Enhanced Baseline	1 Additional Sweeper	3 Additional Sweepers	5 Additional Sweepers	Maximum
Total Swept Lane-miles	365	**487 (34%)**	**729 (100%)**	852 (134%)	1459 (300%)	2188 (500%)	2188 (500%)
Total Cost ($/yr)	$25,868	**$34,768**	**$52,223**	$61,103	$104,319	$153,548	$153,548

Bold values indicate the two best scenarios for the MS4.

4.3. Blaine

Figure 28 shows Blaine's current 4.5 Citywide sweepings per year optimized in the CCWD by reallocating more effort to four priority sweeping zones in the western portion of the city. The optimized existing effort scenario is predicted to increase Blaine's TP and TSS load reductions for receiving waters by 3% and 2% respectively which will increase the credits available to Blaine by 17 lbs/yr and 0.2 tons/yr compared to their 2022 base load reductions (Table 18). One downside of the optimized existing effort scenario is that the credits available for Coon Creek are predicted to decrease because of reduced sweeping in portions of the City that drain directly to Coon Creek. However, because Sand Creek is a tributary to Coon Creek, additional effort in the Sand Creek drainage area also benefits Coon Creek, doubling the value of those credits. In addition, the total credits received are predicted to increase from the optimized existing effort sweeping scenario. The optimized existing effort street sweeping scenario should not cost the city more than the existing street sweeping program aside from a modest increase in disposal costs given that solids recovery is estimated to increase by 2% compared to their 2022 base sweeping. If the city wants to increase their street sweeping effort, the "Three Additional Sweepers" Districtwide modeling scenario is the first scenario showing an increase in both TP and TSS credits for all receiving waters (Figure 29). This scenario entails seven sweepings per year on the eastern half of the city and eight sweepings per year on the western half of the city. This enhanced sweeping scenario equates to sweeping approximately 67% more lane-miles (1278) at a predicted total cost increase of 67% (~$140,000) to achieve additional pollutant load reductions of 54% for TP and 69% for TSS compared to the 2022 base scenario.

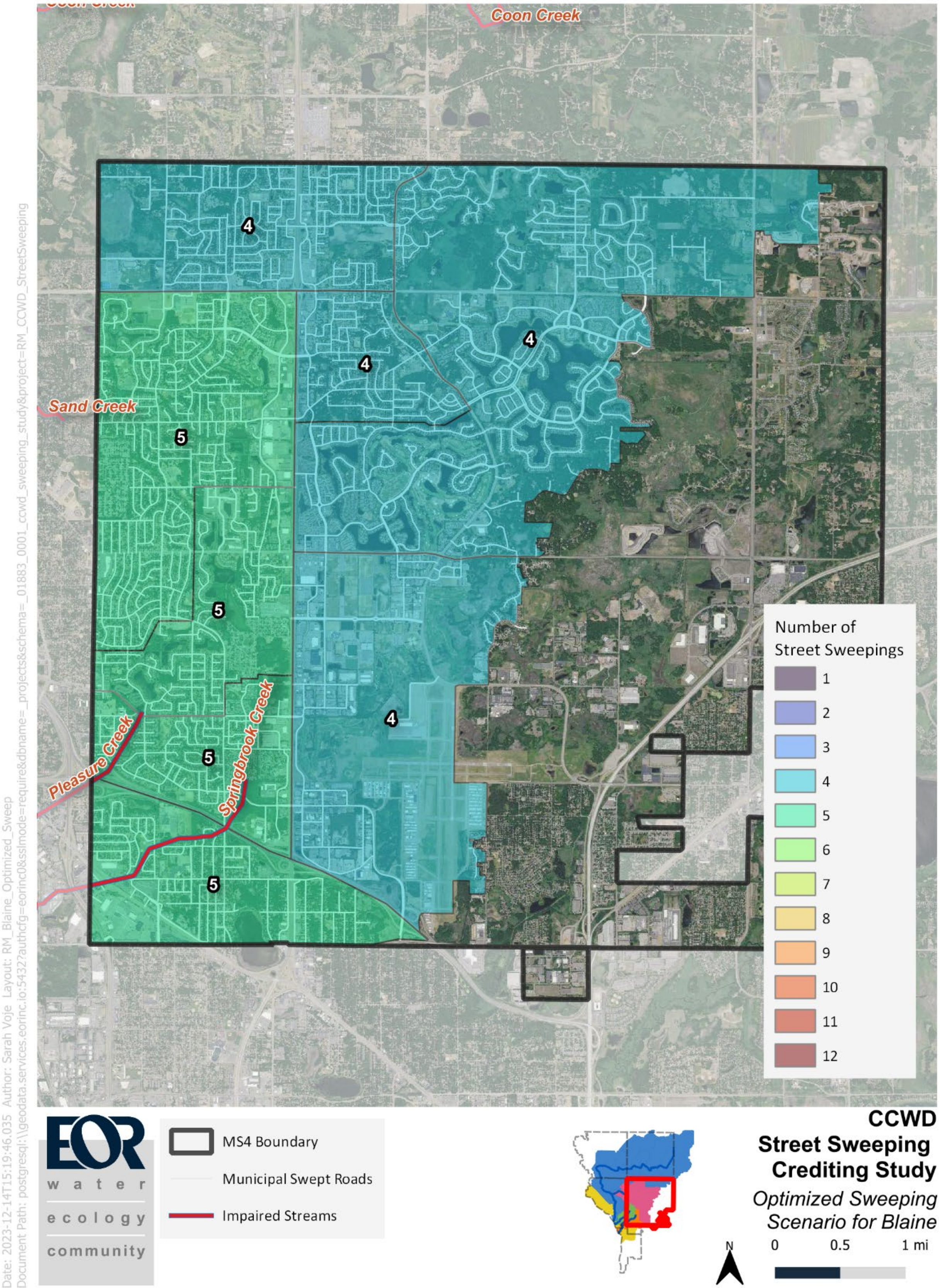

Figure 32 Blaine optimized existing effort street sweeping maintaining current level of effort.

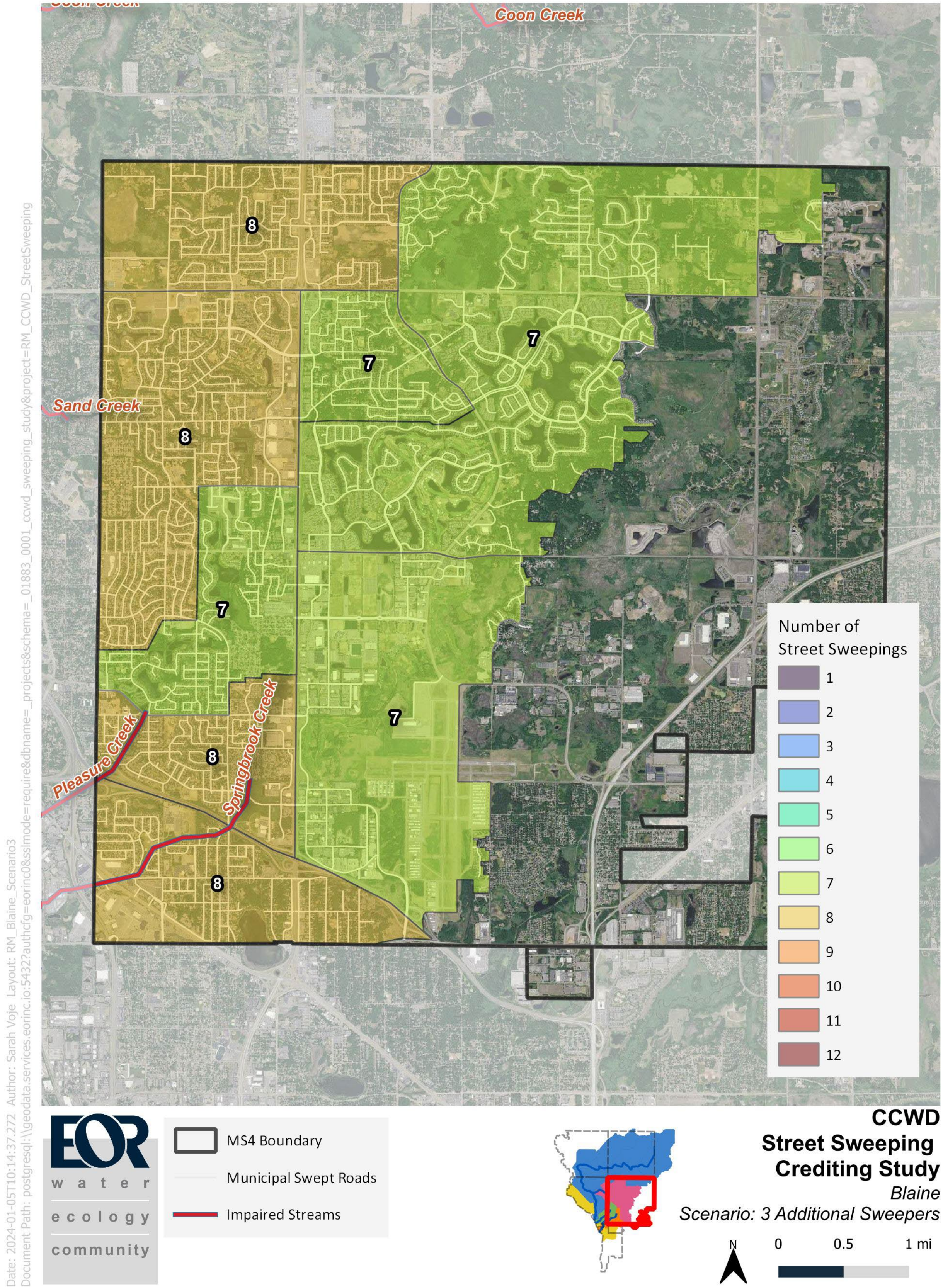

Figure 33 Blaine street sweeping scenario with three additional street sweepers spread across the CCWD.

Table 18 Blaine Predicted Pollutant Load Reduction from the Stream across a range of Sweeping Scenarios.

Stream	Predicted TP Load Reduction from the Stream (lbs/yr)							
	TMDL Baseline[1]	2022 Base	Optimized Existing Effort	Enhanced Baseline	1 Additional Sweeper	3 Additional Sweepers	5 Additional Sweepers	Maximum
Coon Creek	69	69	**68**	66	68	**104**	127	127
Pleasure Creek	52	52	**57**	52	54	**80**	97	97
Sand Creek	313	313	**320**	313	318	**480**	578	578
Springbrook Creek	67	67	**74**	67	74	**109**	124	124
Other	0.7	0.7	**0.8**	0.7	0.8	**1.2**	1.4	1.4
Total	503	503	**520**	503	515	**775**	927	927
	Predicted TSS Load Reduction from the Stream (tons/yr)							
Coon Creek	1.7	1.7	**1.6**	1.5	1.6	**2.9**	3.3	3.3
Pleasure Creek	1.2	1.2	**1.4**	1.1	1.3	**2.1**	2.4	2.4
Sand Creek	8.0	8.0	**8.1**	7.1	8.0	**13.5**	15.5	15.5
Springbrook Creek	1.6	1.6	**1.8**	1.4	1.8	**2.7**	3.0	3.0
Other	0.017	0.017	**0.019**	0.015	0.019	**0.030**	0.033	0.033
Total	12.6	12.6	**12.8**	11.0	12.6	**21.2**	24.3	24.3

[1]The TMDL Baseline predicted load reduction may differ from Phase 1 credits because of the method used to estimate the credits. If the MS4 currently tracks sweepings mass or volume they should continue to do so because they will receive more credits.
Bold values indicate the two best scenarios for the MS4.

Table 19 Blaine Scenario Swept Lane-miles and Cost Summary

MS4 Effort Summary	Scenario						
	2022 Base	Optimized Existing Effort	Enhanced Baseline	1 Additional Sweeper	3 Additional Sweepers	5 Additional Sweepers	Maximum
Total Swept Lane-miles	1916	**1895 (0%)**	1916 (0%)	1861 (-3%)	**3194 (67%)**	5109 (167%)	5109 (167%)
Total Cost ($/yr)	$208,817	**$206,804**	$208,817	$203,057	**$348,327**	$546,553	$546,553

Bold values indicate the two best scenarios for the MS4.

4.4. Coon Rapids

Figure 30 shows Coon Rapids current 6.5 citywide sweepings per year optimized in the CCWD by reallocating more effort to priority sweeping zones. The optimized existing effort scenario increased the sweeping variability with some zones receiving monthly sweepings while others were cut back to enhanced baseline sweeping (twice in spring and fall). A downside of the increased variability is that some impaired receiving waters lose pollutant credits when evaluated individually, but still benefit from enhanced sweeping in contributing tributaries. In Coon Rapids, sweeping zones draining to Sand or Coon Creeks were prioritized over zones draining directly to the Mississippi River because the Mississippi River benefits from all sweeping as the ultimate receiving water. Similarly, any enhanced sweeping implemented in the Sand Creek drainage also benefits Coon Creek, doubling the value of those credits. For the optimized existing effort scenario, without any increase in overall sweeping effort, the total credits available to Coon Rapids increases by 20 lbs/yr for TP and 2.6 tons/yr for TSS compared to 2022 base sweeping (Table 20). There would be a modest annual cost increase (~$1000) incurred by the City for additional disposal because the recovery of solids is modeled to increase by 12%. If the city wants to increase their sweeping effort, the "One Additional Sweeper" Districtwide modeling scenario is an example of where they should prioritize additional street sweeping (Figure 31). This enhanced sweeping scenario entails sweeping most of the city seven times per year and equates to sweeping approximately 13% more lane-miles (322) at a predicted total cost increase of 14.4% (~$22,000) to achieve additional pollutant load reductions of 27% for TSS and 8% for TP compared to existing 2022 effort.

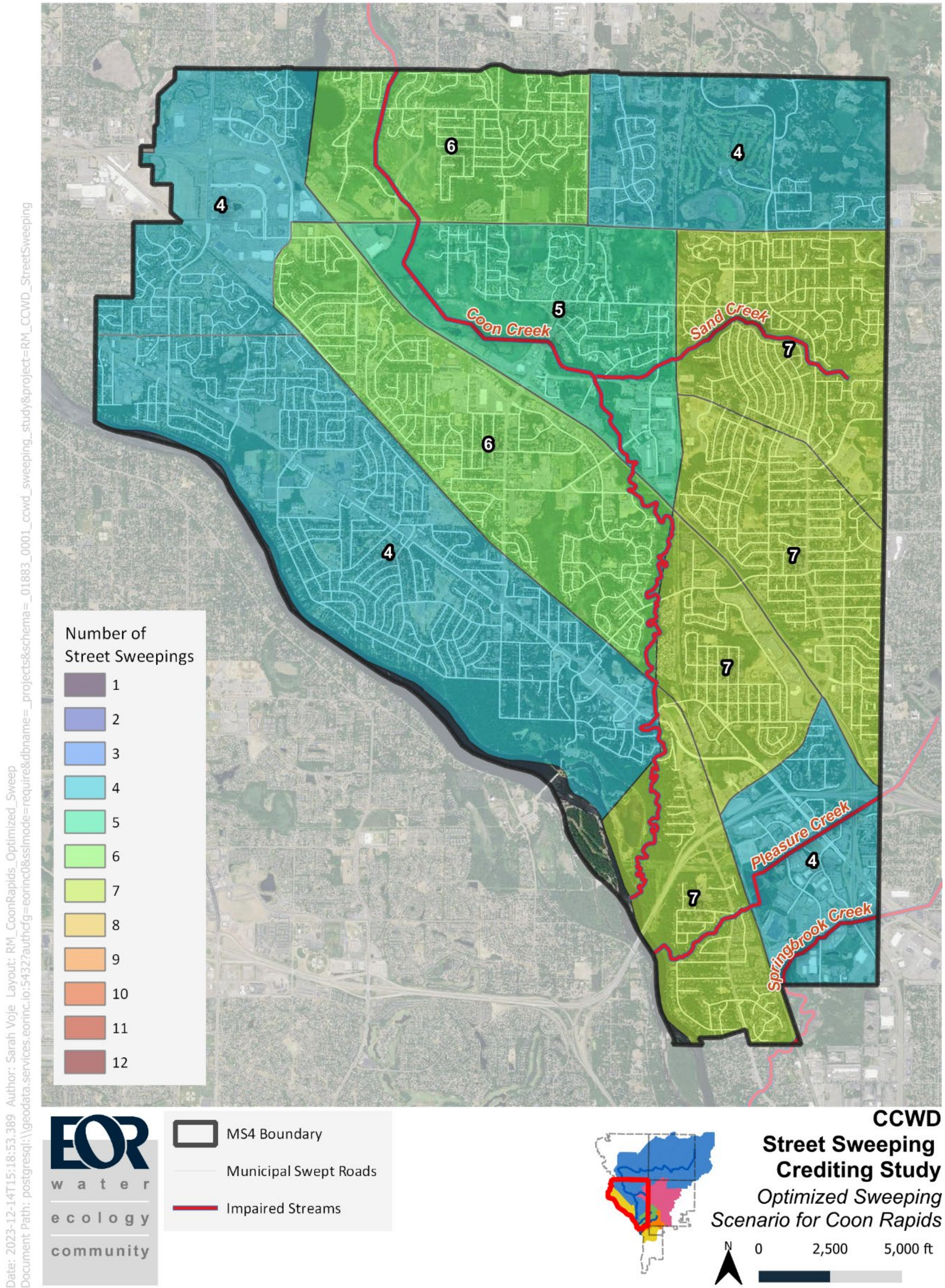

Figure 34 Coon Rapids optimized existing effort street sweeping.

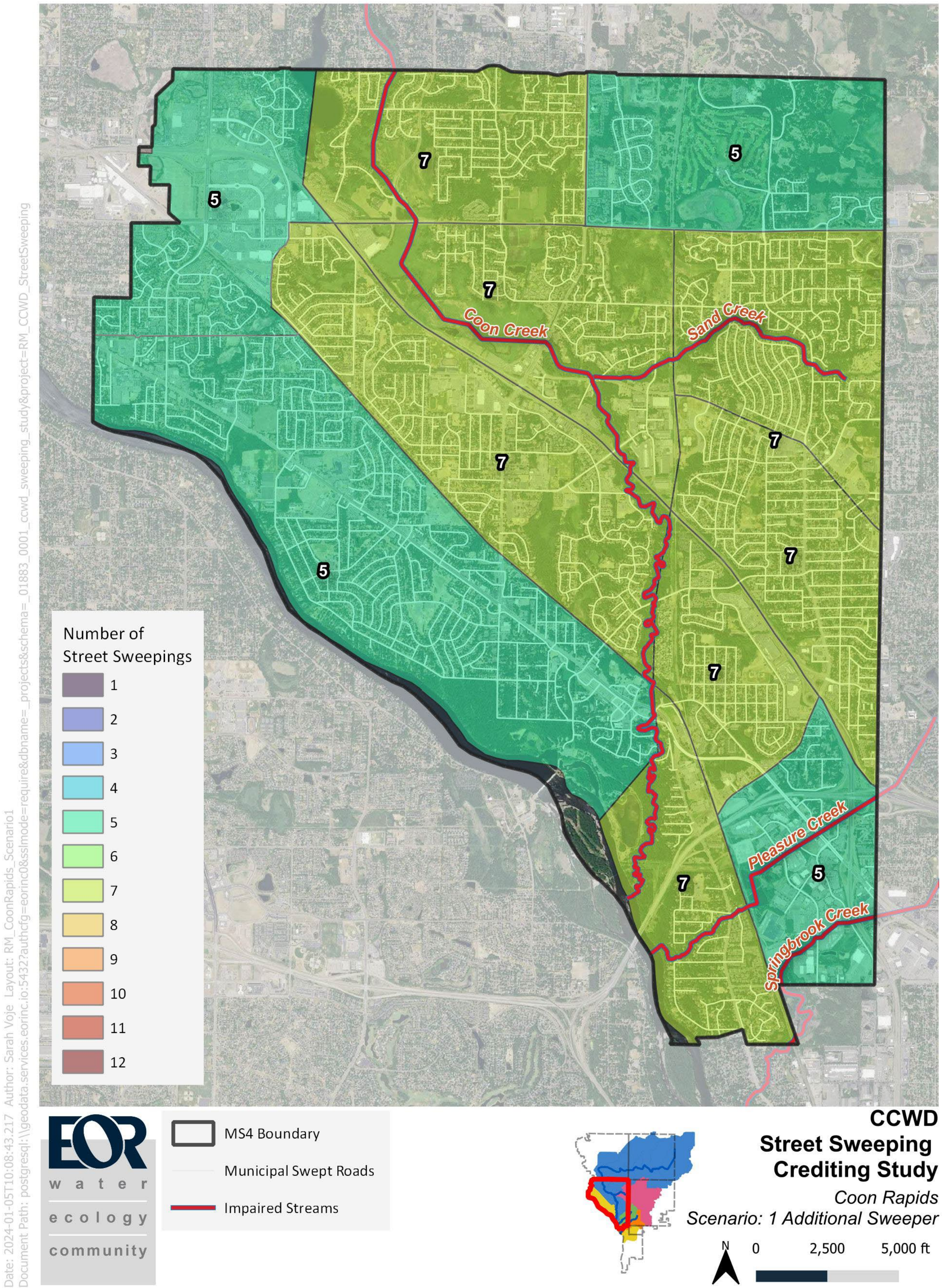

Figure 35 Coon Rapids street sweeping scenarios with one additional street sweeper spread across the CCWD

Table 20 Coon Rapids Predicted Pollutant Load Reduction from the Stream across a range of Sweeping Scenarios.

Stream	Predicted TP Load Reduction from the Stream (lbs/yr)							
	TMDL Baseline[1]	2022 Base	Optimized Existing Effort	Enhanced Baseline	1 Additional Sweeper	3 Additional Sweepers	5 Additional Sweepers	Maximum
Coon Creek	571	571	**621**	571	**648**	828	858	862
Pleasure Creek	29	29	**28**	29	**30**	43	44	44
Sand Creek	135	135	**152**	135	**155**	199	204	204
Springbrook Creek	15	15	**16**	15	**16**	22	23	23
Other	242	242	**195**	242	**219**	223	236	366
Total	993	993	**1013**	887	**1069**	1315	1365	1499
	Predicted TSS Load Reduction from the Stream (tons/yr)							
Coon Creek	18.5	18.5	**21.7**	17.6	**24.8**	29.5	30.1	30.2
Pleasure Creek	0.83	0.83	**0.92**	0.79	**0.99**	1.3	1.4	1.4
Sand Creek	4.1	4.1	**5.5**	3.9	**5.6**	6.6	6.7	6.7
Springbrook Creek	0.47	0.47	**0.59**	0.44	**0.61**	0.76	0.76	0.76
Other	5.7	5.7	**4.5**	5.5	**5.6**	5.7	6.1	9.4
Total	29.6	29.6	**33.2**	28.2	**37.6**	43.9	45.0	48.4

[1]The TMDL Baseline predicted load reduction may differ from Phase 1 credits because of the method used to estimate the credits. If the MS4 currently tracks sweepings mass or volume they should continue to do so because they will receive more credits.

Bold values indicate the two best scenarios for the MS4.

Table 21 Coon Rapids Scenario Swept Lane-miles and Cost Summary

MS4 Effort Summary	Scenario						
	2022 Base	Optimized Existing Effort	Enhanced Baseline	1 Additional Sweeper	3 Additional Sweepers	5 Additional Sweepers	Maximum
Total Swept Lane-miles	2465	**2458 (0%)**	2465 (0%)	**2787 (13%)**	3798 (54%)	4646 (89%)	5377 (118%)
Total Cost ($/yr)	$151,034	**$151,973**	$151,034	**$172,769**	$229,931	$275,131	$317,287

Bold values indicate the two best scenarios for the MS4.

4.5. Fridley

Fridley currently sweeps an average of 7.5 times per year and already reports using enhanced street sweeping strategies for water quality. Figure 32 shows where additional sweeping is predicted to be more beneficial to the impaired streams within CCWD. The optimized existing effort street sweeping scenario, without increasing existing sweeping effort, is predicted to increase pollutant load reductions by 1% for both TP and TSS compared to 2022 base sweeping. (Table 22). Sweeping more than eight times per year is predicted to have smaller gains in pollutant recovery than compared to increases in sweeping below eight times per year (Figure 8). Therefore, additional sweeping effort in Fridley would be less cost effective than enhanced sweeping undertaken by other MS4s in the District. The greatest benefit in pollutant recovery for Fridley is improving leaf collection to maximize TP credits towards achieving Springbrook Creek's TP WLAs. The greatest improvement to Fridley's street sweeping program is to start weighing (or tracking volumes of) the sweeping material they collect which could increase their TP credits by two to three orders of magnitude. Fridley's existing eligible TP credits are based solely on the lane-miles they sweep per year, which is known to be very conservative.

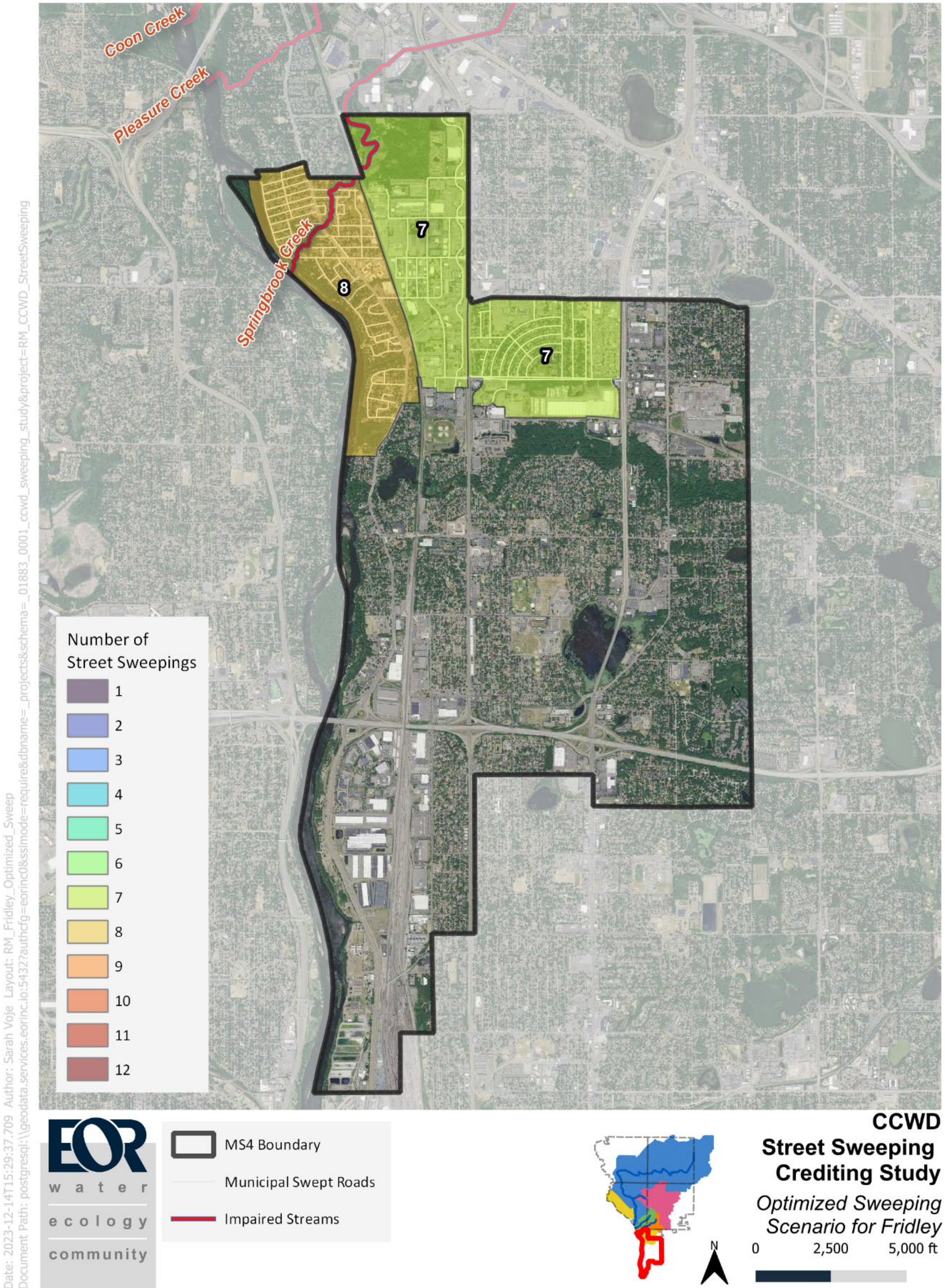

Figure 36. Fridley optimized street sweeping maintaining current level of effort.

Table 22 Fridley Predicted Pollutant Load Reduction from the Stream across a range of Sweeping Scenarios.

Stream	Predicted TP Load Reduction from the Stream (lbs/yr)							
	TMDL Baseline[1]	2022 Base	Optimized Existing Effort	Enhanced Baseline	1 Additional Sweeper	3 Additional Sweepers	5 Additional Sweepers	Maximum
Springbrook Creek	43	60	**64**	60	64	72	73	73
Other	59	82	**80**	82	80	83	86	99
Total	102	142	**144**	132	132	144	156	159
	Predicted TSS Load Reduction from the Stream (tons/yr)							
Springbrook Creek	1.0	1.8	**1.9**	1.8	1.9	2.1	2.1	2.1
Other	1.2	2.2	**2.2**	2.1	2.2	2.3	2.3	2.6
Total	2.2	4.0	**4.1**	3.9	4.1	4.4	4.4	4.7

[1]The TMDL Baseline predicted load reduction may differ from Phase 1 credits because of the method used to estimate the credits. If the MS4 currently tracks sweepings mass or volume they should continue to do so because they will receive more credits.
Bold values indicate the best scenario for the MS4.

Table 23 Fridley Scenario Swept Lane-miles and Cost Summary

MS4 Effort Summary	Scenario						
	2022 Base	Optimized Existing Effort	Enhanced Baseline	1 Additional Sweeper	3 Additional Sweepers	5 Additional Sweepers	Maximum
Total Swept Lane-miles	393	**389 (0%)**	393 (0%)	389 (-1%)	478 (22%)	506 (29%)	629 (60%)
Total Cost ($/yr)	$39,795	**$39,444**	$39,795	$39,444	$47,784	$50,408	$61,846

Bold values indicate the best scenario for the MS4.

4.6. Ham Lake

Ham Lake currently sweeps their streets twice per year, once in the spring and fall. The optimized existing effort scenario evaluated where Ham Lake should sweep if they have additional capacity to sweep half of their streets in targeted, priority zones an additional time in the spring which is shown in Figure 33. The additional 0.5 street sweepings per year entails sweeping 22% more lane-miles (121) and is predicted to increase the City’s TSS load reduction by 40% and TP load reduction by 20% as compared to 2022 base sweeping (Table 24). The cost of implementing the optimized existing effort scenario is estimated to be approximately $88,000/yr compared to the existing program cost at $72,000/yr (23% increase). An additional strategy for increasing the TP credits available to Ham Lake without increasing street sweeping effort is to start weighing the sweeping material they collect (or tracking volumes) which could increase their TP credits by two to three orders of magnitude. Presently, eligible TP credits are based solely on swept lane-miles, a very conservative approach. Lastly, Ham Lake’s eventual street sweeping goal should be enhanced baseline street sweeping (Citywide sweeping twice in the spring and fall). Enhanced baseline sweeping is predicted to increase TSS load reductions/credits by 129% and TP load reductions/credits by 63% while only increasing costs by 101% (~$72,000) compared to 2022 base sweeping.

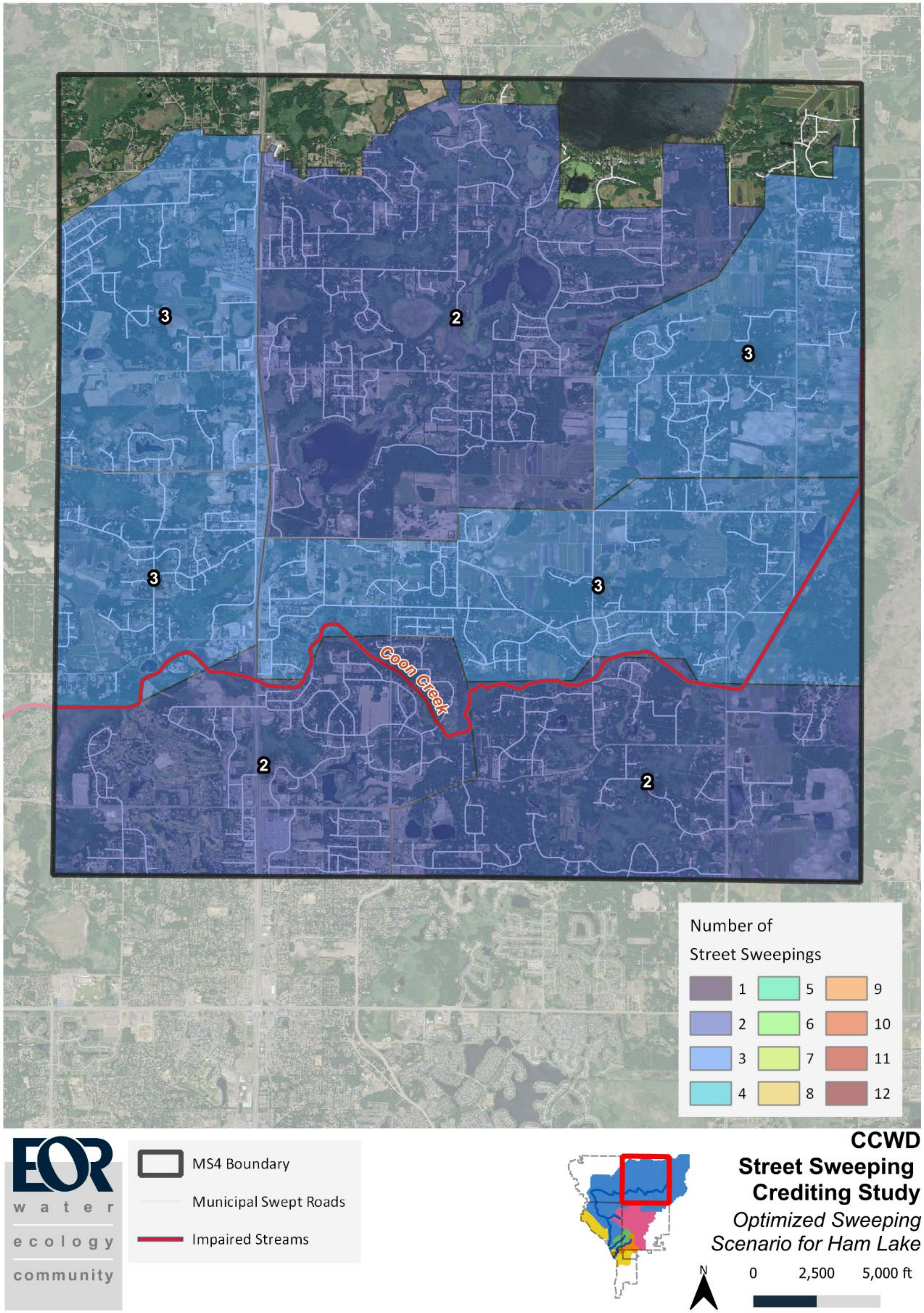

Figure 37. Ham Lake optimized existing effort street sweeping.

Table 24 Ham Lake Predicted Pollutant Load Reduction from the Stream across a range of Sweeping Scenarios.

Stream	Predicted TP Load Reduction from the Stream (lbs/yr)							
	TMDL Baseline[1]	2022 Base	Optimized Existing Effort	Enhanced Baseline	1 Additional Sweeper	3 Additional Sweepers	5 Additional Sweepers	Maximum
Coon Creek	81	194	**234**	**317**	347	581	607	607
Sand Creek	0.3	0.8	**0.8**	**1.3**	1.3	2.3	2.4	2.4
Total	81	195	**234**	**318**	349	583	609	609
	Predicted TSS Load Reduction from the Stream (tons/yr)							
Coon Creek	1.4	4.1	**5.7**	**9.4**	11.1	20.3	20.6	20.6
Sand Creek	0.005	0.015	**0.015**	**0.035**	0.035	0.075	0.076	0.076
Total	1.4	4.1	**5.8**	**9.4**	11.2	20.4	20.7	20.7

[1]The TMDL Baseline predicted load reduction may differ from Phase 1 credits because of the method used to estimate the credits. If the MS4 currently tracks sweepings mass or volume they should continue to do so because they will receive more credits.
Bold values indicate the two best scenarios for the MS4.

Table 25 Ham Lake Scenario Swept Lane-miles and Cost Summary

MS4 Effort Summary	Scenario						
	2022 Base	Optimized Existing Effort	Enhanced Baseline	1 Additional Sweeper	3 Additional Sweepers	5 Additional Sweepers	Maximum
Total Swept Lane-miles	541	**662 (22%)**	**1081 (100%)**	1224 (126%)	2554 (372%)	3244 (500%)	3244 (500%)
Total Cost ($/yr)	$71,588	**$87,817**	**$144,034**	$163,018	$338,830	$426,611	$426,611

Bold values indicate the two best scenarios for the MS4.

4.7. Spring Lake Park

Spring Lake Park currently uses contracted street sweeping to sweep their streets twice per year, once in the spring and once in the fall. Figure 34 shows the optimized existing effort sweeping scenario which represents sweeping half of the city streets an additional time in the spring in the highest priority sweeping zone. The additional sweeping entails 12 additional lane-miles (13% increase) and is predicted to increase TSS load reductions by 19% and TP load reductions by 12% compared to 2022 base sweeping (Table 26). The optimized existing effort scenario is predicted to increase the City's total cost for the portion of the city within CCWD by 14%, from ~$10,000 to $11,300 In addition to increasing their street sweeping, Spring Lake Park could increase their amount of eligible TP credits by weighing the sweeping material they collect (or tracking volumes) which could increase their TP credits by two to three orders of magnitude. If the City is willing to expand their street sweeping program, their eventual goal should be "Enhanced Baseline Sweeping" (Citywide sweeping twice in the spring and fall). Enhanced baseline sweeping is predicted to increase TSS load reductions/credits by 129% and TP load reductions/credits by 63% while roughly doubling costs (~$10,000) compared to 2022 base sweeping. If the City expands their street sweeping program, they should continue to compare contracted sweeping costs to in-house sweeping costs. In-house sweeping will become more economical with more citywide sweeping. Using the average operation unit cost among all MS4s who use one sweeper to sweep their streets, in-house street sweeping with one mechanical broom street sweeper was shown to be more cost effective than contract street sweeping for Spring Lake Park with a break-even point at approximately five citywide sweeps (Figure 35).

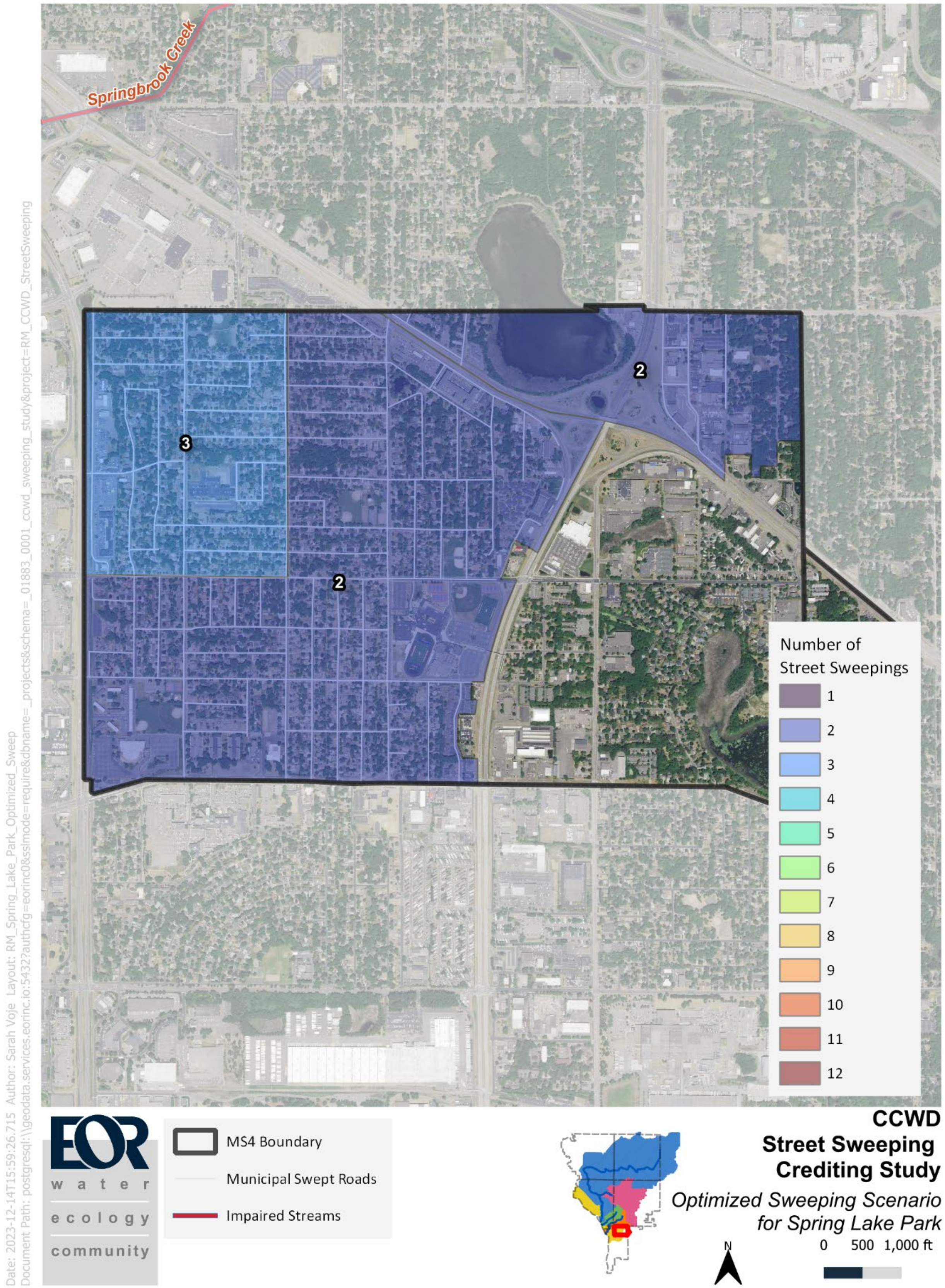

Figure 38 Optimized existing effort Spring Lake Park street sweeping.

Table 26 Spring Lake Park Predicted Pollutant Recovery from the Stream Load across a range of Sweeping Scenarios.

Stream	Predicted TP Load Reduction from the Stream (lbs/yr)							
	TMDL Baseline[1]	2022 Base	Optimized Existing Effort	Enhanced Baseline	1 Additional Sweeper	3 Additional Sweepers	5 Additional Sweepers	Maximum
Springbrook Creek	6.7	6.7	**8.9**	**11**	12	21	21	21
Other	25	25	**26**	**40**	41	45	46	77
Total	31	31	**35**	**51**	53	66	67	98
	Predicted TSS Load Reduction from the Stream (tons/yr)							
Springbrook Creek	0.10	0.10	**0.16**	**0.24**	0.29	0.51	0.52	0.52
Other	0.37	0.37	**0.41**	**0.86**	0.89	1.0	1.0	1.9
Total	0.48	0.48	**0.57**	**1.1**	1.2	1.5	1.5	2.4

[1]The TMDL Baseline predicted load reduction may differ from Phase 1 credits because of the method used to estimate the credits. If the MS4 currently tracks sweepings mass or volume they should continue to do so because they will receive more credits.

Bold values indicate the two best scenarios for the MS4.

Table 27 Spring Lake Park Scenario Swept Lane-miles and Cost Summary

MS4 Effort Summary	Scenario						
	2022 Base	Optimized Existing Effort	Enhanced Baseline	1 Additional Sweeper	3 Additional Sweepers	5 Additional Sweepers	Maximum
Total Swept Lane-miles	87	**99 (13%)**	**174 (100%)**	186 (113%)	262 (201%)	291 (235%)	522 (500%)
Total Cost ($/yr)	$9,937	**$11,297**	**$20,043**	$21,399	$30,010	$33,168	$59,053

Bold values indicate the two best scenarios for the MS4.

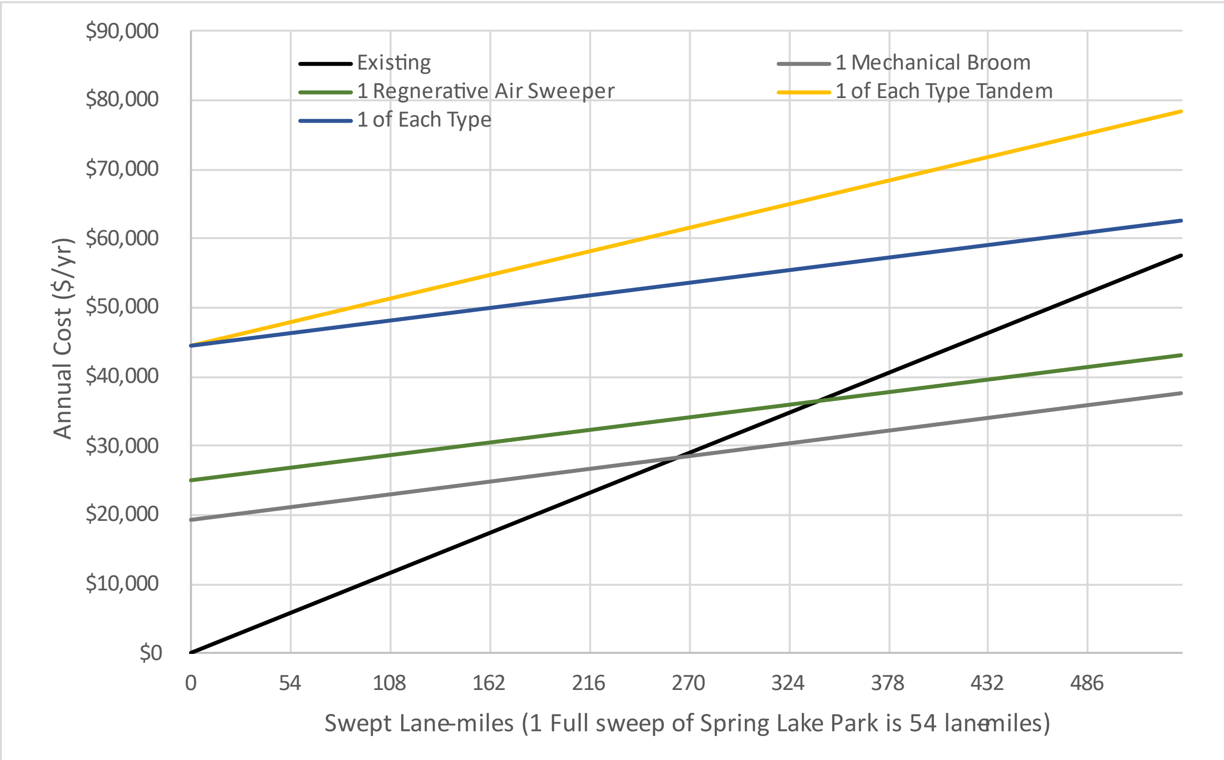

Figure 39 Contract sweeping vs in-house street sweeping in Spring Lake Park.

4.8. Coon Creek Watershed District

Street sweeping is a cost-effective strategy for improving water quality in the CCWD with estimated pollutant load reduction costs between $120 - $1,105 per lb TP and $2,905-$43,000 per ton TSS across all sweeping zones for sweepings efforts ranging from seven to twelve times per year. All MS4s in the CCWD sweep their streets a minimum of twice per year. The four main recommendations to improve street sweeping in the CCWD include:

1. Enhanced baseline street sweeping (twice in the spring and fall) should be the minimum sweeping strategy implemented for all MS4s in the WD.
    - Blaine, Coon Rapids, & Fridley have already achieved this goal.
    - Andover, Anoka County Highways, Ham Lake, & Spring Lake Park would need to roughly double their existing sweeping effort to achieve this goal.
2. Weighing materials may increase TP credits two to three orders of magnitude compared to using swept lane-miles to estimate TP credits. At the very least, volumes of sweepings should be tracked and can be converted to estimated weights.
3. Monthly street sweeping between April and October is the most cost-effective street sweeping schedule for TSS. The cost effectiveness begins to decrease rapidly for street sweeping more than seven times per year.
4. Maximizing fall leaf removal from City streets is the most cost-effective sweeping strategy for removing TP.

Table 28 and Table 29 summarize the TP and TSS predicted credits for each stream, MS4, and sweeping scenario. The actual TP and TSS credits received for street sweeping can only be claimed by an MS4 using MPCA approved methods. MPCA approved crediting methods are described in detail in the Minnesota Stormwater Manual. The methods used in this study are approved on a pilot basis per communications with MPCA staff (see memo). The MS4s need to meet certain modeling and record-keeping criteria to be able to claim credits with this method including:

1. Method Requirements
    - The calculation of TP credits must include a 'discount' or correction for pollutant removal by BMPs between the road and the receiving water body which is already included in this report.
    - The calculation of TSS credits must include a 'discount' or correction for pollutant removal by BMPs between the road and the receiving water body, a 25% reduction in predicted TS recovery to address the high level of uncertainty in TS prediction, and a further reduction in TS so that no more than 5% of the recovered TS is assumed to be TSS. All these assumptions are already included in this report.
    - The MS4 reporting of pollutant credits associated with sweeping must be based on actual miles swept.
    - The MS4s should submit a description of the method with the MS4 pollutant credit reporting and a sample calculation that demonstrates all facets of the methods. If in the future, the proposed method is adopted by the MPCA for general use, this documentation will not be needed.
    - If in the future, MPCA determines that additional data collection or monitoring requirements are needed to reduce uncertainty in the method, the conditions listed here will be revised to incorporate such. If imposed, additional requirements will apply to future sweeping operations.
2. Record Keeping Requirements
    - MS4s must document lane miles swept and submit credit analysis based on actual miles swept. If prescribed sweeping routes are developed and followed consistently, route lane-miles may be determined through GIS analysis and applied to dates of sweeping; however, documentation demonstrating that sweeping was completed, e.g., start and finish odometer readings or GPS tracking must be maintained. Significant deviations from prescribed routes must be accounted for in tracking records.
    - These records should be available for inspective if requested, but do not need to be submitted with MS4 annual reporting.
    - The BMP removal efficiency used to translate predicted load recovery to prediction load reduction should be reviewed approximately every 5 years or as needed to incorporate changes or additions to the MS4 BMP inventory.
    - Tree canopy characterization should be reviewed approximately every 5 years to revise any areas that have been significantly impacted by new or redevelopment or tree disease/removal.
3. Validation Requirements

- MS4s should periodically validate predicted pollutant recovery by measuring the mass of material collected during sweeping.
- Additional monitoring or data collection may be a condition for use of this method in the future.

It is still advantageous for the MS4s to estimate TP credits from the mass or volume of swept material. The predicted TSS credit from the pilot method at this point is greater than the other methods available which are model-based. An updated street sweeping planning calculator is included in the deliverable with the sweeping zones and assumptions used in this study added to the calculations. The updated street sweeping planning calculator can be used to help track pollutant credits using the pilot method described in this study. More updates may be needed to the street sweeping planning calculator to meet the MPCA's criteria for use in the future. For instance, the estimated pollutant removal from other BMPs in between the road and the downstream receiving waterbody is very simplified. In the future, the MS4s in the CCWD will likely need to estimate the credits from each individual BMP as part of their MS4 pollutant credit requirements. One product of this effort may be a GIS layer showing the load reduction percentage throughout each MS4. The average load reduction percentage within each sweeping zone could be a more accurate option to replace the directly connected percentage and assumed pond removal efficiencies used in this study. Another potential update is related to the tree canopy characterization. The tree canopy is estimated from the Twin Cities Metro Area high resolution landcover dataset collected in 2015. An update to this landcover dataset is anticipated to be available in 2024 and should include more recent tree canopy coverages. Lastly in addition to the updates that may be required by the MPCA to use the methods used in this study, street sweeping strategies should be revisited in CCWD once all pollutant credits for all BMPs are estimated. Additional street sweeping may be a very useful and cost-effective strategy in areas with little space or very costly BMP retrofit opportunities. In addition to this report, all model and GIS files and metadata are included as part of the deliverables.

Table 28 Modeled TP Reductions (lbs) for each Sweeping Scenario summarized by MS4 and Receiving Water.

Stream	MS4	TP Credits (lbs)							
		TMDL Basline[1]	2022 Base	Optimized Existing Effort	Enhanced Baseline	1 Additional Sweeper	3 Additional Sweepers	5 Additional Sweepers	Maximum
Coon Creek	Andover	144	181	184	235	253	407	450	450
	Anoka County	60	60	78	97	108	164	187	187
	Blaine	69	69	68	66	68	104	127	127
	Coon Rapids	571	571	621	571	648	828	858	862
	Ham Lake	81	194	234	317	347	581	607	607
	Total	**925**	**1075**	**1185**	**1286**	**1424**	**2084**	**2229**	**2233**
Pleasure Creek	Anoka County	5	5	7	8	9	13	15	15
	Blaine	52	52	57	52	54	80	97	97
	Coon Rapids	29	29	28	29	30	43	44	44
	Total	**86**	**86**	**92**	**89**	**93**	**136**	**156**	**156**
Sand Creek	Anoka County	22	22	25	36	38	61	70	70
	Blaine	313	313	320	313	318	480	578	578
	Coon Rapids	135	135	152	135	155	199	204	204
	Ham Lake	0.3	0.8	0.8	1.3	1.3	2.3	2.4	2.4
	Total	**470.3**	**470.8**	**497.8**	**485.3**	**512.3**	**742.3**	**854.4**	**854.4**
Springbrook Creek	Anoka County	8	8	10	13	14	21	24	24
	Blaine	67	67	74	67	74	109	124	124
	Coon Rapids	15	15	16	15	16	22	23	23
	Fridley	43	60	64	60	64	72	73	73
	Spring Lake Park	6.7	6.7	8.9	11	12	21	21	21
	Total	**139.7**	**156.7**	**172.9**	**166**	**180**	**245**	**265**	**265**

[1]The TMDL Baseline predicted load reduction may differ from Phase 1 credits because of the method used to estimate the credits. If the MS4 currently tracks sweepings mass or volume they should continue to do so because they will receive more credits. This modeling method is more conservative because it accounts for pollutant fate and transport in addition to recovery and is therefore well-suited as a planning tool to estimate relative benefits to receiving waters.

Table 29 Modeled TSS Reductions (tons) for each Sweeping Scenarios summarized by MS4 and Receiving Water.

Stream	MS4	TSS Credits							
		TMDL Baseline[1]	2022 Base	Optimized Existing Effort	Enhanced Baseline	1 Additional Sweeper	3 Additional Sweepers	5 Additional Sweepers	Maximum
Coon Creek	Andover	3.1	4.5	4.7	7.2	8.4	14.8	15.8	15.8
	Anoka County	1.3	1.3	1.9	2.9	3.5	5.6	6.3	6.3
	Blaine	1.7	1.7	1.6	1.5	1.6	2.9	3.3	3.3
	Coon Rapids	18.5	18.5	21.7	17.6	24.8	29.5	30.1	30.2
	Ham Lake	1.4	4.1	5.7	9.4	11.1	20.3	20.6	20.6
	Total	**26.0**	**30.1**	**35.6**	**38.6**	**49.4**	**73.1**	**76.1**	**76.2**
Pleasure Creek	Anoka County	0.10	0.10	0.17	0.23	0.30	0.45	0.51	0.51
	Blaine	1.2	1.2	1.4	1.1	1.3	2.1	2.4	2.4
	Coon Rapids	0.83	0.83	0.92	0.79	0.99	1.3	1.4	1.4
	Total	**2.13**	**2.13**	**2.49**	**2.12**	**2.59**	**3.85**	**4.31**	**4.31**
Sand Creek	Anoka County	0.45	0.45	0.55	1.0	1.1	2.0	2.2	2.2
	Blaine	8.0	8.0	8.1	7.1	8.0	13.5	15.5	15.5
	Coon Rapids	4.1	4.1	5.5	3.9	5.6	6.6	6.7	6.7
	Ham Lake	0.005	0.015	0.015	0.035	0.035	0.075	0.076	0.076
	Total	**12.6**	**12.6**	**14.2**	**12.0**	**14.7**	**22.2**	**24.5**	**24.5**
Springbrook Creek	Anoka County	0.16	0.16	0.25	0.37	0.45	0.72	0.81	0.81
	Blaine	1.6	1.6	1.8	1.4	1.8	2.7	3.0	3.0
	Coon Rapids	0.47	0.47	0.59	0.44	0.61	0.76	0.76	0.76
	Fridley	1.0	1.8	1.9	1.8	1.9	2.1	2.1	2.1
	Spring Lake Park	0.1	0.1	0.16	0.24	0.29	0.51	0.52	0.52
	Total	**3.3**	**4.1**	**4.7**	**4.3**	**5.1**	**6.8**	**7.2**	**7.2**

[1]The TMDL Baseline predicted load reduction may differ from Phase 1 credits because of the method used to estimate the credits. If the MS4 currently tracks sweepings mass or volume they should continue to do so because they will receive more credits.This modeling method is more conservative because it accounts for pollutant fate and transport in addition to recovery and is therefore well-suited as a planning tool to estimate relative benefits to receiving waters.

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APPENDIX A. SUMMARY TABLES AND FIGURES

Table 30 Zone Prioritization Category Values and Total Score

Zone	Road Tree Canopy (%)	Directly Connected (%)	BMP Density (acres/BMP)	Priority Score
Andover-1	17%	91%	74	8
Andover-2	8%	1%	25	4
Andover-3	27%	54%	127	9
Andover-4	24%	67%	92	10
Andover-5	14%	69%	66	7
Andover-6	11%	8%	22	4
Andover-7	15%	40%	55	6
AnokaCo-1	17%	46%	41	6
AnokaCo-2	14%	25%	65	6
Blaine-1	28%	0%	73	8
Blaine-2	16%	0%	34	4
Blaine-3	24%	0%	55	7
Blaine-4	32%	27%	81	11
Blaine-5	25%	0%	43	7
Blaine-6	10%	0%	66	5
Blaine-7	29%	0%	79	8
Blaine-8	29%	0%	62	7
Coon Rapids-1	18%	8%	59	5
Coon Rapids-2	33%	49%	34	9
Coon Rapids-3	21%	0%	35	6
Coon Rapids-4	34%	4%	90	10
Coon Rapids-5	28%	56%	49	8
Coon Rapids-6	25%	70%	21	8
Coon Rapids-7	36%	46%	36	9
Coon Rapids-8	37%	86%	76	12
Coon Rapids-9	32%	70%	22	10
Coon Rapids-10	17%	0%	27	4
Coon Rapids-11	36%	71%	30	10
Fridley-1	41%	25%	30	9
Fridley-2	16%	0%	12	4
Fridley-3	35%	0%	49	9
Ham Lake-1	19%	81%	44	7
Ham Lake-2	23%	7%	69	7
Ham Lake-3	21%	86%	59	9
Ham Lake-4	21%	100%	50	9
Ham Lake-5	23%	79%	59	9
Ham Lake-6	15%	28%	53	6
Ham Lake-7	22%	15%	42	7
Spring Lake Park-1	29%	0%	103	8

Zone	Road Tree Canopy (%)	Directly Connected (%)	BMP Density (acres/BMP)	Priority Score
Spring Lake Park-2	26%	0%	0	6
Spring Lake Park-3	11%	0%	0	4

Table 31 Percentage of Pollutant Load that contributes to the Stream for each Zone.

Zone	Total Phosphorus Stream Load (% Road Load)	Total Suspended Solids Stream Load (% Road Load)[1]
Andover-1	97%	95%
Andover-2	66%	41%
Andover-3	84%	73%
Andover-4	89%	80%
Andover-5	89%	81%
Andover-6	69%	45%
Andover-7	80%	64%
AnokaCo-1	82%	68%
AnokaCo-2	74%	55%
Blaine-1	66%	40%
Blaine-2	66%	40%
Blaine-3	66%	40%
Blaine-4	75%	56%
Blaine-5	66%	40%
Blaine-6	66%	40%
Blaine-7	66%	40%
Blaine-8	66%	40%
Coon Rapids-1	69%	45%
Coon Rapids-2	83%	69%
Coon Rapids-3	66%	40%
Coon Rapids-4	67%	43%
Coon Rapids-5	85%	74%
Coon Rapids-6	90%	82%
Coon Rapids-7	82%	68%
Coon Rapids-8	95%	91%
Coon Rapids-9	90%	82%
Coon Rapids-10	66%	40%
Coon Rapids-11	90%	83%
Fridley-1	75%	55%
Fridley-2	66%	40%
Fridley-3	66%	40%
Ham Lake-1	94%	89%
Ham Lake-2	68%	44%
Ham Lake-3	95%	91%
Ham Lake-4	100%	100%

Zone	Total Phosphorus Stream Load (% Road Load)	Total Suspended Solids Stream Load (% Road Load)[1]
Ham Lake-5	93%	87%
Ham Lake-6	76%	57%
Ham Lake-7	71%	49%
Spring Lake Park-1	66%	40%
Spring Lake Park-2	66%	40%
Spring Lake Park-3	66%	40%

[1]In addition to the TSS percentage shown the assumed fraction of TS that is TSS (5%) and the TSS calibration factor (75%) needs to be applied to the modeled TS load to approximate the stream load reduction.

Table 32 Sweeping Zone Contributing Percentage to each Impaired Stream

Zone	Coon Creek	Pleasure Creek	Sand Creek	Springbrook Creek	Other
Andover-1	100%	0%	0%	0%	0%
Andover-2	100%	0%	0%	0%	0%
Andover-3	100%	0%	0%	0%	0%
Andover-4	100%	0%	0%	0%	0%
Andover-5	100%	0%	0%	0%	0%
Andover-6	100%	0%	0%	0%	0%
Andover-7	100%	0%	0%	0%	0%
AnokaCo-1	62%	6%	10%	8%	14%
AnokaCo-2	39%	0%	49%	6%	6%
Blaine-1	29%	0%	71%	0%	0%
Blaine-2	33%	0%	67%	0%	0%
Blaine-3	0%	0%	100%	0%	0%
Blaine-4	11%	2%	87%	0%	0%
Blaine-5	0%	52%	48%	0%	0%
Blaine-6	0%	0%	100%	0%	0%
Blaine-7	0%	66%	0%	34%	0%
Blaine-8	0%	1%	3%	94%	1%
Coon Rapids-1	43%	0%	0%	0%	57%
Coon Rapids-2	100%	0%	0%	0%	0%
Coon Rapids-3	85%	0%	15%	0%	0%
Coon Rapids-4	3%	0%	0%	0%	97%
Coon Rapids-5	100%	0%	0%	0%	0%
Coon Rapids-6	84%	0%	16%	0%	0%
Coon Rapids-7	19%	0%	81%	0%	0%
Coon Rapids-8	96%	1%	3%	0%	0%
Coon Rapids-9	100%	0%	0%	0%	0%
Coon Rapids-10	1%	82%	0%	18%	0%
Coon Rapids-11	36%	23%	0%	21%	20%
Fridley-1	0%	0%	0%	69%	31%
Fridley-2	0%	0%	0%	20%	80%
Fridley-3	0%	0%	0%	0%	100%

Zone	Coon Creek	Pleasure Creek	Sand Creek	Springbrook Creek	Other
Ham Lake-1	100%	0%	0%	0%	0%
Ham Lake-2	100%	0%	0%	0%	0%
Ham Lake-3	100%	0%	0%	0%	0%
Ham Lake-4	100%	0%	0%	0%	0%
Ham Lake-5	100%	0%	0%	0%	0%
Ham Lake-6	97%	0%	3%	0%	0%
Ham Lake-7	100%	0%	0%	0%	0%
Spring Lake Park-1	0%	0%	0%	60%	40%
Spring Lake Park-2	0%	0%	0%	0%	100%
Spring Lake Park-3	0%	0%	0%	100%	0%

Table 33 Street Sweeping Cost Effectiveness

Zone	TSS Cost Effectiveness ($/ton)		TP Cost Effectiveness ($/lb)	
	Monthly Sweeping	Maximum Sweeping (12/yr)	Monthly Sweeping	Maximum Sweeping (12/yr)
Andover-1	$8,508	$11,978	$378	$486
Andover-2	$26,930	$38,102	$766	$990
Andover-3	$7,853	$10,970	$299	$381
Andover-4	$7,822	$10,954	$316	$404
Andover-5	$10,795	$15,222	$449	$579
Andover-6	$21,687	$30,631	$652	$841
Andover-7	$13,472	$18,991	$495	$638
AnokaCo-1	$8,957	$12,533	$337	$431
AnokaCo-2	$12,331	$17,299	$416	$534
Blaine-1	$15,725	$22,022	$420	$538
Blaine-2	$23,858	$33,688	$658	$850
Blaine-3	$17,797	$24,994	$480	$617
Blaine-4	$9,933	$13,867	$324	$413
Blaine-5	$17,286	$24,263	$466	$598
Blaine-6	$29,294	$41,485	$821	$1,063
Blaine-7	$15,145	$21,190	$404	$516
Blaine-8	$15,353	$21,489	$410	$524
Coon Rapids-1	$10,647	$14,795	$314	$398
Coon Rapids-2	$4,208	$5,728	$153	$191
Coon Rapids-3	$10,651	$14,746	$291	$368
Coon Rapids-4	$6,686	$9,089	$183	$227
Coon Rapids-5	$4,666	$6,404	$178	$224
Coon Rapids-6	$4,618	$6,363	$187	$236
Coon Rapids-7	$4,033	$5,470	$145	$179
Coon Rapids-8	$2,905	$3,934	$120	$149
Coon Rapids-9	$3,742	$5,107	$149	$186
Coon Rapids-10	$12,378	$17,222	$341	$433

Zone	TSS Cost Effectiveness ($/ton)		TP Cost Effectiveness ($/lb)	
	Monthly Sweeping	Maximum Sweeping (12/yr)	Monthly Sweeping	Maximum Sweeping (12/yr)
Coon Rapids-11	$3,243	$4,394	$128	$159
Fridley-1	$6,714	$9,244	$212	$266
Fridley-2	$21,415	$30,184	$592	$762
Fridley-3	$11,217	$15,556	$294	$373
Ham Lake-1	$12,061	$17,059	$517	$668
Ham Lake-2	$20,946	$29,560	$604	$780
Ham Lake-3	$10,805	$15,265	$466	$602
Ham Lake-4	$9,820	$13,872	$441	$569
Ham Lake-5	$10,394	$14,665	$437	$563
Ham Lake-6	$21,172	$29,993	$727	$941
Ham Lake-7	$19,339	$27,302	$595	$768
Spring Lake Park-1	$15,836	$22,181	$422	$540
Spring Lake Park-2	$17,496	$24,562	$470	$603
Spring Lake Park-3	$30,469	$43,171	$853	$1,105

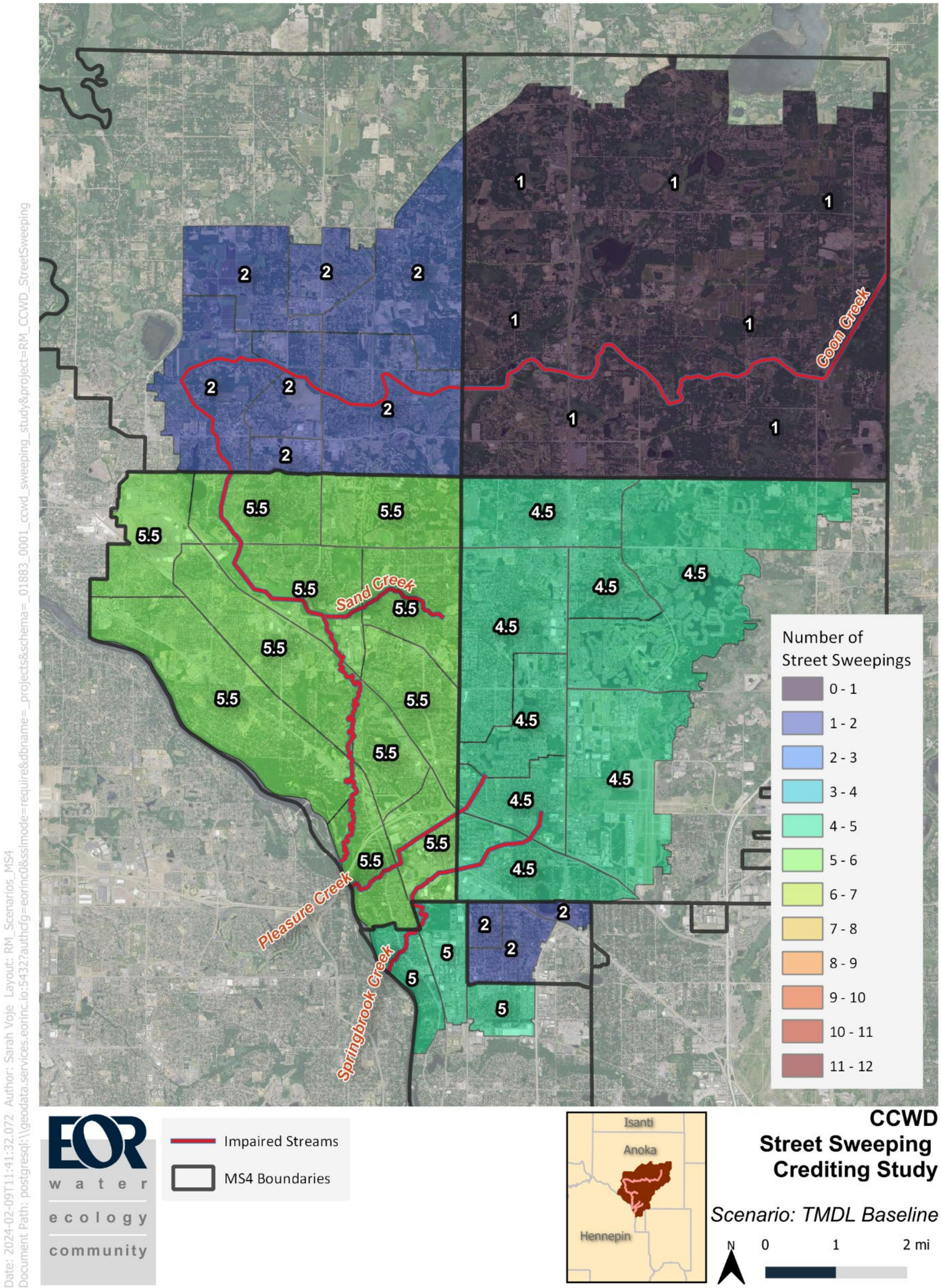

Figure 40 Municipal MS4 sweeping effort in TMDL baseline years (2009-2012).

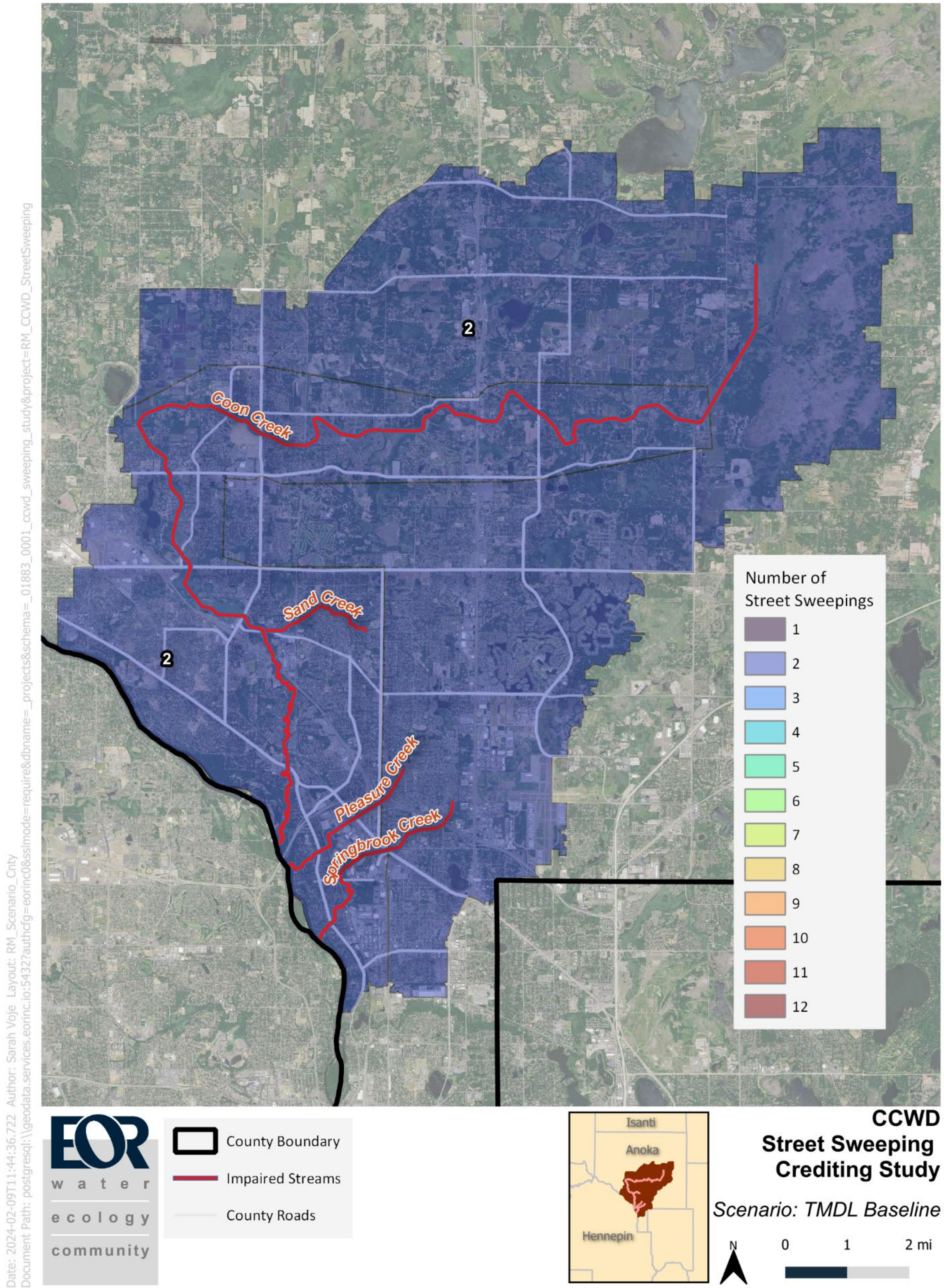

Figure 41 Anoka County TMDL baseline sweeping.

APPENDIX B. CCWD PHASE 1 SUMMARY MEMO

memo

Project Name	Coon Creek Watershed District Street Sweeping Crediting Study	**Date**	06/26/2023
To / Contact info	Justine Dauphinais, Jon Janke CCWD		
Cc / Contact info			
From / Contact info	Paula Kalinosky, Sarah Voje, Trevor Rundhaug EOR		
Regarding	Pollutant Load Reduction Credits for Street Sweeping within TMDL Watersheds		

Pollutant Load Reduction Credits for Street Sweeping, 2009 – 2022, Coon Creek Watershed District MS4

This memo contains a summary of the estimated total phosphorus (TP) and total suspended sediment (TSS) pollutant reduction credits supported by street sweeping data submitted by the following seven (7) MS4 permit holders whose jurisdictions intersect the Coon Creek Watershed District (CCWD).

- City of Andover MS4
- City of Blaine MS4
- City of Coon Rapids MS4
- City of Ham Lake MS4
- City of Fridley MS4
- City of Spring Lake Park MS4
- Anoka County MS4

Note: MnDOT is also an MS4 permit holder within CCWD's jurisdiction, but did not participate in this joint sweeping crediting study

TMDL Watersheds

The CCWD jurisdictional area includes the subwatersheds of four (4) impaired streams – Coon Creek, Sand Creek, Pleasure Creek, and Springbrook Creek. All four streams are impaired for aquatic life due to poor macroinvertebrate bioassessments with total phosphorus (TP) identified as a primary stressor for all four streams and total suspended sediment (TSS) identified as primary stressors in all streams except Springbrook Creek. TMDL Wasteload allocations for TP and TSS have been assigned to all MS4s accordingly; these were formally approved by the MPCA and EPA in 2016. Impaired stream miles, contributing drainage area, and lane-miles of road located within the subwatershed of each impaired stream are summarized in Table 1.

Table 1. CCWD impaired waters, subwatersheds, and associated lane-miles of roadway located within the Coon Creek Watershed District MS4 boundary

			Approx. Length or Area within MS4 Jurisdiction		
Waterbody Name/AUID	Impairments	TMDL WLAs/ Baseline Year	Stream Miles	Watershed Area (acres)	Lane-miles of road maintained[1]
Coon Creek 07010206-530	AQL, AQR	TSS, TP, *E. coli* Baseline: 2009	24.65	47,099	982.8
Sand Creek 07010206-558	AQL, AQR	TSS, TP, *E. coli* Baseline: 2010	2.02	10,122	383.4
Pleasure Creek 07010206-594	AQL, AQR	TSS, TP, *E. coli* Baseline: 2012	2.82	1,728	72.8
Springbrook Creek 07010206-557	AQL, AQR	TP, *E. coli* Baseline: 2012	4	2,644	101.0
Not included in this study:					
Mississippi River[2] 0701206-805	AQC, AQL, AQR	(Hg-F, 2007)	8	4,707	220.5

[1]Lane-miles of municipal or county road located within the subwatershed of the impaired stream.

[2]Includes the Mississippi, North Coon Rapids, South Coon Rapids, Oak Glen, Riverview Creek and Stonybrook Creek subwatersheds.

Results

Table 2 and Table 3 summarize the TP and TSS credits for each MS4 and impaired stream subwatershed within the Coon Creek Watershed District for the years 2009 through 2022. Any increase in pollutant credits compared to the baseline year can be used to document improvement towards meeting MS4 wasteload allocations. MS4 specific memorandums provide more information about each MS4's current street sweeping practices. More information about modeling assumptions are included in Appendix 1.

Table 2 Total Phosphorus Credits for Sweeping by Impaired Stream and MS4 (lbs/yr) (2009-2022)

Impaired Stream	MS4	Year														Eligible Credits
		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	
Coon Creek	Anoka Cty Hwy	653.3	653.3	653.3	653.3	653.3	653.3	653.3	653.3	653.3	653.3	653.3	653.3	653.3	653.3	0
	Andover	81.4	81.4	81.4	81.4	81.4	81.4	81.4	81.4	81.4	81.4	81.4	369.5	369.5	369.5	288.1
	Blaine*	107.8	107.8	107.8	107.8	107.8	107.8	202.2	202.2	202.2	202.2	202.2	202.2	202.2	202.2	94.4
	Coon Rapids*	1,685	1,685	1,685	1,685	1,685	1,685	1,685	1,685	1,685	1,685	1,685	1,685	1,685	1,685	0
	Ham Lake	0.061	0.061	0.061	0.061	0.062	0.062	0.125	0.127	0.128	0.130	0.131	0.131	0.131	0.131	0.07
	Total	2527.56	2527.56	2527.56	2527.56	2527.56	2527.56	2622.03	2622.03	2622.03	2622.03	2622.03	2910.13	2910.13	2910.13	382.57
Sand Creek	Anoka Cty Hwy		281.3	281.3	281.3	281.3	281.3	281.3	281.3	281.3	281.3	281.3	281.3	281.3	281.3	0
	Blaine*		390.1	390.1	390.1	390.1	390.1	729.2	729.2	729.2	731.9	731.9	731.9	731.9	731.9	341.8
	Coon Rapids*		364	364	364	364	364.4	364.4	364.4	364.4	366	366	366	366	366	2.0
	Ham Lake		0.0001	0.0001	0.0001	0.0001	0.0001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0004
	Total		1035.4	1035.4	1035.4	1035.4	1035.8	1374.9	1374.9	1374.9	1379.2	1379.2	1379.2	1379.2	1379.2	343.8
Pleasure Creek	Anoka Cty Hwy				65	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	0
	Blaine*				81.5	81.5	81.5	152.9	152.9	152.9	152.9	152.9	152.9	152.9	152.9	71.4
	Coon Rapids				132	132.0	132.0	132.0	132.0	132.0	132.0	132.0	132.0	132.0	132.0	0
	Total				278.5	278.5	278.5	349.9	349.9	349.9	349.9	349.9	349.9	349.9	349.9	71.4
Springbrook Creek	Anoka Cty Hwy				71.5	71.5	71.5	71.5	71.5	71.5	71.5	71.5	71.5	71.5	71.5	0
	Blaine*				94	94	94	176.3	176.3	176.3	176.3	176.3	176.3	176.3	176.3	82.3
	Coon Rapids*				49	49	49	49	49	49	49	49	49	49	49	0
	Fridley				0.022	0.022	0.022	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.01

Impaired Stream	MS4	Year														Eligible Credits
		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	
	Spring Lake Park				0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0
	Total				214.53	214.53	214.53	296.84	296.84	296.84	296.84	296.84	296.84	296.84	296.84	82.31

*Based on volume of sweeping collected (separate analysis) [1]Underlined columns are the baseline year for the impaired stream TMDL.

Table 3 Total Suspended Solids Credits for Sweeping by Impaired Stream and MS4 (tons/yr) (2009-2022)

Impaired Stream	MS4	Year														Eligible Credits
		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	
Coon Creek	Anoka Cty Hwy	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0
	Andover	0.95	0.95	0.96	0.96	0.96	0.96	0.97	0.98	0.98	0.98	0.99	1.32	1.33	1.33	0.38
	Blaine*	0.17	0.17	0.17	0.17	0.17	0.17	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.15
	Coon Rapids*	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	0
	Ham Lake	0.46	0.46	0.46	0.46	0.53	0.55	1.15	1.27	1.35	1.51	1.57	1.57	1.57	1.57	1.11
	Total	4.08	4.08	4.09	4.09	4.16	4.18	4.94	5.07	5.15	5.31	5.38	5.71	5.72	5.72	1.64
Sand Creek	Anoka Cty Hwy		0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0
	Blaine*		0.87	0.87	0.87	0.87	0.87	1.61	1.61	1.61	1.62	1.62	1.62	1.62	1.62	0.76
	Coon Rapids*		1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.63	1.63	1.63	1.63	1.63	0.03
	Ham Lake		0.005	0.005	0.005	0.0088	0.0088	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.035
	Total		2.775	2.775	2.775	2.7788	2.7788	3.55	3.55	3.55	3.59	3.59	3.59	3.59	3.59	0.825
Pleasure Creek	Anoka Cty Hwy				0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0
	Blaine*				0.12	0.12	0.12	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.10
	Coon Rapids				0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0
	Total				0.33	0.33	0.33	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.10
Springbrook Creek	Anoka Cty Hwy				0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0
	Blaine*				0.19	0.19	0.19	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.16
	Coon Rapids*				0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0

Impaired Stream	MS4	Year														Eligible Credits
		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	
	Fridley				0.09	0.09	0.09	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.01
	Spring Lake Park				0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0
	Total				0.48	0.48	0.48	0.55	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.17

*Based on volume of sweeping collected (separate analysis)

[1]Underlined columns are the baseline year for the impaired stream TMDL.

Appendix 1 Modeling Assumptions

P8 Modeling Strategy and Key Modeling Assumptions:

- Single P8 catchment areas were used to represent portions of each subwatershed intersected by municipal boundaries
    - Catchment imperviousness was estimated using the USGS National Land Cover Data Database (NLCD).
    - A curve number of 68 was used to model all pervious areas.
- Street sweeper pickup efficiency was modeled following recommendations for modeling vacuum/high-efficiency sweeping given that most MS4s in the study used this equipment or employed tandems sweeping practices.
- Pick-up efficiencies were reduced by 50% compared to default to reflect the reduced pick-up efficiency of mechanical broom sweepers in the TSS particle size range (silt & clay sized particles).
- The WLA reduction achieved through street sweeping each year was calculated as:

  WLA = (TSS load in the unswept scenario - TSS load swept scenario)
- Changes in impervious cover from one year to the next were modeled in the following way:
    - New road surfaces were added to swept impervious areas in the model (Tables 4, 5).
    - Other connected and disconnected impervious surfaces were increased in proportion to road surface increase.

Table 4 Lane-miles in each Impaired Stream and MS4 (2009-2022)

Impaired Stream	MS4	Year													
		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Coon Creek	Anoka Cty Hwy	178.3	178.3	178.3	178.3	178.3	178.3	178.3	178.3	178.3	178.3	178.3	178.3	178.3	178.3
	Andover	206.5	206.5	207.5	207.6	208.5	208.7	210.4	211.2	211.7	212.2	213.2	214.6	215.1	215.1
	Blaine	51.2	51.2	51.2	51.2	51.2	54.1	55.8	56.4	60.6	63.5	65.3	65.3	65.3	65.3
	Coon Rapids	245.6	245.6	245.6	245.6	245.6	245.6	245.6	245.6	245.6	245.6	245.6	245.6	245.6	245.6
	Ham Lake	260.3	260.3	260.3	260.3	264.3	265.1	266.6	270.0	272.2	276.9	278.5	278.5	278.5	278.5
	Total	941.9	941.9	942.9	943.0	947.8	951.7	956.6	961.5	968.4	976.5	980.9	982.3	982.8	982.8
Sand Creek	Anoka Cty Hwy	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8
	Blaine	267.1	267.1	267.1	267.1	267.3	267.7	267.7	267.7	267.7	268.0	270.7	270.7	272.8	272.8
	Coon Rapids	53.0	53.0	53.0	53.0	53.0	53.1	53.1	53.1	53.1	53.3	53.3	53.3	53.3	53.3
	Ham Lake	0.4	0.4	0.4	0.4	0.6	0.6	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	Total	376.2	376.2	376.2	376.2	376.6	377.1	378.1	378.1	378.1	378.6	381.3	381.3	383.4	383.4
Pleasure Creek	Anoka Cty Hwy	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7
	Blaine	39.8	39.8	39.8	39.8	39.8	39.8	39.8	39.8	39.8	39.8	39.8	39.8	39.8	39.8
	Coon Rapids	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3
	Total	72.8	72.8	72.8	72.8	72.8	72.8	72.8	72.8	72.8	72.8	72.8	72.8	72.8	72.8
Springbrook Creek	Anoka Cty Hwy	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4
	Blaine	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
	Coon Rapids	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
	Fridley	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3
	Spring Lake Park	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	Total	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0

Table 5 Swept lane-miles by Impaired Stream and MS4 (2009-2022)

Impaired Stream	MS4	Year													
		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Coon Creek	Anoka Cty Hwy	230.2	230.2	230.2	230.2	230.2	230.2	230.2	230.2	209.8	230.2	230.2	230.2	255	225.7
	Andover	413.0	413.0	415.0	415.2	417.0	417.4	420.8	422.4	423.5	424.4	426.4	572.1	573.5	573.5
	Blaine	230.4	230.4	230.4	230.4	230.4	243.5	251.1	253.8	272.7	285.8	293.9	293.9	293.9	293.9
	Coon Rapids	1350.8	1350.8	1350.8	1350.8	1350.8	1350.8	1350.8	1350.8	1350.8	1350.8	1350.8	1350.8	1350.8	1350.8
	Ham Lake	260.3	260.3	260.3	260.3	264.3	265.1	533.2	540	544.4	553.8	557.0	557.0	557.0	557.0
	Total	2485	2485	2487	2487	2493	2507	2786	2797	2801	2845	2858	3004	3030	3001
Sand Creek	Anoka Cty Hwy	97	97	97	97	97	97	97	97	95.5	97	97	97	100.4	95.1
	Blaine	1202.0	1202.0	1202.0	1202.0	1202.9	1204.7	1204.7	1204.7	1204.7	1206.0	1218.2	1218.2	1227.6	1227.6
	Coon Rapids	291.5	291.5	291.5	291.5	291.5	292.1	292.1	292.1	292.1	293.2	293.2	293.2	293.2	293.2
	Ham Lake	0.4	0.4	0.4	0.4	0.6	0.6	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	Total	1591	1591	1591	1591	1592	1594	1597	1597	1595	1599	1611	1611	1624	1619
Pleasure Creek	Anoka Cty Hwy	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	20.2	22.3	22.3	22.3	27.3	19.4
	Blaine	179.1	179.1	179.1	179.1	179.1	179.1	179.1	179.1	179.1	179.1	179.1	179.1	179.1	179.1
	Coon Rapids	106.1	106.1	106.1	106.1	106.1	106.1	106.1	106.1	106.1	106.1	106.1	106.1	106.1	106.1
	Total	308	308	308	308	308	308	308	308	305	308	308	308	313	305
Springbrook Creek	Anoka Cty Hwy	24.6	24.6	24.6	24.6	24.6	24.6	24.6	24.6	23.4	24.6	24.6	24.6	26.1	24.5
	Blaine	255.9	255.9	255.9	255.9	255.9	255.9	255.9	255.9	255.9	255.9	255.9	255.9	255.9	255.9
	Coon Rapids	39.1	39.1	39.1	39.1	39.1	39.1	39.1	39.1	39.1	39.1	39.1	39.1	39.1	39.1
	Fridley	91.5	91.5	91.5	91.5	91.5	91.5	137.3	137.3	137.3	137.3	137.3	137.3	137.3	137.3
	Spring Lake Park	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
	Total	431	431	431	431	431	431	477	477	476	477	477	477	478	477

APPENDIX C. GIS METADATA

The final GIS layers created as part of this project are included in a file geodatabase as part of the project deliverable. For each feature class and raster in the file geodatabase a brief description is provided along with a table describing each field in the feature class.

RASTERS

county_rds – a 1-meter resolution raster depicting county roads used in the analysis to calculate the road tree canopy percentage.

county_rd_tree_canopy – a 1-meter resolution raster depicting the tree canopy coverage on county roads. Tree canopy coverage is estimated from Twin Cities Metro Area high resolution landcover dataset.

muni_roads – a 1-meter resolution raster depicting municipal roads used in the analysis to calculate the road tree canopy percentage.

road_tree_canopy – a 1-meter resolution raster depicting the tree canopy coverage on municipal roads. Tree canopy coverage is estimated from Twin Cities Metro Area high resolution landcover dataset.

FEATURE CLASSES

ccwd_bmps – a points feature class showing the MS4 BMPs compiled into one layer.

The ccwd_bmps layer was compiled from BMP layers received from each MS4 including:

- HamLake_StormFeatures_points,
  - Attribute Query: Layer = POND_-STORMWATER_INVENTORY OR Layer = STORM-RAIN GUARDIAN
- Fridley_Ponds_points,
- CoonRapids_StorageBasins,
- Blaine_Ponds_points and,
- Andover_DetentionBasin.

All layers were reprojected to NAD 1983 UTM 15 N prior to merging.

Table 34 ccwd_bmps Attributes

Field Name	Field Description
Name	Name of the BMP owner

directly_connected – a polygon feature class showing the areas predicted to be directly connected to the stream and have little to no existing BMP treatment. The layer was created using the CCWD catchments layer. No relevant attributes are included in the feature class.

county_sweeping_zones – polygon feature class showing Anoka County sweeping zones.

Table 35 county_sweeping_zones Attributes

Field Name	Field Description
road_tree_canopy_pct	The estimated road tree canopy percentage as decimals
zone	The sweeping zone id

Field Name	Field Description
acres	The sweeping zone area
num_bmps	The number of BMPs in the sweeping zone
bmps_acre	The number of acres per BMP in the sweeping zone
dc_area	The estimated directly connected area in the sweeping zone in acres
dc_pct	The estimated directly connected percentage in the sweeping zone as decimals
canopy_score	The prioritization score based on road tree canopy percentage.
bmp_score	The prioritization score based on the estimated BMP density
dc_score	The prioritization score based on the estimated directly connected percentage
total_score	The sweeping zone total prioritization score
scn_base	The number of complete sweeps in each zone under 2022 baseline conditions
scn_proposed_max	The number of complete sweeps in each zone in the proposed maximum scenario
scn_proposed_min	The number of complete sweeps in each zone under enhanced baseline conditions
scn_sweeper_1	The number of complete sweeps in each zone in the proposed 1 additional sweeper scenario
scn_sweeper_3	The number of complete sweeps in each zone in the proposed 3 additional sweepers scenario
scn_sweeper_5	The number of complete sweeps in each zone in the proposed 5 additionals sweepers scenario

sweeping_zones – polygon feature class showing municipal MS4 sweeping zones.

Table 36 sweeping_zones Attributes.

Field Name	Field Description
road_tree_canopy_pct	The estimated road tree canopy percentage as decimals
zone	The sweeping zone id
acres	The sweeping zone area
numbmps	The number of BMPs in the sweeping zone
bmp_density	The number of acres per BMP in the sweeping zone
dc_acres	The estimated directly connected area in the sweeping zone in acres
dc_pct	The estimated directly connected percentage in the sweeping zone as decimals
canopy_score	The prioritization score based on road tree canopy percentage.
bmp_score	The prioritization score based on the estimated BMP density
dc_score	The prioritization score based on the estimated directly connected percentage
total_score	The sweeping zone total prioritization score
scn_base	The number of complete sweeps in each zone under 2022 baseline conditions
scn_proposed_max	The number of complete sweeps in each zone in the proposed maximum scenario
scn_proposed_min	The number of complete sweeps in each zone under enhanced baseline conditions
scn_sweeper_1	The number of complete sweeps in each zone in the proposed 1 additional sweeper scenario
scn_sweeper_3	The number of complete sweeps in each zone in the proposed 3 additional sweepers scenario
scn_sweeper_5	The number of complete sweeps in each zone in the proposed 5 additional sweepers scenario

zone_co_road_wshd_int – polyline feature class showing the county roads and lane-miles split by county sweeping zones and watersheds.

Table 37 zone_co_road_wshd_int Attributes

Field Name	Field Description
loc_city	County that maintains the road segment
lane_miles	The estimated lane-mile length. Units are in miles.
zone	The sweeping zone id

watershed	The watershed where the road segment is located

zone_road_wshd_int – polyline feature class showing the municipal roads and lane-miles split by municipal MS4 sweeping zones and watersheds.

Table 38 zone_road_wshd_int Attributes

Field Name	Field Description
route_si_1	The road segment type.
loc_city	The municipality that maintains the road segment
new_from_2011	Specifies if the road segment was built since 2011. Values are either yes or no.
year_added	The year the road segment was built for roads built since 2011.
lane_miles	The estimated lane-mile length. Units are in miles
zone	The sweeping zone id
watershed	The watershed where the road segment is located