Rum River
Stormwater Retrofit Analysis

Prepared by:

Anoka Conservation District

for the

CITY OF ANOKA, CITY OF ANDOVER, CITY OF RAMSEY, AND

LOWER RUM RIVER WATERSHED MANAGEMENT ORGANIZATION

Rum River Stormwater Retrofit Analysis: 2024

Prepared for the City of Anoka, the City of Andover, the City of Ramsey, and the Lower Rum River Watershed Management Organization (LRRWMO) by:
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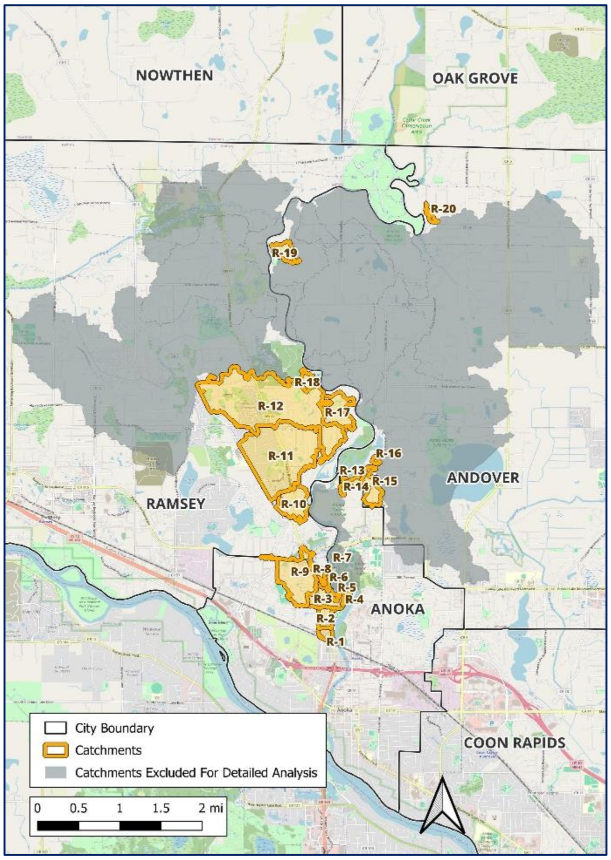
Disclaimer: At the time of printing, this report identifies and ranks potential BMPs for selected subwatersheds in the cities of Anoka, Andover, and Ramsey that drain to the Rum River. This list of practices is not all-inclusive and does not preclude adding additional priority BMPs in the future. An updated copy of the report shall be housed at the Anoka Conservation District.

Abstract



Anoka Conservation District completed this stormwater retrofit analysis (SRA) for the purpose of identifying and ranking water quality improvement projects throughout areas draining to the Rum River. The target area consists of portions of the cities of Anoka, Andover, and Ramsey. These areas are within the Lower Rum River Management Organization.

This analysis is primarily intended to identify potential projects within the target areas to improve water quality in these cities through stormwater retrofits. In this SRA, both costs and pollutant reductions were estimated and used to calculate cost-effectiveness for each potential retrofit identified. Water quality benefits associated with the installation of each identified project were individually modeled using the Source Loading and Management Model for Windows (WinSLAMM). The volume and pollutant estimates in this report are not waste load allocations, nor does this report serve as a TMDL for the study area. The WinSLAMM model was not calibrated and was only used as an estimation tool to provide relative ranking across potential retrofit projects. The costs associated with project design, administration, promotion, land acquisition, opportunity costs, construction oversight, installation, and maintenance were estimated. The total costs over the assumed effective life of each project were then divided by the modeled benefits over the same time period to enable ranking by cost-effectiveness.

The 12,300-acre study area was refined into 20 catchments with a combined area of 1477-acres. A WinSLAMM model was created for each catchment except where noted in the Catchment Profile pages. Details of the volume and pollutant loading within each catchment are provided in the Catchment Profile pages. A variety of stormwater retrofit approaches was identified and potential projects are organized from most cost-effective to least based on pollutants removed. That said, cost-effective opportunities are limited due to the prevalence of existing treatment, primarily stormwater ponds, throughout the study area.

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Executive Summary

Anoka Conservation District (ACD) completed this stormwater retrofit analysis (SRA) for the purpose of identifying and ranking water quality improvement projects in selected subwatersheds that drain to the Rum River. The subwatershed is located in the cities of Anoka, Andover, and Ramsey. Land use consists primarily of residential, commercial, and institutional. Total phosphorus (TP) and total suspended solids (TSS) were the target parameters analyzed. Volume was also documented as a model output.

This analysis is primarily intended to identify potential projects within the target areas to improve water quality in the Rum River through stormwater retrofits. Stormwater retrofits refer to best management practices (BMPs) that are added to an already developed landscape where little open space exists. The process is investigative and creative. Stormwater retrofits can be improperly judged by comparing the total number of projects installed or by comparing costs alone. Those approaches neglect to consider how much pollution is removed per dollar spent. In this report, both costs and pollutant reductions were estimated and used to calculate cost-effectiveness for each potential retrofit identified.

Water quality benefits associated with the installation of each identified project were individually modeled using the Source Loading and Management Model for Windows (WinSLAMM). WinSLAMM uses an abundance of stormwater data from the Upper-Midwest and elsewhere to quantify runoff volumes and pollutant loads from urban areas. It has detailed accounting of pollutant loading from various land uses and allows the user to build a model "landscape". WinSLAMM uses rainfall and temperature data from a typical year (1959 data from Minneapolis for this analysis), routing stormwater through the user's model for each storm.

WinSLAMM estimates volume and pollutant loading based on acreage, land use, and soils information. Therefore, the volume and pollutant estimates in this report are not waste load allocations, nor does this report serve as a TMDL for the study area. The WinSLAMM model was not calibrated and was only used as an estimation tool to provide relative ranking across potential retrofit projects. Specific model inputs (e.g. pollutant probability distribution, runoff coefficient, particulate solids concentration, particle residue delivery, and street delivery files) are detailed in Appendix A – Modeling Methods.

The costs associated with project design, administration, promotion, land acquisition, opportunity costs, construction oversight, installation, and maintenance were estimated. The total costs over the assumed effective life of each project were then divided by the modeled benefits over the same time period to enable ranking by cost-effectiveness.

A variety of stormwater retrofit approaches were identified. They included bioretention (bioinfiltration), enhanced street sweeping, and hydrodynamic devices. Funding limitations and landowner interest will ultimately determine how many retrofits are installed. It is recommended that projects be installed in order of cost-effectiveness (pounds of pollution reduced per dollar spent). Other factors, including a project's educational value/visibility, construction timing, total cost, or non-target pollutant reduction, or multiple benefits considerations also affect project installation decisions and should be considered by resource managers when pursuing projects.

For each type of recommended retrofit, conceptual siting is provided in the project profiles section. The intent of these figures is to provide an understanding of the approach. If a project is selected, site-specific designs must be prepared. In addition, some of the proposed retrofits (e.g. hydrodynamic devices) will require a more detailed feasibility analysis and engineered plan sets if selected. This typically occurs after committed partnerships are formed to install the project. Committed partnerships must include willing landowners, both public and private.

The 12,300-acre study area was refined into 20 catchments with a combined area of 1477-acres. A summary of catchments excluded from detailed analysis has been included in Appendix E – Catchments Excluded from Detailed Analysis. The tables in the Project Ranking and Selection section summarize potential projects ranked by cost-effectiveness with respect to both TP and TSS. Potential projects are organized from most cost-effective to least based on pollutants removed.

In summary, 61 projects were identified throughout the 20 catchments. Project types included bioretention (47, 80% of total) and hydrodynamic devices (12, 20% of total). The prevalence of existing stormwater ponds throughout most of the study area limited the opportunities for large, regional practices. Multiple catchments that discharge directly into the Rum River without some form of existing water quality treatment were targeted for potential project identification.

Overall, cost-effectiveness for TP removal ranged from ~$700/lb-TP to ~$17,800/lb-TP. The most cost-effective projects for TP removal and bioinfiltration basins and enhanced street cleaning practices. Cost-effectiveness for TSS removal ranged from ~$1,400/1,000 lbs-TSS to ~$46,000/1,000 lbs-TSS. Similar to TP, the most cost-effective projects for TSS removal are bioinfiltration practices and enhanced street cleaning practices. Cost-effectiveness values for enhanced street cleaning have been developed and are included in the Project Ranking tables, however, the values from WinSLAMM were found to be very conservative. An alternative for calculating reductions and cost-effectiveness from enhanced street cleaning has been included in Appendix D – Enhanced Street Cleaning Calculator.

Installation of projects in series will result in lower total treatment than the simple sum of treatment achieved by the individual projects due to treatment train effects. Reported treatment levels are dependent upon optimal site selection and sizing. More detail about each project is available in the catchment profile pages of this report. Projects deemed infeasible due to prohibitive size, number, or expense were not included in this report.

Document Organization

This document is organized into five sections, plus references and appendices. Each section is briefly discussed below.

Background

The background section provides a brief description of the landscape characteristics within the study area.

Analytical Process and Elements

The analytical process and elements section overviews the procedures that were followed when analyzing the subwatershed. It explains the processes of retrofit scoping, desktop analysis, field investigation, modeling, cost/treatment analysis, project ranking, and project selection. Refer to Appendix A – Modeling Methods for a detailed description of the modeling methods.

Project Ranking and Selection

The project ranking and selection section describes the methods and rationale for how projects were ranked. Local resource management professionals will be responsible to select and pursue projects, taking into consideration the many possible ways to prioritize projects. Several considerations in addition to project cost-effectiveness for prioritizing installation are included. Project funding opportunities may play a large role in project selection, design, and installation.

This section also ranks stormwater retrofit projects across all catchments to create a prioritized project list. The list is sorted by the cost-effectiveness of each project over 30 years. The final cost per pound treatment value includes installation and maintenance costs over the estimated life of the project. If a practice's effective life was expected to be less than 30 years, rehabilitation or reinstallation costs were included in the cost estimate. There are many possible ways to prioritize projects, and the list provided in this report is merely a starting point.

BMP Descriptions

For each type of project included in this report, there is a description of the rationale for including that type of project, the modeling method employed, and the cost calculations used to estimate associated installation and maintenance expenses.

Catchment Profiles

The drainage area for this analysis was divided into 20 catchments and assigned unique identification numbers. For each catchment, the following information is detailed:

Catchment Description

Within each catchment profile is a table that summarizes basic catchment information including acres, land cover, parcels, and estimated annual pollutant and volume loads under existing conditions. Existing conditions included notable stormwater treatment practices for which information was available from the City of Anoka, the City of Andover, or the City of Ramsey. Small, site-specific practices (e.g. rain-leader disconnect rain gardens) were not included in the existing conditions model. A brief description of the land cover, stormwater infrastructure, and any other important general information is also described in this section. Notable existing stormwater practices are explained and their estimated effectiveness presented.

Retrofit Opportunities

Retrofit opportunities are presented for each catchment and include a description of the proposed BMP, cost-effectiveness table including modeled volume and pollutant reductions, and an overview map showing the contributing drainage area for each BMP.

References

This section identifies various sources of information synthesized to produce the protocol used in this analysis.

Appendices

This section provides supplemental information and/or data used during the analysis.

Background

Many factors are considered when choosing which subwatersheds to analyze for stormwater retrofits. Water quality monitoring data, non-degradation report modeling, and TMDL studies are just a few of the resources available to help determine which water bodies are a priority. Stormwater retrofit analyses supported by a Local Government Unit with sufficient capacity (staff, funding, available GIS data, etc.) to greater facilitate the process also rank highly. For some communities a stormwater retrofit analysis complements their MS4 stormwater permit. The focus is always on a high priority waterbody.

The target area studied for this analysis is located in the cities of Anoka, Andover, and Ramsey – within the Lower Rum River Watershed Management Organization (LRRWMO) – and drains to the Rum River via a variety of outfalls. The area analyzed was divided into 20 catchments and consists of 1477 acres. The selected catchments of the Rum River subwatershed are largely developed and are primarily residential areas. Development throughout these cities has resulted in the installation of subsurface drainage systems (i.e. stormwater infrastructure) to convey stormwater runoff, which increased due to the coverage of impervious surfaces throughout the catchments.

The runoff generated within the subwatershed is still conveyed to the Rum River, as it was historically. However, the runoff is now captured by catch basins and directed underground before being discharged via stormwater pipes. This along with the impervious surfaces has caused increased volume and pollutant loading to the Rum River relative to natural, historical conditions.

Stormwater runoff from impervious surfaces can carry a variety of pollutants. Stormwater treatment to remove these pollutants is prevalent throughout most of the subwatershed, primarily in the form of stormwater ponds. This SRA is intended to review the subwatershed and identify potential projects that will benefit Rum River water quality.

Anoka Conservation District (ACD) completed this SRA for the purpose of identifying and analyzing projects to improve the quality of stormwater runoff from contributing drainage areas to the Rum River. Overall subwatershed loading of TP, TSS, and stormwater volume were estimated for catchments throughout the subwatershed. Proposed retrofits were modeled to estimate each practice's capability for removing pollutants and reducing volume. Finally, each project was ranked based on the estimated cost-effectiveness of the project to reduce pollutants.

Analytical Process and Elements

This stormwater retrofit analysis is a watershed management tool to identify and prioritize potential stormwater retrofit projects by performance and cost-effectiveness. This process helps maximize the value of each dollar spent. The process used for this analysis is outlined in the following pages and was modified from the Center for Watershed Protection's Urban Stormwater Retrofit Practices, Manuals 2 and 3 (Schueler & Kitchell, 2005 and Schueler et al. 2007). Locally relevant design considerations were also incorporated into the process (Technical Documents, Minnesota Stormwater Manual, 2024).

Scoping includes determining the objectives of the retrofits (volume reduction, target pollutant, etc.) and the level of treatment desired. It involves meeting with local stormwater managers, city staff, and watershed management organization members to determine the issues in the subwatershed. This step also helps to define preferred retrofit treatment options and retrofit performance criteria. In order to create a manageable area to analyze in large subwatersheds, a focus area may be determined.

In this analysis, the focus areas were the contributing drainage areas to storm sewer outfalls that discharge directly into the target water body (i.e. the Rum River). Included are areas of residential, commercial, industrial, and institutional land uses. The focus area was divided into 20 catchments using a combination of existing subwatershed mapping data, stormwater infrastructure maps, and observed topography.

The targeted pollutants for this study were TP and TSS, though volume was also estimated and reported. Volume of stormwater was tracked throughout this study because it is necessary for pollutant loading calculations and potential retrofit project considerations. Table 1 describes the target pollutants and their role in water quality degradation. Projects that effectively reduce loading of multiple target pollutants can provide greater immediate and long-term benefits.

Table 1: Target Pollutants

Target Pollutant	Description
Total Suspended Solids (TSS)	Very small mineral and organic particles that can be dispersed into the water column due to turbulent mixing. TSS loading can create turbid and cloudy water conditions and carry particulate phosphorus (PP). As such, reductions in TSS will also result in TP reductions.
Total Phosphorus (TP)	Phosphorus is a nutrient essential to plant growth and is commonly the factor that limits the growth of plants in surface water bodies. TP is a combination of PP, which is bound to sediment and organic debris, and dissolved phosphorus (DP), which is in solution and readily available for plant growth (active).
Volume	Higher runoff volumes and velocities can carry greater amounts of TSS to receiving water bodies. It can also exacerbate in-stream erosion, thereby increasing TSS loading. As such, reductions in volume may reduce TSS loading and, by extension, TP loading.

Desktop analysis involves computer-based scanning of the subwatershed for potential retrofit catchments and/or specific sites. This step also identifies areas that do not need to be analyzed because of existing stormwater treatment or disconnection from the target water body. Accurate GIS data are extremely valuable in conducting the desktop retrofit analysis. Some of the most important GIS layers include 2-foot or finer topography (Light Detection and Ranging [LiDAR] was used for this analysis), surface hydrology, soils, watershed/subwatershed boundaries, parcel boundaries, high-resolution aerial photography, and the stormwater drainage infrastructure (with invert elevations).

Field investigation is conducted after potential retrofits are identified in the desktop analysis to evaluate each site and identify additional opportunities. During the investigation, the drainage area and surface stormwater infrastructure mapping data were verified in areas where the available GIS data were insufficient. Site constraints were assessed to determine the most feasible retrofit options as well as eliminate sites from consideration. The field investigation may have also revealed additional retrofit opportunities that could have gone unnoticed during the desktop search.

Modeling involves assessing multiple scenarios to estimate pollutant loading and potential reductions by proposed retrofits. WinSLAMM (version 10.5.0), which allows routing of multiple catchments and stormwater treatment practices, was used for this analysis. This is important for estimating treatment train effects associated with multiple BMPs in series. Furthermore, it allows for estimation of volume and pollutant loading at the outfall point to the waterbody, which is the primary point of interest in this type of study.

WinSLAMM estimates volume and pollutant loading based on acreage, land use, and soils information. Therefore, the volume and pollutant estimates in this report are not waste load allocations, nor does this report serve as a TMDL for the study area. The WinSLAMM model was not calibrated and was only used as an estimation tool to provide relative ranking across potential retrofit projects. Specific model inputs (e.g. pollutant probability distribution, runoff coefficient, particulate solids concentration, particle residue delivery, and street delivery files) are detailed in Appendix A – Modeling Methods.

The initial step was to create a "base" model, which estimates pollutant loading from each catchment in its present-day state without taking into consideration any existing stormwater treatment. Drainage area delineations were used to model the land uses in each catchment. The drainage areas were consolidated into catchments using geographic information systems (specifically, ArcMap). Land use data (based on 2020 Metropolitan Council land use file) were used to calculate acreages of each land use type within each catchment. Each land use polygon classification was compared with high-resolution 2023 aerial photography, the most recent available at the time of this analysis, as well as ground truthing, and corrected if land use had changed since 2020. This process addressed recent development throughout the study area by reclassifying land use types accordingly. Soil types throughout the study area were predominantly sand based on information available in the Anoka County soil survey. Entering the acreages, land use, and soil data into WinSLAMM ultimately resulted in a model that included estimates of the acreage of each type of source area (roof, road, lawn, etc.) in each catchment.

Once the "base" model was established, an "existing conditions" model was created by incorporating notable existing stormwater treatment practices in the catchment for which data were available from the City of Anoka, the City of Andover, and the City of Ramsey (Figure 3 - Figure 5). For example, street cleaning, stormwater treatment ponds, hydrodynamic devices, and others were included in the "existing conditions" model if information was available.

Finally, each proposed stormwater retrofit practice was added individually to the "existing conditions" model and pollutant reductions were estimated. Because neither a detailed design of each practice nor in-depth site investigation was completed, a generalized design for each practice was used. Whenever possible, site-specific parameters were included. Design parameters were modified to obtain various levels of treatment. It is worth noting that each practice was modeled individually, and the benefits of projects may not be additive, especially if serving the same area (i.e. treatment train effects). Reported treatment levels are dependent upon optimal site selection and sizing. Additional information on the WinSLAMM models can be found in Appendix A – Modeling Methods.

Cost estimating is essential for the comparison and ranking of projects, development of work plans, and pursuit of grants and other funds. All estimates were developed using 2024 dollars. Costs throughout this report were estimated using a multitude of sources. Costs were derived from The Center for Watershed Protection's Urban Subwatershed Restoration Manuals (Schueler & Kitchell, 2005 and Schueler et al. 2007), recent installation costs, and cost estimates provided to ACD by personal contacts. Cost estimates were annualized costs that incorporated the elements listed below over a 30-year period.

Project promotion and administration includes local staff efforts to reach out to landowners, administer related grants, and complete necessary administrative tasks.

Design includes site surveying, engineering, and construction oversight.

Land or easement acquisition covers the cost of purchasing property or the cost of obtaining necessary utility and access easements from landowners.

Construction calculations are project specific and may include all or some of the following: grading, erosion control, vegetation management, structures, mobilization, traffic control, equipment, soil disposal, and rock or other materials.

Maintenance includes annual inspections and minor site remediation such as vegetation management, structural outlet repair and cleaning, and washout repair.

In cases where promotion to landowners is important, such as rain gardens, those costs were included as well. In cases where multiple, similar projects are proposed in the same locality, promotion and administration costs were estimated using a non-linear relationship that accounted for savings with scale. Design assistance from an engineer is assumed for practices in-line with the stormwater conveyance system, involving complex stormwater treatment interactions, or posing a risk for upstream flooding. It should be understood that no site-specific construction investigations were done as part of this stormwater retrofit analysis, and therefore cost estimates account for only general site considerations. Detailed feasibility analyses may be necessary for some projects.

Project ranking is essential to identify which projects could be pursued to achieve water quality goals. Project ranking tables are presented based on cost per 1,000 pounds of TSS and cost per pound of TP removed.

Project selection involves considerations other than project ranking, including but not limited to total cost, treatment train effects, social acceptability, and political feasibility.

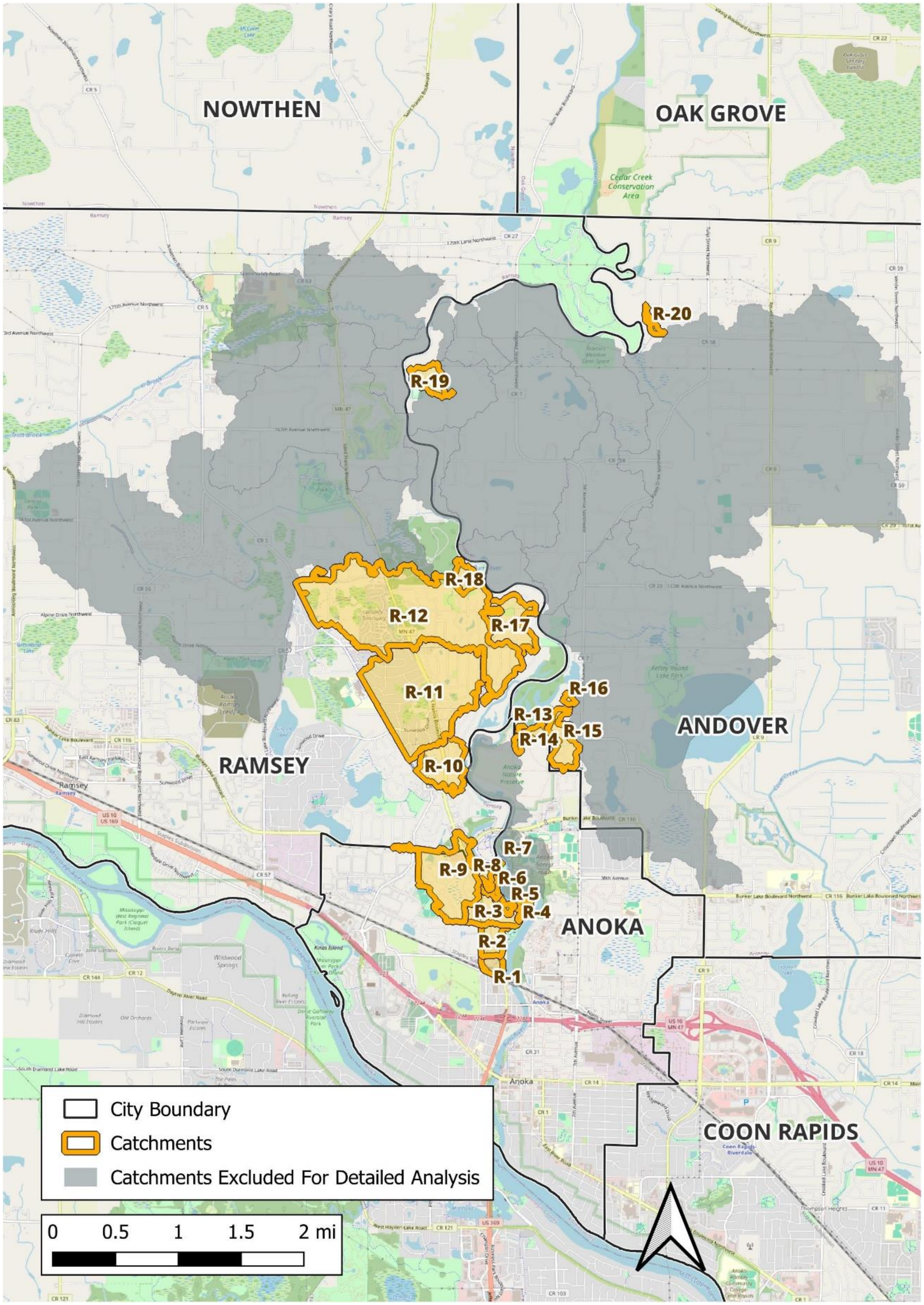


Figure 1: All Rum River catchments reviewed in this analysis (approx. 12,300 acres), including catchments excluded from further detailed analysis.

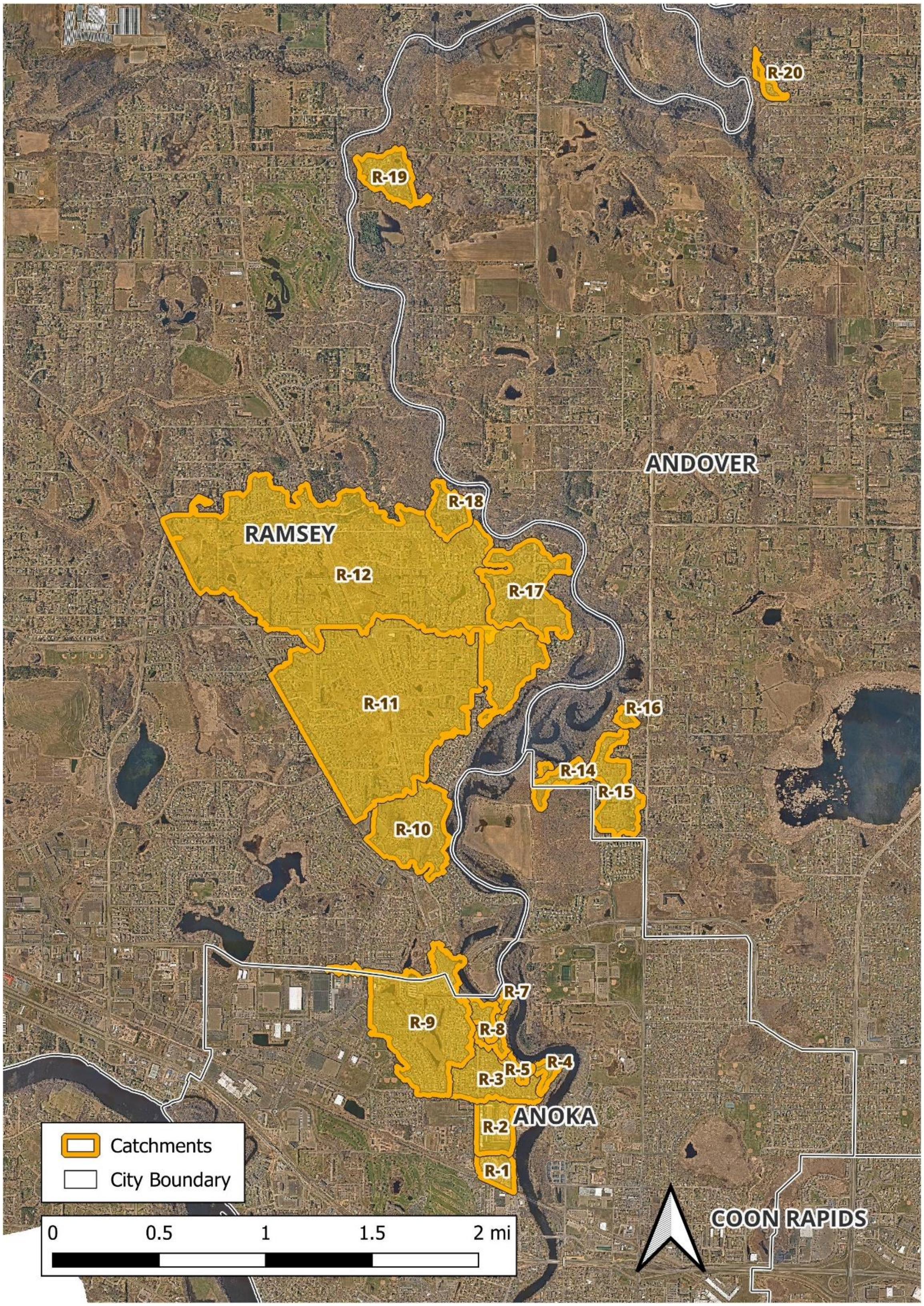


Figure 2: Rum River catchments reviewed in detailed analysis (1477 acres).

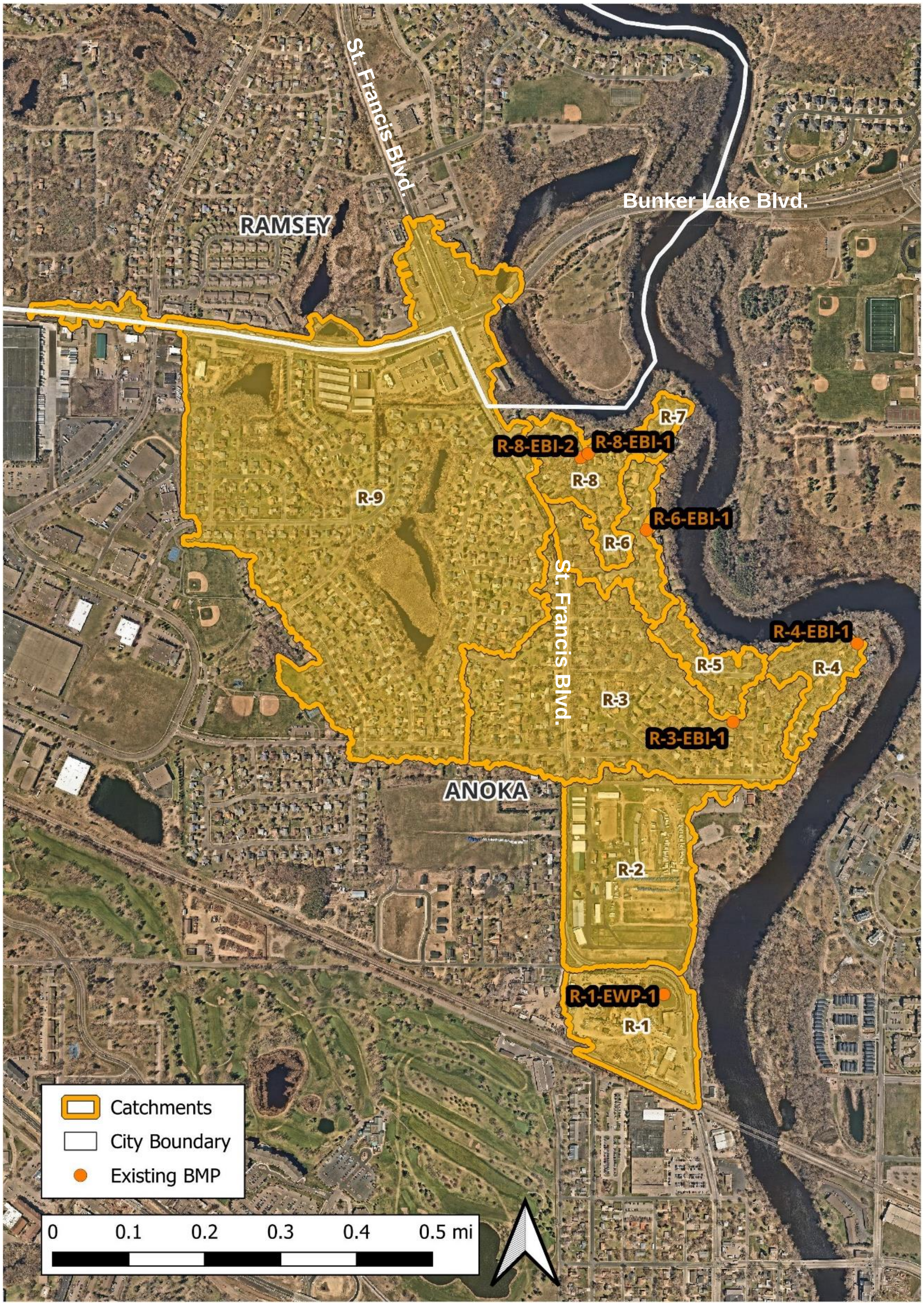


Figure 3: Rum River (Anoka) subwatershed existing BMPs included in the WinSLAMM model. Street sweeping is not shown on the map but was included throughout the study area.

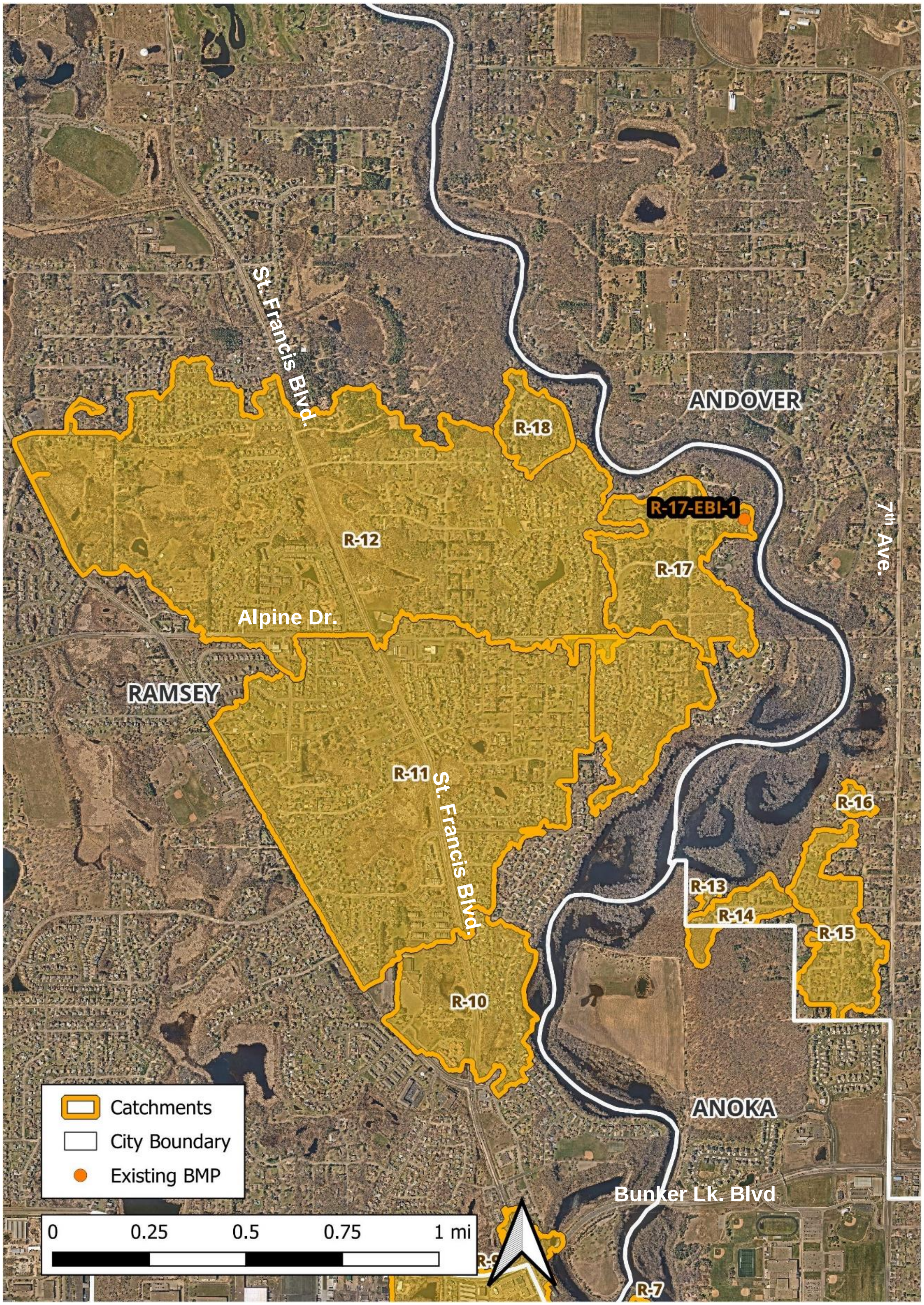


Figure 4: Rum River (Andover-Ramsey) subwatershed existing BMPs included in the WinSLAMM model. Street sweeping is not shown on the map but was included throughout the study area.

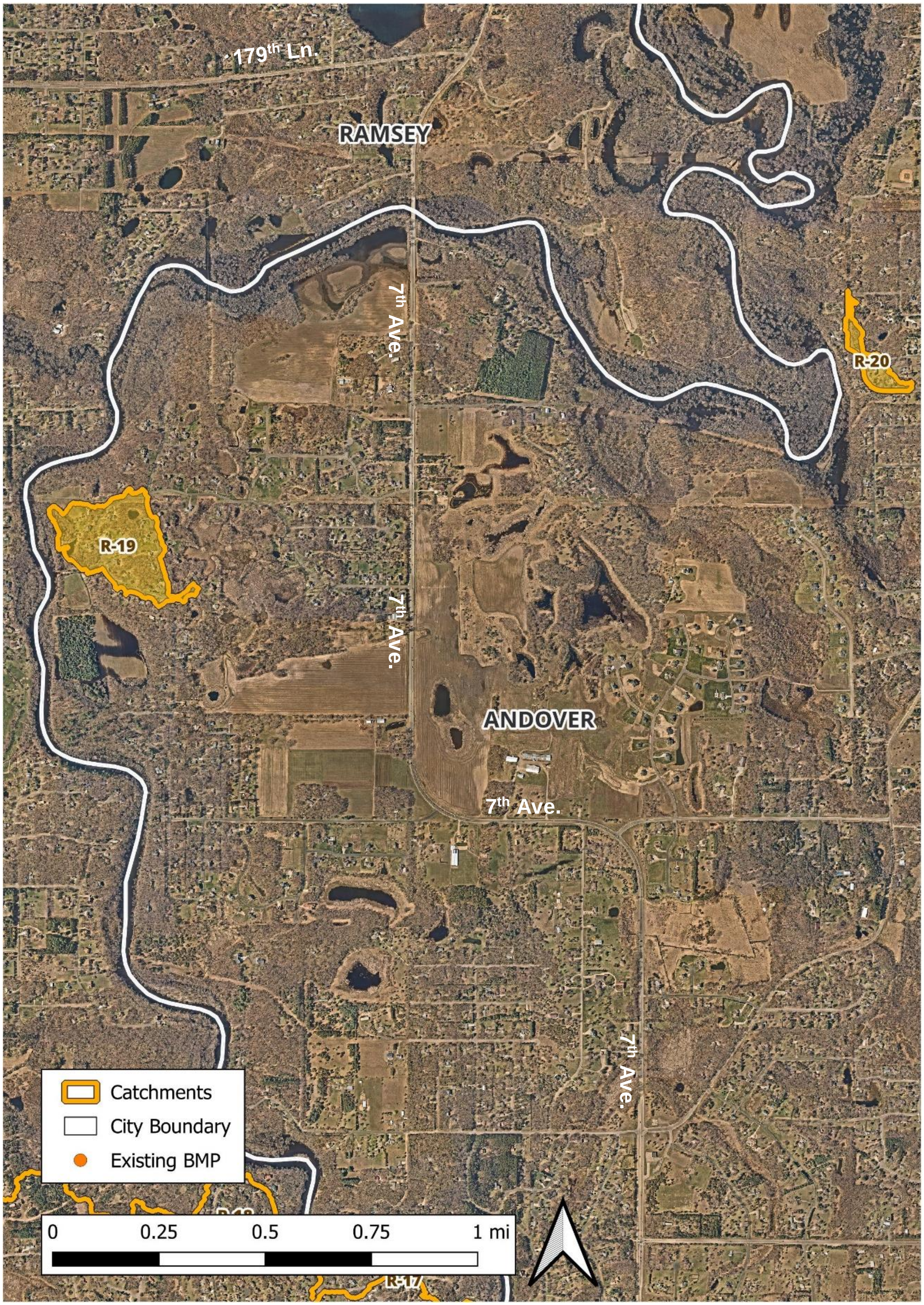


Figure 5: Rum River (northern Andover) subwatershed existing BMPs included in the WinSLAMM model. Street sweeping is not shown on the map but was included throughout the study area.

Project Ranking and Selection

The intent of this analysis is to provide the information necessary to enable local natural resource managers to secure funding for the most cost-effective projects to achieve water quality goals. This analysis ranks potential projects by cost-effectiveness to facilitate project selection. There are many possible ways to prioritize projects, and the list provided in this report is merely a starting point. Local resource management professionals will be responsible to select projects to pursue. Several considerations in addition to project cost-effectiveness for prioritizing installation are included.

Figure 6 - Figure 8 show portions of the drainage area that are currently treated by existing BMPs as well as the areas that could be treated with the retrofit opportunities identified in this report.

Project Ranking

The tables on the following pages rank all modeled projects by cost-effectiveness.

Projects were ranked in two ways:

1) Cost per pound of total phosphorus removed, and
2) Cost per 1,000 pounds of total suspended solids removed.

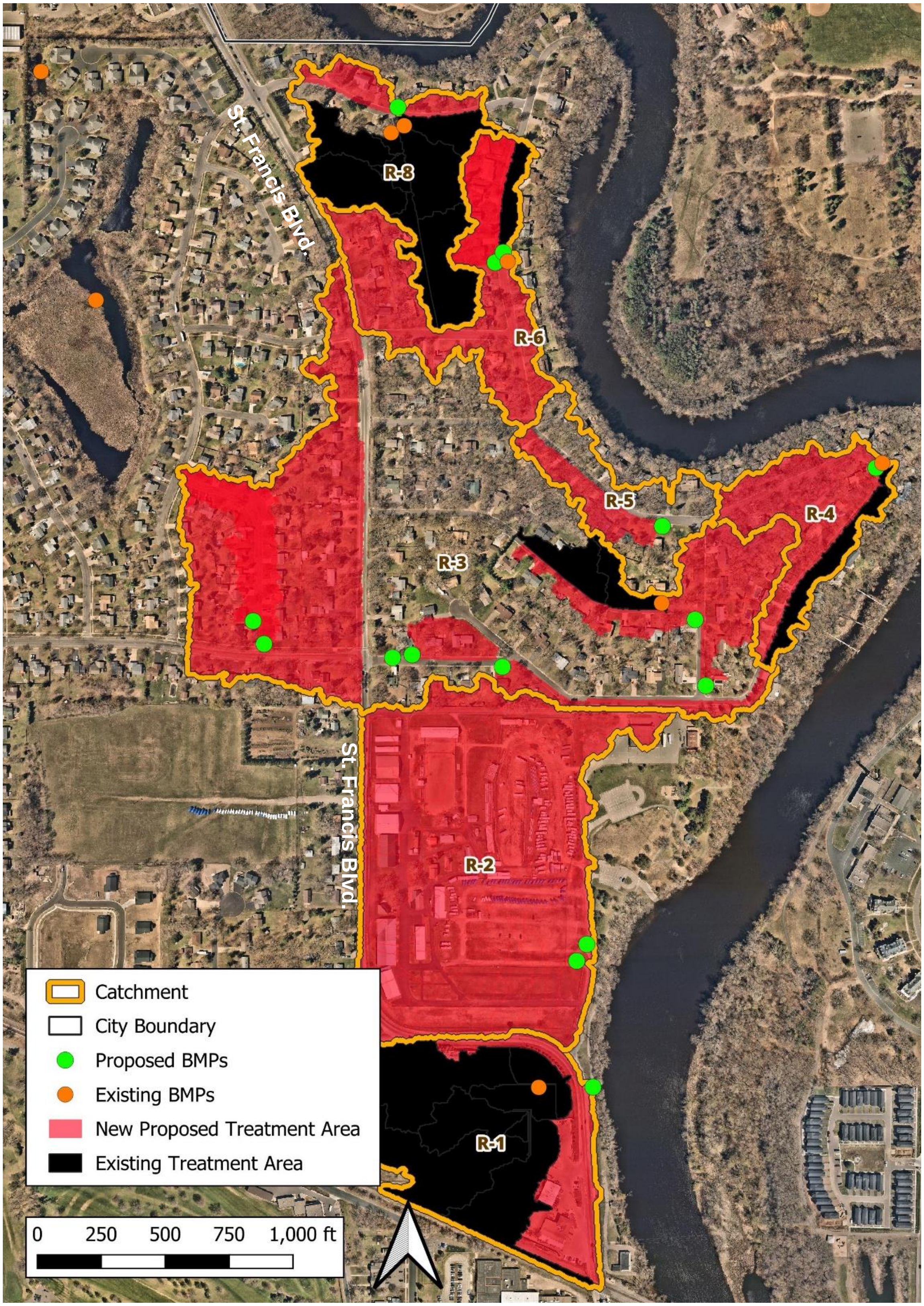


Figure 6: Rum River (Anoka) subwatershed with water quality treatment from existing and proposed BMPs within fully modeled catchments (excludes R-7 and R-9).

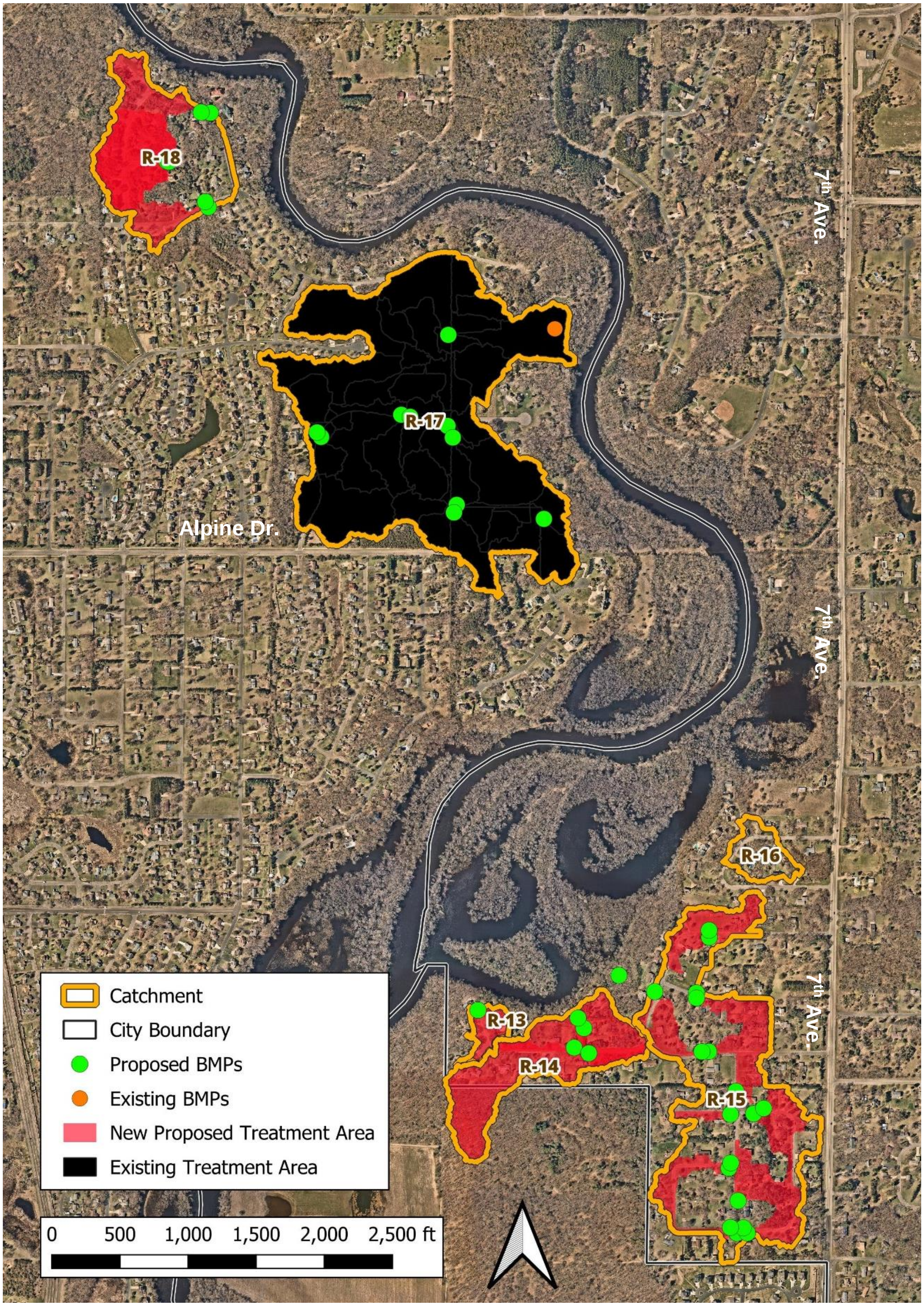


Figure 7: Rum River (Andover-Ramsey) subwatershed with water quality treatment from existing and proposed BMPs within fully modeled catchments (excludes R-9 to R-12).

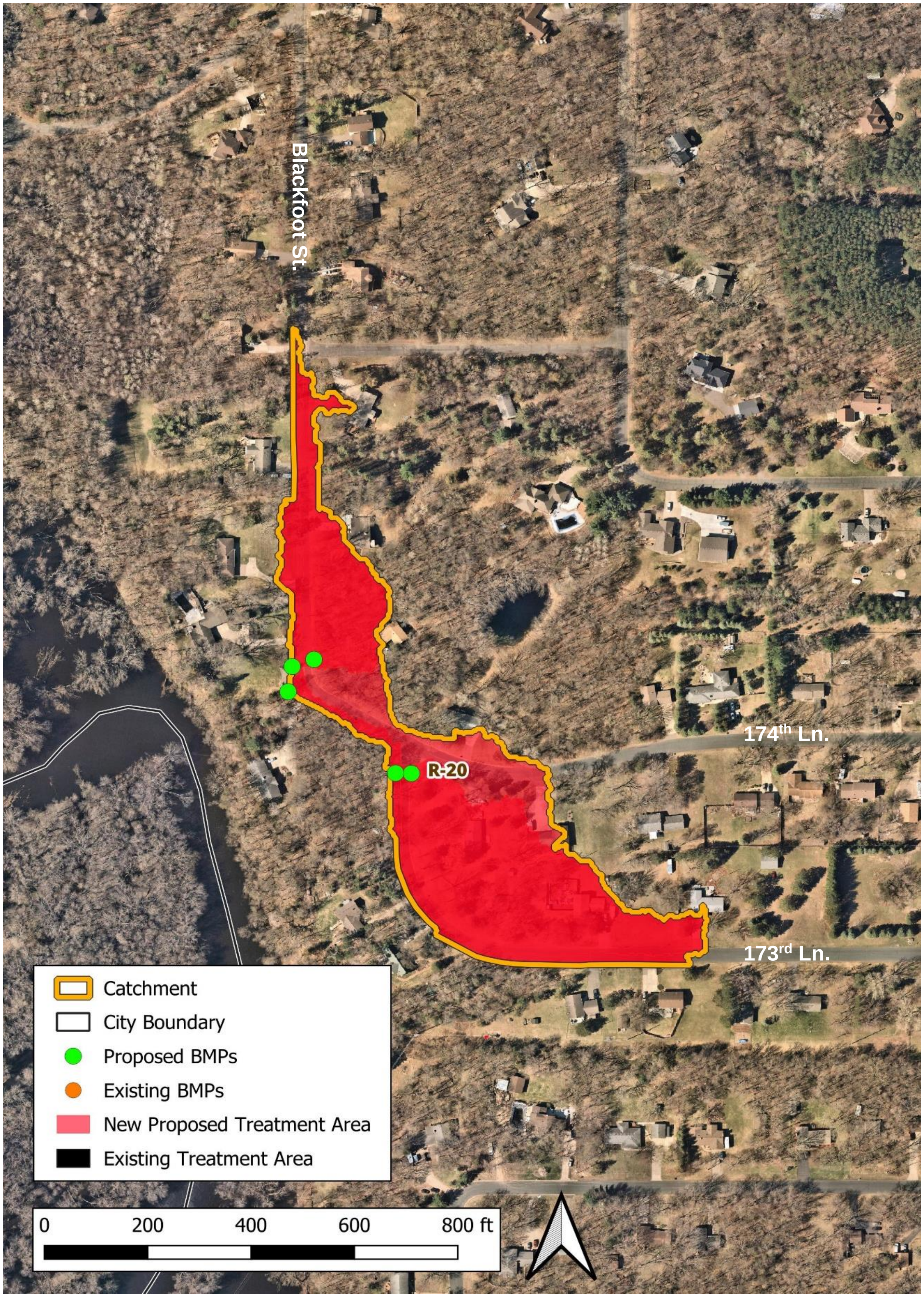


Figure 8: Rum River (northern Andover) subwatershed with water quality treatment from existing and proposed BMPs within fully modeled catchments (excludes R-19).

Table 2: Cost-effectiveness of retrofits with respect to TP reduction. Projects ranked 1 - 73 are shown on this table. TSS and volume reductions are also shown. For more information on each project refer to either the Catchment Profile or BMP Descriptions pages in this report. Volume and pollutant reduction benefits cannot be summed with other projects that provide treatment for the same source area.

Project Rank	Project ID	Page Number	Retrofit Type	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost	Estimated Annual Operations & Maintenance	Estimated cost/ lb-TP/year (30-year)[1]
1	R-18-PBI-3	141	Bioinfiltration Basin	R-18	1.16	369	0.88	$16,984	$225	$683
2	R-2 Enhanced SC	30	Street Cleaning	R-2	0.27	169	0.00	$240	$0	$889
3	R-15-PBI-18	119	Bioinfiltration Basin	R-15	0.89	280	0.66	$16,984	$225	$889
4	R-3-PBI-1	50	Bioinfiltration Basin	R-3	0.57	181	0.43	$10,484	$225	$1,008
5	R-20-PBI-4	152	Bioinfiltration Basin	R-20	0.53	169	0.40	$10,484	$225	$1,078
6	R-15-PBI-13	114	Bioinfiltration Basin	R-15	0.52	164	0.39	$10,484	$225	$1,105
7	R-18-PBI-2	140	Bioinfiltration Basin	R-18	0.52	165	0.39	$10,484	$225	$1,107
8	R-15-PBI-6	107	Bioinfiltration Basin	R-15	0.50	157	0.37	$10,484	$225	$1,149
9	R-3-PBI-2	51	Bioinfiltration Basin	R-3	0.49	154	0.36	$10,484	$225	$1,172
10	R-6-PBI-1	68	Bioinfiltration Basin	R-6	0.48	153	0.36	$10,484	$225	$1,187
11	R-15-PBI-5	106	Bioinfiltration Basin	R-15	0.47	148	0.35	$10,484	$225	$1,222
12	R-5-PBI-1	64	Bioinfiltration Basin	R-5	0.47	147	0.35	$10,484	$225	$1,235
13	R-8-PBI-1	76	Bioinfiltration Basin	R-8	0.62	193	0.47	$16,984	$225	$1,276
14	R-15-PBI-9	110	Bioinfiltration Basin	R-15	0.45	142	0.34	$10,484	$225	$1,277
15	R-3-PBI-5	54	Bioinfiltration Basin	R-3	0.43	135	0.32	$10,484	$225	$1,336
16	R-18-PBI-1	139	Bioinfiltration Basin	R-18	0.59	184	0.45	$16,984	$225	$1,345
17	R-15-PBI-16	117	Bioinfiltration Basin	R-15	0.42	132	0.31	$10,484	$225	$1,368
18	R-15-PBI-7	108	Bioinfiltration Basin	R-15	0.42	130	0.31	$10,484	$225	$1,368
19	R-14 Enhanced SC	30	Street Cleaning	R-14	0.13	57	0.00	$180	$0	$1,385
20	R-15-PBI-10	111	Bioinfiltration Basin	R-15	0.41	126	0.30	$10,484	$225	$1,401
21	R-18-PBI-4	142	Bioinfiltration Basin	R-18	0.41	130	0.31	$10,484	$225	$1,401
22	R-3-PBI-3	52	Bioinfiltration Basin	R-3	0.41	159	0.36	$10,484	$225	$1,401
23	R-3-PBI-6	55	Bioinfiltration Basin	R-3	0.41	128	0.31	$10,484	$225	$1,401
24	R-15-PBI-2	104	Bioinfiltration Basin	R-15	0.40	125	0.30	$10,484	$225	$1,436
25	R-15-PBI-17	118	Bioinfiltration Basin	R-15	0.55	167	0.41	$16,984	$225	$1,438
26	R-20-PBI-2	150	Bioinfiltration Basin	R-20	0.40	124	0.30	$10,484	$225	$1,454
28	R-13 Enhanced SC	30	Street Cleaning	R-13	0.02	9	0.00	$30	$0	$1,500
29	R-16 Enhanced SC	30	Street Cleaning	R-16	0.04	16	0.00	$60	$0	$1,500
27	R-5 Enhanced SC	30	Street Cleaning	R-5	0.06	26	0.00	$90	$0	$1,500
30	R-3-PBI-4	53	Bioinfiltration Basin	R-3	0.37	116	0.28	$10,484	$225	$1,553
31	R-18-PBI-5	143	Bioinfiltration Basin	R-18	0.36	115	0.28	$10,484	$225	$1,587
32	R-15-PBI-11	112	Bioinfiltration Basin	R-15	0.36	111	0.27	$10,484	$225	$1,596
33	R-15-PBI-14	115	Bioinfiltration Basin	R-15	0.35	109	0.27	$10,484	$225	$1,641
34	R-14-PBI-3	98	Bioinfiltration Basin	R-14	0.34	108	0.26	$10,484	$225	$1,675
35	R-17-PBI-2	130	Bioinfiltration Basin	R-17	0.47	143	0.35	$16,984	$225	$1,683

Table continued below.

Table 2: Cost-effectiveness of retrofits with respect to TP reduction (continued).

Project Rank	Project ID	Page Number	Retrofit Type	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost	Estimated Annual Operations & Maintenance	Estimated cost/ lb-TP/year (30-year)[1]
36	R-17-PBI-5	131	Bioinfiltration Basin	R-17	0.47	144	0.35	$16,984	$225	$1,683
37	R-17-PBI-8	134	Bioinfiltration Basin	R-17	0.47	145	0.35	$16,984	$225	$1,683
38	R-15-PBI-15	116	Bioinfiltration Basin	R-15	0.33	100	0.24	$10,484	$225	$1,741
39	R-14-PBI-2	97	Bioinfiltration Basin	R-14	0.31	98	0.24	$10,484	$225	$1,847
40	R-15-PBI-8	109	Bioinfiltration Basin	R-15	0.28	86	0.21	$10,484	$225	$2,052
41	R-15 Enhanced SC	30	Street Cleaning	R-15	0.46	199	0.00	$990	$0	$2,152
42	R-15-PBI-12	113	Bioinfiltration Basin	R-15	0.26	80	0.20	$10,484	$225	$2,209
43	R-3 Enhanced SC	30	Street Cleaning	R-3	0.51	221	0.00	$1,140	$0	$2,235
44	R-14-PBI-1	96	Bioinfiltration Basin	R-14	0.25	82	0.17	$10,484	$225	$2,307
45	R-17-PBI-1	127	Bioinfiltration Basin	R-17	0.24	72	0.18	$10,484	$225	$2,394
46	R-17-PBI-4	130	Bioinfiltration Basin	R-17	0.24	72	0.18	$10,484	$225	$2,394
47	R-17-PBI-6	132	Bioinfiltration Basin	R-17	0.24	73	0.18	$10,484	$225	$2,394
48	R-17-PBI-7	133	Bioinfiltration Basin	R-17	0.24	73	0.18	$10,484	$225	$2,394
49	R-17-PBI-3	129	Bioinfiltration Basin	R-17	0.22	66	0.17	$10,484	$225	$2,611
50	R-18 Enhanced SC	30	Street Cleaning	R-18	0.2	89	0.00	$540	$0	$2,700
51	R-4 Enhanced SC	30	Street Cleaning	R-4	0.06	25	0.00	$180	$0	$3,000
52	R-6 Enhanced SC	30	Street Cleaning	R-6	0.09	40	0.00	$270	$0	$3,000
53	R-20 Enhanced SC	30	Street Cleaning	R-20	0.06	25	0.00	$210	$0	$3,500
54	R-15-PBI-1	103	Bioinfiltration Basin	R-15	0.16	47	0.12	$10,484	$225	$3,590
55	R-20-PBI-1	149	Bioinfiltration Basin	R-20	0.21	65	0.17	$16,984	$225	$3,697
56	R-20-PBI-3	151	Bioinfiltration Basin	R-20	0.15	44	0.11	$10,484	$225	$3,962
57	R-15-PBI-19	120	Bioinfiltration Basin	R-15	0.13	38	0.10	$10,484	$225	$4,419
58	R-15-PBI-3	105	Bioinfiltration Basin	R-15	0.13	37	0.09	$10,484	$225	$4,419
59	R-2-PHD-1	45	Hydrodynamic Device	R-2	1.14	602	0.00	$153,750	$210	$4,680
60	R-17 Enhanced SC	30	Street Cleaning	R-17	0.23	97	0.00	$1,080	$0	$4,696
61	R-8 Enhanced SC	30	Street Cleaning	R-8	0.04	19	0.00	$210	$0	$5,250
62	R-2-PHD-2	46	Hydrodynamic Device	R-2	1.01	541	0.00	$153,750	$210	$5,282
63	R-4-PHD-1	60	Hydrodynamic Device	R-4	0.29	115	0.00	$41,250	$210	$5,542
64	R-20-PHD-1	153	Hydrodynamic Device	R-20	0.36	144	0.00	$57,750	$210	$5,947
65	R-3-PHD-1	56	Hydrodynamic Device	R-3	0.83	332	0.00	$153,750	$210	$6,428
66	R-14-PHD-1	99	Hydrodynamic Device	R-14	0.75	304	0.00	$153,750	$210	$7,151
67	R-1 Enhanced SC	30	Street Cleaning	R-1	0.02	17	0.00	$180	$0	$9,000
68	R-13-PHD-1	92	Hydrodynamic Device	R-13	0.16	64	0.00	$41,250	$210	$9,875
69	R-18-PHD-1	144	Hydrodynamic Device	R-18	0.51	208	0.00	$153,750	$210	$10,379
70	R-6-PHD-1	69	Hydrodynamic Device	R-6	0.38	152	0.00	153,750	210	$14,114
71	R-17-PHD-2	136	Hydrodynamic Device	R-17	0.35	138	0.00	$153,750	$210	$15,243
72	R-1-PHD-1	41	Hydrodynamic Device	R-1	0.32	258	0.00	$153,750	$210	$16,937
73	R-17-PHD-1	135	Hydrodynamic Device	R-17	0.30	117	0.00	$153,750	$210	$17,783

[1][(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TP Reduction)]; enhanced street cleaning is [Probable Project Cost] / [Annual TP Reduction]

Table 3: Cost-effectiveness of retrofits with respect to TSS reduction. Projects ranked 1 - 73 are shown on this table. TP and volume reductions are also shown. For more information on each project refer to either the Catchment Profile or BMP Descriptions pages in this report. Volume and pollutant reduction benefits cannot be summed with other projects that provide treatment for the same source area.

Project Rank	Project ID	Page Number	Retrofit Type	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost	Estimated Annual Operations & Maintenance	Estimated cost/ 1,000lb-TSS/year (30-year)[1]
1	R-2 Enhanced SC	30	Street Cleaning	R-2	0.27	169	0.00	$240	$0	$1,420
2	R-18-PBI-3	141	Bioinfiltration Basin	R-18	1.16	369	0.88	$16,984	$225	$2,144
3	R-15-PBI-18	119	Bioinfiltration Basin	R-15	0.89	280	0.66	$16,984	$225	$2,825
4	R-14 Enhanced SC	30	Street Cleaning	R-14	0.13	57	0.00	$180	$0	$3,158
5	R-3-PBI-1	50	Bioinfiltration Basin	R-3	0.57	181	0.43	$10,484	$225	$3,174
6	R-13 Enhanced SC	30	Street Cleaning	R-13	0.02	9	0.00	$30	$0	$3,333
7	R-20-PBI-4	152	Bioinfiltration Basin	R-20	0.53	169	0.40	$10,484	$225	$3,401
8	R-18-PBI-2	140	Bioinfiltration Basin	R-18	0.52	165	0.39	$10,484	$225	$3,482
9	R-15-PBI-13	114	Bioinfiltration Basin	R-15	0.52	164	0.39	$10,484	$225	$3,503
10	R-5 Enhanced SC	30	Street Cleaning	R-5	0.06	26	0.00	$90	$0	$3,516
11	R-3-PBI-3	52	Bioinfiltration Basin	R-3	0.41	159	0.36	$10,484	$225	$3,613
12	R-15-PBI-6	107	Bioinfiltration Basin	R-15	0.50	157	0.37	$10,484	$225	$3,659
13	R-3-PBI-2	51	Bioinfiltration Basin	R-3	0.49	154	0.36	$10,484	$225	$3,730
14	R-16 Enhanced SC	30	Street Cleaning	R-16	0.04	16	0.00	$60	$0	$3,750
15	R-6-PBI-1	68	Bioinfiltration Basin	R-6	0.48	153	0.36	$10,484	$225	$3,755
16	R-15-PBI-5	106	Bioinfiltration Basin	R-15	0.47	148	0.35	$10,484	$225	$3,882
17	R-5-PBI-1	64	Bioinfiltration Basin	R-5	0.47	147	0.35	$10,484	$225	$3,916
18	R-15-PBI-9	110	Bioinfiltration Basin	R-15	0.45	142	0.34	$10,484	$225	$4,046
19	R-8-PBI-1	76	Bioinfiltration Basin	R-8	0.62	193	0.47	$16,984	$225	$4,097
20	R-3-PBI-5	54	Bioinfiltration Basin	R-3	0.43	135	0.32	$10,484	$225	$4,255
21	R-18-PBI-1	139	Bioinfiltration Basin	R-18	0.59	184	0.45	$16,984	$225	$4,300
22	R-15-PBI-16	117	Bioinfiltration Basin	R-15	0.42	132	0.31	$10,484	$225	$4,352
23	R-15-PBI-7	108	Bioinfiltration Basin	R-15	0.42	130	0.31	$10,484	$225	$4,419
24	R-18-PBI-4	142	Bioinfiltration Basin	R-18	0.41	130	0.31	$10,484	$225	$4,419
25	R-3-PBI-6	55	Bioinfiltration Basin	R-3	0.41	128	0.31	$10,484	$225	$4,488
26	R-15-PBI-10	111	Bioinfiltration Basin	R-15	0.41	126	0.30	$10,484	$225	$4,559
27	R-15-PBI-2	104	Bioinfiltration Basin	R-15	0.40	125	0.30	$10,484	$225	$4,596
28	R-20-PBI-2	150	Bioinfiltration Basin	R-20	0.40	124	0.30	$10,484	$225	$4,625
29	R-15-PBI-17	118	Bioinfiltration Basin	R-15	0.55	167	0.41	$16,984	$225	$4,737
30	R-3-PBI-4	53	Bioinfiltration Basin	R-3	0.37	116	0.28	$10,484	$225	$4,952
31	R-15 Enhanced SC	30	Street Cleaning	R-15	0.46	199	0.00	$990	$0	$4,975
32	R-18-PBI-5	143	Bioinfiltration Basin	R-18	0.36	115	0.28	$10,484	$225	$4,995
33	R-3 Enhanced SC	30	Street Cleaning	R-3	0.51	221	0.00	$1,140	$0	$5,158
34	R-15-PBI-11	112	Bioinfiltration Basin	R-15	0.36	111	0.27	$10,484	$225	$5,175
35	R-15-PBI-14	115	Bioinfiltration Basin	R-15	0.35	109	0.27	$10,484	$225	$5,270

Table continued below.

Table 3: Cost-effectiveness of retrofits with respect to TSS reduction (continued).

Project Rank	Project ID	Page Number	Retrofit Type	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost	Estimated Annual Operations & Maintenance	Estimated cost/ 1,000lb-TSS/year (30-year)[1]
36	R-14-PBI-3	98	Bioinfiltration Basin	R-14	0.34	108	0.26	$10,484	$225	$5,319
37	R-17-PBI-8	134	Bioinfiltration Basin	R-17	0.47	145	0.35	$16,984	$225	$5,456
38	R-17-PBI-5	131	Bioinfiltration Basin	R-17	0.47	144	0.35	$16,984	$225	$5,494
39	R-17-PBI-2	130	Bioinfiltration Basin	R-17	0.47	143	0.35	$16,984	$225	$5,532
40	R-15-PBI-15	116	Bioinfiltration Basin	R-15	0.33	100	0.24	$10,484	$225	$5,745
41	R-14-PBI-2	97	Bioinfiltration Basin	R-14	0.31	98	0.24	$10,484	$225	$5,862
42	R-18 Enhanced SC	30	Street Cleaning	R-18	0.2	89	0.00	$540	$0	$6,067
43	R-15-PBI-8	109	Bioinfiltration Basin	R-15	0.28	86	0.21	$10,484	$225	$6,680
44	R-6 Enhanced SC	30	Street Cleaning	R-6	0.09	40	0.00	$270	$0	$6,750
45	R-14-PBI-1	96	Bioinfiltration Basin	R-14	0.25	82	0.17	$10,484	$225	$7,006
46	R-4 Enhanced SC	30	Street Cleaning	R-4	0.06	25	0.00	$180	$0	$7,171
47	R-15-PBI-12	113	Bioinfiltration Basin	R-15	0.26	80	0.20	$10,484	$225	$7,181
48	R-17-PBI-6	132	Bioinfiltration Basin	R-17	0.24	73	0.18	$10,484	$225	$7,869
49	R-17-PBI-7	133	Bioinfiltration Basin	R-17	0.24	73	0.18	$10,484	$225	$7,869
50	R-17-PBI-1	127	Bioinfiltration Basin	R-17	0.24	72	0.18	$10,484	$225	$7,979
51	R-17-PBI-4	130	Bioinfiltration Basin	R-17	0.24	72	0.18	$10,484	$225	$7,979
52	R-20 Enhanced SC	30	Street Cleaning	R-20	0.06	25	0.00	$210	$0	$8,468
53	R-17-PBI-3	129	Bioinfiltration Basin	R-17	0.22	66	0.17	$10,484	$225	$8,704
54	R-2-PHD-1	45	Hydrodynamic Device	R-2	1.14	602	0.00	$153,750	$210	$8,862
55	R-2-PHD-2	46	Hydrodynamic Device	R-2	1.01	541	0.00	$153,750	$210	$9,861
56	R-1 Enhanced SC	30	Street Cleaning	R-1	0.02	17	0.00	$180	$0	$10,588
57	R-8 Enhanced SC	30	Street Cleaning	R-8	0.04	19	0.00	$210	$0	$11,111
58	R-17 Enhanced SC	30	Street Cleaning	R-17	0.23	97	0.00	$1,080	$0	$11,134
59	R-15-PBI-1	103	Bioinfiltration Basin	R-15	0.16	47	0.12	$10,484	$225	$12,223
60	R-20-PBI-1	149	Bioinfiltration Basin	R-20	0.21	65	0.17	$16,984	$225	$12,247
61	R-20-PBI-3	151	Bioinfiltration Basin	R-20	0.15	44	0.11	$10,484	$225	$13,026
62	R-4-PHD-1	60	Hydrodynamic Device	R-4	0.29	115	0.00	$41,250	$210	$13,807
63	R-20-PHD-1	153	Hydrodynamic Device	R-20	0.36	144	0.00	$57,750	$210	$14,796
64	R-15-PBI-19	120	Bioinfiltration Basin	R-15	0.13	38	0.10	$10,484	$225	$15,118
65	R-15-PBI-3	105	Bioinfiltration Basin	R-15	0.13	37	0.09	$10,484	$225	$15,526
66	R-3-PHD-1	56	Hydrodynamic Device	R-3	0.83	332	0.00	$153,750	$210	$16,069
67	R-14-PHD-1	99	Hydrodynamic Device	R-14	0.75	304	0.00	$153,750	$210	$17,549
68	R-1-PHD-1	41	Hydrodynamic Device	R-1	0.32	258	0.00	$153,750	$210	$20,678
69	R-13-PHD-1	92	Hydrodynamic Device	R-13	0.16	64	0.00	$41,250	$210	$24,727
70	R-18-PHD-1	144	Hydrodynamic Device	R-18	0.51	208	0.00	$153,750	$210	$25,649
71	R-6-PHD-1	69	Hydrodynamic Device	R-6	0.38	152	0.00	153,750	210	35,099
72	R-17-PHD-2	136	Hydrodynamic Device	R-17	0.35	138	0.00	$153,750	$210	$38,659
73	R-17-PHD-1	135	Hydrodynamic Device	R-17	0.30	117	0.00	$153,750	$210	$45,598

[1][(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TSS Reduction)]; enhanced street cleaning is [Probable Project Cost] / [Annual TP Reduction]

Project Selection

The combination of projects selected for pursuit could strive to achieve TP and TSS reductions in the most cost-effective manner possible. Several other factors affecting project installation decisions could be weighed by resource managers when selecting projects to pursue. These factors include but are not limited to the following:

- Total project costs
- Cumulative treatment
- Availability of funding
- Economies of scale
- Landowner willingness
- Project combinations with treatment train effects
- Non-target pollutant reductions
- Timing coordination with other projects to achieve cost savings
- Stakeholder input
- Number of parcels (landowners) involved
- Project visibility
- Educational value
- Long-term impacts on property values and public infrastructure

BMP Descriptions

BMP types proposed throughout the target areas are detailed in this section. This was done to reduce duplicative reporting. For each BMP type, the method of modeling, assumptions made, and cost estimate considerations are described.

BMPs were proposed for a specific site within the research area. Each of these projects, including site location, size, and estimated cost and pollutant reduction potential are noted in detail in the Catchment Profiles section. Project types included in the following sections are:

- Bioretention
    - Curb-cut Rain Gardens (Bioinfiltration)
- Enhanced Street Sweeping
- Hydrodynamic Device

Bioretention

Bioretention BMPs utilize soil and vegetation to treat stormwater runoff from roads, driveways, rooftops, and other impervious surfaces. Differing levels of volume and/or pollutant reductions can be achieved depending on the type of bioretention selected.

Bioretention can function as either filtration (biofiltration) or infiltration (bioinfiltration). Biofiltration BMPs are designed with a buried perforated drain tile that allows water in the basin to discharge to the stormwater drainage system after having been filtered through the soil. Bioinfiltration BMPs have no underdrain, ensuring that all water that enters the basins will either infiltrate into the soil or be evapotranspired into the air. Bioinfiltration provides 100% retention and treatment of captured stormwater, whereas biofiltration basins provide excellent removal of particulate contaminants but limited removal of dissolved contaminants, such as dissolved phosphorus (DP).

Table 4 conveys the general efficacy of the two types of bioretention (biofiltration and bioinfiltration) in terms of the three most common pollutants, total suspended solids (TSS), particular phosphorus (PP), DP, and stormwater volume.

Table 4: Matrix describing curb-cut rain garden efficacy for pollutant removal based on type.

Curb-cut Rain Garden Type	TSS Removal	PP Removal	DP Removal	Volume Reduction	Size of Area Treated	Site Selection and Design Notes
Bioinfiltration	High	High	High	High	High	Optimal sites are low enough in the landscape to capture most of the watershed but high enough to ensure adequate separation from the water table for treatment purposes. Higher soil infiltration rates allow for deeper basins and may eliminate the need for underdrains.
Biofiltration	High	Moderate	Low	Low	High	

The treatment efficacy of a particular bioretention project depends on many factors, including but not limited to the pollutant of concern, the quality of water entering the project, the intensity and duration of storm events, project size, position of the project in the landscape, existing downstream treatment, soil and vegetation characteristics, and project type (i.e. bioinfiltration or biofiltration). Optimally, new bioretention will capture water that would otherwise discharge into a priority waterbody untreated.

The volume and pollutant removal potential of each bioretention practice was estimated using WinSLAMM. In order to calculate cost-benefit, the cost of each project had to be estimated. To estimate the total cost of project installation, labor costs for project outreach and promotion, project design, project administration, and project maintenance over the anticipated life of the practice were considered in addition to actual construction costs. If multiple projects were installed, cost savings could be achieved on the administration and promotion costs (and possibly the construction costs for a large and competitive bid).

Curb-cut Rain Gardens

Curb-cut rain gardens capture stormwater that is in roadside gutters and redirects it into shallow roadside basins. These curb-cut rain gardens can provide treatment for impervious surface runoff from one-to-many properties and can be located anywhere sufficient space is available. Because curb-cut rain gardens capture water that is already part of the stormwater drainage system, they are more likely to provide higher benefits. Generally, curb-cut rain gardens were proposed in areas without sufficient existing stormwater treatment and located immediately upgradient of a catch basin serving a large drainage area.

Figure 9: Rain garden before/after and during a rainfall event

All curb-cut rain gardens were presumed to have pretreatment, mulch, and perennial ornamental and native plants. The useful life of the project was assumed to be 30 years and so all costs are amortized over that time period. Additional costs were included for rehabilitation of the gardens at years 10 and 20. Rehabilitation includes removal of accumulated sediment and supplemental planting. Annual maintenance was assumed to be completed by the landowner of the property at which the rain garden could be installed.

Enhanced Street Sweeping

Street sweeping is a cost-effective way to reduce nutrient and sediment loads entering lakes, streams and wetlands from storm sewers. Sweeping is typically completed in the spring to remove accumulated sediment from winter road treatment, and again in the fall to reduce leaf litter. However, trees adjacent to roadways can be a significant contributor of nutrient loading throughout the year as they drop seeds, pollen, leaves, and other organic debris. Similarly, large gaps in traditional fall and spring sweeping schedules give these materials time to re-accumulate and flush into storm drains before they can be removed.

Figure 10: Roadway buffers, derived from MNDOT right-of-way widths, within which tree canopy cover was calculated.

Enhanced street sweeping is the incorporation of additional sweeping protocols, the timing and location of which are targeted to maximize water quality protection. One way to prioritize locations for enhanced sweeping is to quantify tree canopy cover overhanging and immediately adjacent to roadways; this is because tree canopy cover is highly correlated with the amount of recoverable organic materials on roadways (Kalinosky, 2015) and average total phosphorus concentrations in stormwater runoff (Janke et al. 2017). Tree canopy data can then be combined with stormwater infrastructure information to identify roadways likely contributing most to nutrient inputs derived from fallen tree materials.

Tree canopy cover within the study areas was analyzed following methodology in the *Tree Canopy Assessment Protocol for Enhanced Street Sweeping Prioritization*, produced by Emmons and Oliver Resources Inc. (EOR) for the Lower St. Croix Watershed Partnership (LSCWP).

First, centerline data was compiled for all paved roadways within or immediately adjacent to the targeted subwatershed boundaries. Next, each roadway was assigned a right-of-way width corresponding with its MNDOT functional classification. Right-of-way values were then referenced to generate a buffer around each roadway, and deciduous tree canopy abundance within these buffers (total % coverage) was quantified by intersecting them with the *Twin Cities Metro Area (TCMA) Urban Tree Canopy Classification* dataset; see Figure 10 for an example. Altogether, these processes allowed for canopy cover comparisons within the study areas, and correspondingly the prioritization of roadways most likely to contribute nutrient-rich stormwater derived from tree materials.

The streets are currently swept twice per year in Anoka, Ramsey, and Andover. Enhanced sweeping schedules were modeled for each catchment, and page 30 summarizes the modeling results. Maps are provided of road tree canopy cover percentage in the Catchment Profiles.

Hydrodynamic Devices

In heavily urbanized settings, stormwater is immediately intercepted with roadway catch basins and conveyed rapidly via storm sewer pipes to its destination. Once stormwater is intercepted by catch basins, it can be very difficult to supply treatment without large end-of-pipe projects such as regional ponds. One option is a hydrodynamic device (Figure 11). Hydrodynamic devices are installed in line with the existing storm sewer network and can provide treatment for up to 10-15 acres of upland drainage area. This practice applies some form of filtration, settling, or hydrodynamic separation to remove coarse sediment, litter, oil, and grease. These devices are particularly useful in small but highly urbanized drainage areas and can be used as pretreatment for other downstream stormwater BMPs.

Each device's pollutant removal potential was estimated using WinSLAMM. Devices were sized based on upstream drainage area to ensure peak flow does not exceed each device's design guidelines. For this analysis, Downstream Defender devices were modeled based on available information and to maintain continuity across other SRAs. Devices were proposed along particular storm sewer lines and often just upstream of intersections with another, larger line. Model results assume the device is receiving input from all nearby catch basins noted.

In order to calculate cost-effectiveness, the cost of each project had to be estimated. Cost estimation included labor costs for project outreach, promotion, design, administration, and maintenance over the anticipated life of the practice were considered in addition to actual material and construction costs. Load reduction estimates for these projects are noted in the Catchment Profiles section.

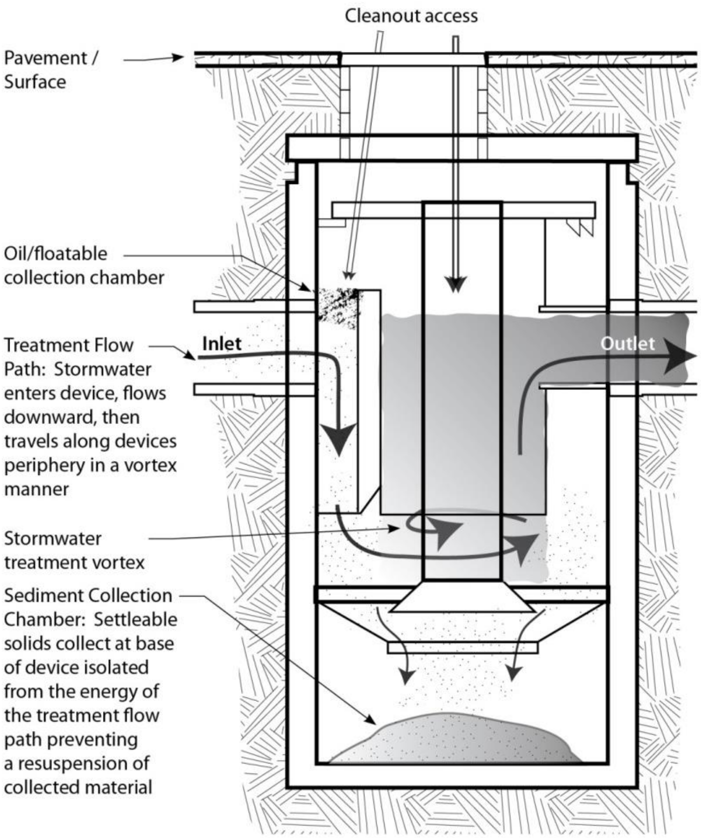
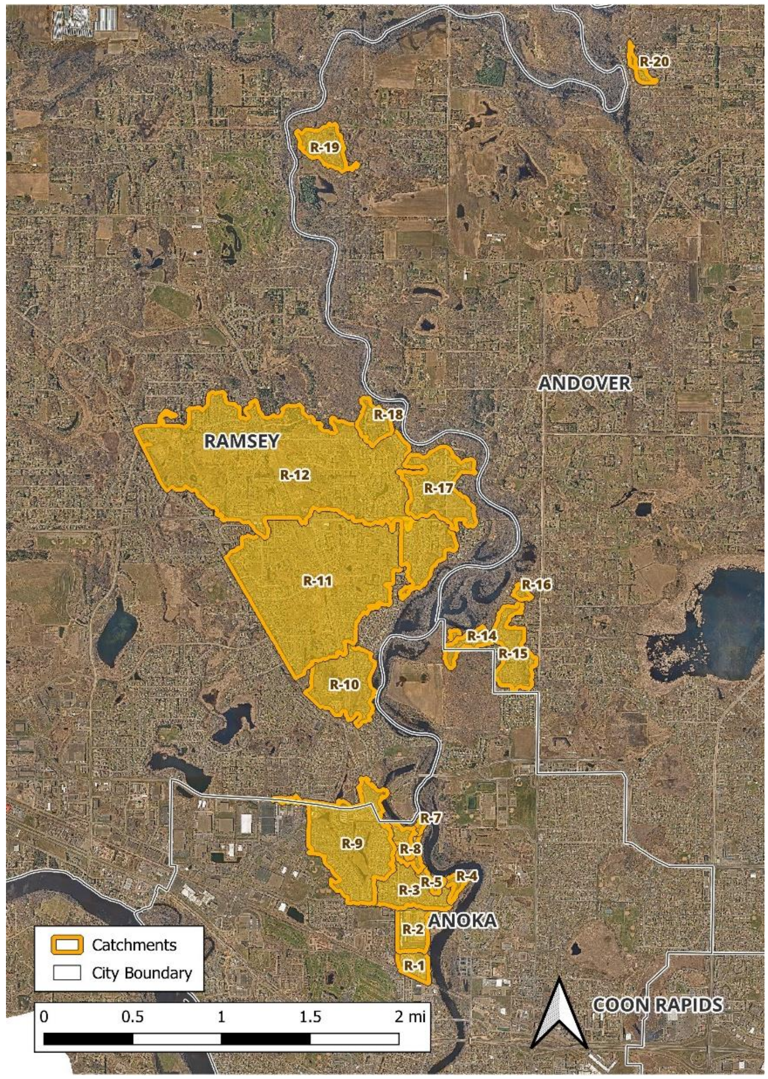


Figure 11: Schematic of a typical hydrodynamic device

Rum River Subwatershed

Catchment Profiles

Catchment ID	Page
R-1	38
R-2	42
R-3	47
R-4	57
R-5	61
R-6	65
R-7	70
R-8	73
R-9	77
R-10	80
R-11	83
R-12	86
R-13	89
R-14	93
R-15	100
R-16	121
R-17	124
R-18	137
R-19	145
R-20	147



Existing Conditions Summary	
Acres	1477.4
Dominant Land Cover	Residential
Volume (ac-ft/yr)	111
TP (lb/yr)	117
TSS (lb/yr)	39,578

SUBWATERSHED SUMMARY

The 12,300-acre study area was refined into 20 catchments with a combined area of 1477-acres for this analysis. Catchment profiles on the following pages provide additional information, including details on existing and proposed stormwater treatment. A summary of catchments excluded from detailed analysis has been included in Appendix E – Catchments Excluded from Detailed Analysis.

EXISTING STORMWATER TREATMENT

There is a considerable amount of existing stormwater treatment throughout the study area. Of particular note are the abundant stormwater ponds and natural bioinfiltration areas. The City of Anoka, the City of Ramsey, and the City of Andover also conduct street cleaning twice per year. Table 5 provides a summary of catchment volume, TSS, and TP loading under base and existing conditions. Reductions associated with exiting BMPs are also included. Additional detail is provided in the Catchment Profiles.

Table 5: Catchment volume, TSS, and TP loading under base and existing conditions. Reductions associated with existing BMPs are also shown.

			BASE CONDITION			EXISTING CONDITION			REDUCTIONS DUE TO EXISTING BMPs		
Catchment	Acres	Dominant Land Cover	Volume (ac-ft/yr)	TSS (lb/yr)	TP (lb/yr)	Volume (ac-ft/yr)	TSS (lb/yr)	TP (lb/yr)	Volume (ac-ft/yr)	TSS (lb/yr)	TP (lb/yr)
R-1	27.24	Industrial	14.7	7510	11.8	14.1	3090	6.6	0.6	4420	5.2
R-2	42.05	Institutional	26.0	10871	23.2	26.0	9977	21.8	0.0	894	1.4
R-3	8.51	Residential	20.7	8917	28.2	20.2	7752	25.3	0.5	1165	2.9
R-4	38.57	Residential	2.5	1083	3.5	2.4	935	3.1	0.1	148	0.4
R-5	22.31	Residential	2.3	996	3.2	2.3	887	2.9	0.0	109	0.3
R-6	38.48	Residential	3.9	1677	5.3	3.6	1403	4.6	0.2	274	0.7
R-7	130.96	Residential	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
R-8	3.1	Residential	4.0	1736	5.5	2.0	728	2.5	2.0	1009	3.0
R-9	13.66	Residential	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
R-10	12.37	Residential	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
R-11	49.34	Residential	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
R-12	95.26	Residential	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
R-13	3.57	Residential	0.8	355	1.1	0.8	317	1.1	0.0	39	0.1
R-14	7.55	Residential	5.2	2318	7.3	5.2	2075	6.8	0.0	243	0.6
R-15	111.62	Residential	17.8	7738	24.7	17.8	6890	22.7	0.0	848	2.0
R-16	6.63	Residential	1.4	623	2.0	1.4	555	1.8	0.0	68	0.2
R-17	10.95	Residential	28.4	12415	39.6	12.4	4306	15.1	16.0	8109	24.6
R-18	30.56	Residential	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
R-19	29.97	Residential	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
R-20	44.06	Residential	2.2	949	3.0	2.2	844	2.8	0.0	105	0.2

RETROFITS CONSIDERED

STORMWATER PONDS

New ponds and retrofits to existing stormwater ponds were considered. However, plan sets were available for most ponds included in the analysis, and no obvious deficiencies were noted. An extensive field inventory of current pond condition was not completed, nor was any water quality monitoring conducted.

Because most of the pollutant reductions from existing BMPs throughout the subwatershed are due to stormwater ponds, continued pond condition inventories will be valuable. Maintenance needs could be identified in the future to ensure all ponds are functioning as originally designed, which is how the ponds were modeled in this analysis. Furthermore, water quality monitoring could identify any hot spots that may warrant the consideration of pond retrofits (e.g. increasing storage volume through either increasing ponding depth or pond footprint or installation of either passive or pump-controlled iron-enhanced sand filters).

ENHANCED STREET SWEEPING

Enhanced street sweeping was also considered throughout the subwatershed. Methodology for the analysis is detailed in the 'Enhanced Street Sweeping' profile in the 'BMP Descriptions' section of this report. Road tree canopy cover maps are also included in each of the Catchment Profiles. However, increasing street sweeping frequency in the WinSLAMM models resulted in marginal additional reductions of TP and TSS.

One of the larger catchments modeled in WinSLAMM, R-3 (50 acres with many roads and primarily residential land use), can be used as an example. Street cleaning frequency was increased to once every eight weeks (i.e. five times per year) in the WinSLAMM model, which resulted in the additional removal of 221 lbs-TSS/yr and 0.51 lbs-TP/yr. Considering the increased frequency results in four additional sweepings per year, the additional pollutant reductions are not very cost-effective (i.e. 55 lbs-TSS/yr and 0.13 lbs-TP/yr per additional sweeping event) compared to other alternatives.

Table 7 provides a summary of the additional annual reductions captured by increasing the street cleaning frequency from twice a year to five times a year, as well as the cost effectiveness. These values are conservative estimates based entirely on the WinSLAMM models, which do not account for variations in tree canopy cover.

Table 7: Additional annual reductions with enhanced street cleaning (5x per year) via WinSLAMM

Catchment ID	TSS (lb/yr)	TP (lb/yr)	Cost/1000lb-TSS*	Cost/lb-TP*
R-1	17	0.02	$10,588	$9,000
R-2	169	0.27	$1,420	$889
R-3	221	0.51	$5,158	$2,235
R-4	25.1	0.06	$7,171	$3,000
R-5	25.6	0.06	$3,516	$1,500
R-6	40	0.09	$6,750	$3,000
R-7	N/A	N/A	N/A	N/A
R-8	18.9	0.04	$11,111	$5,250
R-9	N/A	N/A	N/A	N/A
R-10	N/A	N/A	N/A	N/A
R-11	N/A	N/A	N/A	N/A
R-12	N/A	N/A	N/A	N/A
R-13	9	0.02	$3,333	$1,500
R-14	57	0.13	$3,158	$1,385
R-15	199	0.46	$4,975	$2,152
R-16	16	0.04	$3,750	$1,500
R-17	97	0.23	$11,134	$4,696
R-18	89	0.2	$6,067	$2,700
R-19	N/A	N/A	N/A	N/A
R-20	24.8	0.06	$8,468	$3,500

*Based on $100/curb mile at an additional three sweepings per year.

The weighted average of tree canopy cover for each catchment is summarized in Table 8. Based on the distribution of values, it is recommended that catchments with an average tree canopy cover percentage greater than 30% are prioritized for enhanced street cleaning, preferably if the catchment does not have any existing stormwater treatment beyond street cleaning.

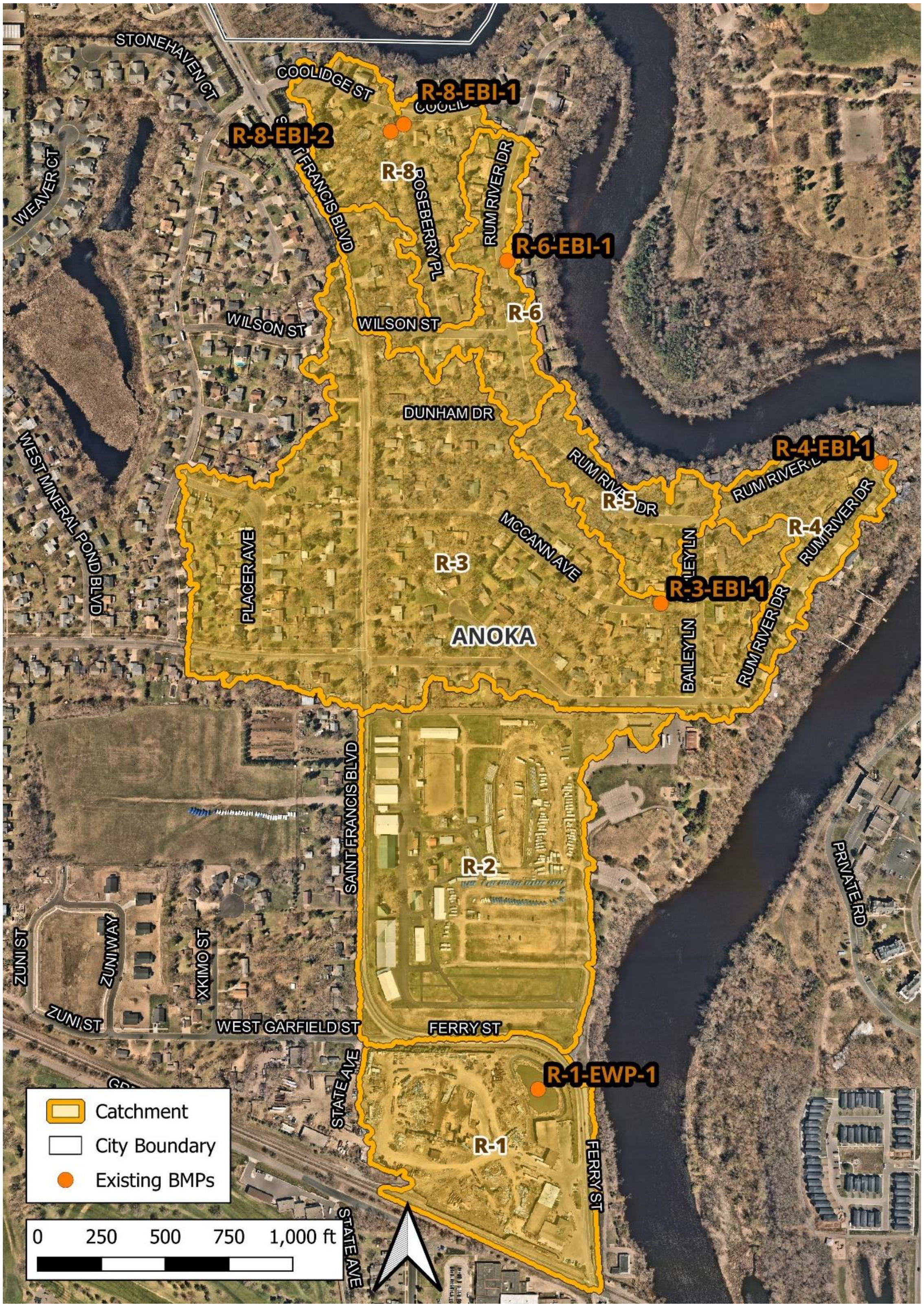
Table 8: Catchment curb-miles and average tree canopy cover percentage

Catchment ID	Curb-miles	Weighted Average % Canopy Cover
R-1	0.6	8.9%
R-2	0.8	17.8%
R-3	3.8	51.6%
R-4	0.6	81.0%
R-5	0.3	71.5%
R-6	0.9	42.6%
R-7	0.3	43.5%
R-8	0.7	38.3%
R-9	7.3	23.7%
R-10	2.6	22.1%
R-11	23.4	17.3%
R-12	26.3	26.3%
R-13	0.1	28.9%
R-14	0.6	27.5%
R-15	3.3	30.0%
R-16	0.2	37.5%
R-17	3.6	34.1%
R-18	1.8	27.7%

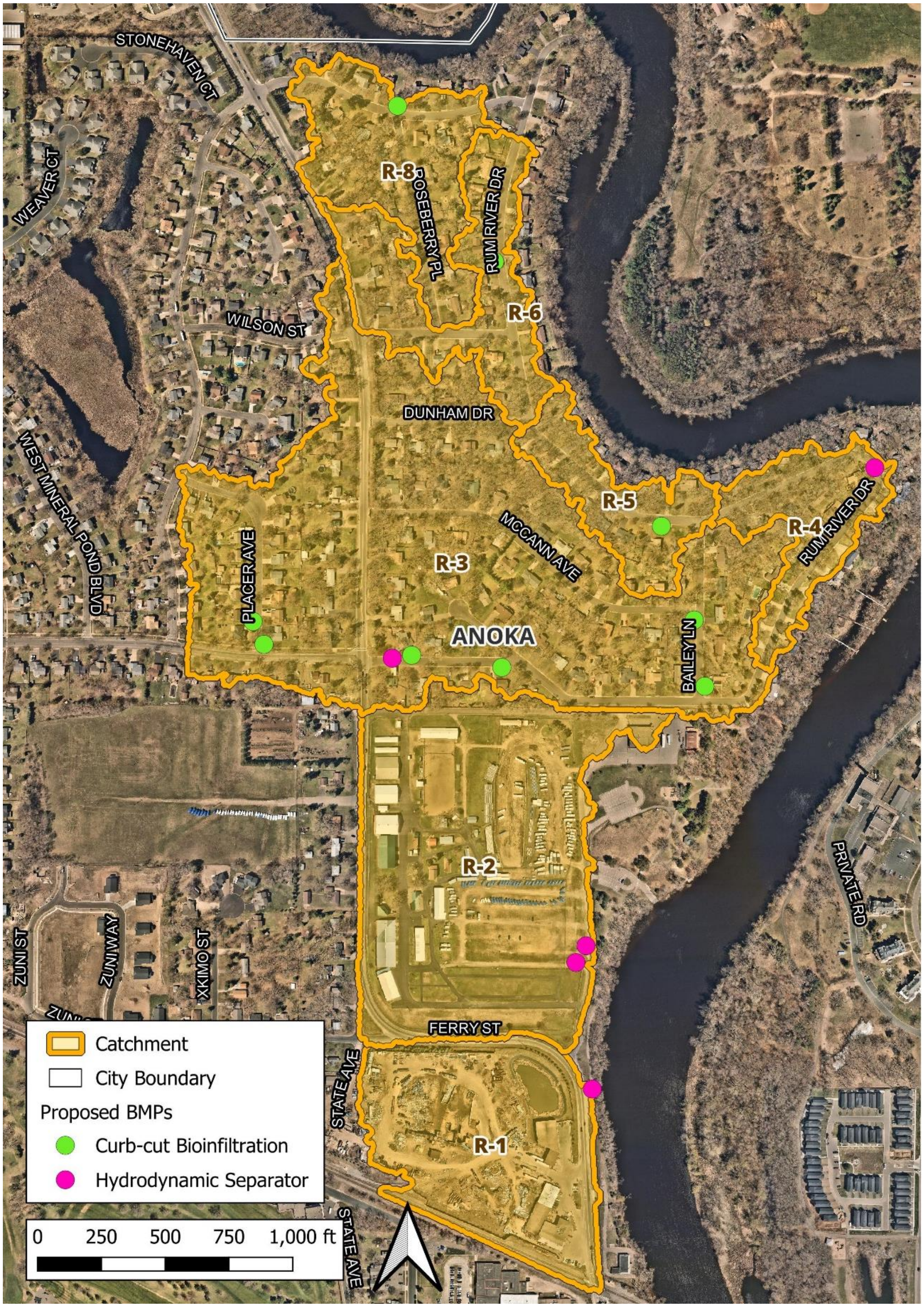
*Catchments R-19 and R-20 were excluded due to their size and distance from other catchments.

Because the values calculated in WinSLAMM are very conservative, an additional estimate for enhanced street cleaning has been included in Appendix D – Enhanced Street Cleaning Calculator. Pollutant load recovery, cost, and cost effectiveness estimates have been included using the "Street Sweeping Planning Calculator: Estimating Nutrient and Solids Load Recovery through Street Sweeping" Excel spreadsheet program (Kalinosky et al., 2014).

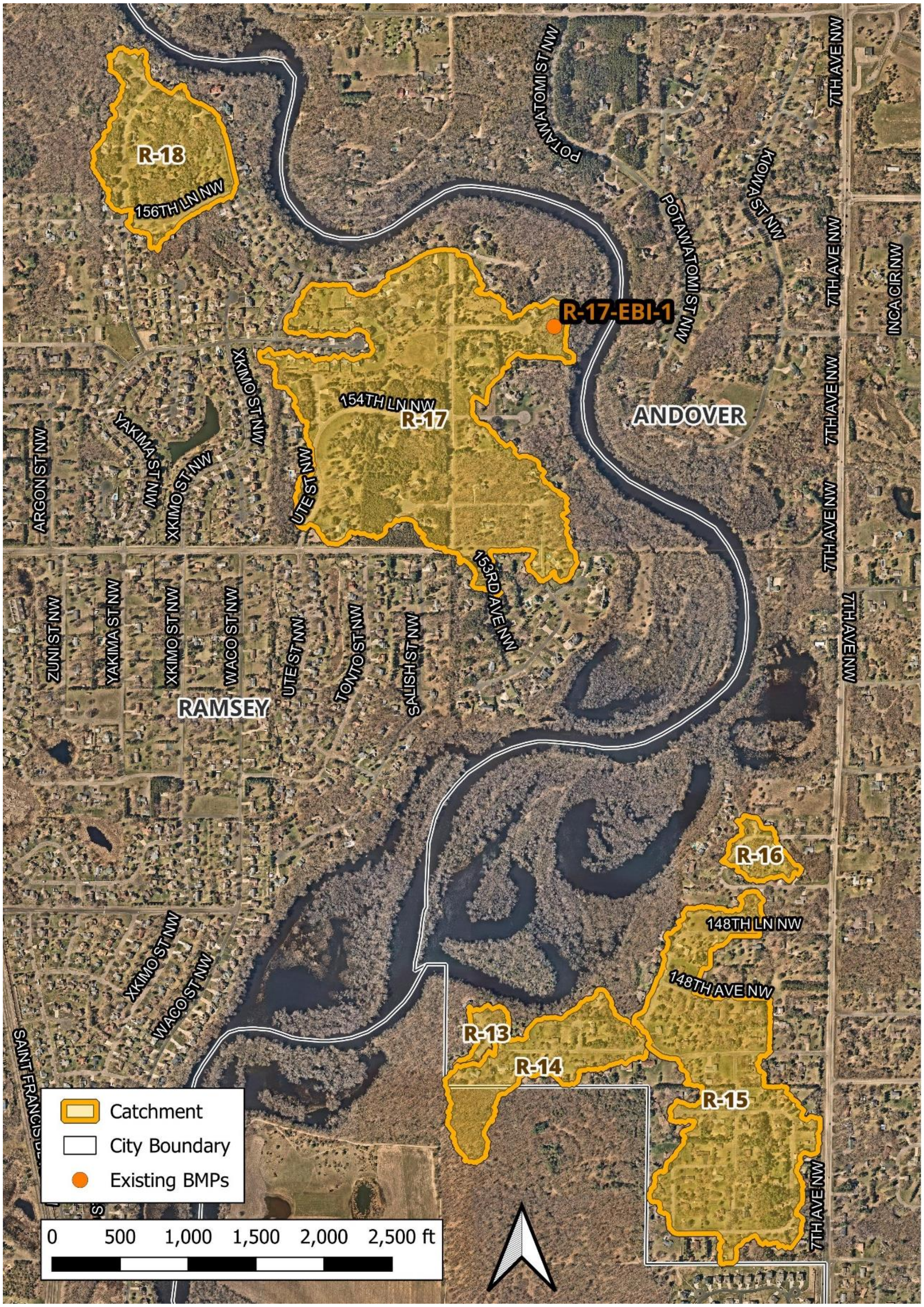
EXISTING RUM RIVER (ANOKA) STORMWATER TREATMENT OVERVIEW



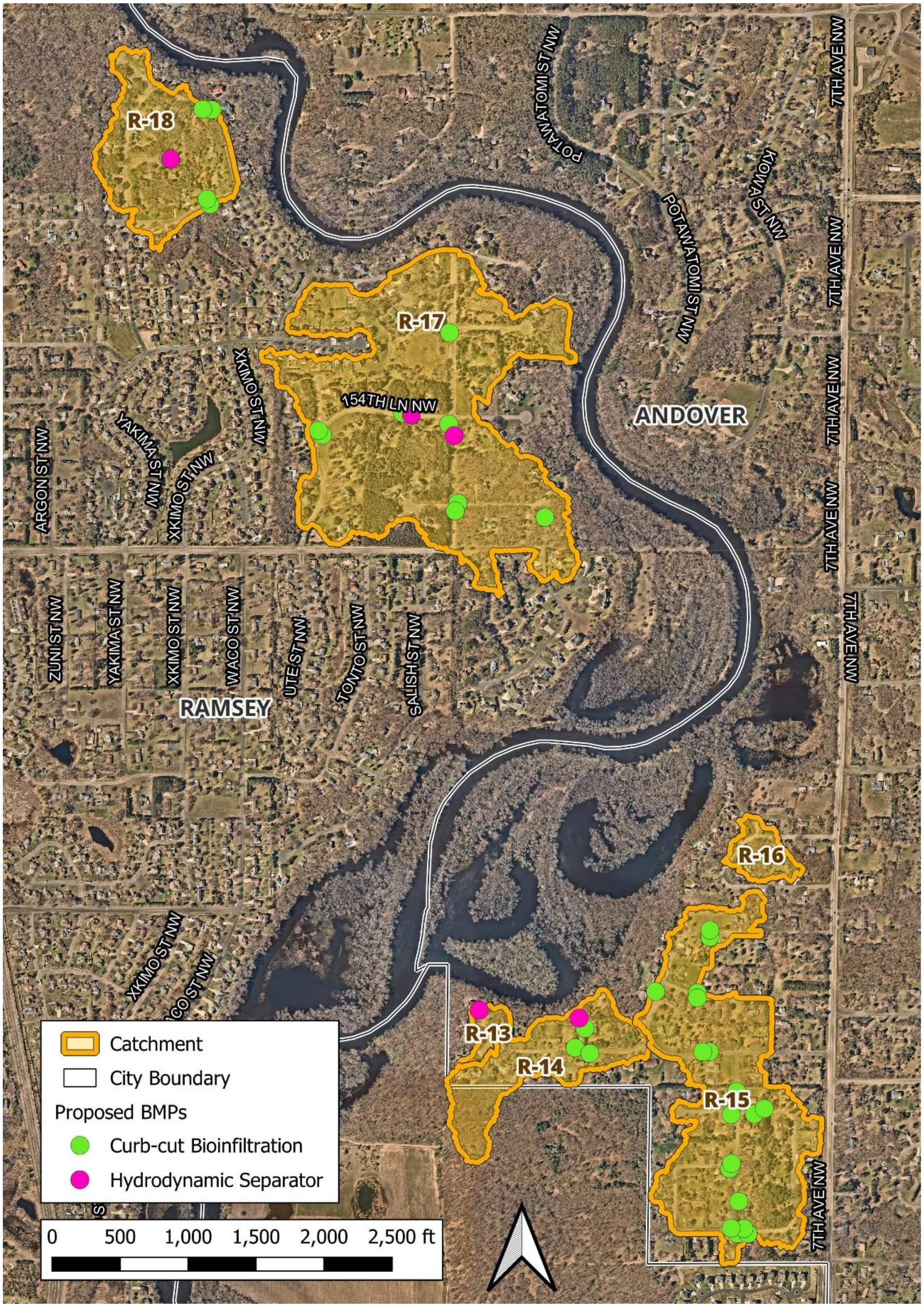
PROPOSED RUM RIVER (ANOKA) RETROFIT OPPORTUNITIES OVERVIEW



EXISTING RUM RIVER (ANDOVER-RAMSEY) STORMWATER TREATMENT OVERVIEW



PROPOSED RUM RIVER (ANDOVER-RAMSEY) RETROFIT OPPORTUNITIES OVERVIEW

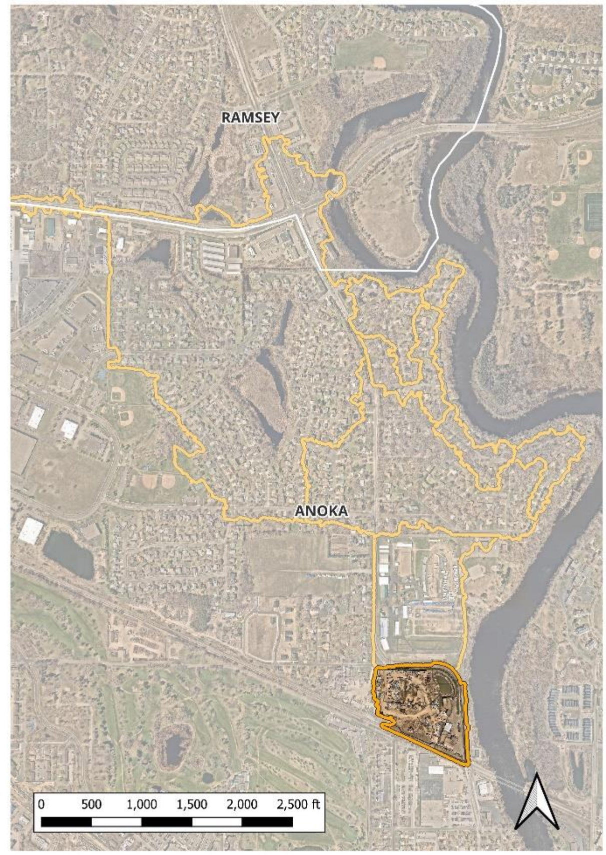


EXISTING RUM RIVER (NORTHERN ANDOVER) STORMWATER TREATMENT OVERVIEW

PROPOSED RUM RIVER (NORTHERN ANDOVER) RETROFIT OPPORTUNITIES OVERVIEW

Catchment R-1

Existing Catchment Summary	
Acres	15.7
Parcels	6
Land Cover	95.3% Industrial 4.7% Institutional



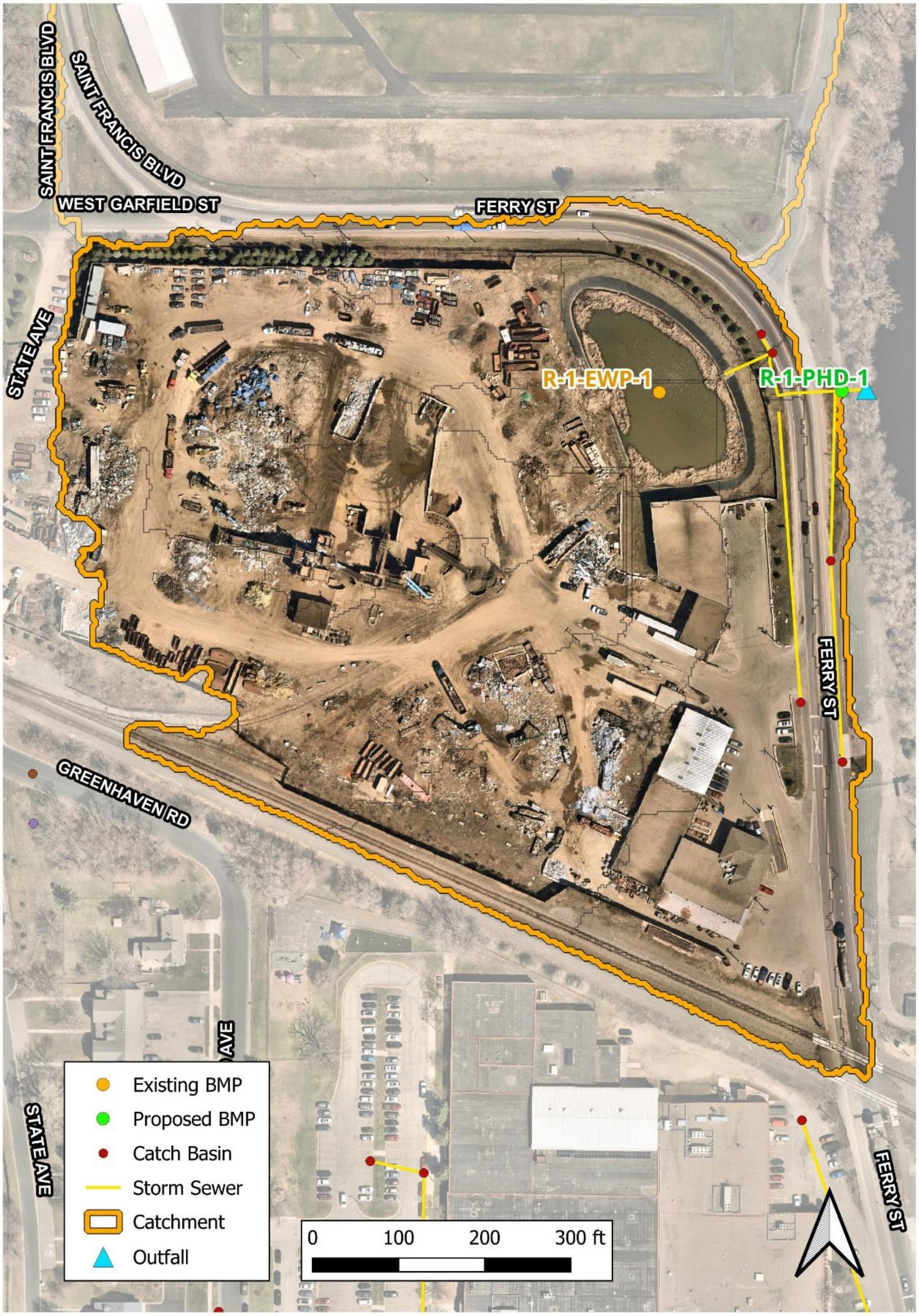
CATCHMENT DESCRIPTION
This catchment is located in Anoka just south of the Anoka Fairgrounds and primarily includes an industrial metal recycling center. Catch basins collect stormwater runoff along Ferry St. that discharge directly into the Rum River.

EXISTING STORMWATER TREATMENT
A private pond located within the metal recycling center provides stormwater treatment for the property. Prior to discharging into the Rum River, stormwater from the wet pond passes through a Structural Pollution Control Device (SPCD). Detailed information on the SPCD could not be found, therefore, it has not been included for modeling purposes. In addition, street cleaning is conducted once in early spring and once in mid-summer by the City of Anoka. Present day stormwater pollutant loading and treatment is summarized in the table below.

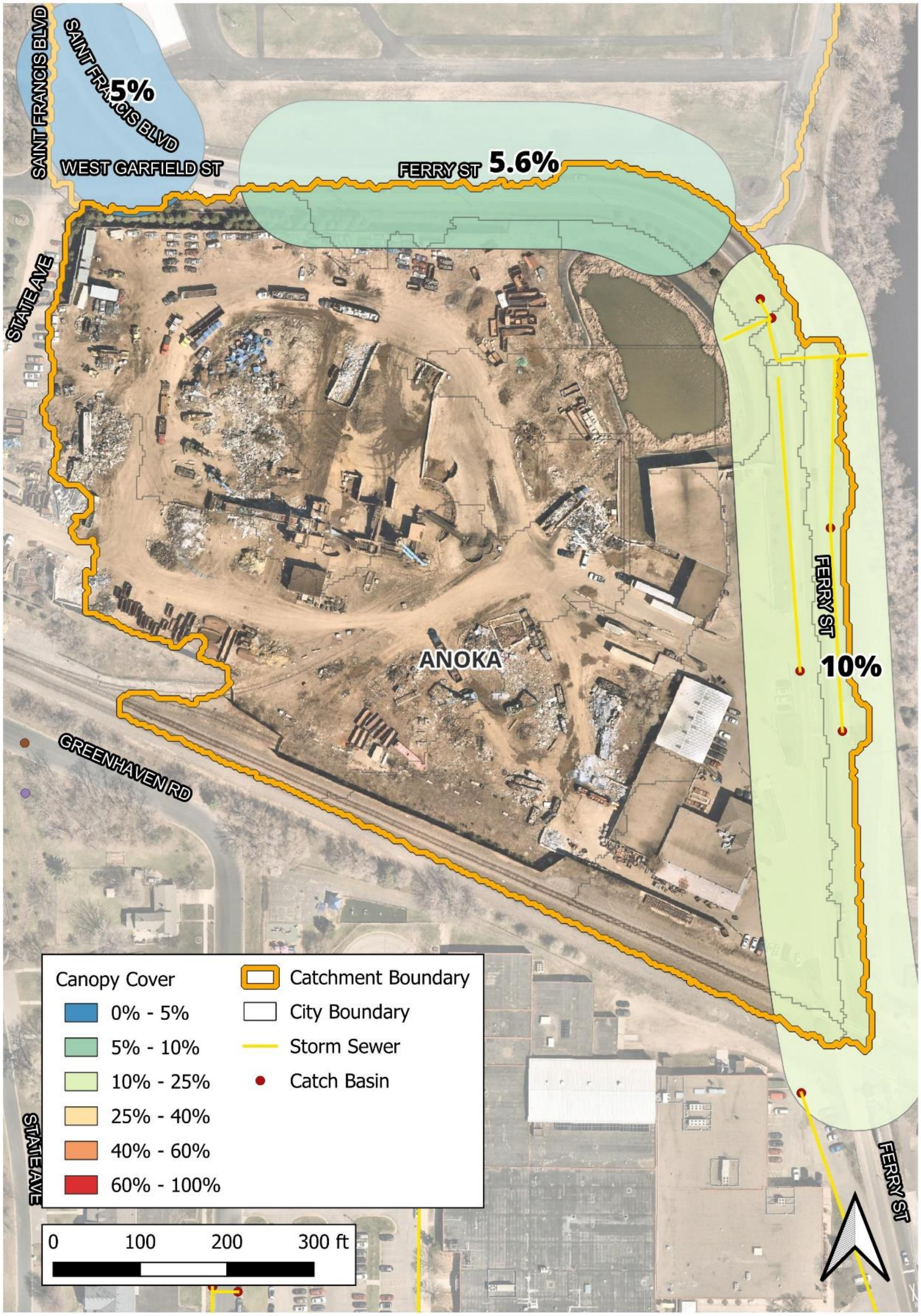
	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	2			
	BMP Types	Street Cleaning, Wet Pond (EWP-1)			
	TP (lb/yr)	11.80	5.24	44%	**6.56**
	TSS (lb/yr)	7,510	4,420	59%	**3,090**
	Volume (acre-feet/yr)	14.7	0.57	4%	**14.1**

RETROFITS CONSIDERED
A hydrodynamic separator is proposed at the catchment outfall. The structure would provide treatment for the entire catchment, including untreated stormwater collected on Ferry St. Given the limited space available, an underground structure was deemed appropriate.

EXISTING STORMWATER TREATMENT AND RETROFIT OPPORTUNITIES

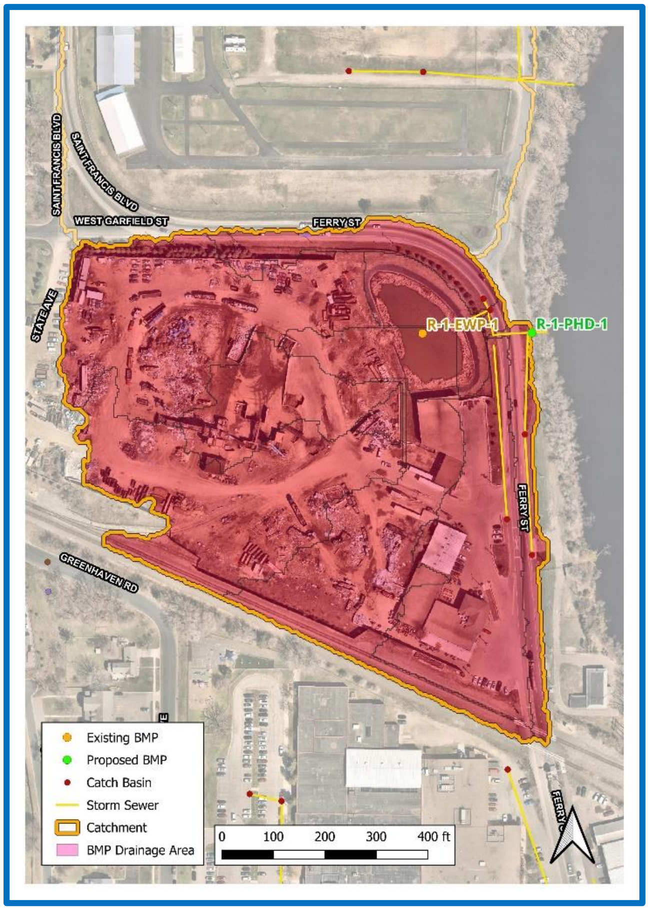


ROAD TREE CANOPY COVER



Project ID: R-1-PHD-1

Ferry St.
Hydrodynamic Device



Drainage Area – 15.7 acres

Location – Ferry St. Outfall

Property Ownership – City of Anoka

Site Specific Information – A hydrodynamic device is proposed in line with the storm sewer line on Ferry St. near the outfall. A device at this location would provide treatment to the entire catchment. The table below provides pollutant removals and estimated costs.

	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	10	ft diameter
	TP (lb/yr)	0.32	4.8%
	TSS (lb/yr)	258	8.3%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***	$3,750	
	Design & Construction Costs**	$150,000	
	Total Estimated Project Cost (2023)	**$153,750**	
	Annual O&M***	$210	
Efficiency	**30-yr Average Cost/lb-TP**	**$16,937**	
	30-yr Average Cost/1,000lb-TSS	**$20,678**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

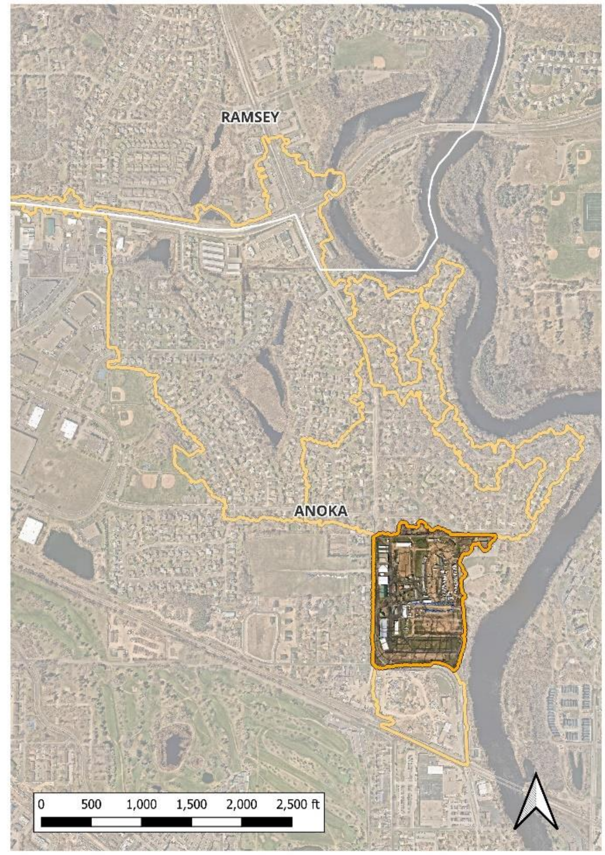
*Indirect Cost: (25 hours at $150/hour)

**Direct Cost: ($100,000 for materials) + ($50,000 for labor and installation costs)

***Per BMP: (1 cleaning/year)*(3 hours/cleaning)*($70/hour)

Catchment R-2

Existing Catchment Summary	
Acres	28.6
Parcels	9
Land Cover	96.4% Institutional 3.1% Residential 0.5% Industrial



CATCHMENT DESCRIPTION

This catchment is located almost entirely within the Anoka County Fairgrounds. Stormwater runoff is collected in multiple catch basins prior to discharging into the Rum River. Land use is primarily institutional property with a few single-family residential backyards along the northern border of the catchment.

EXISTING STORMWATER TREATMENT

The Anoka County Fairgrounds contain a significant number of catch basins as flood control. Street cleaning is conducted once in early spring and once in mid-summer by the City of Anoka. Due to the limited space, no other existing stormwater treatment exists in this catchment. Present day stormwater pollutant loading and treatment is summarized in the table below.

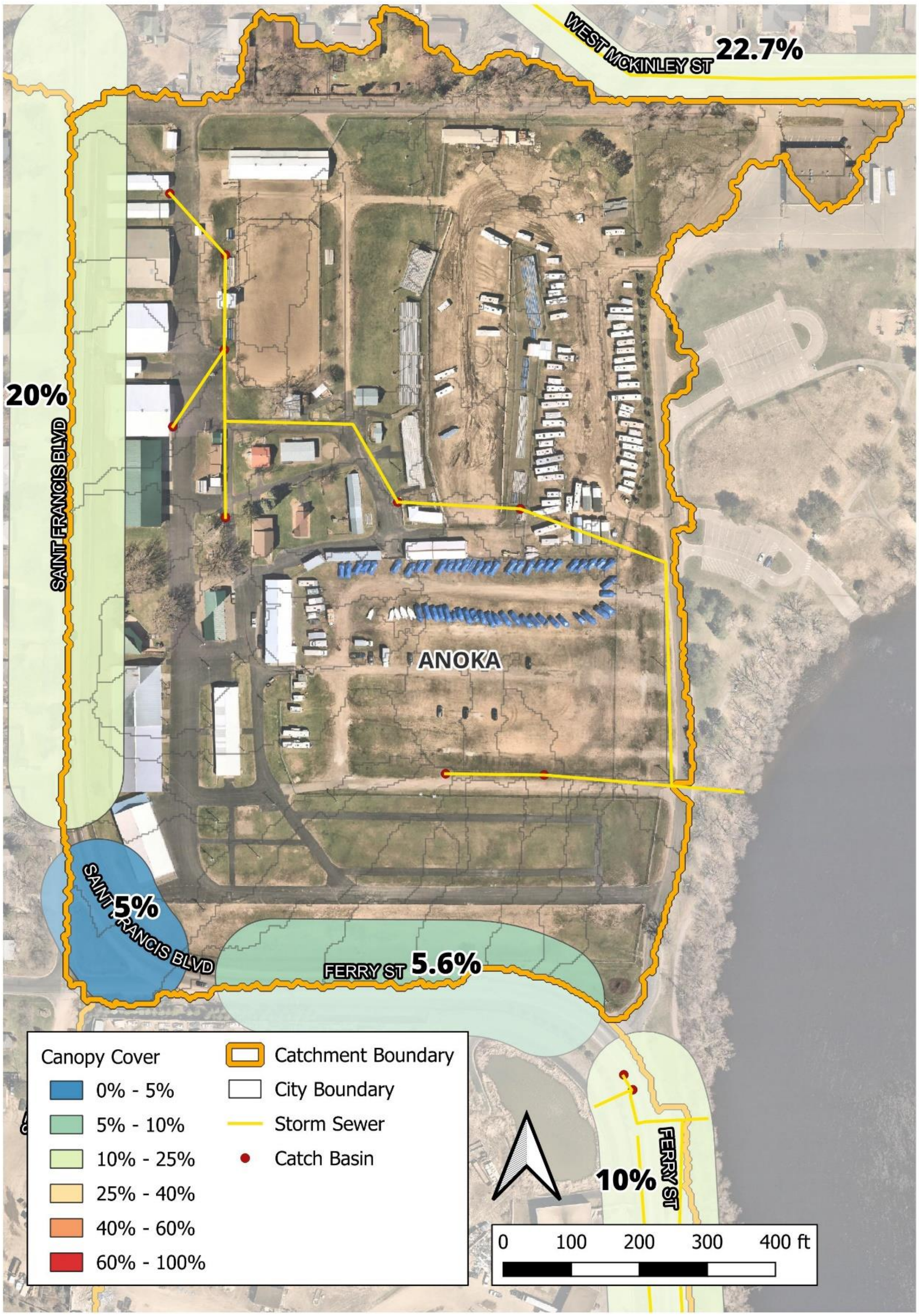
	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	1			
	BMP Types	Street Cleaning			
	TP (lb/yr)	23.21	1.40	6%	**21.81**
	TSS (lb/yr)	10,871	894	8%	**9,977**
	Volume (acre-feet/yr)	26.0	0.00	0%	**26.0**

RETROFITS CONSIDERED

Two hydrodynamic separators are proposed within this catchment. One structure would treat the northern half of the catchment, and one structure would treat the southern half of the catchment. Given the limited space available, underground structures were deemed appropriate.

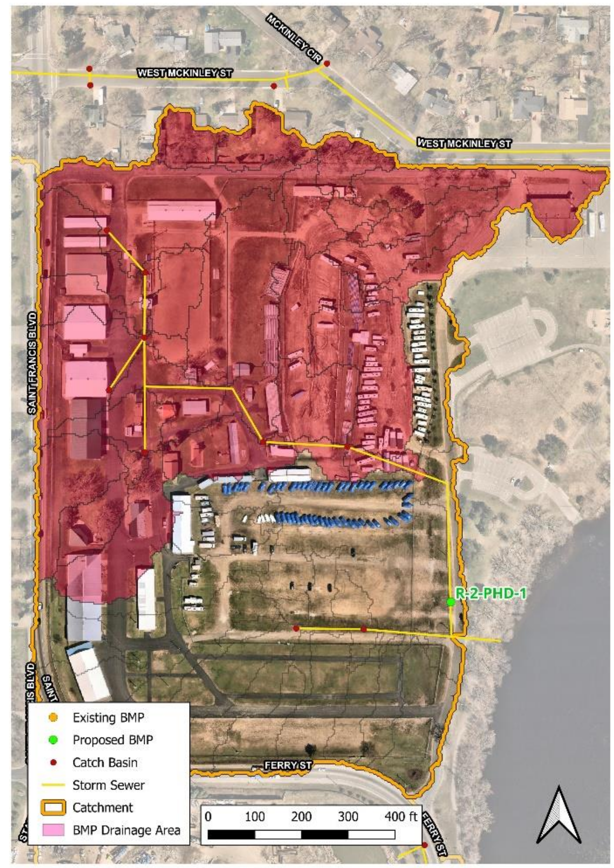
EXISTING STORMWATER TREATMENT AND RETROFIT OPPORTUNITIES

ROAD TREE CANOPY COVER



Project ID:
R-2-PHD-1

Anoka County Fairgrounds
Hydrodynamic Device



Drainage Area – 15.8 acres

Location – Anoka County Fairgrounds

Property Ownership – City of Anoka

Site Specific Information – A hydrodynamic device is proposed in line with the storm sewer line in the Anoka County Fairgrounds. A device at this location would provide treatment to the northern half of the Anoka Fairgrounds. The table below provides pollutant removals and estimated costs.

	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	10	ft diameter
	TP (lb/yr)	1.14	5.2%
	TSS (lb/yr)	602	6.0%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***	$3,750	
	Design & Construction Costs**	$150,000	
	Total Estimated Project Cost (2023)	**$153,750**	
	Annual O&M***	$210	
Efficiency	**30-yr Average Cost/lb-TP**	**$4,680**	
	30-yr Average Cost/1,000lb-TSS	**$8,862**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

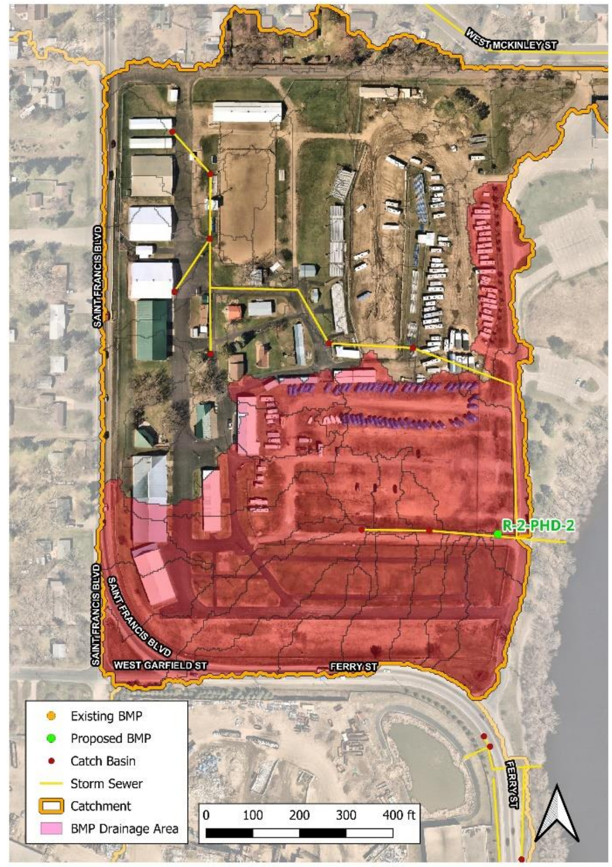
*Indirect Cost: (25 hours at $150/hour)

**Direct Cost: ($100,000 for materials) + ($50,000 for labor and installation costs)

***Per BMP: (1 cleaning/year)*(3 hours/cleaning)*($70/hour)

Project ID: R-2-PHD-2

Anoka County Fairgrounds
Hydrodynamic Device



Drainage Area – 12.7 acres

Location – Anoka County Fairgrounds

Property Ownership – City of Anoka

Site Specific Information – A hydrodynamic device is proposed in line with the storm sewer line in the Anoka County Fairgrounds. A device at this location would provide treatment to the southern half of the Anoka Fairgrounds. The table below provides pollutant removals and estimated costs.

	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	10	ft diameter
	TP (lb/yr)	1.01	4.6%
	TSS (lb/yr)	541	5.4%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***	$3,750	
	Design & Construction Costs**	$150,000	
	Total Estimated Project Cost (2023)	**$153,750**	
	Annual O&M***	$210	
Efficiency	**30-yr Average Cost/lb-TP**	**$5,282**	
	30-yr Average Cost/1,000lb-TSS	**$9,861**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

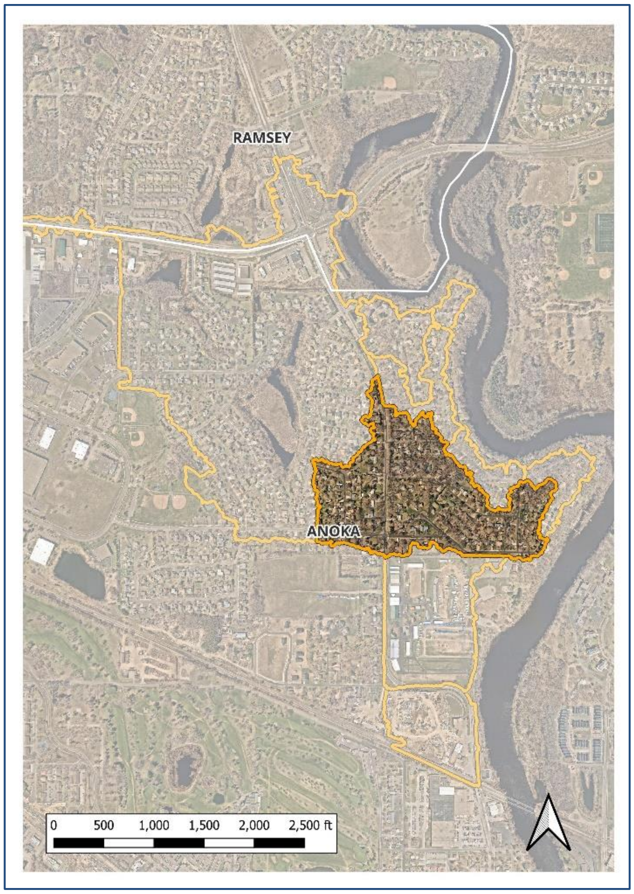
*Indirect Cost: (25 hours at $150/hour)

**Direct Cost: ($100,000 for materials) + ($50,000 for labor and installation costs)

***Per BMP: (1 cleaning/year)*(3 hours/cleaning)*($70/hour)

Catchment R-3

Existing Catchment Summary	
Acres	50.3
Parcels	140
Land Cover	98.4% Residential 1.0% Institutional 0.6% Park



CATCHMENT DESCRIPTION

This catchment is located in a residential neighborhood of Anoka on the west side of the Rum River. Stormwater runoff is collected in multiple catch basins along West McKinley St. prior to discharging into the Rum River.

EXISTING STORMWATER TREATMENT

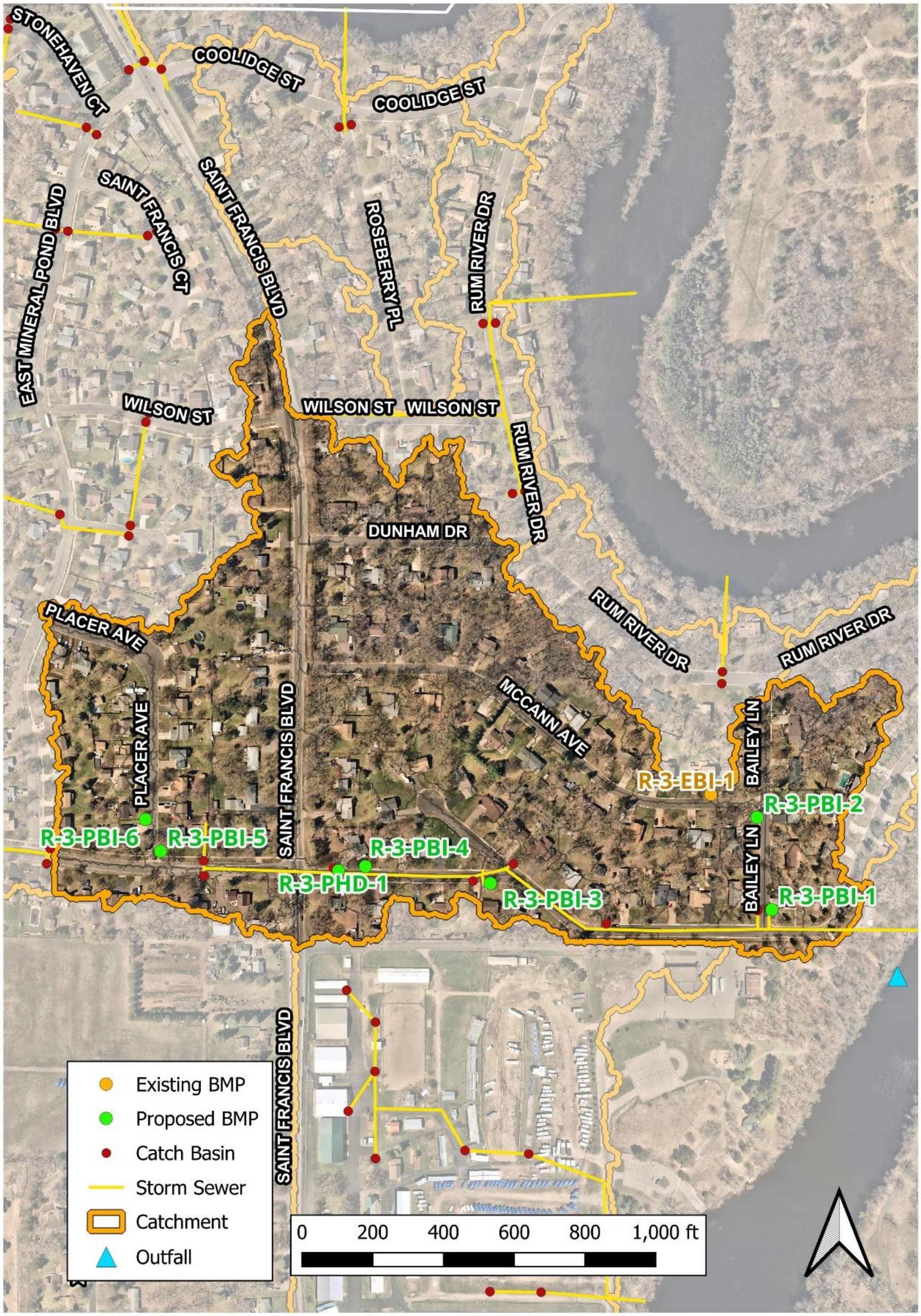
Subsets of the catchment are currently treated by one bioinfiltration basin. In addition, street cleaning is conducted once in early spring and once in mid-summer by the City of Anoka. Present day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	2			
	BMP Types	Street Cleaning, Infiltration Basin (EBI-1)			
	TP (lb/yr)	28.17	2.85	10%	**25.32**
	TSS (lb/yr)	8,917	1,165	13%	**7,752**
	Volume (acre-feet/yr)	20.7	0.48	2%	**20.2**

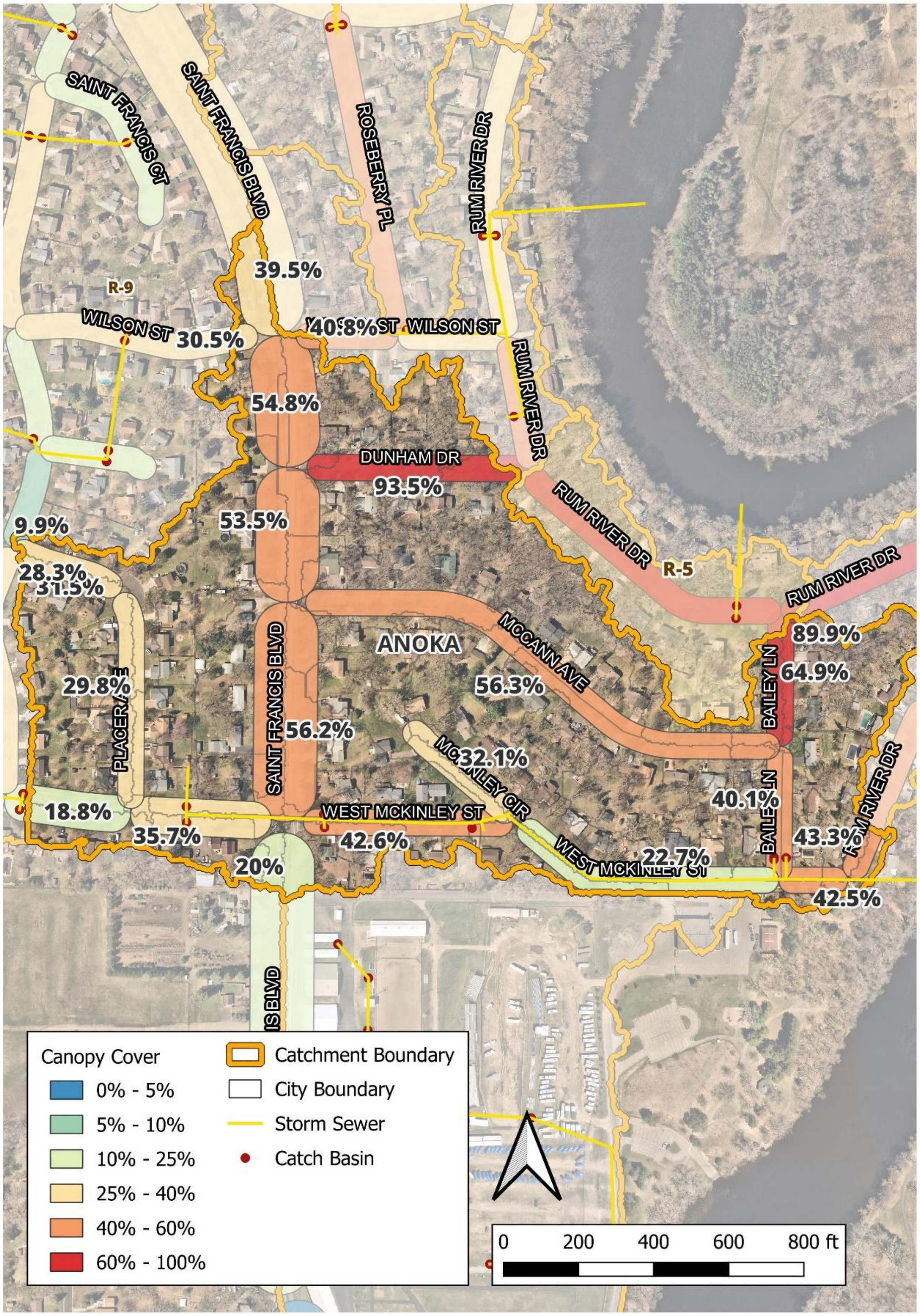
RETROFITS CONSIDERED

Multiple BMPs are proposed within this catchment. They include six bioinfiltration basins and one hydrodynamic separator.

EXISTING STORMWATER TREATMENT AND RETROFIT OPPORTUNITIES



ROAD TREE CANOPY COVER



Project ID:
R-3-PBI-1

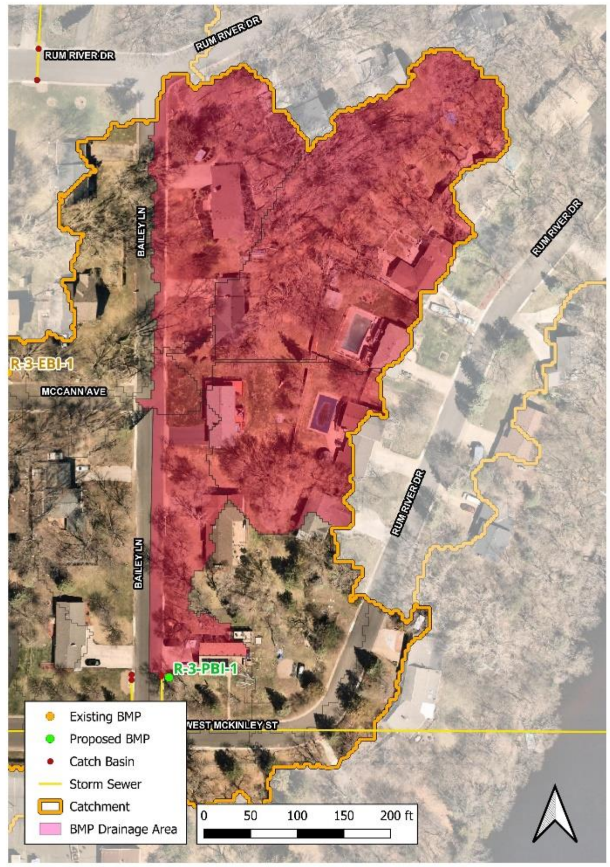
Bailey Ln.
Bioinfiltration Basin

Drainage Area – 3.3 acres

Location – 111 McKinley St NE

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed basin is a standard, single inlet rain garden that would collect stormwater from the north. There is also potential to expand this project to a double inlet rain garden that would include drainage from the east. The table below provides pollutant removals and estimated costs.



	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq ft
	TP (lb/yr)	0.57	2.3%
	TSS (lb/yr)	181	2.3%
	Volume (acre-feet/yr)	0.43	2.1%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,008**	
	30-yr Average Cost/1,000lb-TSS	**$3,174**	
	30-yr Average Cost/ac-ft Vol.	**$1,335**	

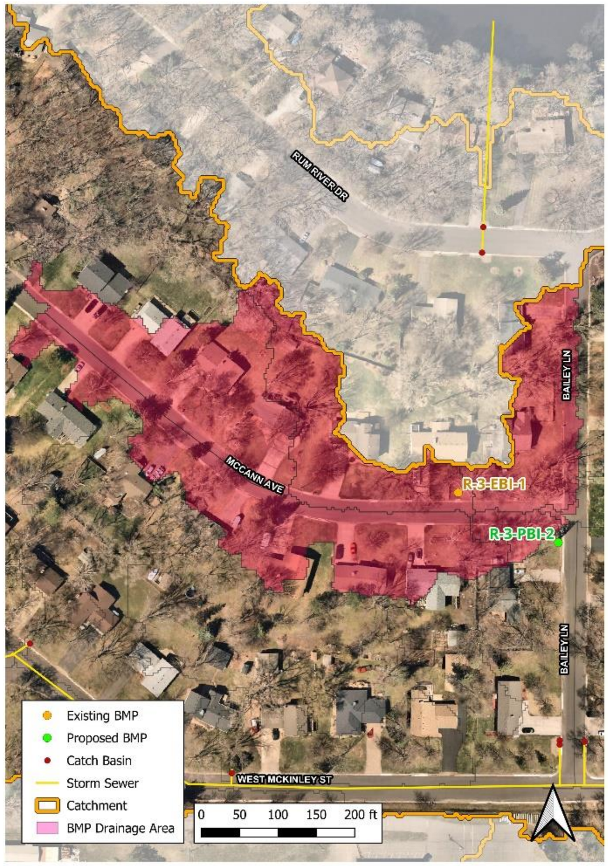
*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-3-PBI-2

Bailey Ln.
Bioinfiltration Basin



Drainage Area – 3.6 acres

Location – 3413 Bailey Ln.

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed basin is a standard, single inlet rain garden. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq ft
	TP (lb/yr)	0.49	1.9%
	TSS (lb/yr)	154	2.0%
	Volume (acre-feet/yr)	0.36	1.8%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,172**	
	30-yr Average Cost/1,000lb-TSS	**$3,730**	
	30-yr Average Cost/ac-ft Vol.	**$1,576**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-3-PBI-3

West McKinley St.
Bioinfiltration Basin

Drainage Area – 1.5 acres

Location – 312 West McKinley St.

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed basin is a standard, single inlet rain garden. The table below provides pollutant removals and estimated costs.

Curb-Cut Bioinfiltration

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Total Size of BMP	250	sq ft
	TP (lb/yr)	0.41	1.6%
	TSS (lb/yr)	159	2.1%
	Volume (acre-feet/yr)	0.36	1.8%
Cost	Administration & Promotion Costs*	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	30-yr Average Cost/lb-TP	**$1,401**	
	30-yr Average Cost/1,000lb-TSS	**$3,613**	
	30-yr Average Cost/ac-ft Vol.	**$1,578**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-3-PBI-4

West McKinley St. Bioinfiltration Basin

Drainage Area – 1.1 acres

Location – 357 West McKinley St

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed basin is a standard, single inlet rain garden. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq ft
	TP (lb/yr)	0.37	1.5%
	TSS (lb/yr)	116	1.5%
	Volume (acre-feet/yr)	0.28	1.4%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,553**	
	30-yr Average Cost/1,000lb-TSS	**$4,952**	
	30-yr Average Cost/ac-ft Vol.	**$2,050**	

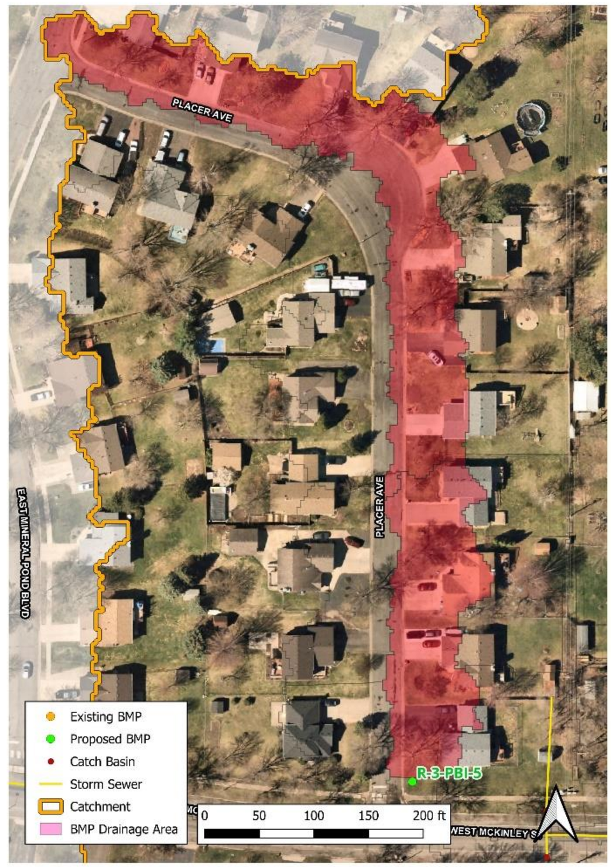
*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID:
R-3-PBI-5

Placer Ave.
Bioinfiltration Basin



Drainage Area – 1.44 acres

Location – 3400 Placer Ave.

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed basin is a standard, single inlet rain garden. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq ft
	TP (lb/yr)	0.43	1.7%
	TSS (lb/yr)	135	1.7%
	Volume (acre-feet/yr)	0.32	1.6%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,336**	
	30-yr Average Cost/1,000lb-TSS	**$4,255**	
	30-yr Average Cost/ac-ft Vol.	**$1,783**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-3-PBI-6

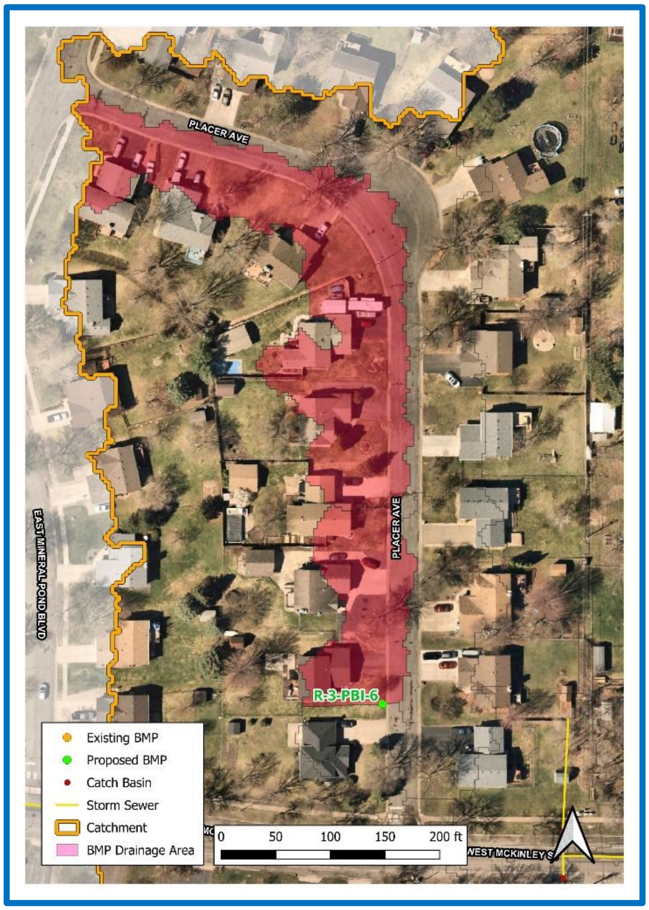
Placer Ave.
Bioinfiltration Basin

Drainage Area – 1.29 acres

Location – 3411 Placer Ave.

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed basin is a standard, single inlet rain garden. The table below provides pollutant removals and estimated costs.



	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq ft
	TP (lb/yr)	0.41	1.6%
	TSS (lb/yr)	128	1.7%
	Volume (acre-feet/yr)	0.31	1.5%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,401**	
	30-yr Average Cost/1,000lb-TSS	**$4,488**	
	30-yr Average Cost/ac-ft Vol.	**$1,871**	

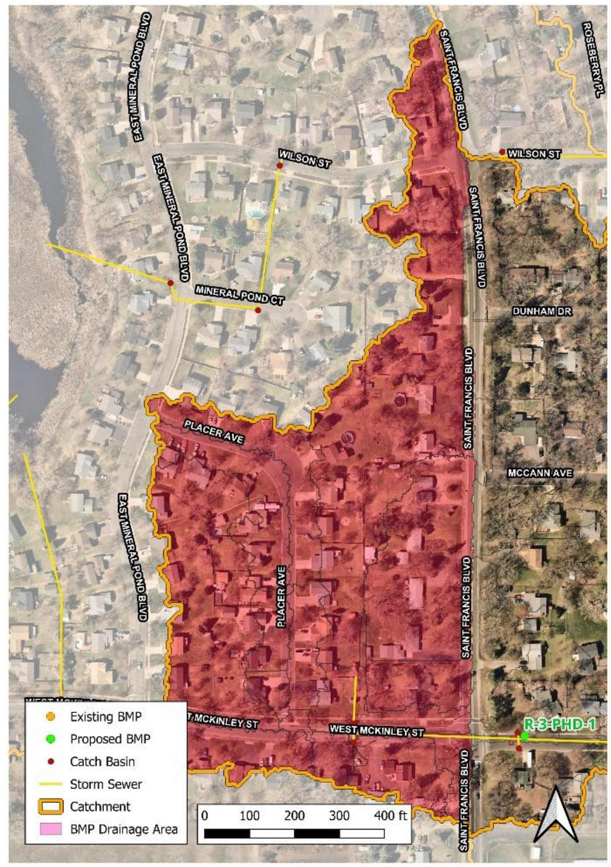
*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-3-PHD-1

West McKinley St.
Hydrodynamic Device



Drainage Area – 16.1 acres

Location – East of the intersection of West McKinley St. and St. Francis Blvd.

Property Ownership – City of Anoka

Site Specific Information – A hydrodynamic device is proposed in line with the storm sewer line near the intersection of West McKinley St. and St. Francis Blvd. A hydrodynamic device here could help manage loads stemming from the west portion of this catchment. The table below provides pollutant removals and estimated costs.

	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	10	ft diameter
	TP (lb/yr)	0.83	3.3%
	TSS (lb/yr)	332	4.3%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***	$3,750	
	Design & Construction Costs**	$150,000	
	Total Estimated Project Cost (2023)	**$153,750**	
	Annual O&M***	$210	
Efficiency	**30-yr Average Cost/lb-TP**	**$6,428**	
	30-yr Average Cost/1,000lb-TSS	**$16,069**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

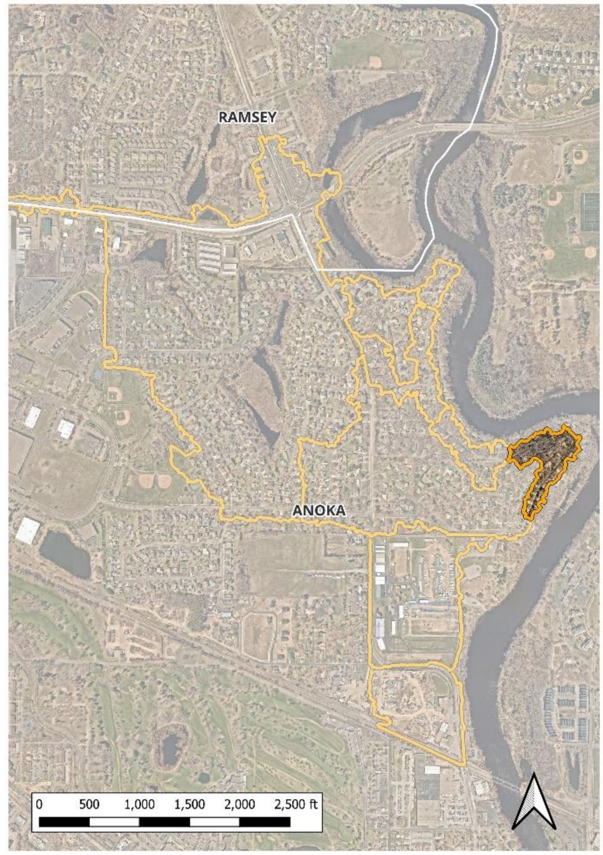
*Indirect Cost: (25 hours at $150/hour)

**Direct Cost: ($100,000 for materials) + ($50,000 for labor and installation costs)

***Per BMP: (1 cleaning/year)*(3 hours/cleaning)*($70/hour)

Catchment R-4

Existing Catchment Summary	
Acres	6.20
Parcels	30
Land Cover	98.1% Residential 0.9% Water 0.6% Open Space 0.4% Institutional



CATCHMENT DESCRIPTION
This catchment is located in a residential neighborhood of Anoka on the west side of the Rum River. Stormwater runoff is routed along Rum River Dr. prior to entering two catch basins that discharge to the Rum River. The contributing drainage area is small and is largely pervious (i.e. residential backyard areas).

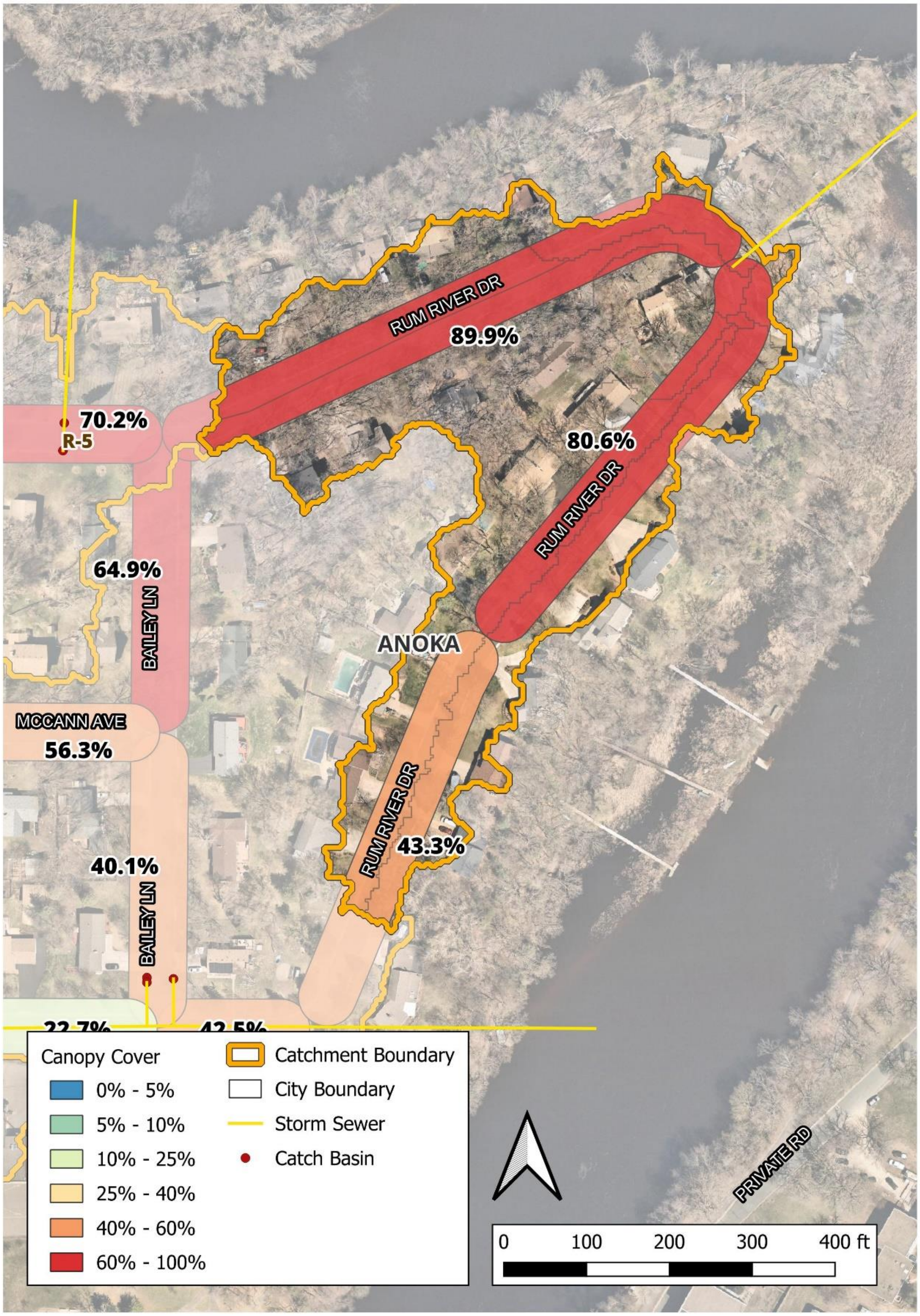
EXISTING STORMWATER TREATMENT
Subsets of the catchment are currently treated by one biofiltration basin. In addition, street cleaning is conducted once in early spring and once in mid-summer by the City of Anoka. Present day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	2			
	BMP Types	Street Cleaning, Filtration Basin (EBI-1)			
	TP (lb/yr)	3.45	0.36	10%	**3.09**
	TSS (lb/yr)	1,083	148	14%	**935**
	Volume (acre-feet/yr)	2.5	0.06	2%	**2.4**

RETROFITS CONSIDERED
One hydrodynamic separator is proposed within this catchment. Given the limited space available, an underground structure was deemed appropriate.

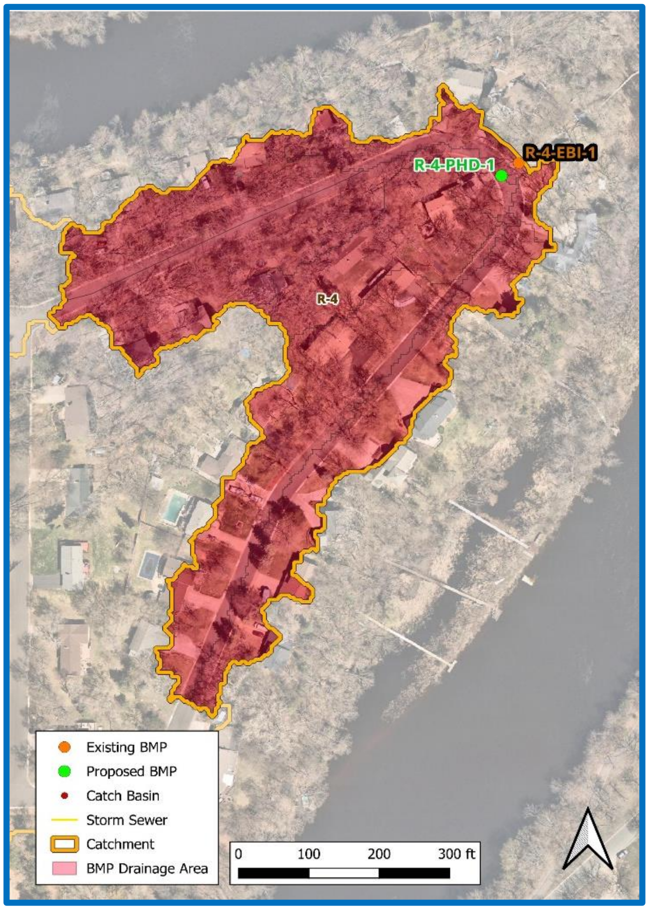
EXISTING STORMWATER TREATMENT AND RETROFIT OPPORTUNITIES

ROAD TREE CANOPY COVER



Project ID: R-4-PHD-1

Rum River Dr.
Hydrodynamic Device



Drainage Area – 6.20 acres

Location – Rum River Dr.

Property Ownership – City of Anoka

Site Specific Information – A hydrodynamic device is proposed in line with the storm sewer line on Rum River Dr. just west of the outfall. A device at this location would provide treatment to runoff from the entire catchment. Note that placement along the stormline downstream of the catch basin could be challenging due to obstructions, however, placement upstream of the catch basin would only provide treatment to the western half of the catchment. The table below provides pollutant removals and estimated costs.

Hydrodynamic Device			
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	6	ft diameter
	TP (lb/yr)	0.29	9.2%
	TSS (lb/yr)	115	12.3%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***	$3,750	
	Design & Construction Costs**	$37,500	
	Total Estimated Project Cost (2023)	**$41,250**	
	Annual O&M***	$210	
Efficiency	**30-yr Average Cost/lb-TP**	**$5,542**	
	30-yr Average Cost/1,000lb-TSS	**$13,807**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

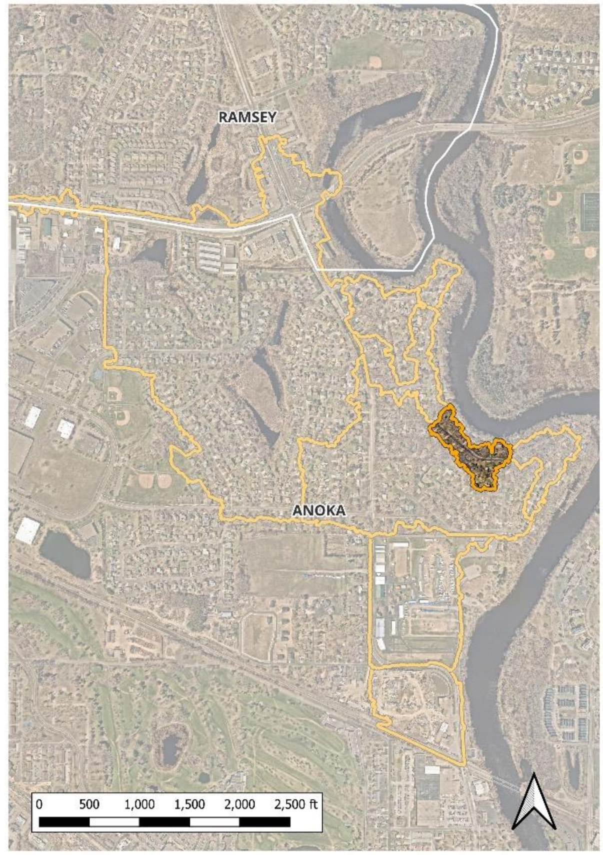
*Indirect Cost: (25 hours at $150/hour)

**Direct Cost: ($25,000 for materials) + ($12,500 for labor and installation costs)

***Per BMP: (1 cleanings/year)*(3 hours/cleaning)*($70/hour)

Catchment R-5

Existing Catchment Summary	
Acres	5.71
Parcels	21
Land Cover	100% Residential



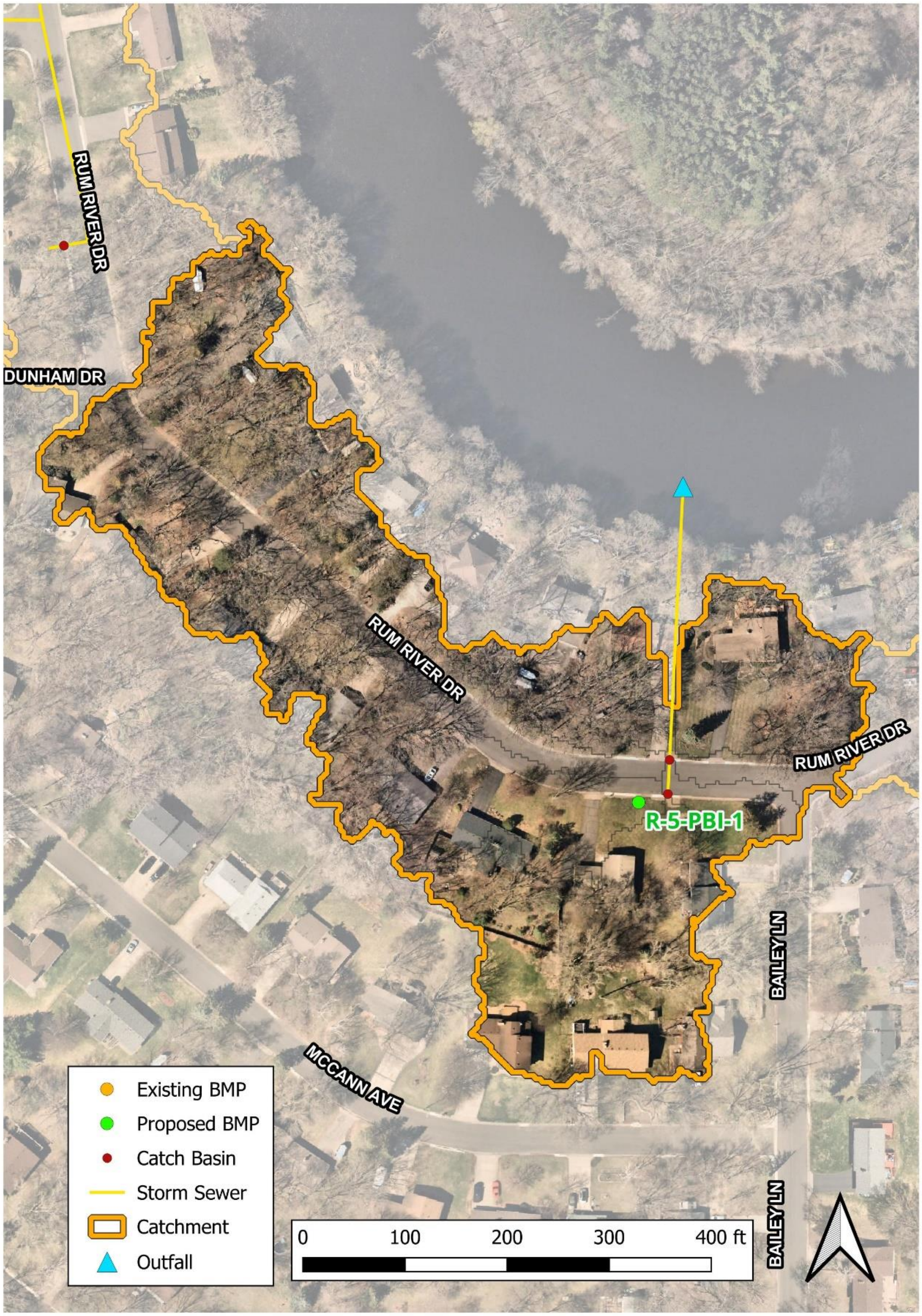
CATCHMENT DESCRIPTION
This catchment is located in a residential neighborhood of Anoka on the west side of the Rum River. Stormwater runoff is routed along Rum River Dr. prior to entering two catch basins that discharge to the Rum River. The contributing drainage area is small and is largely pervious (i.e. residential backyard areas).

EXISTING STORMWATER TREATMENT
Street cleaning is conducted once in early spring and once in mid-summer by the City of Anoka. No other existing stormwater treatment exists in this catchment. Present day stormwater pollutant loading and treatment is summarized in the table below.

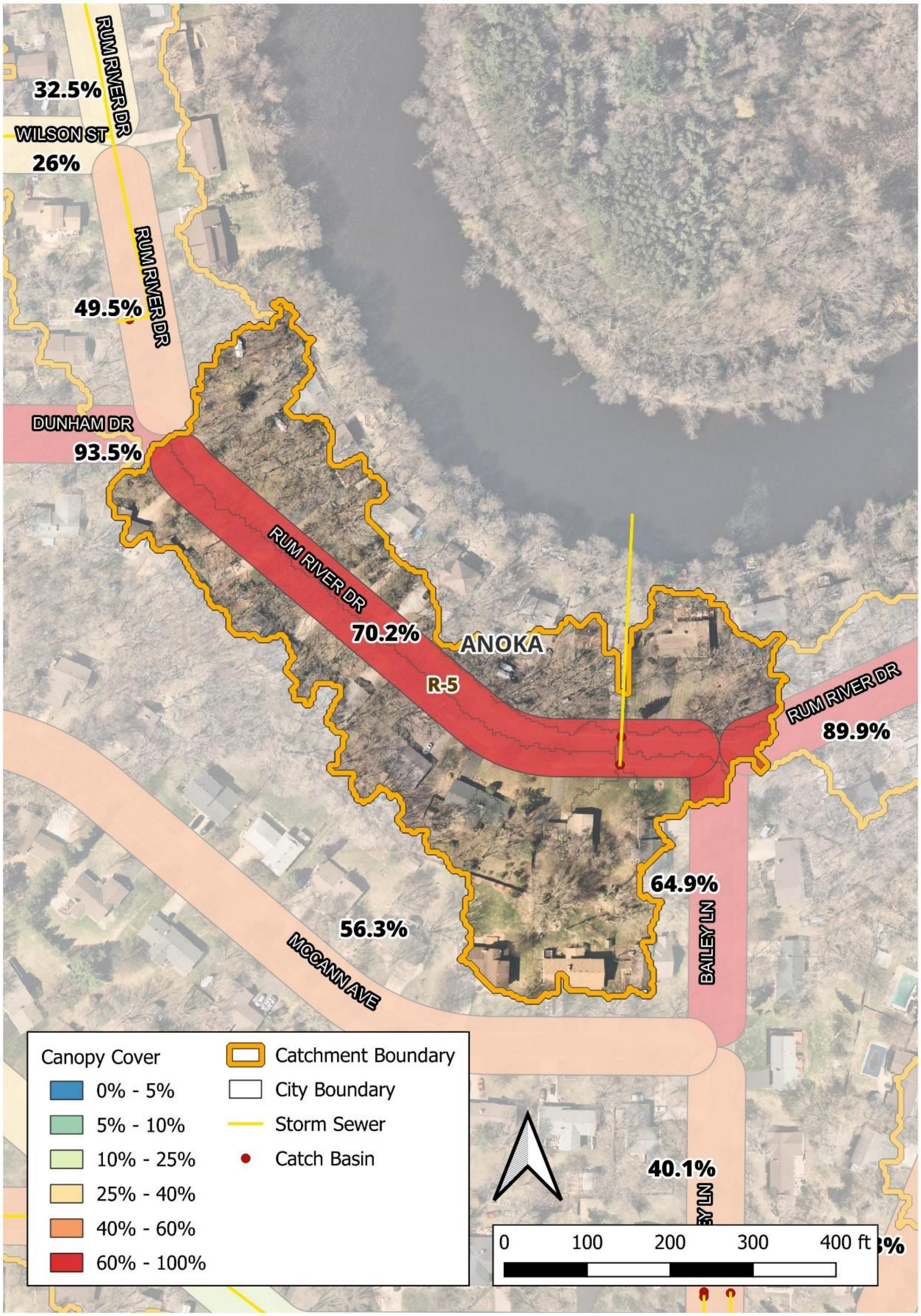
	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	1			
	BMP Types	Street Cleaning			
	TP (lb/yr)	3.18	0.25	8%	**2.92**
	TSS (lb/yr)	996	109	11%	**887**
	Volume (acre-feet/yr)	2.3	0.00	0%	**2.3**

RETROFITS CONSIDERED
A bioinfiltration basin is proposed adjacent to the storm sewer line that outfalls to the Rum River.

EXISTING STORMWATER TREATMENT AND RETROFIT OPPORTUNITIES



ROAD TREE CANOPY COVER



Project ID: R-5-PBI-1

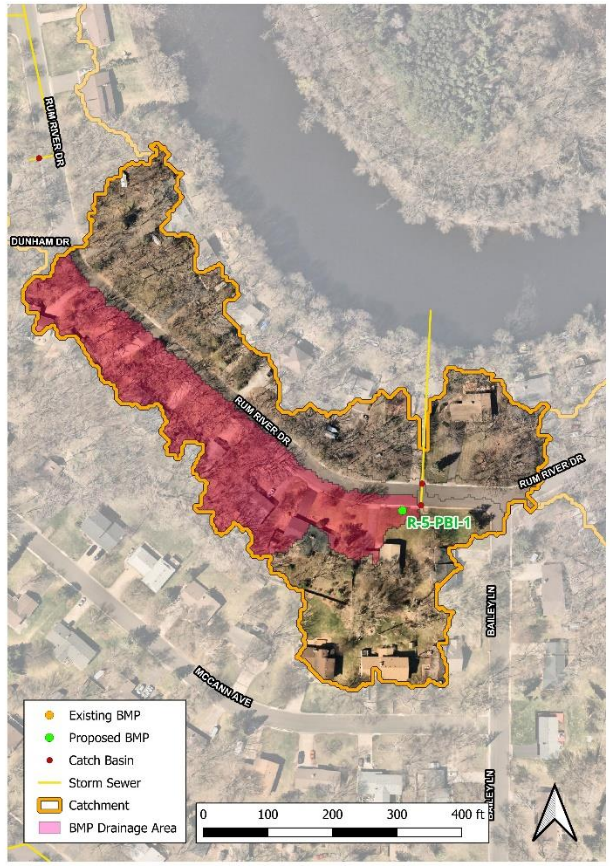
Rum River Dr.
Bioinfiltration Basin

Drainage Area – 1.72 acres

Location – 3533 Rum River Dr.

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed basin is a standard, single inlet rain garden that would collect stormwater from north and east. The table below provides pollutant removals and estimated costs.



	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq ft
	TP (lb/yr)	0.47	15.9%
	TSS (lb/yr)	147	16.5%
	Volume (acre-feet/yr)	0.35	15.2%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,235**	
	30-yr Average Cost/1,000lb-TSS	**$3,916**	
	30-yr Average Cost/ac-ft Vol.	**$1,655**	

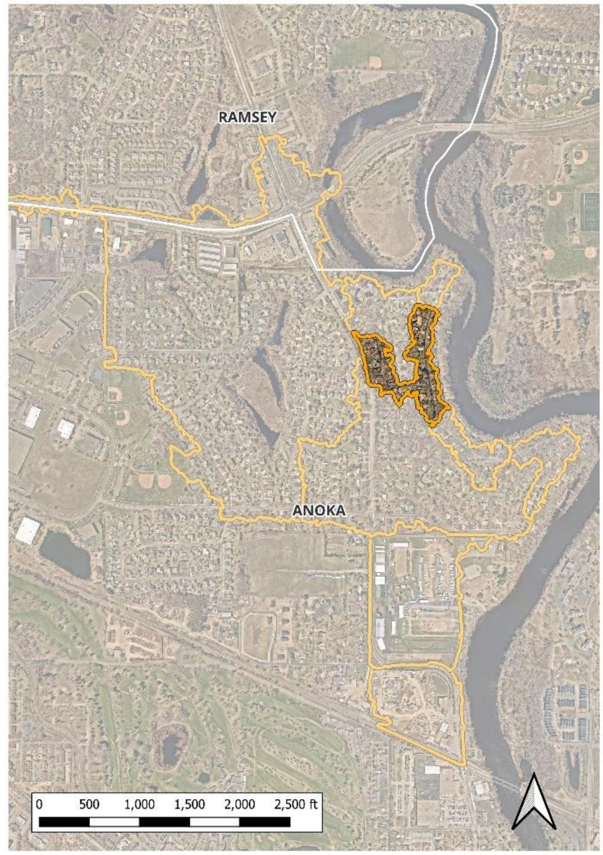
*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Catchment R-6

Existing Catchment Summary	
Acres	9.60
Parcels	40
Land Cover	100% Residential



CATCHMENT DESCRIPTION

This catchment is located in a residential neighborhood of Anoka on the west side of the Rum River. Stormwater runoff is captured through several catch basins and routed through storm sewer lines along Rum River Dr. and Wilson St. prior to discharging directly into the Rum River.

EXISTING STORMWATER TREATMENT

Subsets of the catchment are currently treated by one bioinfiltration basin. In addition, street cleaning is conducted once in early spring and once in mid-summer by the City of Anoka. Present day stormwater pollutant loading and treatment is summarized in the table below.

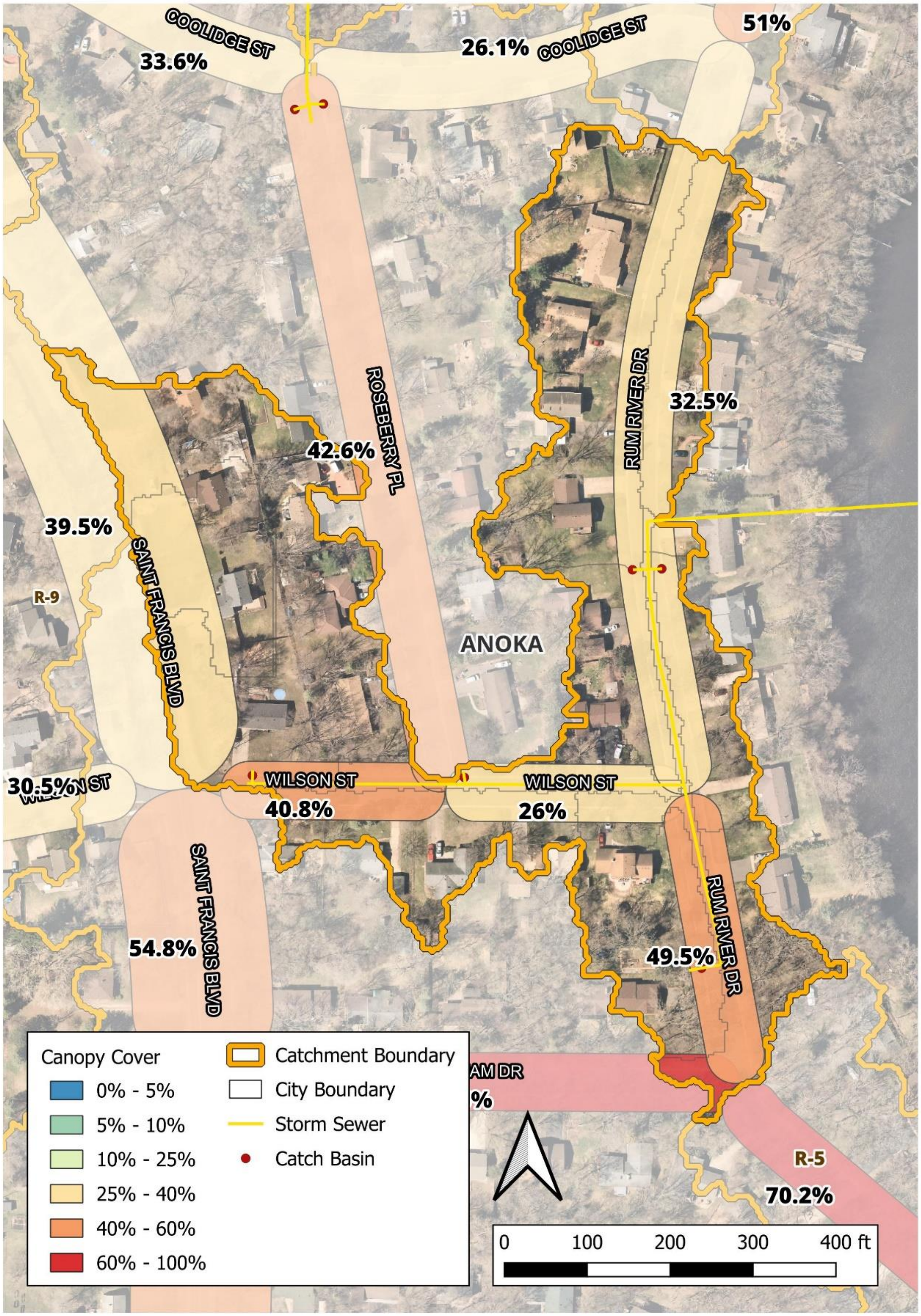
	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	2			
	BMP Types	Street Cleaning, Infiltration Basin (EBI-1)			
	TP (lb/yr)	5.35	0.71	13%	**4.63**
	TSS (lb/yr)	1,677	274	16%	**1,403**
	Volume (acre-feet/yr)	3.9	0.22	6%	**3.6**

RETROFITS CONSIDERED

A bioinfiltration basin and a hydrodynamic device are proposed adjacent to the storm sewer line that outfalls to the Rum River.

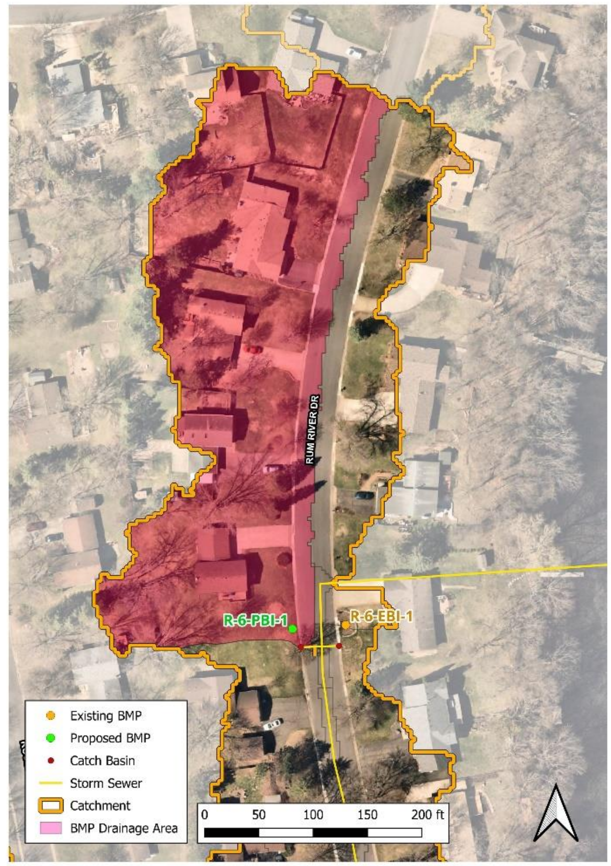
EXISTING STORMWATER TREATMENT AND RETROFIT OPPORTUNITIES

ROAD TREE CANOPY COVER



Project ID: R-6-PBI-1

Rum River Dr.
Bioinfiltration Basin



Drainage Area – 1.93 acres

Location – 3721 / 3711 Rum River Dr.

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed basin is a standard, single inlet rain garden that would collect stormwater from north and east. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq ft
	TP (lb/yr)	0.48	10.4%
	TSS (lb/yr)	153	10.9%
	Volume (acre-feet/yr)	0.36	10.0%
Cost	**Administration & Promotion Costs***		$664
	Design & Construction Costs**		$9,820
	Total Estimated Project Cost (2023)		**$10,484**
	Annual O&M***		$225
Efficiency	**30-yr Average Cost/lb-TP**	**$1,187**	
	30-yr Average Cost/1,000lb-TSS	**$3,755**	
	30-yr Average Cost/ac-ft Vol.	**$1,584**	

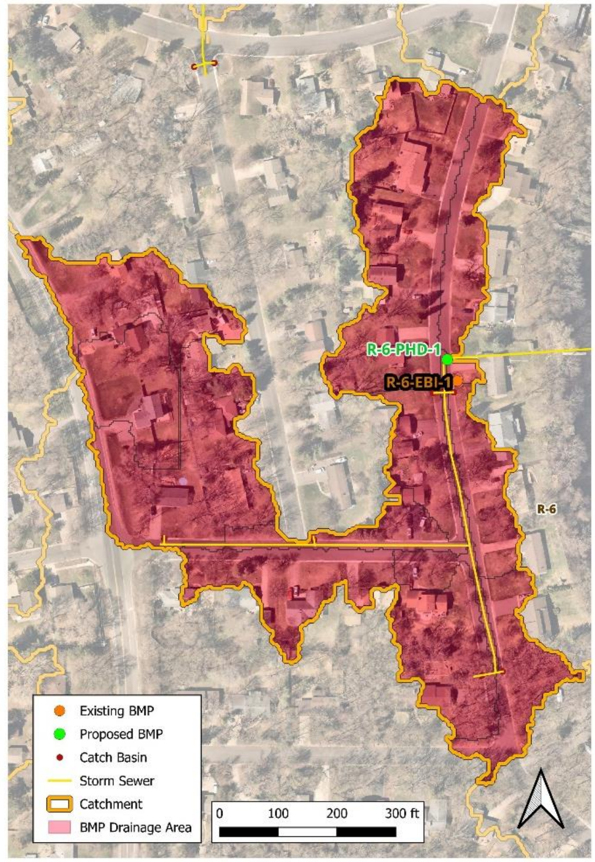
*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID:
R-6-PHD-1

Rum River Dr.
Hydrodynamic Device



Drainage Area – 9.60 acres

Location – Rum River Dr.

Property Ownership – City of Anoka

Site Specific Information – A hydrodynamic device is proposed in line with the storm sewer line on Rum River Dr. near the outlet. A hydrodynamic device here could help manage loads stemming from the entire catchment. The table below provides pollutant removals and estimated costs.

	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	10	ft diameter
	TP (lb/yr)	0.38	8.2%
	TSS (lb/yr)	152	10.8%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***	$3,750	
	Design & Construction Costs**	$150,000	
	Total Estimated Project Cost (2023)	**$153,750**	
	Annual O&M***	$210	
Efficiency	**30-yr Average Cost/lb-TP**	**$14,114**	
	30-yr Average Cost/1,000lb-TSS	**$35,099**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

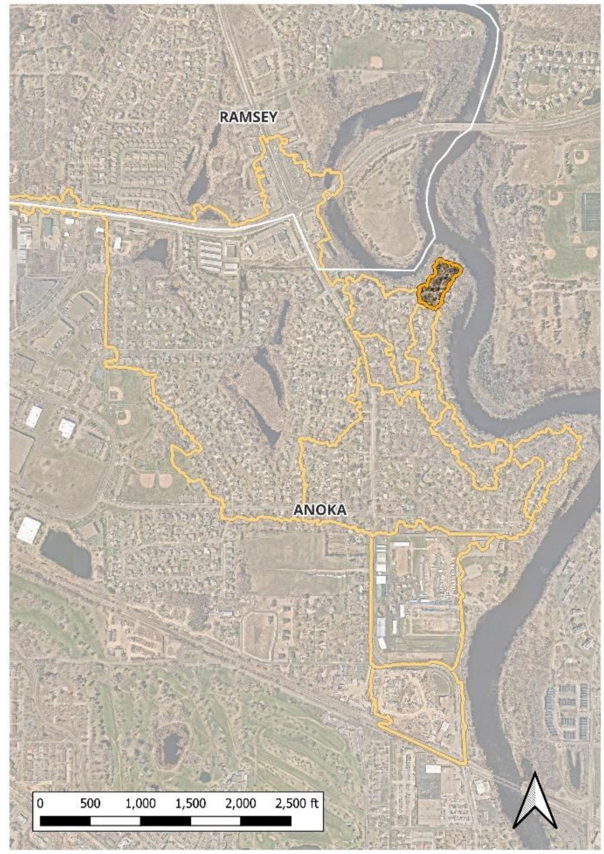
*Indirect Cost: (25 hours at $150/hour)

**Direct Cost: ($100,000 for materials) + ($50,000 for labor and installation costs)

***Per BMP: (1 cleaning/year)*(3 hours/cleaning)*($70/hour)

Catchment R-7

Existing Catchment Summary	
Acres	2.36
Parcels	12
Land Cover	97.2% Residential 2.8% Park



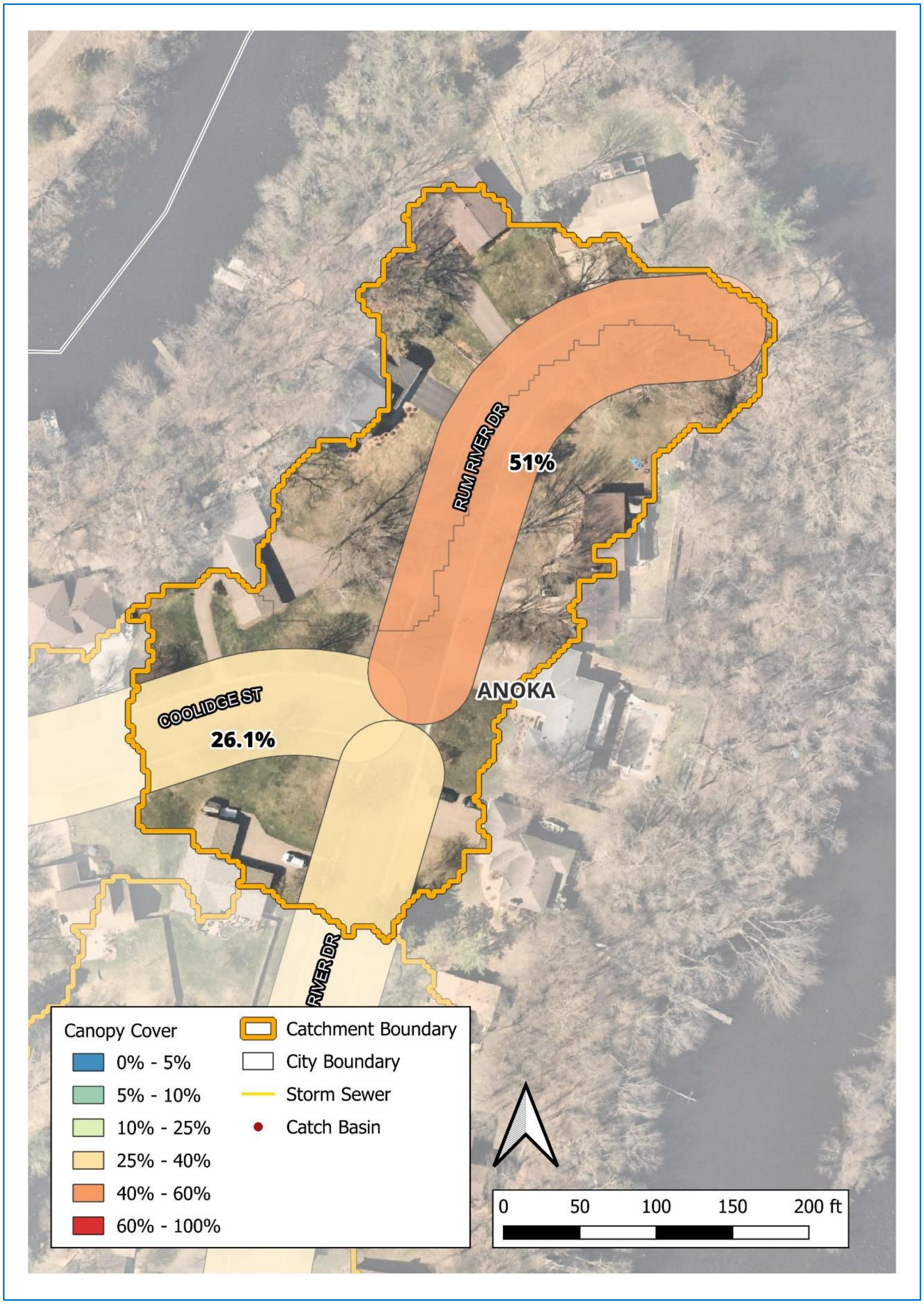
CATCHMENT DESCRIPTION
This catchment is located in a residential neighborhood of Anoka on the west side of the Rum River. Stormwater runoff is routed along Rum River Dr. prior to directly discharging into the Rum River through a curb-cut at the end of the road. There are no catch basins or storm sewer lines in this area. The contributing drainage area is small and is largely pervious (i.e. residential backyard areas).

EXISTING STORMWATER TREATMENT
Stormwater runoff from Rum River Dr. and Coolidge St. flows into a curb cut which allows water to pass through a heavily vegetated / gently sloped upland area before discharging into the Rum River; see Google Street View image below from May 2024. In addition, street cleaning is conducted once in early spring and once in mid-summer by the City of Anoka.

RETROFITS CONSIDERED
Stabilization projects near the curb cut were considered, but site visits noted there were no signs of channelization or erosion from surface runoff in this area. Due to existing treatment and limited space for new projects, no candidate BMPs were identified in this catchment. As such, this catchment and the existing treatment practices were not modeled in WinSLAMM.

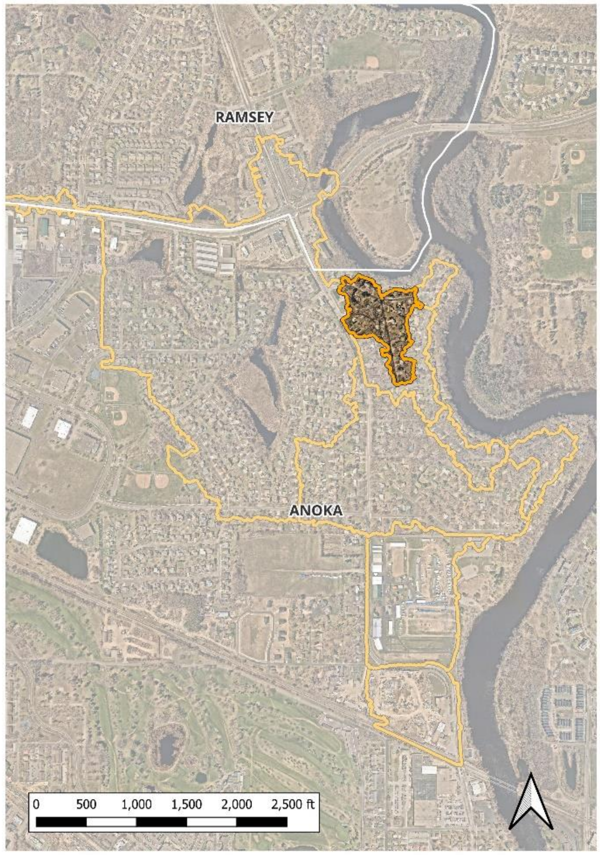
EXISTING STORMWATER TREATMENT AND RETROFIT OPPORTUNITIES

ROAD TREE CANOPY COVER



Catchment R-8

Existing Catchment Summary	
Acres	9.94
Parcels	34
Land Cover	100% Residential



CATCHMENT DESCRIPTION

This catchment is located in a residential neighborhood of Anoka on the west side of the Rum River. Stormwater runoff is routed along Roseberry Pl. and Coolidge St. prior to entering two catch basins that discharge to the Rum River. The contributing drainage area is small and is largely pervious (i.e. residential backyard areas).

EXISTING STORMWATER TREATMENT

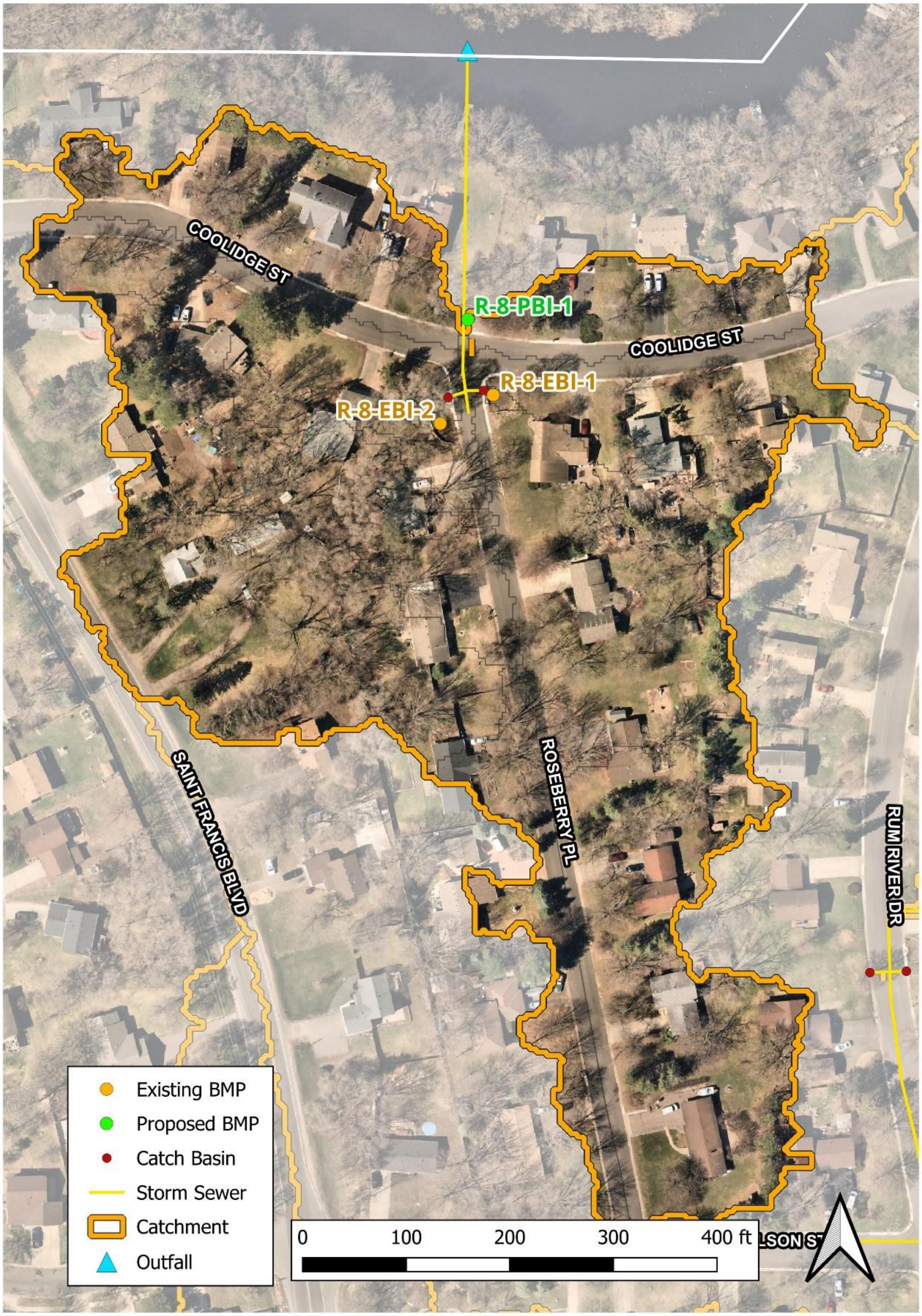
Subsets of the catchment are currently treated by two bioinfiltration basins. In addition, street cleaning is conducted once in early spring and once in mid-summer by the City of Anoka. Present day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	3			
Treatment	BMP Types	Street Cleaning, Infiltration Basin (EBI-1, EBI-2)			
Treatment	TP (lb/yr)	5.53	3.05	55%	**2.49**
Treatment	TSS (lb/yr)	1,736	1,009	58%	**728**
Treatment	Volume (acre-feet/yr)	4.0	1.97	49%	**2.0**

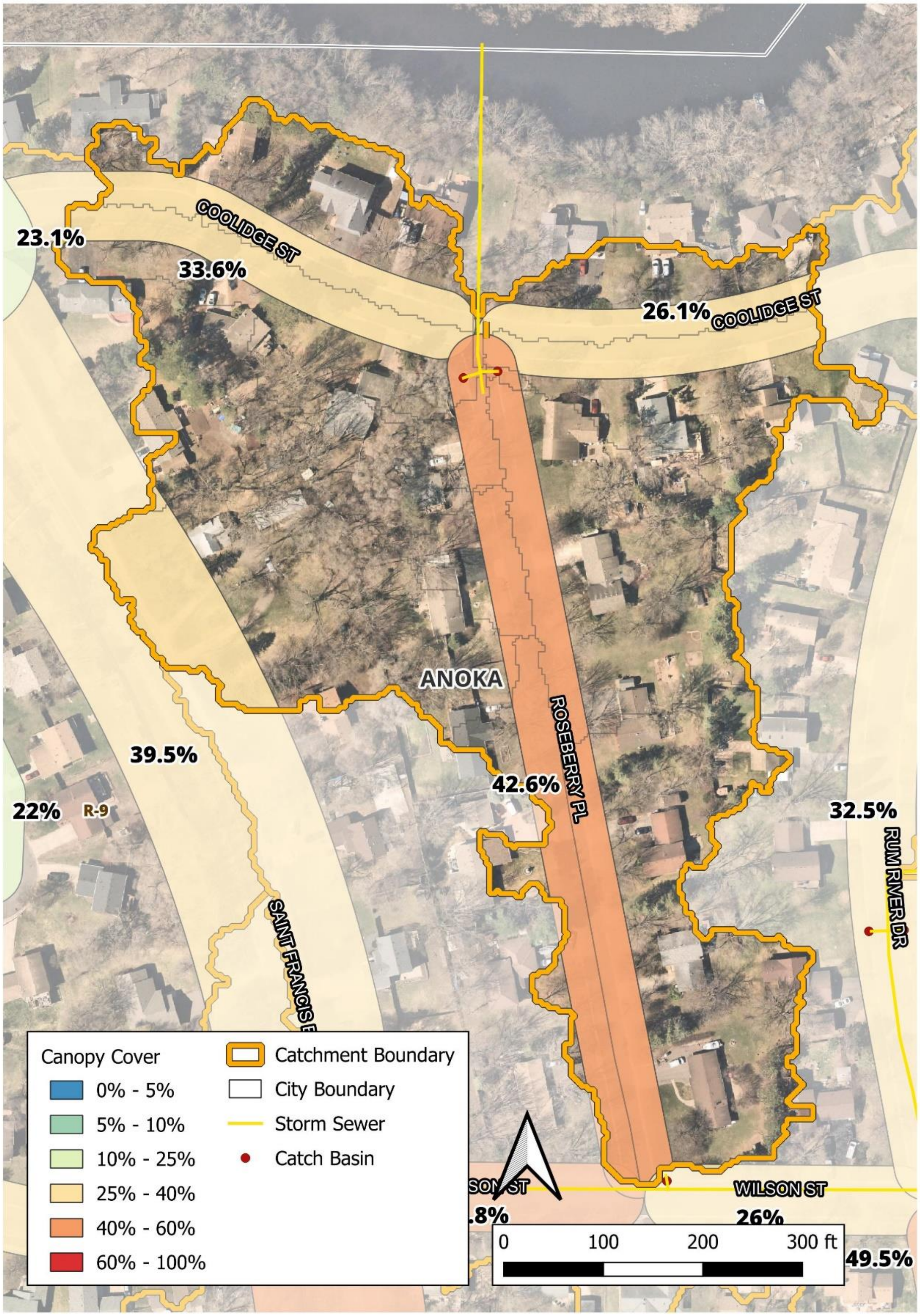
RETROFITS CONSIDERED

A bioinfiltration basin is proposed adjacent to the storm sewer line that outfalls to the Rum River.

EXISTING STORMWATER TREATMENT AND RETROFIT OPPORTUNITIES

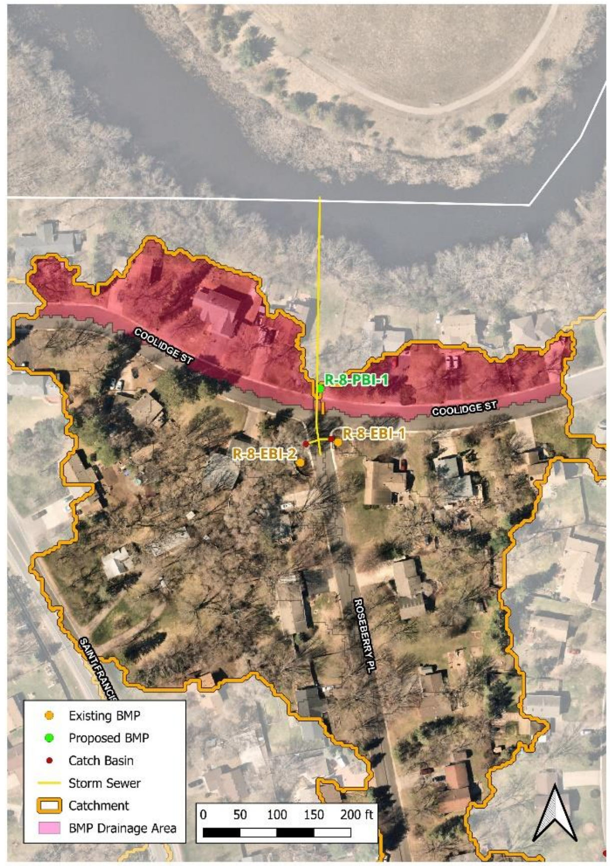


ROAD TREE CANOPY COVER



Project ID: R-8-PBI-1

Coolidge St.
Bioinfiltration Basin



Drainage Area – 1.56 acres

Location – 341 Coolidge St.

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed basin is a large, double inlet rain garden. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	500	sq ft.
	TP (lb/yr)	0.62	24.9%
	TSS (lb/yr)	193	26.5%
	Volume (acre-feet/yr)	0.47	23.2%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$16,320	
	Total Estimated Project Cost (2023)	**$16,984**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,276**	
	30-yr Average Cost/1,000lb-TSS	**$4,097**	
	30-yr Average Cost/ac-ft Vol.	**$1,686**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Catchment R-9

Existing Catchment Summary	
Acres	143.1
Parcels	347
Land Cover	67.9% Residential 16.6% Commercial 6.5% Open 6.2% Water 1.6% Park 1.1% Industrial

CATCHMENT DESCRIPTION

This catchment primarily includes the Mineral and Tower Pond residential areas of Anoka. The majority of this subwatershed flows to one of two wetlands which are effectively landlocked. In the event of extreme precipitation, there is a possibility for these areas to spill over in a stormwater treatment pond near the Rum River Crossings commercial properties, which treats the parking lots in this area and a significant portion of St. Francis Blvd.

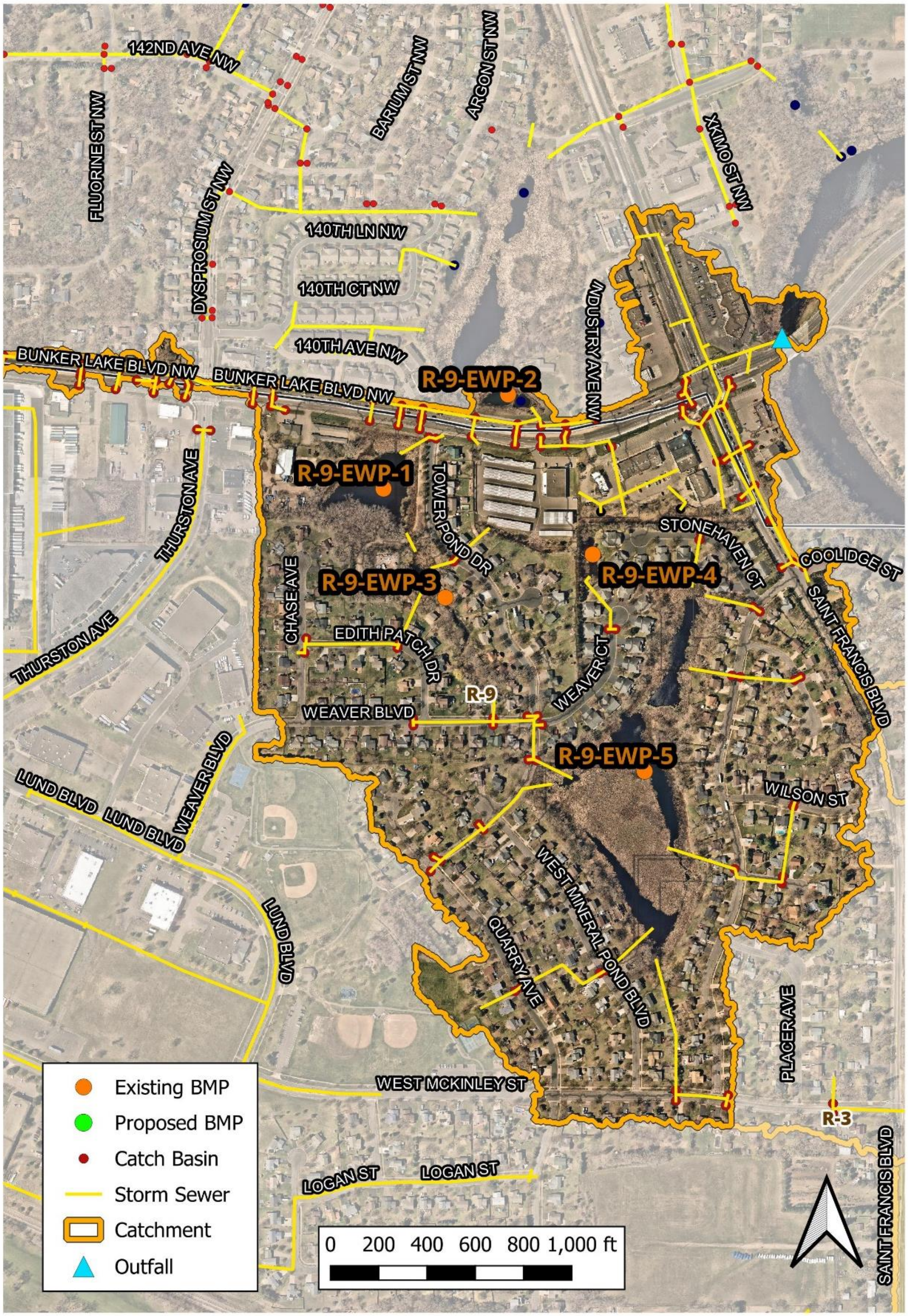
EXISTING STORMWATER TREATMENT

Stormwater runoff from Bunker Lake Blvd. and St. Francis Blvd flow into several catch basins that discharge to an existing stormwater pond near the Rum River Crossings commercial properties. The residential areas to the southwest of this intersection all drain to a series of landlocked stormwater ponds and wetlands. In addition, street cleaning is conducted once in early spring and once in mid-summer by the City of Anoka.

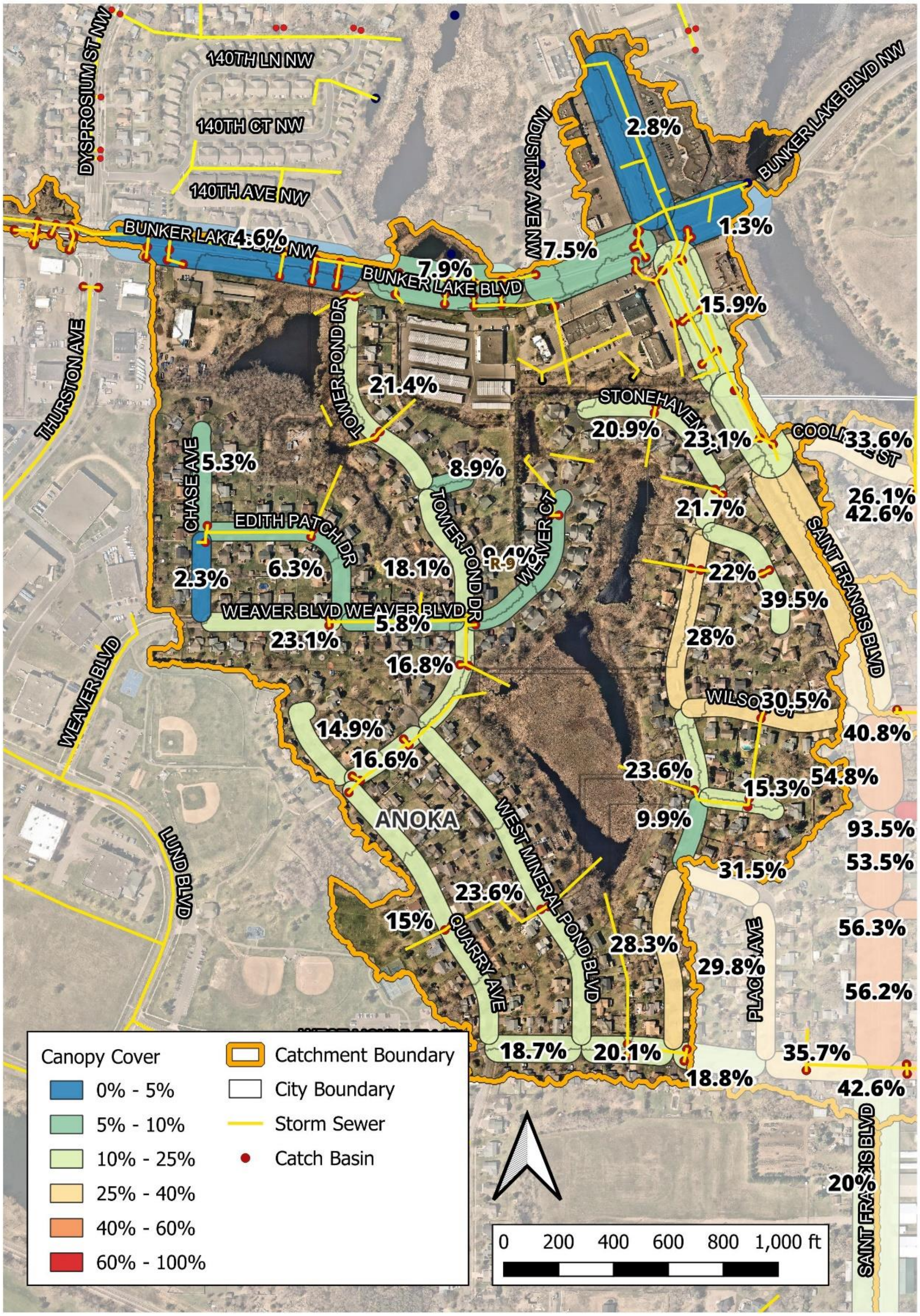
RETROFITS CONSIDERED

There are several catch basins near the intersection of Bunker Lake Blvd. and St. Francis Blvd. that discharge untreated stormwater runoff directly into the Rum River, however, there is limited space available in this area for retrofit opportunities. Given the limited space available, an underground structure was considered, but this intersection was recently reconstructed and it would be cost prohibitive to perform additional reconstruction. Due to existing treatment and limited space for new projects, no candidate BMPs were identified in this catchment. As such, this catchment and the existing treatment practices were not modeled in WinSLAMM.

EXISTING STORMWATER TREATMENT AND RETROFIT OPPORTUNITIES

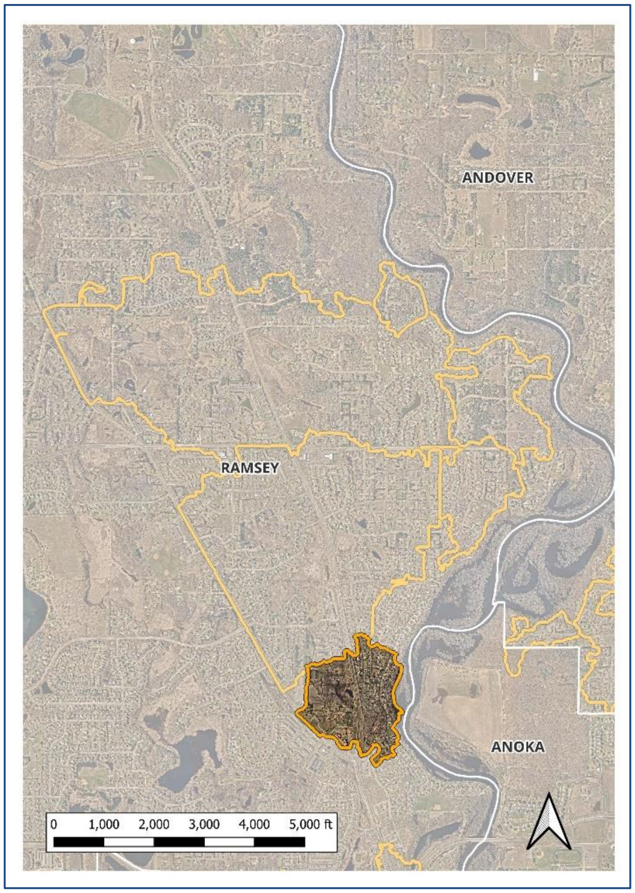


ROAD TREE CANOPY COVER



Catchment R-10

Existing Catchment Summary	
Acres	76.4
Parcels	95
Land Cover	47.1% Residential 39.8% Open 9.1% Institutional 3.3% Park 0.8% Water



CATCHMENT DESCRIPTION

This catchment is located in Ramsey. Land use is a mixture of residential and undeveloped land. In the residential neighborhood of this catchment, stormwater runoff is collected into multiple catch basins that route into one of two stormwater ponds prior to discharging into the Rum River. Likewise, in the undeveloped area of this catchment, stormwater runoff is directly routed into a large stormwater pond. There is no known stormwater infrastructure that connects this stormwater pond on the west side of St. Francis Blvd. to the Rum River.

EXISTING STORMWATER TREATMENT

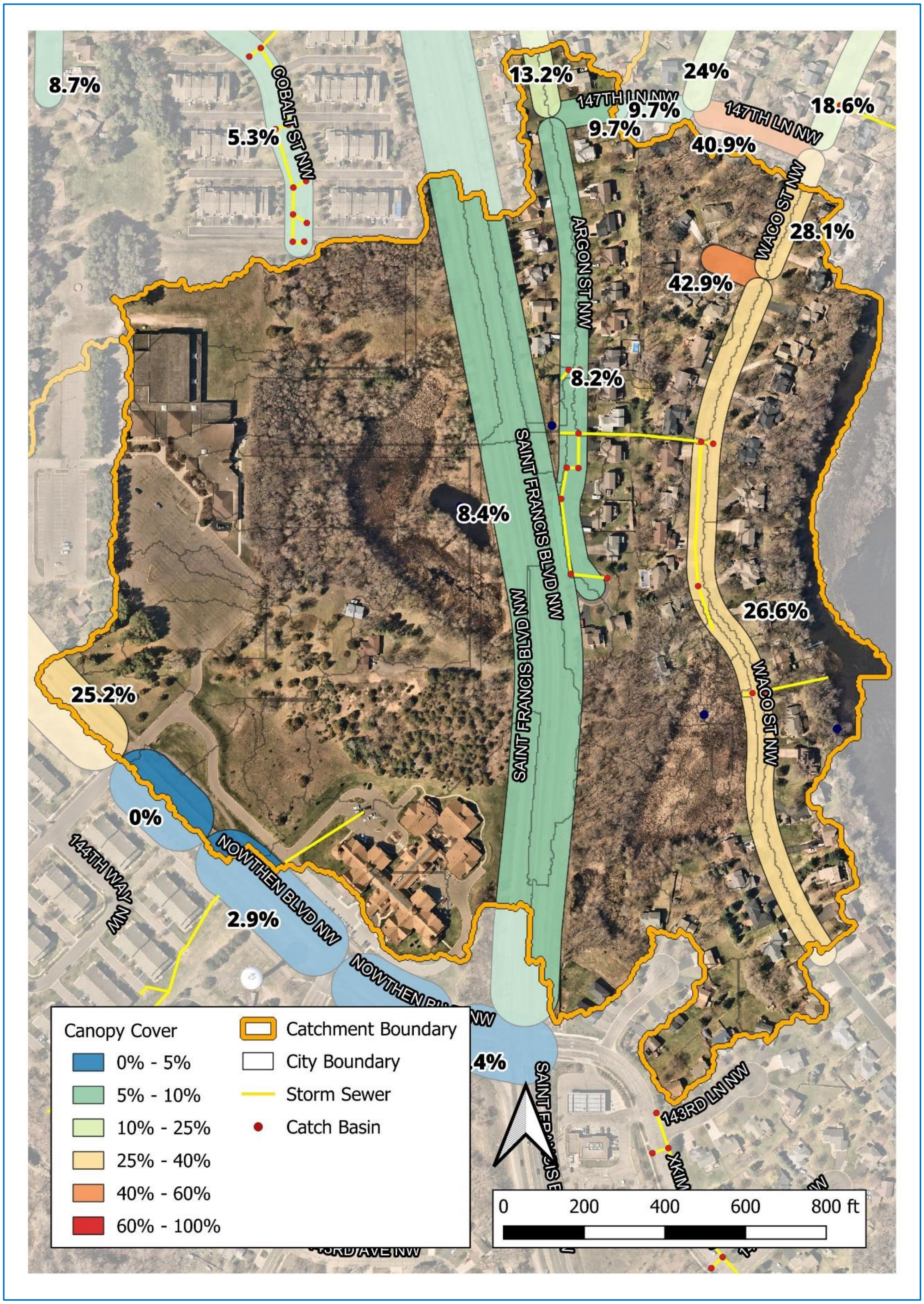
There are currently three stormwater ponds within this catchment – two large ponds on both the west and east side of St. Francis Blvd, and a small pond directly east of St. Francis Blvd. In addition, street cleaning is conducted once in the spring and once in the fall by the City of Ramsey.

RETROFITS CONSIDERED

No retrofits were considered for this catchment due to the scale of existing treatment compared it its relatively small drainage area. As such, this catchment and the existing treatment practices were not modeled in WinSLAMM.

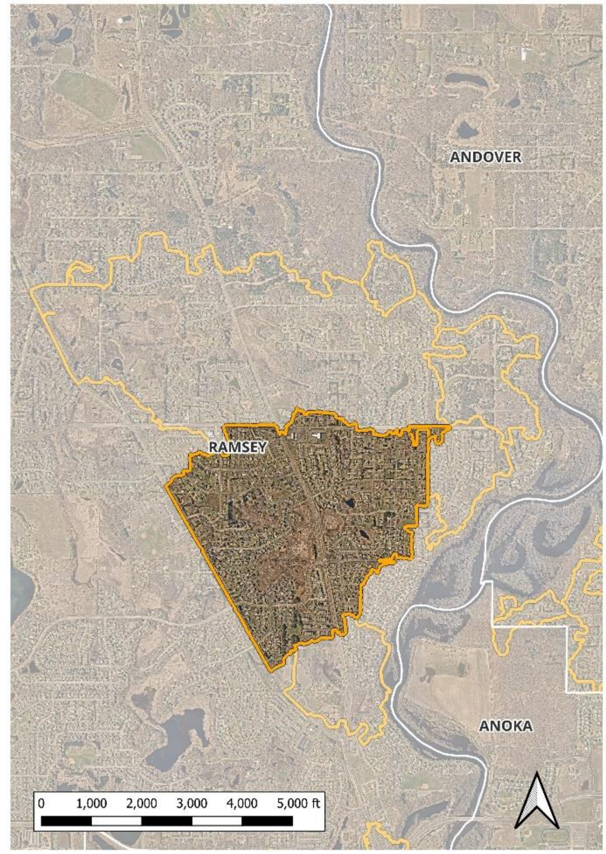
EXISTING STORMWATER TREATMENT AND RETROFIT OPPORTUNITIES

ROAD TREE CANOPY COVER



Catchment R-11

Existing Catchment Summary	
Acres	380.2
Parcels	735
Land Cover	79.7% Residential 13.6% Open 4.4% Park 0.9% Commercial 0.7% Office Park 0.6% Institutional 0.2% Industrial



CATCHMENT DESCRIPTION

This catchment is located in Ramsey. Land use is primarily residential, with a mixture of open land, park, and commercial property throughout.

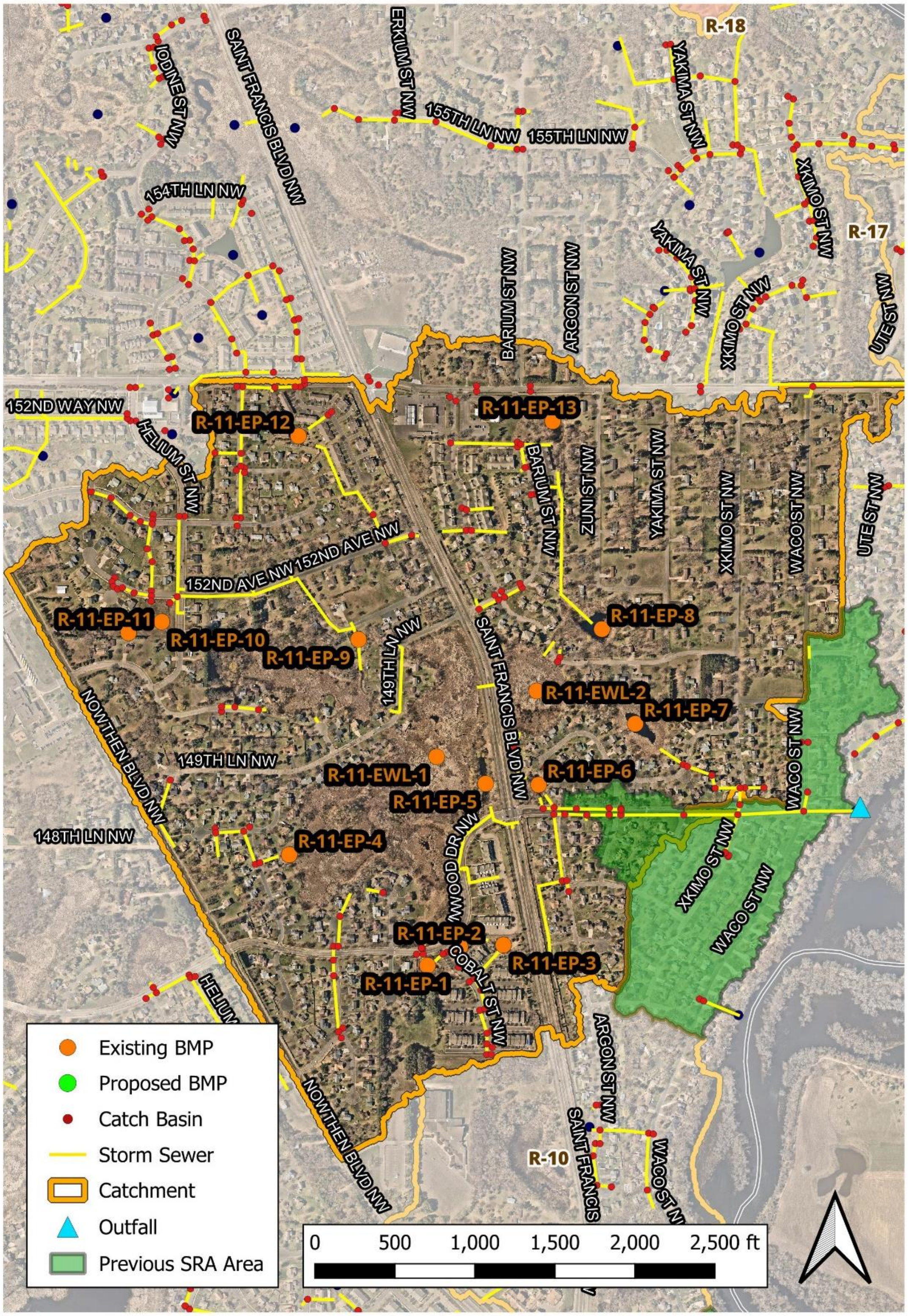
EXISTING STORMWATER TREATMENT

This catchment contains multiple large stormwater ponds throughout that treat the majority of stormwater runoff. In addition, street cleaning is conducted once in the spring and once in the fall by the City of Ramsey.

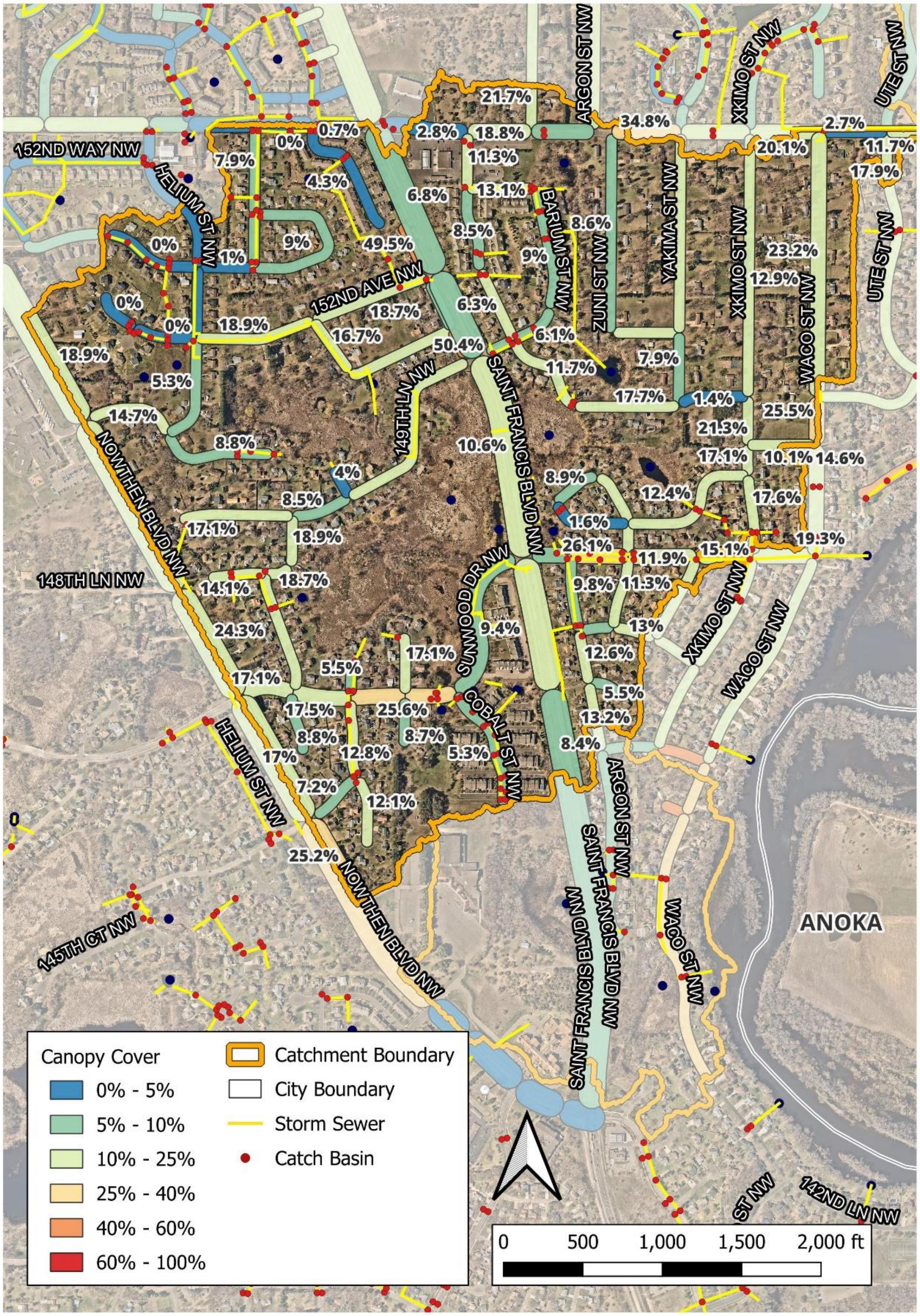
RETROFITS CONSIDERED

A subset of this catchment near the outfall was analyzed in a previous SRA report (Catchment RR-2; City of Ramsey, 2016). In that report, it was noted that approximately 37-acres of this catchment has no known existing stormwater treatment practices outside of street cleaning performed by the City of Ramsey. Multiple bioinfiltration basin practices were proposed in this area, in addition to a hydrodynamic device along the Xkimo St. storm sewer line that would treat residential properties along the roadway. The remaining portion of this catchment is currently treated by multiple existing stormwater ponds. As such, this catchment and the existing treatment practices were not modeled in WinSLAMM.

EXISTING STORMWATER TREATMENT AND RETROFIT OPPORTUNITIES

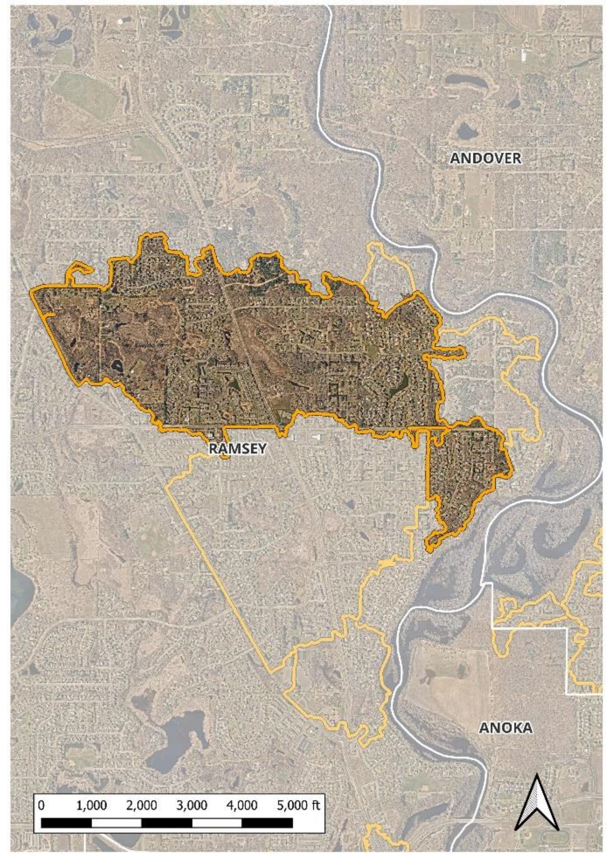


ROAD TREE CANOPY COVER



Catchment R-12

Existing Catchment Summary	
Acres	565.1
Parcels	905
Land Cover	69.0% Residential 23.1% Open 7.1% Park 0.3% Institutional 0.3% Agricultural 0.1% Industrial 0.1% Commercial



CATCHMENT DESCRIPTION

This catchment is located in Ramsey. Land use is primarily residential, with a mixture of open land and park property throughout. The outfall at Catchment R-12 has been decommissioned. Stormwater that used to drain to this point is now channeled into the larger complex of existing stormwater treatment ponds that eventually outlet at Catchment R-18.

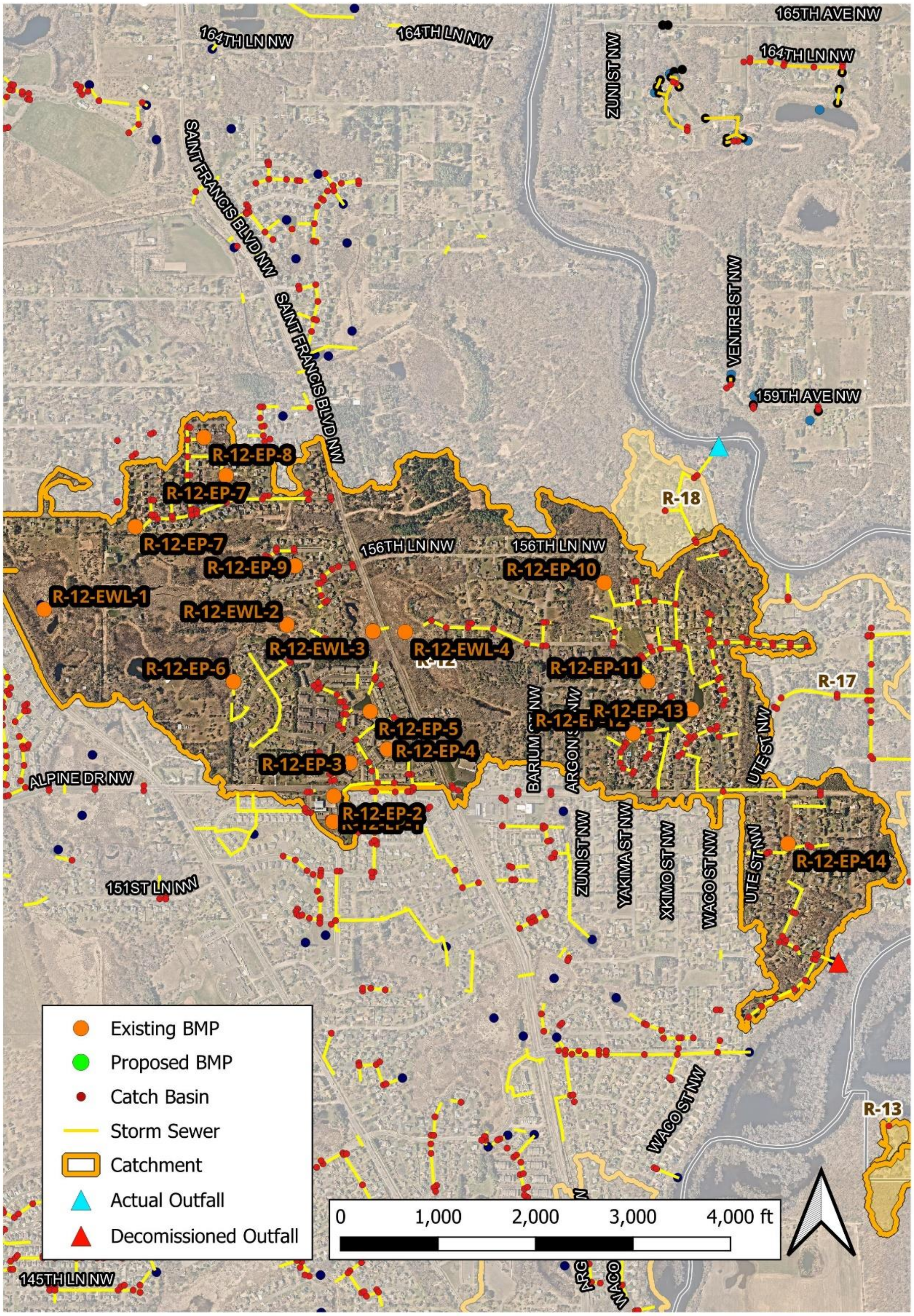
EXISTING STORMWATER TREATMENT

The drainage area for Catchment R-12 is very large and contains a network of multiple existing stormwater treatment ponds.

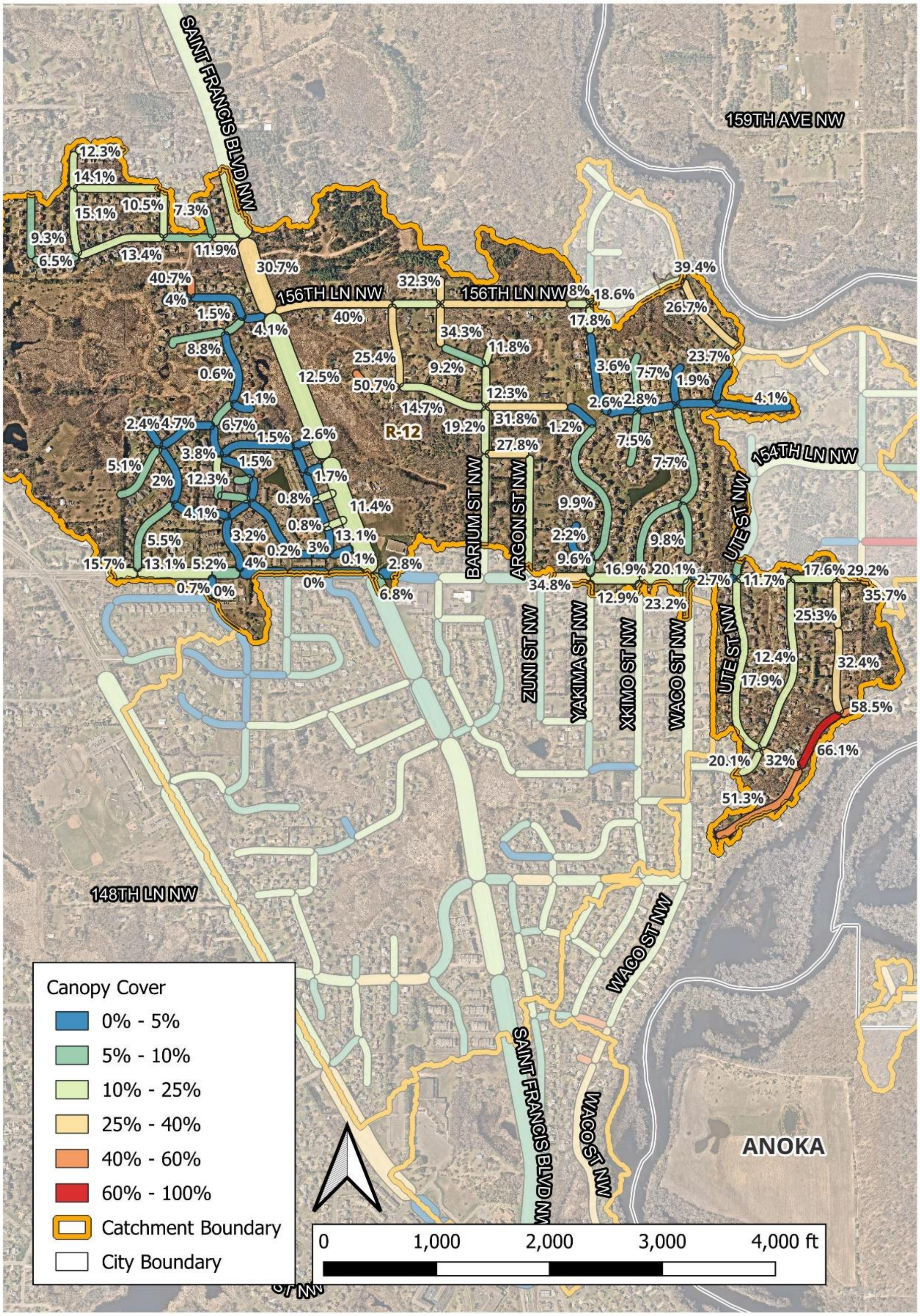
RETROFITS CONSIDERED

The existing stormwater treatment ponds were examined extensively with storm sewer data to map flow networks and to determine sufficient existing treatment. The downstream-most end of this subwatershed – labeled Catchment R-18 – has no existing treatment. Retrofit opportunities have only been identified in Catchment R-18; no opportunities were considered for the larger Catchment R-12 given the extensive network of stormwater treatment ponds. As such, this catchment and the existing treatment practices were not modeled in WinSLAMM.

EXISTING STORMWATER TREATMENT AND RETROFIT OPPORTUNITIES

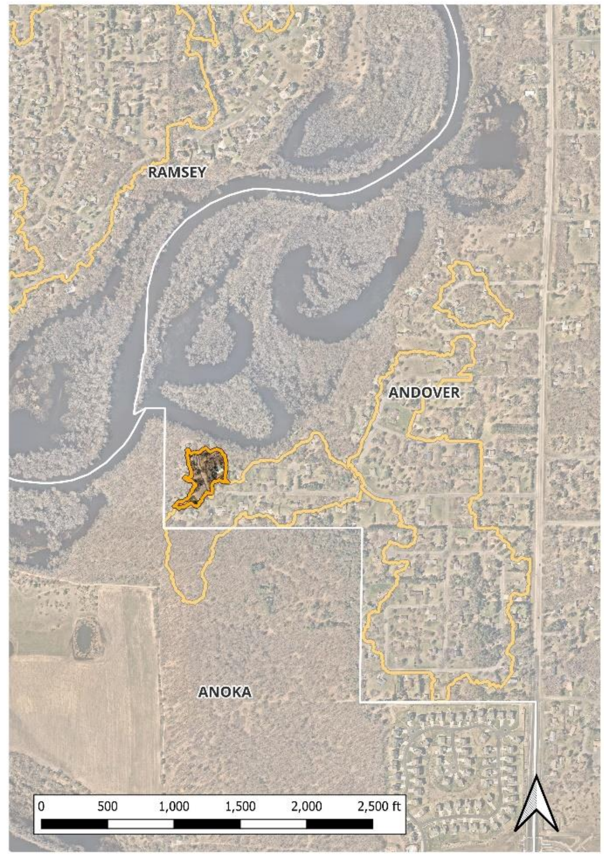


ROAD TREE CANOPY COVER



Catchment R-13

Existing Catchment Summary	
Acres	2.02
Parcels	6
Land Cover	100% Residential



CATCHMENT DESCRIPTION

This catchment is located in a residential neighborhood of Andover on the east side of the Rum River. Stormwater runoff is routed along the cul-de-sac of 147th Ln. prior to entering one catch basin that discharges to the Rum River. The contributing drainage area is small and is equally pervious (i.e. residential backyard) and impervious (i.e. streets).

EXISTING STORMWATER TREATMENT

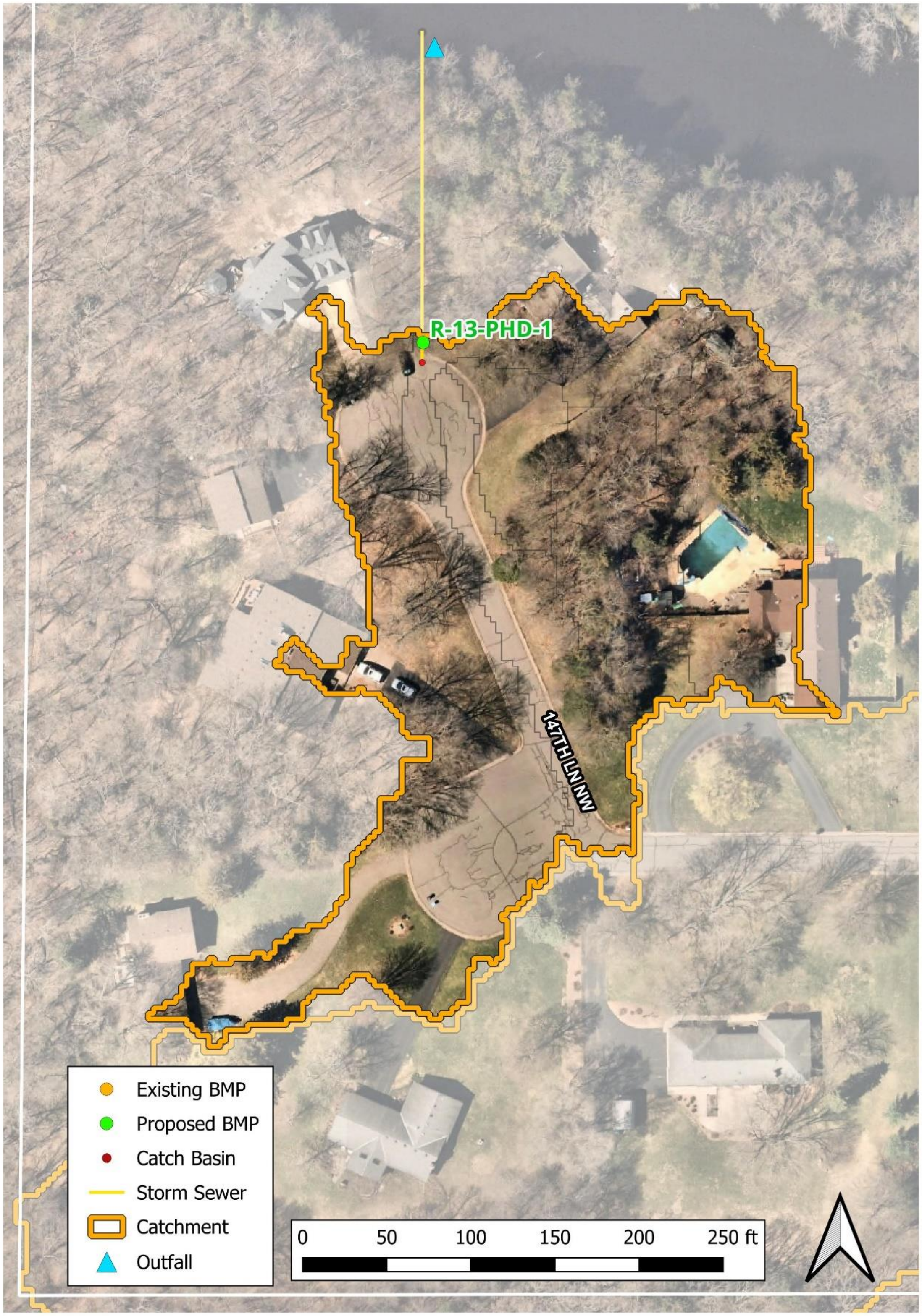
Street cleaning is conducted once in early spring and once in fall by the City of Andover. No other existing stormwater treatment exists in this catchment. Present day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	1			
	BMP Types	Street Cleaning			
	TP (lb/yr)	1.14	0.09	8%	**1.05**
	TSS (lb/yr)	355	39	11%	**317**
	Volume (acre-feet/yr)	0.8	0.00	0%	**0.8**

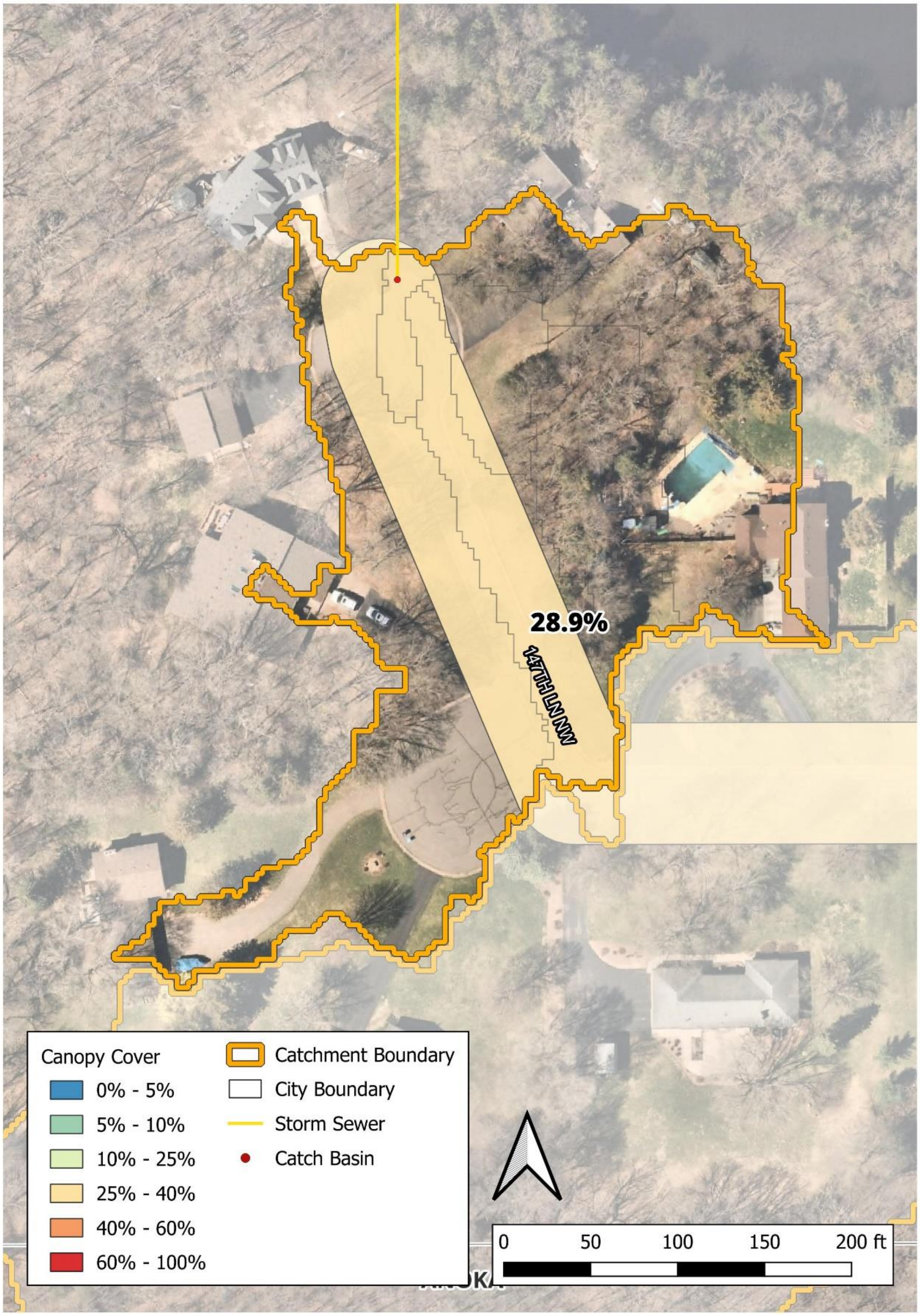
RETROFITS CONSIDERED

A hydrodynamic separator is proposed at the storm sewer line prior to discharging into the Rum River. The structure would provide treatment for the entire catchment.

EXISTING STORMWATER TREATMENT AND RETROFIT OPPORTUNITIES

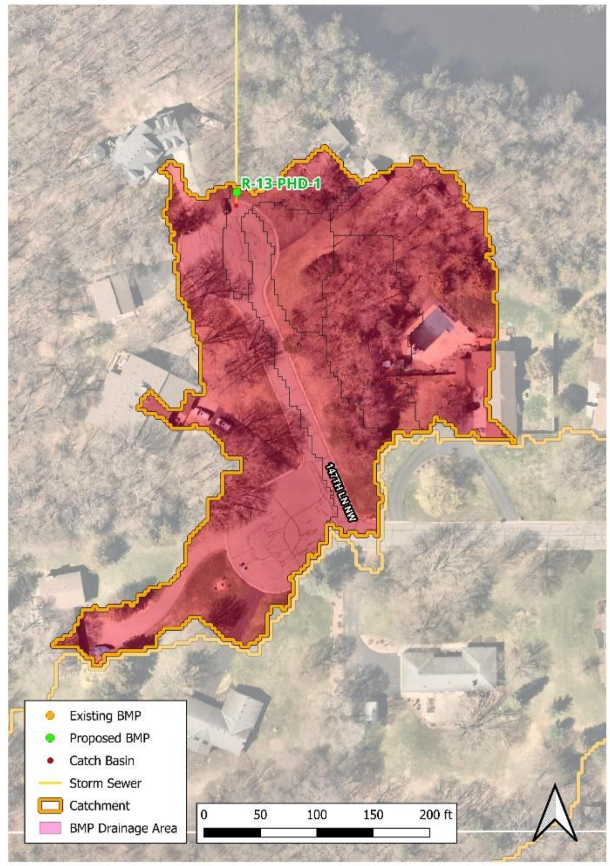


ROAD TREE CANOPY COVER



Project ID: R-13-PHD-1

147th Ln NW
Hydrodynamic Device



Drainage Area – 2.02 acres

Location – 147th Ln NW cul-de-sac

Property Ownership – Public

Site Specific Information – A hydrodynamic device is proposed in line with the storm sewer line on 147th Ln. prior to discharging into the Rum River. A device at this location would provide treatment to the entire catchment. The table below provides pollutant removals and estimated costs.

	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	6	ft diameter
	TP (lb/yr)	0.16	15.3%
	TSS (lb/yr)	64	20.3%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***	$3,750	
	Design & Construction Costs**	$37,500	
	Total Estimated Project Cost (2023)	**$41,250**	
	Annual O&M***	$210	
Efficiency	**30-yr Average Cost/lb-TP**	**$9,875**	
	30-yr Average Cost/1,000lb-TSS	**$24,727**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

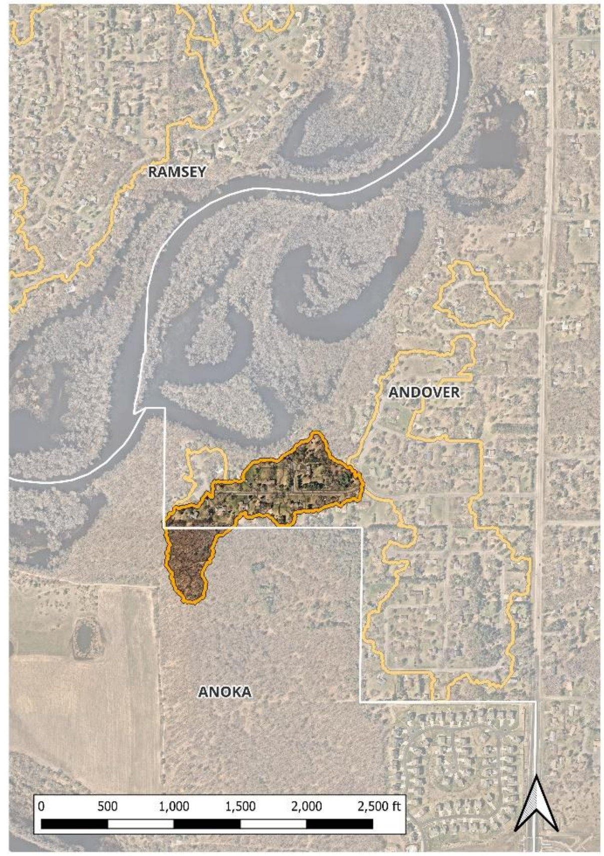
*Indirect Cost: (25 hours at $150/hour)

**Direct Cost: ($25,000 for materials) + ($12,500 for labor and installation costs)

***Per BMP: (1 cleaning/year)*(3 hours/cleaning)*($70/hour)

Catchment R-14

Existing Catchment Summary	
Acres	15.34
Parcels	19
Land Cover	74.0% Residential 26.0% Park



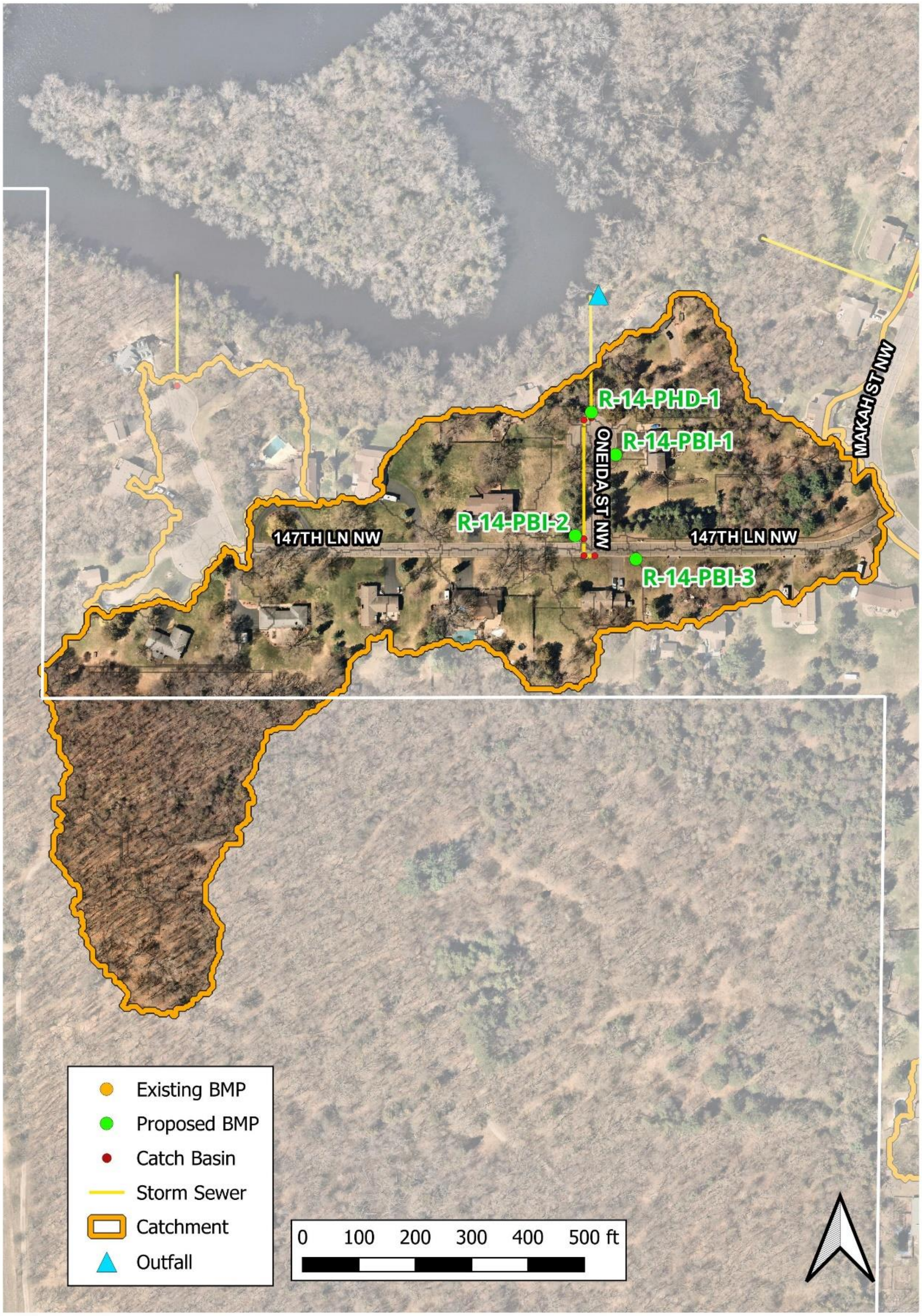
CATCHMENT DESCRIPTION
This catchment is located in a residential neighborhood of Andover on the east side of the Rum River. Stormwater runoff is routed along 147th Ln. and Oneida St. prior to entering catch basins that discharge to the Rum River. The contributing drainage area is small and is largely pervious (i.e. residential backyard areas).

EXISTING STORMWATER TREATMENT
Street cleaning is conducted once in early spring and once in fall by the City of Andover. No other existing stormwater treatment exists in this catchment. Present day stormwater pollutant loading and treatment is summarized in the table below.

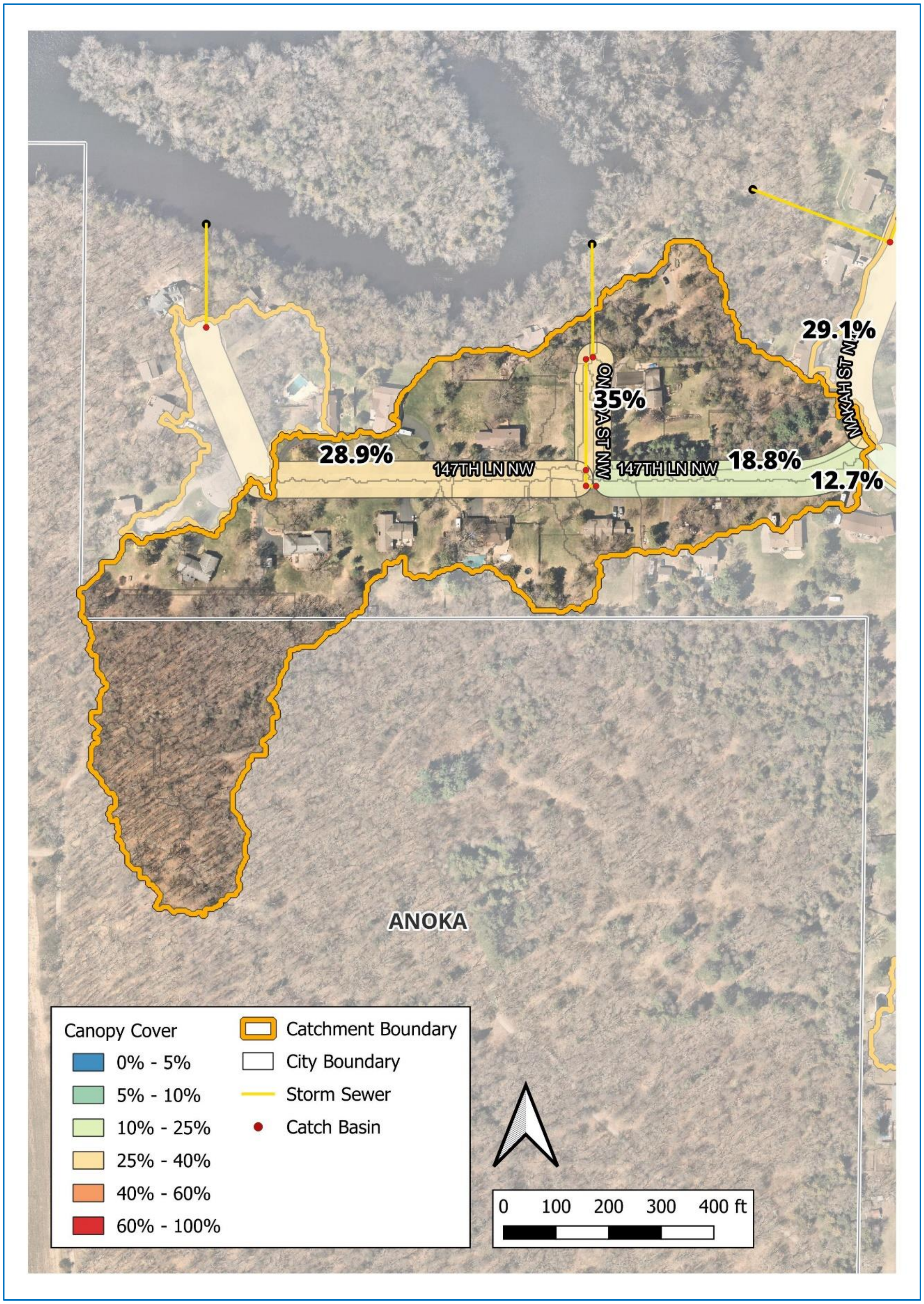
	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	1			
	BMP Types	Street Cleaning			
	TP (lb/yr)	7.34	0.56	8%	**6.78**
	TSS (lb/yr)	2,318	243	10%	**2,075**
	Volume (acre-feet/yr)	5.2	0.00	0%	**5.2**

RETROFITS CONSIDERED
Several BMPs are proposed within this catchment. They include three bioinfiltration basins and one hydrodynamic separator.

EXISTING STORMWATER TREATMENT AND RETROFIT OPPORTUNITIES



ROAD TREE CANOPY COVER



Project ID: R-14-PBI-1

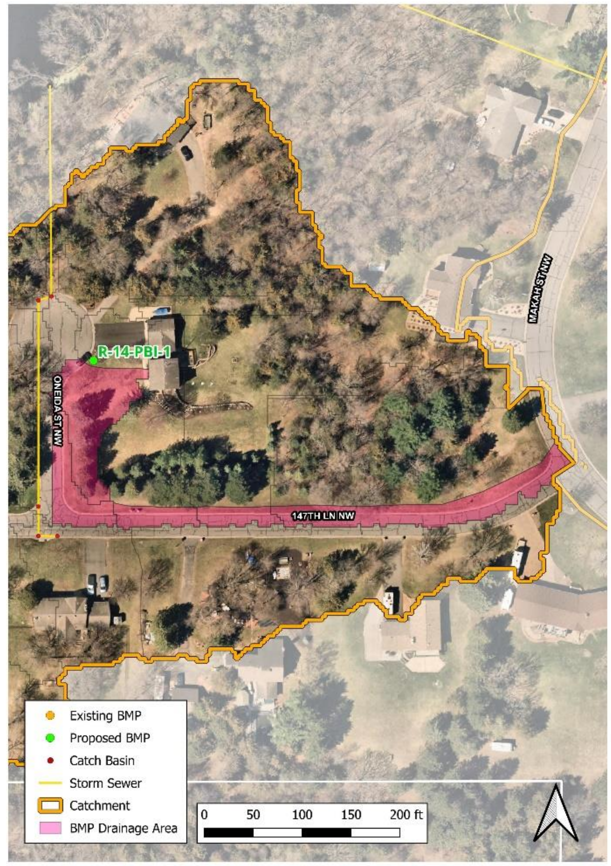
Oneida St.
Bioinfiltration Basin

Drainage Area – 0.48 acres

Location – 14755 Oneida St. NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed basin is a standard, single inlet rain garden. The table below provides pollutant removals and estimated costs.



Curb-Cut Bioinfiltration

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Total Size of BMP	250	sq. ft.
	TP (lb/yr)	0.25	3.7%
	TSS (lb/yr)	82	4.0%
	Volume (acre-feet/yr)	0.17	3.2%
Cost	Administration & Promotion Costs*	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	30-yr Average Cost/lb-TP	**$2,307**	
	30-yr Average Cost/1,000lb-TSS	**$7,006**	
	30-yr Average Cost/ac-ft Vol.	**$3,429**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-14-PBI-2

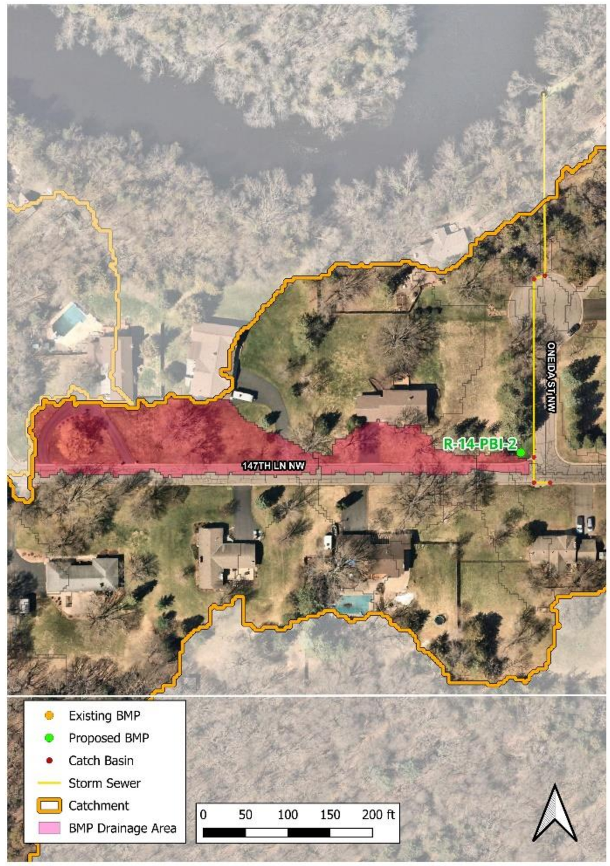
147th Ln.
Bioinfiltration Basin

Drainage Area – 0.78 acres

Location – 4701 147th Ln. NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed basin is a standard, single inlet rain garden. The table below provides pollutant removals and estimated costs.



	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq. ft.
	TP (lb/yr)	0.31	4.6%
	TSS (lb/yr)	98	4.7%
	Volume (acre-feet/yr)	0.24	4.5%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,847**	
	30-yr Average Cost/1,000lb-TSS	**$5,862**	
	30-yr Average Cost/ac-ft Vol.	**$2,433**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-14-PBI-3

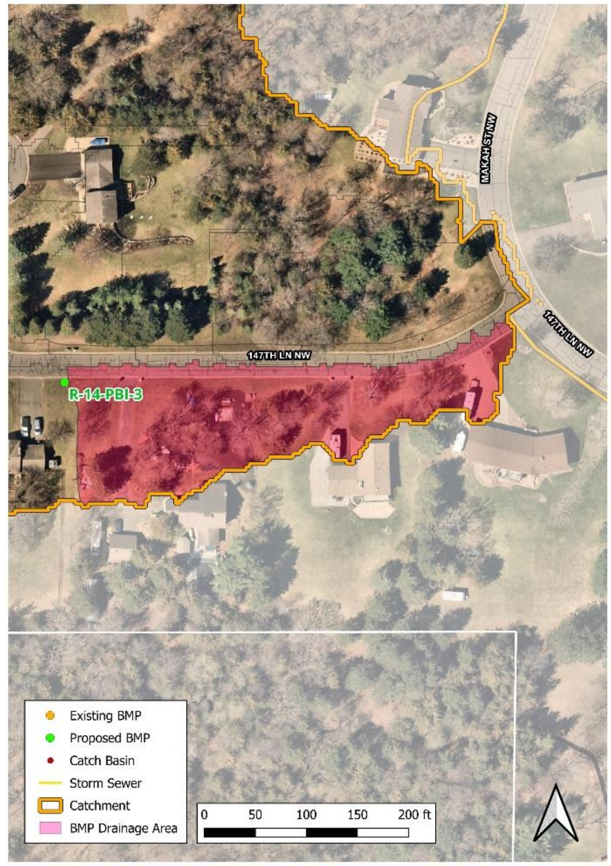
147th Ln
Bioinfiltration Basin

Drainage Area – 0.93 acres

Location – 4650 147th Ln NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed basin is a standard, single inlet rain garden. The table below provides pollutant removals and estimated costs.



	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq. ft.
	TP (lb/yr)	0.34	5.1%
	TSS (lb/yr)	108	5.2%
	Volume (acre-feet/yr)	0.26	5.0%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,675**	
	30-yr Average Cost/1,000lb-TSS	**$5,319**	
	30-yr Average Cost/ac-ft Vol.	**$2,211**	

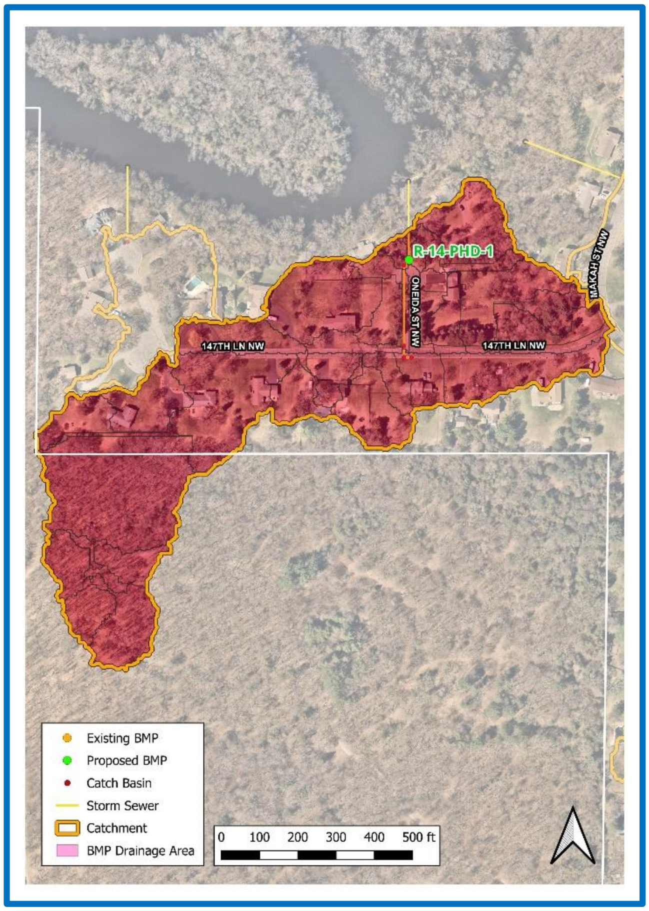
*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-14-PHD-1

Oneida St.
Hydrodynamic Device



Drainage Area – 15.34 acres

Location – Oneida St. NW cul-de-sac

Property Ownership – Public

Site Specific Information – A hydrodynamic device is proposed in line with the storm sewer line at the cul-de-sac of Oneida St. NW. A hydrodynamic device here could help manage loads from the entire catchment. The table below provides pollutant removals and estimated costs.

Hydrodynamic Device			
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	10	ft diameter
	TP (lb/yr)	0.75	11.0%
	TSS (lb/yr)	304	14.7%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***	$3,750	
	Design & Construction Costs**	$150,000	
	Total Estimated Project Cost (2023)	**$153,750**	
	Annual O&M***	$210	
Efficiency	**30-yr Average Cost/lb-TP**	**$7,151**	
	30-yr Average Cost/1,000lb-TSS	**$17,549**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

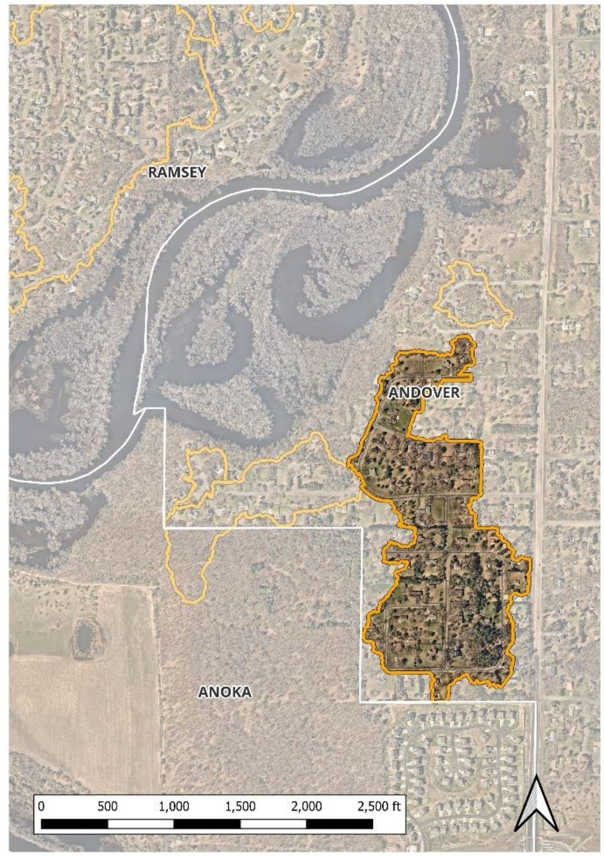
*Indirect Cost: (25 hours at $150/hour)

**Direct Cost: ($100,000 for materials) + ($50,000 for labor and installation costs)

***Per BMP: (1 cleaning/year)*(3 hours/cleaning)*($70/hour)

Catchment R-15

Existing Catchment Summary	
Acres	26.3
Parcels	60
Land Cover	99.6% Residential 0.37% Park



CATCHMENT DESCRIPTION

This catchment is located in a residential neighborhood of Andover on the east side of the Rum River. Stormwater runoff is primarily routed along Lipan St. prior to entering catch basins that discharge to the Rum River.

EXISTING STORMWATER TREATMENT

Street cleaning is conducted once in early spring and once in fall by the City of Andover. No other existing stormwater treatment exists in this catchment. Present day stormwater pollutant loading and treatment is summarized in the table below.

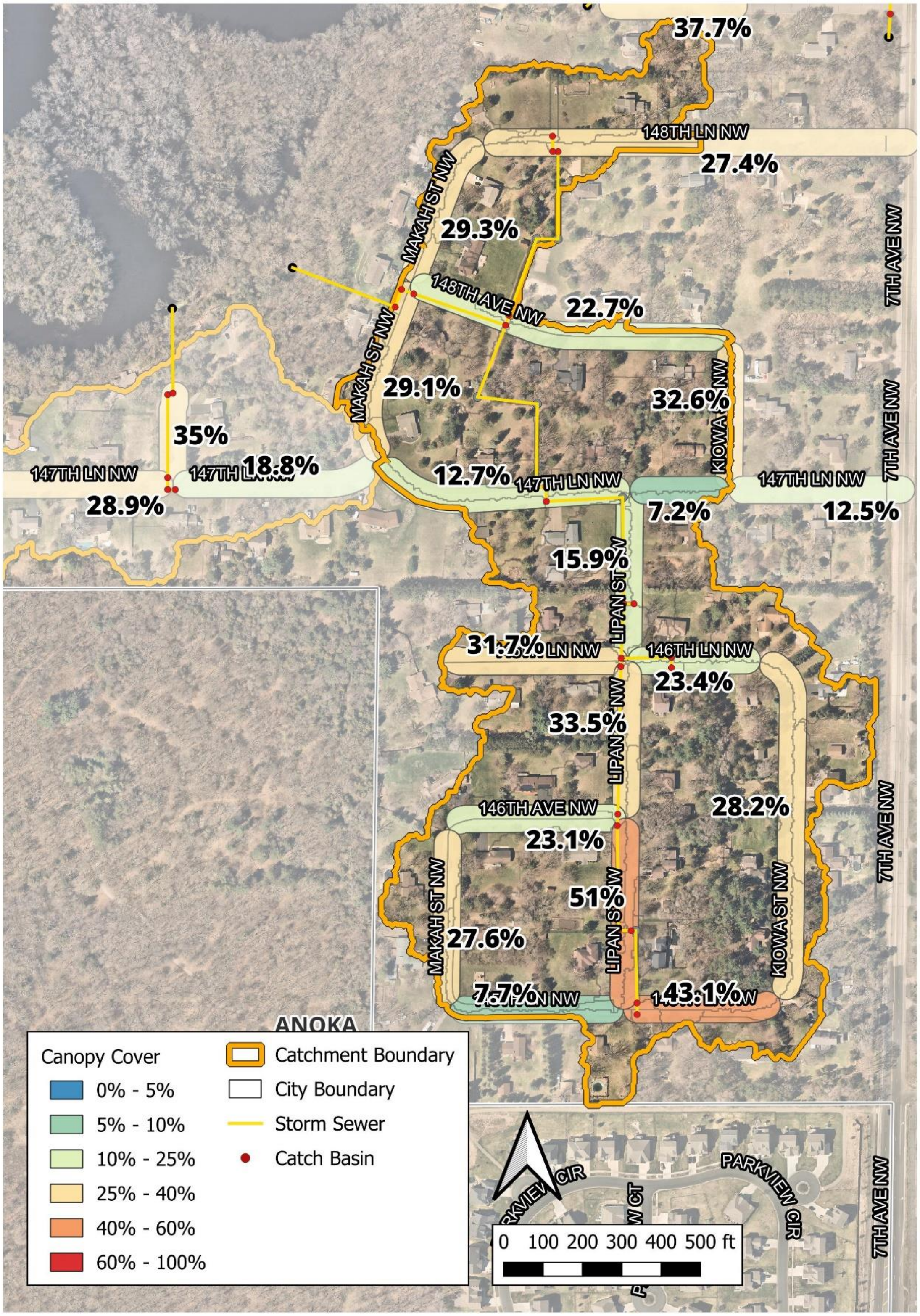
	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	1			
	BMP Types	Street Cleaning			
	TP (lb/yr)	24.67	1.95	8%	**22.72**
	TSS (lb/yr)	7,738	848	11%	**6,890**
	Volume (acre-feet/yr)	17.8	0.00	0%	**17.8**

RETROFITS CONSIDERED

Multiple bioinfiltration basins are proposed within this catchment. The landscape of this catchment is conducive to the installation of bioinfiltration basins, with multiple properties exhibiting minimal slope and above-ground interferences. An end-of-pipe practice, such as a wet pond, was considered at the outfall of the storm sewer. However, it was determined that a practice of this nature would be infeasible given the property boundaries, proximity to the river and associated floodplain, and steepness of slope.

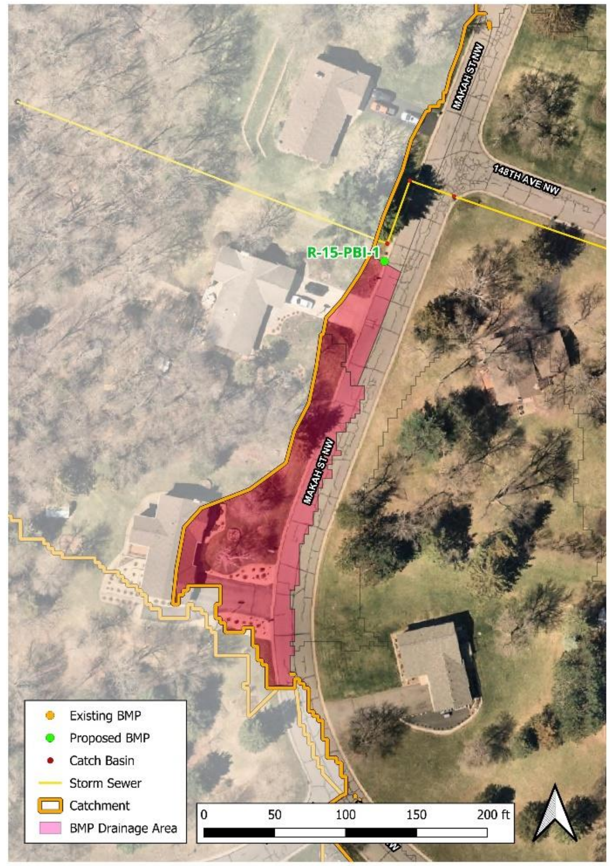
EXISTING STORMWATER TREATMENT AND RETROFIT OPPORTUNITIES

ROAD TREE CANOPY COVER



Project ID:
R-15-PBI-1

Makah St.
Bioinfiltration Basin



Drainage Area – 0.32 acres

Location – 14790 Makah St NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed basin is a standard, single inlet rain garden. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq. ft.
	TP (lb/yr)	0.16	0.7%
	TSS (lb/yr)	47	0.7%
	Volume (acre-feet/yr)	0.12	0.7%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$3,590**	
	30-yr Average Cost/1,000lb-TSS	**$12,223**	
	30-yr Average Cost/ac-ft Vol.	**$4,793**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-15-PBI-2

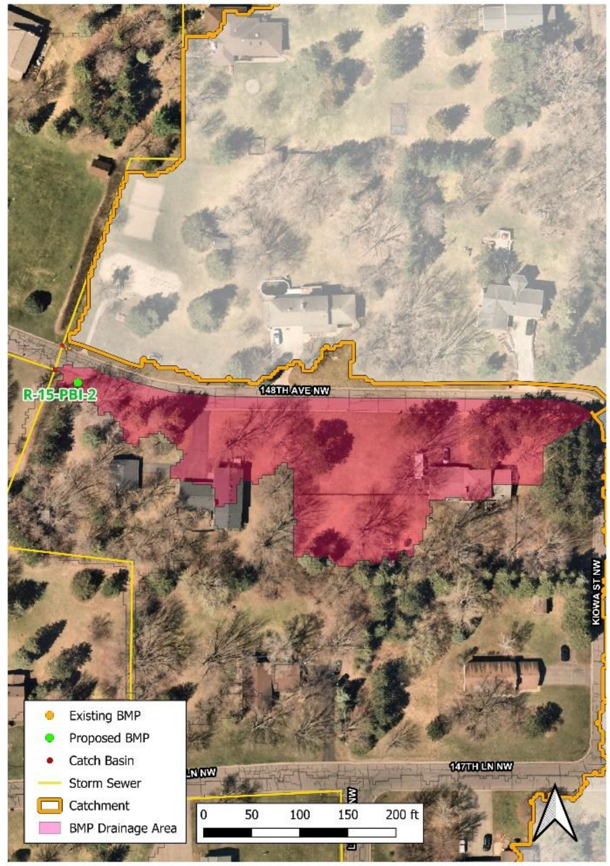
148th Ave.
Bioinfiltration Basin

Drainage Area – 1.22 acres

Location – 4520 148th Ave NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed basin is a standard, single inlet rain garden. The table below provides pollutant removals and estimated costs.



	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq. ft.
	TP (lb/yr)	0.40	1.8%
	TSS (lb/yr)	125	1.8%
	Volume (acre-feet/yr)	0.30	1.7%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,436**	
	30-yr Average Cost/1,000lb-TSS	**$4,596**	
	30-yr Average Cost/ac-ft Vol.	**$1,920**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-15-PBI-3

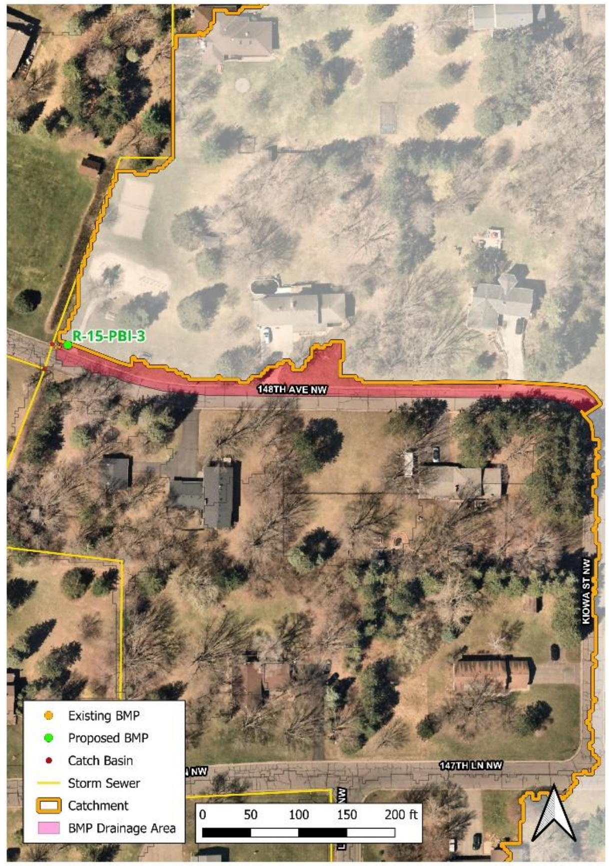
148th Ave.
Bioinfiltration Basin

Drainage Area – 0.28 acres

Location – 4519 148th Ave NW

Property Ownership – Public

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed basin is a standard, single inlet rain garden. The table below provides pollutant removals and estimated costs.



Curb-Cut Bioinfiltration

	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq. ft.
	TP (lb/yr)	0.13	0.6%
	TSS (lb/yr)	37	0.5%
	Volume (acre-feet/yr)	0.09	0.5%
Cost	**Administration & Promotion Costs***		$664
	Design & Construction Costs**		$9,820
	Total Estimated Project Cost (2023)		**$10,484**
	Annual O&M***		$225
Efficiency	**30-yr Average Cost/lb-TP**	**$4,419**	
	30-yr Average Cost/1,000lb-TSS	**$15,526**	
	30-yr Average Cost/ac-ft Vol.	**$6,049**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-15-PBI-5

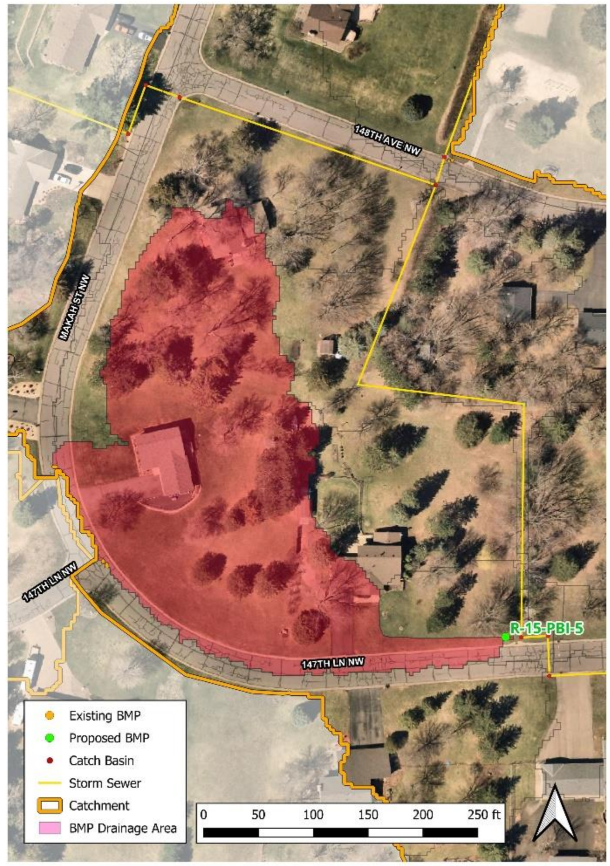
147th Ln.
Bioinfiltration Basin

Drainage Area – 1.78 acres

Location – 4561 147th Ln NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed basin is a standard, single inlet rain garden. The table below provides pollutant removals and estimated costs.



Curb-Cut Bioinfiltration			
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq. ft.
	TP (lb/yr)	0.47	2.1%
	TSS (lb/yr)	148	2.1%
	Volume (acre-feet/yr)	0.35	2.0%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,222**	
	30-yr Average Cost/1,000lb-TSS	**$3,882**	
	30-yr Average Cost/ac-ft Vol.	**$1,641**	

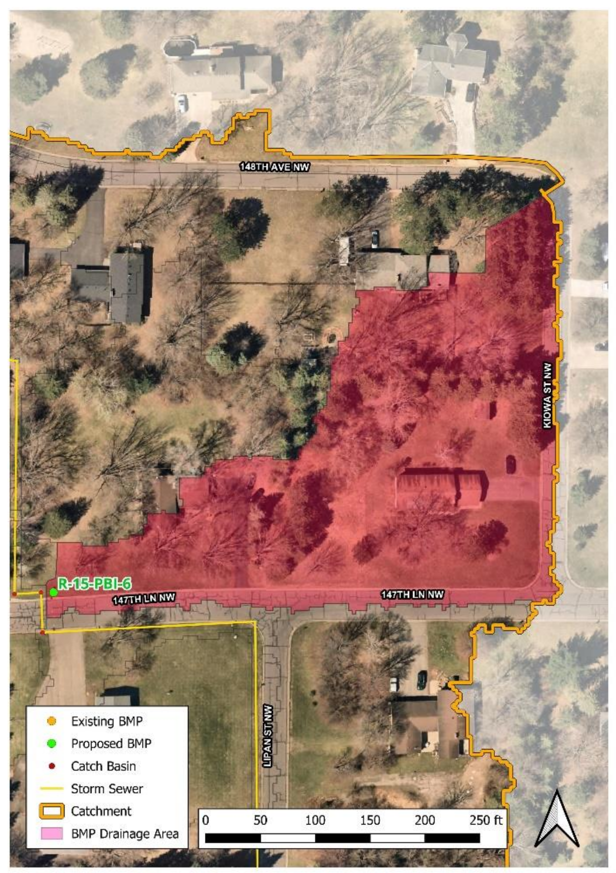
*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-15-PBI-6

147th Ln.
Bioinfiltration Basin



Drainage Area – 2.08 acres

Location – 4531 147th Ln NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed basin is a standard, single inlet rain garden. The table below provides pollutant removals and estimated costs.

Curb-Cut Bioinfiltration

	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq. ft.
	TP (lb/yr)	0.50	2.2%
	TSS (lb/yr)	157	2.3%
	Volume (acre-feet/yr)	0.37	2.1%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,149**	
	30-yr Average Cost/1,000lb-TSS	**$3,659**	
	30-yr Average Cost/ac-ft Vol.	**$1,541**	

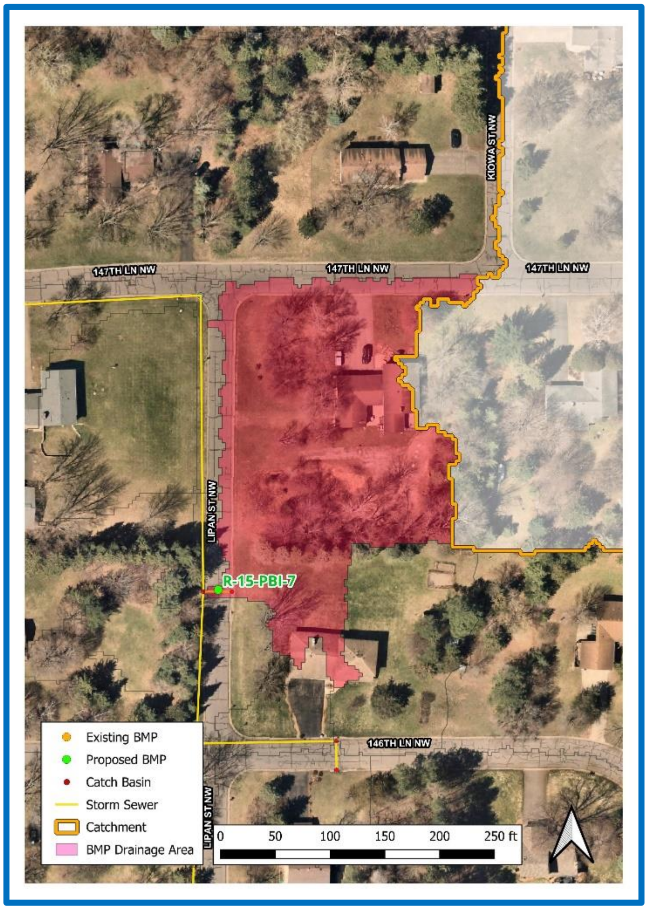
*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-15-PBI-7

146th Ln.
Bioinfiltration Basin



Drainage Area – 1.31 acres

Location – 4477 146th Ln NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed basin is a standard, single inlet rain garden. The table below provides pollutant removals and estimated costs

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq. ft.
	TP (lb/yr)	0.42	1.8%
	TSS (lb/yr)	130	1.9%
	Volume (acre-feet/yr)	0.31	1.7%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,368**	
	30-yr Average Cost/1,000lb-TSS	**$4,419**	
	30-yr Average Cost/ac-ft Vol.	**$1,859**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-15-PBI-8

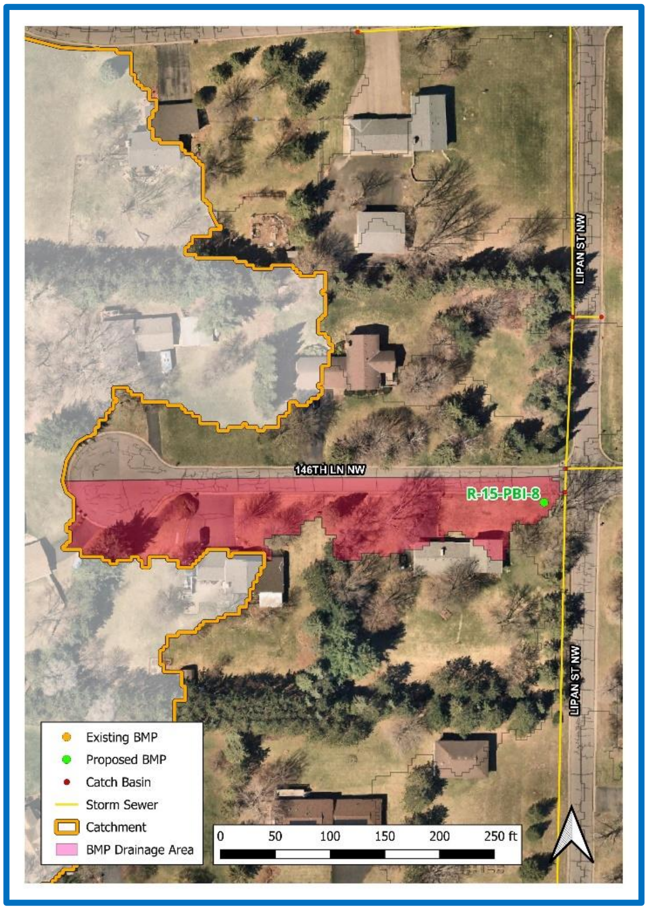
146th Ln.
Bioinfiltration Basin

Drainage Area – 0.64 acres

Location – 4530 146th Ln NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed basin is a standard, single inlet rain garden. The table below provides pollutant removals and estimated costs.



Curb-Cut Bioinfiltration

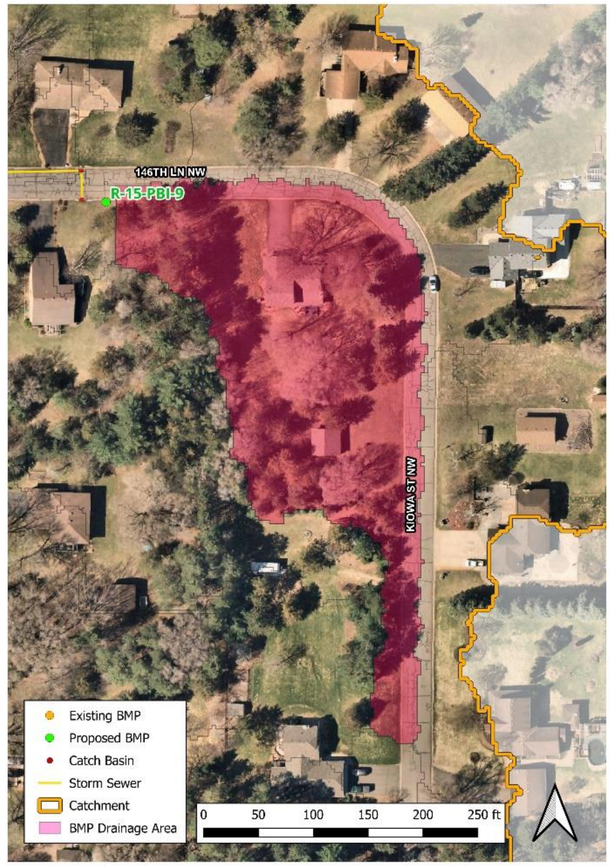
	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Total Size of BMP	250	sq. ft.
Treatment	TP (lb/yr)	0.28	1.2%
Treatment	TSS (lb/yr)	86	1.2%
Treatment	Volume (acre-feet/yr)	0.21	1.2%
Cost	Administration & Promotion Costs*	$664	
Cost	Design & Construction Costs**	$9,820	
Cost	**Total Estimated Project Cost (2023)**	**$10,484**	
Cost	Annual O&M***	$225	
Efficiency	30-yr Average Cost/lb-TP	**$2,052**	
Efficiency	30-yr Average Cost/1,000lb-TSS	**$6,680**	
Efficiency	30-yr Average Cost/ac-ft Vol.	**$2,738**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

Project ID: R-15-PBI-9

146th Ln.
Bioinfiltration Basin



Drainage Area – 1.59 acres

Location – 4484 146th Ln NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed basin is a standard, single inlet rain garden. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq. ft.
	TP (lb/yr)	0.45	2.0%
	TSS (lb/yr)	142	2.1%
	Volume (acre-feet/yr)	0.34	1.9%
Cost	**Administration & Promotion Costs***		$664
	Design & Construction Costs**		$9,820
	Total Estimated Project Cost (2023)		**$10,484**
	Annual O&M***		$225
Efficiency	**30-yr Average Cost/lb-TP**	**$1,277**	
	30-yr Average Cost/1,000lb-TSS	**$4,046**	
	30-yr Average Cost/ac-ft Vol.	**$1,712**	

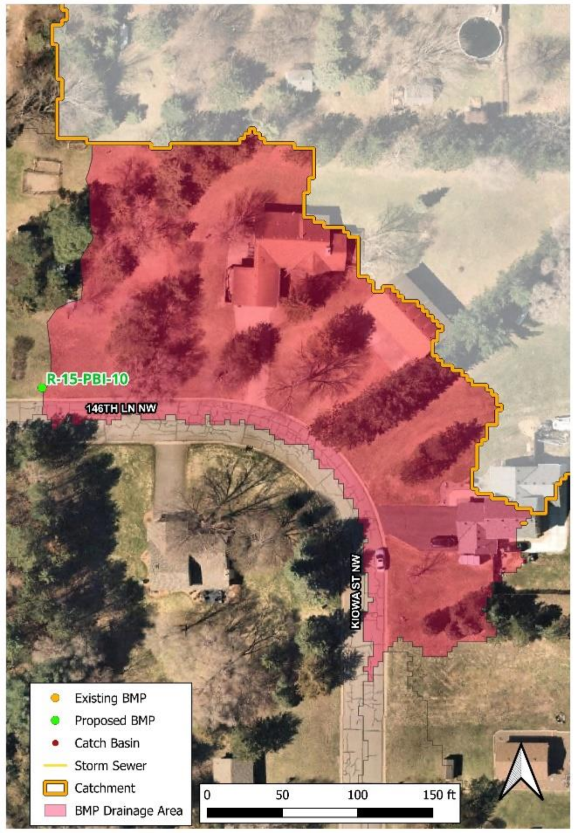
*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-15-PBI-10

146th Ln.
Biofiltration Basin



Drainage Area – 1.24 acres

Location – 4477 146th Ln NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed basin is a standard, single inlet rain garden. The table below provides pollutant removals and estimated costs.

Curb-Cut Bioinfiltration			
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq. ft.
	TP (lb/yr)	0.41	1.8%
	TSS (lb/yr)	126	1.8%
	Volume (acre-feet/yr)	0.30	1.7%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,401**	
	30-yr Average Cost/1,000lb-TSS	**$4,559**	
	30-yr Average Cost/ac-ft Vol.	**$1,904**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-15-PBI-11

146th Ave.
Biofiltration Basin

Drainage Area – 1.0 acres

Location – 4531 146th Ave NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed basin is a standard, single inlet rain garden. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq. ft.
	TP (lb/yr)	0.36	1.6%
	TSS (lb/yr)	111	1.6%
	Volume (acre-feet/yr)	0.27	1.5%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,596**	
	30-yr Average Cost/1,000lb-TSS	**$5,175**	
	30-yr Average Cost/ac-ft Vol.	**$2,132**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-15-PBI-12

146th Ave.
Bioinfiltration Basin

Drainage Area – 0.58 acres

Location – 4530 146th Ave NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed basin is a standard, single inlet rain garden. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq. ft.
	TP (lb/yr)	0.26	1.1%
	TSS (lb/yr)	80	1.2%
	Volume (acre-feet/yr)	0.20	1.1%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$2,209**	
	30-yr Average Cost/1,000lb-TSS	**$7,181**	
	30-yr Average Cost/ac-ft Vol.	**$2,931**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-15-PBI-13

Lipan St.
Bioinfiltration Basin

Drainage Area – 2.36 acres

Location – 14557 Lipan St NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed basin is a standard, single inlet rain garden. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq. ft.
	TP (lb/yr)	0.52	2.3%
	TSS (lb/yr)	164	2.4%
	Volume (acre-feet/yr)	0.39	2.2%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,105**	
	30-yr Average Cost/1,000lb-TSS	**$3,503**	
	30-yr Average Cost/ac-ft Vol.	**$1,475**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID:
R-15-PBI-14

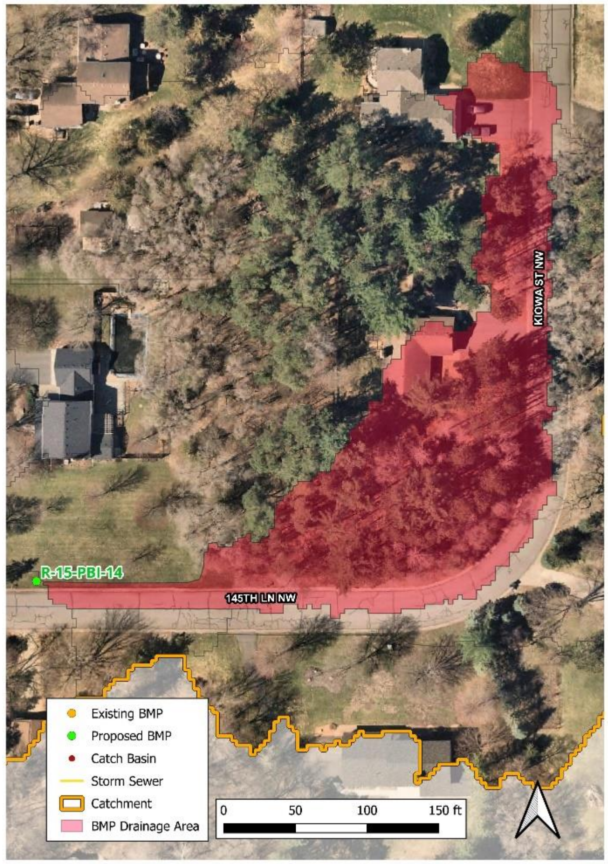
Lipan St.
Bioinfiltration Basin

Drainage Area – 0.97 acres

Location – 14557 Lipan St NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed basin is a standard, single inlet rain garden. The table below provides pollutant removals and estimated costs.



	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq. ft.
	TP (lb/yr)	0.35	1.5%
	TSS (lb/yr)	109	1.6%
	Volume (acre-feet/yr)	0.27	1.5%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,641**	
	30-yr Average Cost/1,000lb-TSS	**$5,270**	
	30-yr Average Cost/ac-ft Vol.	**$2,166**	

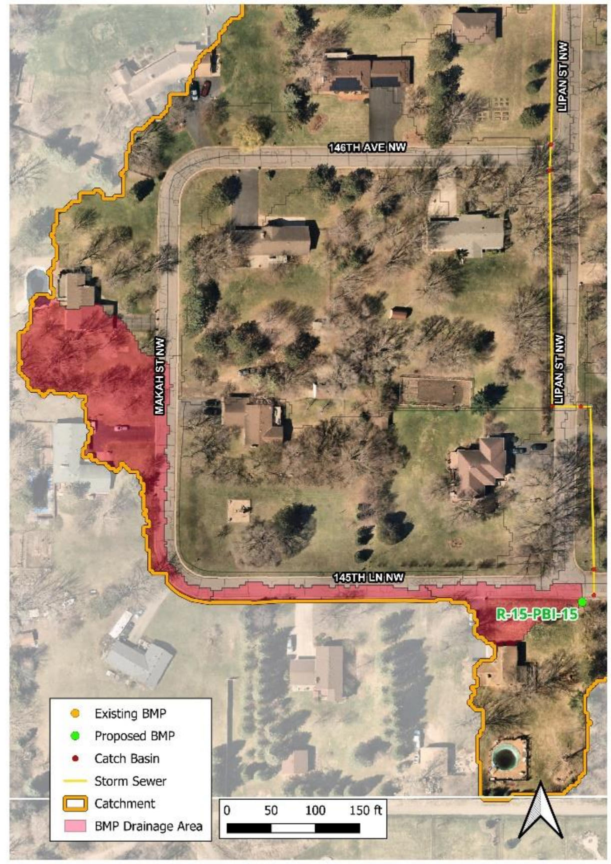
*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-15-PBI-15

145th Ln.
Bioinfiltration Basin



Drainage Area – 0.83 acres

Location – 4520 145th Ln NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed basin is a standard, single inlet rain garden. The table below provides pollutant removals and estimated costs.

Curb-Cut Bioinfiltration			
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq. ft.
	TP (lb/yr)	0.33	1.5%
	TSS (lb/yr)	100	1.5%
	Volume (acre-feet/yr)	0.24	1.4%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,741**	
	30-yr Average Cost/1,000lb-TSS	**$5,745**	
	30-yr Average Cost/ac-ft Vol.	**$2,352**	

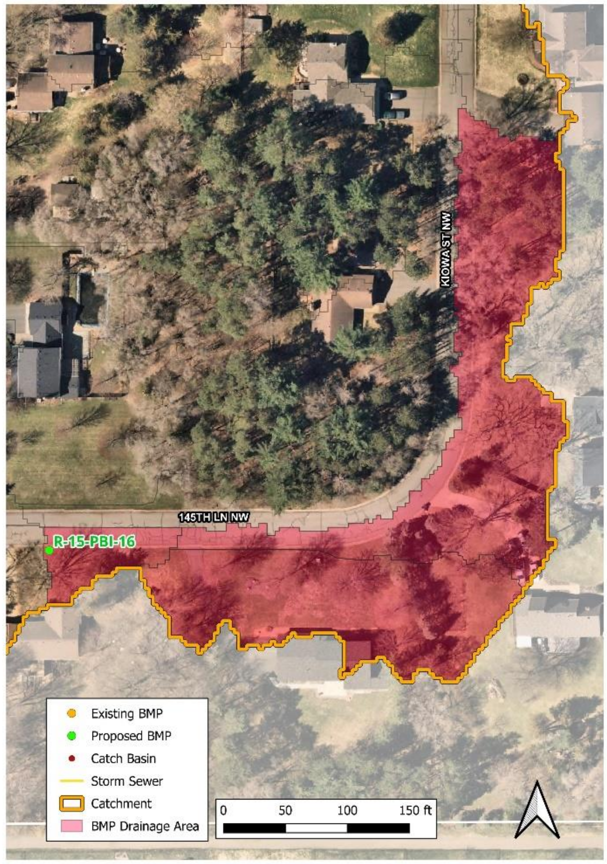
*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-15-PBI-16

145th Ave.
Biofiltration Basin



Drainage Area – 1.37 acres

Location – 4488 145th Ln NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed basin is a standard, single inlet rain garden. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq. ft.
	TP (lb/yr)	0.42	1.8%
	TSS (lb/yr)	132	1.9%
	Volume (acre-feet/yr)	0.31	1.8%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,368**	
	30-yr Average Cost/1,000lb-TSS	**$4,352**	
	30-yr Average Cost/ac-ft Vol.	**$1,826**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-15-PBI-17

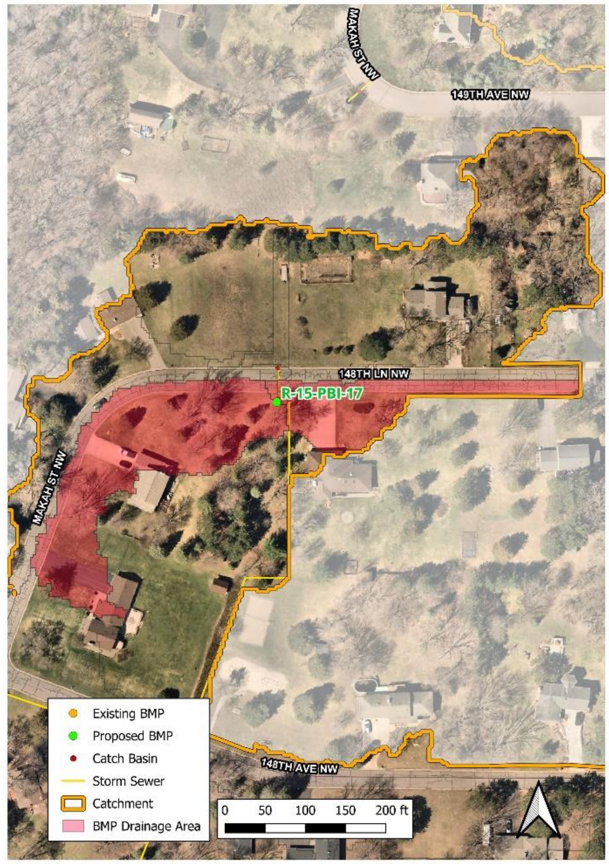
Makah St.
Bioinfiltration Basin

Drainage Area – 1.24 acres

Location – 14875 Makah St NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed basin is a large, double inlet rain garden. The table below provides pollutant removals and estimated costs.



Curb-Cut Bioinfiltration

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Total Size of BMP	500	sq. ft.
	TP (lb/yr)	0.55	2.4%
	TSS (lb/yr)	167	2.4%
	Volume (acre-feet/yr)	0.41	2.3%
Cost	Administration & Promotion Costs*	$664	
	Design & Construction Costs**	$16,320	
	Total Estimated Project Cost (2023)	**$16,984**	
	Annual O&M***	$225	
Efficiency	30-yr Average Cost/lb-TP	**$1,438**	
	30-yr Average Cost/1,000lb-TSS	**$4,737**	
	30-yr Average Cost/ac-ft Vol.	**$1,932**	

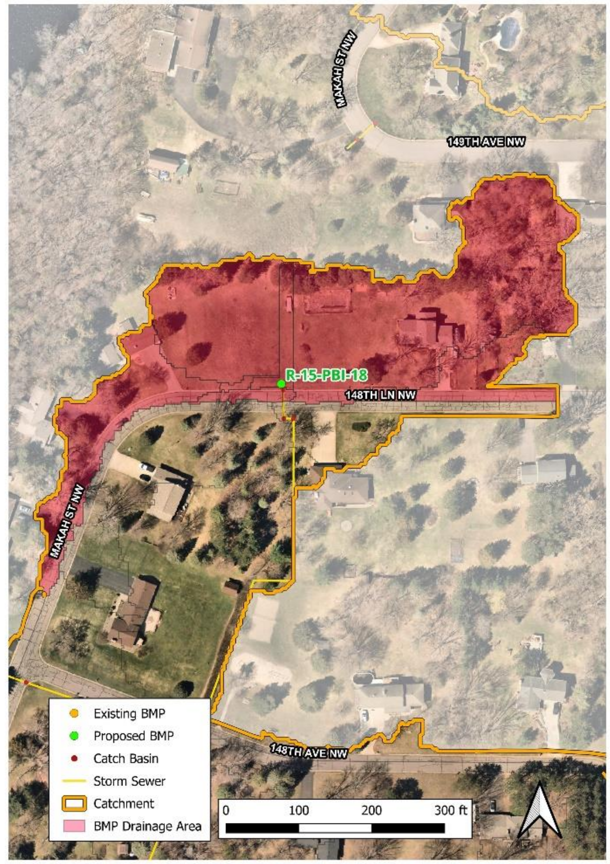
*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-15-PBI-18

148th Ave.
Bioinfiltration Basin



Drainage Area – 3.13 acres

Location – 4511 148th Ln NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed basin is a large, double inlet rain garden. The table below provides pollutant removals and estimated costs.

Curb-Cut Bioinfiltration

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Total Size of BMP	500	sq. ft.
	TP (lb/yr)	0.89	3.9%
	TSS (lb/yr)	280	4.1%
	Volume (acre-feet/yr)	0.66	3.7%
Cost	Administration & Promotion Costs*	$664	
	Design & Construction Costs**	$16,320	
	Total Estimated Project Cost (2023)	**$16,984**	
	Annual O&M***	$225	
Efficiency	30-yr Average Cost/lb-TP	**$889**	
	30-yr Average Cost/1,000lb-TSS	**$2,825**	
	30-yr Average Cost/ac-ft Vol.	**$1,194**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-15-PBI-19

Lipan St.
Bioinfiltration Basin

Drainage Area – 0.25 acres

Location – 14544 Lipan St NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed basin is a standard, single inlet rain garden. The table below provides pollutant removals and estimated costs.

Curb-Cut Bioinfiltration			
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq. ft.
	TP (lb/yr)	0.13	0.6%
	TSS (lb/yr)	38	0.6%
	Volume (acre-feet/yr)	0.10	0.6%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$4,419**	
	30-yr Average Cost/1,000lb-TSS	**$15,118**	
	30-yr Average Cost/ac-ft Vol.	**$5,849**	

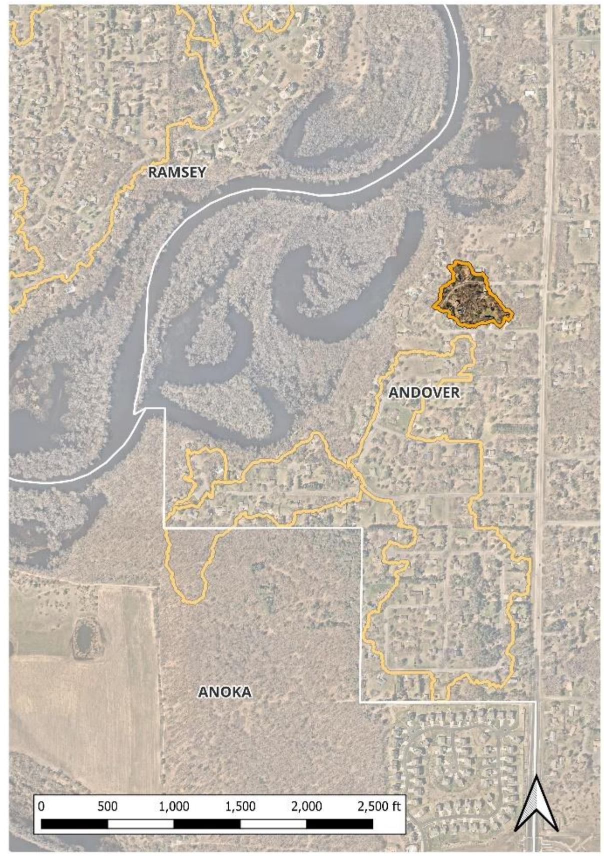
*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Catchment R-16

Existing Catchment Summary	
Acres	3.57
Parcels	9
Land Cover	100% Residential



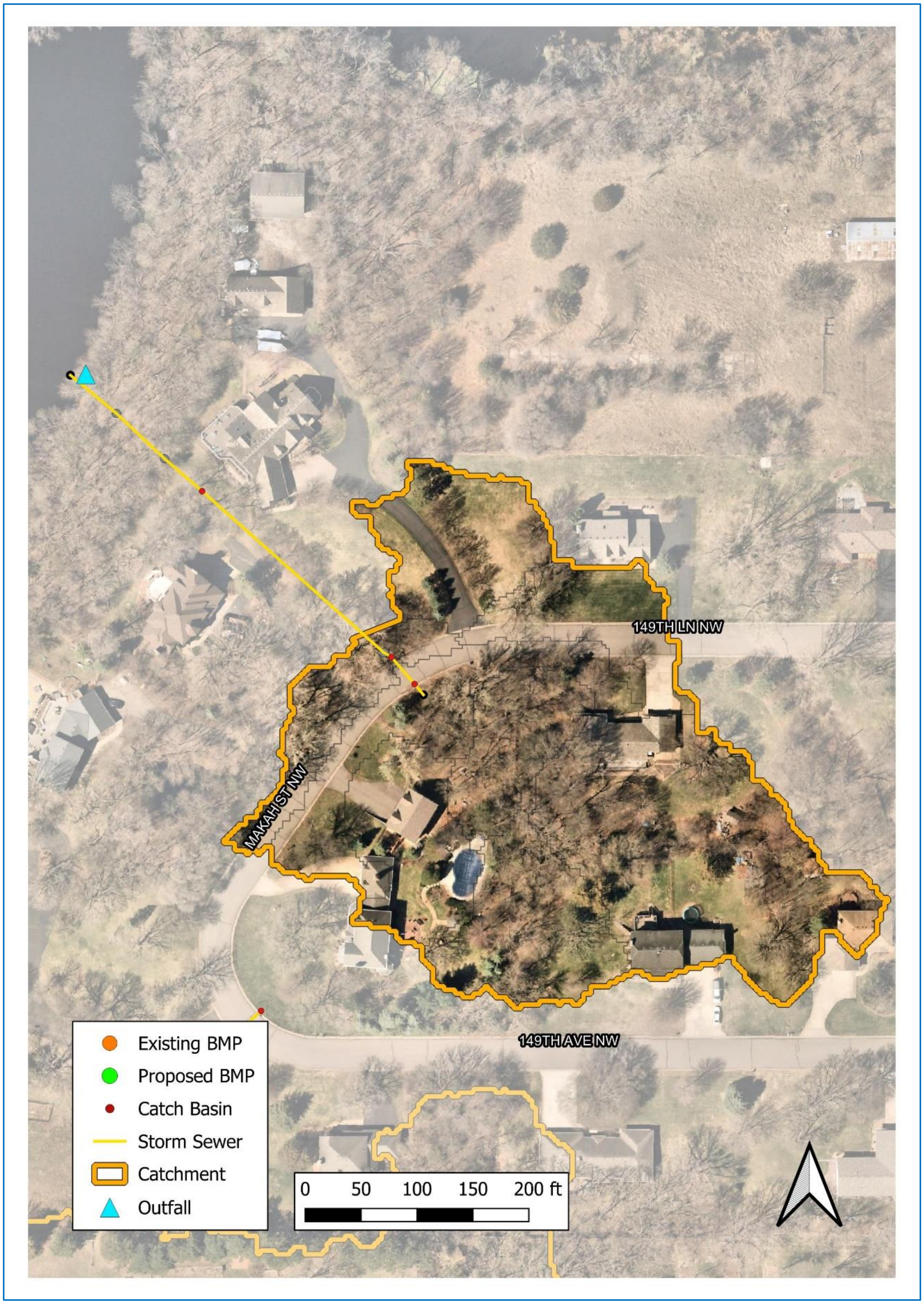
CATCHMENT DESCRIPTION
This catchment is located in a residential neighborhood of Andover on the east side of the Rum River. Stormwater runoff is routed along 149th Ln and Makah St. prior to entering catch basins that discharge to the Rum River. The contributing drainage area is small and is largely pervious (i.e. residential backyard areas).

EXISTING STORMWATER TREATMENT
Street cleaning is conducted once in early spring and once in fall by the City of Andover. No other existing stormwater treatment exists in this catchment. Present day stormwater pollutant loading and treatment is summarized in the table below.

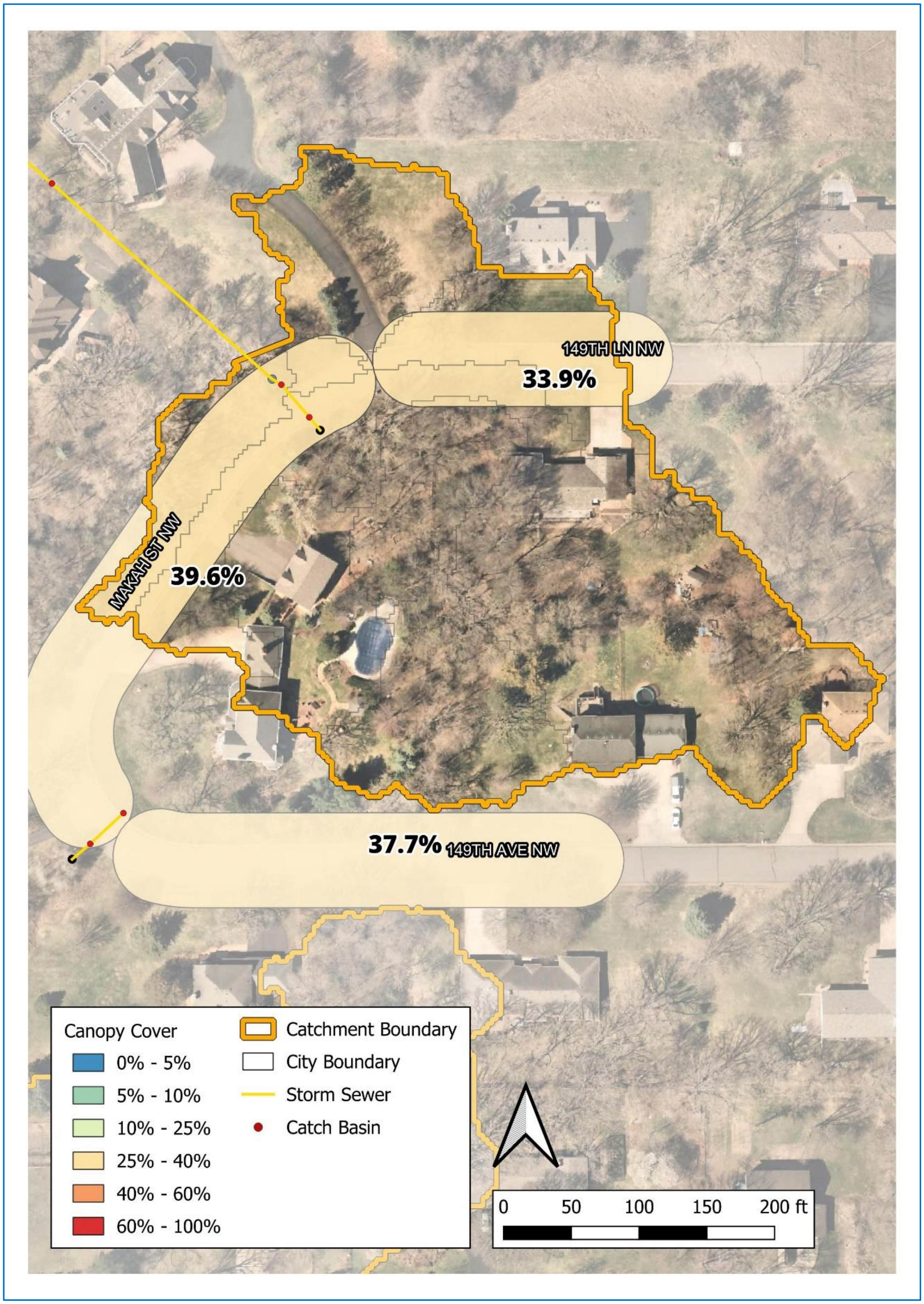
	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	1			
	BMP Types	Street Cleaning			
	TP (lb/yr)	1.99	0.16	8%	**1.83**
	TSS (lb/yr)	623	68	11%	**555**
	Volume (acre-feet/yr)	1.4	0.00	0%	**1.4**

RETROFITS CONSIDERED
No retrofits were considered for this catchment due to the small size of the subcatchments. One project considered was to daylight the existing storm sewer pipe into an existing bioinfiltration basin near the outfall. This would provide treatment to the majority of the catchment, however, this was rejected as it was determined that a project would not be feasible due to general interferences, unknown storm infrastructure depth, and coordination for multiple landowners.

EXISTING STORMWATER TREATMENT AND RETROFIT OPPORTUNITIES

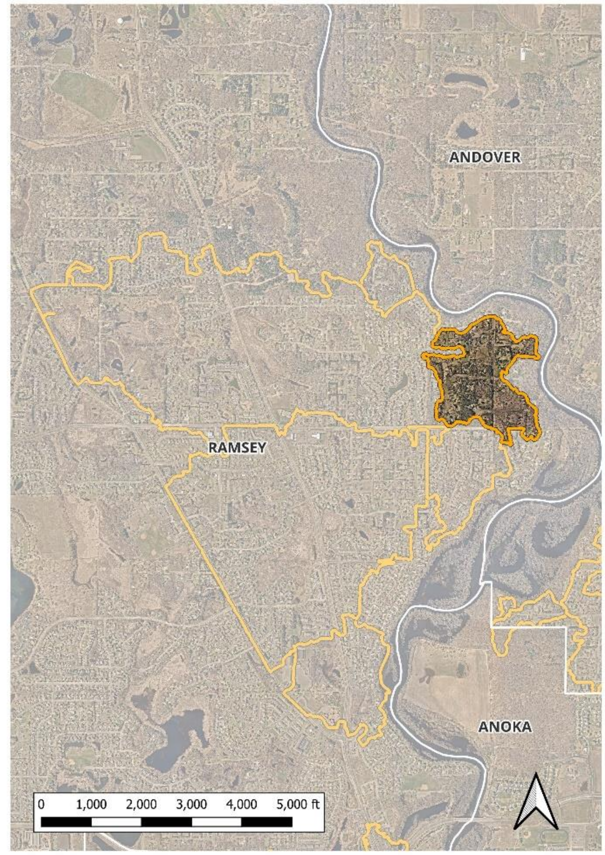


ROAD TREE CANOPY COVER



Catchment R-17

Existing Catchment Summary	
Acres	78.1
Parcels	72
Land Cover	86.4% Residential 7.5% Open 6.1% Park



CATCHMENT DESCRIPTION

This catchment is located in a residential neighborhood of Ramsey on the west side of the Rum River. Land use is primarily residential with open land and park property throughout. Stormwater runoff is collected in multiple catch basins prior to discharging into an existing bioinfiltration area near the end of 155th Ln.

EXISTING STORMWATER TREATMENT

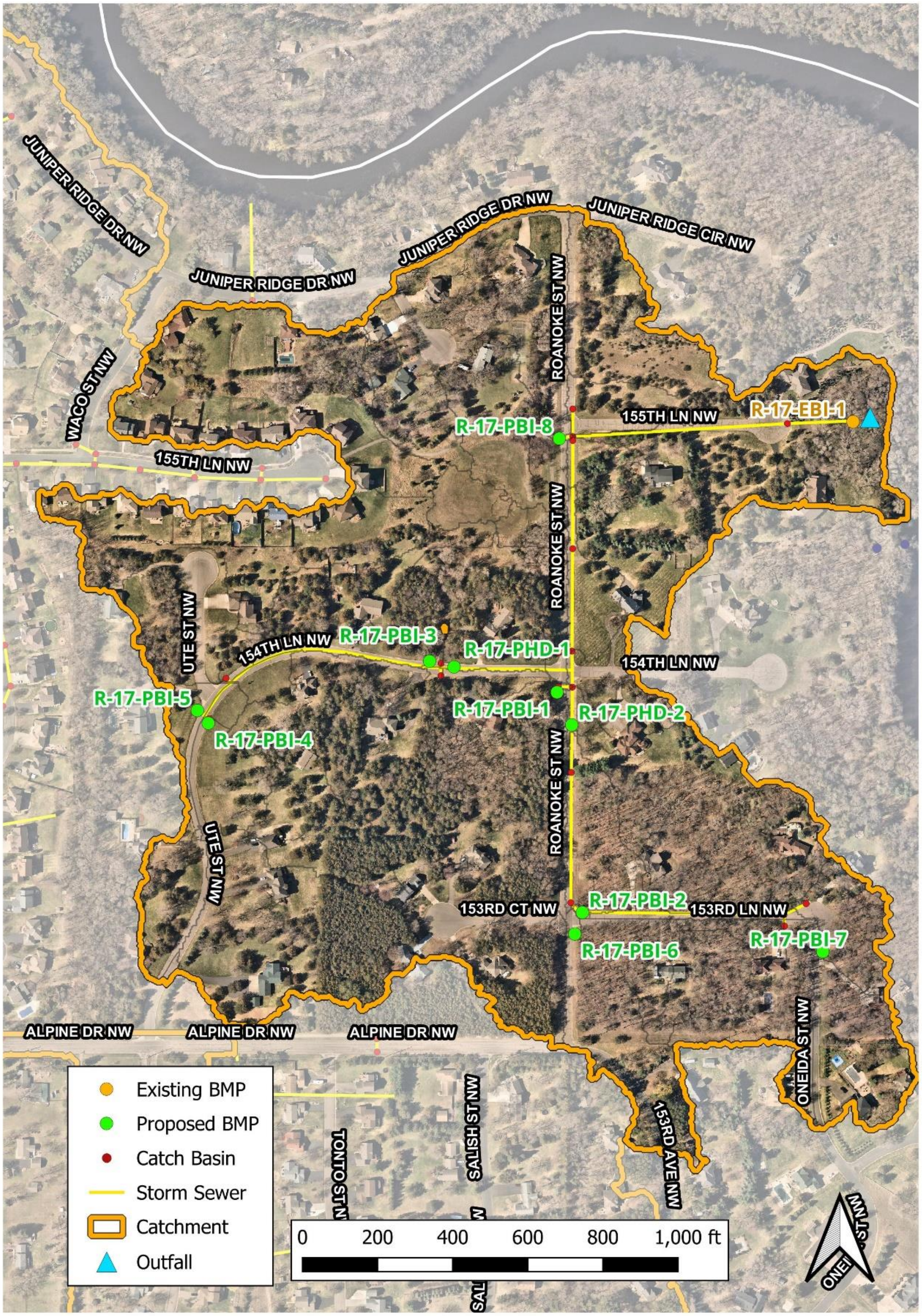
This catchment contains one bioinfiltration basin near the outfall that treats the entire catchment. While this area is large and provides significant treatment to the catchment, it is in close proximity to the Rum River and within the river's floodplain. As a result, the modeled infiltration rate for this bioinfiltration basin was reduced by half to 0.8"/hour (1.63"/hour is typical for sandy soils) to account for factors such as flooding and accumulation of excess leaf debris that would negatively impact the basin's maximum infiltration rate. In addition, street cleaning is conducted once in spring and once in fall by the City of Ramsey. Present day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	2			
	BMP Types	Street Cleaning, Infiltration Basin (EBI-1)			
	TP (lb/yr)	39.62	28.98	73%	**10.64**
	TSS (lb/yr)	12,415	9,422	76%	**2,993**
	Volume (acre-feet/yr)	28.4	19.48	69%	**8.9**

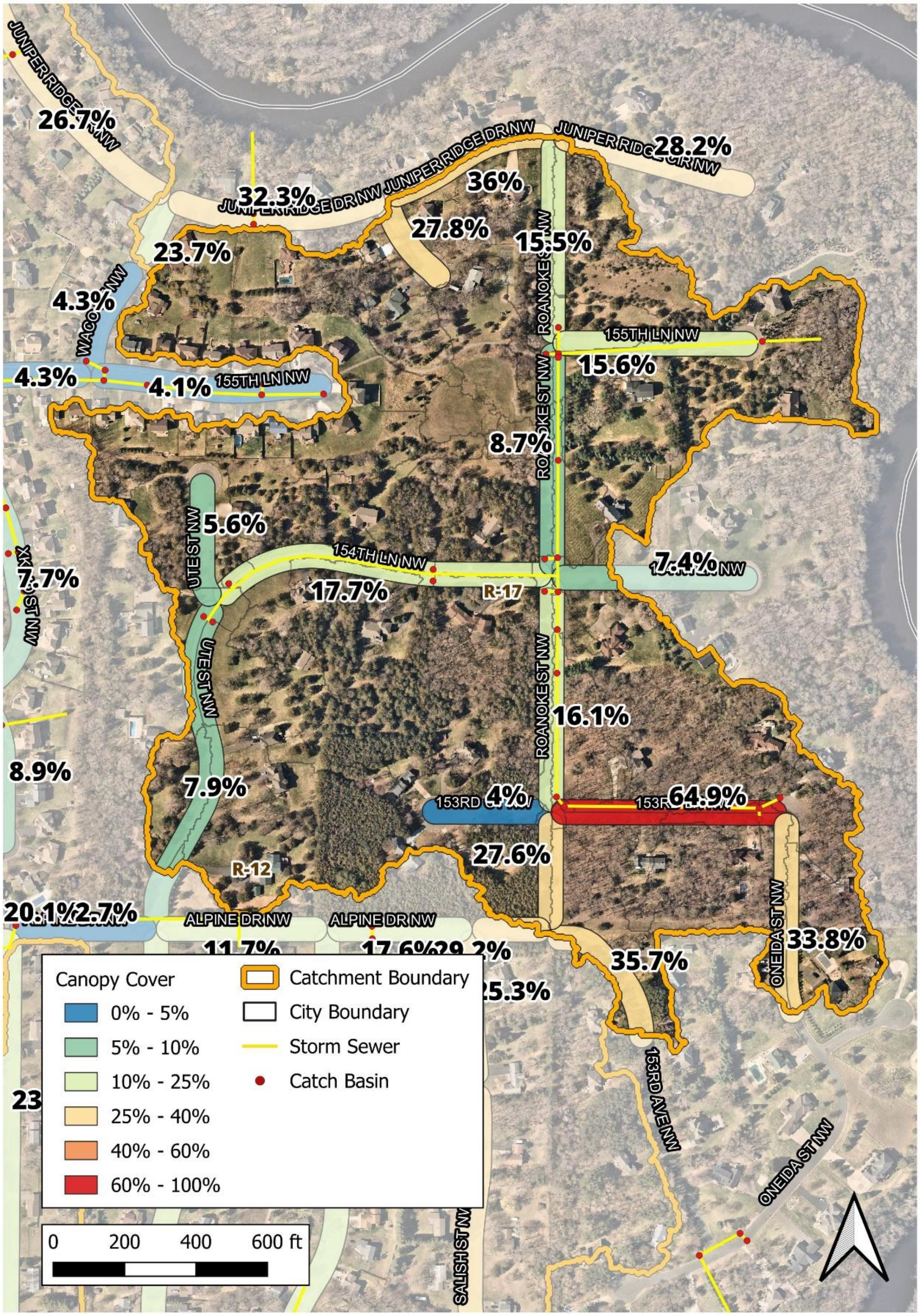
RETROFITS CONSIDERED

Multiple BMPs are proposed within this catchment. They include eight bioinfiltration basins and two hydrodynamic separators.

EXISTING STORMWATER TREATMENT AND RETROFIT OPPORTUNITIES



ROAD TREE CANOPY COVER



Project ID:
R-17-PBI-1

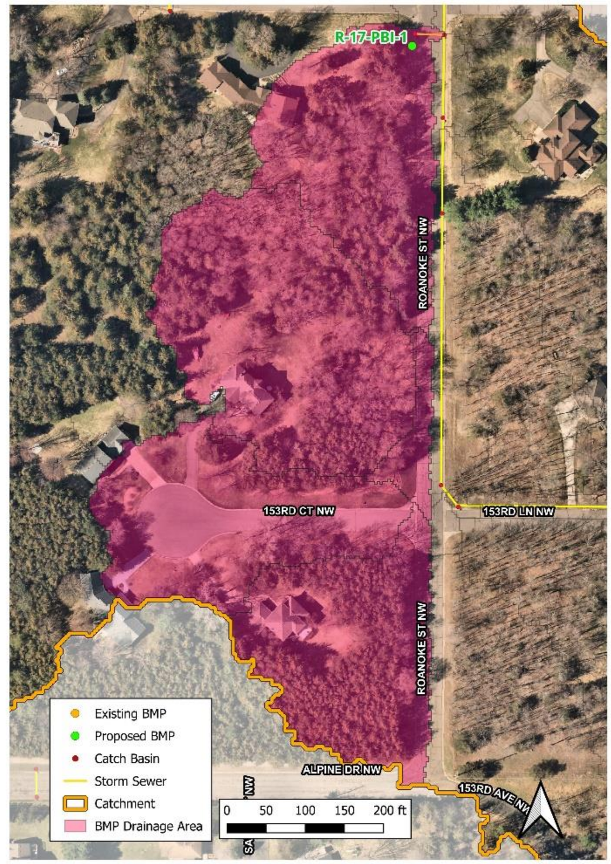
154th Ln.
Bioinfiltration Basin

Drainage Area – 6.37 acres

Location – 4580 154th Ln. NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed location is within the front yard of a private residential house. The proposed basin is a standard, single inlet rain garden that would treat stormwater collected on Roanoke St. NW from the south. The table below provides pollutant removals and estimated costs.



Curb-Cut Bioinfiltration			
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq ft
	TP (lb/yr)	0.12	1.1%
	TSS (lb/yr)	37	1.2%
	Volume (acre-feet/yr)	0.10	1.1%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$4,787**	
	30-yr Average Cost/1,000lb-TSS	**$15,526**	
	30-yr Average Cost/ac-ft Vol.	**$5,982**	

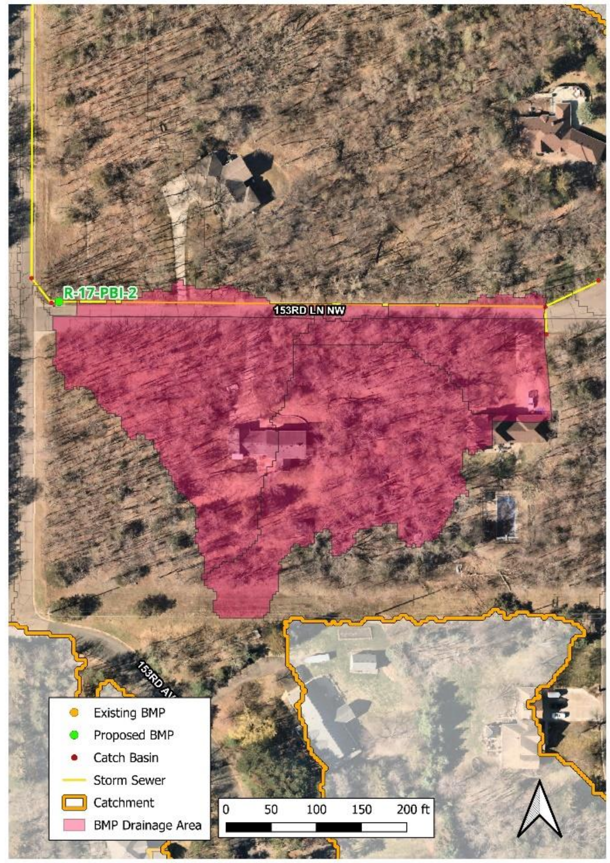
*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-17-PBI-2

153rd Ln.
Bioinfiltration Basin



Drainage Area – 2.77 acres

Location – 4761 153rd Ln NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed location is within the front yard of a private residential house. The proposed basin is a large, single inlet rain garden that would treat stormwater collected on 153rd Ln. to the east. Additionally, there is an opportunity to model this as a large, double inlet rain garden that would treat stormwater runoff collected on both 153rd Ln. to the east and Roanoke St. to the north. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq. ft.
	TP (lb/yr)	0.12	1.1%
	TSS (lb/yr)	37	1.2%
	Volume (acre-feet/yr)	0.10	1.1%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$4,787**	
	30-yr Average Cost/1,000lb-TSS	**$15,526**	
	30-yr Average Cost/ac-ft Vol.	**$5,871**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-17-PBI-3

154th Ln.
Bioinfiltration Basin

Drainage Area – 0.96 acres

Location – 4899 154th Ln NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed location is within the front yard of a private residential house. The proposed basin is a standard, single inlet rain garden that would treat stormwater collected on 154th Ln. from the west. The table below provides pollutant removals and estimated costs.

Curb-Cut Bioinfiltration

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Total Size of BMP	250	sq. ft.
	TP (lb/yr)	0.13	1.2%
	TSS (lb/yr)	41	1.4%
	Volume (acre-feet/yr)	0.11	1.2%
Cost	Administration & Promotion Costs*		$664
	Design & Construction Costs**		$9,820
	Total Estimated Project Cost (2023)		**$10,484**
	Annual O&M***		$225
Efficiency	30-yr Average Cost/lb-TP	**$4,419**	
	30-yr Average Cost/1,000lb-TSS	**$14,011**	
	30-yr Average Cost/ac-ft Vol.	**$5,401**	

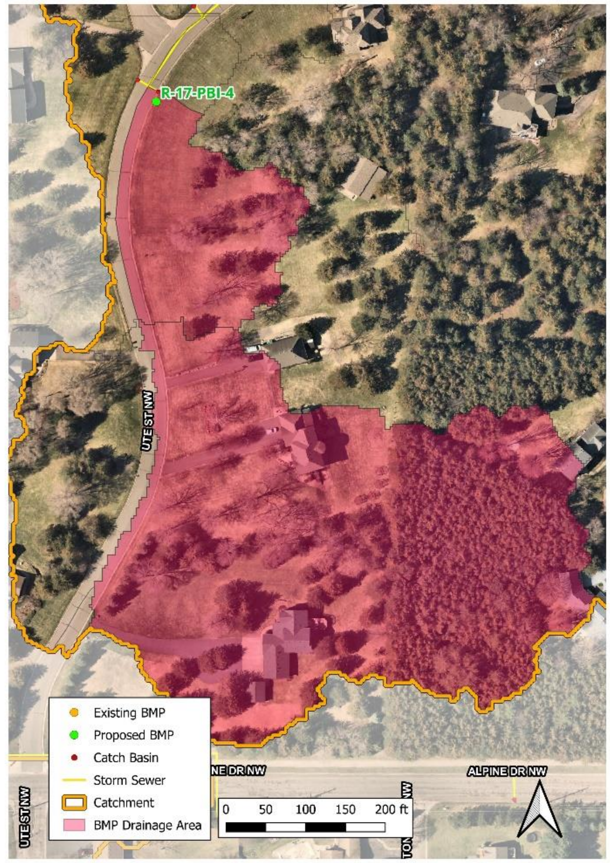
*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-17-PBI-4

154th Ln.
Bioinfiltration Basin



Drainage Area – 6.11 acres

Location – 4920 154th Ln NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed location is within the front yard of a private residential house. The proposed basin is a standard, single inlet rain garden that would treat stormwater collected on Ute St. NW from the south. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq. ft.
	TP (lb/yr)	0.12	1.1%
	TSS (lb/yr)	37	1.2%
	Volume (acre-feet/yr)	0.10	1.1%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$4,787**	
	30-yr Average Cost/1,000lb-TSS	**$15,526**	
	30-yr Average Cost/ac-ft Vol.	**$5,952**	

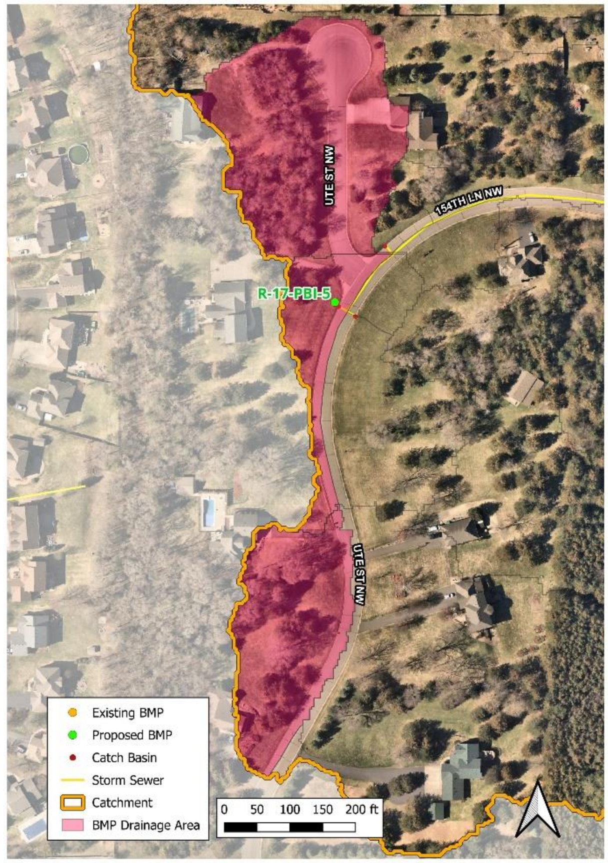
*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-17-PBI-5

Ute St.
Bioinfiltration Basin



Drainage Area – 3.70 acres

Location – 15390 Ute St NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed location is within the front yard of a private residential house. The proposed basin is a large, double inlet rain garden that would treat stormwater collected on Ute St. from both the north and the south. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	500	sq. ft.
	TP (lb/yr)	0.25	2.3%
	TSS (lb/yr)	76	2.5%
	Volume (acre-feet/yr)	0.20	2.2%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$16,320	
	Total Estimated Project Cost (2023)	**$16,984**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$3,165**	
	30-yr Average Cost/1,000lb-TSS	**$10,410**	
	30-yr Average Cost/ac-ft Vol.	**$3,978**	

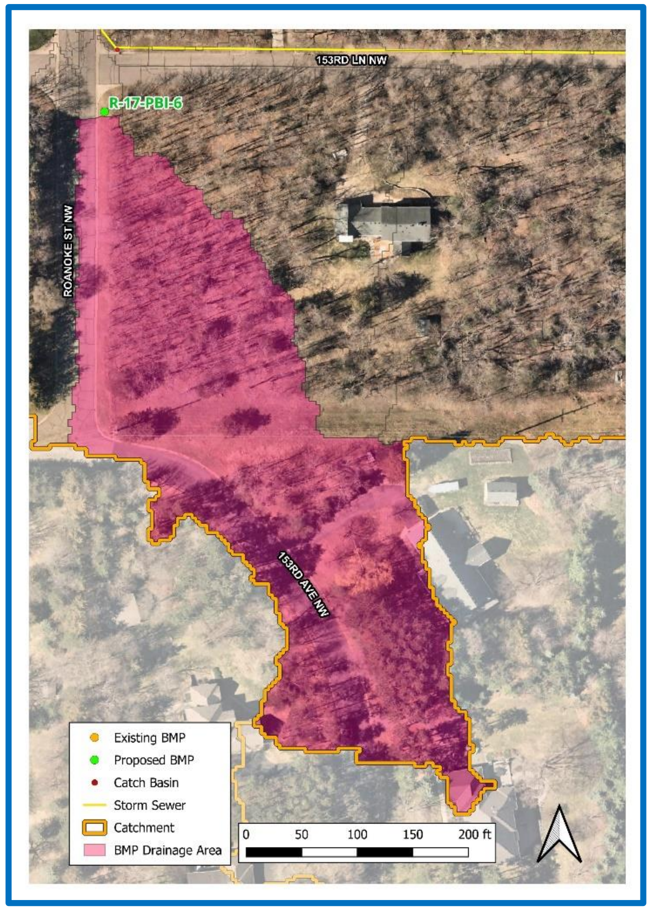
*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-17-PBI-6

153rd Ln.
Bioinfiltration Basin



Drainage Area – 2.31 acres

Location – 4760 153rd Ln NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed location is within the front yard of a private residential house. This area contains several trees that may need to be cleared to install a rain garden at this location. The proposed basin is a standard, single inlet rain garden that would treat stormwater collected on Roanoke St. from the south. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq. ft.
	TP (lb/yr)	0.12	1.1%
	TSS (lb/yr)	38	1.3%
	Volume (acre-feet/yr)	0.10	1.1%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$4,787**	
	30-yr Average Cost/1,000lb-TSS	**$15,118**	
	30-yr Average Cost/ac-ft Vol.	**$5,790**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID:
R-17-PBI-7

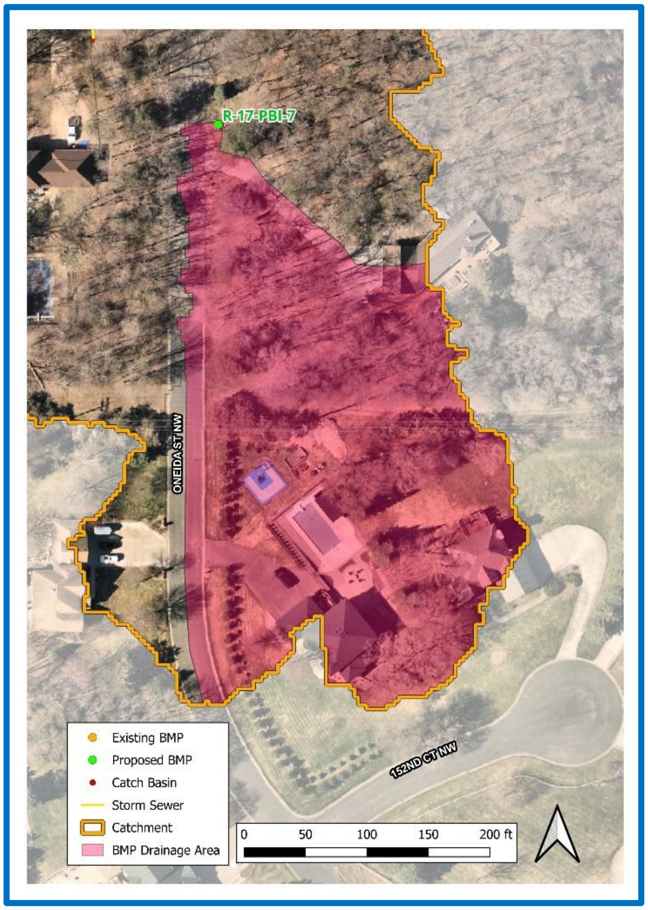
Oneida St.
Bioinfiltration Basin

Drainage Area – 2.07 acres

Location – 15321 Oneida St NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed location is within the front yard of a private residential house. This area contains several trees that may need to be cleared to install a rain garden at this location. The proposed basin is a standard, single inlet rain garden that would treat stormwater collected on Oneida St. from the south. The table below provides pollutant removals and estimated costs.



Curb-Cut Bioinfiltration			
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq. ft.
	TP (lb/yr)	0.13	1.2%
	TSS (lb/yr)	38	1.3%
	Volume (acre-feet/yr)	0.10	1.1%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$4,419**	
	30-yr Average Cost/1,000lb-TSS	**$15,118**	
	30-yr Average Cost/ac-ft Vol.	**$5,729**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-17-PBI-8

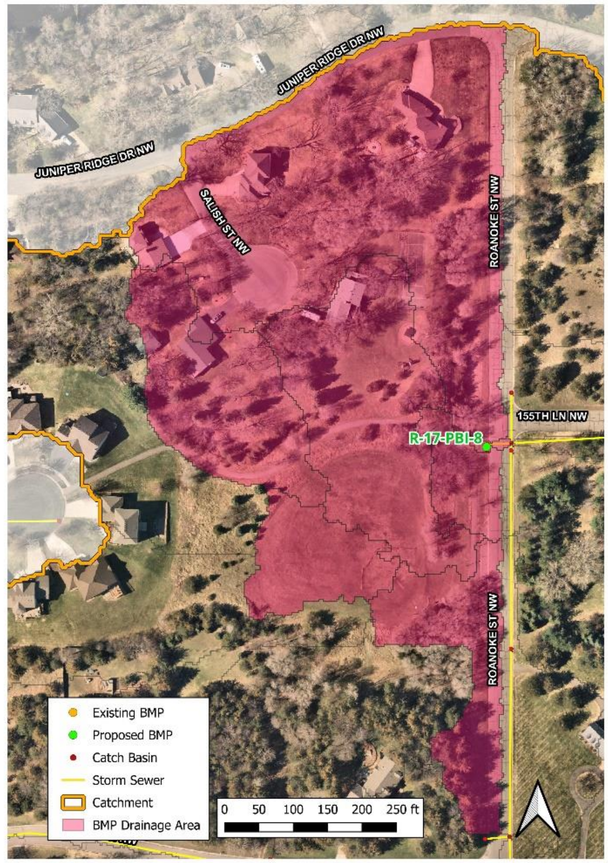
Bear Park
Bioinfiltration Basin

Drainage Area – 9.01 acres

Location – 15500 Roanoke St NW

Property Ownership – City of Ramsey

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed location is within the City of Ramsey Bear Park property. The proposed basin is a large, double inlet rain garden that would treat stormwater collected on Roanoke St. from both the north and the south. The table below provides pollutant removals and estimated costs.



	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	500	sq. ft.
	TP (lb/yr)	0.25	2.3%
	TSS (lb/yr)	75	2.5%
	Volume (acre-feet/yr)	0.19	2.1%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$16,320	
	Total Estimated Project Cost (2023)	**$16,984**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$3,165**	
	30-yr Average Cost/1,000lb-TSS	**$10,548**	
	30-yr Average Cost/ac-ft Vol.	**$4,129**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-17-PHD-1

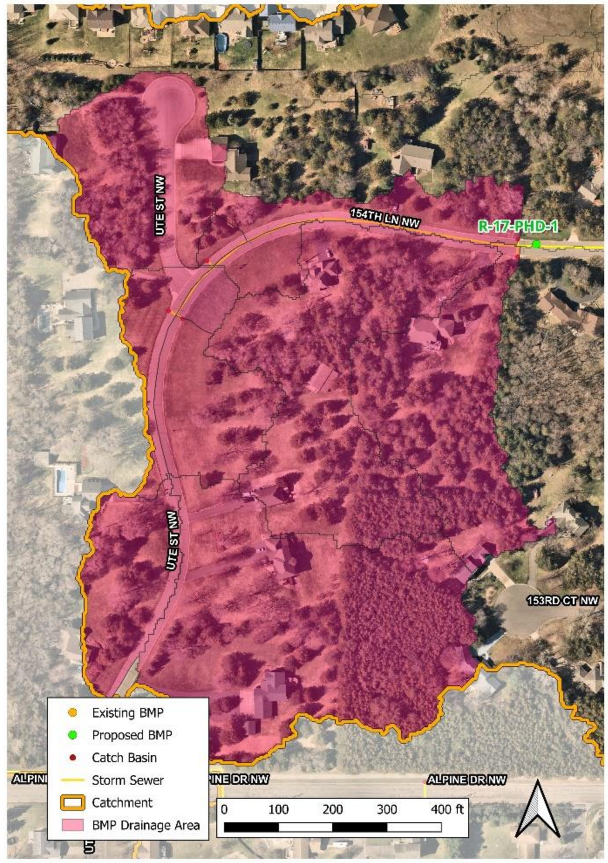
154th Ln.
Hydrodynamic Device

Drainage Area – 17.2 acres

Location – West of the intersection of 154th Ln. NW and Roanoke St. NW

Property Ownership – City of Ramsey

Site Specific Information – A hydrodynamic device is proposed in line with the storm sewer line on 154th Ln. A device at this location would provide treatment to the southwestern portion of the catchment. The table below provides pollutant removals and estimated costs.



	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	10	ft diameter
	TP (lb/yr)	0.20	1.9%
	TSS (lb/yr)	80	2.7%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***	$3,750	
	Design & Construction Costs**	$150,000	
	Total Estimated Project Cost (2023)	**$153,750**	
	Annual O&M***	$210	
Efficiency	**30-yr Average Cost/lb-TP**	**$26,675**	
	30-yr Average Cost/1,000lb-TSS	**$66,688**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

*Indirect Cost: (25 hours at $150/hour)

**Direct Cost: ($100,000 for materials) + ($50,000 for labor and installation costs)

***Per BMP: (1 cleaning/year)*(3 hours/cleaning)*($70/hour)

Project ID: R-17-PHD-2

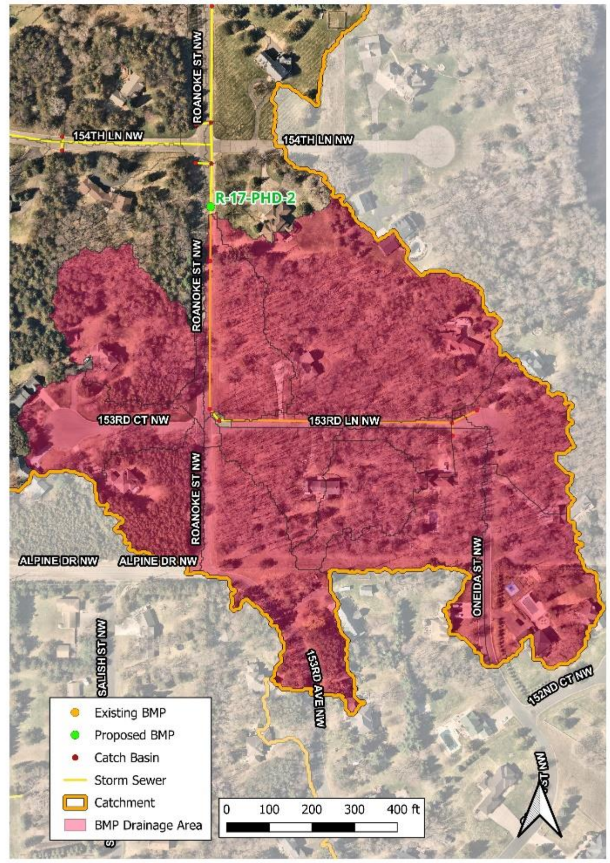
Roanoke St.
Hydrodynamic Device

Drainage Area – 23.0 acres

Location – South of the intersection of 154th Ln. NW and Roanoke St. NW

Property Ownership – City of Ramsey

Site Specific Information – A hydrodynamic device is proposed in line with the storm sewer line on 154th Ln. A device at this location would provide treatment to the southeastern portion of the catchment. The table below provides pollutant removals and estimated costs.



	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	10	ft diameter
	TP (lb/yr)	0.24	2.3%
	TSS (lb/yr)	93	3.1%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***	$3,750	
	Design & Construction Costs**	$150,000	
	Total Estimated Project Cost (2023)	**$153,750**	
	Annual O&M***	$210	
Efficiency	**30-yr Average Cost/lb-TP**	**$22,229**	
	30-yr Average Cost/1,000lb-TSS	**$57,366**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

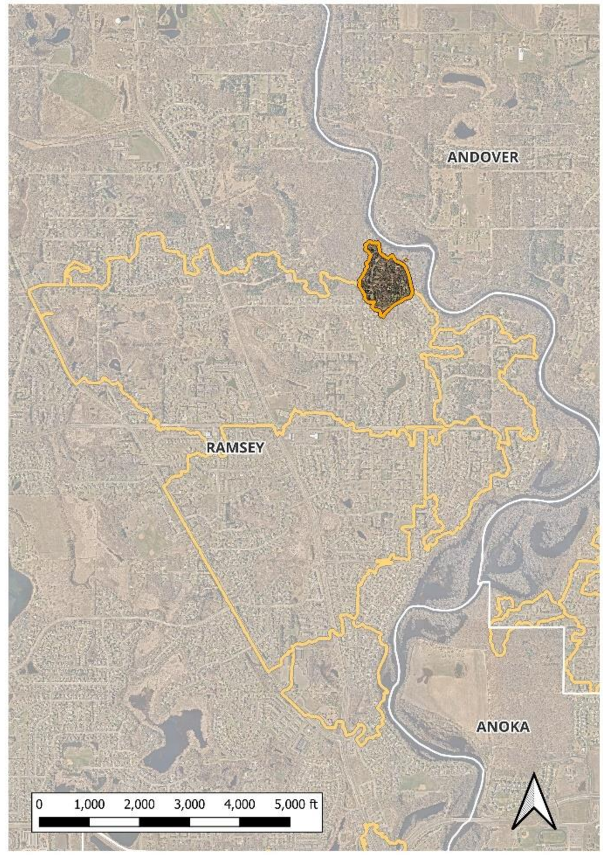
*Indirect Cost: (25 hours at $150/hour)

**Direct Cost: ($100,000 for materials) + ($50,000 for labor and installation costs)

***Per BMP: (1 cleaning/year)*(3 hours/cleaning)*($70/hour)

Catchment R-18

Existing Catchment Summary	
Acres	20.9
Parcels	29
Land Cover	93.4% Residential 6.6% Park



CATCHMENT DESCRIPTION

This catchment is located in Ramsey and primarily consists of single-family residential housing. Stormwater is collected into catch basins prior to discharging directly into the Rum River. Catchment R-18 itself is the most downstream portion of the greater Catchment R-12 area. Because the outfall at Catchment R-12 has been decommissioned, both catchments are effectively the same and share the same outfall. For the purposes of analysis, these catchments remain split as this particular section was noted to have no existing treatment.

EXISTING STORMWATER TREATMENT

Street cleaning is conducted once in the spring and once in the fall by the City of Ramsey. No other existing stormwater treatment exists in this catchment. Present day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	1			
	BMP Types	Street Cleaning			
	TP (lb/yr)	11.20	0.88	8%	**10.32**
	TSS (lb/yr)	3,518	382	11%	**3,136**
	Volume (acre-feet/yr)	8.1	0.00	0%	**8.1**

RETROFITS CONSIDERED

Five bioinfiltration basins and one hydrodynamic device are proposed within this catchment.

EXISTING STORMWATER TREATMENT AND RETROFIT OPPORTUNITIES

Project ID: R-18-PBI-1

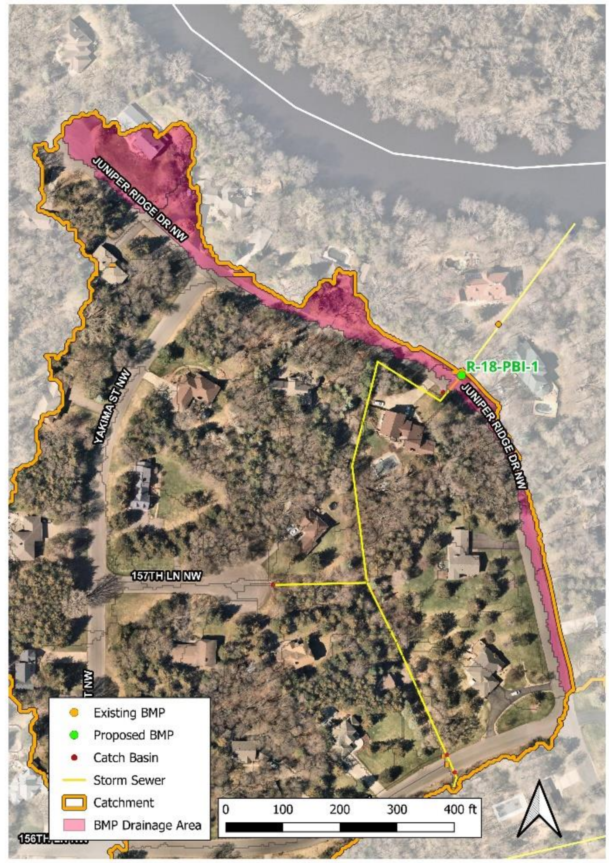
Juniper Ridge Dr. NW
Bioinfiltration Basin

Drainage Area – 1.45 acres

Location – 15775 / 15765 Juniper Ridge Dr. NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed location is within the front yard of a private residential house. The proposed basin is a large, double inlet rain garden that would treat stormwater collected on Juniper Ridge Dr. from both the west and the east. The table below provides pollutant removals and estimated costs.



Curb-Cut Bioinfiltration

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Total Size of BMP	500	sq ft
	TP (lb/yr)	0.59	5.7%
	TSS (lb/yr)	184	5.9%
	Volume (acre-feet/yr)	0.45	5.6%
Cost	Administration & Promotion Costs*	$664	
	Design & Construction Costs**	$16,320	
	Total Estimated Project Cost (2023)	**$16,984**	
	Annual O&M***	$225	
Efficiency	30-yr Average Cost/lb-TP	**$1,345**	
	30-yr Average Cost/1,000lb-TSS	**$4,300**	
	30-yr Average Cost/ac-ft Vol.	**$1,765**	

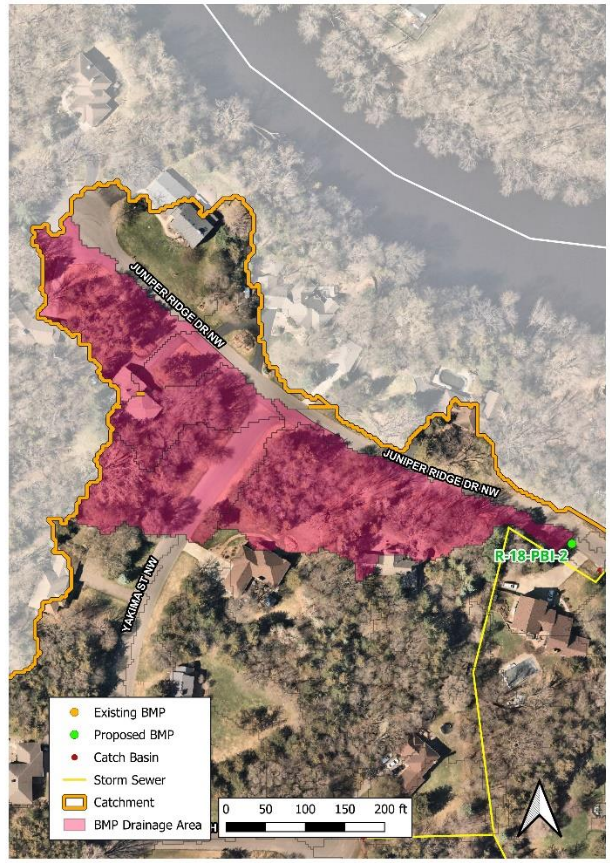
*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-18-PBI-2

Juniper Ridge Dr. NW
Bioinfiltration Basin



Drainage Area – 2.41

Location – 15760 Juniper Ridge Dr. NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed location is within the front yard of a private residential house. The proposed basin is a standard, single inlet rain garden that would treat stormwater collected on Juniper Ridge Dr. from the west. The table below provides pollutant removals and estimated costs.

Curb-Cut Bioinfiltration

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Total Size of BMP	250	sq ft
	TP (lb/yr)	0.52	5.0%
	TSS (lb/yr)	165	5.3%
	Volume (acre-feet/yr)	0.39	4.9%
Cost	Administration & Promotion Costs*	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	30-yr Average Cost/lb-TP	**$1,107**	
	30-yr Average Cost/1,000lb-TSS	**$3,482**	
	30-yr Average Cost/ac-ft Vol.	**$1,464**	

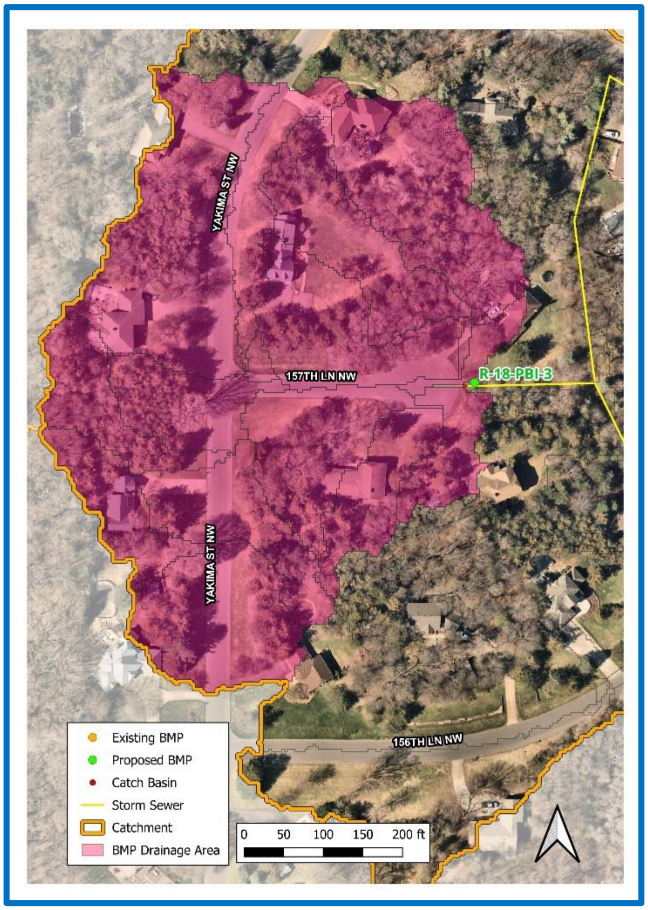
*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-18-PBI-3

157th Ln. NW
Bioinfiltration Basin



Drainage Area – 7.43 acres

Location – 157th Ln NW Outlot

Property Ownership – City of Ramsey

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed location is within the 157th Ln. outlot. The proposed basin is a large, double inlet rain garden that would treat stormwater collected on 157th Ln. and Yakima St. to the west. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	500	sq ft
	TP (lb/yr)	1.16	11.2%
	TSS (lb/yr)	369	11.8%
	Volume (acre-feet/yr)	0.88	10.9%
Cost	**Administration & Promotion Costs***		$664
	Design & Construction Costs**		$16,320
	Total Estimated Project Cost (2023)		**$16,984**
	Annual O&M***		$225
Efficiency	**30-yr Average Cost/lb-TP**	**$683**	
	30-yr Average Cost/1,000lb-TSS	**$2,144**	
	30-yr Average Cost/ac-ft Vol.	**$903**	

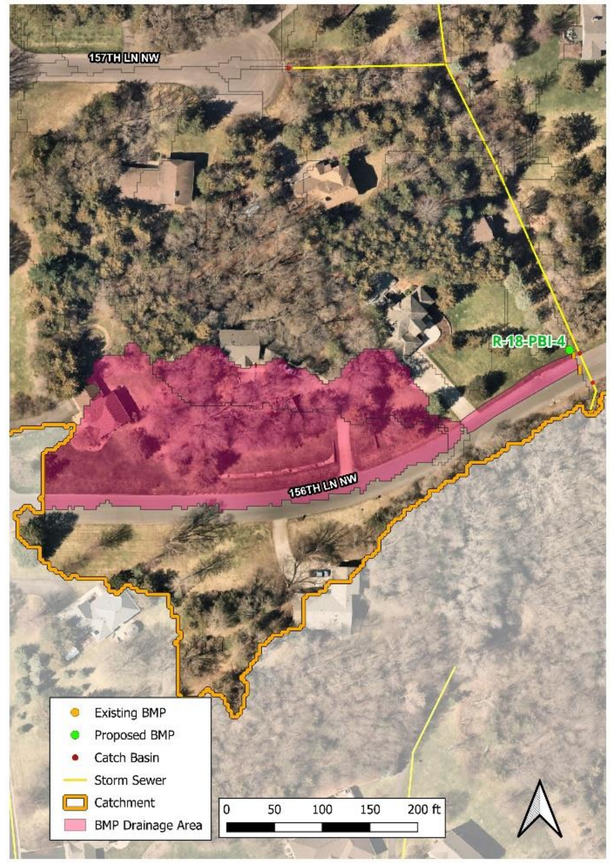
*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-18-PBI-4

156th Ln. NW
Bioinfiltration Basin



Drainage Area – 1.32 acres

Location – 5150 156th Ln. NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed location is within the front yard of a private residential house. The proposed basin is a standard, single inlet rain garden that would treat stormwater collected on 156th Ln. from the west. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq ft
	TP (lb/yr)	0.41	4.0%
	TSS (lb/yr)	130	4.1%
	Volume (acre-feet/yr)	0.31	3.8%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,401**	
	30-yr Average Cost/1,000lb-TSS	**$4,419**	
	30-yr Average Cost/ac-ft Vol.	**$1,853**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-18-PBI-5

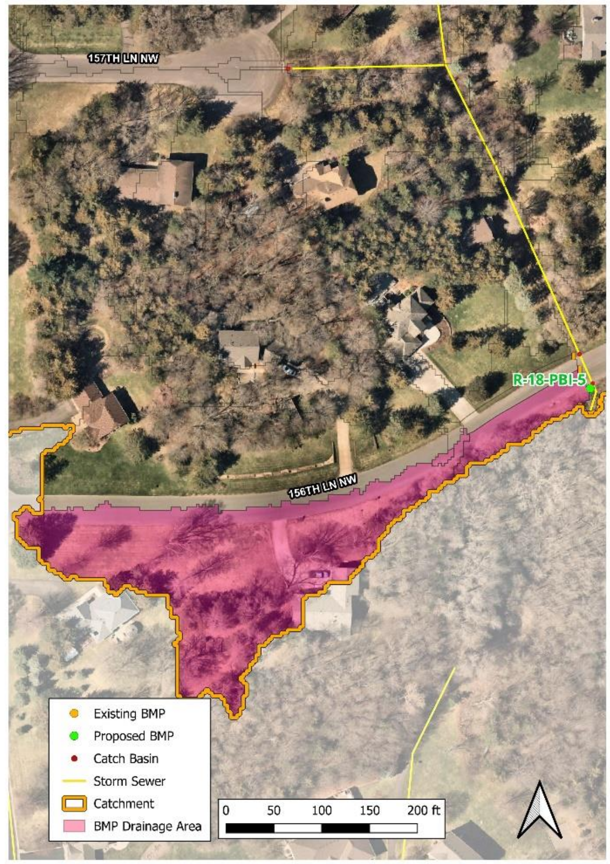
156th Ln. NW
Bioinfiltration Basin

Drainage Area – 1.17 acres

Location – 5160 156th Ln. NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed location is within the front yard of a private residential house. The proposed basin is a standard, single inlet rain garden that would treat stormwater collected on 156th Ln. from the west. The table below provides pollutant removals and estimated costs.



Curb-Cut Bioinfiltration

	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq ft
	TP (lb/yr)	0.36	3.5%
	TSS (lb/yr)	115	3.7%
	Volume (acre-feet/yr)	0.28	3.4%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,587**	
	30-yr Average Cost/1,000lb-TSS	**$4,995**	
	30-yr Average Cost/ac-ft Vol.	**$2,088**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-18-PHD-1

157th Ln. NW

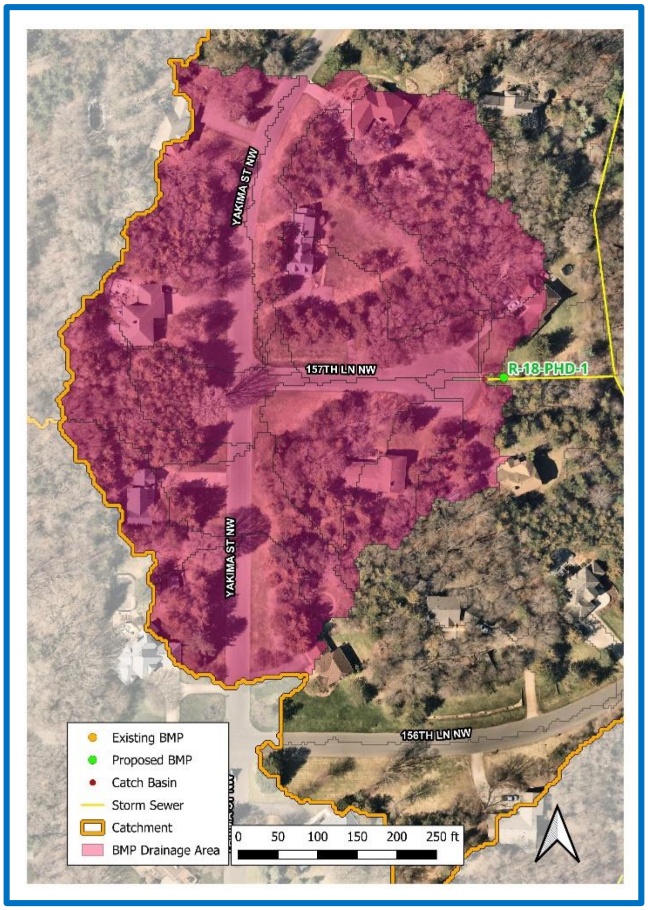
Hydrodynamic Device

Drainage Area – 7.43 acres

Location – 157th Ln NW Outlot

Property Ownership – City of Ramsey

Site Specific Information – A hydrodynamic device is proposed in line with the storm sewer line on 157th Ln. A device at this location would provide treatment to stormwater runoff collected on 157th Ln. and Yakima St. to the west. The table below provides pollutant removals and estimated costs.



Hydrodynamic Device			
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	10	ft diameter
	TP (lb/yr)	0.51	5.0%
	TSS (lb/yr)	208	6.6%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***		$3,750
	Design & Construction Costs**		$150,000
	Total Estimated Project Cost (2023)		**$153,750**
	Annual O&M***		$210
Efficiency	**30-yr Average Cost/lb-TP**	**$10,379**	
	30-yr Average Cost/1,000lb-TSS	**$25,649**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

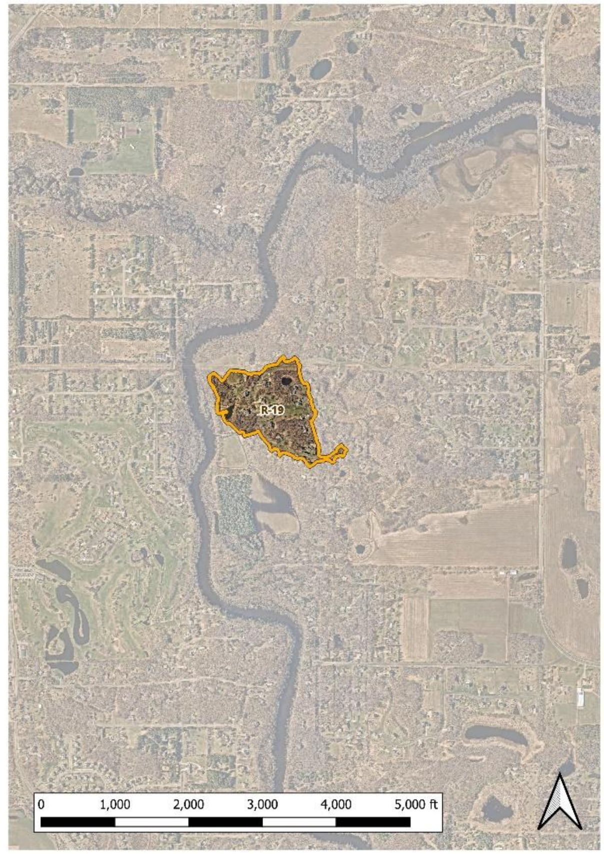
*Indirect Cost: (25 hours at $150/hour)

**Direct Cost: ($100,000 for materials) + ($50,000 for labor and installation costs)

***Per BMP: (1 cleaning/year)*(3 hours/cleaning)*($70/hour)

Catchment R-19

Existing Catchment Summary	
Acres	30.2
Parcels	28
Land Cover	71.9% Residential 26.2% Open 1.9% Park



CATCHMENT DESCRIPTION

This catchment is located in Andover and primarily consists of residential housing with sections of undeveloped land throughout. Stormwater is collected in catch basins on 169th Ln. and 171st Ave. that route into an existing stormwater pond near the outfall prior to discharging into the Rum River.

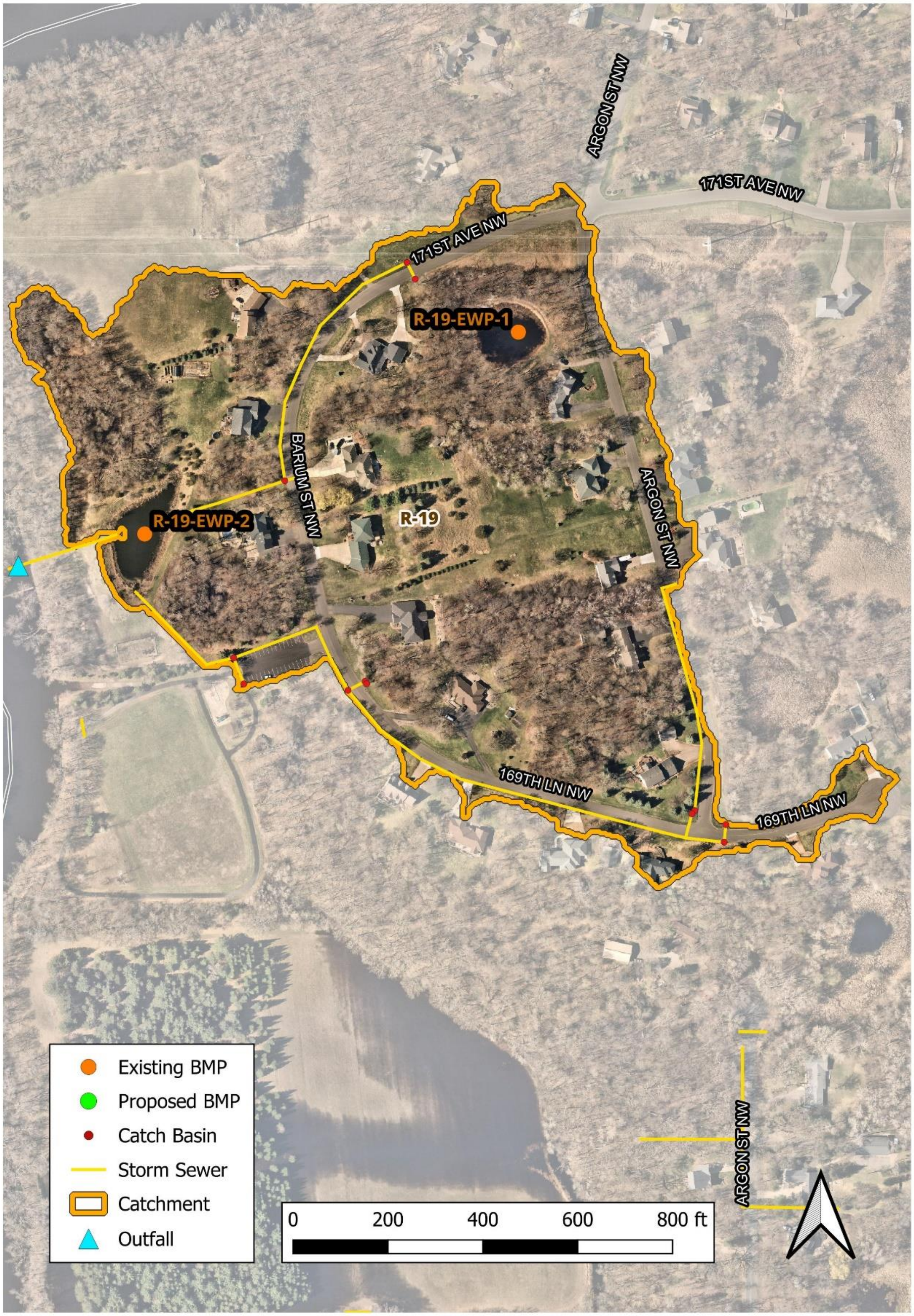
EXISTING STORMWATER TREATMENT

This catchment contains two existing stormwater ponds, one of which treats the entire catchment near the outfall as all stormwater infrastructure routes to this pond. In addition, street cleaning is conducted once in early spring and once in fall by the City of Andover.

RETROFITS CONSIDERED

No retrofits were considered for this catchment due to the scale of existing treatment compared to its relatively small drainage area. As such, this catchment and the existing treatment practices were not modeled in WinSLAMM.

EXISTING STORMWATER TREATMENT AND RETROFIT OPPORTUNITIES



Catchment R-20

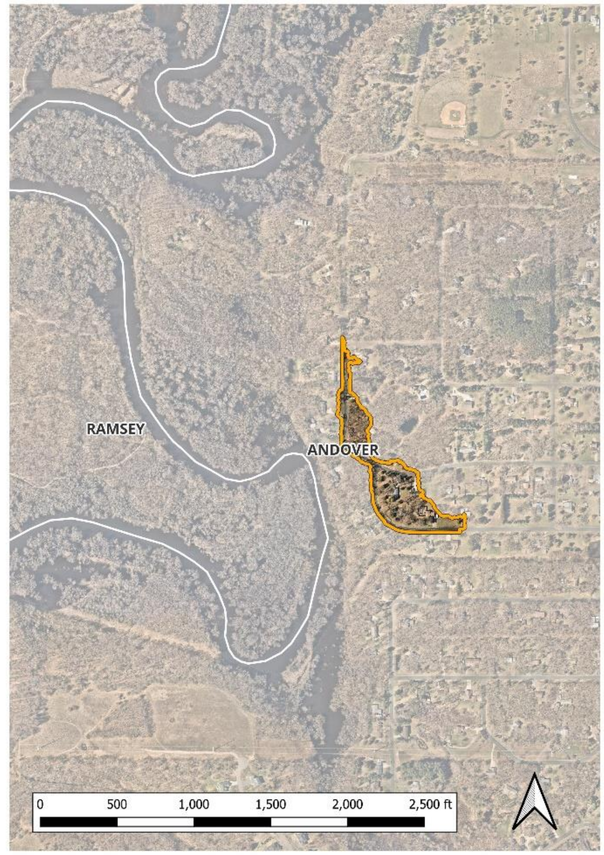
Existing Catchment Summary	
Acres	5.80
Parcels	11
Land Cover	91.6% Residential 8.4% Open

CATCHMENT DESCRIPTION

This catchment is located in Andover and primarily consists of residential single-family houses. Stormwater runoff is collected in catch basins along Blackfoot St. and 174th Ave. that discharge directly into the Rum River. The contributing drainage area is small and is largely pervious (i.e. residential backyard areas).

EXISTING STORMWATER TREATMENT

Street cleaning is conducted once in early spring and once in fall by the City of Andover. No other existing stormwater treatment exists in this catchment. Present day stormwater pollutant loading and treatment is summarized in the table below.



	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	1			
	BMP Types	Street Cleaning			
	TP (lb/yr)	3.03	0.24	8%	**2.79**
	TSS (lb/yr)	949	105	11%	**844**
	Volume (acre-feet/yr)	2.2	0.00	0%	**2.2**

RETROFITS CONSIDERED

Four bioinfiltration basins and one hydrodynamic device are proposed within this catchment.

EXISTING STORMWATER TREATMENT AND RETROFIT OPPORTUNITIES

Project ID: R-20-PBI-1

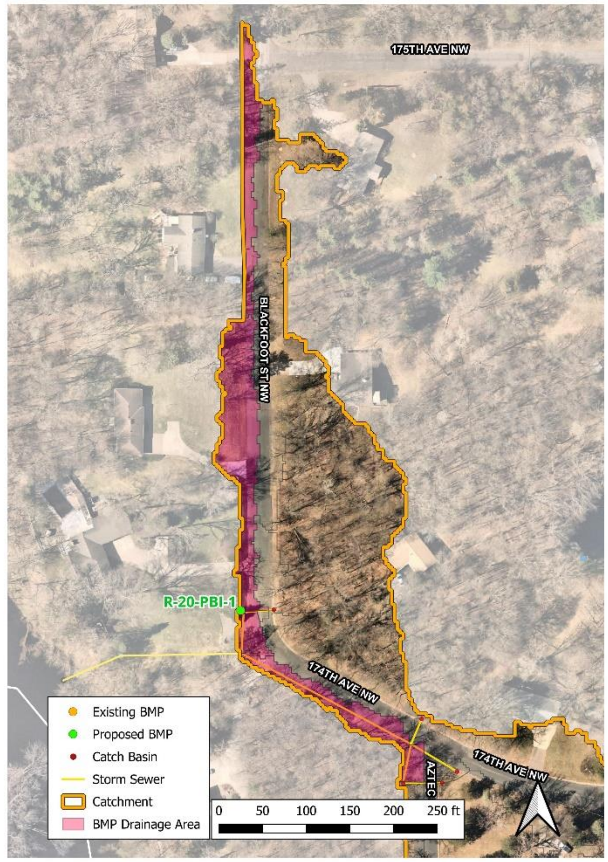
Blackfoot St.
Bioinfiltration Basin

Drainage Area – 0.50 acres

Location – 17400 Blackfoot St. NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed location is within the front yard of a private residential house. The proposed basin is a large, double inlet rain garden that would treat stormwater collected on Blackfoot St. from the north and 174th Ave. from the southeast. The table below provides pollutant removals and estimated costs.



	Bioinfiltration Basin		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	500	sq. ft.
	TP (lb/yr)	0.21	7.7%
	TSS (lb/yr)	65	7.7%
	Volume (acre-feet/yr)	0.17	7.6%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$16,320	
	Total Estimated Project Cost (2023)	**$16,984**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$3,697**	
	30-yr Average Cost/1,000lb-TSS	**$12,247**	
	30-yr Average Cost/ac-ft Vol.	**$4,766**	

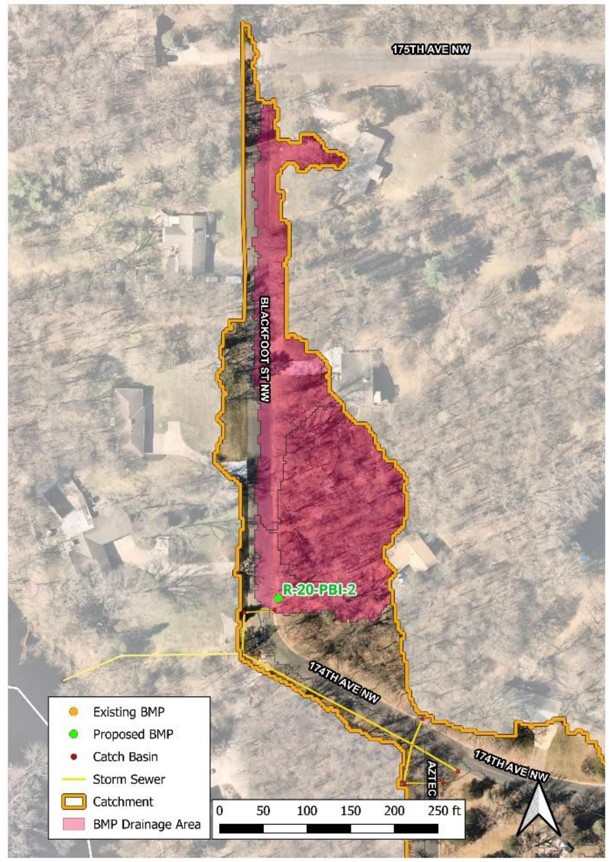
*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-20-PBI-2

174th Ave.
Bioinfiltration Basin



Drainage Area – 1.20 acres

Location – 3953 174th Ave NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed location is within the front yard of a private residential house. This area contains several trees that may need to be cleared to install a rain garden at this location. The proposed basin is a standard, single inlet rain garden that would treat stormwater collected on Blackfoot St. from the north. The table below provides pollutant removals and estimated costs.

Bioinfiltration Basin

	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq. ft.
	TP (lb/yr)	0.40	14.2%
	TSS (lb/yr)	124	14.7%
	Volume (acre-feet/yr)	0.30	13.7%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,454**	
	30-yr Average Cost/1,000lb-TSS	**$4,625**	
	30-yr Average Cost/ac-ft Vol.	**$1,931**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-20-PBI-3

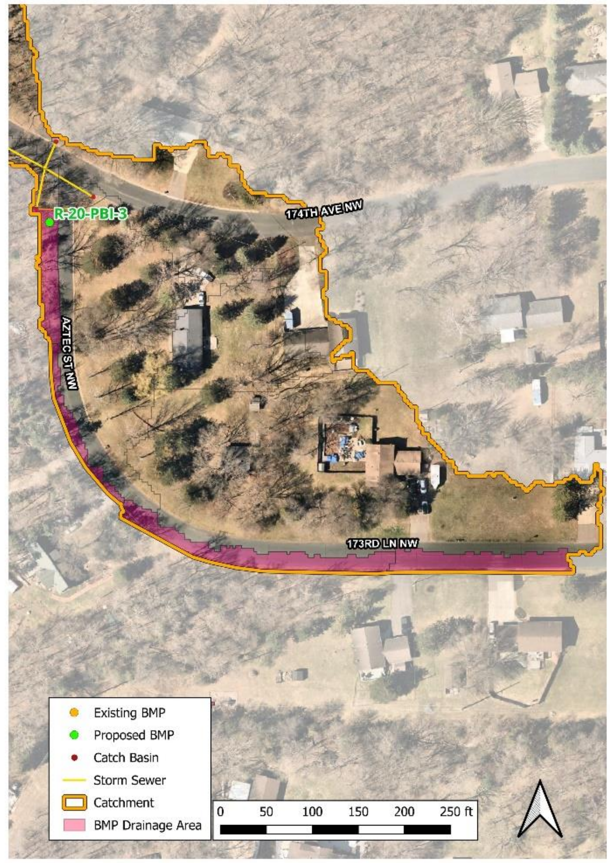
Aztec St.
Bioinfiltration Basin

Drainage Area – 0.35 acres

Location – PIN: 053224330021

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed location is on undeveloped property near the curb of Aztec St. This area contains several trees that may need to be cleared to install a rain garden at this location. The proposed basin is a standard, single inlet rain garden that would treat stormwater collected on Aztec St. from the south. The table below provides pollutant removals and estimated costs.



Bioinfiltration Basin			
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq. ft.
	TP (lb/yr)	0.15	5.2%
	TSS (lb/yr)	44	5.2%
	Volume (acre-feet/yr)	0.11	5.1%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$9,820	
	Total Estimated Project Cost (2023)	**$10,484**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$3,962**	
	30-yr Average Cost/1,000lb-TSS	**$13,026**	
	30-yr Average Cost/ac-ft Vol.	**$5,150**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-20-PBI-4

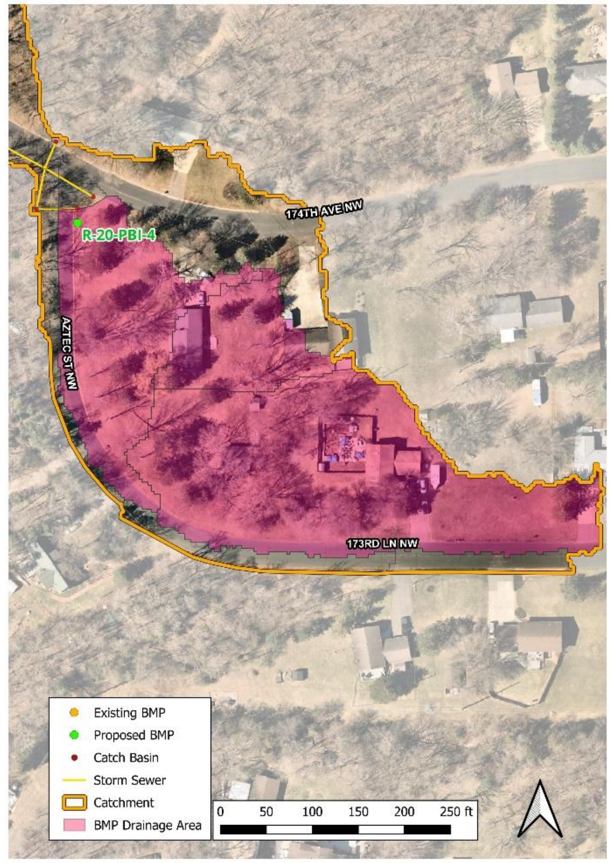
Aztec St.
Bioinfiltration Basin

Drainage Area – 2.72 acres

Location – 17317 Aztec St. NW

Property Ownership – Private

Site Specific Information – An opportunity for a bioinfiltration basin exists at this location. The proposed location is within the front yard of a private residential house. The proposed basin is a standard, single inlet rain garden that would treat stormwater collected on Aztec St. from the south. The table below provides pollutant removals and estimated costs.



	Bioinfiltration Basin		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq. ft.
	TP (lb/yr)	0.53	19.1%
	TSS (lb/yr)	169	20.0%
	Volume (acre-feet/yr)	0.40	18.3%
Cost	**Administration & Promotion Costs***		$664
	Design & Construction Costs**		$9,820
	Total Estimated Project Cost (2023)		**$10,484**
	Annual O&M***		$225
Efficiency	**30-yr Average Cost/lb-TP**	**$1,078**	
	30-yr Average Cost/1,000lb-TSS	**$3,401**	
	30-yr Average Cost/ac-ft Vol.	**$1,439**	

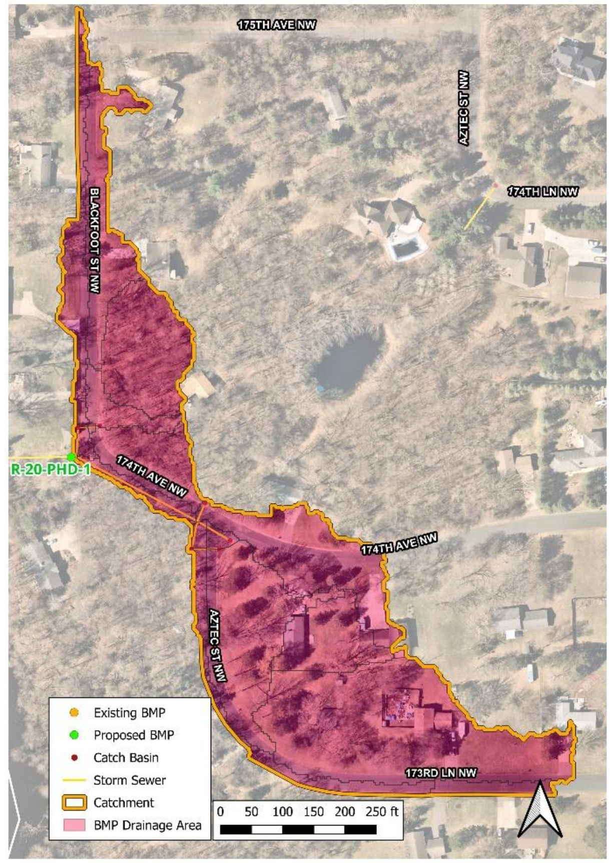
*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: R-20-PHD-1

174th Ave.
Hydrodynamic Device



Drainage Area – 5.80 acres

Location – 174th Ave NW

Property Ownership – Public

Site Specific Information – A hydrodynamic device is proposed in line with the storm sewer line at the intersection of Blackfoot St. and 174th Ave. near the outfall. A device at this location would provide treatment to the entire catchment. The table below provides pollutant removals and estimated costs.

	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	8	ft diameter
	TP (lb/yr)	0.36	12.9%
	TSS (lb/yr)	144	17.1%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***	$3,750	
	Design & Construction Costs**	$54,000	
	Total Estimated Project Cost (2023)	**$57,750**	
	Annual O&M***	$210	
Efficiency	**30-yr Average Cost/lb-TP**	**$5,947**	
	30-yr Average Cost/1,000lb-TSS	**$14,796**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

*Indirect Cost: (25 hours at $150/hour)

**Direct Cost: ($36,000 for materials) + ($18,000 for labor and installation costs)

***Per BMP: (1 cleaning/year)*(3 hours/cleaning)*($70/hour)

References

Anoka Conservation District. 2016. City of Ramsey Stormwater Retrofit Analysis.

Janke, Benjamin D., Jacques C. Finlay, and Sarah E. Hobbie. 2017. Trees and Streets as Drivers of Urban Stormwater Nutrient Pollution. Sci. Technol. DOI: 10.1021/acs.est.7b02225 Environ.

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

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

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

Schueler, T. and A. Kitchell. 2005. *Methods to Develop Restoration Plans for Small Urban Watersheds. Manual 2, Urban Subwatershed Restoration Manual Series*. Center for Watershed Protection. Ellicott City, MD.

Schueler, T., D. Hirschman, M. Novotney, and J. Zielinski. 2007. *Urban Stormwater Retrofit Practices. Manual 3, Urban Subwatershed Restoration Manual Series. Center for Watershed Protection*. Ellicott City, MD.

Technical documents. (2024). *Minnesota Stormwater Manual*.

Appendix A – Modeling Methods

The following sections include WinSLAMM model details for each type of best management practice modeled for this analysis.

WinSLAMM

Pollutant and volume reductions were estimated using the stormwater model Source Load and Management Model for Windows (WinSLAMM). WinSLAMM uses an abundance of stormwater data from the Upper-Midwest and elsewhere to quantify runoff volumes and pollutant loads from urban areas. It has detailed accounting of pollutant loading from various land uses, and allows the user to build a model “landscape”. WinSLAMM uses rainfall and temperature data from a typical year (1959 data from Minneapolis for this analysis), routing stormwater through the user’s model for each storm. WinSLAMM version 10.5.0 was used for this analysis to estimate volume and pollutant loading and reductions. Additional inputs for WinSLAMM are provided in Table 6.

Table 6: General WinSLAMM Model Inputs (i.e. Current File Data)

Parameter	File/Method
Land use acreage	ArcMap; Metropolitan Council 2020 Land Use, corrected using 2023 aerial photography
Precipitation/Temperature Data	Minneapolis 1959 – best approximation of a typical year
Winter season	Included in model. Winter dates are 11-4 to 3-13.
Pollutant probability distribution	WI_GEO01.ppd
Runoff coefficient file	WI_SL06 Dec06.rsv
Particulate solids concentration file	WI_AVG01.psc
Particle residue delivery file	WI_DLV01.prr
Street delivery files	WI files for each land use

Existing Conditions

Existing stormwater BMPs were included in the WinSLAMM model for which information was available. The practices listed below were included in the existing conditions models.

Biofiltration Basins

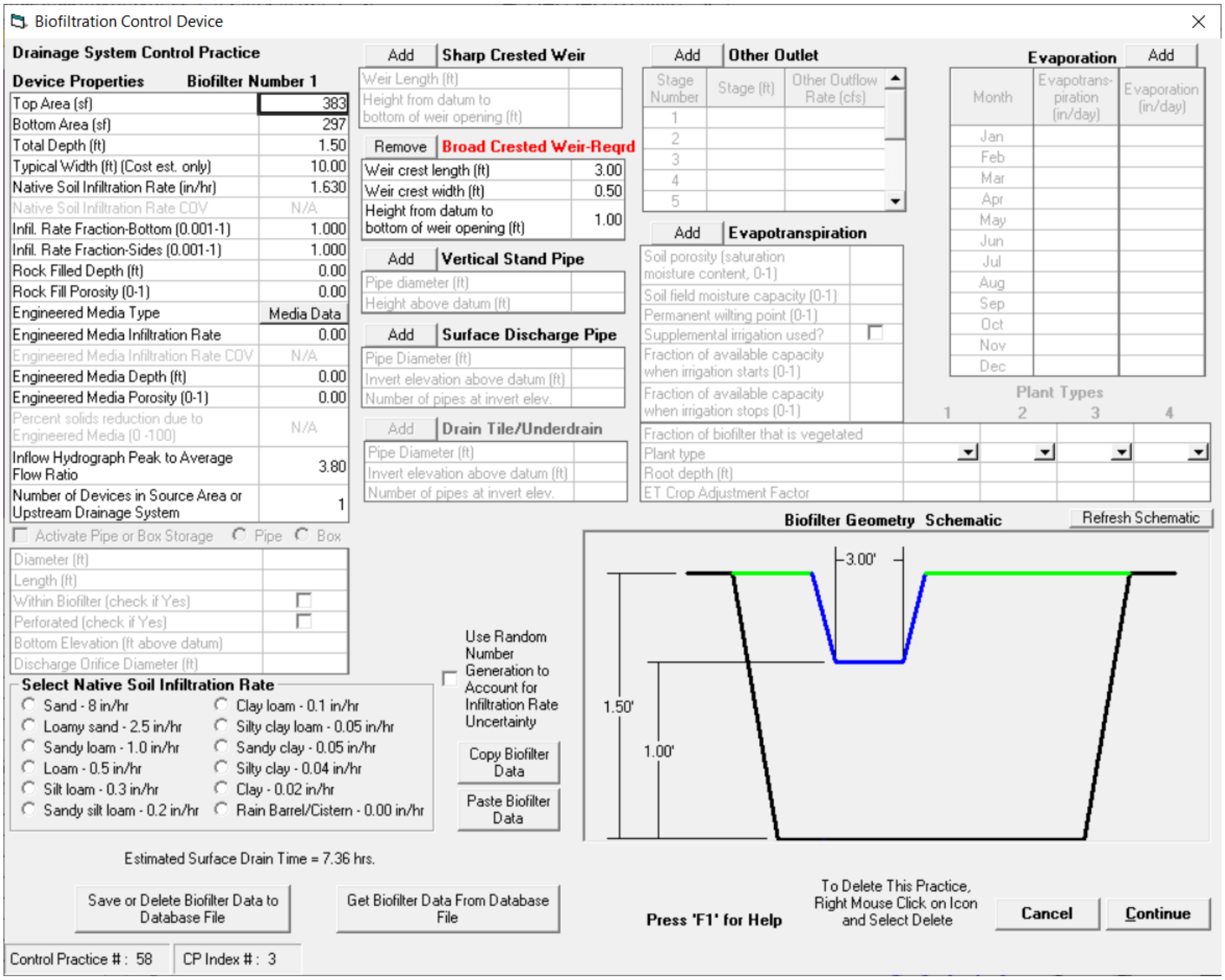


Figure 12: R-3-EBI-1

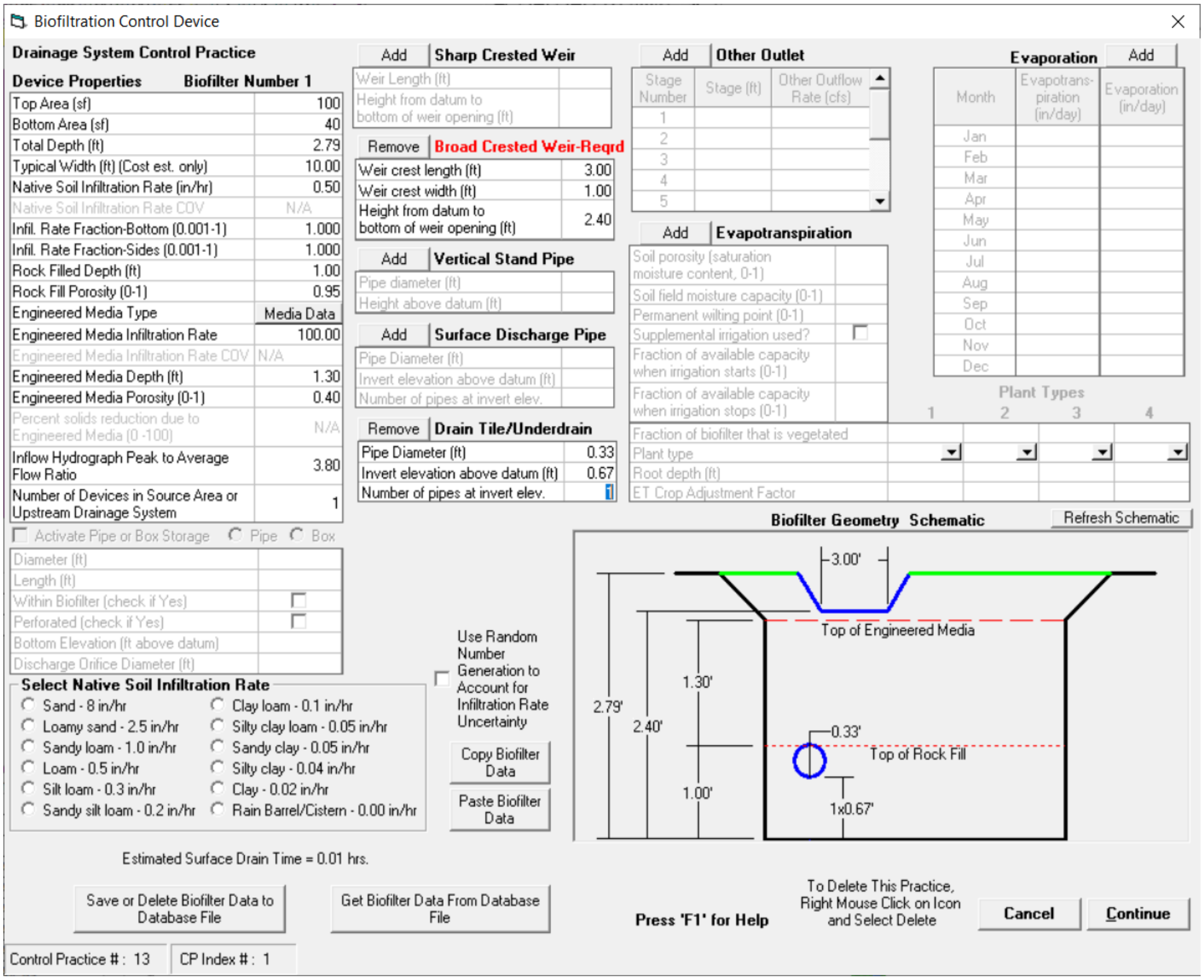


Figure 13: R-4-EBI-1

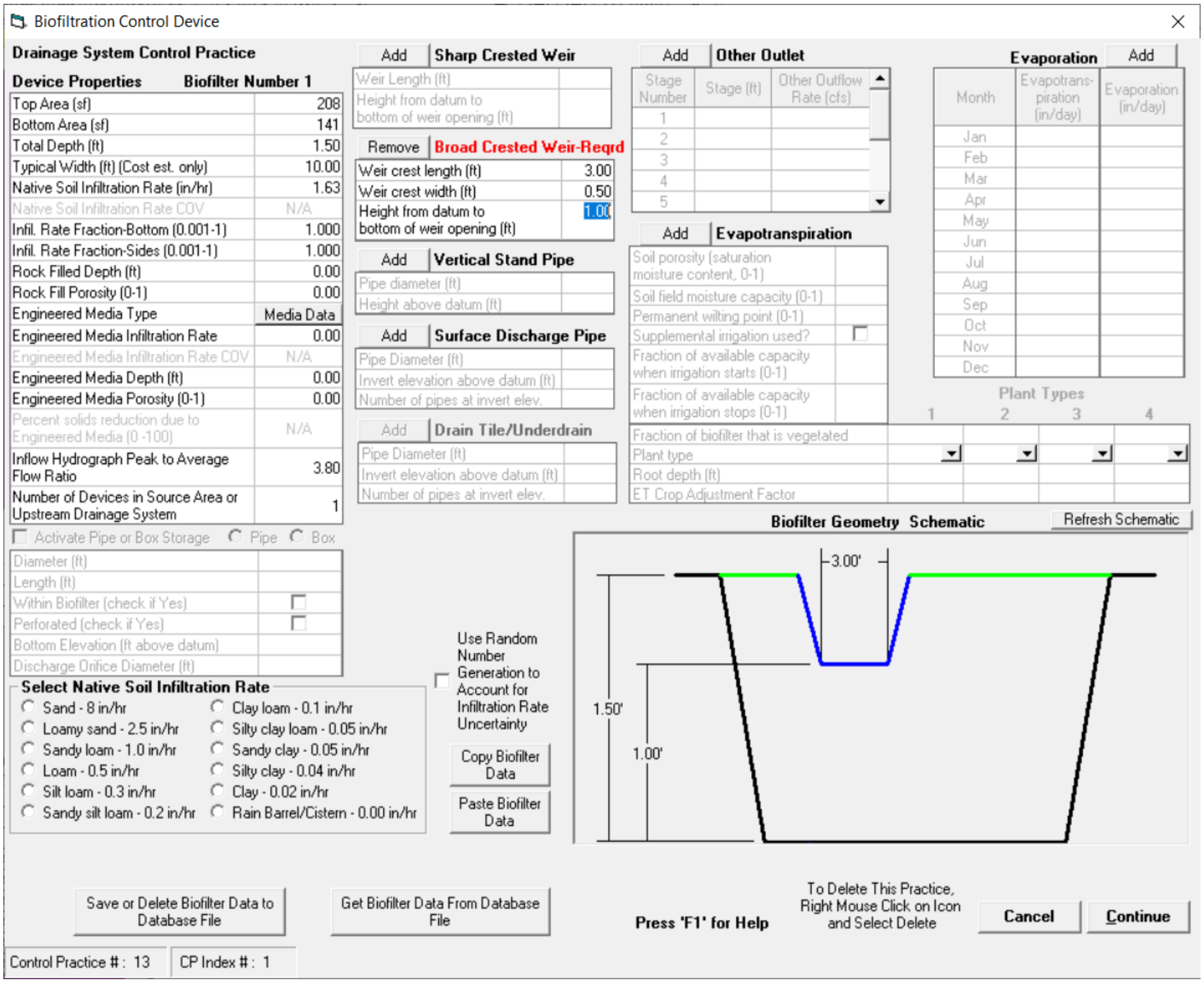


Figure 14: R-6-EBI-1

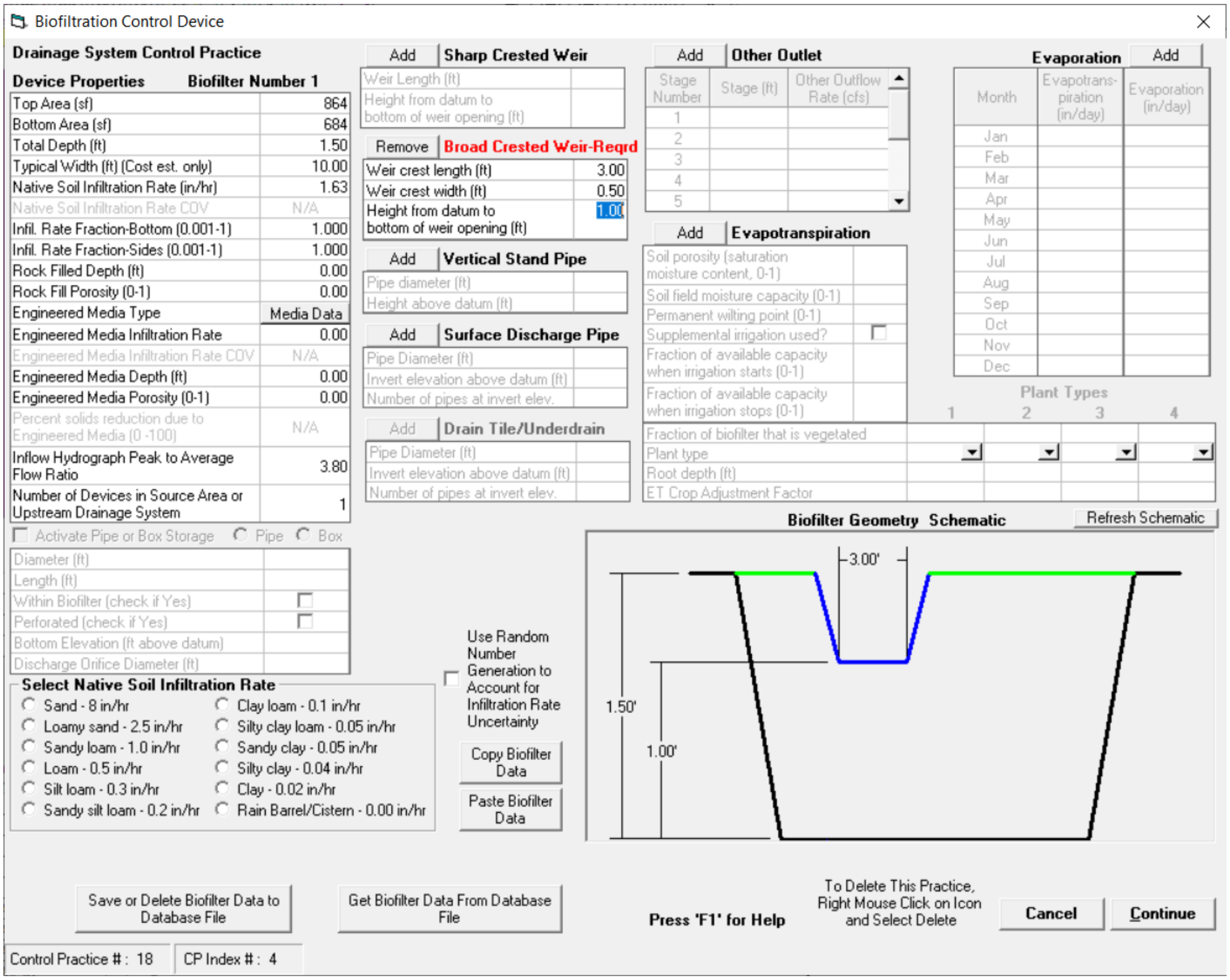


Figure 15: R-8-EBI-1

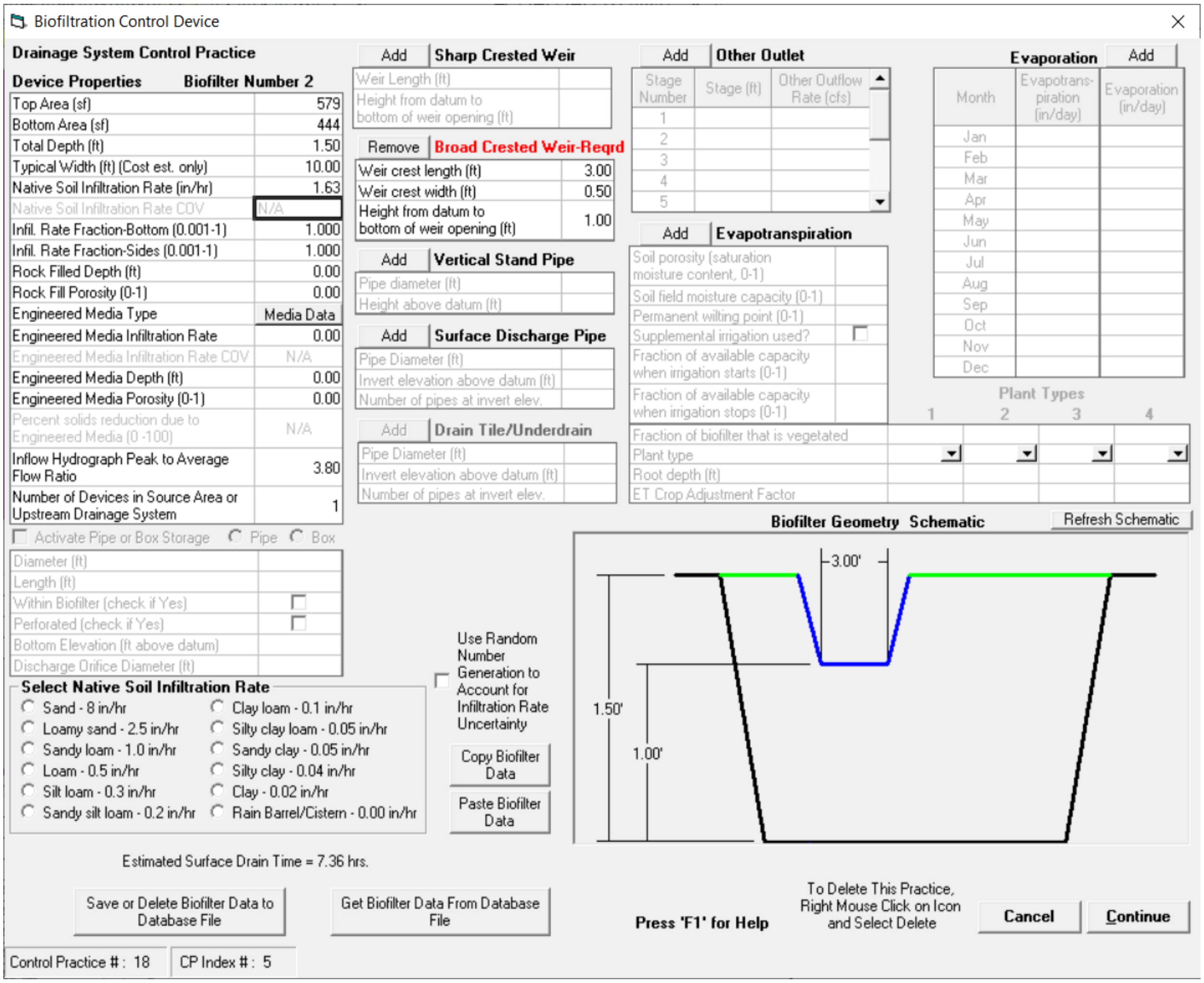


Figure 16: R-8-EBI-2

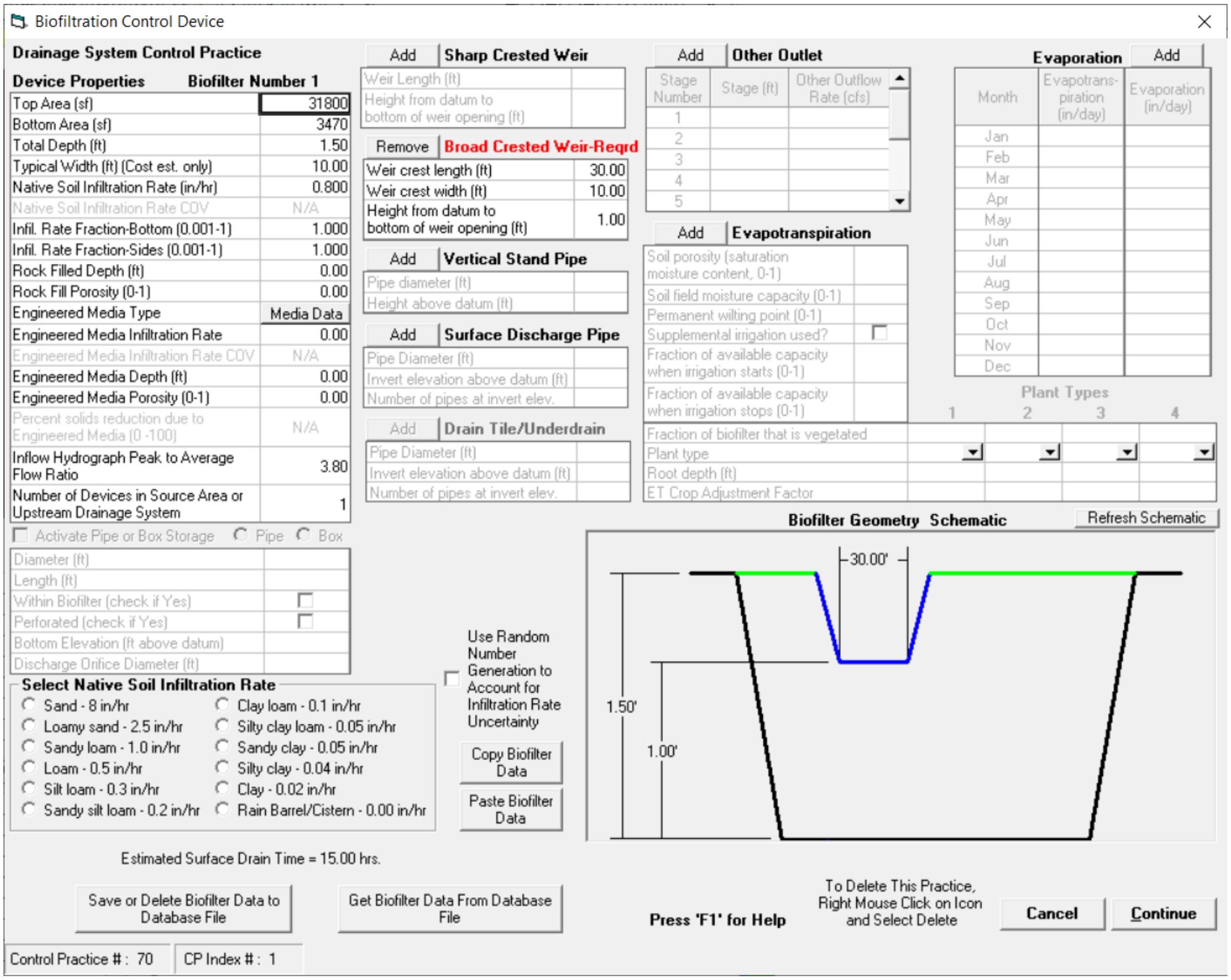


Figure 17: R-17-EBI-1

Street Cleaning

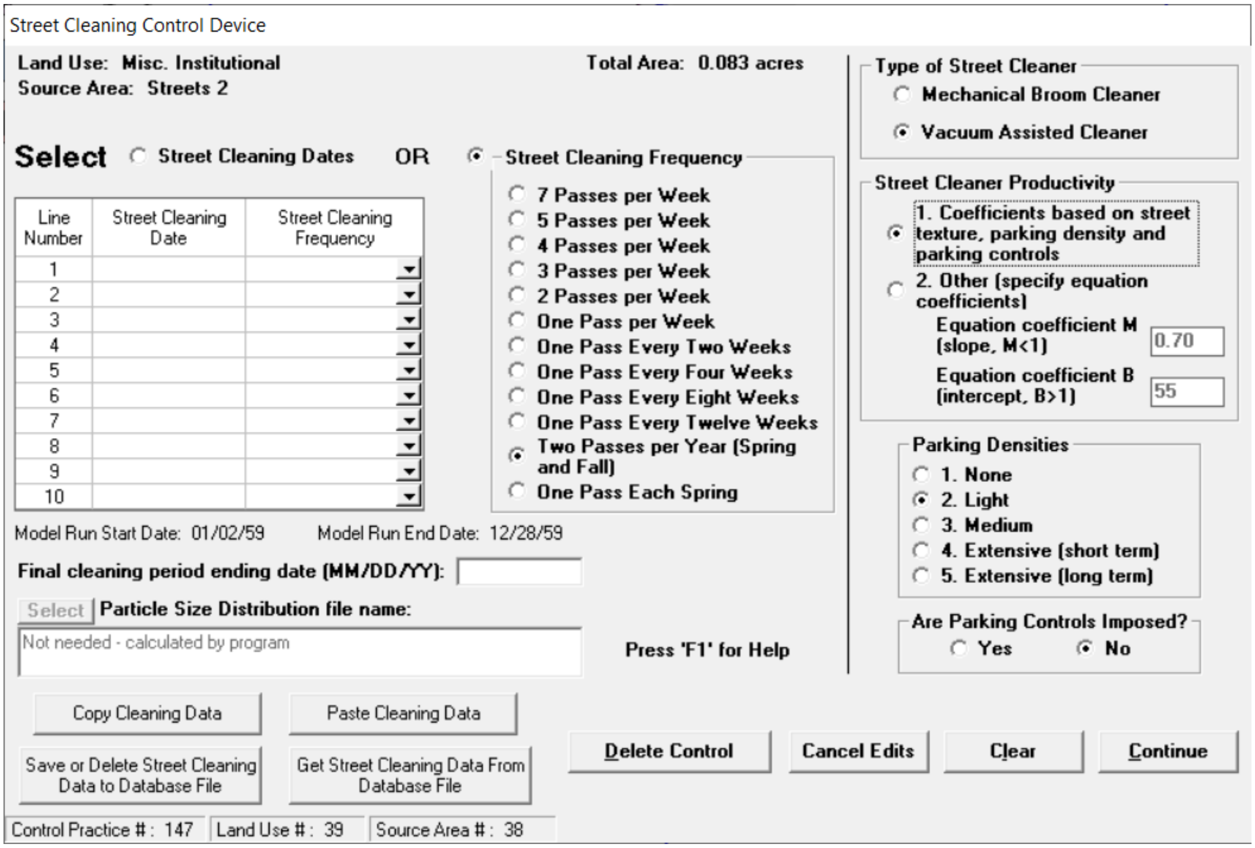


Figure 18: Typical street cleaning parameters for the City of Anoka. Street cleaning occurs twice per year, once in early spring and once in mid-summer.

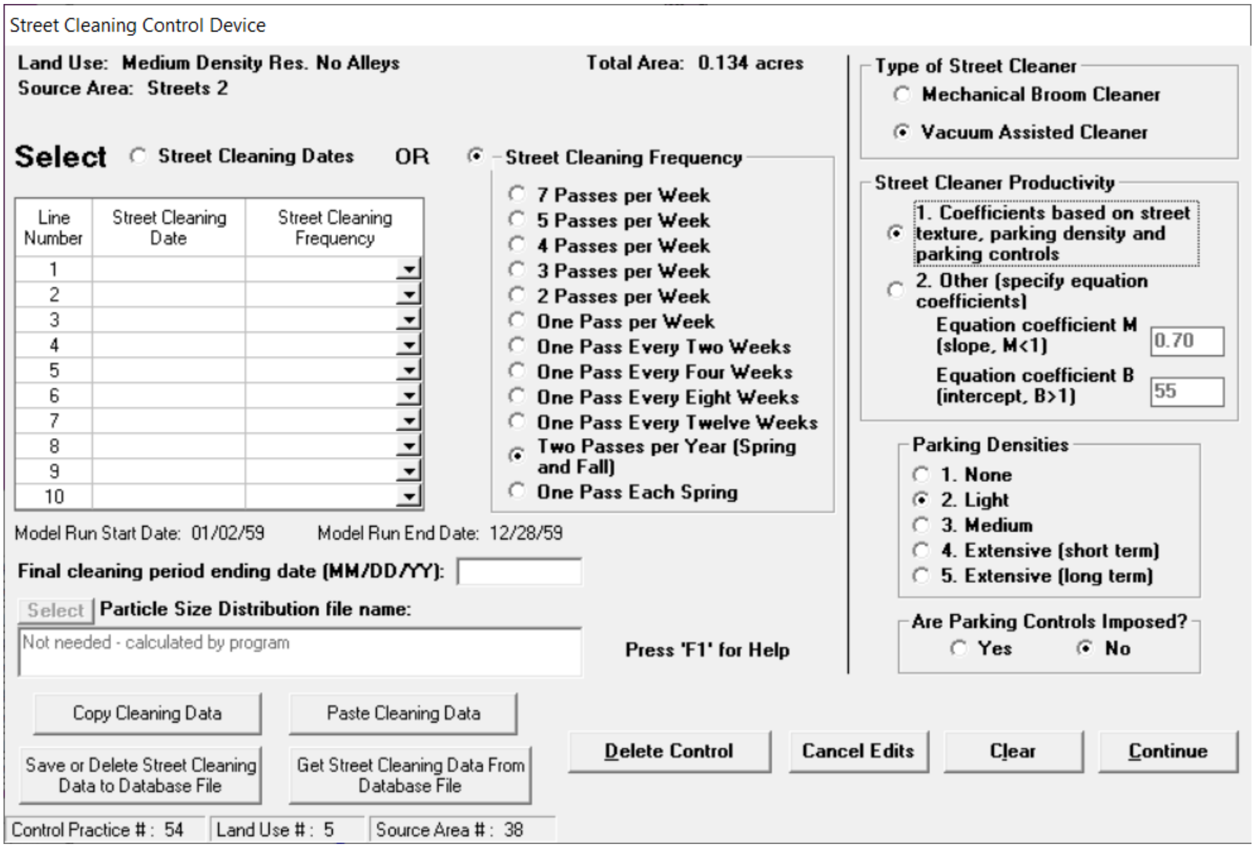


Figure 19: Typical street cleaning parameters for the City of Andover. Street cleaning occurs twice per year, once in spring and once in fall.

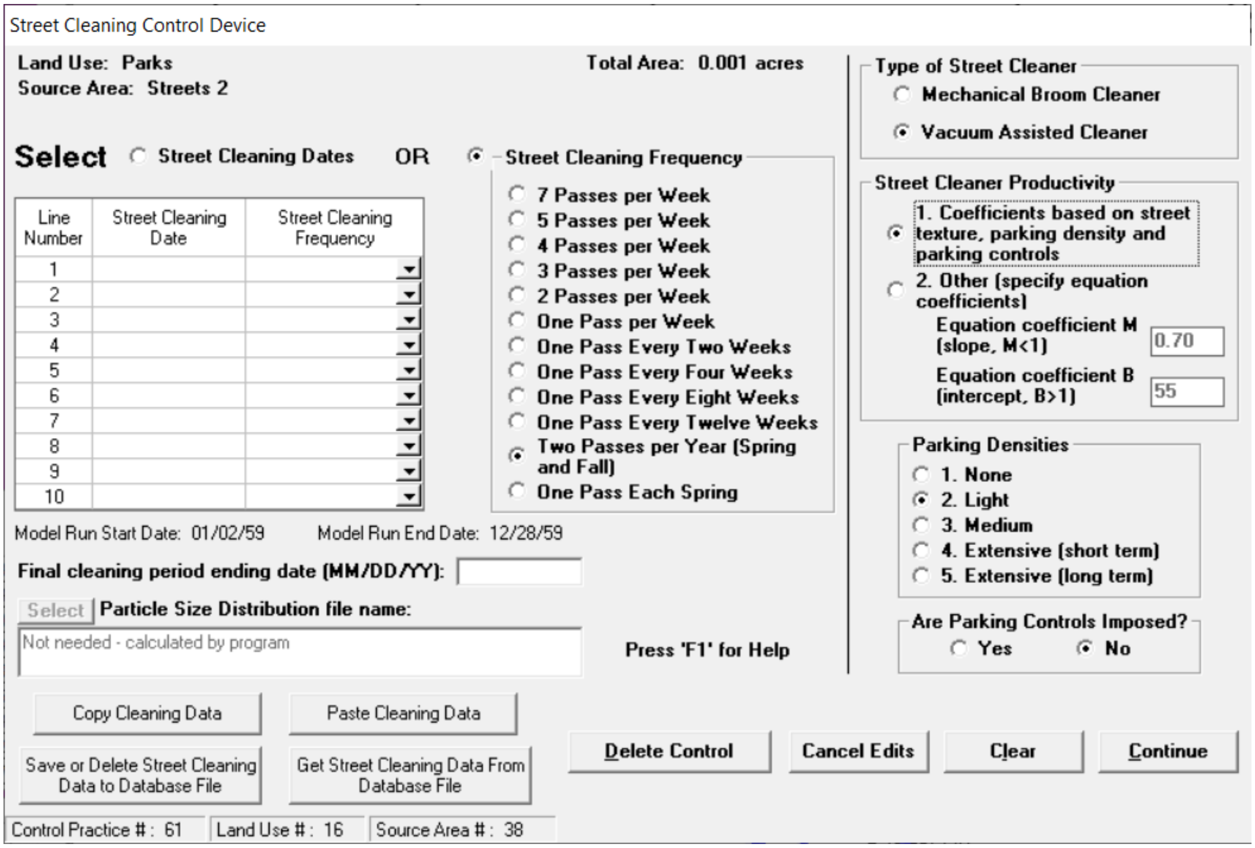


Figure 20: Typical street cleaning parameters for the City of Ramsey. Street cleaning occurs twice per year, once in spring and once in fall.

Wet Ponds

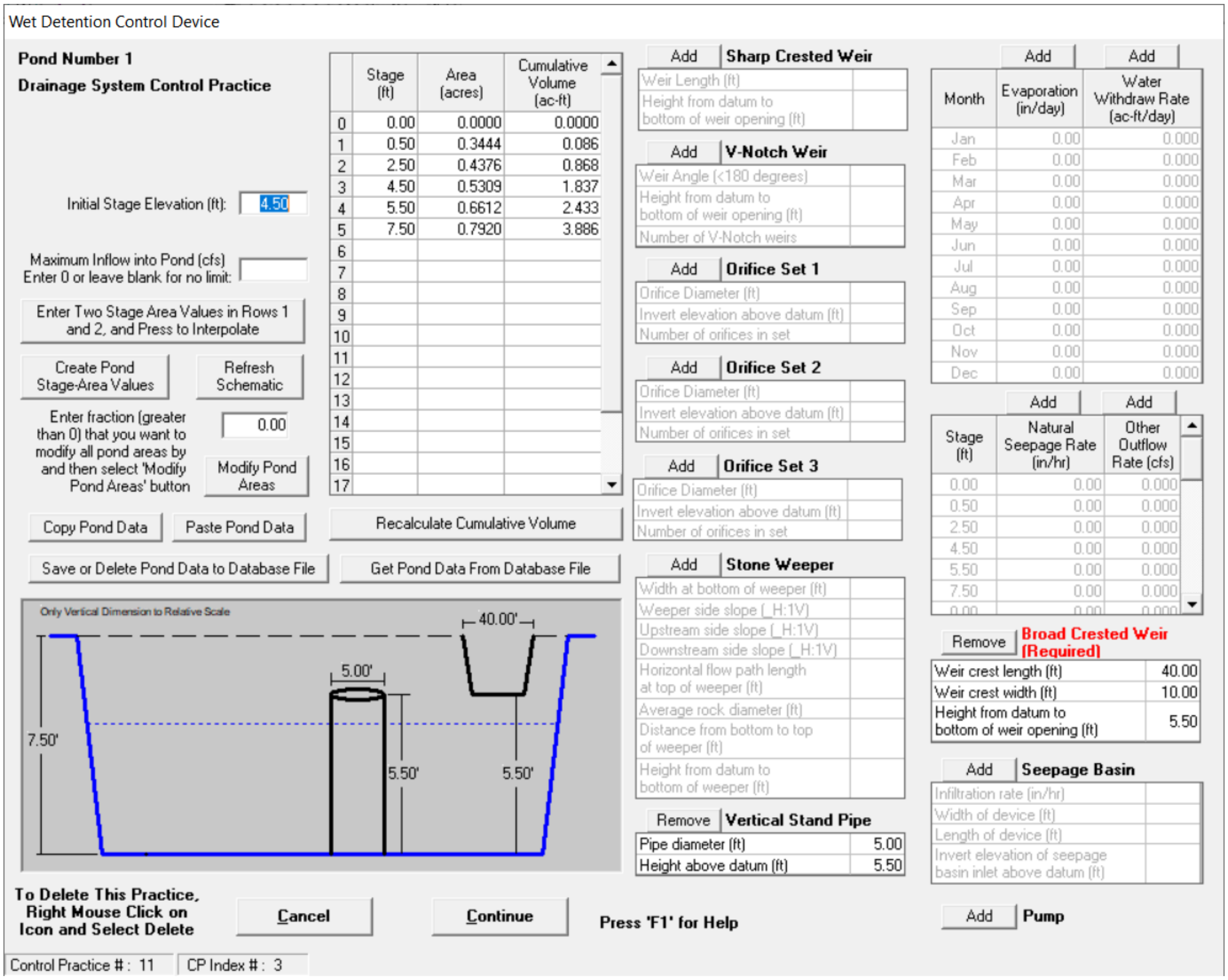


Figure 21: R-1-EWP-1

Proposed Conditions

The practices listed below were included in the proposed conditions WinSLAMM models.

Biofiltration Basins

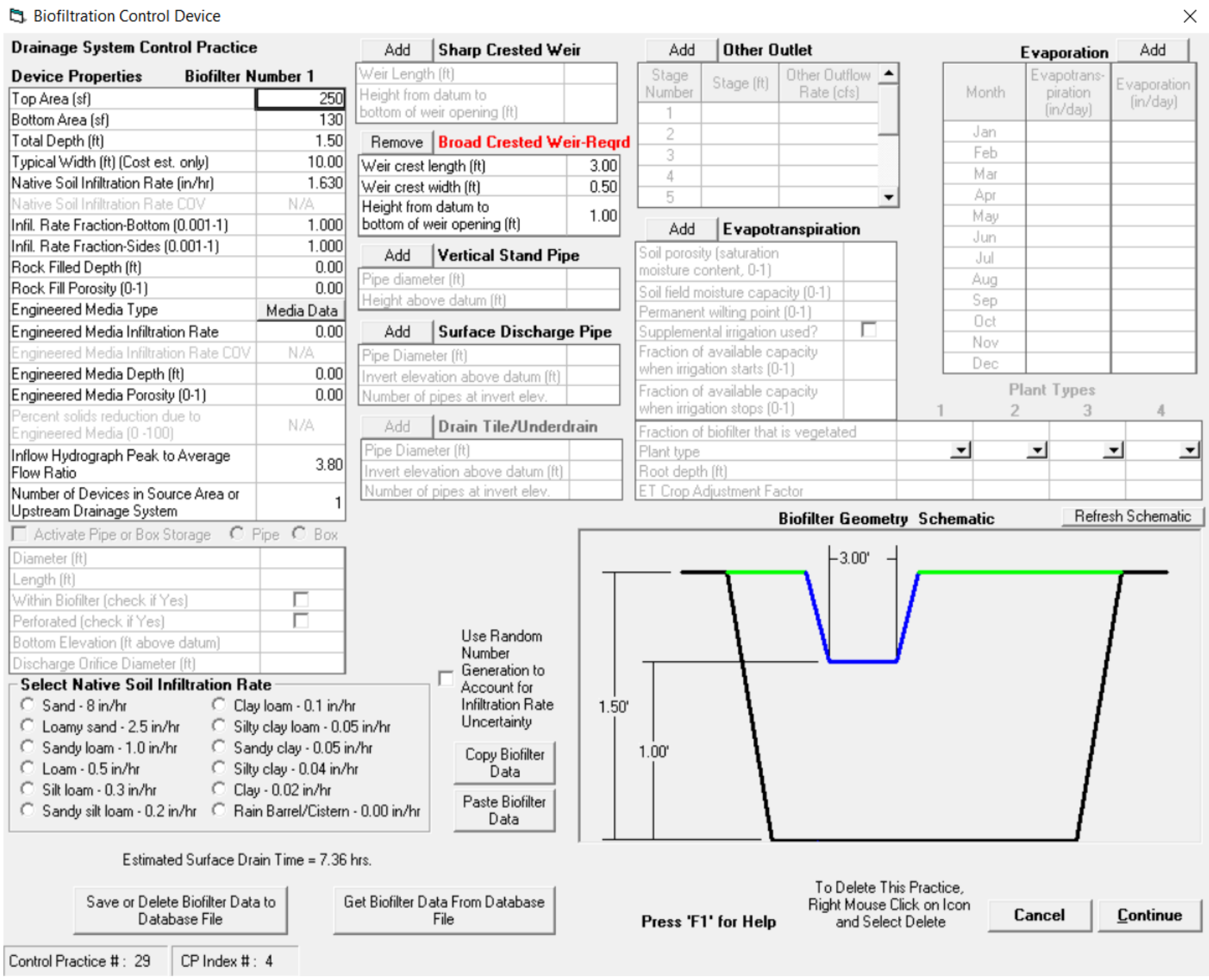


Figure 22: Typical parameters for a standard-sized, single inlet bioinfiltration basin.

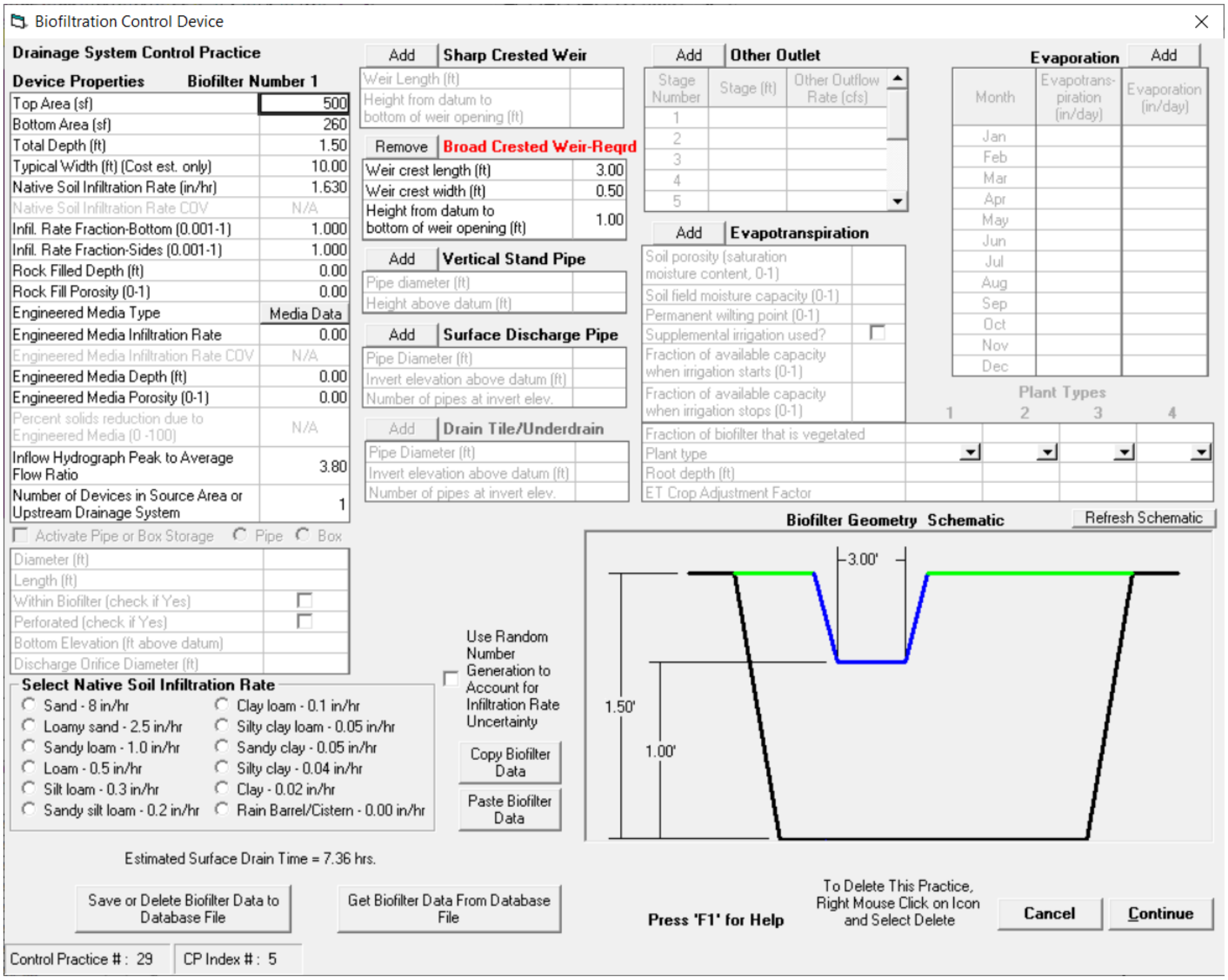


Figure 23: Typical parameters for a large-sized, double-inlet bioinfiltration basin.

Hydrodynamic Devices

Table 7: Hydrodynamic Device Sizing Criteria

Drainage Area (acres)	Peak Q (cfs)	Hydrodynamic Device Diameter (ft)
1	1.97	4
2	3.90	6
3	5.83	6
4	7.77	6
5	9.72	8
6	11.68	8
7	13.65	8
≥8	15.63	10

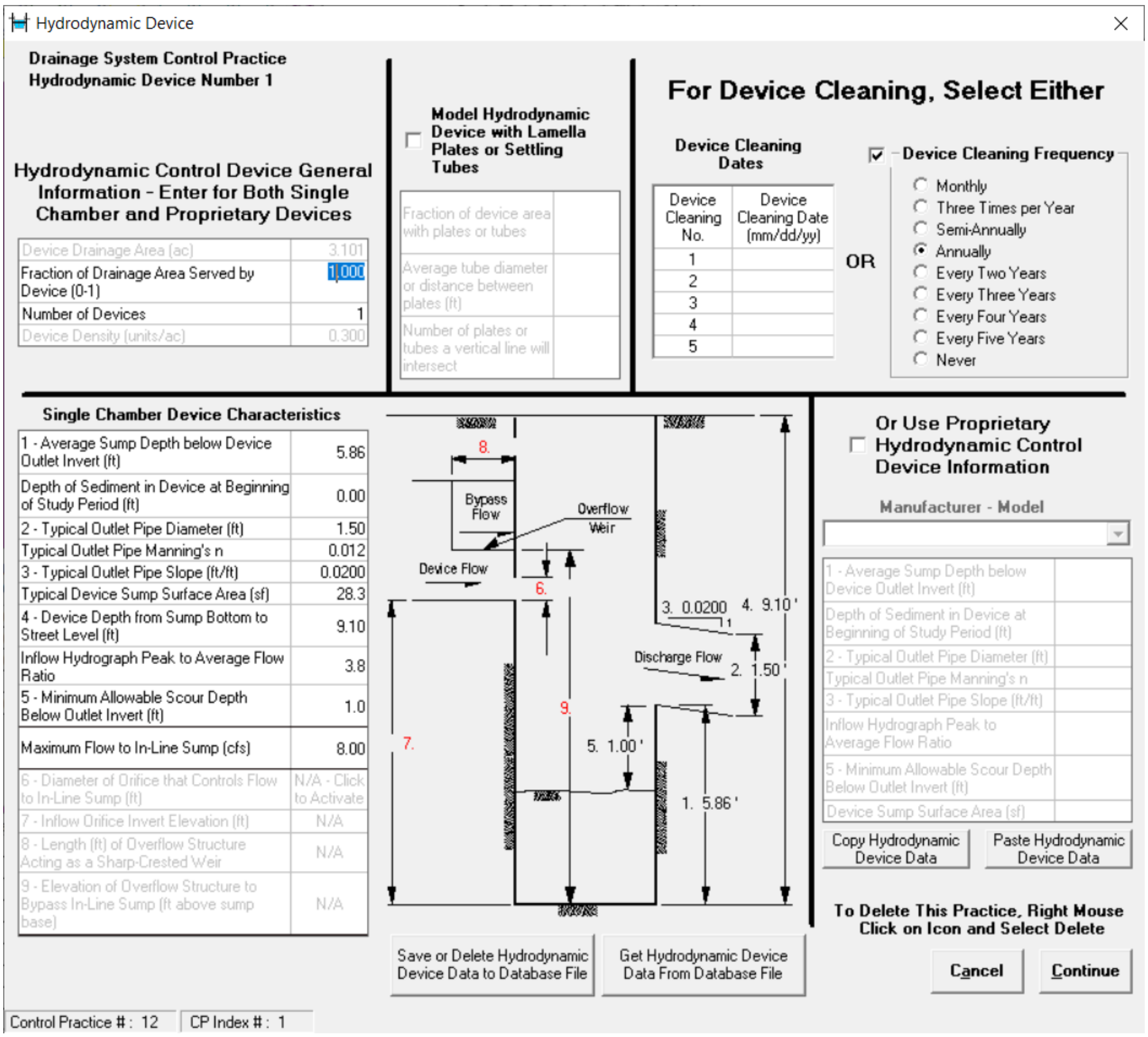


Figure 24: Typical parameters for 6-ft diameter hydrodynamic device.

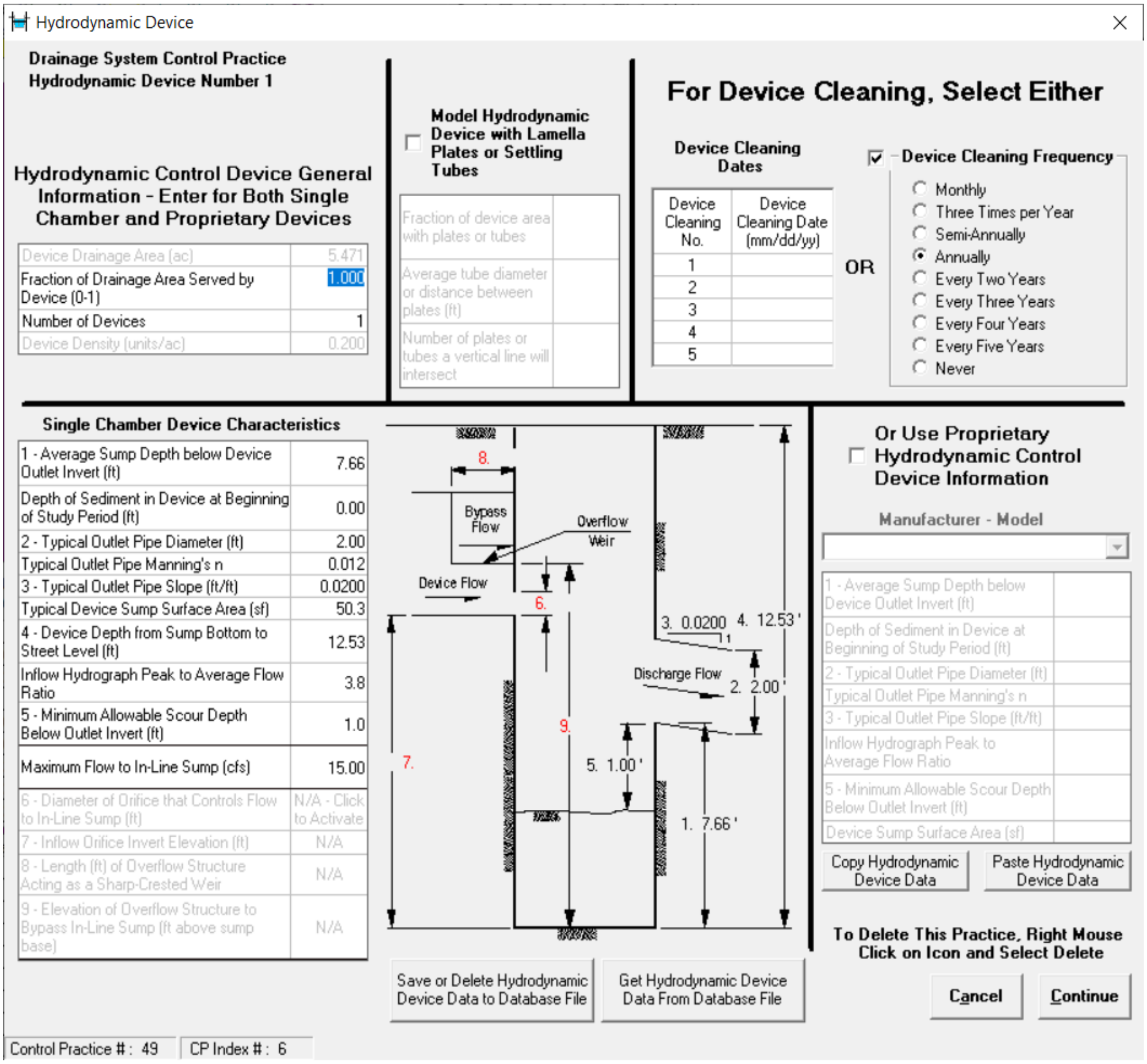


Figure 25: Typical parameters for 8-ft diameter hydrodynamic device.

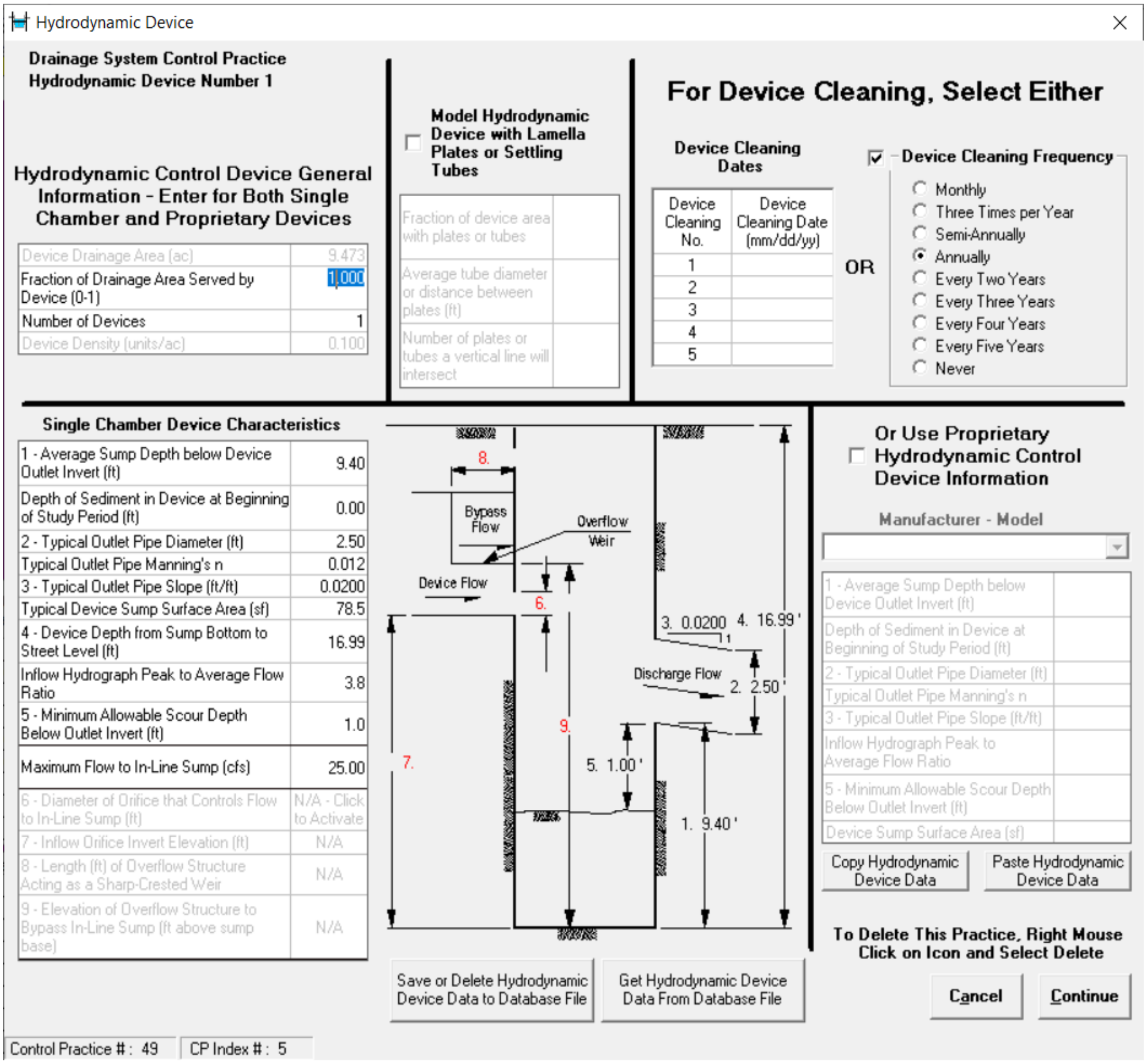


Figure 26: Typical parameters for 10-ft diameter hydrodynamic device.

Appendix B – Soil Information

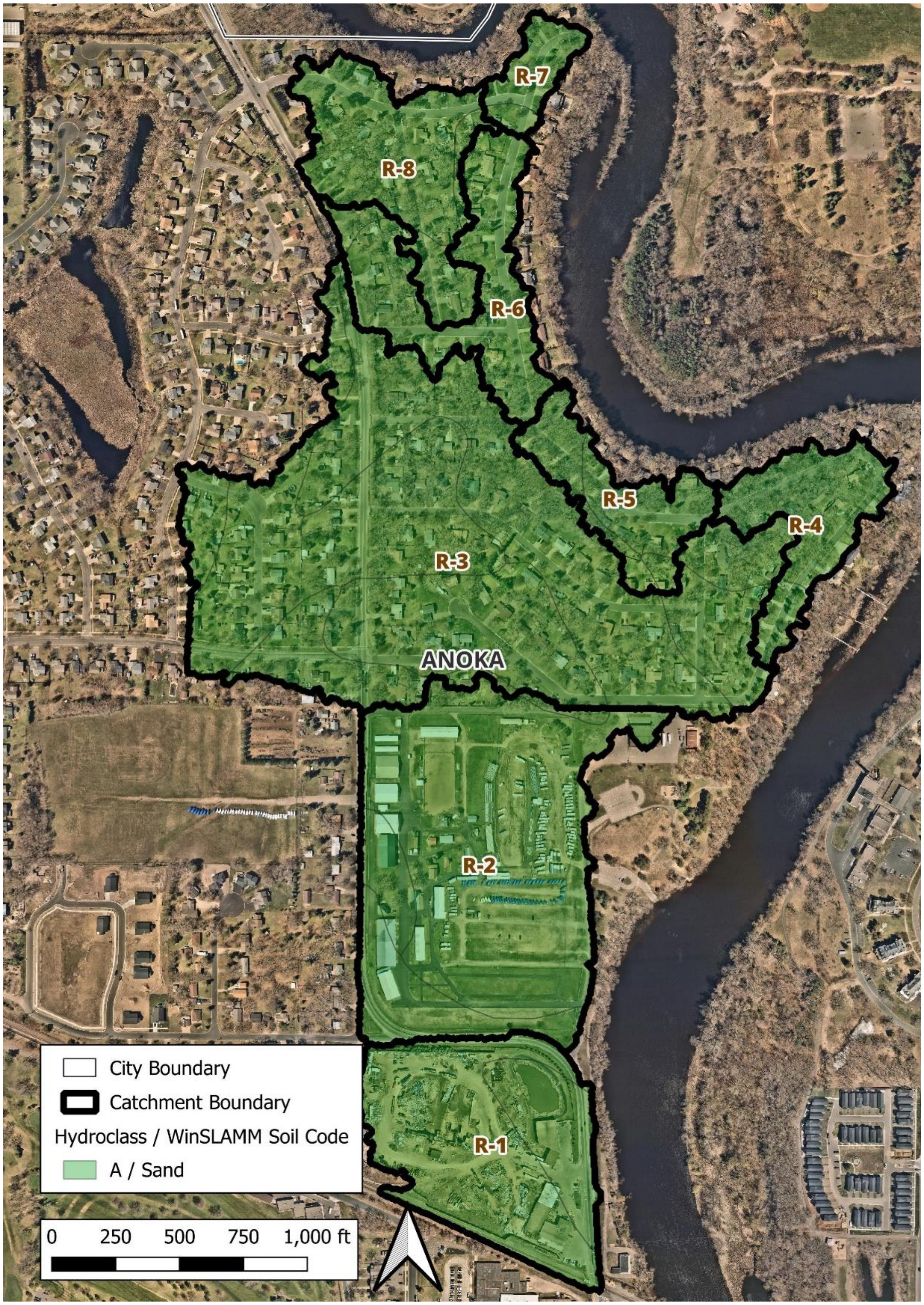


Figure 27: Rum River (Anoka) subwatershed soil hydroclass and texture used for WinSLAMM model.

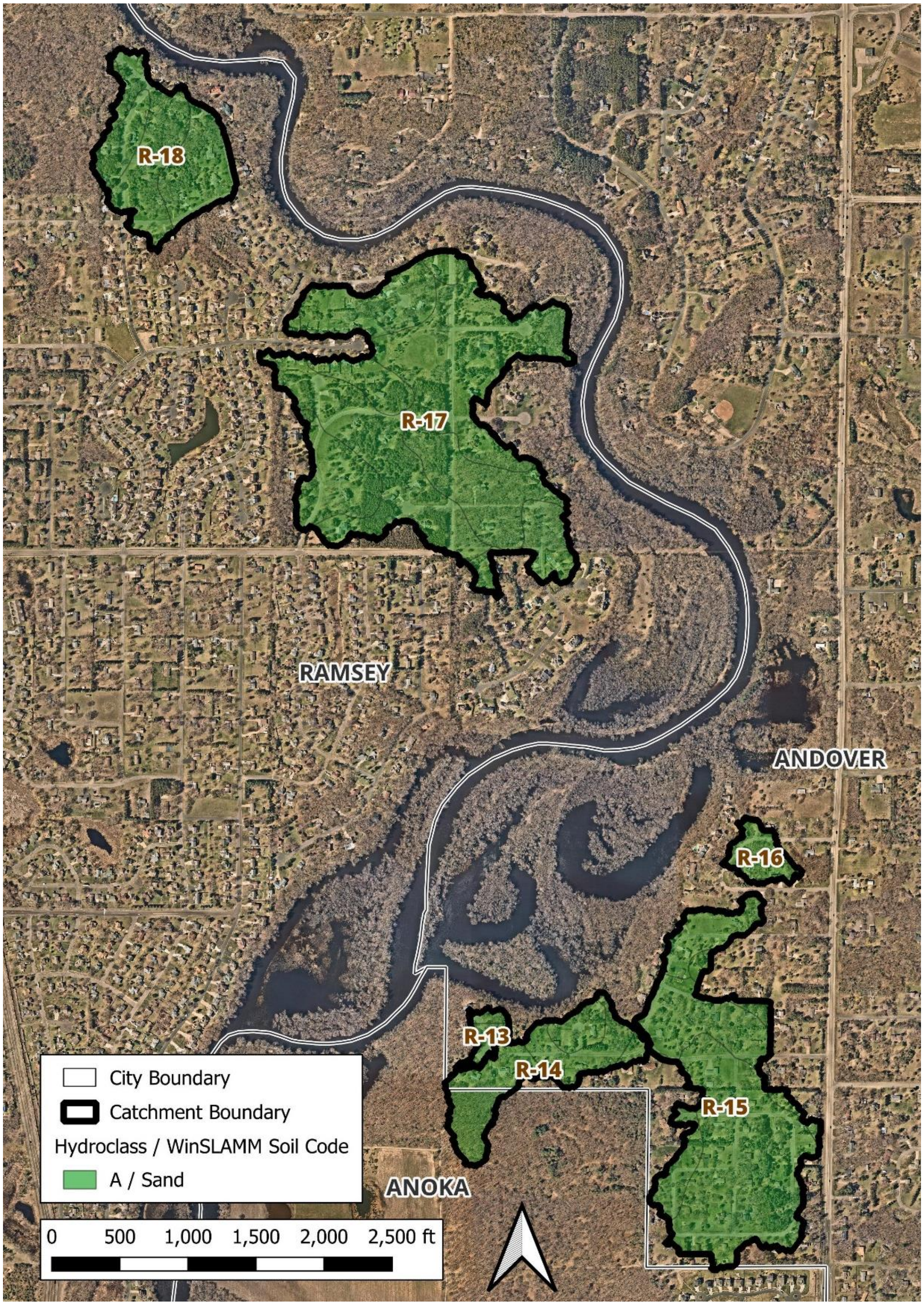


Figure 28: Rum River (Andover-Ramsey) subwatershed soil hydroclass and texture used for WinSLAMM model.

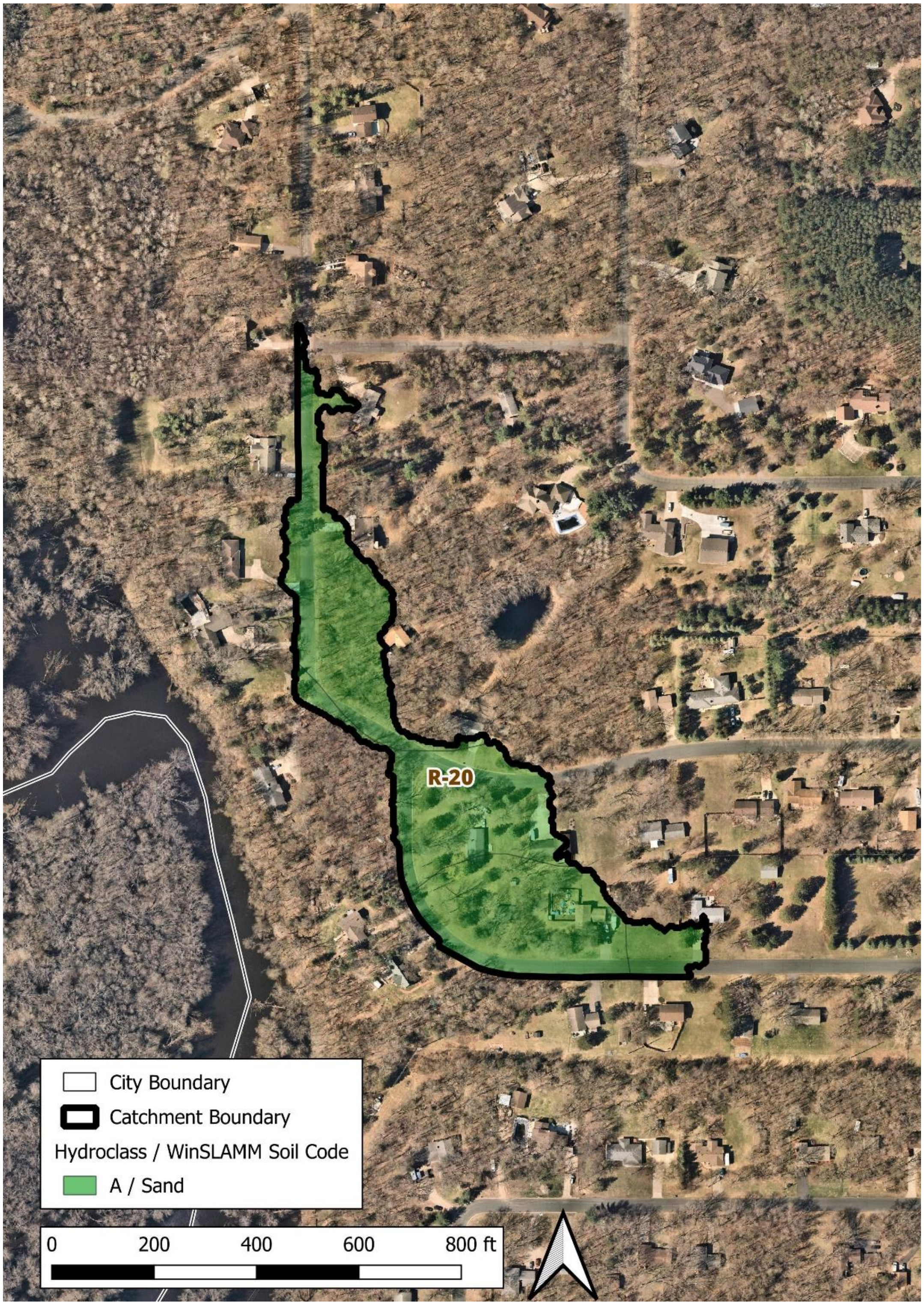


Figure 29: Rum River (northern Andover) subwatershed soil hydroclass and texture used for WinSLAMM model.

Appendix C – Wellhead Protection Areas

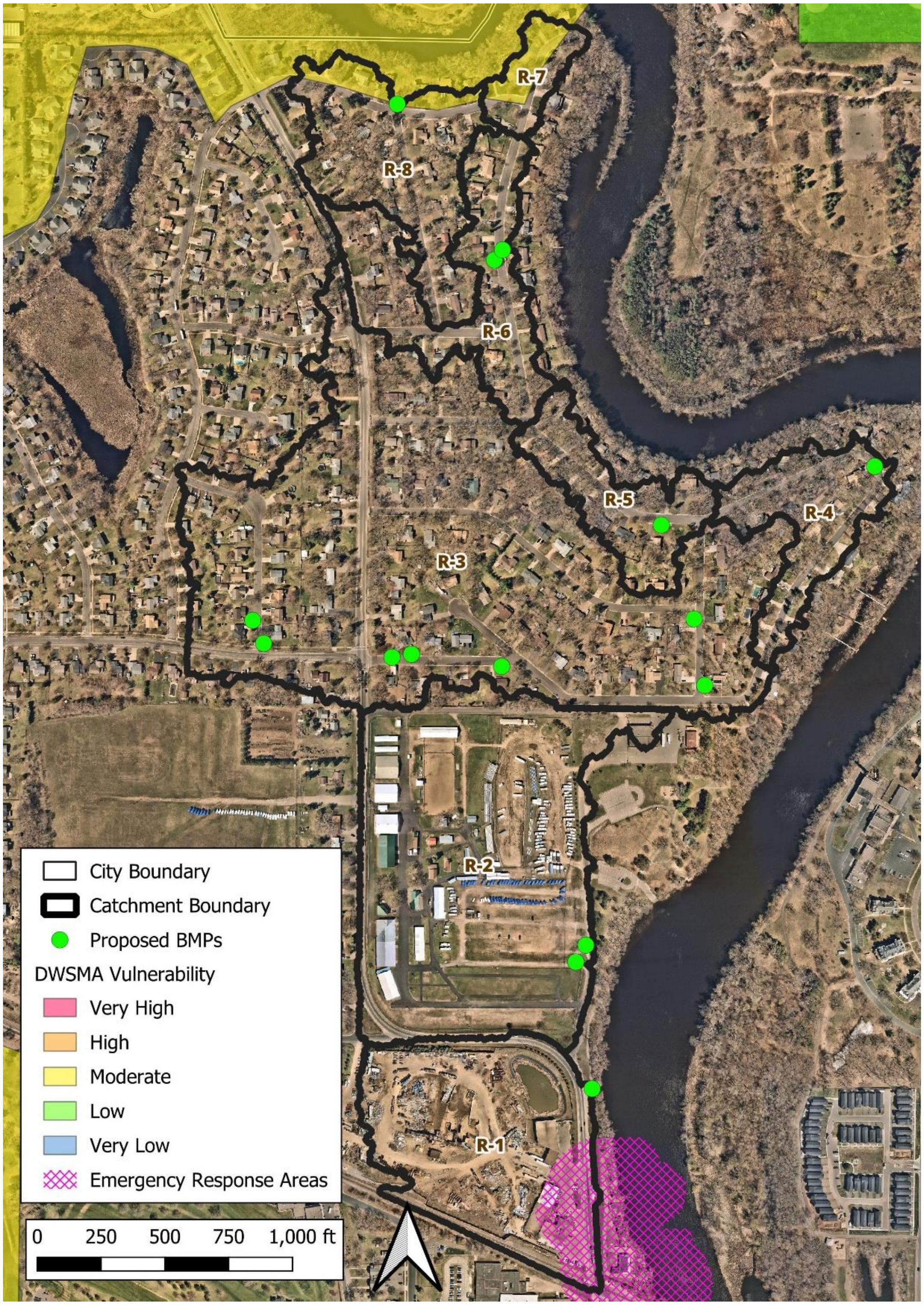


Figure 30: Rum River (Anoka) subwatershed Drinking Water Supply Management Area (DWSMA) Vulnerability and Emergency Response Areas.

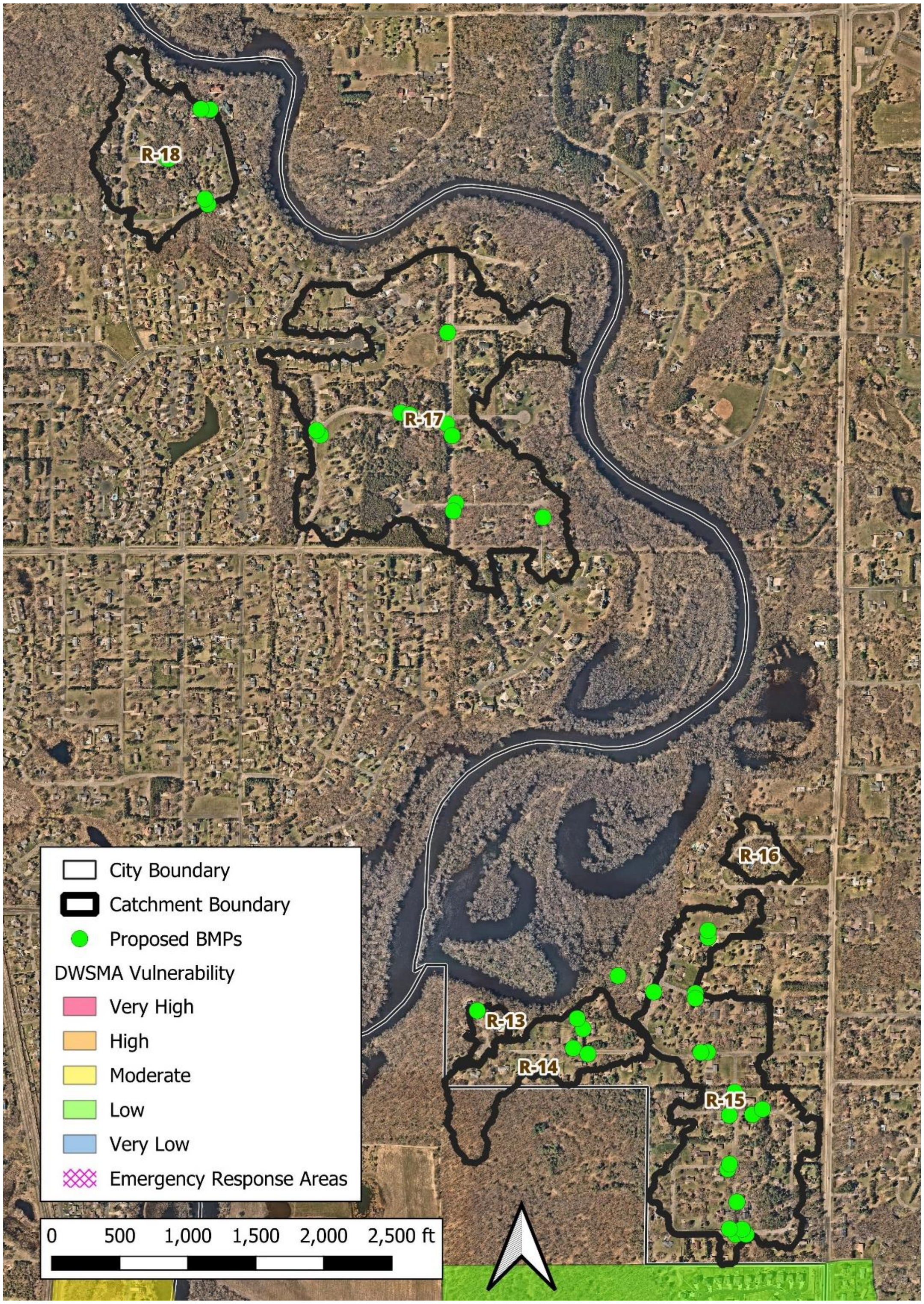


Figure 31: Rum River (Andover-Ramsey) subwatershed Drinking Water Supply Management Area (DWSMA) Vulnerability and Emergency Response Areas.

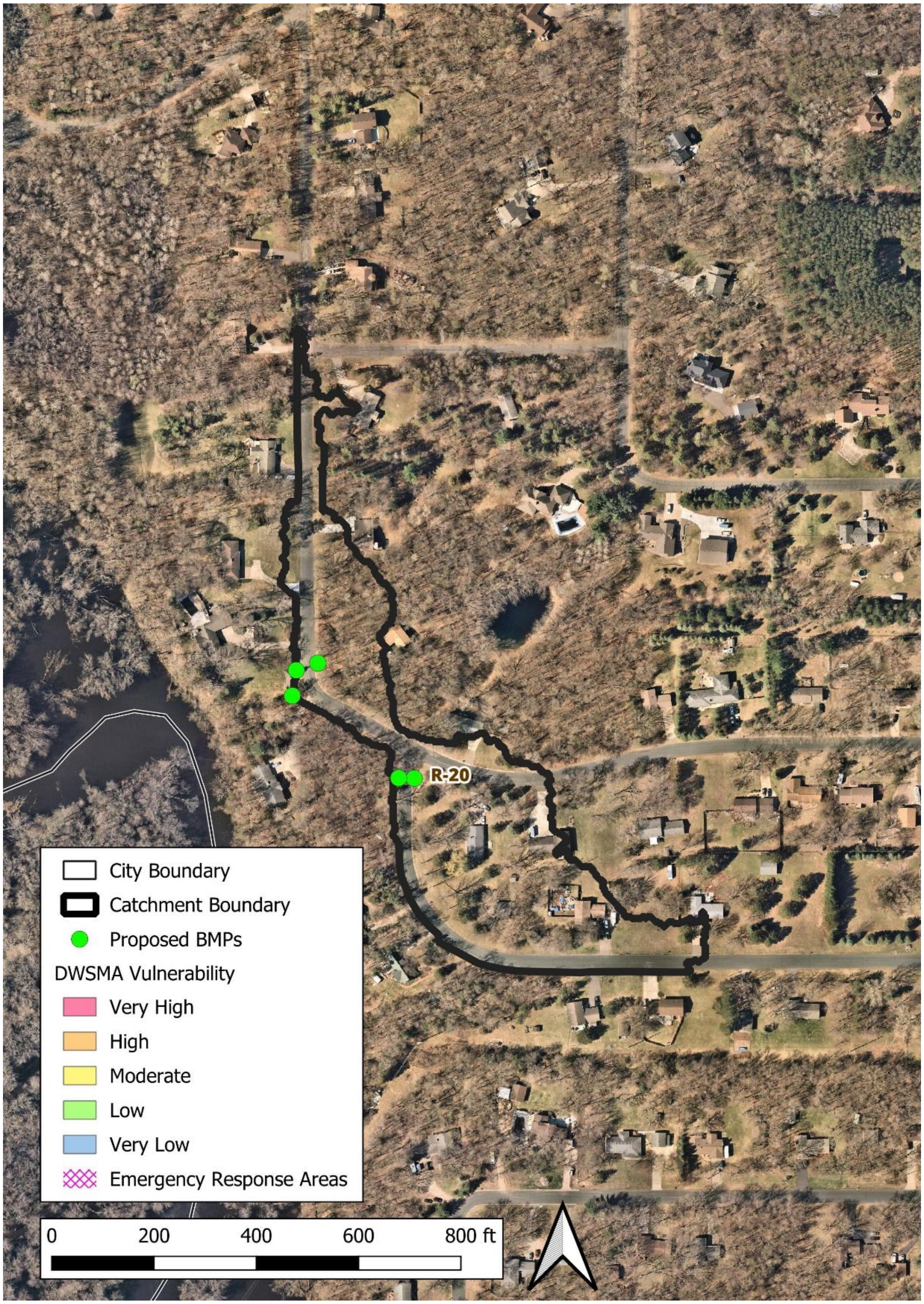


Figure 32: Rum River (northern Andover) subwatershed Drinking Water Supply Management Area (DWSMA) Vulnerability and Emergency Response Areas.

Appendix D – Enhanced Street Cleaning Calculator

Table 8: Recover calculator input values

Route ID	Curb-miles	Average % Canopy Cover	Unique Cost ($/curb-mile)
R-1	0.6	8.9	100
R-2	0.8	17.8	100
R-3	3.8	51.6	100
R-4	0.6	81.0	100
R-5	0.3	71.5	100
R-6	0.9	42.6	100
R-7	0.3	43.5	100
R-8	0.7	38.3	100
R-9	7.3	23.7	100
R-10	2.6	22.1	100
R-11	23.4	17.3	100
R-12	26.3	26.3	100
R-13	0.1	28.9	100
R-14	0.6	27.5	100
R-15	3.3	30.0	100
R-16	0.2	37.5	100
R-17	3.6	34.1	100
R-18	1.8	27.7	100

The unique cost ($/curb-mile) was selected at $100/curb-mile as a representative number. This is approximately the median value collected from case studies for street sweeping (Minnesota Stormwater Manual, 2023).

Table 9: Current conditions (twice per year)

Route	Predicted Annual				
	Wet solids, lb	Dry solids, lb	Nitrogen, lb	Phosphorus, lb	Cost, $
R-1 - 2x per year	765	550	1.9	0.4	$ 120.00
R-2 - 2x per year	1469	1019	5.1	0.8	$ 160.00
R-3 - 2x per year	27839	16876	330.0	17.2	$ 760.00
R-4 - 2x per year	14649	7899	506.2	9.9	$ 120.00
R-5 - 2x per year	4964	2780	121.4	3.3	$ 60.00
R-6 - 2x per year	4561	2866	39	3	$ 180.00
R-7 - 2x per year	1577	988	13.9	1.0	$ 60.00
R-8 - 2x per year	2975	1902	21.7	1.8	$ 140.00
R-9 - 2x per year	17064	11561	73.3	9.7	$ 1,460.00
R-10 - 2x per year	5692	3881	23.1	3.2	$ 520.00
R-11 - 2x per year	42089	29251	143.2	23.5	$ 4,680.00
R-12 - 2x per year	68383	45850	322.8	39.3	$ 5,260.00
R-13 - 2x per year	289	192	1.5	0.2	$ 20.00
R-14 - 2x per year	1639	1093	8.1	0.9	$ 120.00
R-15 - 2x per year	9984	6596	53.9	5.8	$ 660.00
R-16 - 2x per year	823	527	5.8	0.5	$ 40.00
R-17 - 2x per year	12882	8373	80.8	7.6	$ 720.00
R-18 - 2x per year	4956	3305	24.6	2.9	$ 360.00

*Due to size and distance from other catchments, R-19 and R-20 were not considered for enhanced street cleaning.

Table 10: Proposed enhanced street sweeping conditions (five times per year)

Route	Predicted Annual				
	Wet solids, lb	Dry solids, lb	Nitrogen, lb	Phosphorus, lb	Cost, $
R-1 - 5x per year	1213	906	3.7	0.7	$ 300.00
R-2 - 5x per year	2329	1678	9.7	1.3	$ 400.00
R-3 - 5x per year	44140	27797	631.1	27.9	$ 1,900.00
R-4 - 5x per year	23227	13010	968.2	16.1	$ 300.00
R-5 - 5x per year	7871	4579	232.2	5.3	$ 150.00
R-6 - 5x per year	7232	4721	74.5	4.5	$ 450.00
R-7 - 5x per year	2501	1627	26.6	1.5	$ 150.00
R-8 - 5x per year	4717	3132	41.6	2.9	$ 350.00
R-9 - 5x per year	27056	19042	140.2	15.8	$ 3,650.00
R-10 - 5x per year	9025	6393	44.1	5.2	$ 1,300.00
R-11 - 5x per year	66734	48181	273.9	38.2	$ 11,700.00
R-12 - 5x per year	108424	75523	617.4	63.7	$ 13,150.00
R-13 - 5x per year	459	316	2.9	0.3	$ 50.00
R-14 - 5x per year	2598	1801	15.5	1.5	$ 300.00
R-15 - 5x per year	15830	10865	103.1	9.4	$ 1,650.00
R-16 - 5x per year	1304	869	11.2	0.8	$ 100.00
R-17 - 5x per year	20425	13792	154.5	12.3	$ 1,800.00
R-18 - 5x per year	7858	5443	47.1	4.6	$ 900.00

*Due to size and distance from other catchments, R-19 and R-20 were not considered for enhanced street cleaning.

Table 11: Annual load recovery and cost effectiveness from 2x per year to 5x per year*

Catchment ID	Wet solids, lb	Dry solids, lb	Nitrogen, lb	Phosphorus, lb	Cost/lb-TP
R-1	448.0	355.8	1.7	0.3	$695
R-2	860.0	659.2	4.6	0.5	$470
R-3	16301.1	10921.3	301.2	10.7	$107
R-4	8577.8	5111.6	462.0	6.1	$29
R-5	2906.8	1799.0	110.8	2.0	$44
R-6	2670.8	1854.7	35.6	1.7	$158
R-7	923.7	639.1	12.7	0.6	$152
R-8	1741.9	1230.6	19.8	1.1	$191
R-9	9991.7	7481.4	66.9	6.0	$363
R-10	3333.0	2511.6	21.0	2.0	$389
R-11	24645.0	18929.7	130.7	14.6	$481
R-12	40041.1	29672.0	294.6	24.4	$324
R-13	169.3	124.2	1.4	0.1	$289
R-14	959.5	707.6	7.4	0.6	$307
R-15	5846.0	4268.7	49.2	3.6	$275
R-16	481.7	341.3	5.3	0.3	$198
R-17	7543.1	5418.7	73.7	4.7	$230
R-18	2902.1	2138.6	22.5	1.8	$304

*NOTE: Values do not account for existing BMP treatment.

Appendix E – Catchments Excluded from Detailed Analysis

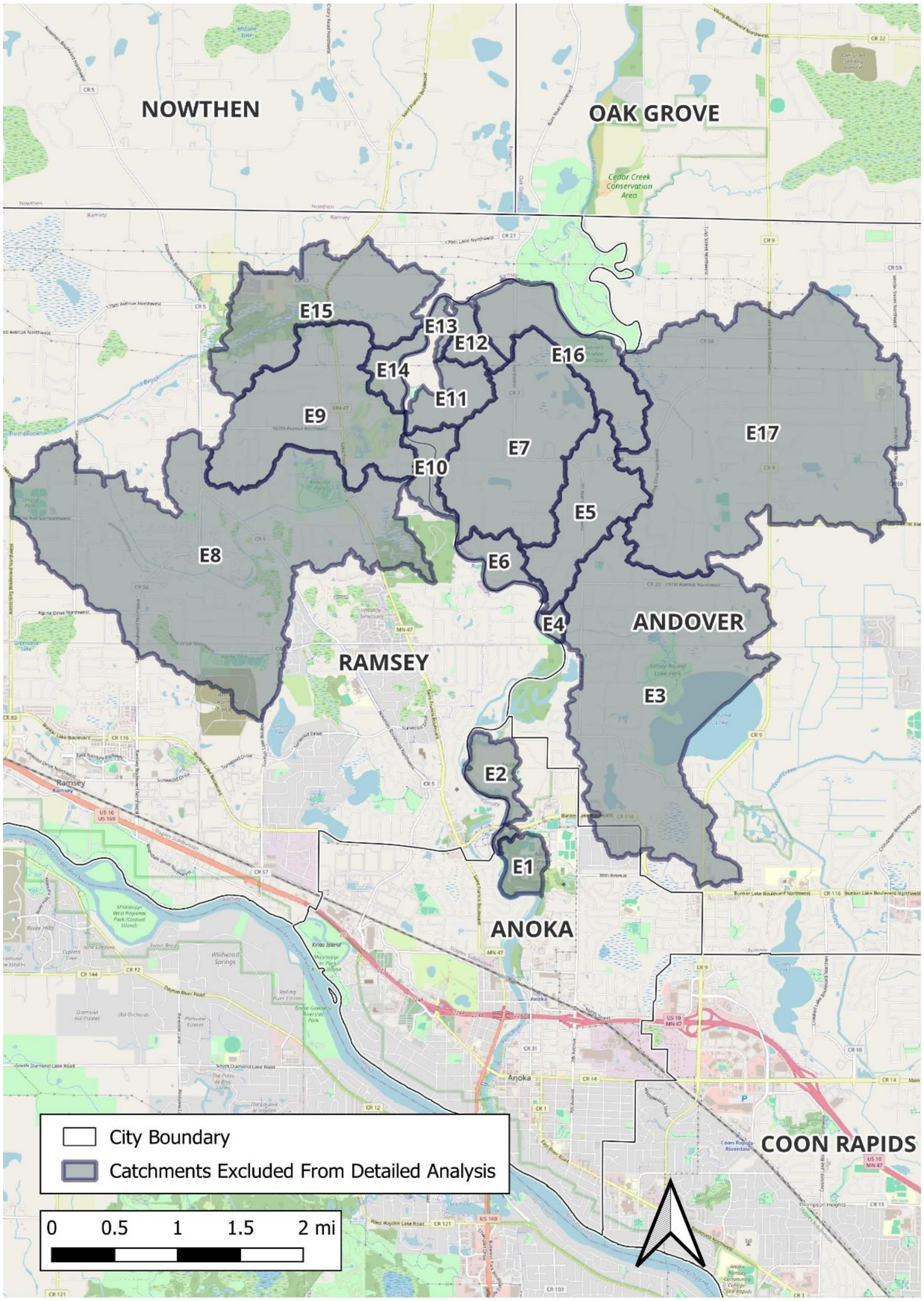


Figure 33: Rum River catchments excluded from detailed analysis.

Table 12: Summary of catchments excluded from detailed analysis.

Catchment ID	Area (acres)	Notes
E2	144.1	Mostly undeveloped / natural land with no storm sewer infrastructure.
E1	100.0	Mostly undeveloped.
E3	1850.9	Large network of connected wetlands and private/ roadside ditches. Storm sewer infrastructure outlets to Round Lake or stormwater pond(s) prior to ditch outfall.
E4	31.0	Mostly undeveloped with just one culvert to connect wetland areas.
E5	414.4	Private ditch network. Most storm sewer infrastructure outlets to a pond, wetland, or infiltration area prior to entering ditch. Low-density residential with small drainage areas to catch basins.
E6	115.7	Natural or low density residential land. Some culverts allowing passage of water to low-lying detention areas but no defined stormwater outfall(s).
E7	856.5	Largely undeveloped watershed. Crop fields actively being converted to new development. Existing residential development is either newer with sufficient stormwater treatment, or older with sandy roadside ditch networks.
E9	840.9	Minimal to no storm sewer infrastructure. Stormwater is effectively managed with roadside ditches leading to ponds or natural wetland areas. Most runoff to the Rum River likely stems from the golf course.
E8	2425.7	Large watershed for ditch tributary to Rum River. Storm sewer infrstructure is minimal and that which does exist flows to ponds or other wetland/low areas. Low density residential areas managed sufficiently with roadside ditches.
E10	122.3	No storm sewer infrastructure. Runoff passes to/ through roadside ditches and other undeveloped spaces prior to entering the Rum River.
E11	165.7	Primarily undeveloped / dominated by wetlands. Stormwater infrastructure that does exist sends runoff to / through a large wetland complex and flooplain prior to reaching the Rum River.
E12	92.9	There are some storm water sewers, but water runs to and through detention ponds prior to entering wetland complex leading to the Rum River. No distinct channel / outfall.
E13	36.8	Small subwatershed with minimal storm sewer infrastructure; water passes through a detention basin prior to entering a wetland/ floodplain complex.
E14	100.0	No storm sewer infrastructure. Minimal overland runoff passing through sandy roadside ditches.
E15	717.4	Downstream portions of Trott Brook and Ford Brook subwatersheds being analyzed in separate studies. Minimal direct storm sewer inputs in this stretch.
E16	414.2	Predominantly natural/ undeveloped land. Runoff passes through the watershed as overland flow to / through networks of floodplain wetlands.
E17	2418.4	Large watershed associated with a large ditch tributary. Land use varies and contains some agriculture and some low density developed area with some storm sewer infrastructure. The size and low development made this infeasible / low priority for this SRA.