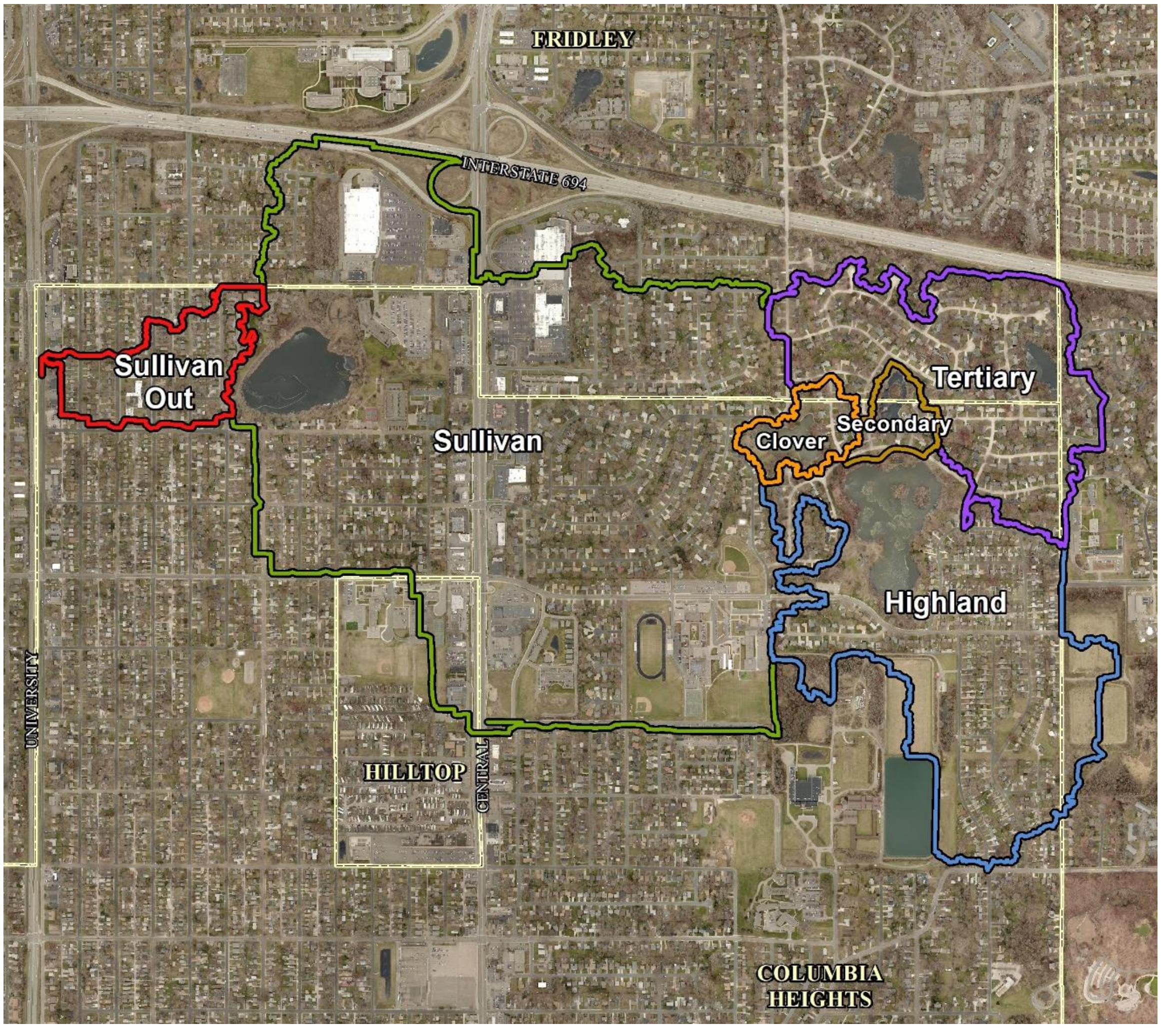

Highland and Sullivan Lakes Stormwater Retrofit Analysis

Prepared by:

ANOKA CONSERVATION DISTRICT

for the

MISSISSIPPI WATERSHED MANAGEMENT ORGANIZATION

Highland and Sullivan Lakes Stormwater Retrofit Analysis: 2019

Prepared for the MWMO by:
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Acknowledgements
The authors and the Mississippi Watershed Management Organization (MWMO) would like to thank the Highland and Sullivan Lakes Stormwater Retrofit Analysis Technical Advisory Committee (TAC), who reviewed this report and aided with identification of potential retrofit sites. In addition to the authors and MWMO staff identified above, this collaborative TAC included:

- Brett Eidem, MWMO
- Kevin Hansen, City of Columbia Heights
- Stephanie Johnson, MWMO (Project Manager)
- Jim Kosluchar, City of Fridley
- Jon Lennander, City of Fridley

Funding provided in part by the Clean Water Fund from the Clean Water, Land, and Legacy Amendment

Suggested citation:
Mississippi Watershed Management Organization. 2019. *Highland and Sullivan Lakes Stormwater Retrofit Analysis.*

Disclaimer: At the time of printing, this report identifies and ranks potential BMPs for selected subwatersheds in the cities of Columbia Heights and Fridley that drain to Highland and Sullivan Lakes. 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 either the Anoka Conservation District or the Mississippi Watershed Management Organization.

Abstract

The Mississippi Watershed Management Organization (MWMO) contracted the Anoka Conservation District to complete this stormwater retrofit analysis (SRA) for the purpose of identifying and ranking water quality improvement projects throughout the drainage areas to Highland and Sullivan Lakes. The target areas consist of portions of northern Columbia Heights and southern Fridley that drain to Highland and Sullivan Lakes. The MWMO specified total phosphorus (TP) and total suspended solids (TSS) as the target pollutants for the analysis. Because TMDLs do not exist for either impaired waterbody, annual subwatershed-wide reduction goals for TP and TSS are not available.

This analysis is primarily intended to identify potential projects within the target areas to improve water quality in Highland and Sullivan Lakes 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.

Drainage areas within the 715-acre study area were consolidated into 26 catchments and six drainage networks (groups of catchments draining to a common priority waterbody). A WinSLAMM model was created for each of the six drainage networks, which included Highland Lake (139 acres), Clover Pond (11 acres), Secondary Pond (8 acres), Tertiary Pond (92 acres), Sullivan Lake (433 acres), and an area west of the Sullivan Lake outlet (32 acres). Details of the volume and pollutant loading within each drainage network 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.

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Executive Summary

The Mississippi Watershed Management Organization (MWMO) contracted the Anoka Conservation District (ACD) to complete this stormwater retrofit analysis (SRA) for the purpose of identifying and ranking water quality improvement projects in selected subwatersheds that drain to Highland Lake, Sullivan Lake, and three nearby stormwater ponds (Clover Pond, Secondary Pond, Tertiary Pond). Included in the analysis is an additional area draining toward the Mississippi River west of Sullivan Lake. The subwatersheds are located in the cities of Columbia Heights and Fridley and consist of mostly commercial, residential, and park land uses. 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 six water bodies listed above 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 was identified. They included bioretention (bioinfiltration, biofiltration, and high performance modular biofiltration systems), hydrodynamic devices, existing stormwater pond modifications, new stormwater ponds, and iron enhanced sand filter beds for ponds.

If all of these practices were installed, significant pollutant reductions could be accomplished. However, funding limitations and landowner interest make this goal unlikely. Instead, 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 also affect project installation decisions and need to be weighed by resource managers when selecting projects to pursue.

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, many of the proposed retrofits (e.g. new ponds) 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 715-acre target study area was consolidated into six drainage networks and 26 catchments. 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, 123 projects were identified throughout the six drainage networks. Project types generally consisted of biofiltration (71, 58% of total), bioinfiltration (27, 22% of total), hydrodynamic devices (21, 17% of total), and stormwater pond installations or modifications (4, 3% of total). The fully developed landscape limited opportunities for large, regional practices; the limited open space available within most of the drainage networks was more suitable for small-scale bioretention practices.

The effectiveness of these small-scale bioretention practices was also limited by slow draining, silty soils throughout most of the drainage area, except for the Sullivan Out watershed area. Most of these projects are located in residential neighborhoods with small drainage areas (typically 0.5-2 acres). In a residential setting with silty soils and less than two acres of contributing drainage area, bioinfiltration practices with a nine-inch ponding depth were the most cost-effective retrofit option. Given 0.2 in/hr infiltration rates, this reduced ponding depth facilitates drawdown in 45 hours, which is at the upper end of an acceptable wet period. Because of this lengthy drawdown time, biofiltration practices were preferred in the model if a catch basin tie-in was feasible. In similar settings with greater than two acres of drainage area, High Performance Modular Biofiltration Systems (HPMBS) were found to be the most cost-effective retrofit option, given the availability of an underdrain. These systems cost significantly more than similarly sized bioretention practices, but they offer better pollutant removal per dollar at sites where contributing drainage areas were larger than two acres. HPMBS systems also have significantly shorter drawdown periods because of a high media filtration rate.

Overall, cost-effectiveness for TP removal ranged from ~$390/lb-TP to ~$8,900/lb-TP. The most cost-effective projects for TP removal were ponds, bioinfiltration basins, and high-performance modular biofiltration systems. Cost-effectiveness for TSS removal ranged from ~$1,100/1,000 lbs-TSS to ~$20,850/1,000 lbs-TSS. Similar to TP, the most cost-effective projects for TSS removal were ponds, bioinfiltration basins, and high-performance modular biofiltration systems. The two most cost-effective projects, a new regional stormwater pond near Sullivan Lake and a pond retrofit south of Highland Lake, both additionally require a land purchase or agreement to store stormwater on another entities' property.

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 can be found in the catchment profile pages of this report. Projects that were 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 amount of pollutant removed by 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 areas targeted for this analysis were consolidated into 43 catchments distributed throughout six drainage networks and assigned unique identification numbers. For each catchment, the following information is detailed:

Drainage Network

Catchments were grouped into drainage networks based on their geographic distribution throughout the study area and drainage to a common waterbody (i.e. Highland Lake, Clover Pond, Secondary Pond, Tertiary Pond, Sullivan Lake, or the Mississippi River). The drainage networks were used to further subdivide the report to aid with organization and clarity.

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 either the MWMO, City of Columbia Heights, or City of Fridley. 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 Recommendations

Retrofit recommendations 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 drainage areas studied for this analysis are located in the City of Columbia Heights and City of Fridley within the MWMO and drain to a variety of priority water bodies: Highland Lake, Clover Pond, Secondary Pond, Tertiary Pond, Sullivan Lake, and the Mississippi River. The primary targets for water quality improvement are Highland Lake and Sullivan Lake.

Highland Lake is a shallow lake with a surface area of approximately 14 acres. The lake is immediately surrounded by Kordiak Park and is positioned within an urbanized residential neighborhood. There are seven inlets to the lake via storm sewer pipe and two outlets, one to Clover Pond and one to Secondary Pond. Highland Lake was listed as an impaired water in 2004 by the Minnesota Pollution Control Agency (MPCA) for nutrients and biological indicators. A Total Maximum Daily Load (TMDL) study has not been completed for Highland Lake, but the MPCA has identified 2025 as the target completion year.

Sullivan Lake (also known as Sandy Lake) is also a shallow lake with a surface area of approximately 17 acres. Sullivan Lake Park encompasses the lake, and the immediate surrounding land use is a mix of residential and commercial properties. There are seven inlets to the lake via storm sewer pipe and a single outlet that ultimately discharges to the Mississippi River. Sullivan Lake was listed as an impaired water in 2002 by the MPCA for nutrients and biological indicators. Similar to Highland, a TMDL has not yet been completed but has a target completion year of 2025. Additional details regarding lake water quality data for both Highland and Sullivan Lakes are available in Water Almanacs prepared by the Anoka Conservation District.

The area analyzed was divided into six subwatersheds based on priority waterbody and consists of 715 acres. Boundaries of the total focus area are approximately Interstate 694 on the north, University Ave. on the west, Stinson Blvd. on the east, and 47th Ave. on the south. It was selected for analysis due to a number of reasons: 1) water quality data are available, 2) Highland and Sullivan Lakes are impaired for both nutrients and biological indicators, 3) there is currently limited existing stormwater treatment throughout the subwatersheds, 4) a hydraulic and hydrologic analysis is being conducted simultaneously in the same subwatershed, thereby allowing both water quantity and quality issues to be investigated, and 5) the Cities of Columbia Heights and Fridley are planning street reconstruction projects within the target area, which may present opportunities for water quality improvement projects. Stormwater retrofits may provide cost-effective options for additional treatment of runoff, thereby improving water quality in the priority water bodies.

The catchments analyzed are heavily urbanized. Development throughout the Cities of Columbia Heights and Fridley 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 areas targeted for this analysis is still conveyed to the high priority water bodies, as it was historically. However, the runoff is now captured by catch basins and directed underground before being discharged to the priority water bodies via stormwater pipes. This along with the impervious surfaces has caused increased volume and pollutant loading to the priority water bodies relative to natural, historical conditions.

Stormwater runoff from impervious surfaces can carry a variety of pollutants. While stormwater treatment to remove these pollutants is adequate in some areas, other areas were built prior to modern-day stormwater treatment technologies and requirements. The MWMO identified urban stormwater management as a focus area within their 2011-2021 Watershed Management Plan and explicitly cited the challenges associated with implementing stormwater retrofits within a highly urbanized watershed (MWMO, 2011). This SRA is intended to identify potential projects that will benefit the priority water bodies.

The MWMO contracted the ACD to complete this SRA for the purpose of identifying and analyzing projects to improve the quality of stormwater runoff from contributing drainage areas to Highland Lake, Clover Pond, Secondary Pond, Tertiary Pond, Sullivan Lake, and the Mississippi River. Overall subwatershed loading of TP, TSS, and stormwater volume were estimated for subdivided drainage networks throughout the focus area. 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, 2019).

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 bodies (i.e. Highland Lake, Sullivan Lake, Clover Pond, Secondary Pond, Tertiary Pond, and the Mississippi River). Included are areas of residential, commercial, industrial, and institutional land uses. The focus areas were divided into 43 catchments using a combination of existing subwatershed mapping data provided by Barr Engineering Co. that was generated as part of the hydrologic and hydraulic model that included the same focus areas (more details provided in the 'Modeling' section), 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 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 particulate phosphorus (PP), which is bound to sediment and organic debris, and dissolved phosphorus (DP), which is in solution and readily available for plant growth (active).
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 with it PP. As such, reductions in TSS will also result in TP reductions.
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. However, in-stream erosion is not an issue in these catchments because stormwater is piped directly to the target water bodies.

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 10.4.1), 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. Soils throughout the study area were predominantly either sand or silt based on the information available in the Anoka County soil survey. 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 completed by Barr Engineering as part of the hydrologic and hydraulic model for an area encompassing the focus area of this study were used to model the land uses in each catchment. The delineation file used to inform this report is 'Draft_subwatersheds_091218', developed on September 12th, 2018 by Barr Engineering Co. The drainage areas were consolidated into catchments using geographic information systems (specifically, ArcMap). Land use data (based on 2010 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 2017 aerial photography, the most recent available at the time of this analysis, as well as ground trothing and corrected if land use had changed since 2010. This process addressed recent development throughout the study area by reclassifying land use types accordingly. Soil types throughout the focus area were modeled as sand and silt in this analysis based on the 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 Columbia Heights and the City of Fridley (Figure 1 and Figure 2). Please note only the Highland Lake and Sullivan Lake drainage networks had existing stormwater treatment practices in addition to street cleaning. For example, street cleaning with vacuum street sweepers, 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.

Bioretention retrofits were modeled as either biofiltration or bioinfiltration practices based on the underlying soil type assumptions and a particular practice's proximity to a structure that could receive an underdrain connection. In areas with sandy soils, bioinfiltration was modeled with a native soil infiltration rate of 1.63"/hour to estimate volume and pollutant reductions of the proposed retrofits. In areas with silty soils, biofiltration was modeled wherever possible with a native soil infiltration rate of 0.2"/hour. If a proposed project location had silty soils and connection of an underdrain to an existing stormwater structure was not possible, the maximum ponding depth of the proposed practice was reduced to achieve an acceptable maximum estimated drawdown time (i.e. <48 hours). All modeling details for proposed retrofits are available 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 2019 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) and recent installation costs and cost estimates provided to the 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** cover 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 pound of TP and per 1,000 pounds of TSS removed.

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

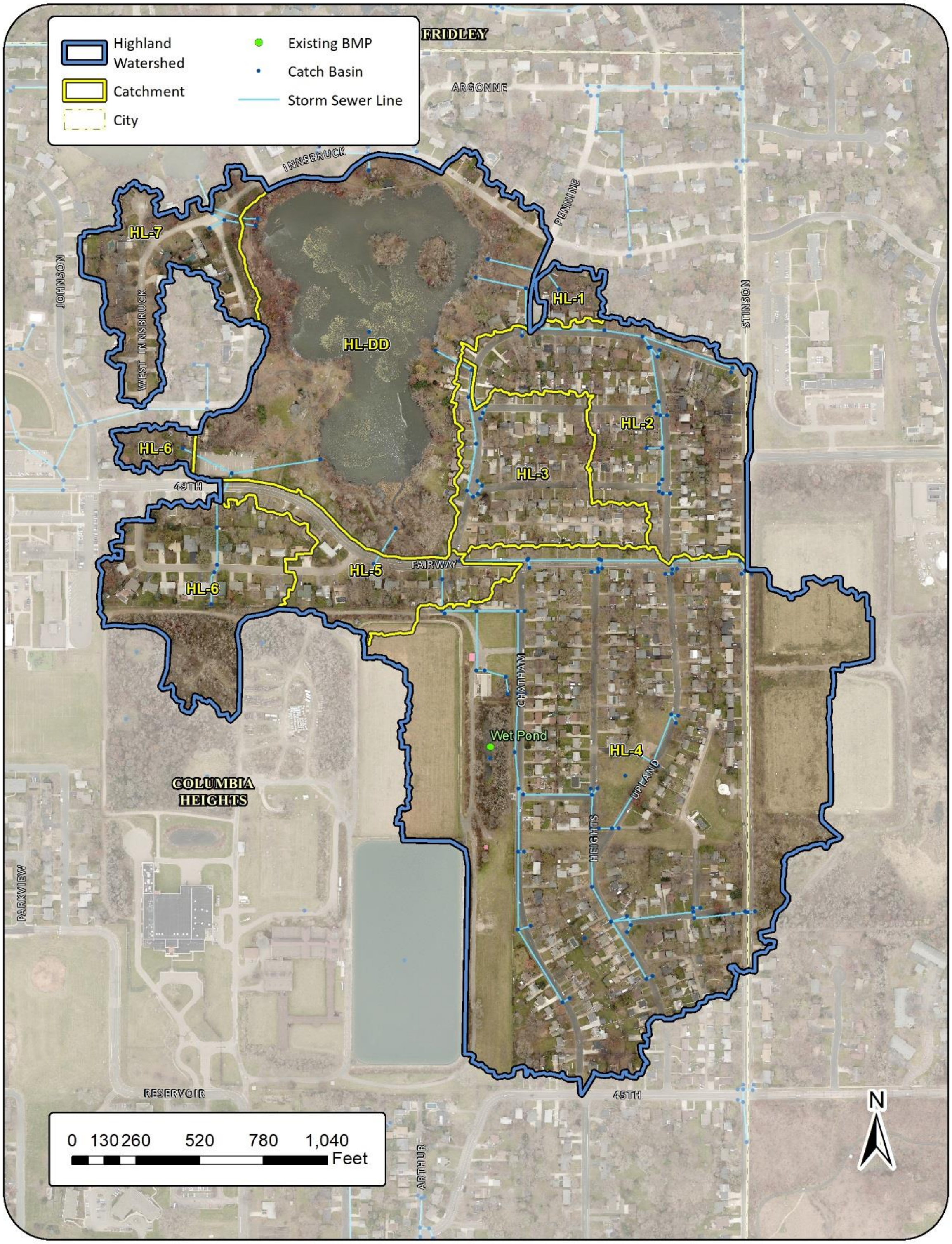


Figure 1: Highland Lake drainage network map showing existing BMPs included in the WinSLAMM model. Street sweeping is not shown on the map but was included throughout

Figure 2: Sullivan Lake drainage network map showing existing BMPs included in the WinSLAMM model. Street sweeping is not shown on the map but was included throughout

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.

Project Ranking

If all identified practices were installed, significant pollution reduction could be accomplished. However, funding limitations and landowner interest will likely be limiting factors for implementation. The tables on the following pages rank all modeled projects by cost-effectiveness.

For the six target waterbodies 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.

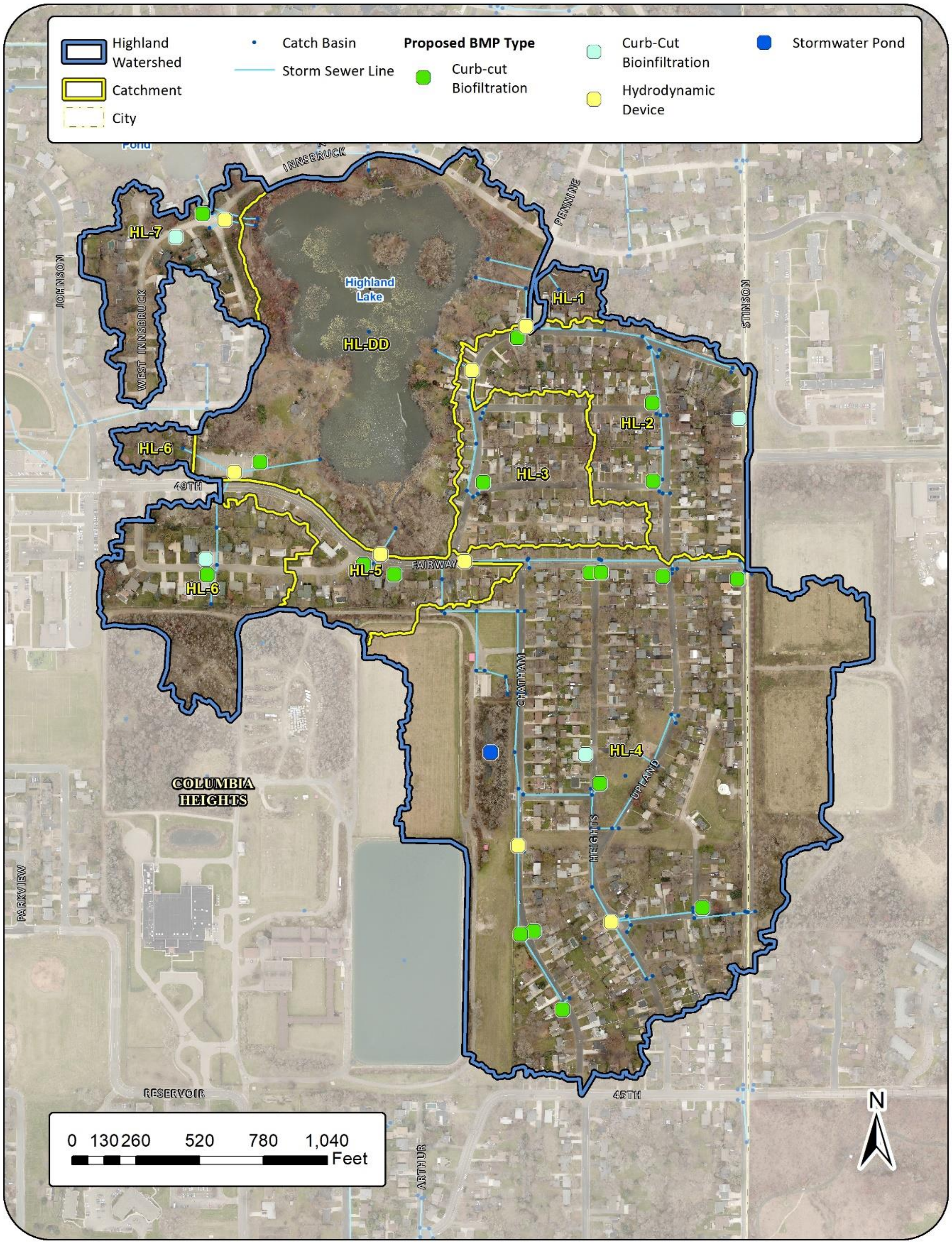


Figure 3: Study area map showing the proposed retrofits in the Highland Lake drainage network included in this report.

Table 2: Cost-effectiveness of retrofits with respect to TP reduction. Projects ranked 1 – 16 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	HL-4 SP-1	71	Pond Modification	HL-4	10.41	3,634	0.0	$92,300.00	$1,000.00	$391.61
2	HL-5 BF-2	88	Curb-Cut Biofiltration	HL-5	0.24	81	0.05	$11,004.00	$295.00	$2,757.50
3	HL-7 BF-1	97	Curb-Cut Biofiltration	HL-7	0.24	82	0.07	$11,004.00	$295.00	$2,757.50
4	HL-7 BI-1	98	Curb-Cut Bioinfiltration	HL-7	0.20	56	0.14	$10,004.00	$225.00	$2,792.33
5	HL-2 BI-1	62	Curb-Cut Bioinfiltration	HL-2	0.19	54	0.14	$10,004.00	$225.00	$2,939.30
6	HL-4 BI-1	81	Curb-Cut Bioinfiltration	HL-4	0.18	52	0.12	$10,004.00	$225.00	$3,102.59
7	HL-6 BI-1	93	Curb-Cut Bioinfiltration	HL-6	0.17	48	0.12	$10,004.00	$225.00	$3,285.10
8	HL-4 BF-5	76	Curb-Cut Biofiltration	HL-4	0.20	67	0.05	$11,004.00	$295.00	$3,309.00
9	HL-6 BF-1	92	Curb-Cut Biofiltration	HL-6	0.20	48	0.05	$11,004.00	$295.00	$3,309.00
10	HL-5 BF-1	87	Curb-Cut Biofiltration	HL-5	0.19	65	0.05	$11,004.00	$295.00	$3,483.16
11	HL-2 BF-1	59	Curb-Cut Biofiltration	HL-2	0.18	59	0.05	$11,004.00	$295.00	$3,676.67
12	HL-4 BF-2	73	Curb-Cut Biofiltration	HL-4	0.18	61	0.05	$11,004.00	$295.00	$3,676.67
13	HL-4 BF-4	75	Curb-Cut Biofiltration	HL-4	0.18	60	0.05	$11,004.00	$295.00	$3,676.67
14	HL-4 BF-8	79	Curb-Cut Biofiltration	HL-4	0.18	61	0.05	$11,004.00	$295.00	$3,676.67
15	HL-2 HD-1	63	Hydrodynamic Device	HL-2	1.00	351	0.00	$111,750.00	$630.00	$4,355.00
16	HL-4 BF-3	74	Curb-Cut Biofiltration	HL-4	0.15	48	0.05	$11,004.00	$295.00	$4,412.00

[1][(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TP Reduction)]

Table 3: Cost-effectiveness of retrofits with respect to TP reduction. Projects ranked 17-31 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]
17	HL-3 BF-1	66	Curb-Cut Biofiltration	HL-3	0.14	47	0.05	$11,004.00	$295.00	$4,727.14
18	HL-DD B F-1	54	Curb-Cut Biofiltration	HL-DD	0.14	43	0.02	$11,004.00	$295.00	$4,727.14
19	HL-4 BF-6	77	Curb-Cut Biofiltration	HL-4	0.13	38	0.02	$11,004.00	$295.00	$5,090.77
20	HL-4 BF-9	80	Curb-Cut Biofiltration	HL-4	0.13	40	0.02	$11,004.00	$295.00	$5,090.77
21	HL-6 HD-1	94	Hydrodynamic Device	HL-6	0.84	292	0.00	$111,750.00	$630.00	$5,184.52
22	HL-5 HD-1	89	Hydrodynamic Device	HL-5	0.49	172	0.00	$57,750.00	$630.00	$5,214.29
23	HL-4 HD-3	84	Hydrodynamic Device	HL-4	0.79	274	0.00	$111,750.00	$630.00	$5,512.66
24	HL-3 HD-1	67	Hydrodynamic Device	HL-3	0.73	253	0.00	$111,750.00	$630.00	$5,965.75
25	HL-4 HD-1	82	Hydrodynamic Device	HL-4	0.73	264	0.00	$111,750.00	$630.00	$5,965.75
26	HL-2 BF-2	60	Curb-Cut Biofiltration	HL-2	0.11	32	0.02	$11,004.00	$295.00	$6,016.36
27	HL-4 BF-1	72	Curb-Cut Biofiltration	HL-4	0.11	33	0.02	$11,004.00	$295.00	$6,016.36
28	HL-4 BF-7	78	Curb-Cut Biofiltration	HL-4	0.11	34	0.02	$11,004.00	$295.00	$6,016.36
29	HL-2 BF-3	61	Curb-Cut Biofiltration	HL-2	0.10	32	0.02	$11,004.00	$295.00	$6,618.00
30	HL-7 HD-1	99	Hydrodynamic Device	HL-7	0.65	226	0.00	$111,750.00	$630.00	$6,700.00
31	HL-4 HD-2	83	Hydrodynamic Device	HL-4	0.24	82	0.00	$30,750.00	$630.00	$6,895.83

[1][(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TP Reduction)]

Table 4: Cost-effectiveness of retrofits with respect to TSS reduction. Projects ranked 1 – 16 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	HL-4 SP-1	71	Pond Modification	HL-4	10.41	3,634	0.0	$92,300.00	$1,000.00	$1,121.81
2	HL-7 BF-1	97	Curb-Cut Biofiltration	HL-7	0.24	82	0.07	$11,004.00	$295.00	$8,070.73
3	HL-5 BF-2	88	Curb-Cut Biofiltration	HL-5	0.24	81	0.05	$11,004.00	$295.00	$8,170.37
4	HL-4 BF-5	76	Curb-Cut Biofiltration	HL-4	0.20	67	0.05	$11,004.00	$295.00	$9,877.61
5	HL-7 BI-1	98	Curb-Cut Bioinfiltration	HL-7	0.20	56	0.14	$10,004.00	$225.00	$9,972.62
6	HL-5 BF-1	87	Curb-Cut Biofiltration	HL-5	0.19	65	0.05	$11,004.00	$295.00	$10,181.54
7	HL-2 BI-1	62	Curb-Cut Bioinfiltration	HL-2	0.19	54	0.14	$10,004.00	$225.00	$10,341.98
8	HL-4 BI-1	81	Curb-Cut Bioinfiltration	HL-4	0.18	52	0.12	$10,004.00	$225.00	$10,739.74
9	HL-4 BF-2	73	Curb-Cut Biofiltration	HL-4	0.18	61	0.05	$11,004.00	$295.00	$10,849.18
10	HL-4 BF-8	79	Curb-Cut Biofiltration	HL-4	0.18	61	0.05	$11,004.00	$295.00	$10,849.18
11	HL-4 BF-4	75	Curb-Cut Biofiltration	HL-4	0.18	60	0.05	$11,004.00	$295.00	$11,030.00
12	HL-2 BF-1	59	Curb-Cut Biofiltration	HL-2	0.18	59	0.05	$11,004.00	$295.00	$11,216.95
13	HL-6 BI-1	93	Curb-Cut Bioinfiltration	HL-6	0.17	48	0.12	$10,004.00	$225.00	$11,634.72
14	HL-2 HD-1	63	Hydrodynamic Device	HL-2	1.00	351	0.00	$111,750.00	$630.00	$12,407.41
15	HL-4 BF-3	74	Curb-Cut Biofiltration	HL-4	0.15	48	0.05	$11,004.00	$295.00	$13,787.50
16	HL-6 BF-1	92	Curb-Cut Biofiltration	HL-6	0.20	48	0.05	$11,004.00	$295.00	$13,787.50

[1][(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TSS Reduction/1000)]

Table 5: Cost-effectiveness of retrofits with respect to TSS reduction. Projects ranked 17 – 31 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]
17	HL-3 BF-1	66	Curb-Cut Biofiltration	HL-3	0.14	47	0.05	$11,004.00	$295.00	$14,080.85
18	HL-5 HD-1	89	Hydrodynamic Device	HL-5	0.49	172	0.00	$57,750.00	$630.00	$14,854.65
19	HL-6 HD-1	94	Hydrodynamic Device	HL-6	0.84	292	0.00	$111,750.00	$630.00	$14,914.38
20	HL-DD B F-1	54	Curb-Cut Biofiltration	HL-DD	0.14	43	0.02	$11,004.00	$295.00	$15,390.70
21	HL-4 HD-3	84	Hydrodynamic Device	HL-4	0.79	274	0.00	$111,750.00	$630.00	$15,894.16
22	HL-4 HD-1	82	Hydrodynamic Device	HL-4	0.73	264	0.00	$111,750.00	$630.00	$16,496.21
23	HL-4 BF-9	80	Curb-Cut Biofiltration	HL-4	0.13	40	0.02	$11,004.00	$295.00	$16,545.00
24	HL-3 HD-1	67	Hydrodynamic Device	HL-3	0.73	253	0.00	$111,750.00	$630.00	$17,213.44
25	HL-4 BF-6	77	Curb-Cut Biofiltration	HL-4	0.13	38	0.02	$11,004.00	$295.00	$17,415.79
26	HL-7 HD-1	99	Hydrodynamic Device	HL-7	0.65	226	0.00	$111,750.00	$630.00	$19,269.91
27	HL-4 BF-7	78	Curb-Cut Biofiltration	HL-4	0.11	34	0.02	$11,004.00	$295.00	$19,464.71
28	HL-4 BF-1	72	Curb-Cut Biofiltration	HL-4	0.11	33	0.02	$11,004.00	$295.00	$20,054.55
29	HL-4 HD-2	83	Hydrodynamic Device	HL-4	0.24	82	0.00	$30,750.00	$630.00	$20,182.93
30	HL-2 BF-2	60	Curb-Cut Biofiltration	HL-2	0.11	32	0.02	$11,004.00	$295.00	$20,681.25
31	HL-2 BF-3	61	Curb-Cut Biofiltration	HL-2	0.10	32	0.02	$11,004.00	$295.00	$20,681.25

[1][(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TSS Reduction/1000)]

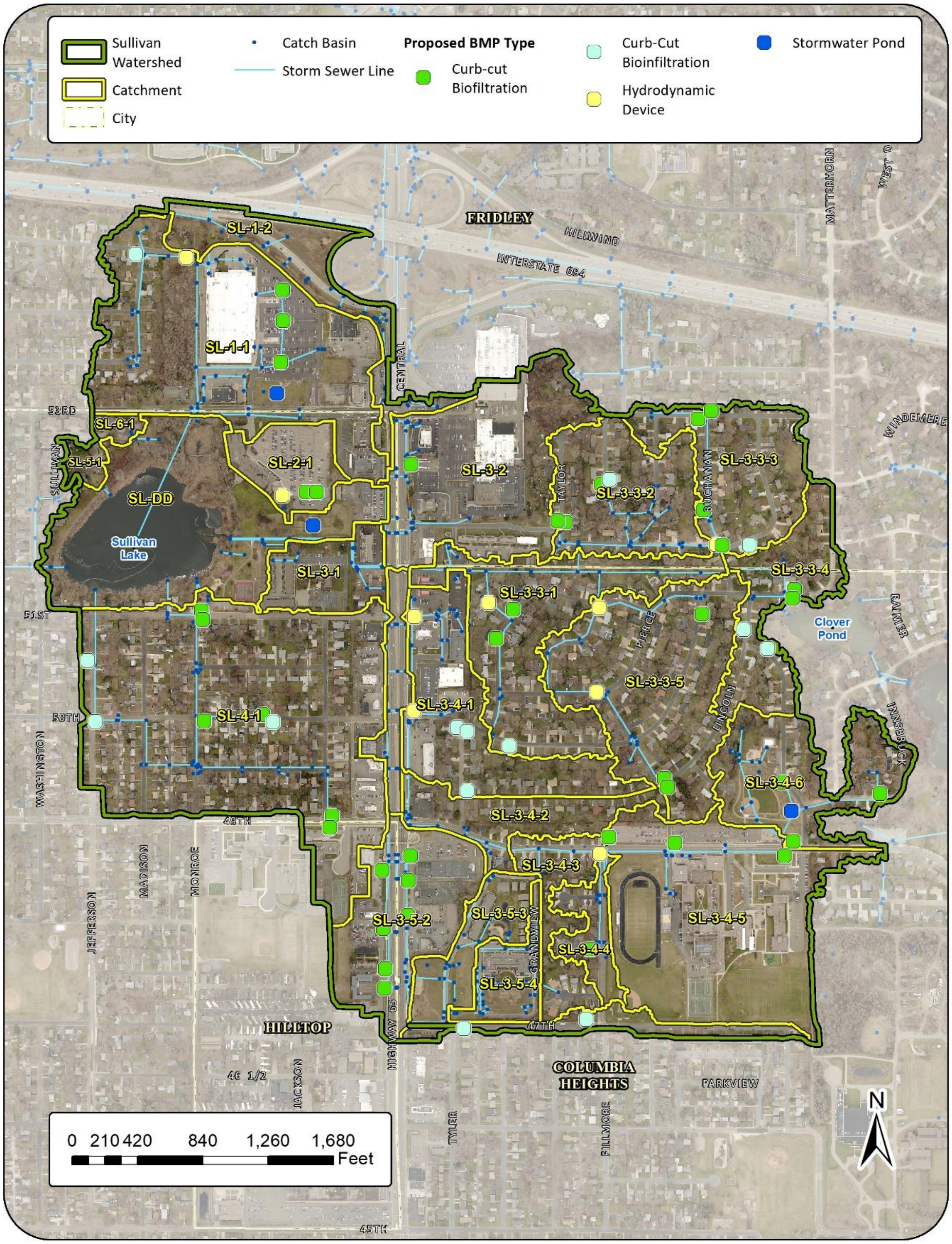


Figure 4: Study area map showing the proposed retrofits in the Sullivan Lake drainage network included in this report.

Table 6: Cost-effectiveness of retrofits with respect to TP reduction. Projects ranked 1 – 17 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	SL- Regional Pond	104	New Wet Pond + IESF	SL-DD	105.4 - 129.8	41,860 -48045	0.0	$1,923,020 - $2,032,019	$3,191 - $5,389	$563.35 - $638.44
2	SL- Regional Pond	104	New Wet Pond	SL-DD	93.20	38,768	0.0	$1,549,646.00	$2,092.00	$576.68
3	SL-1-1 BI-1	114	Curb-Cut Bioinfiltration	SL-1-1	0.42	129	0.32	$10,004.00	$225.00	$1,329.68
4	SL-1-1 BF-3	113	Curb-Cut Biofiltration HPMBS	SL-1-1	1.21	667	0.00	$33,504.00	$741.67	$1,535.92
5	SL-2-1 BF-1	119	Curb-Cut Biofiltration HPMBS	SL-2-1	1.13	599	0.02	$33,504.00	$741.67	$1,647.58
6	SL-3-2- BF-1	126	Curb-Cut Biofiltration HPMBS	SL-3-2	0.95	527	0.02	$33,504.00	$741.67	$1,956.28
7	SL-4-1 BI-1	196	Curb-Cut Bioinfiltration	SL-4-1	0.28	83	0.23	$10,004.00	$225.00	$1,994.52
8	SL-4-1 BI-3	198	Curb-Cut Bioinfiltration	SL-4-1	0.25	76	0.21	$10,004.00	$225.00	$2,233.87
9	SL-2-1 BF-2	120	Curb-Cut Biofiltration HPMBS	SL-2-1	0.79	418	0.01	$33,504.00	$741.67	$2,346.55
10	SL-3-3-5 BF-1	150	Curb-Cut Biofiltration	SL-3-3-5	0.25	82	0.05	$11,004.00	$295.00	$2,647.20
11	SL-3-4-1 BI-3	158	Curb-Cut Bioinfiltration	SL-3-4-1	0.21	59	0.16	$10,004.00	$225.00	$2,659.37
12	SL-3-3-2 BI-1	136	Curb-Cut Bioinfiltration	SL-3-3-2	0.20	56	0.14	$10,004.00	$225.00	$2,792.33
13	SL-3-3-3 BI-1	142	Curb-Cut Bioinfiltration	SL-3-3-3	0.20	59	0.14	$10,004.00	$225.00	$2,792.33
14	SL-3-3-4 BI-2	148	Curb-Cut Bioinfiltration	SL-3-3-4	0.20	56	0.14	$10,004.00	$225.00	$2,792.33
15	SL-3-4-1 BI-1	156	Curb-Cut Bioinfiltration	SL-3-4-1	0.20	57	0.16	$10,004.00	$225.00	$2,792.33
16	SL-3-4-1 BI-2	157	Curb-Cut Bioinfiltration	SL-3-4-1	0.20	58	0.16	$10,004.00	$225.00	$2,792.33
17	SL-3-3-5 BF-3	152	Curb-Cut Biofiltration	SL-3-3-5	0.23	77	0.05	$11,004.00	$295.00	$2,877.39

[1][(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TP Reduction)]

Table 7: Cost-effectiveness of retrofits with respect to TP reduction. Projects ranked 18 – 34 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]
18	SL-3-4-5 BF-1	167	Curb-Cut Biofiltration	SL-3-4-5	0.23	91	0.07	$11,004.00	$295.00	$2,877.39
19	SL-3-4-5 BF-3	169	Curb-Cut Biofiltration	SL-3-4-5	0.23	89	0.07	$11,004.00	$295.00	$2,877.39
20	SL-3-4-6 BF-2	173	Curb-Cut Biofiltration	SL-3-4-6	0.23	80	0.07	$11,004.00	$295.00	$2,877.39
21	SL-3-3-1 BI-1	130	Curb-Cut Bioinfiltration	SL-3-3-1	0.19	54	0.14	$10,004.00	$225.00	$2,939.30
22	SL-1-1 BF-2	112	Curb-Cut Biofiltration HPMBS	SL-1-1	0.63	349	0.00	$33,504.00	$741.67	$2,949.95
23	SL-3-3-2 BF-2	134	Curb-Cut Biofiltration	SL-3-3-2	0.22	74	0.05	$11,004.00	$295.00	$3,008.18
24	SL-3-3-3 BF-4	141	Curb-Cut Biofiltration	SL-3-3-3	0.22	74	0.05	$11,004.00	$295.00	$3,008.18
25	SL-3-4-5 BF-2	168	Curb-Cut Biofiltration	SL-3-4-5	0.22	88	0.07	$11,004.00	$295.00	$3,008.18
26	SL-3-3-4 BI-1	147	Curb-Cut Bioinfiltration	SL-3-3-4	0.18	52	0.12	$10,004.00	$225.00	$3,102.59
27	SL-3-3-4 BF-1	145	Curb-Cut Biofiltration	SL-3-3-4	0.21	70	0.05	$11,004.00	$295.00	$3,151.43
28	SL-3-5-2 BF-5	181	Curb-Cut Biofiltration	SL-3-5-2	0.21	97	0.07	$11,004.00	$295.00	$3,151.43
29	SL-4-1 BF-2	191	Curb-Cut Biofiltration	SL-4-1	0.21	81	0.07	$11,004.00	$295.00	$3,151.43
30	SL-3-5-2 BF-7	183	Curb-Cut Biofiltration	SL-3-5-2	0.20	94	0.05	$11,004.00	$295.00	$3,309.00
31	SL-3-4-6 SP-2	171	New Wet Pond	SL-3-4-6	3.16	1,381	0.00	$319,477.60	$348.62	$3,480.34
32	SL-4-1 BF-6	195	Curb-Cut Biofiltration	SL-4-1	0.19	92	0.07	$11,004.00	$295.00	$3,483.16
33	SL-3-5-3 BI-1	186	Curb-Cut Bioinfiltration	SL-3-5-3	0.16	60	0.14	$10,004.00	$225.00	$3,490.42
34	SL-1-1 SP-1	110	New Wet Pond	SL-1-1	2.68	1,477	0.00	$268,930.00	$440.00	$3,509.08

[1][(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TP Reduction)]

Table 8: Cost-effectiveness of retrofits with respect to TP reduction. Projects ranked 35-51 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]
35	SL-3-3-3 BF-1	138	Curb-Cut Biofiltration	SL-3-3-3	0.18	59	0.05	$11,004.00	$295.00	$3,676.67
36	SL-3-4-6 BF-3	174	Curb-Cut Biofiltration	SL-3-4-6	0.18	67	0.05	$11,004.00	$295.00	$3,676.67
37	SL-4-1 BF-4	193	Curb-Cut Biofiltration	SL-4-1	0.18	85	0.07	$11,004.00	$295.00	$3,676.67
38	SL-3-5-2 BF-6	182	Curb-Cut Biofiltration	SL-3-5-2	0.17	82	0.07	$11,004.00	$295.00	$3,892.94
39	SL-3-5-3 BF-1	185	Curb-Cut Bioinfiltration	SL-3-5-3	0.17	71	0.07	$11,004.00	$295.00	$3,892.94
40	SL-1-1 BF-1	111	Curb-Cut Biofiltration HPMBS	SL-1-1	0.45	249	0.00	$33,504.00	$741.67	$4,129.93
41	SL-3-3-1 BF-2	129	Curb-Cut Biofiltration	SL-3-3-1	0.16	53	0.05	$11,004.00	$295.00	$4,136.25
42	SL-3-3-3 BF-3	140	Curb-Cut Biofiltration	SL-3-3-3	0.16	51	0.05	$11,004.00	$295.00	$4,136.25
43	SL-3-3-5 BF-2	151	Curb-Cut Biofiltration	SL-3-3-5	0.16	52	0.05	$11,004.00	$295.00	$4,136.25
44	SL-4-1 BF-1	190	Curb-Cut Biofiltration	SL-4-1	0.16	66	0.05	$11,004.00	$295.00	$4,136.25
45	SL-4-1 BF-5	194	Curb-Cut Biofiltration	SL-4-1	0.16	78	0.07	$11,004.00	$295.00	$4,136.25
46	SL-3-3-3 HD-1	143	Hydrodynamic Device	SL-3-3-3	1.03	366	0.00	$111,750.00	$630.00	$4,228.16
47	SL-4-1 BI-2	197	Curb-Cut Bioinfiltration	SL-4-1	0.13	52	0.16	$10,004.00	$225.00	$4,295.90
48	SL-3-3-1 BF-1	128	Curb-Cut Biofiltration	SL-3-3-1	0.15	49	0.02	$11,004.00	$295.00	$4,412.00
49	SL-3-3-3 BF-2	139	Curb-Cut Biofiltration	SL-3-3-3	0.15	49	0.02	$11,004.00	$295.00	$4,412.00
50	SL-3-4-1 HD-2	160	Hydrodynamic Device	SL-3-4-1	0.95	398	0.00	$111,750.00	$630.00	$4,584.21
51	SL-3-3-1 HD-1	131	Hydrodynamic Device	SL-3-3-1	0.93	327	0.00	$111,750.00	$630.00	$4,682.80

[1][(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TP Reduction)]

Table 9: Cost-effectiveness of retrofits with respect to TP reduction. Projects ranked 52-67 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]
52	SL-3-3-5 HD-1	153	Hydrodynamic Device	SL-3-3-5	0.93	323	0.00	$111,750.00	$630.00	$4,682.80
53	SL-3-3-2 BF-3	135	Curb-Cut Biofiltration	SL-3-3-2	0.14	48	0.02	$11,004.00	$295.00	$4,727.14
54	SL-3-3-4 BF-2	146	Curb-Cut Biofiltration	SL-3-3-4	0.14	45	0.02	$11,004.00	$295.00	$4,727.14
55	SL-3-5-2 BF-1	177	Curb-Cut Biofiltration	SL-3-5-2	0.14	76	0.07	$11,004.00	$295.00	$4,727.14
56	SL-3-4-1 HD-1	159	Hydrodynamic Device	SL-3-4-1	0.52	282	0.00	$57,750.00	$630.00	$4,913.46
57	SL-2-1- HD-1	121	Hydrodynamic Device	SL-1-2	0.50	268	0.00	$57,750.00	$630.00	$5,089.64
58	SL-3-4-4 BF-1	164	Curb-Cut Biofiltration	SL-3-4-4	0.13	41	0.05	$11,004.00	$295.00	$5,090.77
59	SL-3-4-6 BF-1	172	Curb-Cut Biofiltration	SL-3-4-6	0.13	40	0.05	$11,004.00	$295.00	$5,090.77
60	SL-3-5-2 BF-2	178	Curb-Cut Biofiltration	SL-3-5-2	0.13	73	0.07	$11,004.00	$295.00	$5,090.77
61	SL-3-3-5 HD-2	154	Hydrodynamic Device	SL-3-3-5	0.85	295	0.00	$111,750.00	$630.00	$5,123.53
62	SL-3-4-4 HD-1	165	Hydrodynamic Device	SL-3-4-4	0.48	183	0.00	$57,750.00	$630.00	$5,322.92
63	SL-3-3-2 BF-1	133	Curb-Cut Biofiltration	SL-3-3-2	0.12	38	0.02	$11,004.00	$295.00	$5,515.00
64	SL-4-1 BF-3	192	Curb-Cut Biofiltration	SL-4-1	0.12	37	0.02	$11,004.00	$295.00	$5,515.00
65	SL-3-5-2 BF-3	179	Curb-Cut Biofiltration	SL-3-5-2	0.11	60	0.05	$11,004.00	$295.00	$6,016.36
66	SL-3-5-2 BF-4	180	Curb-Cut Biofiltration	SL-3-5-2	0.11	56	0.05	$11,004.00	$295.00	$6,016.36
67	SL-1-1 HD-1	115	Hydrodynamic Device	SL-1-1	0.49	209	0.00	$111,750.00	$630.00	$8,887.76

[1][(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TP Reduction)]

Table 10: Cost-effectiveness of retrofits with respect to TSS reduction. Projects ranked 1 – 17 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	SL- Regional Pond	104	New Wet Pond	SL-DD	93.20	38,768	0.0	$1,549,646.00	$2,092.00	$1,386.37
2	SL- Regional Pond	104	New Wet Pond + IESF	SL-DD	105.4 - 129.8	41,860 -48045	0.0	$1,923,020 - $2,032,019	$3,191 - $5,389	$1521.96 - $1,607.52
3	SL-1-1 BF-3	113	Curb-Cut Biofiltration HPMBS	SL-1-1	1.21	667	0.00	$33,504.00	$741.67	$2,786.31
4	SL-2-1 BF-1	119	Curb-Cut Biofiltration HPMBS	SL-2-1	1.13	599	0.02	$33,504.00	$741.67	$3,102.62
5	SL-3-2- BF-1	126	Curb-Cut Biofiltration HPMBS	SL-3-2	0.95	527	0.02	$33,504.00	$741.67	$3,526.50
6	SL-1-1 BI-1	114	Curb-Cut Bioinfiltration	SL-1-1	0.42	129	0.32	$10,004.00	$225.00	$4,329.20
7	SL-2-1 BF-2	120	Curb-Cut Biofiltration HPMBS	SL-2-1	0.79	418	0.01	$33,504.00	$741.67	$4,446.09
8	SL-1-1 BF-2	112	Curb-Cut Biofiltration HPMBS	SL-1-1	0.63	349	0.00	$33,504.00	$741.67	$5,325.12
9	SL-1-1 SP-1	110	New Wet Pond	SL-1-1	2.68	1,477	0.00	$268,930.00	$440.00	$6,367.19
10	SL-4-1 BI-1	196	Curb-Cut Bioinfiltration	SL-4-1	0.28	83	0.23	$10,004.00	$225.00	$6,728.51
11	SL-3-5-2 BF-5	181	Curb-Cut Biofiltration	SL-3-5-2	0.21	97	0.07	$11,004.00	$295.00	$6,822.68
12	SL-3-5-2 BF-7	183	Curb-Cut Biofiltration	SL-3-5-2	0.20	94	0.05	$11,004.00	$295.00	$7,040.43
13	SL-4-1 BF-6	195	Curb-Cut Biofiltration	SL-4-1	0.19	92	0.07	$11,004.00	$295.00	$7,193.48
14	SL-3-4-5 BF-1	167	Curb-Cut Biofiltration	SL-3-4-5	0.23	91	0.07	$11,004.00	$295.00	$7,272.53
15	SL-4-1 BI-3	198	Curb-Cut Bioinfiltration	SL-4-1	0.25	76	0.21	$10,004.00	$225.00	$7,348.25
16	SL-3-4-5 BF-3	169	Curb-Cut Biofiltration	SL-3-4-5	0.23	89	0.07	$11,004.00	$295.00	$7,435.96
17	SL-1-1 BF-1	111	Curb-Cut Biofiltration HPMBS	SL-1-1	0.45	249	0.00	$33,504.00	$741.67	$7,463.72

[1][(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TSS Reduction/1000)]

Table 11: Cost-effectiveness of retrofits with respect to TSS reduction. Projects ranked 18 - 34 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]
18	SL-3-4-5 BF-2	168	Curb-Cut Biofiltration	SL-3-4-5	0.22	88	0.07	$11,004.00	$295.00	$7,520.45
19	SL-4-1 BF-4	193	Curb-Cut Biofiltration	SL-4-1	0.18	85	0.07	$11,004.00	$295.00	$7,785.88
20	SL-3-4-6 SP-2	171	New Wet Pond	SL-3-4-6	3.16	1,381	0.00	$319,477.60	$348.62	$7,963.70
21	SL-3-3-5 BF-1	150	Curb-Cut Biofiltration	SL-3-3-5	0.25	82	0.05	$11,004.00	$295.00	$8,070.73
22	SL-3-5-2 BF-6	182	Curb-Cut Biofiltration	SL-3-5-2	0.17	82	0.07	$11,004.00	$295.00	$8,070.73
23	SL-4-1 BF-2	191	Curb-Cut Biofiltration	SL-4-1	0.21	81	0.07	$11,004.00	$295.00	$8,170.37
24	SL-3-4-6 BF-2	173	Curb-Cut Biofiltration	SL-3-4-6	0.23	80	0.07	$11,004.00	$295.00	$8,272.50
25	SL-4-1 BF-5	194	Curb-Cut Biofiltration	SL-4-1	0.16	78	0.07	$11,004.00	$295.00	$8,484.62
26	SL-3-3-5 BF-3	152	Curb-Cut Biofiltration	SL-3-3-5	0.23	77	0.05	$11,004.00	$295.00	$8,594.81
27	SL-3-5-2 BF-1	177	Curb-Cut Biofiltration	SL-3-5-2	0.14	76	0.07	$11,004.00	$295.00	$8,707.89
28	SL-3-3-2 BF-2	134	Curb-Cut Biofiltration	SL-3-3-2	0.22	74	0.05	$11,004.00	$295.00	$8,943.24
29	SL-3-3-3 BF-4	141	Curb-Cut Biofiltration	SL-3-3-3	0.22	74	0.05	$11,004.00	$295.00	$8,943.24
30	SL-3-4-1 HD-1	159	Hydrodynamic Device	SL-3-4-1	0.52	282	0.00	$57,750.00	$630.00	$9,060.28
31	SL-3-5-2 BF-2	178	Curb-Cut Biofiltration	SL-3-5-2	0.13	73	0.07	$11,004.00	$295.00	$9,065.75
32	SL-3-5-3 BI-1	186	Curb-Cut Bioinfiltration	SL-3-5-3	0.16	60	0.14	$10,004.00	$225.00	$9,307.78
33	SL-3-5-3 BF-1	185	Curb-Cut Bioinfiltration	SL-3-5-3	0.17	71	0.07	$11,004.00	$295.00	$9,321.13
34	SL-3-3-4 BF-1	145	Curb-Cut Biofiltration	SL-3-3-4	0.21	70	0.05	$11,004.00	$295.00	$9,454.29

[1][(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TSS Reduction/1000)]

Table 12: Cost-effectiveness of retrofits with respect to TSS reduction. Projects ranked 35 - 51 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]
35	SL-3-3-3 BI-1	142	Curb-Cut Bioinfiltration	SL-3-3-3	0.20	59	0.14	$10,004.00	$225.00	$9,465.54
36	SL-3-4-1 BI-3	158	Curb-Cut Bioinfiltration	SL-3-4-1	0.21	59	0.16	$10,004.00	$225.00	$9,465.54
37	SL-2-1- HD-1	121	Hydrodynamic Device	SL-1-2	0.50	268	0.00	$57,750.00	$630.00	$9,533.58
38	SL-3-4-1 BI-2	157	Curb-Cut Bioinfiltration	SL-3-4-1	0.20	58	0.16	$10,004.00	$225.00	$9,628.74
39	SL-3-4-1 BI-1	156	Curb-Cut Bioinfiltration	SL-3-4-1	0.20	57	0.16	$10,004.00	$225.00	$9,797.66
40	SL-3-4-6 BF-3	174	Curb-Cut Biofiltration	SL-3-4-6	0.18	67	0.05	$11,004.00	$295.00	$9,877.61
41	SL-3-3-2 BI-1	136	Curb-Cut Bioinfiltration	SL-3-3-2	0.20	56	0.14	$10,004.00	$225.00	$9,972.62
42	SL-3-3-4 BI-2	148	Curb-Cut Bioinfiltration	SL-3-3-4	0.20	56	0.14	$10,004.00	$225.00	$9,972.62
43	SL-4-1 BF-1	190	Curb-Cut Biofiltration	SL-4-1	0.16	66	0.05	$11,004.00	$295.00	$10,027.27
44	SL-3-3-1 BI-1	130	Curb-Cut Bioinfiltration	SL-3-3-1	0.19	54	0.14	$10,004.00	$225.00	$10,341.98
45	SL-3-3-4 BI-1	147	Curb-Cut Bioinfiltration	SL-3-3-4	0.18	52	0.12	$10,004.00	$225.00	$10,739.74
46	SL-4-1 BI-2	197	Curb-Cut Bioinfiltration	SL-4-1	0.13	52	0.16	$10,004.00	$225.00	$10,739.74
47	SL-3-4-1 HD-2	160	Hydrodynamic Device	SL-3-4-1	0.95	398	0.00	$111,750.00	$630.00	$10,942.21
48	SL-3-5-2 BF-3	179	Curb-Cut Biofiltration	SL-3-5-2	0.11	60	0.05	$11,004.00	$295.00	$11,030.00
49	SL-3-3-3 BF-1	138	Curb-Cut Biofiltration	SL-3-3-3	0.18	59	0.05	$11,004.00	$295.00	$11,216.95
50	SL-3-5-2 BF-4	180	Curb-Cut Biofiltration	SL-3-5-2	0.11	56	0.05	$11,004.00	$295.00	$11,817.86
51	SL-3-3-3 HD-1	143	Hydrodynamic Device	SL-3-3-3	1.03	366	0.00	$111,750.00	$630.00	$11,898.91

[1][(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TSS Reduction/1000)]

Table 13: Cost-effectiveness of retrofits with respect to TSS reduction. Projects ranked 52 - 67 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]
52	SL-3-3-1 BF-2	129	Curb-Cut Biofiltration	SL-3-3-1	0.16	53	0.05	$11,004.00	$295.00	$12,486.79
53	SL-3-3-5 BF-2	151	Curb-Cut Biofiltration	SL-3-3-5	0.16	52	0.05	$11,004.00	$295.00	$12,726.92
54	SL-3-3-3 BF-3	140	Curb-Cut Biofiltration	SL-3-3-3	0.16	51	0.05	$11,004.00	$295.00	$12,976.47
55	SL-3-3-1 HD-1	131	Hydrodynamic Device	SL-3-3-1	0.93	327	0.00	$111,750.00	$630.00	$13,318.04
56	SL-3-3-5 HD-1	153	Hydrodynamic Device	SL-3-3-5	0.93	323	0.00	$111,750.00	$630.00	$13,482.97
57	SL-3-3-1 BF-1	128	Curb-Cut Biofiltration	SL-3-3-1	0.15	49	0.02	$11,004.00	$295.00	$13,506.12
58	SL-3-3-3 BF-2	139	Curb-Cut Biofiltration	SL-3-3-3	0.15	49	0.02	$11,004.00	$295.00	$13,506.12
59	SL-3-3-2 BF-3	135	Curb-Cut Biofiltration	SL-3-3-2	0.14	48	0.02	$11,004.00	$295.00	$13,787.50
60	SL-3-4-4 HD-1	165	Hydrodynamic Device	SL-3-4-4	0.48	183	0.00	$57,750.00	$630.00	$13,961.75
61	SL-3-3-4 BF-2	146	Curb-Cut Biofiltration	SL-3-3-4	0.14	45	0.02	$11,004.00	$295.00	$14,706.67
62	SL-3-3-5 HD-2	154	Hydrodynamic Device	SL-3-3-5	0.85	295	0.00	$111,750.00	$630.00	$14,762.71
63	SL-3-4-4 BF-1	164	Curb-Cut Biofiltration	SL-3-4-4	0.13	41	0.05	$11,004.00	$295.00	$16,141.46
64	SL-3-4-6 BF-1	172	Curb-Cut Biofiltration	SL-3-4-6	0.13	40	0.05	$11,004.00	$295.00	$16,545.00
65	SL-3-3-2 BF-1	133	Curb-Cut Biofiltration	SL-3-3-2	0.12	38	0.02	$11,004.00	$295.00	$17,415.79
66	SL-4-1 BF-3	192	Curb-Cut Biofiltration	SL-4-1	0.12	37	0.02	$11,004.00	$295.00	$17,886.49
67	SL-1-1 HD-1	115	Hydrodynamic Device	SL-1-1	0.49	209	0.00	$111,750.00	$630.00	$20,837.32

[1][(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TSS Reduction/1000)]

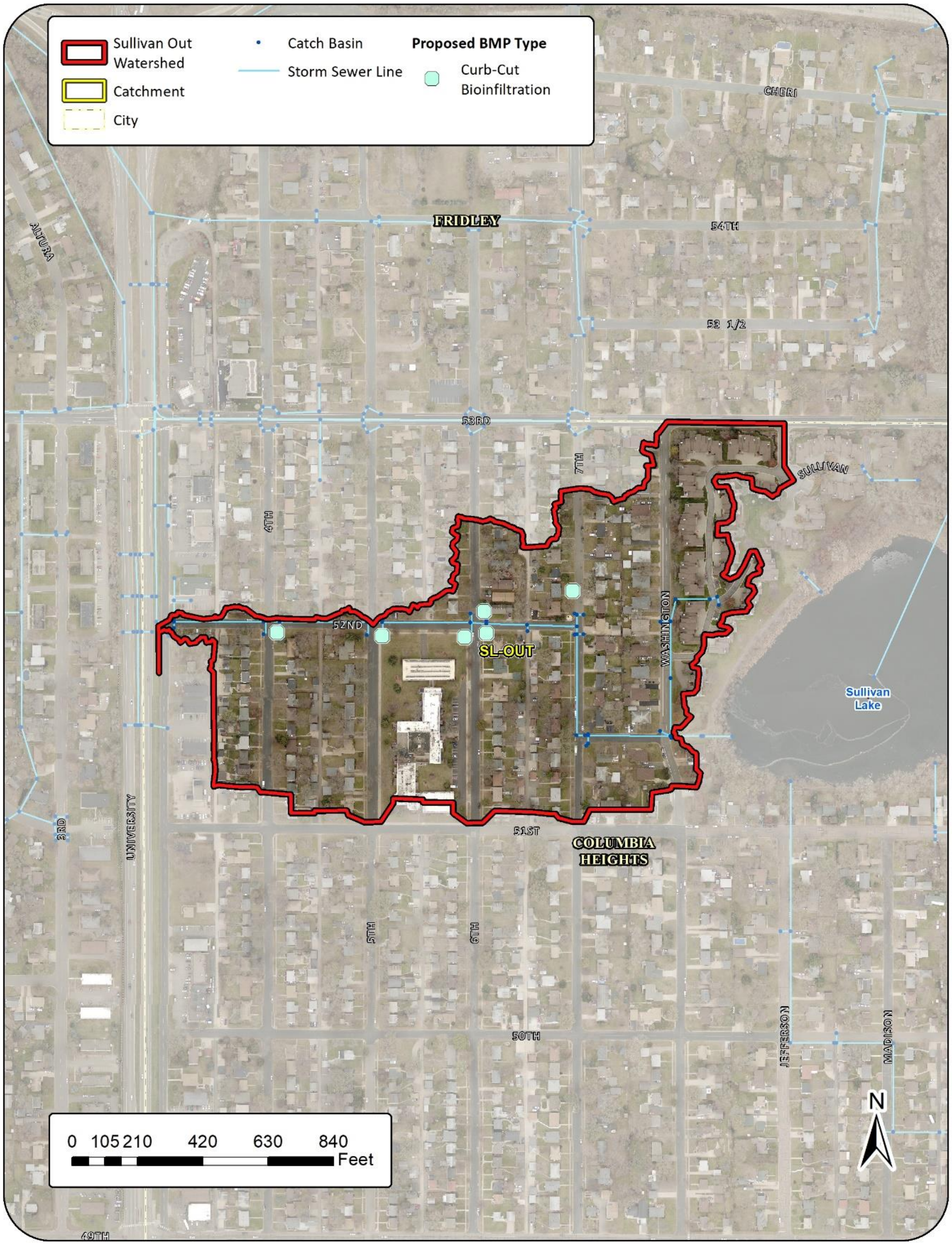


Figure 5: Study area map showing the proposed retrofits in the Sullivan OUT drainage network included in this report.

Table 14: Cost-effectiveness of retrofits with respect to TP reduction. Projects ranked 1 –6 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	SL-OUT BI-6	211	Curb-Cut Bioinfiltration	SL-OUT	0.55	169	0.44	$10,004.00	$225.00	$1,015.39
2	SL-OUT BI-5	210	Curb-Cut Bioinfiltration	SL-OUT	0.45	168	0.51	$10,004.00	$225.00	$1,241.04
3	SL-OUT BI-3	208	Curb-Cut Bioinfiltration	SL-OUT	0.42	133	0.37	$10,004.00	$225.00	$1,329.68
4	SL-OUT BI-2	207	Curb-Cut Bioinfiltration	SL-OUT	0.34	102	0.27	$10,004.00	$225.00	$1,642.55
5	SL-OUT BI-4	209	Curb-Cut Bioinfiltration	SL-OUT	0.31	114	0.51	$10,004.00	$225.00	$1,801.51
6	SL-OUT BI-1	206	Curb-Cut Bioinfiltration	SL-OUT	0.25	75	0.20	$10,004.00	$225.00	$2,233.87

[1][(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TP Reduction)]

Table 15: Cost-effectiveness of retrofits with respect to TSS reduction. Projects ranked 1 – 6 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	SL-OUT BI-6	211	Curb-Cut Bioinfiltration	SL-OUT	0.55	169	0.44	$10,004.00	$225.00	$3,304.54
2	SL-OUT BI-5	210	Curb-Cut Bioinfiltration	SL-OUT	0.45	168	0.51	$10,004.00	$225.00	$3,324.21
3	SL-OUT BI-3	208	Curb-Cut Bioinfiltration	SL-OUT	0.42	133	0.37	$10,004.00	$225.00	$4,199.00
4	SL-OUT BI-4	209	Curb-Cut Bioinfiltration	SL-OUT	0.31	114	0.51	$10,004.00	$225.00	$4,898.83
5	SL-OUT BI-2	207	Curb-Cut Bioinfiltration	SL-OUT	0.34	102	0.27	$10,004.00	$225.00	$5,475.16
6	SL-OUT BI-1	206	Curb-Cut Bioinfiltration	SL-OUT	0.25	75	0.20	$10,004.00	$225.00	$7,446.22

[1][(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TSS Reduction/1000)]

Figure 6: Study area map showing the proposed retrofits in the Clover Pond drainage network included in this report.

Table 16: Cost-effectiveness of retrofits with respect to TP reduction. Projects ranked 1 –3 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	HL-CLOVER-1 BF-3	220	Curb-Cut Biofiltration	HL-Clover-1	0.17	55	0.05	$11,004.00	$295.00	$3,962.87
2	HL-CLOVER-1 BF-1	218	Curb-Cut Biofiltration	HL-Clover-1	0.13	42	0.0	$11,004.00	$295.00	$5,051.91
3	HL-CLOVER-1 BF-2	219	Curb-Cut Biofiltration	HL-Clover-1	0.12	40	0.04	$11,004.00	$295.00	$5,337.10

[1][(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TP Reduction)]

Table 17: Cost-effectiveness of retrofits with respect to TSS reduction. Projects ranked 1 – 3 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	HL-CLOVER-1 BF-3	220	Curb-Cut Biofiltration	HL-Clover-1	0.17	55	0.05	$11,004.00	$295.00	$12,032.73
2	HL-CLOVER-1 BF-1	218	Curb-Cut Biofiltration	HL-Clover-1	0.13	42	0.0	$11,004.00	$295.00	$15,757.14
3	HL-CLOVER-1 BF-2	219	Curb-Cut Biofiltration	HL-Clover-1	0.12	40	0.04	$11,004.00	$295.00	$16,545.00

[1][(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TSS Reduction/1000)]

Figure 7: Study area map showing the proposed retrofits in the Secondary Pond drainage network included in this report.

Table 19: Cost-effectiveness of retrofits with respect to TP reduction. Projects ranked 1 –5 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	HL-SECONDARY-1 BI-1	230	Curb-Cut Bioinfiltration	HL-Secondary-1	0.14	36	0.1	$10,004.00	$295.00	$4,394.87
2	HL-SECONDARY-1 BF-3	229	Curb-Cut Biofiltration	HL-Secondary-1	0.15	45	0.05	$11,004.00	$295.00	$4,532.88
3	HL-SECONDARY-1 HD-1	231	Hydrodynamic Device	HL-Secondary-1	0.29	97	0.00	$30,750.00	$630.00	$5,667.81
4	HL-SECONDARY-1 BF-2	228	Curb-Cut Biofiltration	HL-Secondary-1	0.11	32	0.03	$11,004.00	$295.00	$5,856.64
5	HL-SECONDARY-1 BF-1	227	Curb-Cut Biofiltration	HL-Secondary-1	0.11	32	0.04	$11,004.00	$295.00	$6,243.40

[1][(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TP Reduction)]

Table 18: Cost-effectiveness of retrofits with respect to TSS reduction. Projects ranked 1 – 5 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	HL-SECONDARY-1 BF-3	229	Curb-Cut Biofiltration	HL-Secondary-1	0.15	45	0.05	$11,004.00	$295.00	$14,706.67
2	HL-SECONDARY-1 HD-1	231	Hydrodynamic Device	HL-Secondary-1	0.29	97	0.00	$30,750.00	$630.00	$17,061.86
3	HL-SECONDARY-1 BI-1	230	Curb-Cut Bioinfiltration	HL-Secondary-1	0.14	36	0.1	$10,004.00	$295.00	$17,457.41
4	HL-SECONDARY-1 BF-1	227	Curb-Cut Biofiltration	HL-Secondary-1	0.11	32	0.04	$11,004.00	$295.00	$20,681.25
5	HL-SECONDARY-1 BF-2	228	Curb-Cut Biofiltration	HL-Secondary-1	0.11	32	0.03	$11,004.00	$295.00	$20,681.25

[1][(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TSS Reduction/1000)]

Figure 8: Study area map showing the proposed retrofits in the Tertiary Pond drainage network included in this report.

Table 20: Cost-effectiveness of retrofits with respect to TP reduction. Projects ranked 1 –12 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	HL-TERTIARY-3 BF-2	245	Curb-Cut Biofiltration	HL-TERTIARY-3	0.26	85	0.07	$11,004.00	$295.00	$2,545.38
2	HL-TERTIARY-4 BF-2	250	Curb-Cut Biofiltration	HL-TERTIARY-4	0.25	84	0.07	$11,004.00	$295.00	$2,647.20
3	HL-TERTIARY-1 BI-1	238	Curb-Cut Bioinfiltration	HL-TERTIARY-1	0.21	56	0.16	$10,004.00	$225.00	$2,659.37
4	HL-TERTIARY-4 BI-1	253	Curb-Cut Bioinfiltration	HL-TERTIARY-4	0.21	55	0.16	$10,004.00	$225.00	$2,659.37
5	HL-TERTIARY-4 BI-2	254	Curb-Cut Bioinfiltration	HL-TERTIARY-4	0.19	50	0.14	$10,004.00	$225.00	$2,939.30
6	HL-TERTIARY-4 BF-4	252	Curb-Cut Biofiltration	HL-TERTIARY-4	0.21	68	0.07	$11,004.00	$295.00	$3,151.43
7	HL-TERTIARY-4 BF-1	249	Curb-Cut Biofiltration	HL-TERTIARY-4	0.20	63	0.05	$11,004.00	$295.00	$3,309.00
8	HL-TERTIARY-4 BF-3	251	Curb-Cut Biofiltration	HL-TERTIARY-4	0.17	51	0.05	$11,004.00	$295.00	$3,892.94
9	HL-TERTIARY-4 HD-1	255	Hydrodynamic Device	HL-TERTIARY-4	1.07	369	0.00	$111,750.00	$630.00	$4,070.09
10	HL-TERTIARY-3 HD-1	246	Hydrodynamic Device	HL-TERTIARY-3	1.00	346	0.00	$111,750.00	$630.00	$4,355.00
11	HL-TERTIARY-3 BF-1	244	Curb-Cut Biofiltration	HL-TERTIARY-3	0.15	46	0.05	$11,004.00	$295.00	$4,412.00
12	HL-TERTIARY-1 HD-1	239	Hydrodynamic Device	HL-TERTIARY-1	0.30	101	0.0	$30,750.00	$630.00	$5,516.67

[1][(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TP Reduction)]

Table 21: Cost-effectiveness of retrofits with respect to TSS reduction. Projects ranked 1 – 12 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	HL-TERTIARY-3 BF-2	245	Curb-Cut Biofiltration	HL-TERTIARY-3	0.26	85	0.07	$11,004.00	$295.00	$7,785.88
2	HL-TERTIARY-4 BF-2	250	Curb-Cut Biofiltration	HL-TERTIARY-4	0.25	84	0.07	$11,004.00	$295.00	$7,878.57
3	HL-TERTIARY-4 BF-4	252	Curb-Cut Biofiltration	HL-TERTIARY-4	0.21	68	0.07	$11,004.00	$295.00	$9,732.35
4	HL-TERTIARY-1 BI-1	238	Curb-Cut Bioinfiltration	HL-TERTIARY-1	0.21	56	0.16	$10,004.00	$225.00	$9,972.62
5	HL-TERTIARY-4 BI-1	253	Curb-Cut Bioinfiltration	HL-TERTIARY-4	0.21	55	0.16	$10,004.00	$225.00	$10,153.94
6	HL-TERTIARY-4 BF-1	249	Curb-Cut Biofiltration	HL-TERTIARY-4	0.20	63	0.05	$11,004.00	$295.00	$10,504.76
7	HL-TERTIARY-4 BI-2	254	Curb-Cut Bioinfiltration	HL-TERTIARY-4	0.19	50	0.14	$10,004.00	$225.00	$11,169.33
8	HL-TERTIARY-4 HD-1	255	Hydrodynamic Device	HL-TERTIARY-4	1.07	369	0.00	$111,750.00	$630.00	$11,802.17
9	HL-TERTIARY-3 HD-1	246	Hydrodynamic Device	HL-TERTIARY-3	1.00	346	0.00	$111,750.00	$630.00	$12,586.71
10	HL-TERTIARY-4 BF-3	251	Curb-Cut Biofiltration	HL-TERTIARY-4	0.17	51	0.05	$11,004.00	$295.00	$12,976.47
11	HL-TERTIARY-3 BF-1	244	Curb-Cut Biofiltration	HL-TERTIARY-3	0.15	46	0.05	$11,004.00	$295.00	$14,386.96
12	HL-TERTIARY-1 HD-1	239	Hydrodynamic Device	HL-TERTIARY-1	0.30	101	0.0	$30,750.00	$630.00	$16,386.14

[1][(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TSS Reduction/1000)]

Project Selection

The combination of projects selected for pursuit could strive to achieve TSS and TP reductions in the most cost-effective manner possible. Several other factors affecting project installation decisions should 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 (Biofiltration and Bioinfiltration)
    - High Performance Modular Biofiltration Systems
    - Residential Bioretention Comparison
- Hydrodynamic Device
- Iron-Enhanced Sand Filter
- Modification to an Existing Pond
- New Stormwater Pond

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 DP.

Table 22 conveys the general efficacy of the two types of bioretention (biofiltration and bioinfiltration) in terms of the most three most common pollutants, total suspended solids (TSS), particular phosphorus (PP), dissolved phosphorus (DP), and stormwater volume.

Table 22: 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).

Please note infiltration examples included in this section would require site-specific investigations to verify soils are appropriate for infiltration.

Curb-cut Rain Gardens (Biofiltration and Bioinfiltration)

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.

In areas with quick draining sandy soils, bioinfiltration practices were proposed regardless of the location's proximity to a catch basin. In slower draining silty soils, biofiltration practices were preferred if site conditions allowed for proper space and proximity to a catch basin to facilitate basin draining via an underdrain. In both of these cases, a 12-inch ponding depth basin with a 250 sq-ft top footprint was modeled. In silty areas where siting did not allow for close proximity to a catch basin, a 9-inch ponding depth infiltration basin was proposed to allow complete drawdown of the basin within 48 hours following a storm event (Figure 9).

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. Annual maintenance was assumed to be completed by the landowner of the property at which the rain garden could be installed.

High Performance Modular Biofiltration Systems (HPMBS)

HPMBS is a biofiltration system with fast draining, high performance media (100 in/hr) that allows the filtration of large volumes of water within a small basin footprint. The high performance media also has documented pollutant reductions through independent testing of 80% TSS (Specification High Performance Modular Biofiltration System (HPMBS)). These systems were proposed at catch basins within parking lots where space is believed to be at a premium. Proposed HPMBS were designed with a 12-inch ponding depth and a 100 sq.-ft. top footprint to facilitate complete basin design, including surrounding low concrete walls and fencing, within the footprint of a single parking space (Figure 2).

All HPMBS were presumed to have pretreatment, mulch, and perennial ornamental and native plants with the addition of low concrete walls and wrought iron fencing surrounding the basin. 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 year 15. Annual maintenance was assumed to be completed by the landowner of the property at which the HPMBS could be installed.

Figure 10: An HPMBS basin installed at a parking lot catch basin. The total footprint of the practice is about the size of one parking space.

Residential Bioretention Comparison

Biofiltration, bioinfiltration, and HPMBS practices can all be installed interchangeably with each other given proper space and soil drainage rates. HPMBS systems can treat larger volumes of water in a smaller footprint, but may be cost-prohibitive to be utilized widely in a bioretention network. Standard biofiltration and bioinfiltration basins can be adequately sized to treat large volumes of water from large drainage areas, but may be space prohibitive in a parking lot setting where grading leads stormwater to centralized catch basins within the parking area. Table 23 compares the performance of the three bioretention systems for TP, TSS, and volume reduction in various sized drainage areas given medium density residential land use and slow draining silty soils (i.e. 0.2 in/hr).

Table 23: Estimated annual TP, TSS, and volume reduction for various bioretention basin types based on contributing drainage area with medium density residential land use and street cleaning twice in the spring and twice in the fall. Units are in lbs-TP, lbs-TSS, and ac-ft volume removed from the overall load annually. All scenarios run with a 0.2 in/hour native soil infiltration rate.

Drainage Area (acres)	*Bioretention Basin Type*								
	12” Biofiltration w/ underdrain			9” Bioinfiltration			12” HPMBS*		
	250 sq-ft top area			250 sq-ft top area			100 sq-ft top area		
	TP (lbs)	TSS (lbs)	Vol (ac-ft)	TP (lbs)	TSS (lbs)	Vol (ac-ft)	TP (lbs)	TSS (lbs)	Vol (ac-ft)
0.5	0.12 (30.8%)	37.74 (41.1%)	1619 (15.6%)	0.15 (39.6%)	42.06 (45.8%)	4603 (44.4%)	0.22 (57.5%)	74.27 (80.9%)	462 (4.5%)
1	0.16 (21.3%)	53.7 (29.2%)	1990 (9.6%)	0.18 (24.0%)	52.1 (28.4%)	5751 (27.8%)	0.43 (56.7%)	147.76 (80.5%)	492 (2.4%)
2	0.21 (13.5%)	69.9 (19.0%)	2401 (5.8%)	0.20 (13.0%)	56.8 (15.5%)	6474 (15.6%)	0.83 (54.0%)	284.64 (77.5%)	538 (1.3%)
3	0.23 (10.0%)	78.2 (14.2%)	2656 (4.3%)	0.20 (8.8%)	57.2 (10.4%)	6617 (10.6%)	1.17 (51.1%)	407.3 (73.9%)	582 (0.9%)

4	0.24 (7.9%)	82.8 (11.3%)	2806 (3.4%)	0.20 (6.7%)	57.9 (7.9%)	6703 (8.1%)	1.49 (48.6%)	520.2 (70.8%)	613 (0.7%)
5	0.25 (6.6%)	86.2 (9.4%)	2939 (2.8%)	0.21 (5.4%)	58.6 (6.4%)	6793 (6.6%)	1.77 (46.2%)	622.1 (67.8%)	645 (0.6%)

**High Performance Modular Biofiltration System*

Table 24 shows the cost-effectiveness TP, TSS, and volume reductions over 30-years for biofiltration, bioinfiltration, and HPMBS. Below are the cost assumptions used.

- Biofiltration – Indirect cost (8 hours at $73/hour), direct cost ($30/sq-ft for materials and labor + 40 hours at $73/hour), and maintenance ($220/year for rehabilitation at years 10 and 20 + $75/year for routine maintenance)
- Bioinfiltration – Indirect cost (8 hours at $73/hour), direct cost ($26/sq-ft for materials and labor + 40 hours at $73/hour), and maintenance ($150/year for rehabilitation at years 10 and 20 + $75/year for routine maintenance)
- HPMBS – Indirect cost (8 hours at $73/hour), direct cost ($200/sq-ft for materials and labor + 40 hours at $73/hour), and maintenance ($200/year for rehabilitation at year 15 + $75/year for routine maintenance)

Table 24: Cost-effectiveness of TP, TSS, and volume reduction over 30-years for various bioretention basin types based on contributing drainage area with medium density residential land use and street cleaning twice in the spring and twice in the fall. Units are in dollars/lb-TP, dollars/lb-TSS, and dollars/ac-ft volume removed from the overall load annually. All scenarios run with a 0.2 in/hour native soil infiltration rate.

Drainage Area (acres)	***Bioretention Basin Type***								
	12” Biofiltration w/ underdrain			9” Bioinfiltration			12” HPMBS*		
	250 sq-ft top area			250 sq-ft top area			100 sq-ft top area		
	Cost/ lb-TP	Cost/ 1,000 lbs-TSS	Cost/ ac-ft-Vol	Cost/ lb-TP	Cost/ 1,000 lbs-TSS	Cost/ ac-ft-Vol	Cost/ lb-TP	Cost/ 1,000 lbs-TSS	Cost/ ac-ft-Vol
0.5	$5,515	$17,536	$17,806	$3,723	$13,278	$5,285	$6,934	$20,539	$143,830
1	$4,136	$12,324	$14,486	$3,103	$10,719	$4,230	$3,548	$10,324	$135,060
2	$3,151	$9,468	$12,007	$2,792	$9,832	$3,758	$1,838	$5,359	$123,512
3	$2,877	$8,463	$10,854	$2,792	$9,763	$3,676	$1,304	$3,745	$114,174
4	$2,735	$7,933	$10,274	$2,738	$9,645	$3,629	$1,026	$2,932	$108,400
5	$2,637	$7,677	$9,809	$2,711	$9,530	$3,581	$863	$2,452	$103,022

**High Performance Modular Biofiltration System*

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.

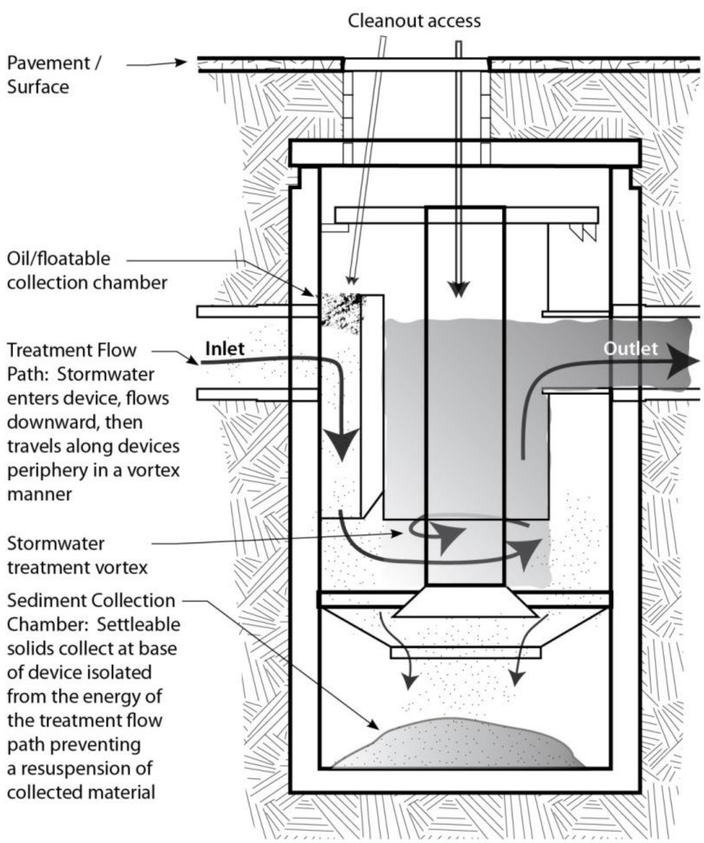


Figure 11: Schematic of a typical hydrodynamic device

Iron-Enhanced Sand Filter

Wet retention ponds, although very effective in treating stormwater for suspended sediment and nutrients bound to sediment, have shown a limited ability at retaining dissolved species of nutrients. This is most notable for phosphorus, which easily adsorbs to sediment when in particulate form but also exists in dissolved form. Median values for pollutant removal percentage by wet retention ponds are 84% for TSS and 50% for TP (MN Stormwater Manual). For the case of phosphorus, dissolved species typically constitute 40-50% of TP in urban stream systems, but only 34% (median efficiency; Weiss et al., 2005) of dissolved phosphorus is treated by the pond. Thus, a majority of the phosphorus escaping wet retention ponds is in dissolved form. This has important effects downstream as dissolved phosphorus is a readily available nutrient for algal uptake in waterbodies and can be a main cause for nutrient eutrophication.

To address this deficiency, researchers at the University of Minnesota developed a method to augment phosphorus retention within a sand filter. The technology was titled the “Iron Enhanced Sand Filter” (IESF). Locally, this practice has also been identified as the “Minnesota Filter.” IESFs rely on the properties of iron to bind dissolved phosphorus as it passes through an iron rich medium. Depending on topographic characteristics of the installation sites, IESFs can rely on gravitational flow and natural water level fluctuation, or water pumping to hydrate the IESF. IESFs must be designed to prevent anoxic conditions in the filter medium because such conditions will release the bound phosphorus. Because IESFs are intended to remove dissolved phosphorus and not organic phosphorus, they are typically constructed just downstream of stormwater ponds, minimizing the amount of suspended solids that could compromise their efficacy and drastically increase maintenance. As an alternative to an IESF, a ferric-chloride injection system could be installed to bind dissolved phosphorus into a flocculent, which would settle in the bottom of the new pond.

Figure 12 shows an IESF that is installed at an elevation slightly above the normal water level of the pond so that following a storm event the increase in depth of the pond would be first diverted to the IESF. Alternatively, the IESF could be positioned at a higher elevation, and a pump could route water to the IESF via pipes. This configuration allows the IESF to provide treatment throughout the year rather than relying on rise and fall of the water in the pond like the pond bench configuration. The filter would have drain tile installed along the base of the trench and would outlet downstream of the current pond outlet. Large storm events that overwhelm the IESF’s capacity would exit the pond via the existing outlet.

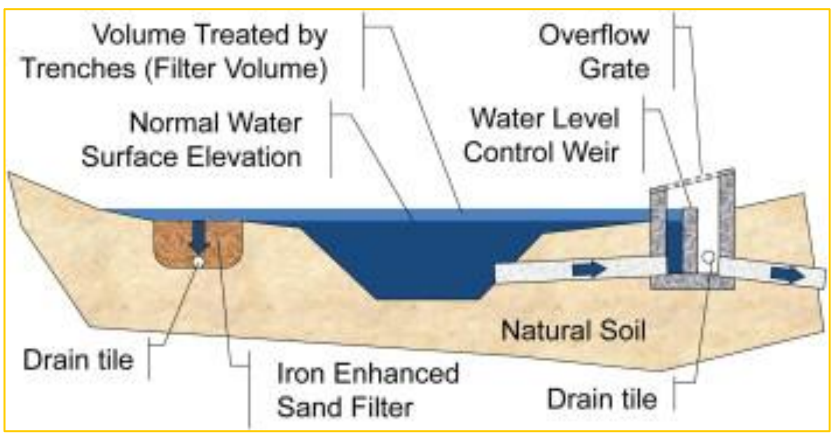


Figure 12: Iron Enhanced Sand Filter Concept (Erickson & Gulliver, 2010)

Benefits for stormwater ponds were modeled utilizing WinSLAMM. After selecting an optimal pond configuration in terms of cost-benefit, or by using the existing pond configuration if no updates are needed, modeling for an IESF was also completed in WinSLAMM. WinSLAMM is able to calculate flow and pollutant concentration through constructed features such as rain gardens with underdrains, soil amendments, and controlled overflow elevations. An IESF works much the same way. Storm event based discharge volumes and phosphorus concentrations estimated by WinSLAMM at the pond outlet were entered into WinSLAMM as inputs into the IESF. Various iterations of IESFs were modeled to identify an optimal treatment level compared to construction costs and space available. A detailed account of the methodologies used is included in Appendix A – Modeling Methods.

To account for the DP treated by the IESF, an additional 80% DP removal was assumed for each IESF in addition to any removal by the pond. This value is based on laboratory and field tests performed by the University of Minnesota (Erickson & Gulliver, 2010) and assumes only removal of DP species within the device. Load reduction estimates for these projects are noted in the Catchment Profiles sections.

In order to calculate cost-benefit, the cost of each project had to be estimated. IESF projects were assumed to involve some excavation and disposal of soil, land acquisition (if necessary), erosion control, and vegetation management. Additionally, project engineering, promotion, administration, construction oversight, and long-term maintenance had to be considered in order to capture the true cost of the effort. Annual maintenance costs were estimated to be $10,000 per acre of IESF based on information received from local, private consulting firms. Additional costs associated with specific projects are listed in Appendix B – Project Cost Estimates.

Modification to an Existing Pond

Developments prior to enactment of contemporary stormwater rules often included wet detention ponds that were frequently designed purely for flood control based on the land use, impervious cover, soils, and topography of the time. Changes to stormwater rules since the early 1970's have altered the way ponds are designed.

Enactment of the National Pollution Discharge Elimination System (NPDES) in 1972 followed by research conducted by the Environmental Protection Agency in the early 1980's as part of the Nationwide Urban Runoff Program (NURP) set standards by which stormwater best management practices should be designed. Municipal Separate Storm Sewer System (MS4) guidelines issued in 1990 (affecting cities with more than 100,000 residents) and 1999 (for cities with less than 100,000 residents) required municipalities to obtain an NPDES permit and develop a plan for managing their stormwater.

Listed below are six strategies that exist for retrofitting a stormwater pond to increase pollutant retention (modified from *Urban Stormwater Retrofit Practices*):

- Excavate pond bottom to increase permanent pool storage
- Raise the embankment to increase flood pool storage
- Widen pond area to increase both permanent and flood pool storage
- Route additional drainage area to the pond and increase storage
- Modify the riser
- Update pool geometry or add pretreatment (e.g. forebay)

These strategies can be employed separately or together to improve BMP effectiveness. Each strategy is limited by cost-effectiveness and constraints of space on the current site. Pond retrofits are preferable to most new BMPs as additional land usually does not need to be purchased, stormwater easements already exist, maintenance issues change little following project completion, and construction costs are greatly cheaper. There can also be a positive effect on reducing the rate of overflow from the pond, thereby reducing the risk for erosion (and thus further pollutant generation) downstream.

For this analysis, all existing ponds were modeled in the water quality model WinSLAMM to estimate their effectiveness based on best available information for pond characteristics and land use and soils. Costs associated with specific projects are listed in Appendix B – Project Cost Estimates.

New Stormwater Pond

If properly designed, wet retention ponds have controlled outflows to manage discharge rates and are sized to achieve predefined water quality goals. Wet retention ponds treat stormwater through a variety of processes, but primarily through sedimentation. Ponds are most often designed to contain a permanent pool storage depth; it is this permanent pool of water that separates the practice from most other stormwater BMPs, including detention ponds (Figure 13).

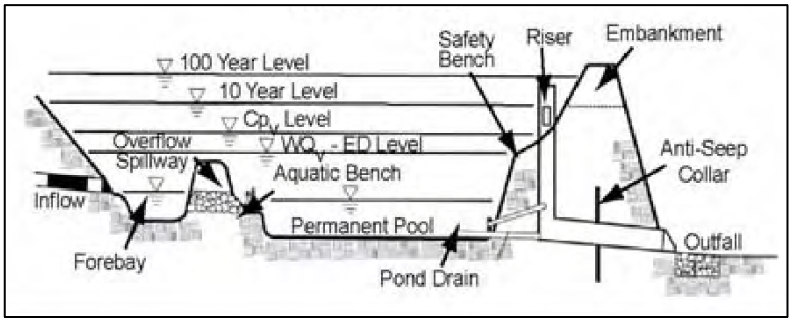


Figure 13: Schematic of a stormwater retention pond.

Wet retention pond depth generally ranges from 3'-8' deep. If ponds are less than 3' deep, winds can increase mixing through the full water depth and re-suspend sediments, thereby increasing turbidity. Scour may also occur during rain events following dry periods. If more than 8' deep, thermal stratification can occur, creating a layer of low dissolved oxygen near the sediment that can release bound phosphorus. Above the permanent pool depth is the flood depth, which provides water quality treatment directly following storm events. Separating the permanent pool depth and the flood depth is the primary outlet control, which is often designed to control outflow rate. Configurations for the outlet control may include a V-notch or circular weir, multiple orifices, or a multiple-stage weir. Each of these can be configured within a skimmer structure or trash rack to provide additional treatment for larger, floatable items. Above the flood depth is the emergency control structure, which is available to bypass water from the largest rainfall events, such as the 100-year precipitation event. Ponds also often include a pretreatment practice, either a forebay or sedimentation basin adjacent to the pond or storm sewer sumps, hydrodynamic devices, or other basins upstream of the practice to simplify maintenance and extend the effective life of the pond.

Outside of sedimentation, other important processes occurring in ponds are nutrient assimilation and evapotranspiration by plants. The addition of shoreline plants to pond designs has increased greatly since the 1980's because of the positive effects these plants were found to have for both water quality purposes and increasing terrestrial and aquatic wildlife habitat. The ability of the pond to regulate discharge rates should also be noted. This can reduce downstream in-channel erosion, thereby decreasing TSS and TP loading from within the channel.

With the multitude of considerations for these practices, ponds must be designed by professional engineers. This report provides a rudimentary description of ponding opportunities and cost estimates for project planning purposes. Ponds proposed in this analysis are designed (using a minimum of 1,800 cubic feet of permanent pool volume per acre of drainage area to the pond) and simulated within the water quality model WinSLAMM, which takes into account upland pollutant loading, pond bathymetry, and outlet control device(s) to estimate stormwater volume, TSS, and TP retention capacity. The model was run with and without the identified project and the difference in pollutant loading was calculated.

In order to calculate cost-benefit, the cost of each project had to be estimated. All new stormwater ponds were assumed to involve excavation and disposal of soil, installation of inlet and outlet control structures and emergency overflow, land acquisition, erosion control, and vegetation management. Additionally, project engineering, promotion, administration, construction oversight, and long-term maintenance (including annual inspections and removal of accumulated sediment/debris from the pretreatment area) had to be considered in order to capture the true cost of the effort. Complete pond dredging is not included in the long-term maintenance cost because project life is estimated to be 30 years. Load reduction estimates for these projects are noted in the Catchment Profiles section. Additional costs associated with specific projects are listed in Appendix B – Project Cost Estimates

Catchment Profiles

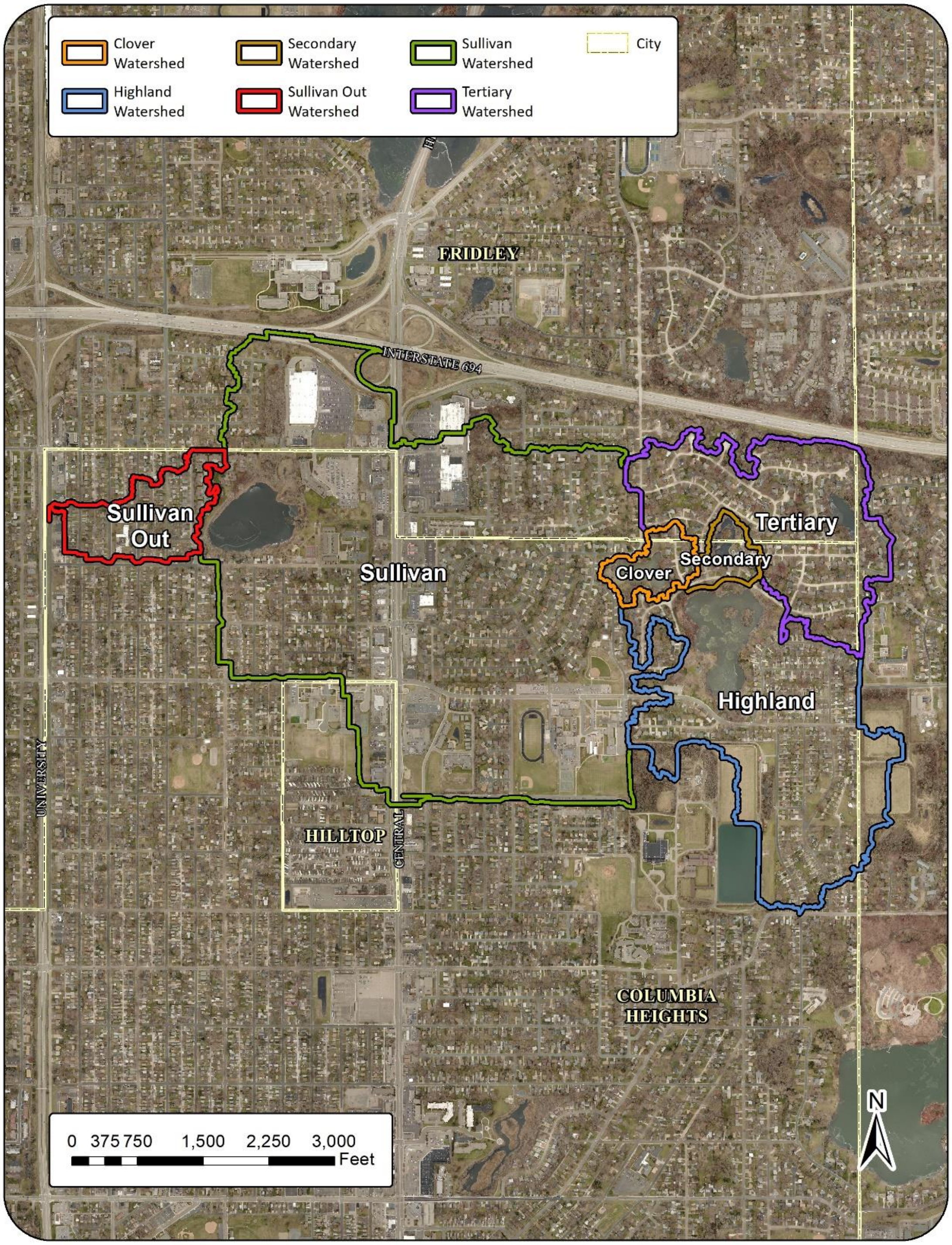
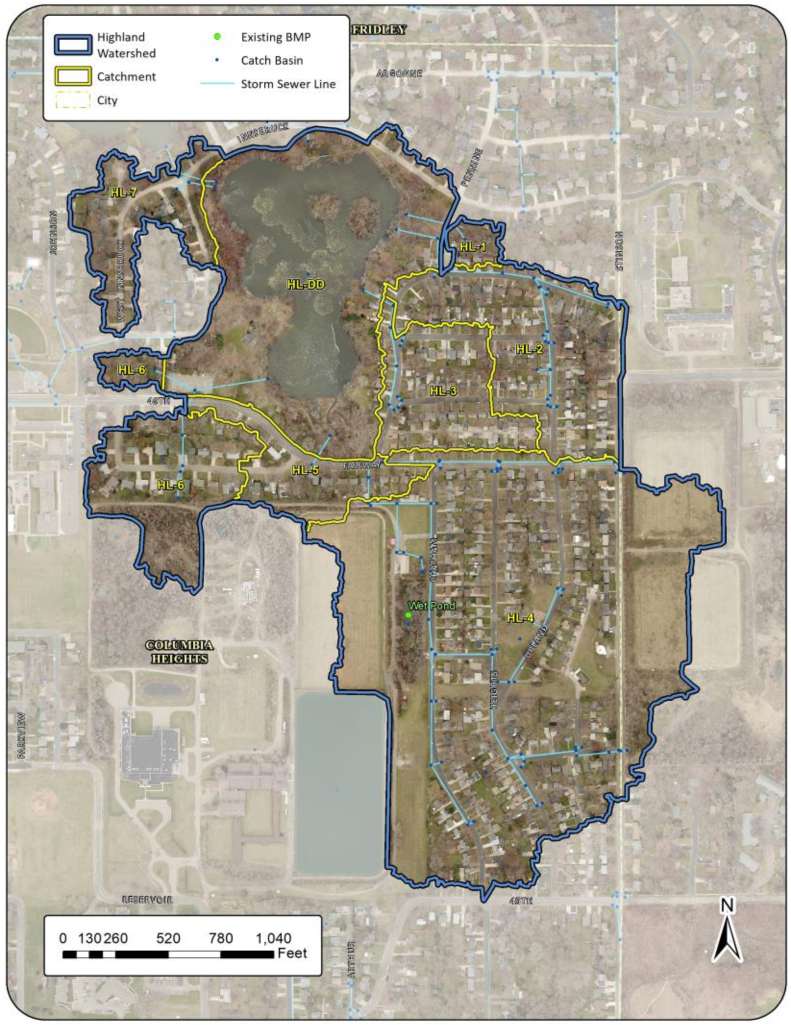


Figure 14: The 715-acre drainage area was divided into six subwatersheds for this analysis. Catchment profiles on the following pages provide additional information.

Highland Lake Drainage Network

Catchment ID	Page
HL-DD	52
HL-1	55
HL-2	57
HL-3	64
HL-4	68
HL-5	85
HL-6	90
HL-7	95

Existing Network Summary	
Acres	139.5
Dominant Land Cover	Residential
Volume (ac-ft/yr)	54.4
TP (lb/yr)	91.0
TSS (lb/yr)	20,578



DRAINAGE NETWORK SUMMARY

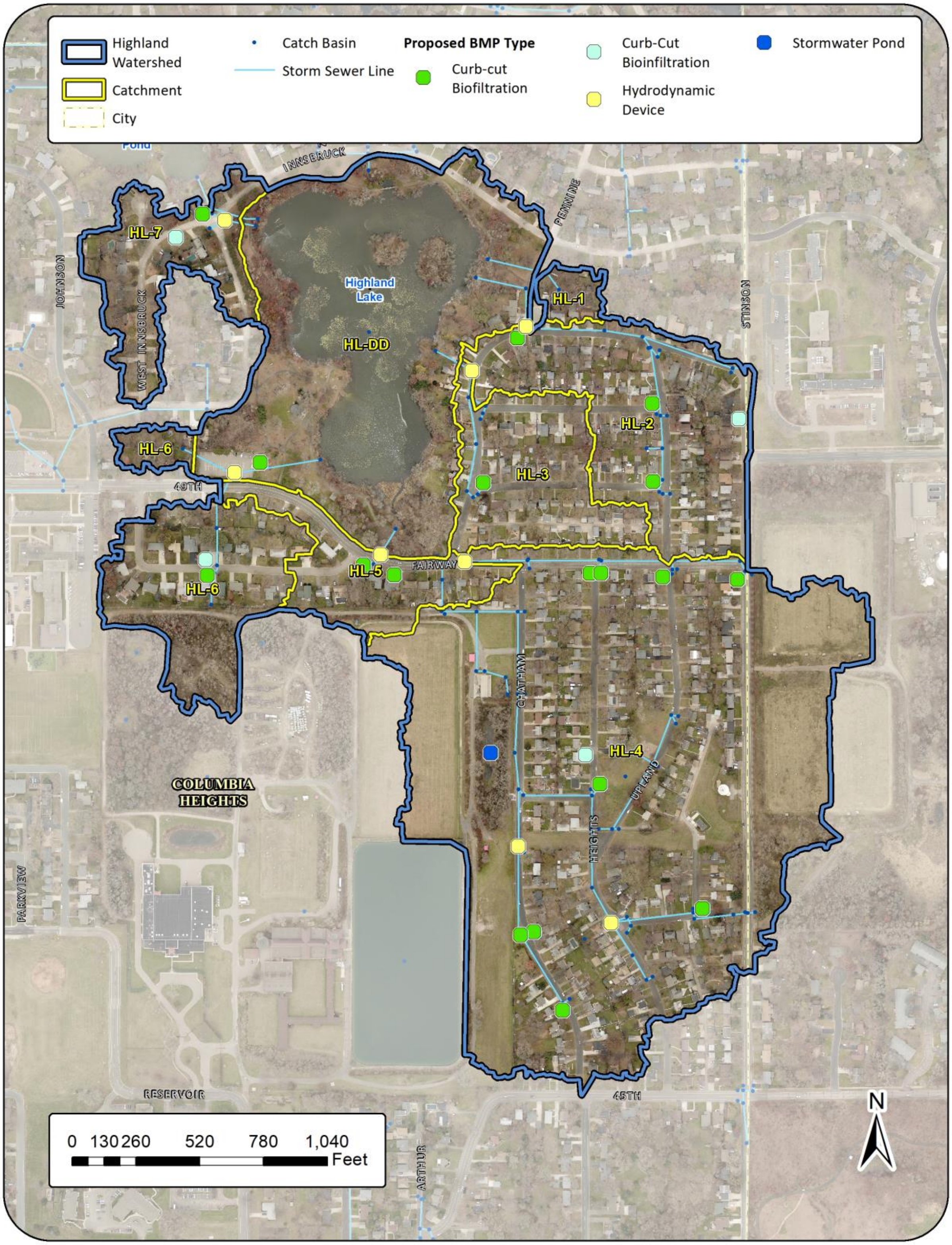
The Highland Lake drainage network includes all areas draining to Highland Lake. Eight catchments lie within this drainage network. Seven catchments have a dedicated outfall to Highland Lake, and one catchment represents the near-lake area comprised of Kordiak Park that directly drains into Highland Lake.

Catchment size varies from 1.2 acres up to nearly 70 acres. Notable areas of the drainage network include Kordiak Park, residential areas around the lake, and the eastern portion of the Minneapolis Water Works property.

EXISTING STORMWATER TREATMENT

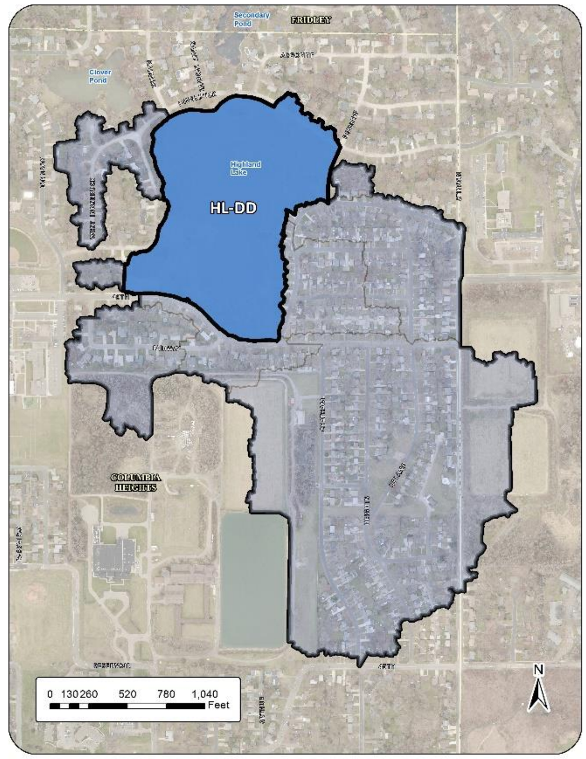
Stormwater runoff generated within this drainage network is conveyed to one of the seven outfalls via storm sewer pipe. Existing treatment consists of street cleaning conducted by the City of Columbia Heights and a stormwater pond located on the Minneapolis Water Works property. Additional detail is provided in the Catchment Profiles.

NETWORK RETROFIT RECOMMENDATIONS



Catchment HL-DD

Existing Catchment Summary	
Acres	18.9
Parcels	25
Land Cover	86.3% Open Space 13.7% Residential



CATCHMENT DESCRIPTION

This catchment consists of the near-lake areas that discharge directly to Highland Lake. Areas worth noting include the northeastern corner that includes approximately five residential properties and the southwest corner that includes the public parking lot for Kordiak Park. Stormwater runoff from the northeast, residential area is routed via curb-cut into a shallow depressed area within Kordiak Park. Stormwater runoff from the public parking lot in the southwest is routed to a rain garden, although its functionality may be less than optimal based on observations from City of Columbia Heights staff.

EXISTING STORMWATER TREATMENT

The primary stormwater treatment in the catchment is street cleaning, performed four times per year by the City of Columbia Heights. 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)	12.4	0.6	5%	**11.7**
	TSS (lb/yr)	2,836	274	10%	**2,562**
	Volume (acre-feet/yr)	5.8	0.0	0%	**5.8**

RETROFIT RECOMMENDATIONS OVERVIEW

One biofiltration basin was sited to maximize contributing drainage area, on a property with sufficient space and slope to accommodate a basin, and adjacent to a catch basin to accommodate an underdrain connection to the storm sewer infrastructure.

RETROFIT RECOMMENDATIONS

Project ID: HL-DD BF-1

Kordiak Park Biofiltration Basin

Drainage Area – 0.9 acres
Location – East side of parking lot located in the southwest corner of Kordiak Park north of 49th Avenue NE
Property Ownership – Private
Site Specific Information – Stormwater runoff from the parking lot in Kordiak Park could be treated using bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq-ft
	TP (lb/yr)	0.14	1.2%
	TSS (lb/yr)	43	1.7%
	Volume (acre-feet/yr)	0.02	0.4%
Cost	**Administration & Promotion Costs***	$584	
	Design & Construction Costs**	$10,420	
	Total Estimated Project Cost (2019)	**$11,004**	
	Annual O&M***	$295	
Efficiency	**30-yr Average Cost/lb-TP**	**$4,727**	
	30-yr Average Cost/1,000lb-TSS	**$15,391**	
	30-yr Average Cost/ac-ft Vol.	**$28,774**	

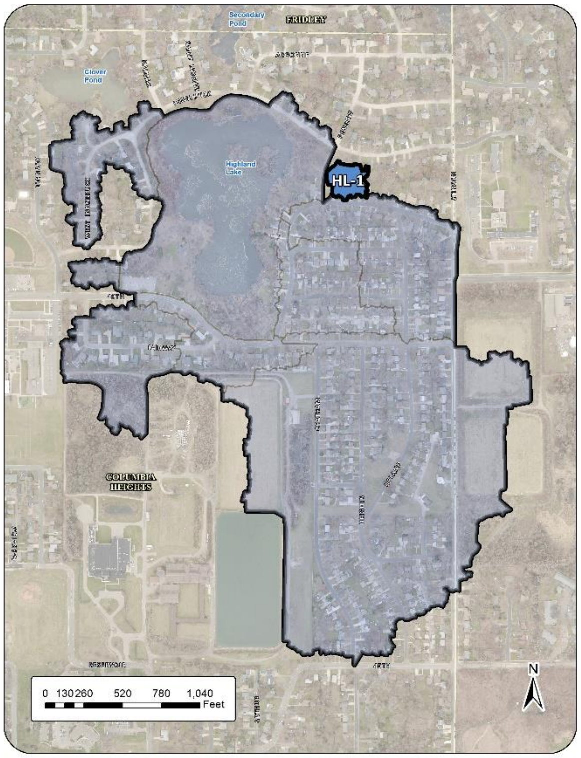
*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Catchment HL-1

Existing Catchment Summary	
Acres	1.23
Parcels	8
Land Cover	100% Residential



CATCHMENT DESCRIPTION

This catchment consists of backyard drainage from approximately eight residential lots. There is a storm sewer line connection that drains the low-lying area in the backyards of the parcels and discharges to Highland Lake.

EXISTING STORMWATER TREATMENT

There is no existing stormwater treatment in this catchment. Because this catchment consists of only residential backyards, which are predominantly permeable, stormwater treatment is likely not warranted. 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)	1.0	0.1	8%	**0.9**
	TSS (lb/yr)	263	38	14%	**225**
	Volume (acre-feet/yr)	0.6	0.0	0%	**0.6**

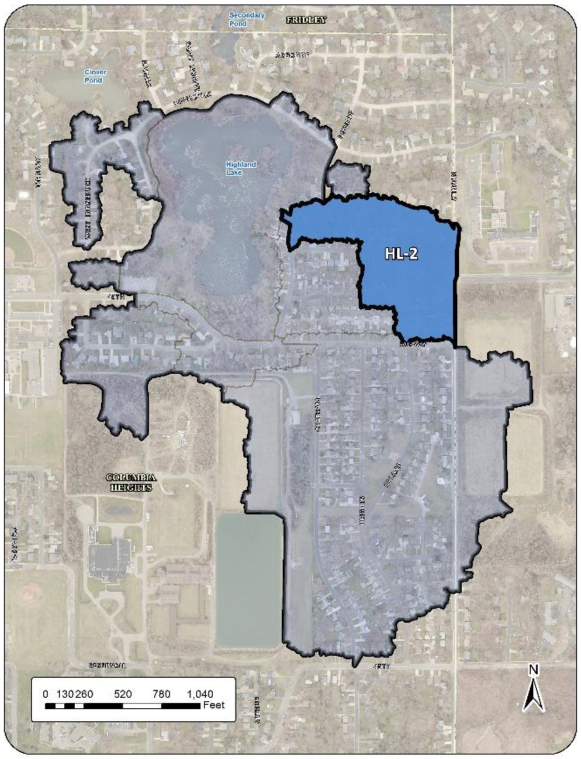
RETROFIT RECOMMENDATIONS OVERVIEW

No stormwater retrofits are recommended for this catchment because it consists solely of residential backyards.

RETROFIT RECOMMENDATIONS

Catchment HL-2

Existing Catchment Summary	
Acres	15.3
Parcels	95
Land Cover	98.8% Residential 1.1% Institutional 0.1% Open Space



CATCHMENT DESCRIPTION

This catchment is on the east side of Highland Lake and consists entirely of medium density residential land use. The catch basins along East Upland Crest NE and North Upland Crest NE collect runoff and route it to Highland Lake via the storm sewer line.

EXISTING STORMWATER TREATMENT

The primary stormwater treatment in the catchment is street cleaning, performed four times per year by the City of Columbia Heights. 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)	12.8	1.1	8%	**11.7**
	TSS (lb/yr)	3,299	471	14%	**2,828**
	Volume (acre-feet/yr)	7.3	0.0	0%	**7.3**

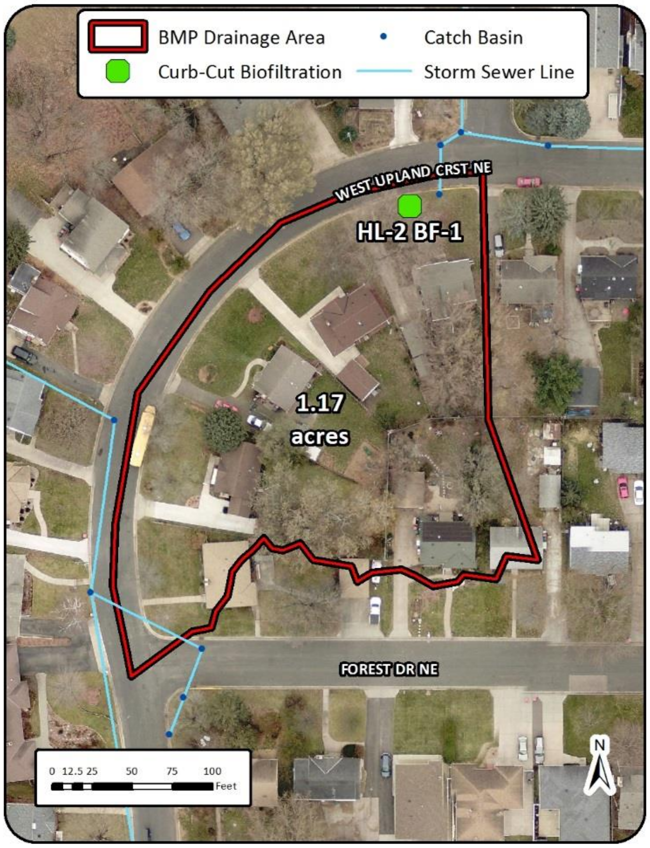
RETROFIT RECOMMENDATIONS OVERVIEW

Five BMPs are proposed in catchment HL-2. They include one hydrodynamic device, three biofiltration basins, and one bioinfiltration basin. The hydrodynamic device is positioned to provide treatment for the entire catchment. The biofiltration basins were sited to maximize contributing drainage areas, on properties with sufficient space and slope to accommodate a basin, and adjacent to catch basins to accommodate underdrain connections to the storm sewer infrastructure. The bioinfiltration basin was sited at a property with a large contributing drainage area and sufficient space and slope to accommodate a basin. However, the property is not adjacent to a catch basin, so infiltration will be the primary process for stormwater treatment.

RETROFIT RECOMMENDATIONS

Project ID: HL-2 BF-1

West Upland Crest NE Biofiltration Basin



Drainage Area – 1.2 acres
Location – Southwest corner of intersection between West Upland Crest NE and Pennine Pass NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq-ft
	TP (lb/yr)	0.18	1.5%
	TSS (lb/yr)	59	2.1%
	Volume (acre-feet/yr)	0.05	0.6%
Cost	**Administration & Promotion Costs***	$584	
	Design & Construction Costs**	$10,420	
	Total Estimated Project Cost (2019)	**$11,004**	
	Annual O&M***	$295	
Efficiency	**30-yr Average Cost/lb-TP**	**$3,677**	
	30-yr Average Cost/1,000lb-TSS	**$11,217**	
	30-yr Average Cost/ac-ft Vol.	**$14,387**	

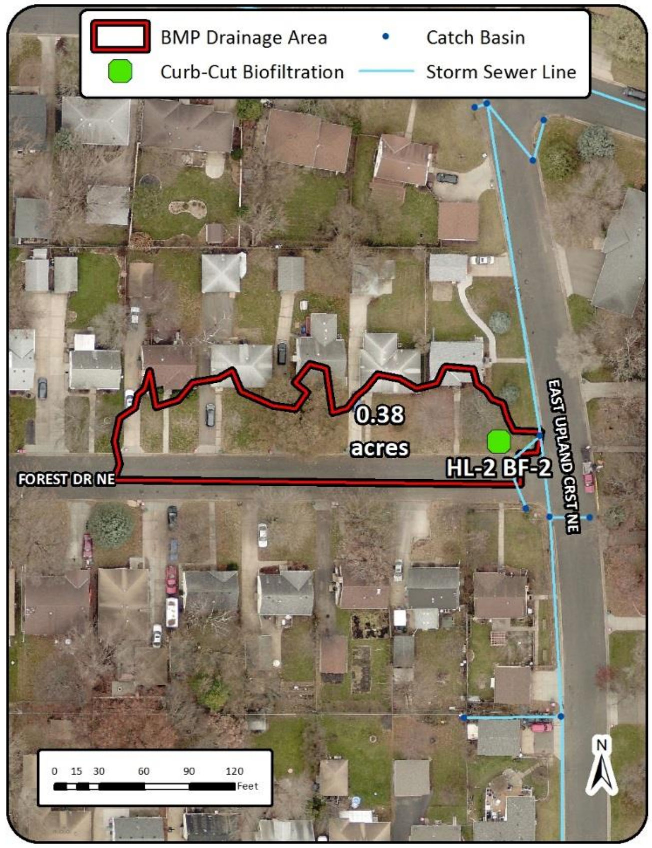
*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: HL-2 BF-2

Forest Drive NE
Biofiltration Basin



Drainage Area – 0.4 acres
Location – Northwest corner of intersection between Forest Drive NE and East Upland Crest NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

Curb-Cut Biofiltration

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Total Size of BMP	250	sq-ft
	TP (lb/yr)	0.11	0.9%
	TSS (lb/yr)	32	1.1%
	Volume (acre-feet/yr)	0.02	0.3%
Cost	Administration & Promotion Costs*	$584	
	Design & Construction Costs**	$10,420	
	Total Estimated Project Cost (2019)	**$11,004**	
	Annual O&M***	$295	
Efficiency	30-yr Average Cost/lb-TP	**$6,016**	
	30-yr Average Cost/1,000lb-TSS	**$20,681**	
	30-yr Average Cost/ac-ft Vol.	**$28,774**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: HL-2 BF-3

Highland Place NE Biofiltration Basin

Drainage Area – 0.4 acres
Location – Northwest corner of intersection between Highland Place NE and East Upland Crest NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	Total Size of BMP	250	sq-ft
	TP (lb/yr)	0.10	0.9%
	TSS (lb/yr)	32	1.1%
	Volume (acre-feet/yr)	0.02	0.3%
Cost	Administration & Promotion Costs*	$584	
	Design & Construction Costs**	$10,420	
	Total Estimated Project Cost (2019)	**$11,004**	
	Annual O&M***	$295	
Efficiency	30-yr Average Cost/lb-TP	**$6,618**	
	30-yr Average Cost/1,000lb-TSS	**$20,681**	
	30-yr Average Cost/ac-ft Vol.	**$28,774**	

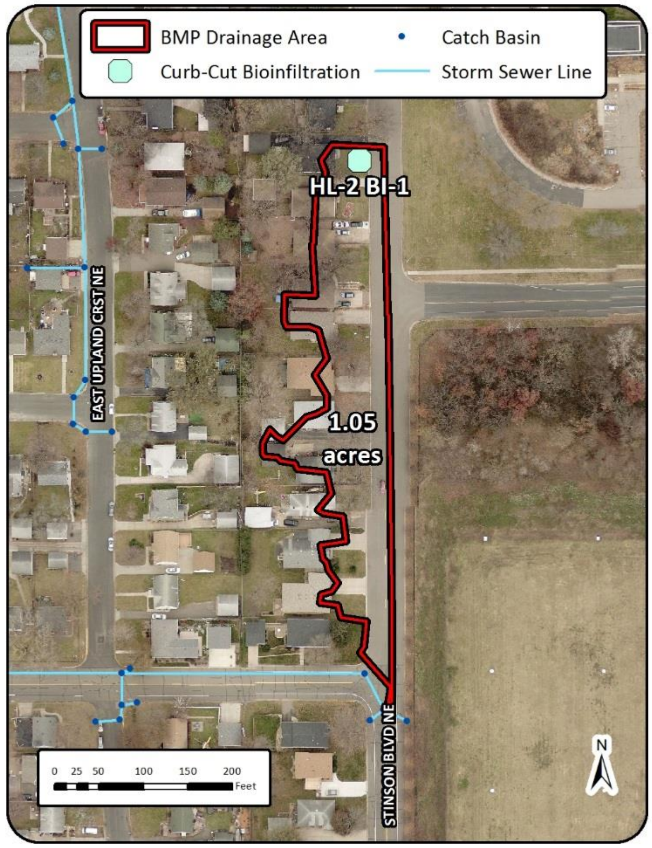
*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: HL-2 BI-1

Stinson Boulevard NE Bioinfiltration Basin



Drainage Area – 1.0 acres
Location – West side of Stinson Boulevard NE south of North Upland Crest NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration is preferred. However, optimal sites are not necessarily adjacent to an existing catch basin to serve as the connection point for an underdrain outlet. This basin is proposed to rely on infiltration, and the infiltration rate and ponding depth were adjusted accordingly to reflect the native soil infiltration rates and ensure drawdown in less than 48 hours. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	1.6%
	TSS (lb/yr)	54	1.9%
	Volume (acre-feet/yr)	0.14	1.9%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$9,420
	Total Estimated Project Cost (2019)		**$10,004**
	Annual O&M***		$225
Efficiency	**30-yr Average Cost/lb-TP**	**$2,939**	
	30-yr Average Cost/1,000lb-TSS	**$10,342**	
	30-yr Average Cost/ac-ft Vol.	**$4,047**	

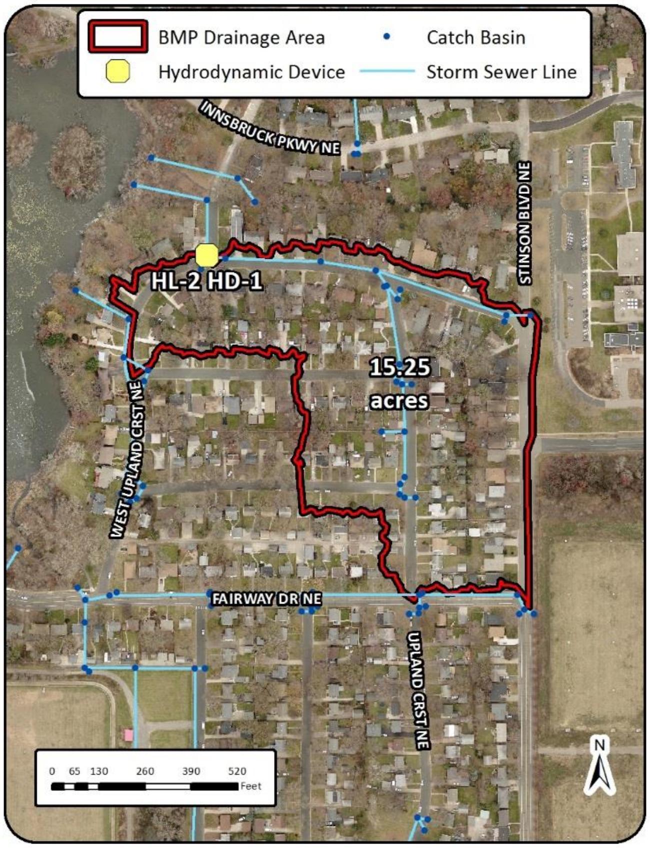
*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $73/hour for design)

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

Project ID: HL-2 HD-1

Pennine Pass NE
Hydrodynamic Device



Drainage Area – 15.3 acres
Location – Northwest corner of intersection between West Upland Crest NE and Pennine Pass NE
Property Ownership – Public
Site Specific Information – A hydrodynamic device is proposed in line with the storm sewer line on Pennine Pass NE just north of the West Upland Crest NE. A device at this location would provide treatment to runoff 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)	1.00	8.6%
	TSS (lb/yr)	351	12.4%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***	$3,750	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2019)	**$111,750**	
	Annual O&M***	$630	
Efficiency	**30-yr Average Cost/lb-TP**	**$4,355**	
	30-yr Average Cost/1,000lb-TSS	**$12,407**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

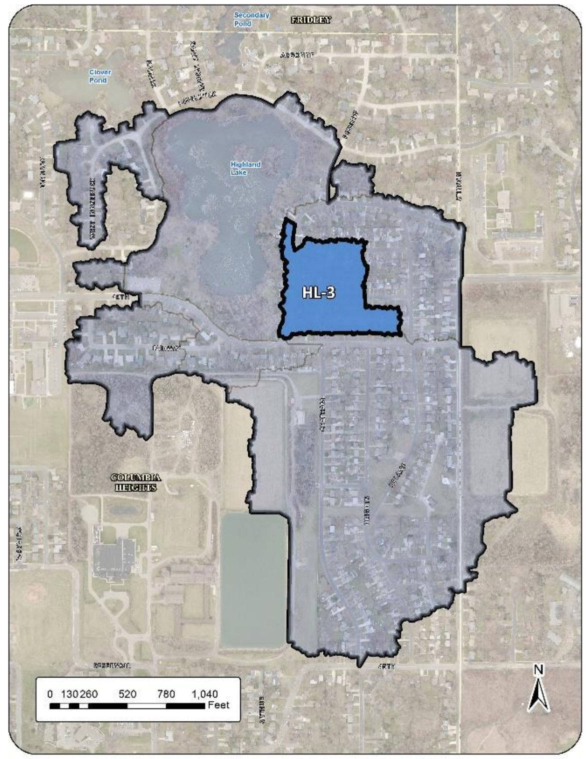
*Indirect Cost: (25 hours at $150/hour)

**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)

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

Catchment HL-3

Existing Catchment Summary	
Acres	9.0
Parcels	68
Land Cover	98.5% Residential 1.5% Open Space



CATCHMENT DESCRIPTION

Catchment HL-3 is also on the east side of Highland Lake and consists entirely of medium density residential land use. Catch basins on West Upland Crest NE collect runoff and route it to Highland Lake via the storm sewer line.

EXISTING STORMWATER TREATMENT

The primary stormwater treatment in the catchment is street cleaning, performed four times per year by the City of Columbia Heights. 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)	7.5	0.6	8%	**6.8**
	TSS (lb/yr)	1,910	272	14%	**1,638**
	Volume (acre-feet/yr)	4.2	0.0	0%	**4.2**

RETROFIT RECOMMENDATIONS OVERVIEW

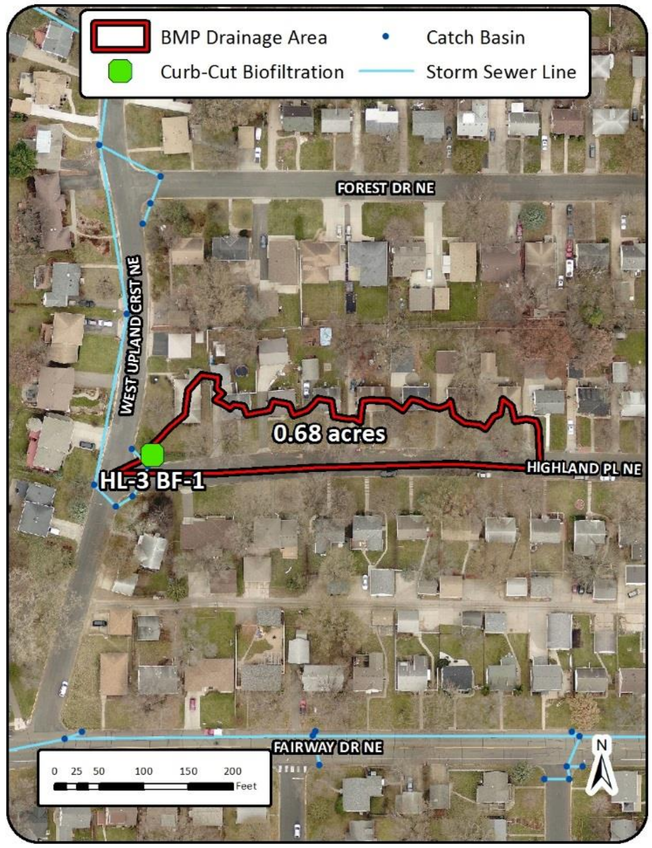
One biofiltration basin and one hydrodynamic device are proposed in catchment HL-2. The biofiltration basin was sited to maximize contributing drainage area, on a property with sufficient space and slope to accommodate the basin, and adjacent to catch basins to accommodate underdrain connections to the storm sewer infrastructure. The hydrodynamic device is positioned to provide treatment for the entire catchment.

RETROFIT RECOMMENDATIONS

Project ID: HL-3 BF-1

Highland Place NE Biofiltration Basin

Drainage Area – 0.7 acres
Location – Northeast corner of intersection between Highland Place NE and West Upland Crest NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.



	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	Total Size of BMP	250	sq-ft
	TP (lb/yr)	0.14	2.0%
	TSS (lb/yr)	47	2.9%
	Volume (acre-feet/yr)	0.05	1.1%
Cost	Administration & Promotion Costs*	$584	
	Design & Construction Costs**	$10,420	
	Total Estimated Project Cost (2019)	**$11,004**	
	Annual O&M***	$295	
Efficiency	30-yr Average Cost/lb-TP	**$4,727**	
	30-yr Average Cost/1,000lb-TSS	**$14,081**	
	30-yr Average Cost/ac-ft Vol.	**$14,387**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: HL-3 HD-1

West Upland Crest NE Hydrodynamic Device

Drainage Area – 9.0 acres
Location – West Upland Crest NE north of Forest Drive NE
Property Ownership – Public
Site Specific Information – A hydrodynamic device is proposed in line with the storm sewer line on West Upland Crest NE just before it outlets to Highland Lake. A device at this location would provide treatment to runoff 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
Treatment	**TP (lb/yr)**	0.73	10.7%
Treatment	**TSS (lb/yr)**	253	15.4%
Treatment	**Volume (acre-feet/yr)**	0.00	0.0%
Cost	**Administration & Promotion Costs***	$3,750	
Cost	**Design & Construction Costs****	$108,000	
Cost	**Total Estimated Project Cost (2019)**	**$111,750**	
Cost	**Annual O&M*****	$630	
Efficiency	**30-yr Average Cost/lb-TP**	**$5,966**	
Efficiency	**30-yr Average Cost/1,000lb-TSS**	**$17,213**	
Efficiency	**30-yr Average Cost/ac-ft Vol.**	**n/a**	

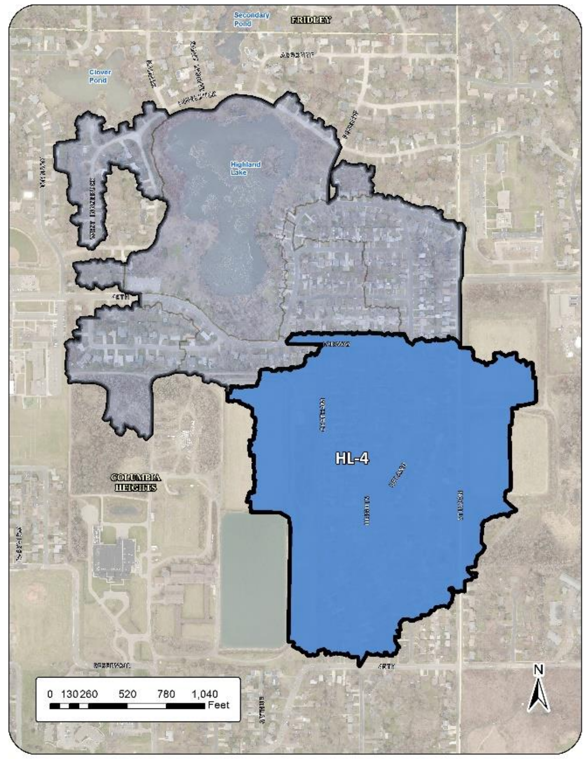
*Indirect Cost: (25 hours at $150/hour)

**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)

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

Catchment HL-4

Existing Catchment Summary	
Acres	69.6
Parcels	204
Land Cover	54.9% Residential 45.1% Open Space



CATCHMENT DESCRIPTION

Catchment HL-4 is the largest of the Highland Lake catchments and is located on the southeast side of the lake. Similar to the other Highland Lake catchments, the land use in HL-4 is predominantly medium density residential. Hilltop Park is located near the center of the catchment and the eastern portions of the Minneapolis Water Works property make up the western side of the catchment. Stormwater infrastructure located throughout the catchment collects and routes runoff directly to Highland Lake. The Minneapolis Water Works property does have an existing stormwater pond that provides treatment to some of the runoff generated on that property.

EXISTING STORMWATER TREATMENT

The primary stormwater treatment in the catchment is street cleaning, performed four times per year by the City of Columbia Heights. In addition to street cleaning, the Minneapolis Water Works property has a wet pond located on the eastern side of the property that provides stormwater treatment for areas of the property located within catchment HL-4. Available stormwater infrastructure suggests the pond has an outlet on the north end that ultimately connects to the stormwater infrastructure in HL-4. 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			
	TP (lb/yr)	48.2	8.1	17%	**40.1**
	TSS (lb/yr)	11,542	2,975	26%	**8,567**
	Volume (acre-feet/yr)	25.5	0.0	0%	**25.5**

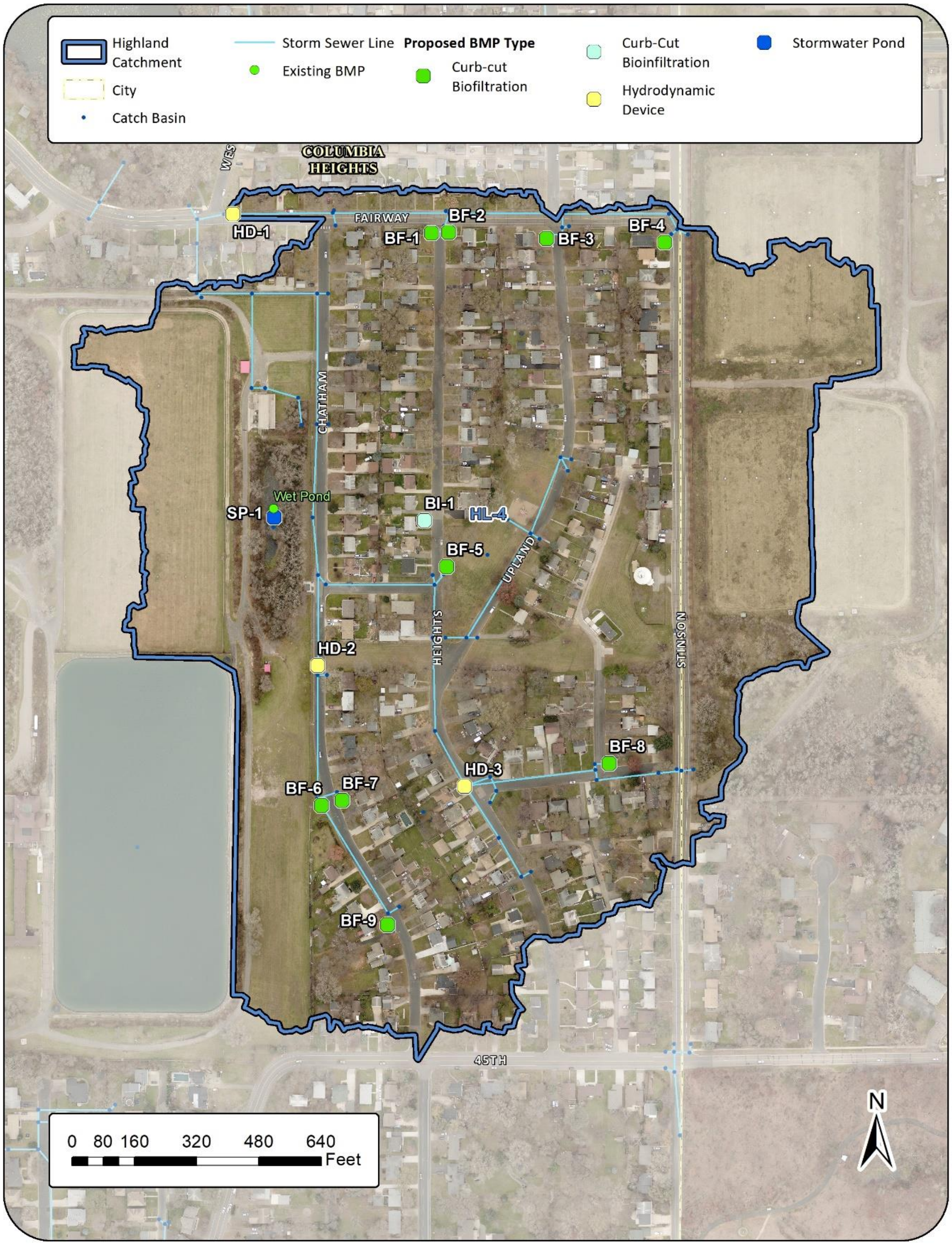
RETROFITS CONSIDERED BUT REJECTED

A new stormwater pond was considered within the open space of Hilltop Park. However, the contributing drainage area was significantly less than the 10 acres recommended for a wet pond. In addition, daylighting the storm sewer lines into bioretention basins within the open areas of the park was considered, but the elevations of the storm sewer lines would require a significant depression within the relatively small park.

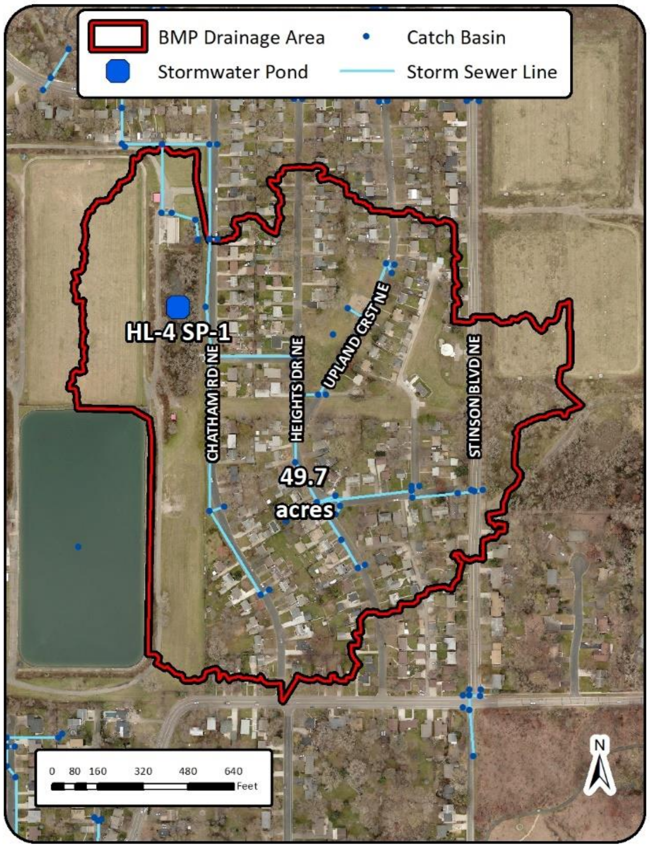
RETROFIT RECOMMENDATIONS OVERVIEW

A total of 14 retrofits are proposed in catchment HL-4 including one stormwater pond, three hydrodynamic devices, nine biofiltration basins, and one bioinfiltration basin. The stormwater pond consists of a retrofit to an existing stormwater pond on the Minneapolis Water Works property. The hydrodynamic devices are positioned at the convergence of multiple storm sewer lines in order to treat the largest contributing drainage area possible for the corresponding device size. The biofiltration basins were sited to maximize contributing drainage areas, on properties with sufficient space and slope to accommodate a basin, and adjacent to catch basins to accommodate underdrain connections to the storm sewer infrastructure. The bioinfiltration basin was sited at a property with a large contributing drainage area and sufficient space and slope to accommodate a basin. However, the property is not adjacent to a catch basin, so infiltration will be the primary process for stormwater treatment.

RETROFIT RECOMMENDATIONS



Project ID:
HL-4 SP-1
Chatham Road NE
Stormwater Pond



Drainage Area – 49.7 acres
Location – West of Chatham Road NE near the northeast corner of the Minneapolis Water Works property
Property Ownership – Public
Site Specific Information – The existing pond on the Minneapolis Water Works property has sufficient capacity to provide treatment for additional acreage. The storm sewer line that runs north-south along Chatham Road NE could be diverted into the pond, thereby providing treatment to an additional 35.7 acres. The table below provides pollutant removals and estimated costs.

Pond Modification

	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	1.00	acres
	TP (lb/yr)	10.4	26.0%
	TSS (lb/yr)	3,634	42.4%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***		$7,300
	Design & Construction Costs**		$85,000
	Total Estimated Project Cost (2019)		**$92,300**
	Annual O&M***		$1,000
Efficiency	**30-yr Average Cost/lb-TP**	**$392**	
	30-yr Average Cost/1,000lb-TSS	**$1,122**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

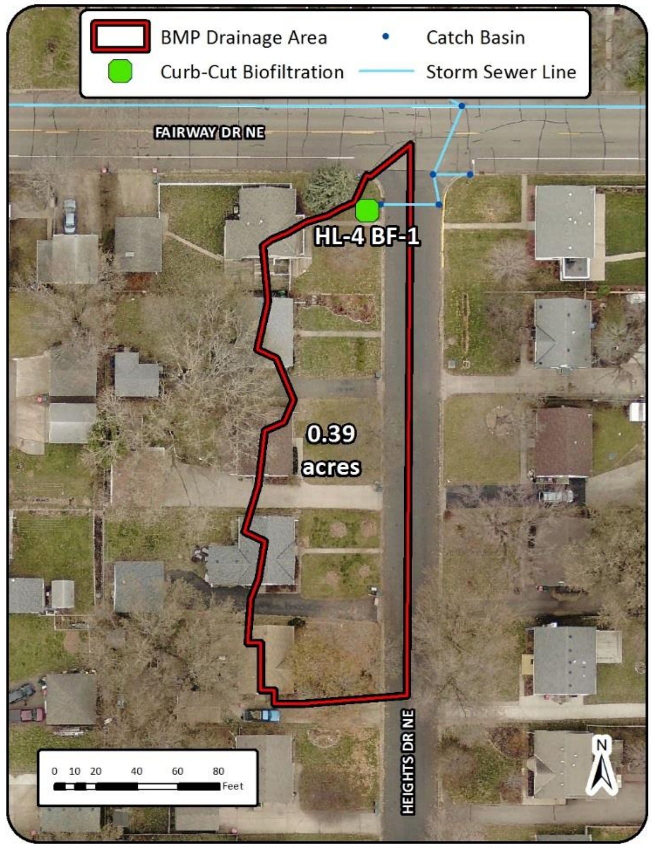
*Indirect Cost: (100 hours at $73/hour)

**Direct Cost: See Appendix B for detailed cost information

***$1,000/acre - Annual inspection and sediment/debris removal from pretreatment area

Project ID: HL-4 BF-1

Heights Drive NE
Biofiltration Basin



Drainage Area – 0.4 acres
Location – Southwest corner of intersection between Fairway Drive NE and Heights Drive NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

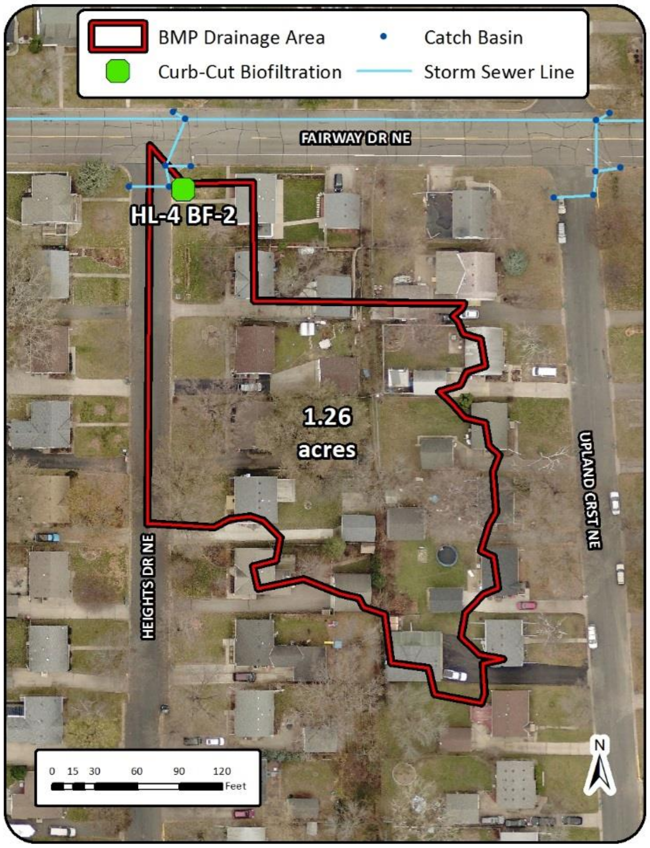
	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq-ft
	TP (lb/yr)	0.11	0.3%
	TSS (lb/yr)	33	0.4%
	Volume (acre-feet/yr)	0.02	0.1%
Cost	**Administration & Promotion Costs***	$584	
	Design & Construction Costs**	$10,420	
	Total Estimated Project Cost (2019)	**$11,004**	
	Annual O&M***	$295	
Efficiency	**30-yr Average Cost/lb-TP**	**$6,016**	
	30-yr Average Cost/1,000lb-TSS	**$20,055**	
	30-yr Average Cost/ac-ft Vol.	**$28,774**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID:
HL-4 BF-2
Heights Drive NE Biofiltration Basin



Drainage Area – 1.3 acres
Location – Southeast corner of intersection between Fairway Drive NE and Heights Drive NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq-ft
	TP (lb/yr)	0.18	0.4%
	TSS (lb/yr)	61	0.7%
	Volume (acre-feet/yr)	0.05	0.2%
Cost	**Administration & Promotion Costs***	$584	
	Design & Construction Costs**	$10,420	
	Total Estimated Project Cost (2019)	**$11,004**	
	Annual O&M***	$295	
Efficiency	**30-yr Average Cost/lb-TP**	**$3,677**	
	30-yr Average Cost/1,000lb-TSS	**$10,849**	
	30-yr Average Cost/ac-ft Vol.	**$14,387**	

*Indirect Cost: (8 hours at $73/hour base cost)

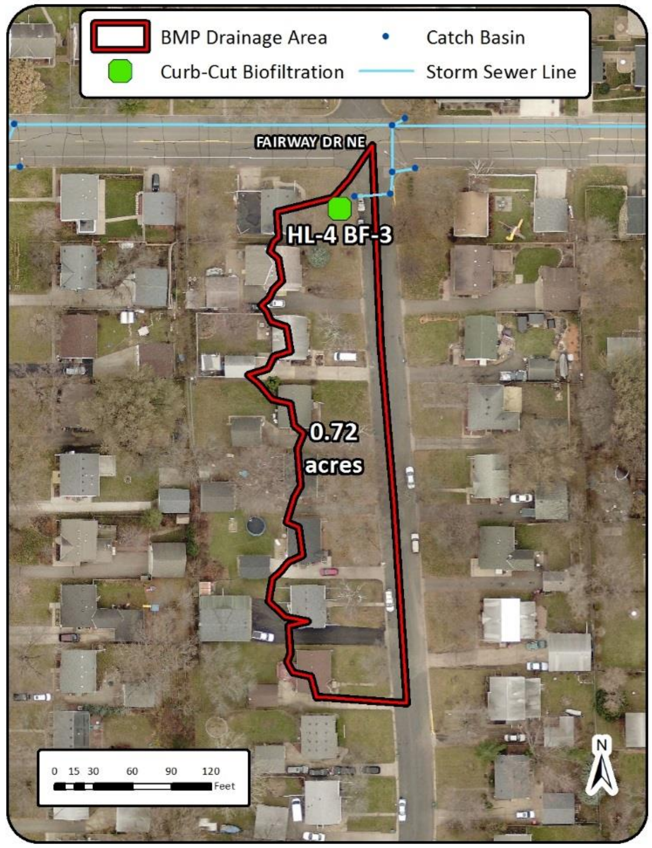
**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: HL-4 BF-3

Upland Crest NE Biofiltration Basin

Drainage Area – 0.7 acres
Location – Northwest corner of intersection between Fairway Drive NE and Upland Crest NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.



	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq-ft
	TP (lb/yr)	0.15	0.4%
	TSS (lb/yr)	48	0.6%
	Volume (acre-feet/yr)	0.05	0.2%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$4,412**	
	30-yr Average Cost/1,000lb-TSS	**$13,788**	
	30-yr Average Cost/ac-ft Vol.	**$14,387**	

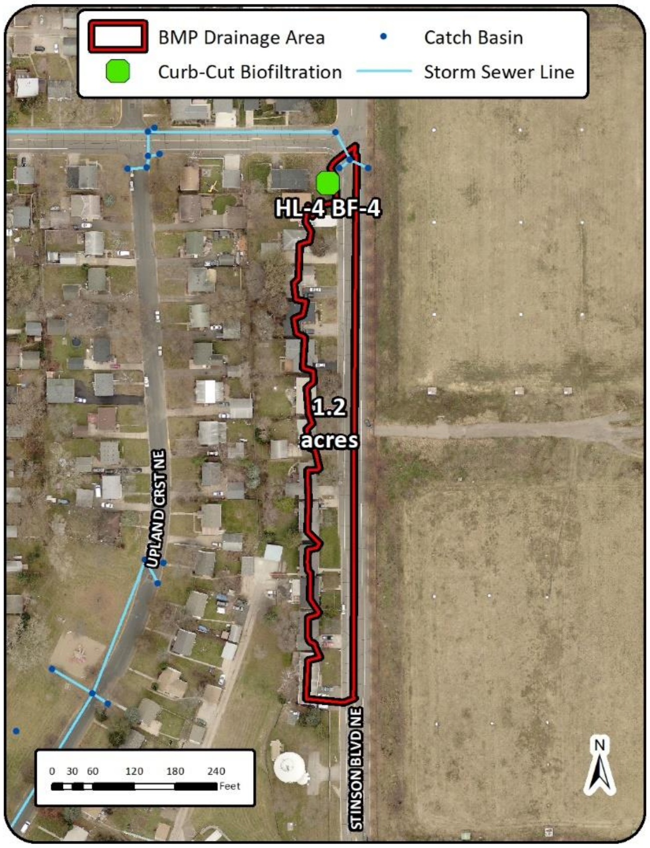
*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: HL-4 BF-4

Stinson Boulevard NE Biofiltration Basin



Drainage Area – 1.2 acres
Location – Southwest corner of intersection between Fairway Drive NE and Stinson Boulevard NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	Total Size of BMP	250	sq-ft
	TP (lb/yr)	0.18	0.4%
	TSS (lb/yr)	60	0.7%
	Volume (acre-feet/yr)	0.05	0.2%
Cost	Administration & Promotion Costs*	$584	
	Design & Construction Costs**	$10,420	
	Total Estimated Project Cost (2019)	**$11,004**	
	Annual O&M***	$295	
Efficiency	30-yr Average Cost/lb-TP	**$3,677**	
	30-yr Average Cost/1,000lb-TSS	**$11,030**	
	30-yr Average Cost/ac-ft Vol.	**$14,387**	

*Indirect Cost: (8 hours at $73/hour base cost)

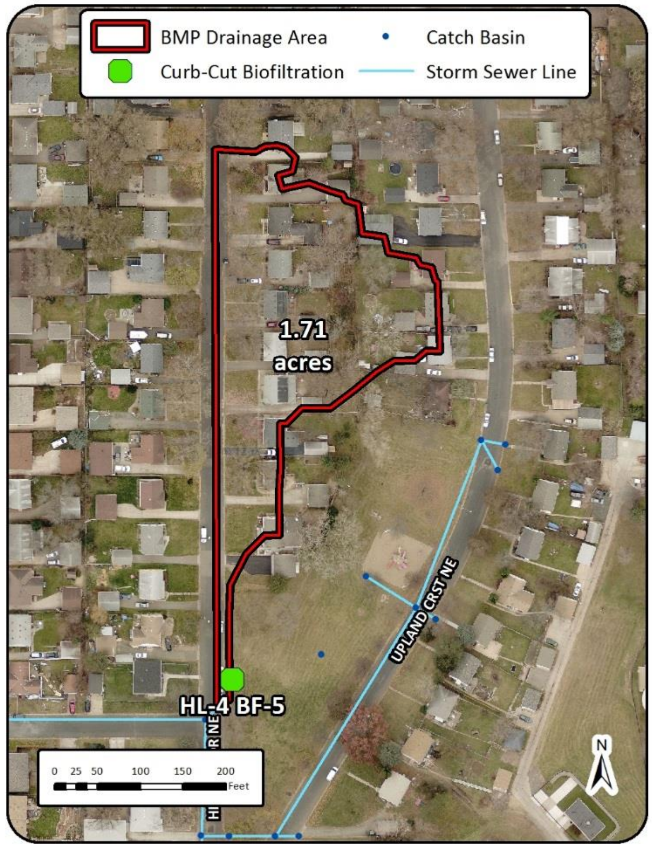
**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: HL-4 BF-5

Heights Drive NE Biofiltration Basin

Drainage Area – 1.7 acres
Location – Northeast of intersection between Golf Place NE and Heights Drive NE in Hilltop Park
Property Ownership – Public
Site Specific Information – Open space along the western side of Hilltop Park along Heights Drive NE could be used for a bioretention basin. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.



	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq-ft
	TP (lb/yr)	0.20	0.5%
	TSS (lb/yr)	67	0.8%
	Volume (acre-feet/yr)	0.05	0.2%
Cost	**Administration & Promotion Costs***	$584	
	Design & Construction Costs**	$10,420	
	Total Estimated Project Cost (2019)	**$11,004**	
	Annual O&M***	$295	
Efficiency	**30-yr Average Cost/lb-TP**	**$3,309**	
	30-yr Average Cost/1,000lb-TSS	**$9,878**	
	30-yr Average Cost/ac-ft Vol.	**$14,387**	

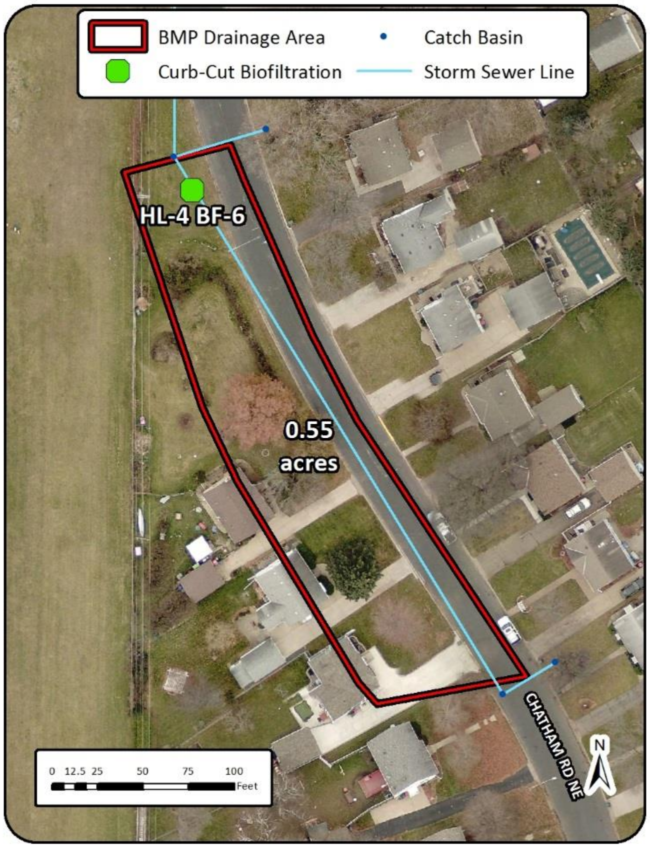
*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: HL-4 BF-6

Chatham Road NE
Biofiltration Basin



Drainage Area – 0.5 acres
Location – West side of Chatham Road NE north of 45th Avenue NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

Curb-Cut Biofiltration			
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	Total Size of BMP	250	sq-ft
	TP (lb/yr)	0.13	0.3%
	TSS (lb/yr)	38	0.4%
	Volume (acre-feet/yr)	0.02	0.1%
Cost	Administration & Promotion Costs*		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	30-yr Average Cost/lb-TP	**$5,091**	
	30-yr Average Cost/1,000lb-TSS	**$17,416**	
	30-yr Average Cost/ac-ft Vol.	**$28,774**	

*Indirect Cost: (8 hours at $73/hour base cost)

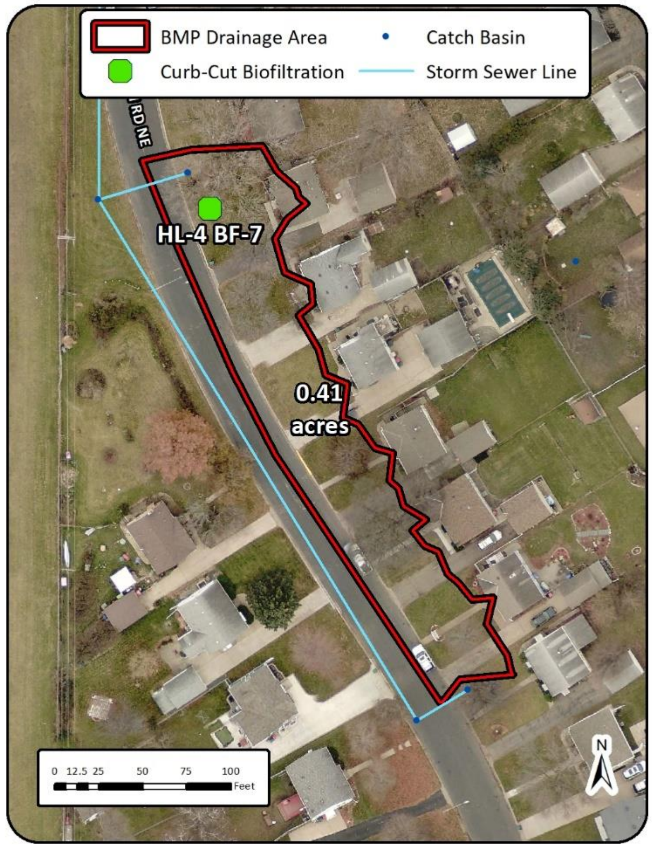
**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: HL-4 BF-7

Chatham Road NE
Biofiltration Basin

Drainage Area – 0.4 acres
Location – East side of Chatham Road NE north of 45th Avenue NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.



Curb-Cut Biofiltration

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Total Size of BMP	250	sq-ft
	TP (lb/yr)	0.11	0.3%
	TSS (lb/yr)	34	0.4%
	Volume (acre-feet/yr)	0.02	0.1%
Cost	Administration & Promotion Costs*	$584	
	Design & Construction Costs**	$10,420	
	Total Estimated Project Cost (2019)	**$11,004**	
	Annual O&M***	$295	
Efficiency	30-yr Average Cost/lb-TP	**$6,016**	
	30-yr Average Cost/1,000lb-TSS	**$19,465**	
	30-yr Average Cost/ac-ft Vol.	**$28,774**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: HL-4 BF-8

Maiden Lane NE
Biofiltration Basin

Drainage Area – 1.3 acres
Location – Northeast corner of intersection between Maiden Lane NE and Ivanhoe Place NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

Curb-Cut Biofiltration

	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq-ft
	TP (lb/yr)	0.18	0.4%
	TSS (lb/yr)	61	0.7%
	Volume (acre-feet/yr)	0.05	0.2%
Cost	**Administration & Promotion Costs***	$584	
	Design & Construction Costs**	$10,420	
	Total Estimated Project Cost (2019)	**$11,004**	
	Annual O&M***	$295	
Efficiency	**30-yr Average Cost/lb-TP**	**$3,677**	
	30-yr Average Cost/1,000lb-TSS	**$10,849**	
	30-yr Average Cost/ac-ft Vol.	**$14,387**	

*Indirect Cost: (8 hours at $73/hour base cost)

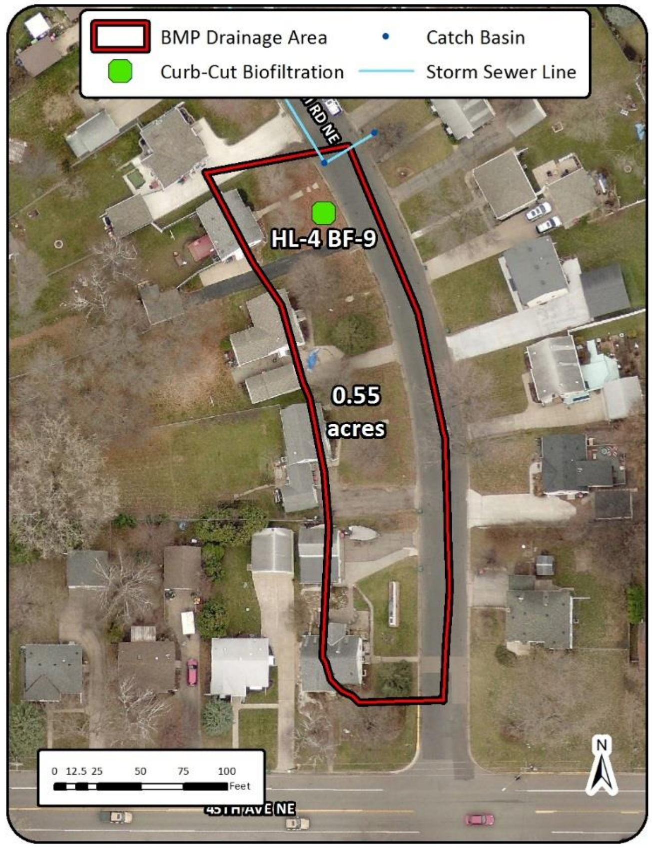
**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: HL-4 BF-9

Chatham Road NE
Biofiltration Basin

Drainage Area – 0.5 acres
Location – West side of Chatham Road NE north of 45th Avenue NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.



Curb-Cut Biofiltration

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Total Size of BMP	250	sq-ft
	TP (lb/yr)	0.13	0.3%
	TSS (lb/yr)	40	0.5%
	Volume (acre-feet/yr)	0.02	0.1%
Cost	Administration & Promotion Costs*	$584	
	Design & Construction Costs**	$10,420	
	Total Estimated Project Cost (2019)	**$11,004**	
	Annual O&M***	$295	
Efficiency	30-yr Average Cost/lb-TP	**$5,091**	
	30-yr Average Cost/1,000lb-TSS	**$16,545**	
	30-yr Average Cost/ac-ft Vol.	**$28,774**	

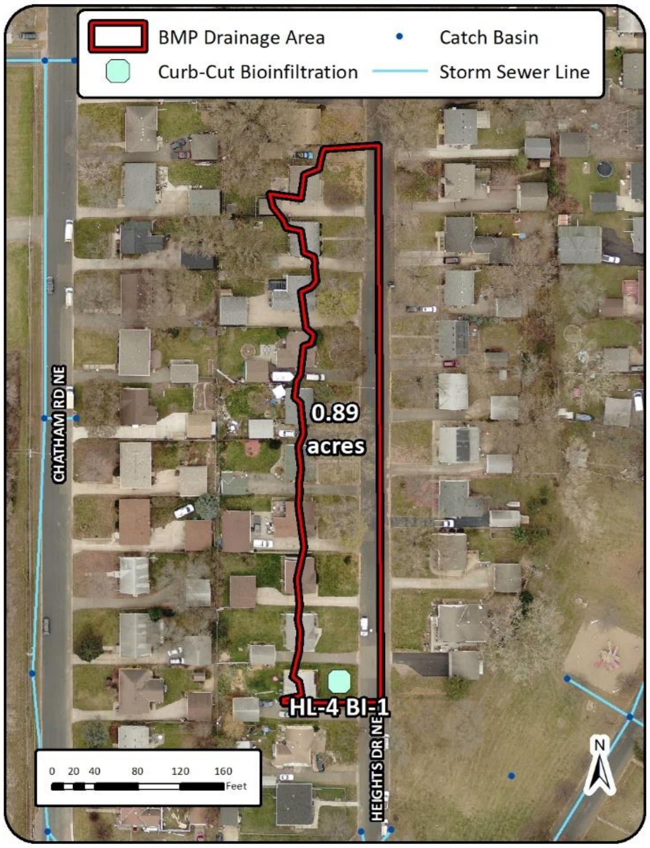
*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: HL-4 BI-1

Stinson Boulevard NE Bioinfiltration Basin



Drainage Area – 0.9 acres
Location – West side of Heights Drive NE north of the intersection between Golf Place NE and Heights Drive NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration is preferred. However, optimal sites are not necessarily adjacent to an existing catch basin to serve as the connection point for an underdrain outlet. This basin is proposed to rely on infiltration, and the infiltration rate and ponding depth were adjusted accordingly to reflect the native soil infiltration rates and ensure drawdown in less than 48 hours. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	Total Size of BMPs	250	sq-ft
	TP (lb/yr)	0.2	0.4%
	TSS (lb/yr)	52	0.6%
	Volume (acre-feet/yr)	0.12	0.5%
Cost	Administration & Promotion Costs*	$584	
	Design & Construction Costs**	$9,420	
	Total Estimated Project Cost (2019)	**$10,004**	
	Annual O&M***	$225	
Efficiency	30-yr Average Cost/lb-TP	**$3,103**	
	30-yr Average Cost/1,000lb-TSS	**$10,740**	
	30-yr Average Cost/ac-ft Vol.	**$4,856**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $73/hour for design)

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

Project ID: HL-4 HD-1

Fairway Drive NE Hydrodynamic Device

Drainage Area – 15.3 acres
Location – Southeast corner of intersection between Fairway Drive NE and West Upland Crest NE
Property Ownership – Public
Site Specific Information – A hydrodynamic device is proposed in line with the storm sewer line on Fairway Drive NE. This hydrodynamic device is positioned at the convergence of multiple storm sewer lines in order to treat the largest contributing drainage area possible for the corresponding device size. 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)	0.73	1.8%
	TSS (lb/yr)	264	3.1%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	Administration & Promotion Costs*	$3,750	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2019)	**$111,750**	
	Annual O&M***	$630	
Efficiency	30-yr Average Cost/lb-TP	**$5,966**	
	30-yr Average Cost/1,000lb-TSS	**$16,496**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

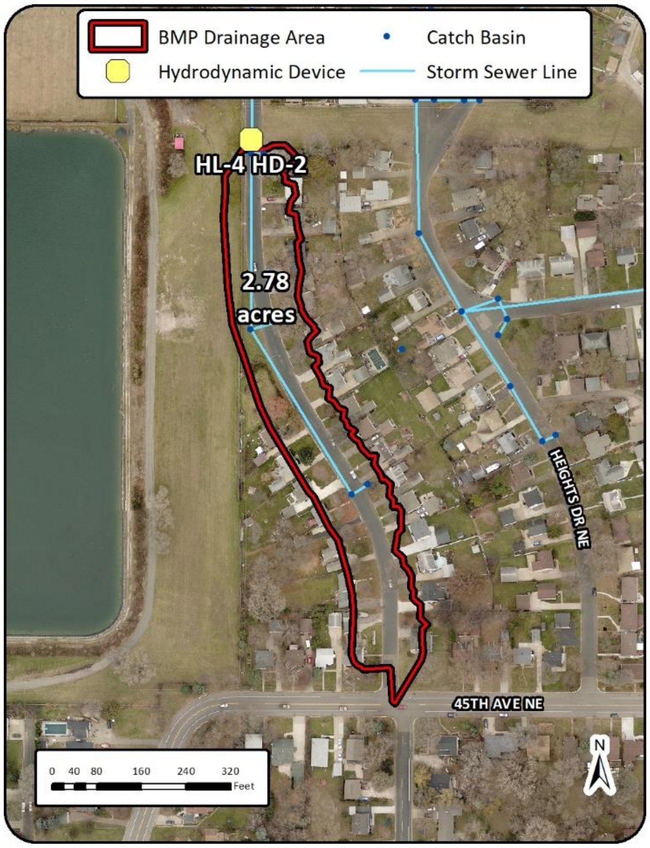
*Indirect Cost: (25 hours at $150/hour)

**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)

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

Project ID: HL-4 HD-2

Chatham Road NE
Hydrodynamic Device



Drainage Area – 2.8 acres
Location – Chatham Road NE south of the intersection with Golf Place NE
Property Ownership – Public
Site Specific Information – A hydrodynamic device is proposed in line with the storm sewer line on Chatham Road NE. This hydrodynamic device is positioned at the convergence of multiple storm sewer lines in order to treat the largest contributing drainage area possible for the corresponding device size. 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)	0.24	0.6%
	TSS (lb/yr)	82	1.0%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***	$3,750	
	Design & Construction Costs**	$27,000	
	Total Estimated Project Cost (2019)	**$30,750**	
	Annual O&M***	$630	
Efficiency	**30-yr Average Cost/lb-TP**	**$6,896**	
	30-yr Average Cost/1,000lb-TSS	**$20,183**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

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

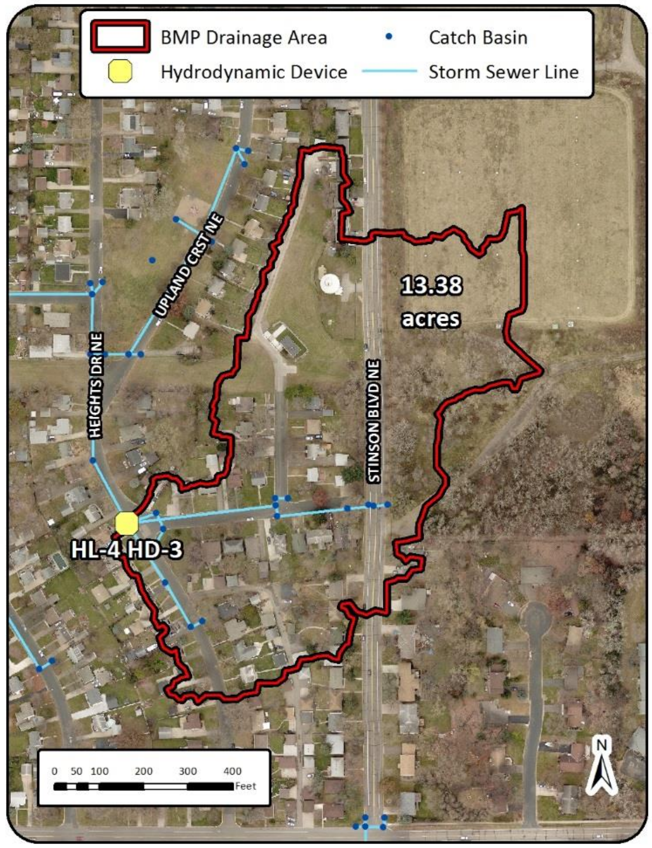
**Direct Cost: ($18,000 for materials) + ($9,000 for labor and installation costs)

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

Project ID: HL-4 HD-3

Heights Drive NE Hydrodynamic Device

Drainage Area – 13.4 acres
Location – West side of intersection between Maiden Lane NE and Heights Drive NE
Property Ownership – Public
Site Specific Information – A hydrodynamic device is proposed in line with the storm sewer line on Heights Drive NE. This hydrodynamic device is positioned at the convergence of multiple storm sewer lines in order to treat the largest contributing drainage area possible for the corresponding device size. 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)	0.79	2.0%
	TSS (lb/yr)	274	3.2%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***	$3,750	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2019)	**$111,750**	
	Annual O&M***	$630	
Efficiency	**30-yr Average Cost/lb-TP**	**$5,513**	
	30-yr Average Cost/1,000lb-TSS	**$15,894**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

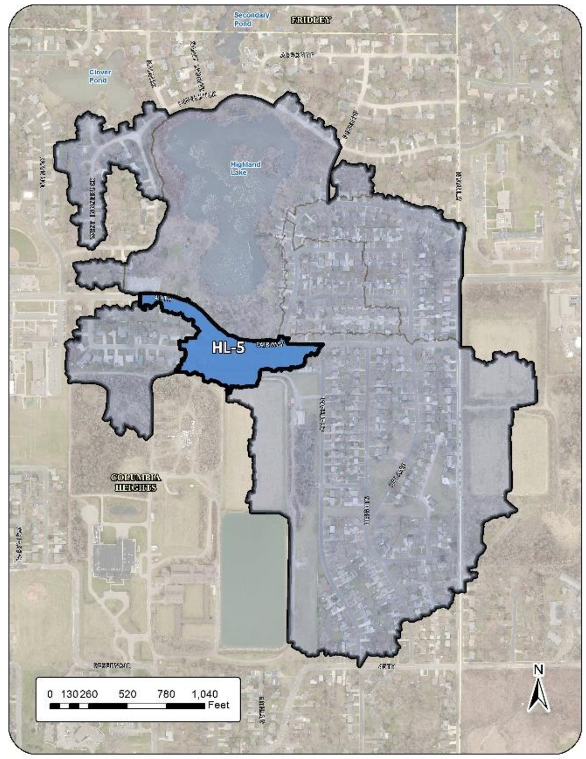
*Indirect Cost: (25 hours at $150/hour)

**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)

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

Catchment HL-5

Existing Catchment Summary	
Acres	6.4
Parcels	29
Land Cover	78.4% Residential 21.6% Open Space



CATCHMENT DESCRIPTION

This catchment primarily consists of residential properties along 49th Ave. NE/Fairway Drive NE on the south side of Highland Lake. Catch basins on 49th Ave. NE/Fairway Drive NE collect runoff and route it to Highland Lake via the storm sewer line.

EXISTING STORMWATER TREATMENT

The primary stormwater treatment in the catchment is street cleaning, performed four times per year by the City of Columbia Heights. 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)	5.0	0.4	8%	**4.6**
	TSS (lb/yr)	1,252	166	13%	**1,086**
	Volume (acre-feet/yr)	2.7	0.0	0%	**2.7**

RETROFIT RECOMMENDATIONS OVERVIEW

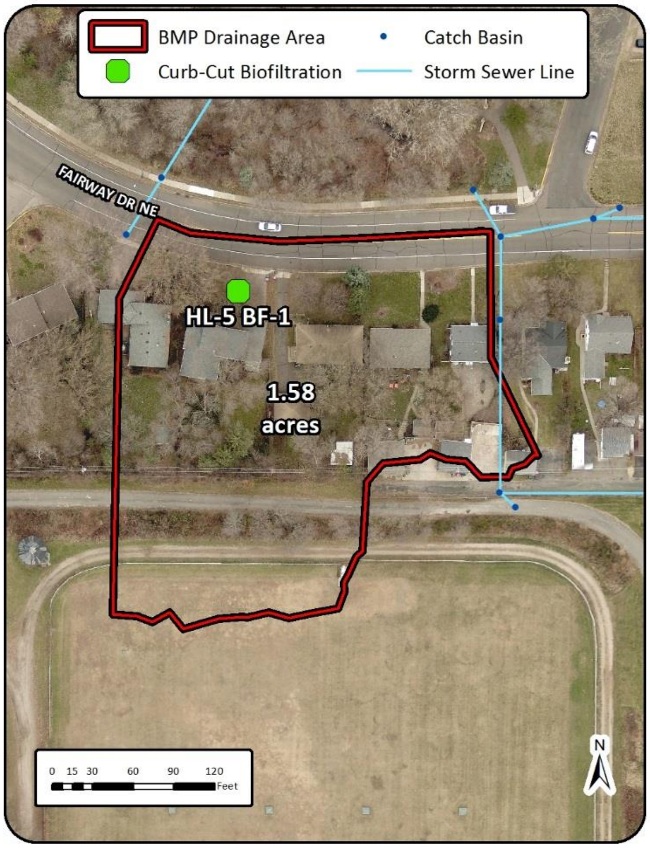
Two biofiltration basins and one hydrodynamic device were proposed in catchment HL-5. The biofiltration basins were sited to maximize contributing drainage areas, on properties with sufficient space and slope to accommodate a basin, and adjacent to catch basins to accommodate underdrain connections to the storm sewer infrastructure. The hydrodynamic device was positioned at the convergence of multiple storm sewer lines in order to treat the largest contributing drainage area possible for the corresponding device size.

RETROFIT RECOMMENDATIONS

Project ID: HL-5 BF-1

Fairway Drive NE Biofiltration Basin

Drainage Area – 1.6 acres
Location – South side of Fairway Drive NE west of West Upland Crest NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.



Curb-Cut Biofiltration

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Total Size of BMP	250	sq-ft
	TP (lb/yr)	0.19	4.1%
	TSS (lb/yr)	65	6.0%
	Volume (acre-feet/yr)	0.05	1.7%
Cost	Administration & Promotion Costs*	$584	
	Design & Construction Costs**	$10,420	
	Total Estimated Project Cost (2019)	**$11,004**	
	Annual O&M***	$295	
Efficiency	30-yr Average Cost/lb-TP	**$3,483**	
	30-yr Average Cost/1,000lb-TSS	**$10,182**	
	30-yr Average Cost/ac-ft Vol.	**$14,387**	

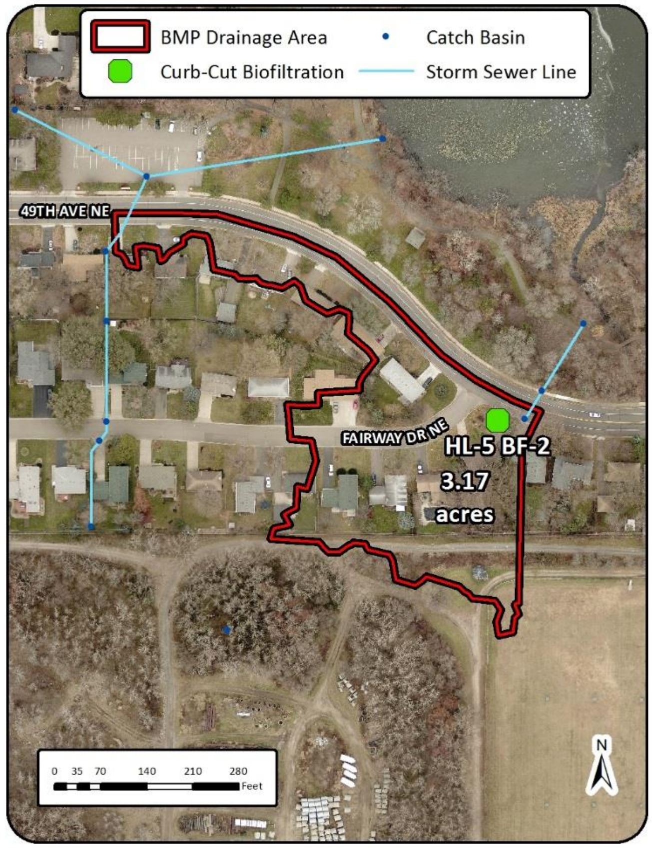
*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: HL-5 BF-2

Fairway Drive NE
Biofiltration Basin



Drainage Area – 3.2 acres
Location – South side of Fairway Drive NE west of storm sewer line that outlets to the south side of Highland Lake
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	Total Size of BMP	250	sq-ft
Treatment	TP (lb/yr)	0.24	5.2%
Treatment	TSS (lb/yr)	81	7.5%
Treatment	Volume (acre-feet/yr)	0.05	1.7%
Cost	Administration & Promotion Costs*	$584	
Cost	Design & Construction Costs**	$10,420	
Cost	Total Estimated Project Cost (2019)	**$11,004**	
Cost	Annual O&M***	$295	
Efficiency	**30-yr Average Cost/lb-TP**	**$2,758**	
Efficiency	**30-yr Average Cost/1,000lb-TSS**	**$8,170**	
Efficiency	**30-yr Average Cost/ac-ft Vol.**	**$14,387**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID:
HL-5 HD-1
Fairway Drive NE
Hydrodynamic Device

Drainage Area – 6.4 acres
Location – North side of Fairway Drive NE at south end of Highland Lake
Property Ownership – Public
Site Specific Information – A hydrodynamic device is proposed in line with the storm sewer line on Fairway Drive NE that runs north-south and outlets into the south end of Highland Lake. A device at this location would provide treatment to runoff 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**	8	ft diameter
	TP (lb/yr)	0.49	10.6%
	TSS (lb/yr)	172	15.8%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***	$3,750	
	Design & Construction Costs**	$54,000	
	Total Estimated Project Cost (2019)	**$57,750**	
	Annual O&M***	$630	
Efficiency	**30-yr Average Cost/lb-TP**	**$5,214**	
	30-yr Average Cost/1,000lb-TSS	**$14,855**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

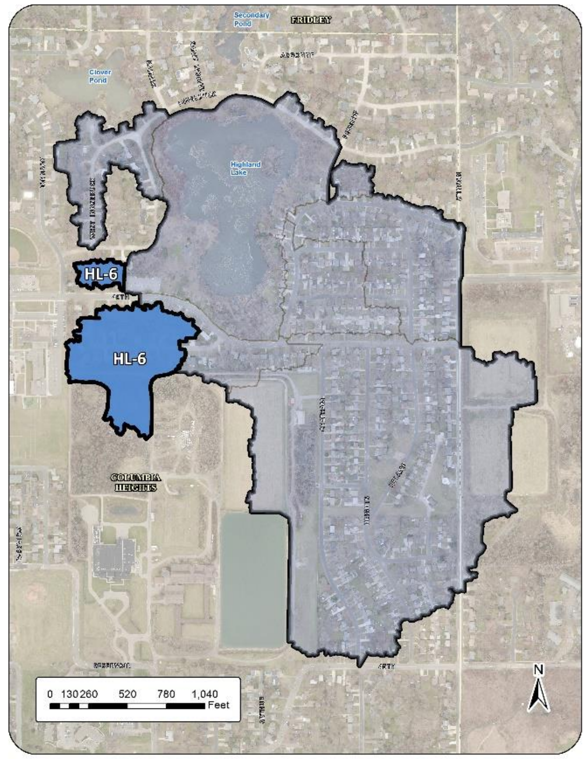
*Indirect Cost: (25 hours at $150/hour)

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

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

Catchment HL-6

Existing Catchment Summary	
Acres	11.7
Parcels	49
Land Cover	71.4% Residential 28.2% Open Space 0.4% Institutional



CATCHMENT DESCRIPTION

Catchment HL-6 consists of two separate drainage areas. Runoff is collected by catch basins and routed through storm sewer lines from each area. The storm sewer lines then converge on the southwest side of Highland Lake before discharging. The small, northern drainage area consists only of backyard runoff from approximately eight residential properties. The southern drainage area consists of residential properties along Fairway and a small portion of the northern extent of the Minneapolis Water Works property.

EXISTING STORMWATER TREATMENT

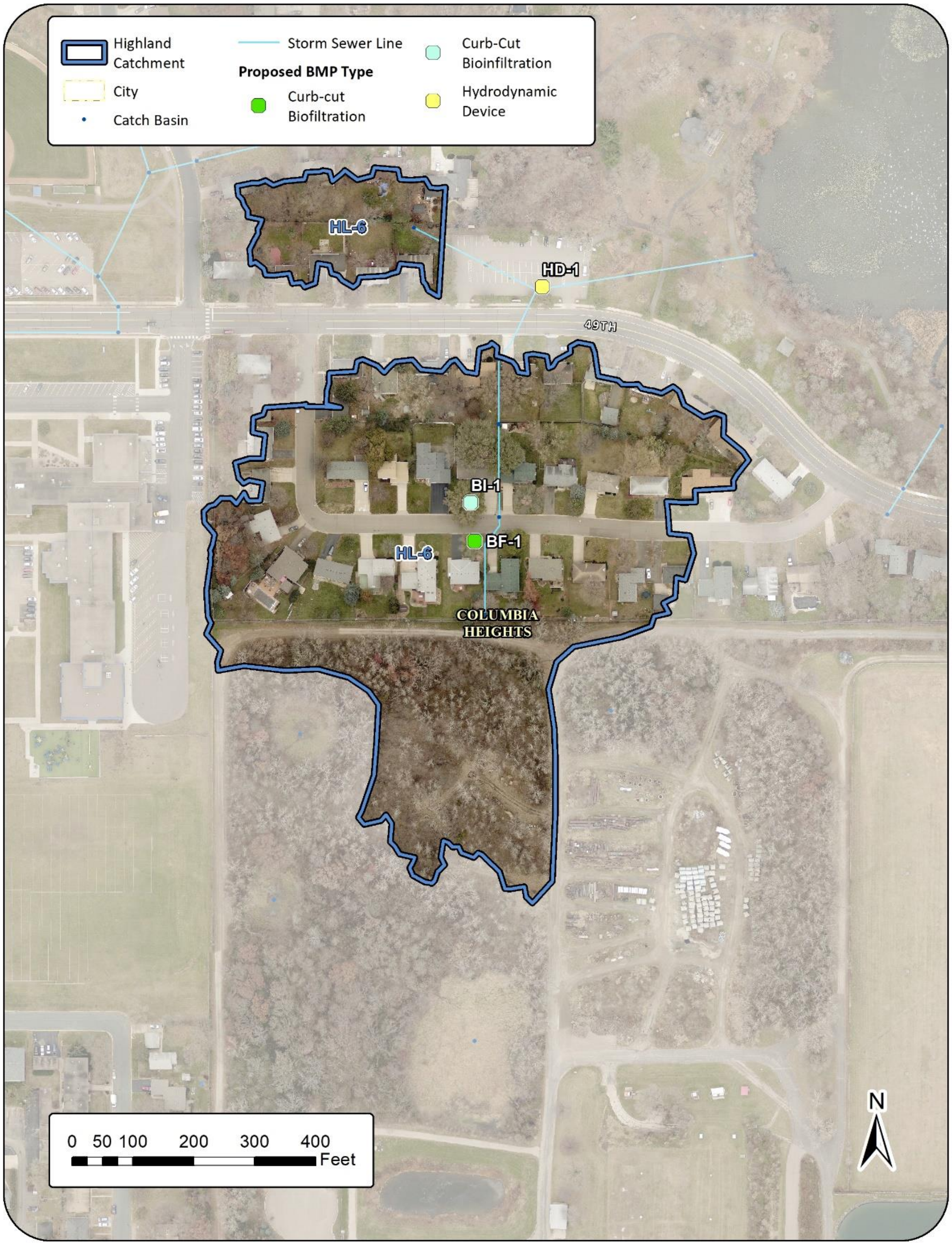
The primary stormwater treatment in the catchment is street cleaning, performed four times per year by the City of Columbia Heights. Present-day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	1			
	BMP Types	Street Cleaning			
	TP (lb/yr)	8.9	0.7	7%	**8.3**
	TSS (lb/yr)	2,216	286	13%	**1,930**
	Volume (acre-feet/yr)	4.8	0.0	0%	**4.8**

RETROFIT RECOMMENDATIONS OVERVIEW

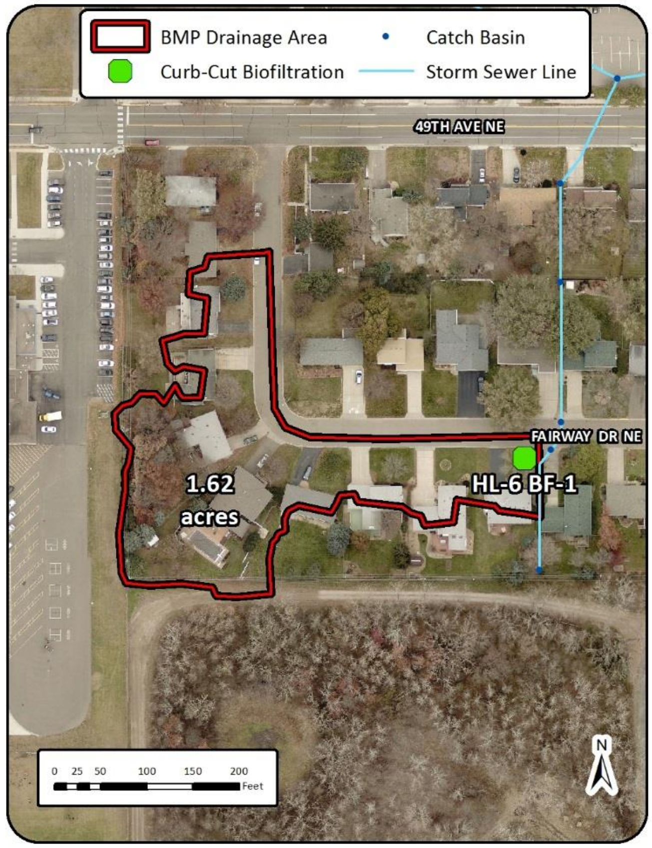
One biofiltration basin and one bioinfiltration basin were proposed in catchment HL-5. The biofiltration basin was sited to maximize contributing drainage area, on a property with sufficient space and slope to accommodate a basin, and adjacent to a catch basin to accommodate an underdrain connection to the storm sewer infrastructure. The bioinfiltration basin was sited at a property with a large contributing drainage area and sufficient space and slope to accommodate a basin. However, the property is not adjacent to a catch basin, so infiltration will be the primary process for stormwater treatment.

RETROFIT RECOMMENDATIONS



Project ID: HL-6 BF-1

Fairway Drive NE Biofiltration Basin



Drainage Area – 1.6 acres
Location – South side of Fairway Drive NE west of storm sewer line that drains to Highland Lake
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq-ft
	TP (lb/yr)	0.20	2.4%
	TSS (lb/yr)	48	2.5%
	Volume (acre-feet/yr)	0.05	1.0%
Cost	**Administration & Promotion Costs***	$584	
	Design & Construction Costs**	$10,420	
	Total Estimated Project Cost (2019)	**$11,004**	
	Annual O&M***	$295	
Efficiency	**30-yr Average Cost/lb-TP**	**$3,309**	
	30-yr Average Cost/1,000lb-TSS	**$13,788**	
	30-yr Average Cost/ac-ft Vol.	**$14,387**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: HL-6 BI-1

Fairway Drive NE Bioinfiltration Basin

Drainage Area – 0.7 acres
Location – North side of Fairway Drive NE west of the storm sewer line that drains to Highland Lake
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration is preferred. However, optimal sites are not necessarily adjacent to an existing catch basin to serve as the connection point for an underdrain outlet. This basin is proposed to rely on infiltration, and the infiltration rate and ponding depth were adjusted accordingly to reflect the native soil infiltration rates and ensure drawdown in less than 48 hours. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	2.1%
	TSS (lb/yr)	48	2.5%
	Volume (acre-feet/yr)	0.12	2.4%
Cost	**Administration & Promotion Costs***	$584	
	Design & Construction Costs**	$9,420	
	Total Estimated Project Cost (2019)	**$10,004**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$3,285**	
	30-yr Average Cost/1,000lb-TSS	**$11,635**	
	30-yr Average Cost/ac-ft Vol.	**$4,856**	

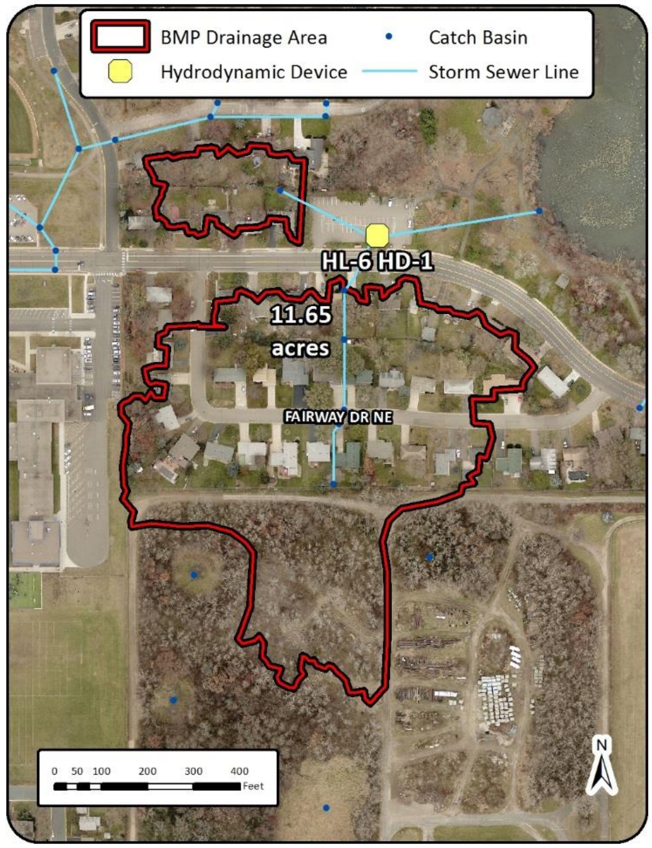
*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $73/hour for design)

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

Project ID: HL-6 HD-1

Kordiak Park
Hydrodynamic Device



Drainage Area – 11.7 acres
Location – Within the Kordiak Park parking lot downstream of the convergence between the two storm sewer lines
Property Ownership – Public
Site Specific Information – A hydrodynamic device is proposed in line with the storm sewer line that runs west-east in the southwest corner of Kordiak Park, under the parking lot. A device at this location would provide treatment to runoff 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)	0.84	10.1%
	TSS (lb/yr)	292	15.1%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***	$3,750	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2019)	**$111,750**	
	Annual O&M***	$630	
Efficiency	**30-yr Average Cost/lb-TP**	**$5,185**	
	30-yr Average Cost/1,000lb-TSS	**$14,914**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

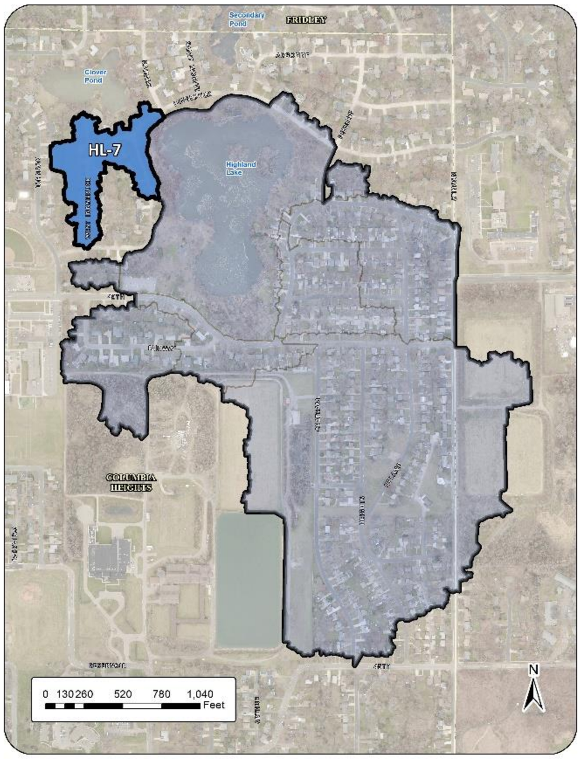
*Indirect Cost: (25 hours at $150/hour)

**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)

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

Catchment HL-7

Existing Catchment Summary	
Acres	7.6
Parcels	31
Land Cover	87.4% Residential 12.6% Open Space



CATCHMENT DESCRIPTION

Positioned on the northwest side of Highland Lake, catchment HL-7 is comprised of medium density residential land use along West Innsbruck Parkway NE. Catch basins near the intersection of West Innsbruck Parkway NE and Innsbruck Parkway NE collect stormwater runoff and route it to Highland Lake via the storm sewer line.

EXISTING STORMWATER TREATMENT

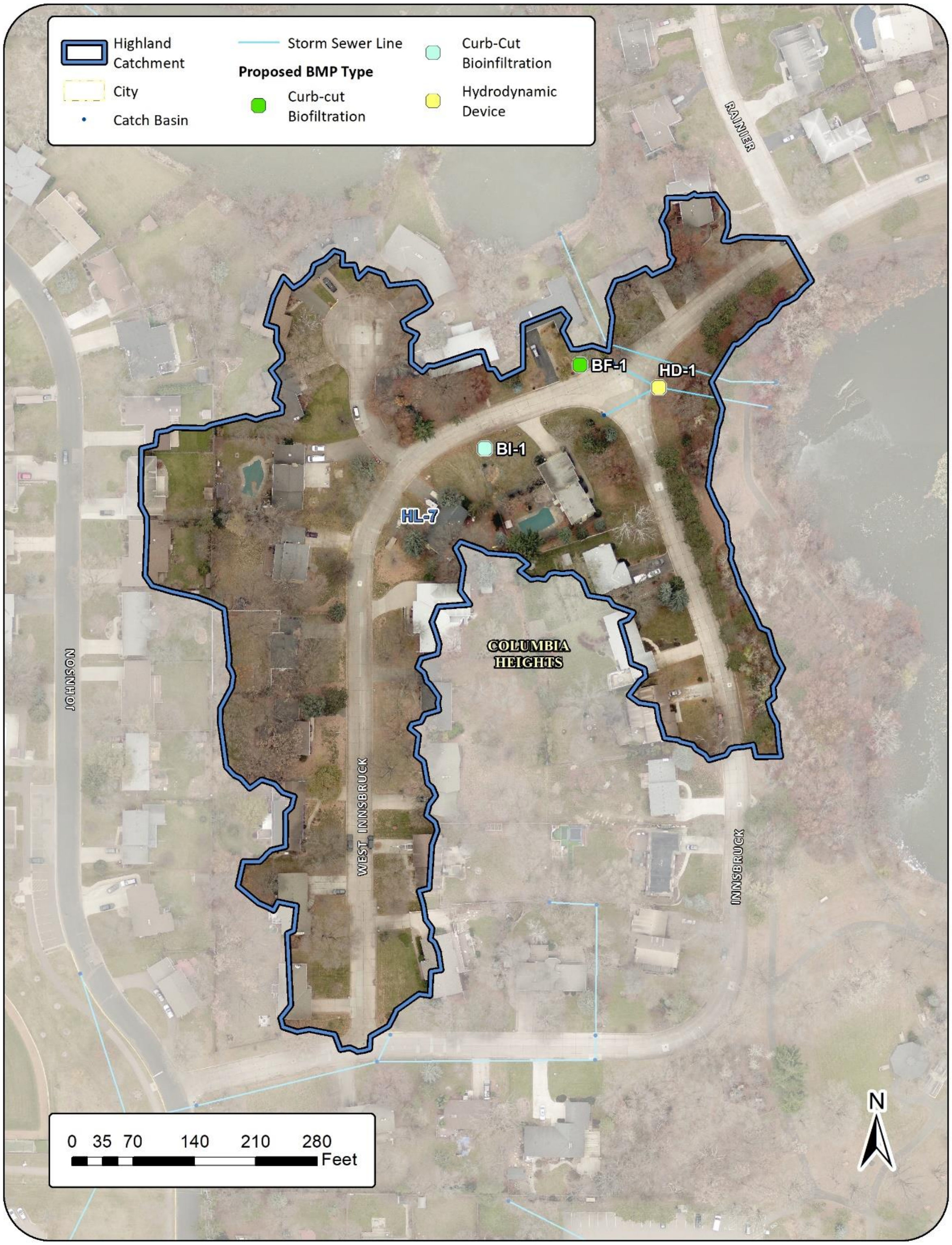
The primary stormwater treatment in the catchment is street cleaning, performed four times per year by the City of Columbia Heights. Present-day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	1			
	BMP Types	Street Cleaning			
	TP (lb/yr)	6.1	0.5	8%	**5.6**
	TSS (lb/yr)	1,550	213	14%	**1,337**
	Volume (acre-feet/yr)	3.4	0.0	0%	**3.4**

RETROFIT RECOMMENDATIONS OVERVIEW

Three projects were proposed catchment HL-7. One biofiltration basin was sited to maximize contributing drainage area, on a property with sufficient space and slope to accommodate a basin, and adjacent to a catch basin to accommodate an underdrain connection to the storm sewer infrastructure. One bioinfiltration basin was sited at a property with a large contributing drainage area and sufficient space and slope to accommodate a basin. However, the property is not adjacent to a catch basin, so infiltration will be the primary process for stormwater treatment. Lastly, one hydrodynamic device was positioned at the convergence of multiple storm sewer lines in order to treat the largest contributing drainage area possible for the corresponding device size.

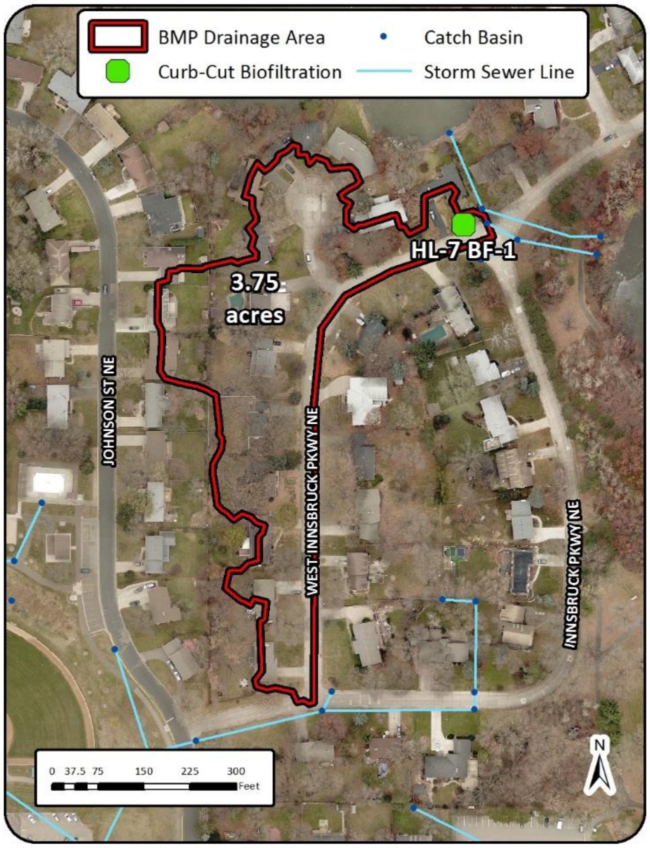
RETROFIT RECOMMENDATIONS



Project ID: HL-7 BF-1

West Innsbruck Parkway NE Biofiltration Basin

Drainage Area – 3.7 acres
Location – North side of the intersection between West Innsbruck Parkway NE and Innsbruck Parkway NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.



Curb-Cut Biofiltration

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Total Size of BMP	250	sq-ft
	TP (lb/yr)	0.24	4.3%
	TSS (lb/yr)	82	6.1%
	Volume (acre-feet/yr)	0.07	2.0%
Cost	Administration & Promotion Costs*	$584	
	Design & Construction Costs**	$10,420	
	Total Estimated Project Cost (2019)	**$11,004**	
	Annual O&M***	$295	
Efficiency	30-yr Average Cost/lb-TP	**$2,758**	
	30-yr Average Cost/1,000lb-TSS	**$8,071**	
	30-yr Average Cost/ac-ft Vol.	**$9,591**	

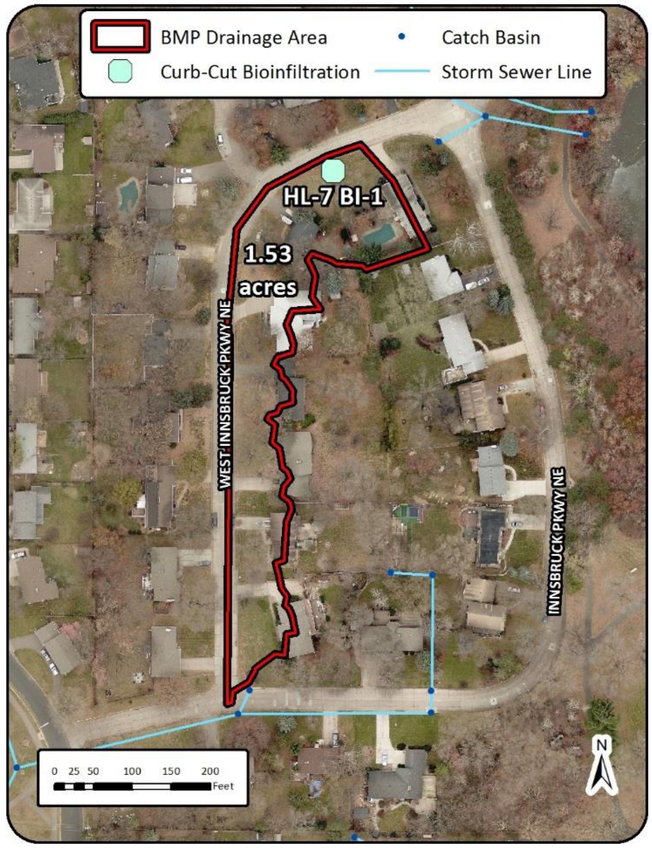
*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: HL-7 BI-1

West Innsbruck Parkway NE Bioinfiltration Basin



Drainage Area – 1.5 acres
Location – South side of Innsbruck Parkway NE west of the intersection with Innsbruck Parkway NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration is preferred. However, optimal sites are not necessarily adjacent to an existing catch basin to serve as the connection point for an underdrain outlet. This basin is proposed to rely on infiltration, and the infiltration rate and ponding depth were adjusted accordingly to reflect the native soil infiltration rates and ensure drawdown in less than 48 hours. The table below provides pollutant removals and estimated costs.

Curb-Cut Bioinfiltration

	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	Total Size of BMPs	250	sq-ft
Treatment	TP (lb/yr)	0.2	3.5%
Treatment	TSS (lb/yr)	56	4.2%
Treatment	Volume (acre-feet/yr)	0.14	4.1%
Cost	Administration & Promotion Costs*	$584	
Cost	Design & Construction Costs**	$9,420	
Cost	Total Estimated Project Cost (2019)	**$10,004**	
Cost	Annual O&M***	$225	
Efficiency	30-yr Average Cost/lb-TP	**$2,792**	
Efficiency	30-yr Average Cost/1,000lb-TSS	**$9,973**	
Efficiency	30-yr Average Cost/ac-ft Vol.	**$4,047**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $73/hour for design)

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

Project ID: HL-7 HD-1

Innsbruck Parkway NE Hydrodynamic Device

Drainage Area – 7.6 acres
Location – East side of the intersection between West Innsbruck Parkway NE and Innsbruck Parkway NE
Property Ownership – Public
Site Specific Information – A hydrodynamic device is proposed in line with the storm sewer line on West Innsbruck Parkway NE before it discharges into the northwest corner of Highland Lake. A device at this location would provide treatment to runoff 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)	0.65	11.5%
	TSS (lb/yr)	226	16.9%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	Administration & Promotion Costs*		$3,750
	Design & Construction Costs**		$108,000
	Total Estimated Project Cost (2019)		**$111,750**
	Annual O&M***		$630
Efficiency	30-yr Average Cost/lb-TP	**$6,700**	
	30-yr Average Cost/1,000lb-TSS	**$19,270**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

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

**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)

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

Sullivan Lake Drainage Network

Catchment ID	Page
SL-DD	102
SL-1	107
SL-2	117
SL-3	122
SL-4	188
SL-5	199
SL-6	201

Existing Network Summary	
Acres	432.7
Dominant Land Cover	Residential
Volume (ac-ft/yr)	267.7
TP (lb/yr)	286.3
TSS (lb/yr)	87,231

DRAINAGE NETWORK SUMMARY

The Sullivan Lake drainage network includes all areas draining to Sullivan Lake. Seven catchments lie within this drainage network. Six catchments have a dedicated outfall to Highland Lake, and one catchment represents the near-lake area comprised of Sullivan Lake Park that directly drains into Sullivan Lake.

Catchment size varies from 1.6 acres up to nearly 280 acres. Notable areas of the drainage network include Sullivan Lake Park, the Target and Medtronic campuses, the Highway 65 corridor, Columbia Heights High School, Ramsdell Park, and expansive residential areas.

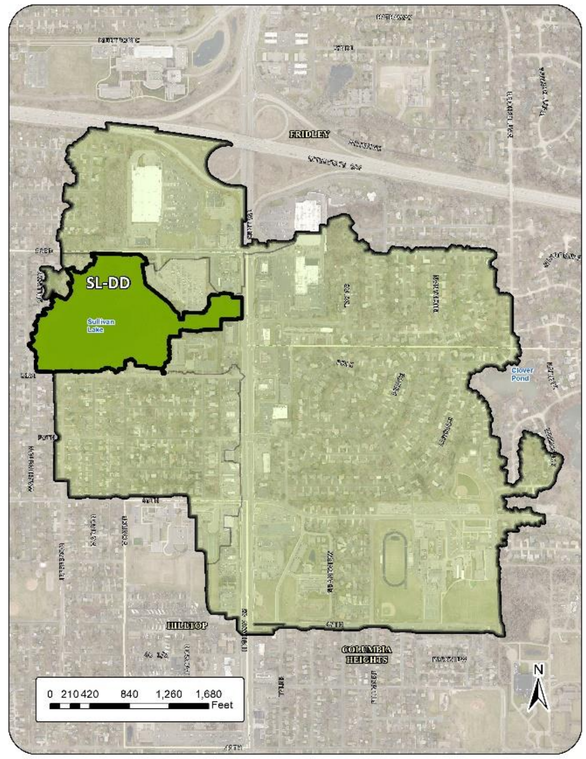
EXISTING STORMWATER TREATMENT

Stormwater runoff generated within this drainage network is conveyed to one of the six outfalls via storm sewer pipe. A wide variety of treatment exists throughout the Sullivan Lake drainage network and includes, wet ponds, infiltration ponds, underground infiltration, hydrodynamic devices, a swale, and street cleaning conducted by the City of Columbia Heights and the City of Fridley. Additional detail is provided in the Catchment Profiles.

NETWORK RETROFIT RECOMMENDATIONS – DETAILS IN CATCHMENT PROFILES

Catchment SL-DD

Existing Catchment Summary	
Acres	21.2
Parcels	57
Land Cover	76.1% Open Space 17.1% Residential 6.4% Commercial 0.4% Freeway



CATCHMENT DESCRIPTION

Direct drainage to Sullivan Lake consists of the nearshore areas of the lake as well as the backyards of residential properties adjacent to the lake. The catchment extends eastward to include some park area, open space, and a small portion of commercial property drainage along Highway 65.

EXISTING STORMWATER TREATMENT

The nearshore areas that drain to Sullivan Lake do not have any specific stormwater treatment. Present-day stormwater pollutant loading and treatment is summarized in the table below.

This catchment was not modeled individually but in conjunction with all of the contributing drainage area to the proposed regional pond. The proposed regional pond is the only practice existing or proposed in catchment SL-DD.

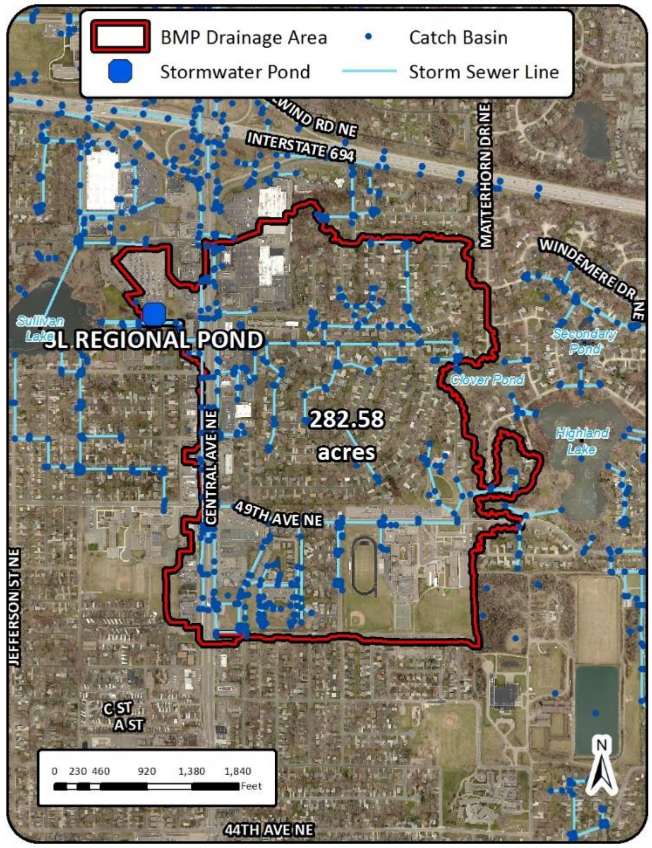
RETROFIT RECOMMENDATIONS OVERVIEW

One regional pond that provides treatment from multiple catchments is proposed.

RETROFIT RECOMMENDATIONS

Project ID: SL-Regional SP-1

Medtronic Property Stormwater Pond



Drainage Area – 282.6 acres
Location – South end of Medtronic property in line with the two 48" diameter storm sewer lines flowing east west into Sullivan Lake
Property Ownership – Private
Site Specific Information – Approximately 2.6 acres of open space exist on the south end of the Medtronic property. Two 48" storm sewer lines flow east west along the southern border of the property and provide drainage to all of catchment SL-3. In addition to providing treatment to runoff from catchment SL-3, the entire Medtronic campus is proposed to be routed into the pond. The pond was also modeled in conjunction with three different sizes of iron-enhanced sand filter. The tables below provides pollutant removals and estimated costs. Note the property is owned by Medtronic.

	New Wet Pond		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	2.09	acres
	TP (lb/yr)	93.2	37.8%
	TSS (lb/yr)	38,768	51.5%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***		$10,950
	Design & Construction Costs**		$1,538,696
	Total Estimated Project Cost (2019)		**$1,549,646**
	Annual O&M***		$2,092
Efficiency	**30-yr Average Cost/lb-TP**	**$577**	
	30-yr Average Cost/1,000lb-TSS	**$1,386**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

*Indirect Cost: (150 hours at $73/hour)

**Direct Cost: See Appendix B for detailed cost information

***$1,000/acre - Annual inspection and sediment/debris removal from pretreatment area

New Wet Pond + IESF (0.1 Acre)			
	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Total Size of BMPs	2.19	acres
	TP (lb/yr)	105.4	42.7%
	TSS (lb/yr)	41,860	55.6%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	Administration & Promotion Costs*	$18,250	
	Design & Construction Costs**	$1,904,770	
	Total Estimated Project Cost (2019)	**$1,923,020**	
	Annual O&M***	$3,191	
Efficiency	30-yr Average Cost/lb-TP	**$638**	
	30-yr Average Cost/1,000lb-TSS	**$1,608**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

*Indirect Cost: (250 hours at $73/hour)

**Direct Cost: See Appendix B for detailed cost information

***$1,000/acre Pond - Annual inspection and sediment/debris removal from pretreatment area

$10,000/acre IESF - Annual inspection, sediment and debris removal, bench tilling

New Wet Pond + IESF (0.2 Acre)			
	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Total Size of BMPs	2.29	acres
	TP (lb/yr)	117.6	47.6%
	TSS (lb/yr)	44,953	59.7%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	Administration & Promotion Costs*	$18,250	
	Design & Construction Costs**	$1,958,445	
	Total Estimated Project Cost (2019)	**$1,976,695**	
	Annual O&M***	$4,290	
Efficiency	30-yr Average Cost/lb-TP	**$597**	
	30-yr Average Cost/1,000lb-TSS	**$1,561**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

*Indirect Cost: (250 hours at $73/hour)

**Direct Cost: See Appendix B for detailed cost information

***$1,000/acre - Annual inspection and sediment/debris removal from pretreatment area

$10,000/acre IESF - Annual inspection, sediment and debris removal, bench tilling

New Wet Pond + IESF (0.3 Acre)			
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	2.39	acres
	TP (lb/yr)	129.8	52.6%
	TSS (lb/yr)	48,045	63.8%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***		$18,250
	Design & Construction Costs**		$2,013,769
	Total Estimated Project Cost (2019)		**$2,032,019**
	Annual O&M***		$5,389
Efficiency	**30-yr Average Cost/lb-TP**	**$563**	
	30-yr Average Cost/1,000lb-TSS	**$1,522**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

*Indirect Cost: (250 hours at $73/hour)

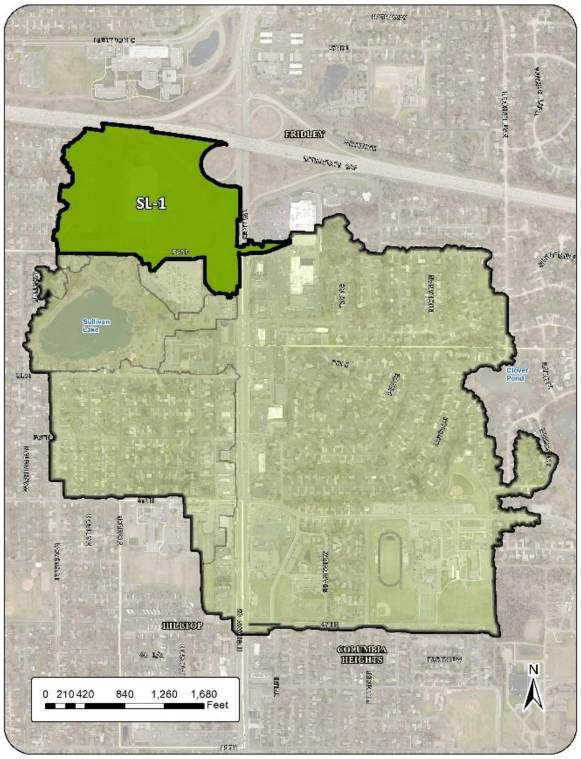
**Direct Cost: See Appendix B for detailed cost information

***$1,000/acre - Annual inspection and sediment/debris removal from pretreatment area

$10,000/acre IESF - Annual inspection, sediment and debris removal, bench tilling

Catchment SL-1

Existing Catchment Summary	
Acres	56.9
Parcels	71
Land Cover	48.9% Commercial 21.9% Open Space 20.4% Residential 7.4% Freeway 1.4% Institutional



CATCHMENT DESCRIPTION

This catchment consists of two subcatchments, SL-1-1 and SL-1-2. SL-1-1 is comprised of medium density residential land use in the west, the Target building and parking lot in the center, and the Pawn America and Ember's properties in the east. SL-1-2 includes small portions of the Menards parking lot as well as the intersection of Highway 65 and 53rd Ave. NE. Runoff from SL-1-2 is routed into a swale that runs along the southern side of the off-ramp from Interstate 694. The swale then outlets to storm sewer line that joins with the storm sewer line from SL-1-1 before entering the north side of Sullivan Lake.

EXISTING STORMWATER TREATMENT

A variety of existing stormwater treatment exists in Catchment SL-1. A swale that runs along the southern boundary of SL-1-2 provides treatment to runoff primarily generated from Highway 65 and associated businesses. A stormwater pond north of the exit ramp on Interstate 694 provides treatment for runoff from the highway. Another stormwater pond is located near the Pawn America parking lot. Two hydrodynamic separators are also within subcatchments SL-1-2, one in the Target parking lot, and one in the Petco parking lot. Finally, street cleaning is performed four times per year by the City of Fridley and the City of Columbia Heights. 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	7			
	BMP Types	Street Cleaning, Hydrodynamic Device (3), Wet Pond, Swale, Dry Feature			
	TP (lb/yr)	39.1	5.5	14%	**33.5**
	TSS (lb/yr)	15,772	3,045	19%	**12,727**
	Volume (acre-feet/yr)	50.8	1.5	3%	**49.3**

RETROFIT RECOMMENDATIONS OVERVIEW

One stormwater pond, three biofiltration basins, one bioinfiltration basin, and one hydrodynamic device are proposed. Details are provided in the project profile pages.

RETROFITS CONSIDERED BUT REJECTED

Check dams within the swale that runs along the southern boundary of SL-1-2 were considered. However, further investigation of the swale revealed dense vegetation and gradual grade change suggesting significant filtering within the swale currently exists.

RETROFIT RECOMMENDATIONS

Project ID: SL-1-1 SP-1

Target
Stormwater Pond

Drainage Area – 12.27 acres
Location – South end of Target parking lot north of 53rd Avenue NE
Property Ownership – Private
Site Specific Information – Approximately 1.35 acres of open space exists between the southern end of the Target parking lot and 53rd Avenue NE. The area is understood to be required green space for the site. Rerouting the primary, 36" diameter storm sewer line from the Target parking lot into a stormwater pond could provide the pollutant removals detailed below. Note that the property is owned by Target.

	New Wet Pond		
	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Total Size of BMPs	0.44	acres
	TP (lb/yr)	2.68	8.0%
	TSS (lb/yr)	1,477	11.6%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	Administration & Promotion Costs*	$7,300	
	Design & Construction Costs**	$261,630	
	Total Estimated Project Cost (2019)	**$268,930**	
	Annual O&M***	$440	
Efficiency	30-yr Average Cost/lb-TP	**$3,509**	
	30-yr Average Cost/1,000lb-TSS	**$6,367**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

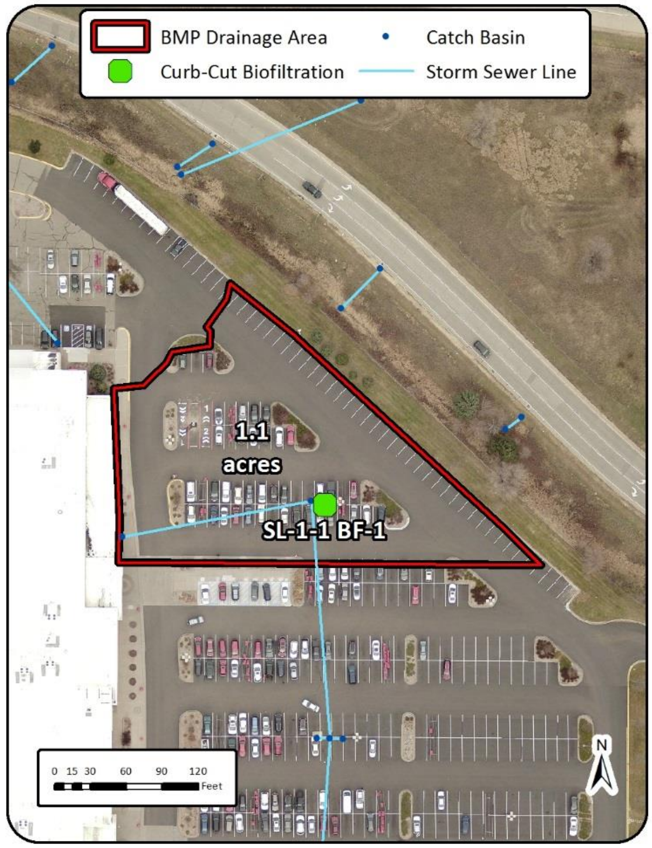
*Indirect Cost: (100 hours at $73/hour)

**Direct Cost: See Appendix B for detailed cost information

***$1,000/acre - Annual inspection and sediment/debris removal from pretreatment area

Project ID: SL-1-1 BF-1

Target
Biofiltration Basin



Drainage Area – 1.1 acres
Location – North end of Target parking lot near existing catch basins
Property Ownership – Private
Site Specific Information – The large parking lot of Target could be retrofit with bioretention to provide additional water quality treatment. Because of the silty soils in this catchment and the presumed compaction within the parking lot, biofiltration was proposed. More specifically, a high performance modular biofiltration system was proposed with a 100" per hour filtration rate. This system will limit the size of the footprint required for the bioretention system. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Parking Lot HPMBS		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	100	sq-ft
	TP (lb/yr)	0.5	1.3%
	TSS (lb/yr)	249	2.0%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$32,920
	Total Estimated Project Cost (2019)		**$33,504**
	Annual O&M***		$742
Efficiency	**30-yr Average Cost/lb-TP**	**$4,130**	
	30-yr Average Cost/1,000lb-TSS	**$7,464**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($200/sq-ft materials and labor) + (40 hours at $73/hour design) + ($10k concrete/fencing)

***Per BMP: ($200/sq-ft at year 15 for media replacement) + ($75/year for routine maintenance)

Project ID: SL-1-1 BF-2

Target
Biofiltration Basin

Drainage Area – 1.6 acres
Location – Center of Target parking lot near existing catch basins
Property Ownership – Private
Site Specific Information – The large parking lot of Target could be retrofit with bioretention to provide additional water quality treatment. Because of the silty soils in this catchment and the presumed compaction within the parking lot, biofiltration was proposed. More specifically, a high performance modular biofiltration system was proposed with a 100" per hour filtration rate. This system will limit the size of the footprint required for the bioretention system. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

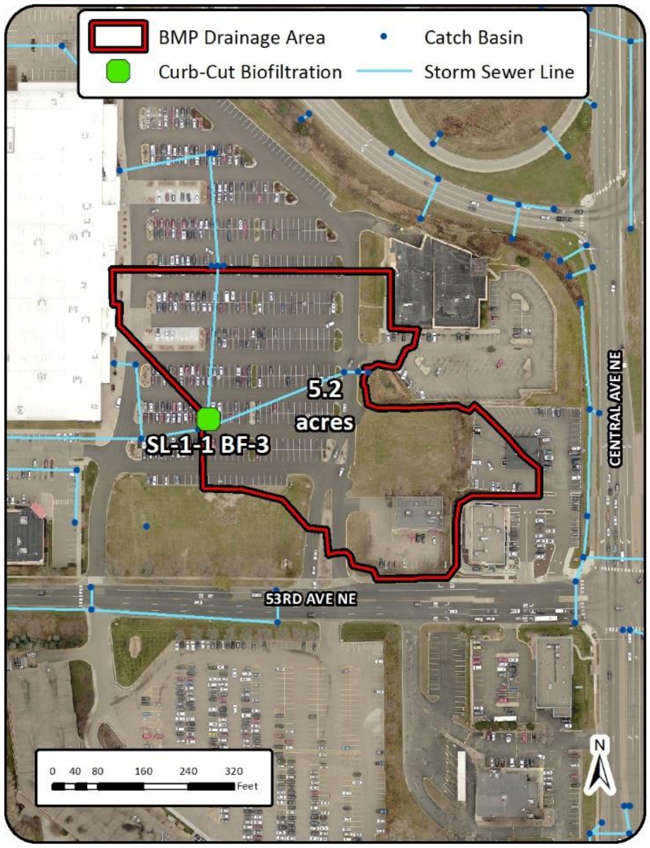
	Parking Lot HPMBS		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	100	sq-ft
	TP (lb/yr)	0.6	1.9%
	TSS (lb/yr)	349	2.7%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$32,920
	Total Estimated Project Cost (2019)		**$33,504**
	Annual O&M***		$742
Efficiency	**30-yr Average Cost/lb-TP**	**$2,950**	
	30-yr Average Cost/1,000lb-TSS	**$5,325**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($200/sq-ft materials and labor) + (40 hours at $73/hour design) + ($10k concrete/fencing)

***Per BMP: ($200/sq-ft at year 15 for media replacement) + ($75/year for routine maintenance)

Project ID:
SL-1-1 BF-3
Target
Biofiltration Basin



Drainage Area – 5.2 acres
Location – South end of Target parking lot near existing catch basins
Property Ownership – Private
Site Specific Information – The large parking lot of Target could be retrofit with bioretention to provide additional water quality treatment. Because of the silty soils in this catchment and the presumed compaction within the parking lot, biofiltration was proposed. More specifically, a high performance modular biofiltration system was proposed with a 100" per hour filtration rate. This system will limit the size of the footprint required for the bioretention system. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Parking Lot HPMBS		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	100	sq-ft
	TP (lb/yr)	1.2	3.6%
	TSS (lb/yr)	667	5.2%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$32,920
	Total Estimated Project Cost (2019)		**$33,504**
	Annual O&M***		$742
Efficiency	**30-yr Average Cost/lb-TP**	**$1,536**	
	30-yr Average Cost/1,000lb-TSS	**$2,786**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($200/sq-ft materials and labor) + (40 hours at $73/hour design) + ($10k concrete/fencing)

***Per BMP: ($200/sq-ft at year 15 for media replacement) + ($75/year for routine maintenance)

Project ID: SL-1-1 BI-1

Madison Street NE Bioinfiltration Basin

Drainage Area – 1.6 acres
Location – Southwest corner of intersection between Cheri Lane NE and Madison Street NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration is preferred. However, optimal sites are not necessarily adjacent to an existing catch basin to serve as the connection point for an underdrain outlet. This basin is proposed to rely on infiltration, and the infiltration rate and ponding depth were adjusted accordingly to reflect the native soil infiltration rates and ensure drawdown in less than 48 hours. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.4	1.3%
	TSS (lb/yr)	129	1.0%
	Volume (acre-feet/yr)	0.32	0.7%
Cost	**Administration & Promotion Costs***	$584	
	Design & Construction Costs**	$9,420	
	Total Estimated Project Cost (2019)	**$10,004**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,330**	
	30-yr Average Cost/1,000lb-TSS	**$4,329**	
	30-yr Average Cost/ac-ft Vol.	**$1,738**	

*Indirect Cost: (8 hours at $73/hour base cost)

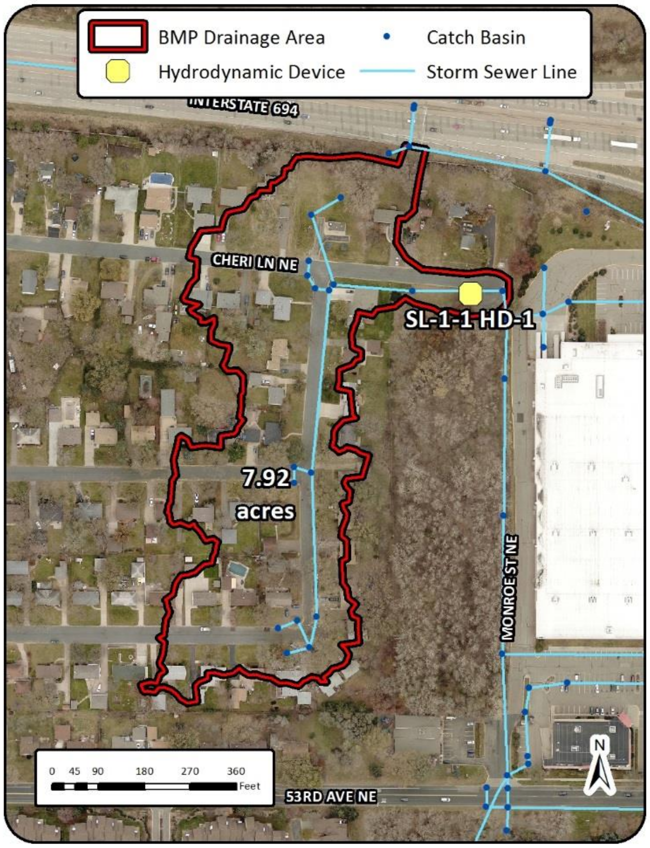
**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $73/hour for design)

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

Project ID: SL-1-1 HD-1

Cheri Lane NE
Hydrodynamic Device

Drainage Area – 7.9 acres
Location – East end of Cheri Lane NE within cul-de-sac
Property Ownership – Public
Site Specific Information – A hydrodynamic device is proposed in line with the storm sewer line on Cheri Lane NE before it turns south and flows along Monroe Street NE and discharges into Sullivan Lake. The table below provides pollutant removals and estimated costs.



	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	10	ft diameter
	TP (lb/yr)	0.5	1.5%
	TSS (lb/yr)	209	1.6%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***		$3,750
	Design & Construction Costs**		$108,000
	Total Estimated Project Cost (2019)		**$111,750**
	Annual O&M***		$630
Efficiency	**30-yr Average Cost/lb-TP**	**$8,888**	
	30-yr Average Cost/1,000lb-TSS	**$20,837**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

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

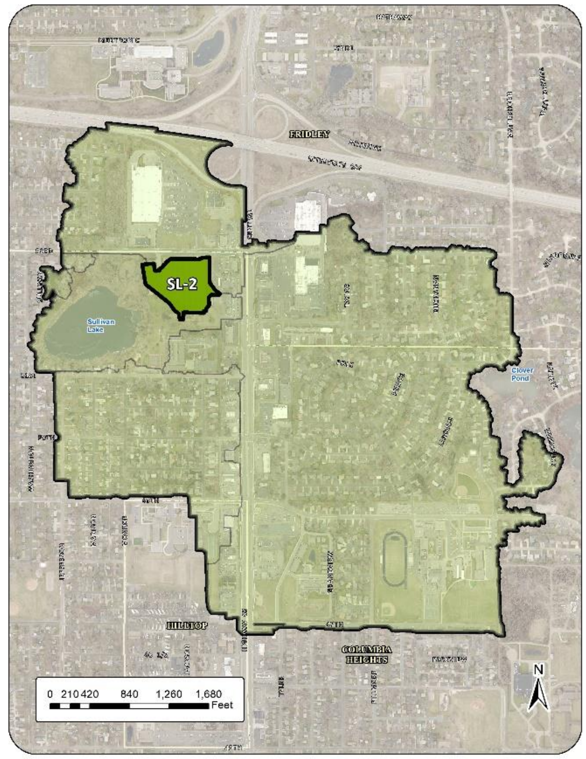
**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)

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

RETROFIT RECOMMENDATIONS

Catchment SL-2

Existing Catchment Summary	
Acres	7.5
Parcels	3
Land Cover	97.7% Commercial 2.3% Open Space



CATCHMENT DESCRIPTION

SL-2 consists entirely of the Medtronic campus (building and parking lot). Runoff is routed to the east side of Sullivan Lake via the storm sewer lines.

EXISTING STORMWATER TREATMENT

One stormwater pond exists on the Medtronic property. Runoff from a 2015 parking lot expansion on the south end of the property is routed to the pond. Runoff from the majority of the campus is piped to Sullivan Lake without treatment. 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			
	TP (lb/yr)	39.1	5.5	14%	**33.5**
	TSS (lb/yr)	15,772	3,045	19%	**12,727**
	Volume (acre-feet/yr)	50.8	1.5	3%	**49.3**

RETROFIT RECOMMENDATIONS OVERVIEW

Two biofiltration basins and one hydrodynamic device were proposed in catchment SL-2. Details are provided in the following project profile pages.

RETROFIT RECOMMENDATIONS

Project ID: SL-2-1 BF-1

Medtronic Parking Lot Biofiltration Basin

Drainage Area – 2.4 acres
Location – Southeast end of Medtronic parking lot
Property Ownership – Private
Site Specific Information – The large parking lot of Medtronic could be retrofit with bioretention to provide additional water quality treatment. Because of the silty soils in this catchment and the presumed compaction within the parking lot, biofiltration was proposed. More specifically, a high performance modular biofiltration system was proposed with a 100" per hour filtration rate. This system will limit the size of the footprint required for the bioretention system. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

Parking Lot HPMBS

	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	100	sq-ft
	TP (lb/yr)	1.1	3.4%
	TSS (lb/yr)	599	4.7%
	Volume (acre-feet/yr)	0.02	0.0%
Cost	**Administration & Promotion Costs***	$584	
	Design & Construction Costs**	$32,920	
	Total Estimated Project Cost (2019)	**$33,504**	
	Annual O&M***	$742	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,648**	
	30-yr Average Cost/1,000lb-TSS	**$3,103**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($200/sq-ft materials and labor) + (40 hours at $73/hour design) + ($10k concrete/fencing)

***Per BMP: ($200/sq-ft at year 15 for media replacement) + ($75/year for routine maintenance)

Project ID: SL-2-1 BF-2

Medtronic Parking Lot
Biofiltration Basin

Drainage Area – 1.5 acres
Location – Southwest end of Medtronic parking lot
Property Ownership – Private
Site Specific Information – The large parking lot of Medtronic could be retrofit with bioretention to provide additional water quality treatment. Because of the silty soils in this catchment and the presumed compaction within the parking lot, biofiltration was proposed. More specifically, a high performance modular biofiltration system was proposed with a 100" per hour filtration rate. This system will limit the size of the footprint required for the bioretention system. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Parking Lot HPMBS		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	100	sq-ft
	TP (lb/yr)	0.8	2.4%
	TSS (lb/yr)	418	3.3%
	Volume (acre-feet/yr)	0.01	0.0%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$32,920
	Total Estimated Project Cost (2019)		**$33,504**
	Annual O&M***		$742
Efficiency	**30-yr Average Cost/lb-TP**	**$2,347**	
	30-yr Average Cost/1,000lb-TSS	**$4,446**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($200/sq-ft materials and labor) + (40 hours at $73/hour design) + ($10k concrete/fencing)

***Per BMP: ($200/sq-ft at year 15 for media replacement) + ($75/year for routine maintenance)

Project ID: SL-2-1 HD-1

Medtronic Parking Lot Hydrodynamic Device

Drainage Area – 4.9 acres
Location – Southwest side of parking lot
Property Ownership – Public
Site Specific Information – A hydrodynamic device is proposed in line with the storm sewer line that exits the Medtronic parking lot on the southwest side. The pipe currently discharges directly to Sullivan Lake. A hydrodynamic device at this location would provide water quality treatment to runoff from the entire Medtronic parking lot not currently receiving any treatment. 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)	0.5	1.5%
	TSS (lb/yr)	268	2.1%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***	$3,750	
	Design & Construction Costs**	$54,000	
	Total Estimated Project Cost (2019)	**$57,750**	
	Annual O&M***	$630	
Efficiency	**30-yr Average Cost/lb-TP**	**$5,090**	
	30-yr Average Cost/1,000lb-TSS	**$9,534**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

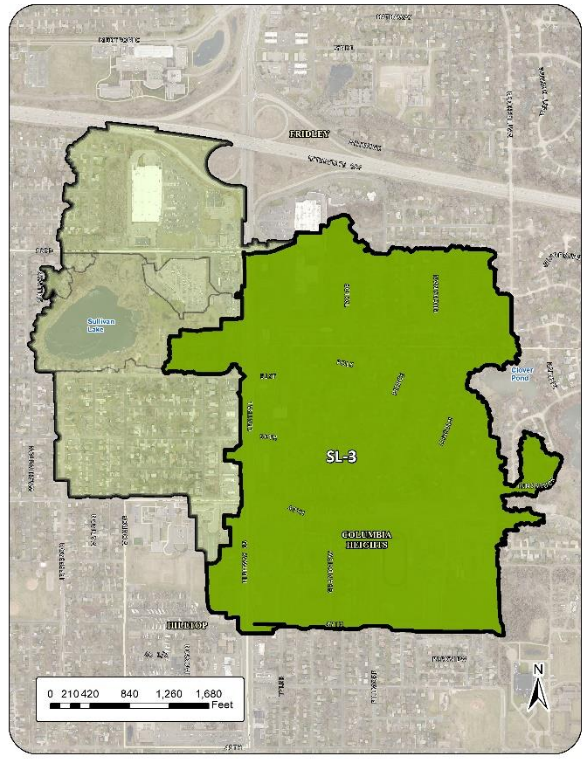
*Indirect Cost: (25 hours at $150/hour)

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

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

Catchment SL-3

Existing Catchment Summary	
Acres	279.5
Parcels	962
Land Cover	58.5% Residential 16.2% Institutional 15.6% Commercial 5.3% Freeway 4.4% Open Space



CATCHMENT DESCRIPTION

This is the largest catchment in the analysis and consists of approximately 280 acres. The catchment was divided into 17 subcatchments based on stormwater infrastructure connectivity. Catchment SL-3 includes the Menards campus on the north end, extends to Highland lake on the east end, Columbia Heights High School on the south end, and Highway 65 on the west end. The primary storm sewer line flows from east to west through backyard areas between 51st Avenue NE and 52nd Avenue NE, which is the primary outlet for Clover Pond. The other main storm sewer line that runs from south to north along Highway 65 intersects the east-west line just north of 51st Avenue NE. The lines then discharge into Sullivan Lake on the east end.

EXISTING STORMWATER TREATMENT

Catchment SL-3 has a variety of existing stormwater treatment. Infiltration basins, wet ponds, underground infiltration, and hydrodynamic separators are all present. Five infiltration basins throughout the catchment provide stormwater treatment in Ramsdell Park (2), residential backyards west of Matterhorn Drive NE (1), LivINN Hotel Minneapolis North/Fridley (1), and St. Timothy's Lutheran Church (1). One wet pond is present on the Grand Central Lofts property. Five underground infiltration areas throughout the catchment provide stormwater treatment for the Columbia Heights High School campus (1), Grand Central Lofts property (2), and Planet Fitness (2). Three hydrodynamic separators provide water quality treatment within Catchment SL-3 at Grand Central Lofts (1) and Applebee's (2). Finally, street cleaning is performed four times per year by the City of Fridley and the City of Columbia Heights. 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**	15			
	BMP Types	Street Cleaning, Hydrodynamic Device (3), Dry Feature (3), Infiltration Pond (2), Wet Pond (1), Underground Infiltration (5)			
	TP (lb/yr)	221.0	21.8	10%	**199.2**
	TSS (lb/yr)	67,495	9,632	14%	**57,863**
	Volume (acre-feet/yr)	169.3	0.1	0%	**169.3**

RETROFIT RECOMMENDATIONS OVERVIEW

A total of 47 retrofits were proposed in catchment SL-3, including a stormwater pond, biofiltration basins, bioinfiltration basins, and hydrodynamic devices. Details are included in the following project profile pages.

RETROFITS CONSIDERED BUT REJECTED

A retrofit to an existing pond in subcatchments SL-3-2 on the LivINN Hotel was considered. However, space is extremely limited between the parking lot and 52nd Avenue NE.

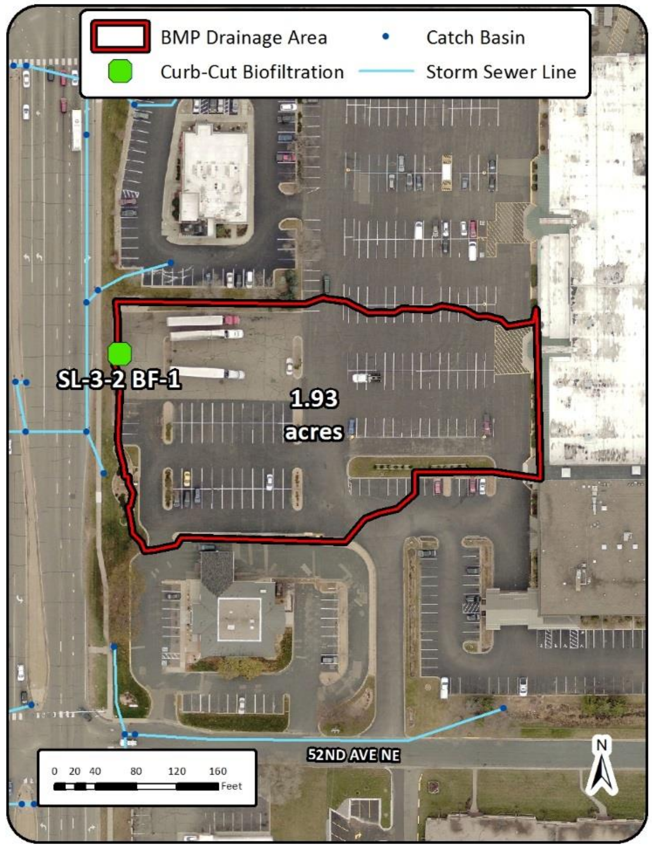
A new stormwater pond was considered in subcatchments SL-3-4-5 in the northwest corner of the Columbia Heights High School campus. However, the contributing drainage area was primarily landscaped areas of the campus, and the impervious areas that did drain to the potential pond location flow over turfed area prior to reaching the storm sewer inlet. The main sewer line that runs east west along 49th Avenue NE, just north of the potential pond location, drains more acreage than could be treated in the space available.

RETROFIT RECOMMENDATIONS

RETROFIT RECOMMENDATIONS

Project ID: SL-3-2 BF-1

Menards
Biofiltration Basin



Drainage Area – 1.9 acres
Location – Northwest corner of LivINN Hotel parking lot
Property Ownership – Private
Site Specific Information – The large parking lot of the LivINN Hotel could be retrofit with bioretention to provide additional water quality treatment. Because of the silty soils in this catchment and the presumed compaction within the parking lot, biofiltration was proposed. More specifically, a high performance modular biofiltration system was proposed with a 100" per hour filtration rate. This system will limit the size of the footprint required for the bioretention system. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Parking Lot HPMBS		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	100	sq-ft
	TP (lb/yr)	1.0	0.5%
	TSS (lb/yr)	527	0.9%
	Volume (acre-feet/yr)	0.02	0.0%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$32,920
	Total Estimated Project Cost (2019)		**$33,504**
	Annual O&M***		$742
Efficiency	**30-yr Average Cost/lb-TP**	**$1,956**	
	30-yr Average Cost/1,000lb-TSS	**$3,527**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($200/sq-ft materials and labor) + (40 hours at $73/hour design) + ($10k concrete/fencing)

***Per BMP: ($200/sq-ft at year 15 for media replacement) + ($75/year for routine maintenance)

RETROFIT RECOMMENDATIONS

Project ID: SL-3-3-1 BF-1

Polk Place NE
Biofiltration Basin

Drainage Area – 0.8 acres
Location – North corner of intersection between Polk Place NE and Polk Circle NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	0.1%
	TSS (lb/yr)	49	0.1%
	Volume (acre-feet/yr)	0.02	0.0%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$4,412**	
	30-yr Average Cost/1,000lb-TSS	**$13,506**	
	30-yr Average Cost/ac-ft Vol.	**$28,774**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-3-3-1 BF-2

Polk Place NE
Biofiltration Basin

Drainage Area – 1.0 acres
Location – West side of Polk Place NE north of intersection with Pierce Terrace NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	0.1%
	TSS (lb/yr)	53	0.1%
	Volume (acre-feet/yr)	0.05	0.0%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$4,136**	
	30-yr Average Cost/1,000lb-TSS	**$12,487**	
	30-yr Average Cost/ac-ft Vol.	**$14,387**	

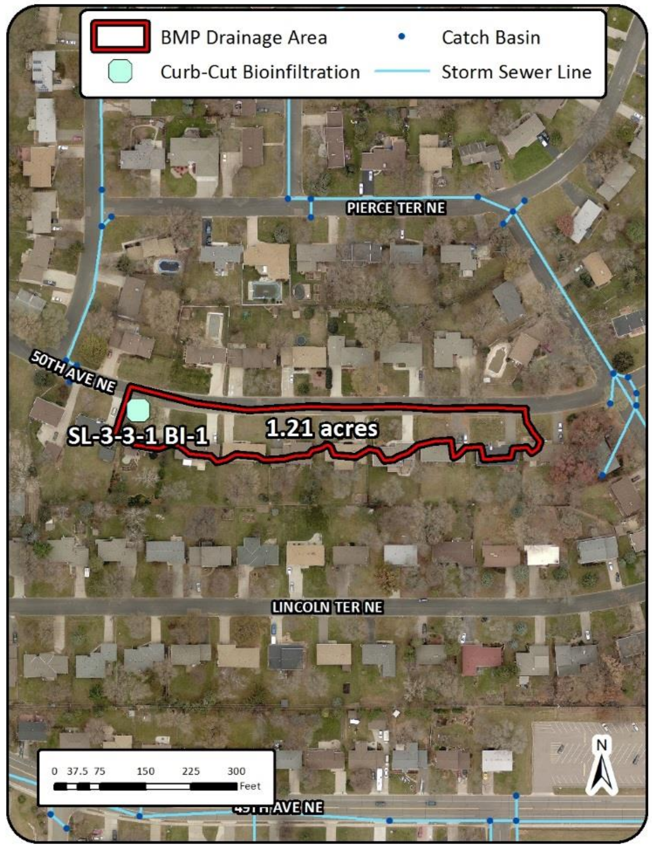
*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-3-3-1 BI-1

50th Avenue NE
Bioinfiltration Basin



Drainage Area – 1.2 acres
Location – South side of 50th Avenue NE east of intersection with Polk Place NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration is preferred. However, optimal sites are not necessarily adjacent to an existing catch basin to serve as the connection point for an underdrain outlet. This basin is proposed to rely on infiltration, and the infiltration rate and ponding depth were adjusted accordingly to reflect the native soil infiltration rates and ensure drawdown in less than 48 hours. The table below provides pollutant removals and estimated costs.

Curb-Cut Bioinfiltration

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Total Size of BMPs	250	sq-ft
	TP (lb/yr)	0.2	0.1%
	TSS (lb/yr)	54	0.1%
	Volume (acre-feet/yr)	0.14	0.1%
Cost	Administration & Promotion Costs*		$584
	Design & Construction Costs**		$9,420
	Total Estimated Project Cost (2019)		**$10,004**
	Annual O&M***		$225
Efficiency	30-yr Average Cost/lb-TP	**$2,939**	
	30-yr Average Cost/1,000lb-TSS	**$10,342**	
	30-yr Average Cost/ac-ft Vol.	**$4,047**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $73/hour for design)

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

Project ID: SL-3-3-1 HD-1

Polk Circle NE
Hydrodynamic Device

Drainage Area – 13.7 acres
Location – Northwest extent of Polk Circle NE within cul-de-sac
Property Ownership – Public
Site Specific Information – A hydrodynamic device is proposed in line with the storm sewer line on Polk Circle NE. It could be placed within the cul-de-sac. The table below provides pollutant removals and estimated costs.

	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	10	ft diameter
	TP (lb/yr)	0.9	0.5%
	TSS (lb/yr)	327	0.6%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***		$3,750
	Design & Construction Costs**		$108,000
	Total Estimated Project Cost (2019)		**$111,750**
	Annual O&M***		$630
Efficiency	**30-yr Average Cost/lb-TP**	**$4,683**	
	30-yr Average Cost/1,000lb-TSS	**$13,318**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

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

**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)

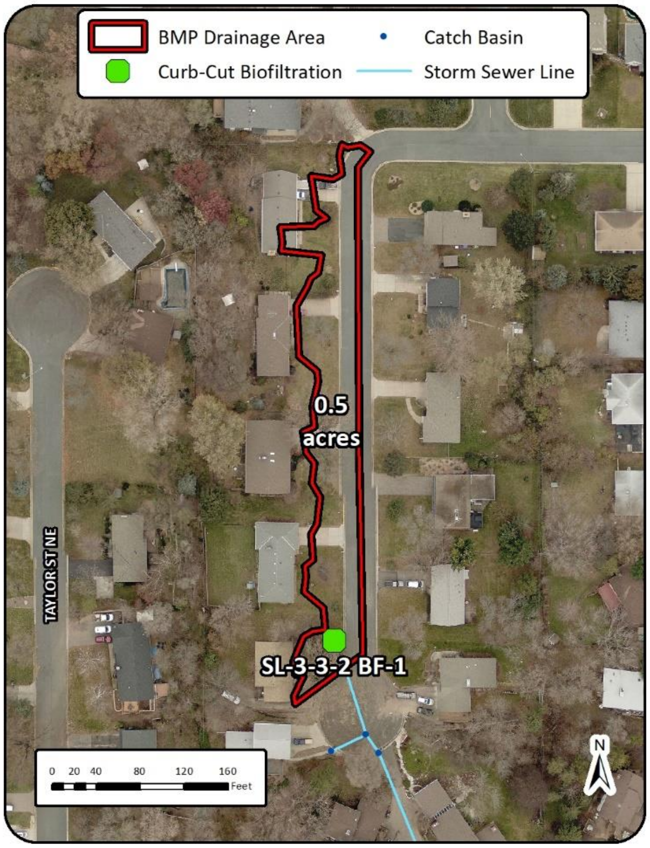
***Per BMP: (3 cleanings/year)*(3 hours/cleaning)*($70/hour)

RETROFIT RECOMMENDATIONS

Project ID: SL-3-3-2 BF-1

Fillmore Street NE
Biofiltration Basin

Drainage Area – 0.5 acres
Location – West side of Fillmore Street NE at north end of cul-de-sac
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.



	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.1	0.1%
	TSS (lb/yr)	38	0.1%
	Volume (acre-feet/yr)	0.02	0.0%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$5,515**	
	30-yr Average Cost/1,000lb-TSS	**$17,416**	
	30-yr Average Cost/ac-ft Vol.	**$28,774**	

*Indirect Cost: (8 hours at $73/hour base cost)

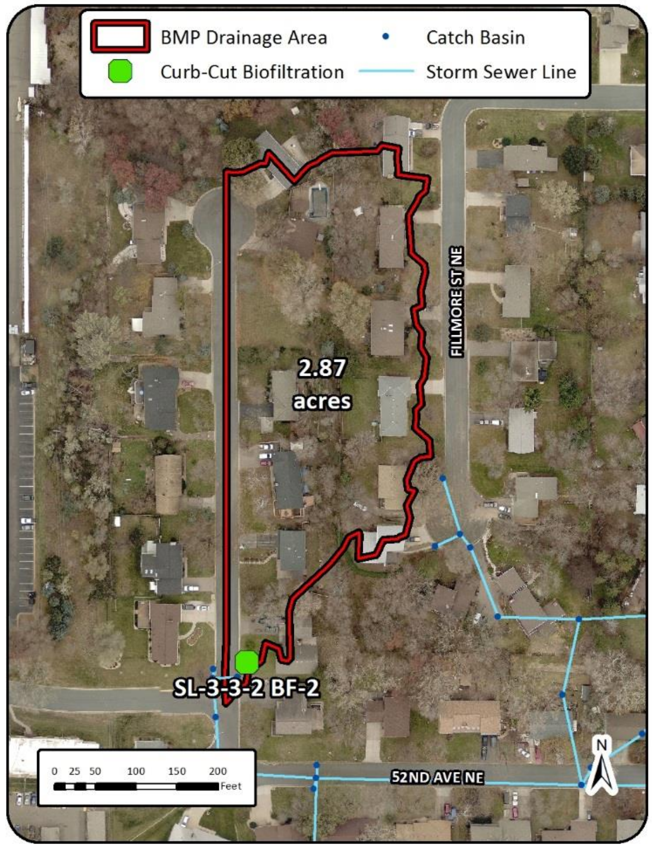
**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-3-3-2 BF-2

Taylor Street NE Biofiltration Basin

Drainage Area – 2.9 acres
Location – East side of Taylor Street NE just north of intersection with 52nd Avenue NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.



	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	0.1%
	TSS (lb/yr)	74	0.1%
	Volume (acre-feet/yr)	0.05	0.0%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$3,008**	
	30-yr Average Cost/1,000lb-TSS	**$8,943**	
	30-yr Average Cost/ac-ft Vol.	**$14,387**	

*Indirect Cost: (8 hours at $73/hour base cost)

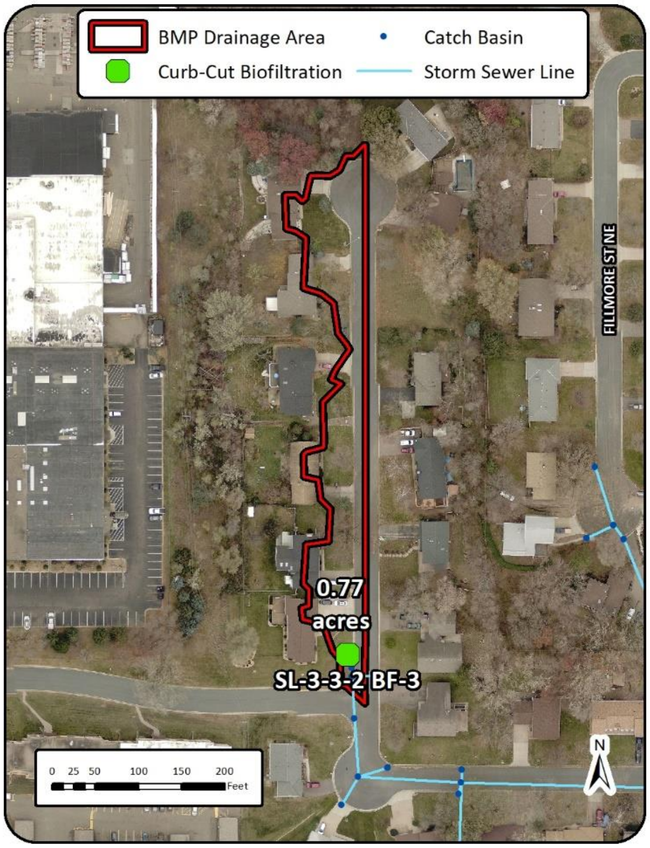
**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-3-3-2 BF-3

Taylor Street NE
Biofiltration Basin

Drainage Area – 0.8 acres
Location – West side of Taylor Street NE just north of intersection with 52nd Avenue NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.



Curb-Cut Biofiltration

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Total Size of BMPs	250	sq-ft
	TP (lb/yr)	0.1	0.1%
	TSS (lb/yr)	48	0.1%
	Volume (acre-feet/yr)	0.02	0.0%
Cost	Administration & Promotion Costs*	$584	
	Design & Construction Costs**	$10,420	
	Total Estimated Project Cost (2019)	**$11,004**	
	Annual O&M***	$295	
Efficiency	30-yr Average Cost/lb-TP	**$4,727**	
	30-yr Average Cost/1,000lb-TSS	**$13,788**	
	30-yr Average Cost/ac-ft Vol.	**$28,774**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-3-3-2 BI-1

Fillmore Street NE Bioinfiltration Basin

Drainage Area – 2.0 acres
Location – East side of Fillmore Street NE just north of the cul-de-sac
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration is preferred. However, optimal sites are not necessarily adjacent to an existing catch basin to serve as the connection point for an underdrain outlet. This basin is proposed to rely on infiltration, and the infiltration rate and ponding depth were adjusted accordingly to reflect the native soil infiltration rates and ensure drawdown in less than 48 hours.

The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	0.1%
	TSS (lb/yr)	56	0.1%
	Volume (acre-feet/yr)	0.14	0.1%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$9,420
	Total Estimated Project Cost (2019)		**$10,004**
	Annual O&M***		$225
Efficiency	**30-yr Average Cost/lb-TP**	**$2,792**	
	30-yr Average Cost/1,000lb-TSS	**$9,973**	
	30-yr Average Cost/ac-ft Vol.	**$4,047**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $73/hour for design)

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

RETROFIT RECOMMENDATIONS

Project ID: SL-3-3-3 BF-1

53rd Avenue NE
Biofiltration Basin

Drainage Area – 1.3 acres
Location – Southwest corner of intersection between 53rd Avenue NE and Buchanan Street NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

Curb-Cut Biofiltration

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Total Size of BMPs	250	sq-ft
	TP (lb/yr)	0.2	0.1%
	TSS (lb/yr)	59	0.1%
	Volume (acre-feet/yr)	0.05	0.0%
Cost	Administration & Promotion Costs*	$584	
	Design & Construction Costs**	$10,420	
	Total Estimated Project Cost (2019)	**$11,004**	
	Annual O&M***	$295	
Efficiency	**30-yr Average Cost/lb-TP**	**$3,677**	
	30-yr Average Cost/1,000lb-TSS	**$11,217**	
	30-yr Average Cost/ac-ft Vol.	**$14,387**	

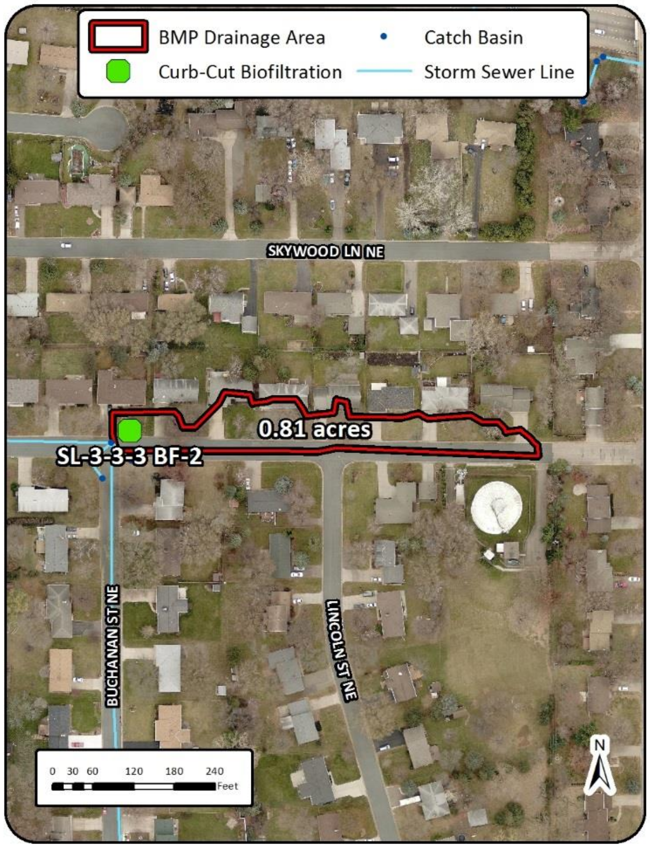
*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-3-3-3 BF-2

53rd Avenue NE
Biofiltration Basin



Drainage Area – 0.8 acres
Location – Northeast corner of intersection between 53rd Avenue NE and Buchanan Street NE ***Property Ownership*** – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

Curb-Cut Biofiltration

	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	0.1%
	TSS (lb/yr)	49	0.1%
	Volume (acre-feet/yr)	0.02	0.0%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$4,412**	
	30-yr Average Cost/1,000lb-TSS	**$13,506**	
	30-yr Average Cost/ac-ft Vol.	**$28,774**	

*Indirect Cost: (8 hours at $73/hour base cost)

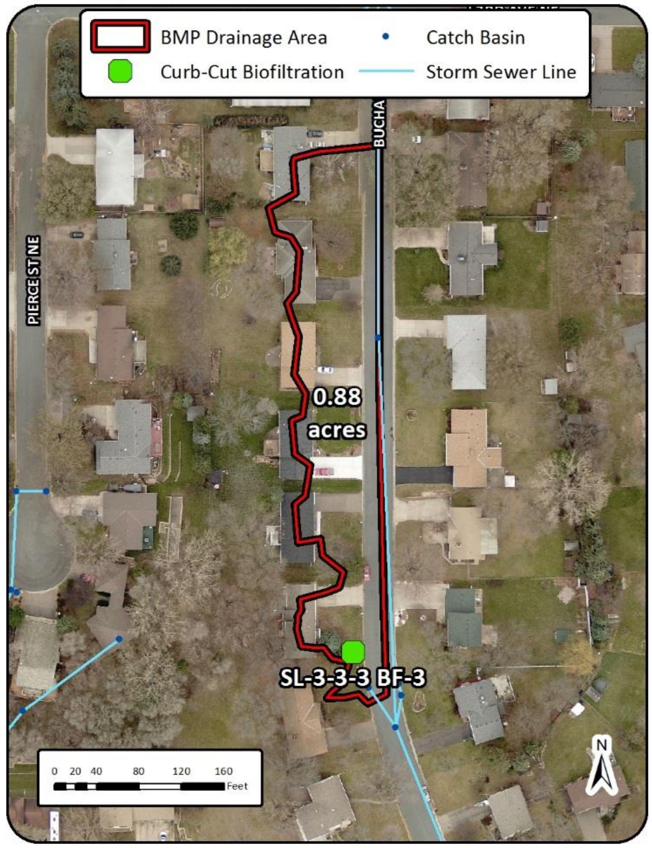
**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-3-3-3 BF-3

Buchanan Street NE
Biofiltration Basin

Drainage Area – 0.9 acres
Location – West side of Buchanan Street NE north of intersection with 52nd Avenue NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.



	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	0.1%
	TSS (lb/yr)	51	0.1%
	Volume (acre-feet/yr)	0.05	0.0%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$4,136**	
	30-yr Average Cost/1,000lb-TSS	**$12,976**	
	30-yr Average Cost/ac-ft Vol.	**$14,387**	

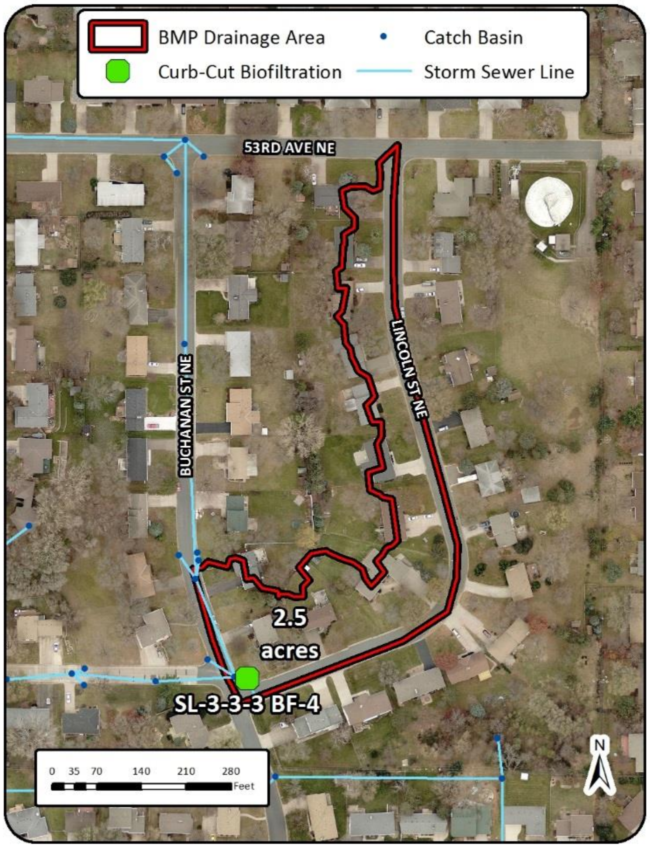
*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-3-3-3 BF-4

Buchanan Street NE Biofiltration Basin



Drainage Area – 2.5 acres
Location – Northeast corner of intersection between Lincoln Street NE and Buchanan Street NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	0.1%
	TSS (lb/yr)	74	0.1%
	Volume (acre-feet/yr)	0.05	0.0%
Cost	**Administration & Promotion Costs***	$584	
	Design & Construction Costs**	$10,420	
	Total Estimated Project Cost (2019)	**$11,004**	
	Annual O&M***	$295	
Efficiency	**30-yr Average Cost/lb-TP**	**$3,008**	
	30-yr Average Cost/1,000lb-TSS	**$8,943**	
	30-yr Average Cost/ac-ft Vol.	**$14,387**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-3-3-3 BI-1

Lincoln Street NE Bioinfiltration Basin

Drainage Area – 4.7 acres
Location – South side of Lincoln Street NE east of intersection with Buchanan Street NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration is preferred. However, optimal sites are not necessarily adjacent to an existing catch basin to serve as the connection point for an underdrain outlet. This basin is proposed to rely on infiltration, and the infiltration rate and ponding depth were adjusted accordingly to reflect the native soil infiltration rates and ensure drawdown in less than 48 hours. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	0.1%
	TSS (lb/yr)	59	0.1%
	Volume (acre-feet/yr)	0.14	0.1%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$9,420
	Total Estimated Project Cost (2019)		**$10,004**
	Annual O&M***		$225
Efficiency	**30-yr Average Cost/lb-TP**	**$2,792**	
	30-yr Average Cost/1,000lb-TSS	**$9,466**	
	30-yr Average Cost/ac-ft Vol.	**$4,047**	

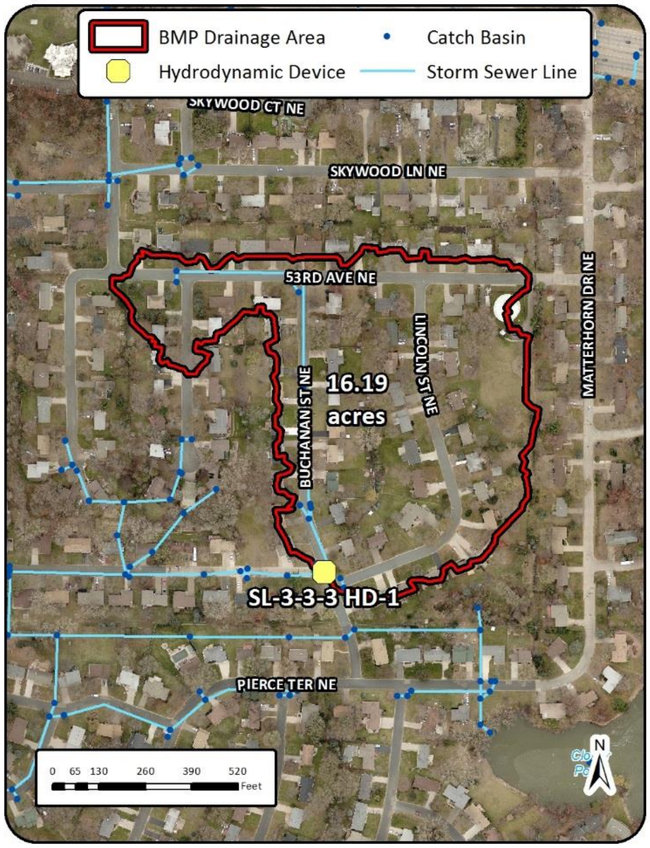
*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $73/hour for design)

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

Project ID: SL-3-3-3 HD-1

52nd Avenue NE
Hydrodynamic Device



Drainage Area – 16.2 acres
Location – Intersection of 52nd Avenue NE, Buchanan Street NE, and Lincoln Street NE
Property Ownership – Public
Site Specific Information – A hydrodynamic device is proposed in line with the 24" storm sewer line on 52nd Avenue NE. Placement at this location limits the contributing drainage area to a size that could be treated by a single hydrodynamic device. The table below provides pollutant removals and estimated costs.

Hydrodynamic Device

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Total Size of BMPs	10	ft diameter
	TP (lb/yr)	1.0	0.5%
	TSS (lb/yr)	366	0.6%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	Administration & Promotion Costs*	$3,750	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2019)	**$111,750**	
	Annual O&M***	$630	
Efficiency	30-yr Average Cost/lb-TP	**$4,228**	
	30-yr Average Cost/1,000lb-TSS	**$11,899**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

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

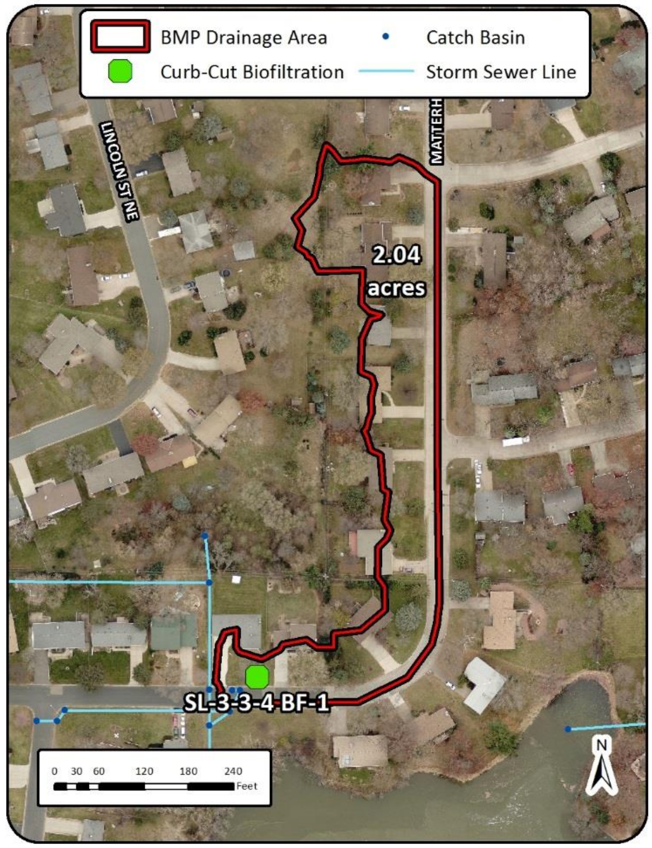
**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)

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

RETROFIT RECOMMENDATIONS

Project ID: SL-3-3-4 BF-1

Pierce Terrace NE
Biofiltration Basin



Drainage Area – 2.0 acres
Location – North side of Pierce Terrace NE west of Matterhorn Drive NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

Curb-Cut Biofiltration

	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	0.1%
	TSS (lb/yr)	70	0.1%
	Volume (acre-feet/yr)	0.05	0.0%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$3,151**	
	30-yr Average Cost/1,000lb-TSS	**$9,454**	
	30-yr Average Cost/ac-ft Vol.	**$14,387**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-3-3-4 BF-2

Pierce Terrace NE Biofiltration Basin

Drainage Area – 0.7 acres
Location – South side of Pierce Terrace NE west of Matterhorn Drive NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

Curb-Cut Biofiltration

	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.1	0.1%
	TSS (lb/yr)	45	0.1%
	Volume (acre-feet/yr)	0.02	0.0%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$4,727**	
	30-yr Average Cost/1,000lb-TSS	**$14,707**	
	30-yr Average Cost/ac-ft Vol.	**$28,774**	

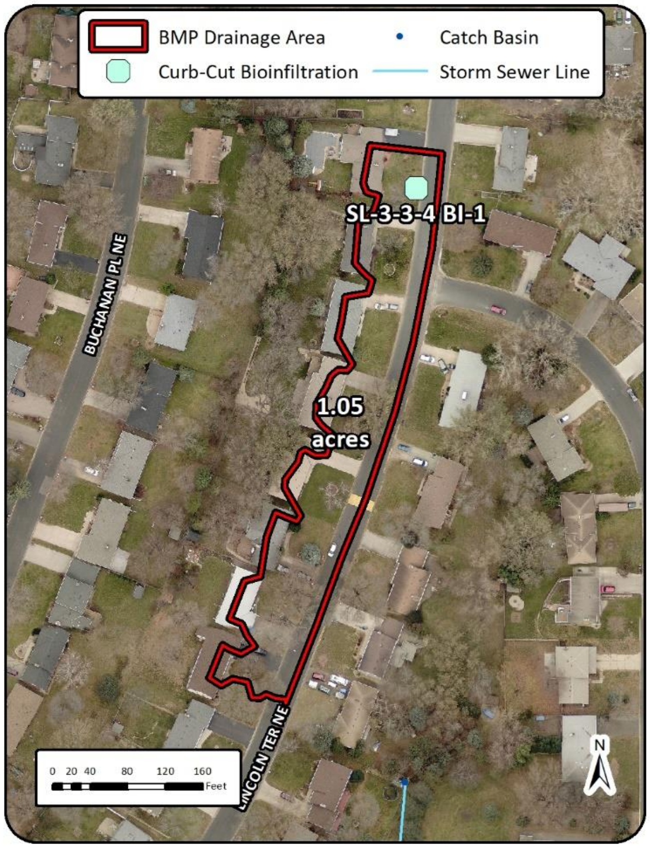
*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-3-3-4 BI-1

Lincoln Terrace NE Bioinfiltration Basin



Drainage Area – 1.1 acres
Location – West side of Lincoln Terrace NE south of intersection with Pierce Terrace NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration is preferred. However, optimal sites are not necessarily adjacent to an existing catch basin to serve as the connection point for an underdrain outlet. This basin is proposed to rely on infiltration, and the infiltration rate and ponding depth were adjusted accordingly to reflect the native soil infiltration rates and ensure drawdown in less than 48 hours. The table below provides pollutant removals and estimated costs.

Curb-Cut Bioinfiltration

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Total Size of BMPs	250	sq-ft
	TP (lb/yr)	0.2	0.1%
	TSS (lb/yr)	52	0.1%
	Volume (acre-feet/yr)	0.12	0.1%
Cost	Administration & Promotion Costs*		$584
	Design & Construction Costs**		$9,420
	Total Estimated Project Cost (2019)		**$10,004**
	Annual O&M***		$225
Efficiency	30-yr Average Cost/lb-TP	**$3,103**	
	30-yr Average Cost/1,000lb-TSS	**$10,740**	
	30-yr Average Cost/ac-ft Vol.	**$4,856**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $73/hour for design)

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

Project ID: SL-3-3-4 BI-2

Johnson Street NE
Bioinfiltration Basin

Drainage Area – 1.8 acres
Location – North side of Johnson Street NE east of intersection with Lincoln Terrace NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration is preferred. However, optimal sites are not necessarily adjacent to an existing catch basin to serve as the connection point for an underdrain outlet. This basin is proposed to rely on infiltration, and the infiltration rate and ponding depth were adjusted accordingly to reflect the native soil infiltration rates and ensure drawdown in less than 48 hours. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	0.1%
	TSS (lb/yr)	56	0.1%
	Volume (acre-feet/yr)	0.14	0.1%
Cost	**Administration & Promotion Costs***	$584	
	Design & Construction Costs**	$9,420	
	Total Estimated Project Cost (2019)	**$10,004**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$2,792**	
	30-yr Average Cost/1,000lb-TSS	**$9,973**	
	30-yr Average Cost/ac-ft Vol.	**$4,047**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $73/hour for design)

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

RETROFIT RECOMMENDATIONS

Project ID: SL-3-3-5 BF-1

Buchanan Place NE
Biofiltration Basin

Drainage Area – 4.1 acres
Location – Southeast corner of intersection between Pierce Terrace NE and Buchanan Place NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

Curb-Cut Biofiltration			
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.3	0.1%
	TSS (lb/yr)	82	0.1%
	Volume (acre-feet/yr)	0.05	0.0%
Cost	**Administration & Promotion Costs***	$584	
	Design & Construction Costs**	$10,420	
	Total Estimated Project Cost (2019)	**$11,004**	
	Annual O&M***	$295	
Efficiency	**30-yr Average Cost/lb-TP**	**$2,647**	
	30-yr Average Cost/1,000lb-TSS	**$8,071**	
	30-yr Average Cost/ac-ft Vol.	**$14,387**	

*Indirect Cost: (8 hours at $73/hour base cost)

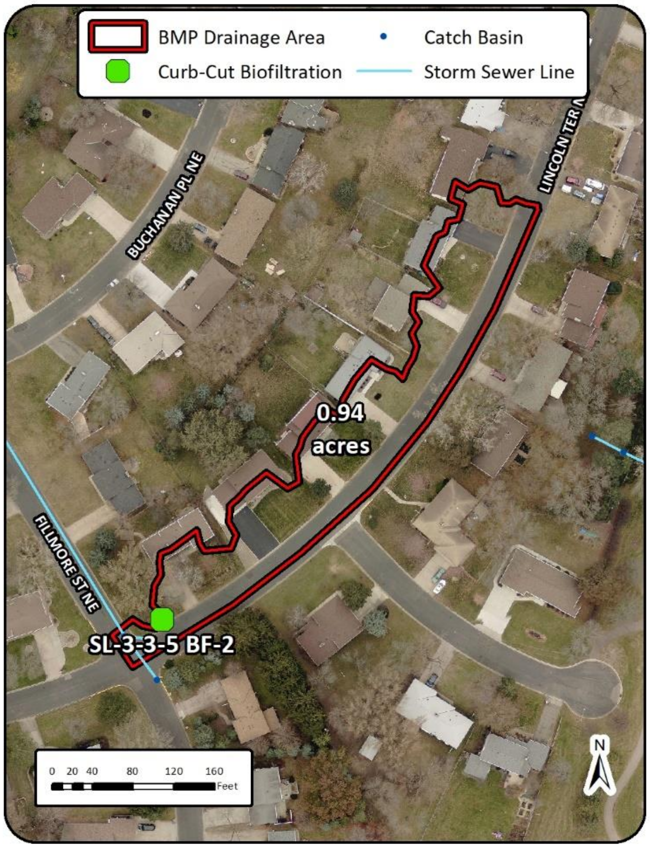
**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-3-3-5 BF-2

Lincoln Terrace NE
Biofiltration Basin

Drainage Area – 0.9 acres
Location – Northeast corner of intersection between Lincoln Terrace NE and Fillmore Street NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.



Curb-Cut Biofiltration			
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	0.1%
	TSS (lb/yr)	52	0.1%
	Volume (acre-feet/yr)	0.05	0.0%
Cost	**Administration & Promotion Costs***	$584	
	Design & Construction Costs**	$10,420	
	Total Estimated Project Cost (2019)	**$11,004**	
	Annual O&M***	$295	
Efficiency	**30-yr Average Cost/lb-TP**	**$4,136**	
	30-yr Average Cost/1,000lb-TSS	**$12,727**	
	30-yr Average Cost/ac-ft Vol.	**$14,387**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-3-3-5 BF-3

Lincoln Terrace NE Biofiltration Basin

Drainage Area – 2.9 acres
Location – Southeast corner of intersection between Lincoln Terrace NE and Fillmore Street NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

Curb-Cut Biofiltration			
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	0.1%
	TSS (lb/yr)	77	0.1%
	Volume (acre-feet/yr)	0.05	0.0%
Cost	**Administration & Promotion Costs***	$584	
	Design & Construction Costs**	$10,420	
	Total Estimated Project Cost (2019)	**$11,004**	
	Annual O&M***	$295	
Efficiency	**30-yr Average Cost/lb-TP**	**$2,877**	
	30-yr Average Cost/1,000lb-TSS	**$8,595**	
	30-yr Average Cost/ac-ft Vol.	**$14,387**	

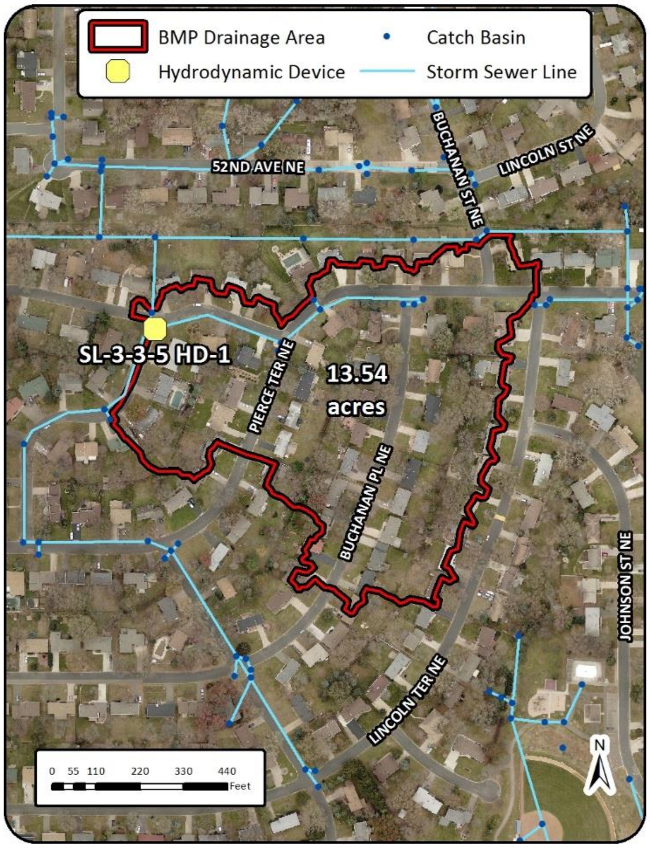
*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-3-3-5 HD-1

Mulcare Drive NE
Hydrodynamic Device



Drainage Area – 13.5 acres
Location – Southeast corner of intersection between Polk Place NE and Mulcare Drive NE
Property Ownership – Public
Site Specific Information – A hydrodynamic device is proposed in line with the 15” storm sewer line that runs east west along Polk Place NE before it intersects with the north south line on Mulcare Drive NE. Placement at this location limits the contributing drainage area to a size that could be treated by a single hydrodynamic device. The table below provides pollutant removals and estimated costs.

	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	10	ft diameter
	TP (lb/yr)	0.9	0.5%
	TSS (lb/yr)	323	0.6%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***		$3,750
	Design & Construction Costs**		$108,000
	Total Estimated Project Cost (2019)		**$111,750**
	Annual O&M***		$630
Efficiency	**30-yr Average Cost/lb-TP**	**$4,683**	
	30-yr Average Cost/1,000lb-TSS	**$13,483**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

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

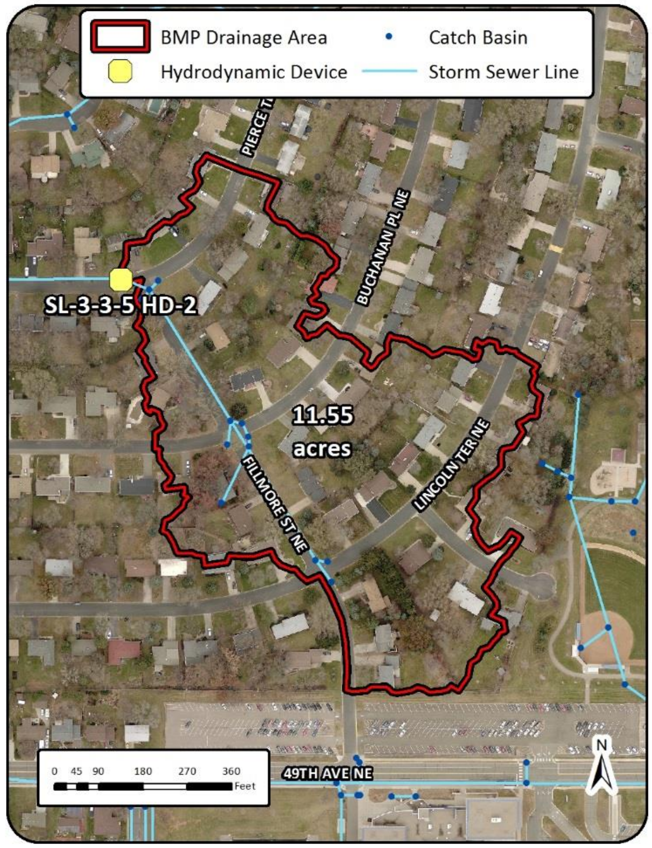
**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)

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

Project ID: SL-3-3-5 HD-2

Pierce Terrace NE
Hydrodynamic Device

Drainage Area – 11.5 acres
Location – Northwest corner of the intersection between Pierce Terrace NE and Fillmore Street NE
Property Ownership – Public
Site Specific Information – A hydrodynamic device is proposed in line with the 12" storm sewer line that runs east west along Pierce Terrace NE west of the connection with the storm sewer line from Fillmore Street NE. Placement at this location limits the contributing drainage area to a size that could be treated by a single hydrodynamic device. The table below provides pollutant removals and estimated costs.



	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	10	ft diameter
	TP (lb/yr)	0.9	0.4%
	TSS (lb/yr)	295	0.5%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***	$3,750	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2019)	**$111,750**	
	Annual O&M***	$630	
Efficiency	**30-yr Average Cost/lb-TP**	**$5,124**	
	30-yr Average Cost/1,000lb-TSS	**$14,763**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

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

**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)

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

RETROFIT RECOMMENDATIONS

Project ID: SL-3-4-1 BI-1

Tyler Street NE Bioinfiltration Basin

Drainage Area – 7.9 acres
Location – Southwest corner of intersection between 50th Avenue NE and Tyler Street NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration is preferred. However, optimal sites are not necessarily adjacent to an existing catch basin to serve as the connection point for an underdrain outlet. This basin is proposed to rely on infiltration, and the infiltration rate and ponding depth were adjusted accordingly to reflect the native soil infiltration rates and ensure drawdown in less than 48 hours. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	0.1%
	TSS (lb/yr)	57	0.1%
	Volume (acre-feet/yr)	0.16	0.1%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$9,420
	Total Estimated Project Cost (2019)		**$10,004**
	Annual O&M***		$225
Efficiency	**30-yr Average Cost/lb-TP**	**$2,792**	
	30-yr Average Cost/1,000lb-TSS	**$9,798**	
	30-yr Average Cost/ac-ft Vol.	**$3,469**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $73/hour for design)

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

Project ID: SL-3-4-1 BI-2

Tyler Street NE
Bioinfiltration Basin

Drainage Area – 7.2 acres
Location – Southeast corner of intersection between 50th Avenue NE and Tyler Street NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration is preferred. However, optimal sites are not necessarily adjacent to an existing catch basin to serve as the connection point for an underdrain outlet. This basin is proposed to rely on infiltration, and the infiltration rate and ponding depth were adjusted accordingly to reflect the native soil infiltration rates and ensure drawdown in less than 48 hours. The table below provides pollutant removals and estimated costs.

Curb-Cut Bioinfiltration			
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	0.1%
	TSS (lb/yr)	58	0.1%
	Volume (acre-feet/yr)	0.16	0.1%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$9,420
	Total Estimated Project Cost (2019)		**$10,004**
	Annual O&M***		$225
Efficiency	**30-yr Average Cost/lb-TP**	**$2,792**	
	30-yr Average Cost/1,000lb-TSS	**$9,629**	
	30-yr Average Cost/ac-ft Vol.	**$3,469**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $73/hour for design)

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

Project ID: SL-3-4-1 BI-3

Lincoln Terrace NE Bioinfiltration Basin

Drainage Area – 5.9 acres
Location – Northeast corner of intersection between Lincoln Terrace NE and Tyler Street NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration is preferred. However, optimal sites are not necessarily adjacent to an existing catch basin to serve as the connection point for an underdrain outlet. This basin is proposed to rely on infiltration, and the infiltration rate and ponding depth were adjusted accordingly to reflect the native soil infiltration rates and ensure drawdown in less than 48 hours. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	0.1%
	TSS (lb/yr)	59	0.1%
	Volume (acre-feet/yr)	0.16	0.1%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$9,420
	Total Estimated Project Cost (2019)		**$10,004**
	Annual O&M***		$225
Efficiency	**30-yr Average Cost/lb-TP**	**$2,659**	
	30-yr Average Cost/1,000lb-TSS	**$9,466**	
	30-yr Average Cost/ac-ft Vol.	**$3,469**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $73/hour for design)

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

Project ID: SL-3-4-1 HD-1

51st Court NE
Hydrodynamic Device

Drainage Area – 7.3 acres
Location – East side of intersection between 51st Court NE and Highway 65
Property Ownership – Public
Site Specific Information – A hydrodynamic device is proposed in line with the 21" storm sewer line that runs east west on 51st Court NE. The storm sewer line provides drainage for the Aldi, White Castle, and Planet Fitness properties. Placement at this location limits the contributing drainage area to a size that could be treated by a single hydrodynamic device. The table below provides pollutant removals and estimated costs.

	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	8	ft diameter
	TP (lb/yr)	0.5	0.3%
	TSS (lb/yr)	282	0.5%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***	$3,750	
	Design & Construction Costs**	$54,000	
	Total Estimated Project Cost (2019)	**$57,750**	
	Annual O&M***	$630	
Efficiency	**30-yr Average Cost/lb-TP**	**$4,913**	
	30-yr Average Cost/1,000lb-TSS	**$9,060**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

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

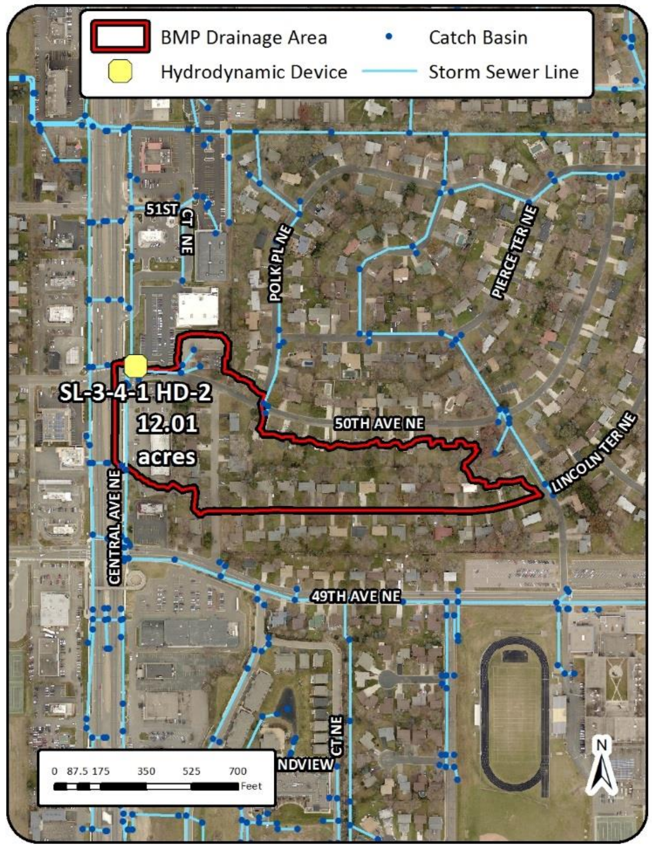
**Direct Cost: ($36,000 for materials) + ($18,000 for labor and installation costs)

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

Project ID: SL-3-4-1 HD-2

50th Avenue NE
Hydrodynamic Device

Drainage Area – 12.0 acres
Location – East side of intersection between 50th Avenue NE and Highway 65
Property Ownership – Public
Site Specific Information – A hydrodynamic device is proposed in line with the 12" storm sewer line that runs east west on 50th Avenue NE. The storm sewer line provides drainage for both residential and commercial land uses. Placement at this location limits the contributing drainage area to a size that could be treated by a single hydrodynamic device. The table below provides pollutant removals and estimated costs.



Hydrodynamic Device

	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	10	ft diameter
	TP (lb/yr)	1.0	0.5%
	TSS (lb/yr)	398	0.7%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***		$3,750
	Design & Construction Costs**		$108,000
	Total Estimated Project Cost (2019)		**$111,750**
	Annual O&M***		$630
Efficiency	**30-yr Average Cost/lb-TP**	**$4,584**	
	30-yr Average Cost/1,000lb-TSS	**$10,942**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

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

**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)

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

RETROFIT RECOMMENDATIONS

RETROFIT RECOMMENDATIONS

RETROFIT RECOMMENDATIONS

Project ID: SL-3-4-4 BF-1

Khyber Lane NE
Biofiltration Basin

Drainage Area – 0.6 acres
Location – Southwest corner of intersection between Khyber Lane NE and Fillmore Street NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.1	0.1%
	TSS (lb/yr)	41	0.1%
	Volume (acre-feet/yr)	0.05	0.0%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$5,091**	
	30-yr Average Cost/1,000lb-TSS	**$16,141**	
	30-yr Average Cost/ac-ft Vol.	**$14,387**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-3-4-4 HD-1

Fillmore Street NE
Hydrodynamic Device

Drainage Area – 5.1 acres
Location – Southwest corner of intersection between 49th Avenue NE and Fillmore Street NE
Property Ownership – Public
Site Specific Information – A hydrodynamic device is proposed in line with the 15" storm sewer line running north south along Fillmore Street NE before it intersects with the east west line along 49th Avenue NE. Placement at this location limits the contributing drainage area to a size that could be treated by a single hydrodynamic device. The table below provides pollutant removals and estimated costs.

	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	8	ft diameter
	TP (lb/yr)	0.5	0.2%
	TSS (lb/yr)	183	0.3%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***		$3,750
	Design & Construction Costs**		$54,000
	Total Estimated Project Cost (2019)		**$57,750**
	Annual O&M***		$630
Efficiency	**30-yr Average Cost/lb-TP**	**$5,323**	
	30-yr Average Cost/1,000lb-TSS	**$13,962**	
	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: (3 cleanings/year)*(3 hours/cleaning)*($70/hour)

RETROFIT RECOMMENDATIONS

Project ID: SL-3-4-5 BF-1

Columbia Heights High School Biofiltration Basin

Drainage Area – 2.3 acres
Location – West side of western parking lot located north of 49th Avenue NE on the Columbia Heights High School campus
Property Ownership – Public
Site Specific Information – Runoff from the large parking lot on the Columbia Heights High School campus could be treated with bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

Curb-Cut Biofiltration

	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	0.1%
	TSS (lb/yr)	91	0.2%
	Volume (acre-feet/yr)	0.07	0.0%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$2,877**	
	30-yr Average Cost/1,000lb-TSS	**$7,273**	
	30-yr Average Cost/ac-ft Vol.	**$9,591**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-3-4-5 BF-2

Columbia Heights High School Biofiltration Basin

Drainage Area – 1.7 acres
Location – Southwest corner of central parking lot located north of 49th Avenue NE on the Columbia Heights High School campus
Property Ownership – Public
Site Specific Information – Runoff from the large parking lot on the Columbia Heights High School campus could be treated with bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	0.1%
	TSS (lb/yr)	88	0.2%
	Volume (acre-feet/yr)	0.07	0.0%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$3,008**	
	30-yr Average Cost/1,000lb-TSS	**$7,520**	
	30-yr Average Cost/ac-ft Vol.	**$9,591**	

*Indirect Cost: (8 hours at $73/hour base cost)

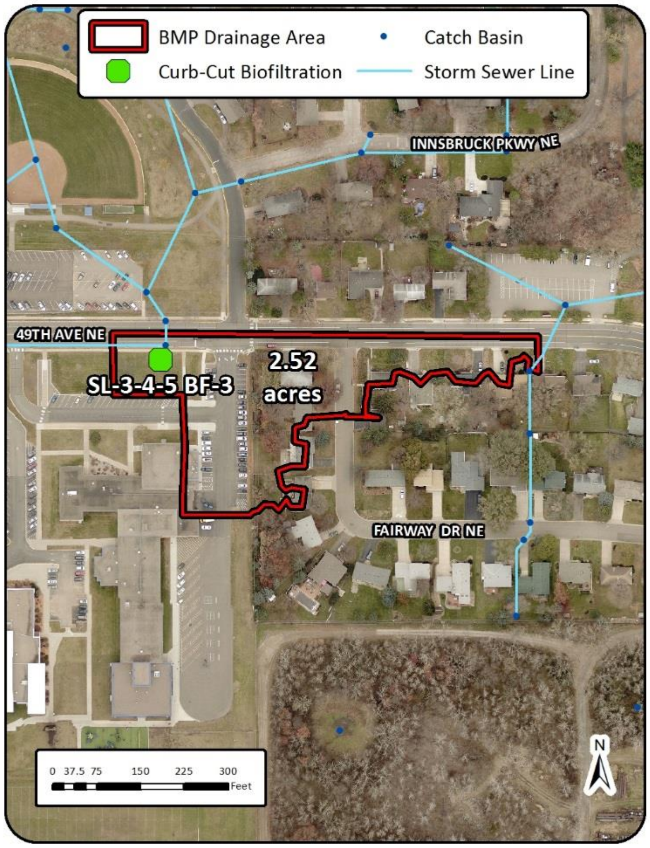
**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-3-4-5 BF-3

Columbia Heights High School Biofiltration Basin

Drainage Area – 2.5 acres
Location – South side of 49th Avenue NE on the Columbia Heights High School campus west of intersection with Johnson Street NE
Property Ownership – Public
Site Specific Information – Runoff from single-family residential lots and the Columbia Heights High School parking lot in this catchment provide could be treated with bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.



	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	0.1%
	TSS (lb/yr)	89	0.2%
	Volume (acre-feet/yr)	0.07	0.0%
Cost	**Administration & Promotion Costs***	$584	
	Design & Construction Costs**	$10,420	
	Total Estimated Project Cost (2019)	**$11,004**	
	Annual O&M***	$295	
Efficiency	**30-yr Average Cost/lb-TP**	**$2,877**	
	30-yr Average Cost/1,000lb-TSS	**$7,436**	
	30-yr Average Cost/ac-ft Vol.	**$9,591**	

*Indirect Cost: (8 hours at $73/hour base cost)

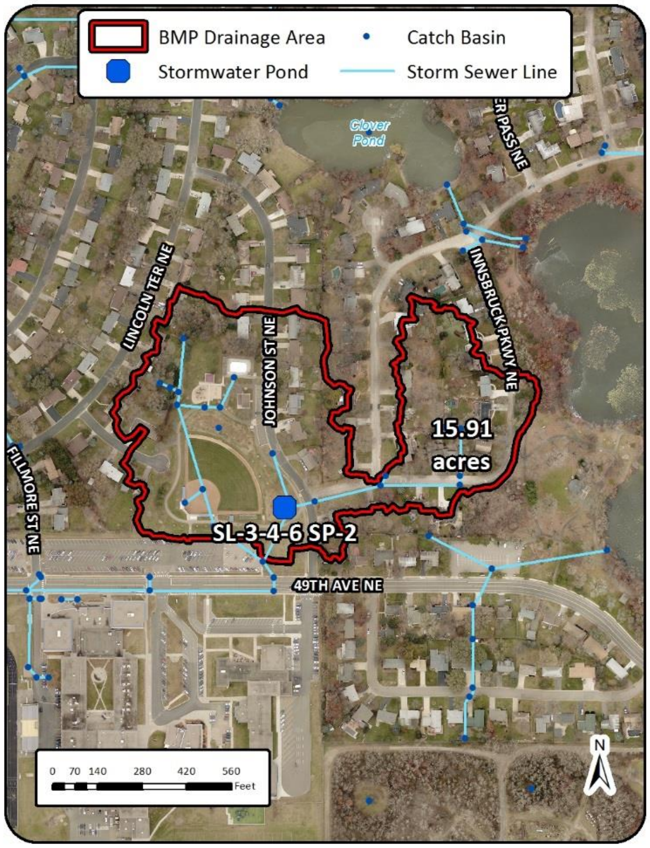
**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

RETROFIT RECOMMENDATIONS

Project ID: SL-3-4-6 SP-2

Ramsdell Park Stormwater Pond



Drainage Area – 15.9 acres
Location – Southeast corner of Ramsdell Park north of the intersection between 49th Avenue NE and Johnson Street NE
Property Ownership – Public
Site Specific Information – Two infiltration basins exist on the east side of Ramsdell Park. The basins could be excavated and connected, and the storm sewer line on Johnson Street NE could be routed to the wet pond. The table below provides pollutant removals and estimated costs.

New Wet Pond			
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	0.35	acres
	TP (lb/yr)	3.2	1.6%
	TSS (lb/yr)	1,381	2.4%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***		$7,300
	Design & Construction Costs**		$312,178
	Total Estimated Project Cost (2019)		**$319,478**
	Annual O&M***		$349
Efficiency	**30-yr Average Cost/lb-TP**	**$3,480**	
	30-yr Average Cost/1,000lb-TSS	**$7,964**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

*Indirect Cost: (100 hours at $73/hour)

**Direct Cost: See Appendix B for detailed cost information

***$1,000/acre - Annual inspection and sediment/debris removal from pretreatment area

Project ID: SL-3-4-6 BF-1

Innsbruck Parkway NE Biofiltration Basin

Drainage Area – 0.6 acres
Location – North side of Innsbruck Parkway NE east of intersection with West Innsbruck Parkway NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.1	0.1%
	TSS (lb/yr)	40	0.1%
	Volume (acre-feet/yr)	0.05	0.0%
Cost	**Administration & Promotion Costs***	$584	
	Design & Construction Costs**	$10,420	
	Total Estimated Project Cost (2019)	**$11,004**	
	Annual O&M***	$295	
Efficiency	**30-yr Average Cost/lb-TP**	**$5,091**	
	30-yr Average Cost/1,000lb-TSS	**$16,545**	
	30-yr Average Cost/ac-ft Vol.	**$14,387**	

*Indirect Cost: (8 hours at $73/hour base cost)

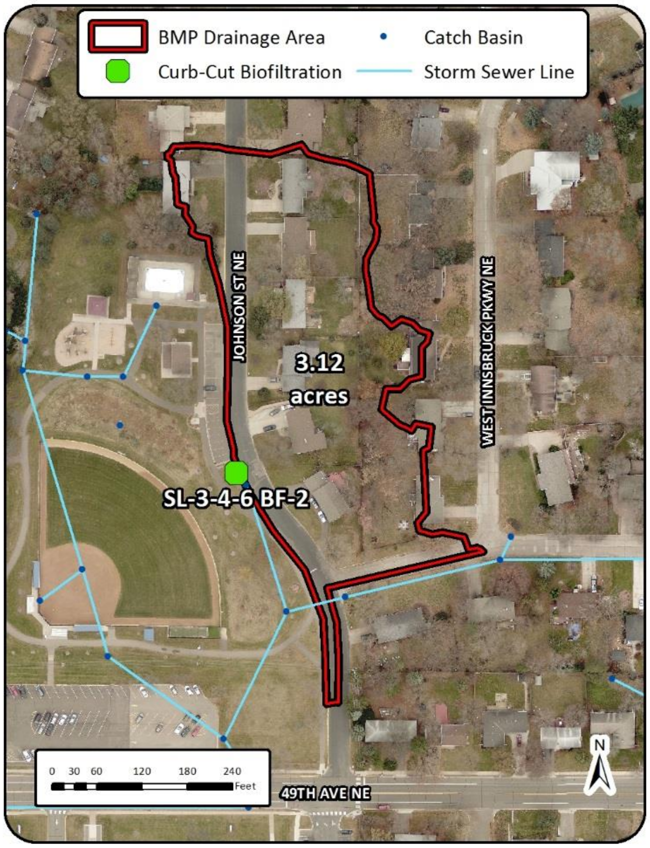
**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-3-4-6 BF-2

Johnson Street NE
Biofiltration Basin

Drainage Area – 3.1 acres
Location – West side of Johnson Street NE north of intersection with Innsbruck Parkway NE within Ramsdell Park
Property Ownership – Public
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.



Curb-Cut Biofiltration

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Total Size of BMPs	250	sq-ft
	TP (lb/yr)	0.2	0.1%
	TSS (lb/yr)	80	0.1%
	Volume (acre-feet/yr)	0.07	0.0%
Cost	Administration & Promotion Costs*		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	30-yr Average Cost/lb-TP	**$2,877**	
	30-yr Average Cost/1,000lb-TSS	**$8,273**	
	30-yr Average Cost/ac-ft Vol.	**$9,591**	

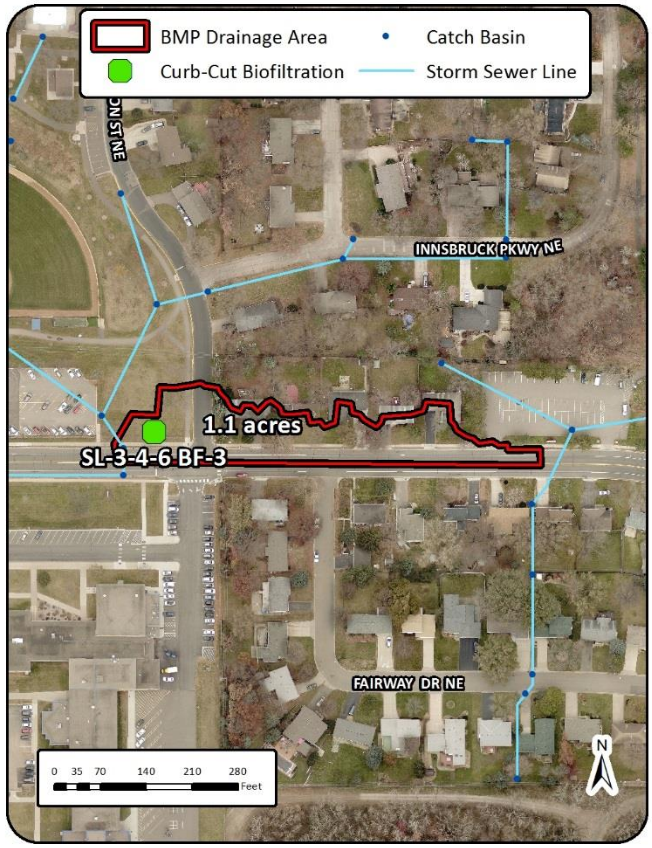
*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-3-4-6 BF-3

49th Avenue NE
Biofiltration Basin



Drainage Area – 1.1 acres
Location – Southwest corner of intersection between 49th Avenue NE and Johnson Street NE on the Columbia Heights High School property
Property Ownership – Public
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

Curb-Cut Biofiltration

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Total Size of BMPs	250	sq-ft
	TP (lb/yr)	0.2	0.1%
	TSS (lb/yr)	67	0.1%
	Volume (acre-feet/yr)	0.05	0.0%
Cost	Administration & Promotion Costs*		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	30-yr Average Cost/lb-TP	**$3,677**	
	30-yr Average Cost/1,000lb-TSS	**$9,878**	
	30-yr Average Cost/ac-ft Vol.	**$14,387**	

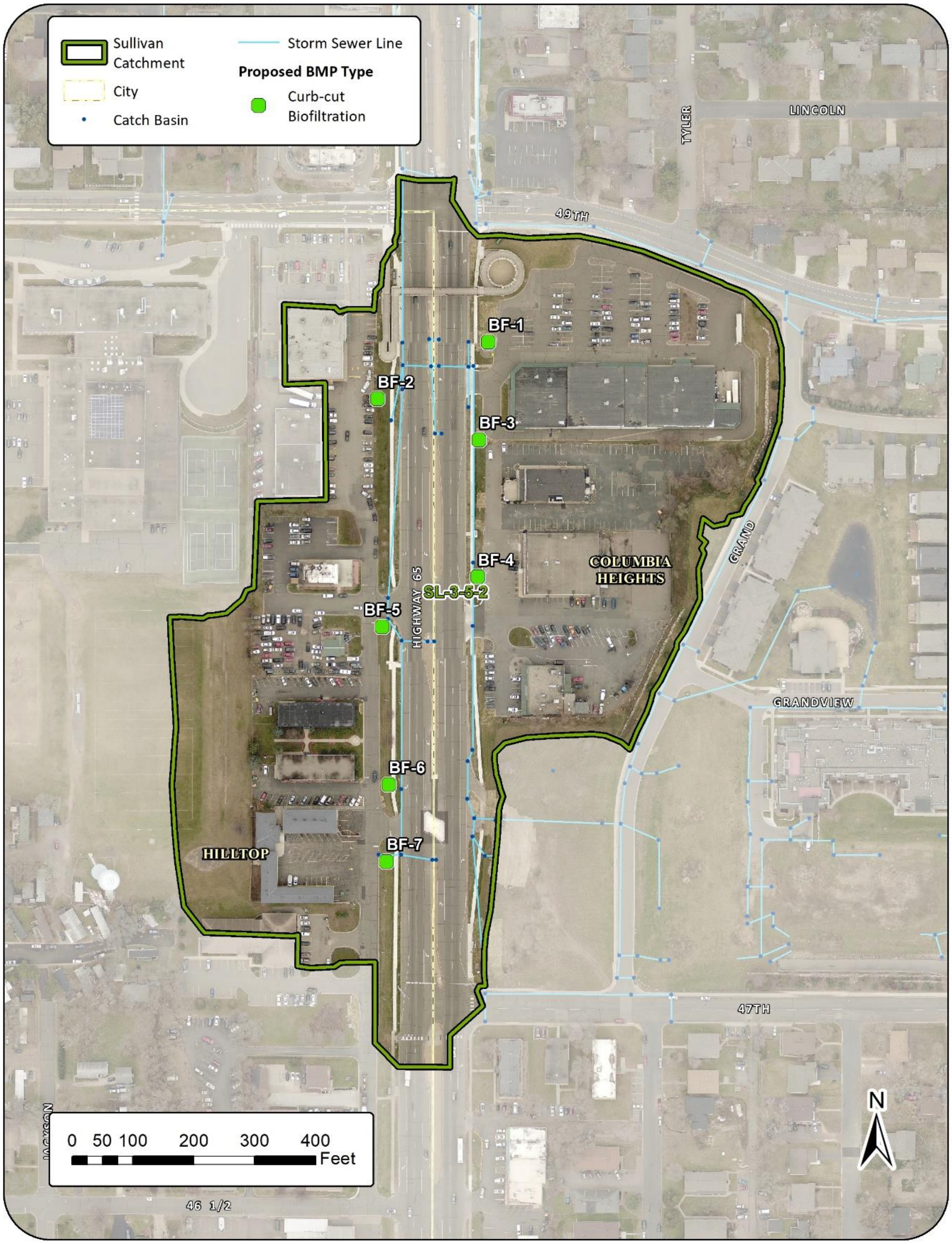
*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

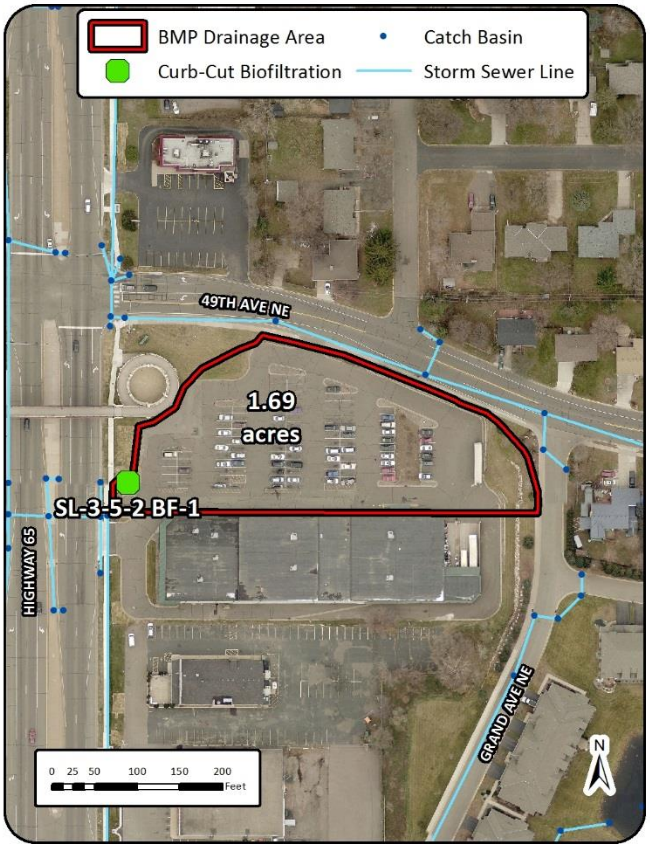
RETROFIT RECOMMENDATIONS

RETROFIT RECOMMENDATIONS



Project ID: SL-3-5-2 BF-1

Highway 65, Savers Biofiltration Basin



Drainage Area – 1.7 acres
Location – West side of Savers parking lot
Property Ownership – Private
Site Specific Information – Runoff from the Savers parking lot in this catchment provide could be treated with bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

Curb-Cut Biofiltration			
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.1	0.1%
	TSS (lb/yr)	76	0.1%
	Volume (acre-feet/yr)	0.07	0.0%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$4,727**	
	30-yr Average Cost/1,000lb-TSS	**$8,708**	
	30-yr Average Cost/ac-ft Vol.	**$9,591**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-3-5-2 BF-2

Highway 65, Walgreens Biofiltration Basin

Drainage Area – 1.4 acres
Location – Southeast corner of Walgreens parking lot
Property Ownership – Private
Site Specific Information – Expansive parking lot area drains to a single catch basin located on the southeast corner of the Walgreens property. Space is available for a bioretention practice to treat stormwater runoff. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.1	0.1%
	TSS (lb/yr)	73	0.1%
	Volume (acre-feet/yr)	0.07	0.0%
Cost	**Administration & Promotion Costs***	$584	
	Design & Construction Costs**	$10,420	
	Total Estimated Project Cost (2019)	**$11,004**	
	Annual O&M***	$295	
Efficiency	**30-yr Average Cost/lb-TP**	**$5,091**	
	30-yr Average Cost/1,000lb-TSS	**$9,066**	
	30-yr Average Cost/ac-ft Vol.	**$9,591**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-3-5-2 BF-3

Highway 65, NE Halal Market & Deli

Biofiltration Basin

Drainage Area – 0.8 acres
Location – Northwest corner of NE Halal Market & Deli parking lot
Property Ownership – Private
Site Specific Information – Stormwater runoff from the parking lot could be treated using bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

Curb-Cut Biofiltration			
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.1	0.1%
	TSS (lb/yr)	60	0.1%
	Volume (acre-feet/yr)	0.05	0.0%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$6,016**	
	30-yr Average Cost/1,000lb-TSS	**$11,030**	
	30-yr Average Cost/ac-ft Vol.	**$14,387**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-3-5-2 BF-4

Highway 65, Welle Auto Supply
Biofiltration Basin

Drainage Area – 0.6 acres
Location – West side of Welle Auto Supply parking lot
Property Ownership – Private
Site Specific Information – Stormwater runoff from the parking lot could be treated using bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.1	0.1%
	TSS (lb/yr)	56	0.1%
	Volume (acre-feet/yr)	0.05	0.0%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$6,016**	
	30-yr Average Cost/1,000lb-TSS	**$11,818**	
	30-yr Average Cost/ac-ft Vol.	**$14,387**	

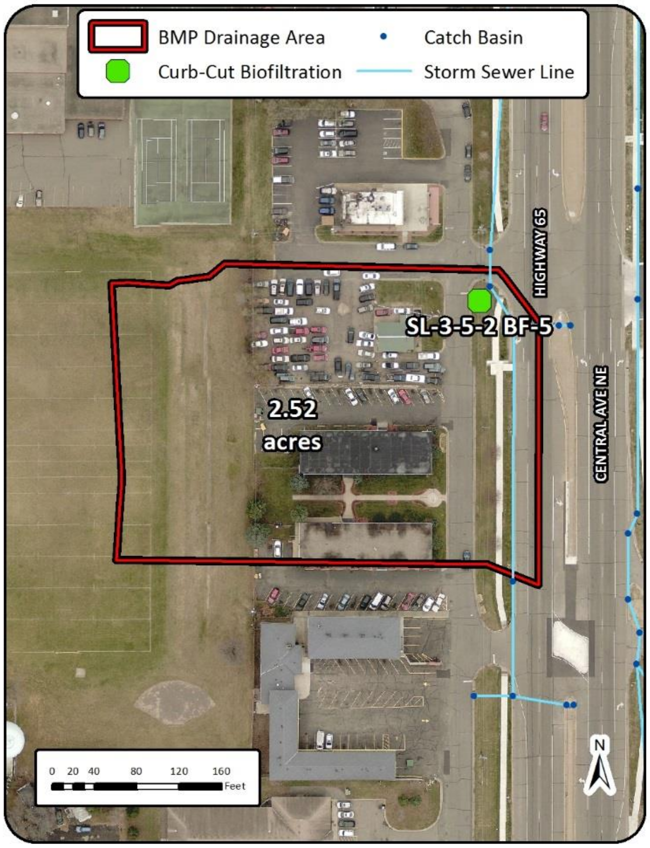
*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-3-5-2 BF-5

Highway 65, 48th Avenue NE
Biofiltration Basin



Drainage Area – 2.5 acres
Location – Southeast corner of intersection between 48 Avenue NE and Central Avenue Service Road
Property Ownership – Private
Site Specific Information – Stormwater runoff from an apartment complex and Tri City Auto Sales could be treated using bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

Curb-Cut Biofiltration			
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	0.1%
	TSS (lb/yr)	97	0.2%
	Volume (acre-feet/yr)	0.07	0.0%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$3,151**	
	30-yr Average Cost/1,000lb-TSS	**$6,823**	
	30-yr Average Cost/ac-ft Vol.	**$9,591**	

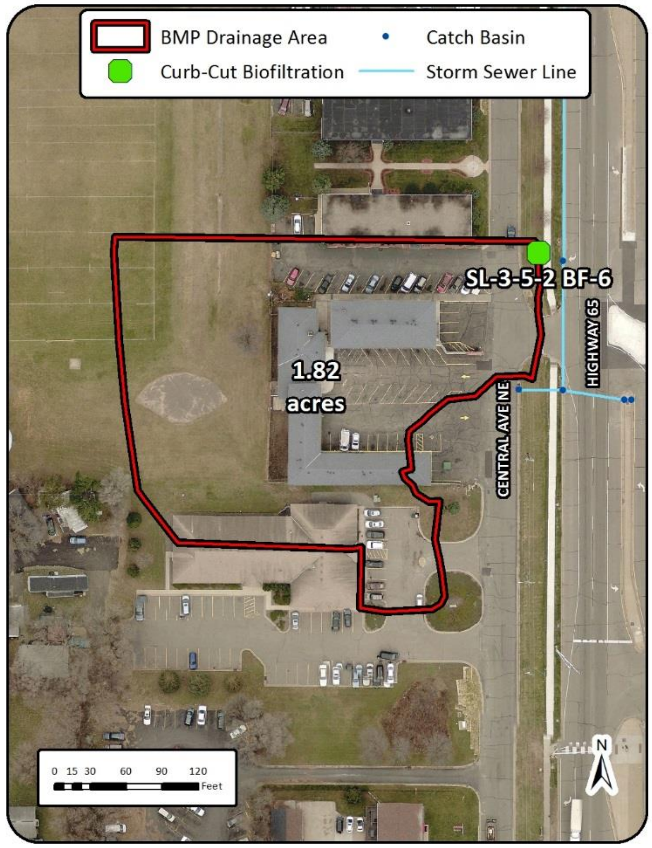
*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-3-5-2 BF-6

Highway 65, Starlite Motel Biofiltration Basin



Drainage Area – 1.8 acres
Location – Northeast of Starlite Motel in median between Highway 65 and Central Avenue Service Road
Property Ownership – Private
Site Specific Information – Runoff from the Starlite motel could be treated using bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	0.1%
	TSS (lb/yr)	82	0.1%
	Volume (acre-feet/yr)	0.07	0.0%
Cost	**Administration & Promotion Costs***	$584	
	Design & Construction Costs**	$10,420	
	Total Estimated Project Cost (2019)	**$11,004**	
	Annual O&M***	$295	
Efficiency	**30-yr Average Cost/lb-TP**	**$3,893**	
	30-yr Average Cost/1,000lb-TSS	**$8,071**	
	30-yr Average Cost/ac-ft Vol.	**$9,591**	

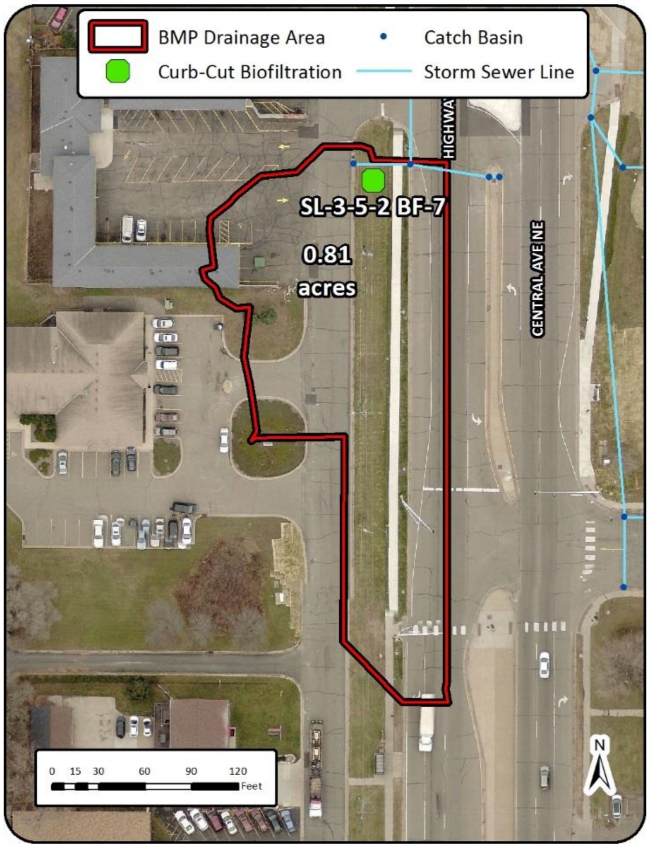
*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-3-5-2 BF-7

Highway 65, Starlite Motel Biofiltration Basin



Drainage Area – 0.8 acres
Location – Southeast of Starlite motel in median between Highway 65 and Central Avenue Service Road
Property Ownership – Private
Site Specific Information – Runoff from the southeastern corner of the Starlite Motel parking lot and along Central Avenue Service Road could be treated using bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

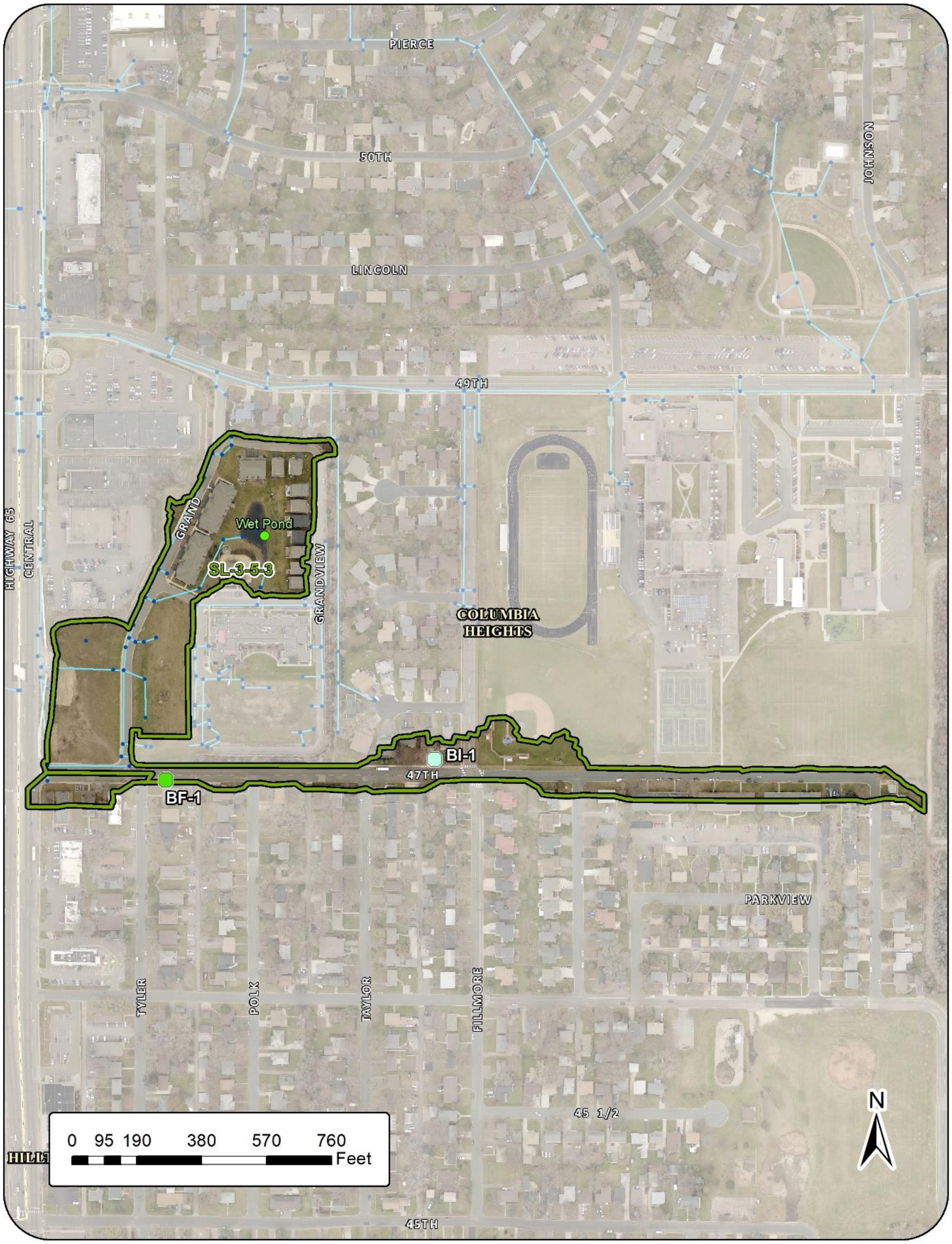
	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	0.1%
	TSS (lb/yr)	94	0.2%
	Volume (acre-feet/yr)	0.05	0.0%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$3,309**	
	30-yr Average Cost/1,000lb-TSS	**$7,040**	
	30-yr Average Cost/ac-ft Vol.	**$14,387**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

RETROFIT RECOMMENDATIONS



Project ID: SL-3-5-3 BF-1

47th Avenue NE
Bioinfiltration Basin

Drainage Area – 2.1 acres
Location – Southeast corner of intersection between 47th Avenue NE and Tyler Street NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	0.1%
	TSS (lb/yr)	71	0.1%
	Volume (acre-feet/yr)	0.07	0.0%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$3,893**	
	30-yr Average Cost/1,000lb-TSS	**$9,321**	
	30-yr Average Cost/ac-ft Vol.	**$9,591**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-3-5-3 BI-1

47th Avenue NE Bioinfiltration Basin

Drainage Area – 2.1 acres
Location – North side of 47th Avenue NE west of intersection with Fillmore Street NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration is preferred. However, optimal sites are not necessarily adjacent to an existing catch basin to serve as the connection point for an underdrain outlet. This basin is proposed to rely on infiltration, and the infiltration rate and ponding depth were adjusted accordingly to reflect the native soil infiltration rates and ensure drawdown in less than 48 hours. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	0.1%
	TSS (lb/yr)	60	0.1%
	Volume (acre-feet/yr)	0.14	0.1%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$9,420
	Total Estimated Project Cost (2019)		**$10,004**
	Annual O&M***		$225
Efficiency	**30-yr Average Cost/lb-TP**	**$3,490**	
	30-yr Average Cost/1,000lb-TSS	**$9,308**	
	30-yr Average Cost/ac-ft Vol.	**$4,047**	

*Indirect Cost: (8 hours at $73/hour base cost)

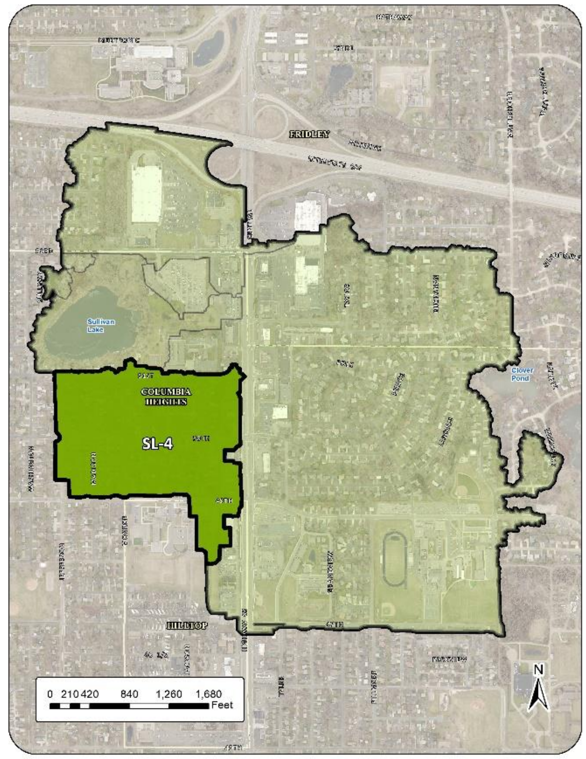
**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $73/hour for design)

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

RETROFIT RECOMMENDATIONS

Catchment SL-4

Existing Catchment Summary	
Acres	64.7
Parcels	245
Land Cover	80.6% Residential 11.6% Commercial 5.7% Institutional 1.4% Open Space 0.7% Freeway



CATCHMENT DESCRIPTION

This catchment largely consists of medium density residential land use. The eastern side includes commercial properties along the Highway 65 corridor. The stormwater infrastructure throughout the catchment has three outlets to Sullivan Lake along the southern shoreline.

EXISTING STORMWATER TREATMENT

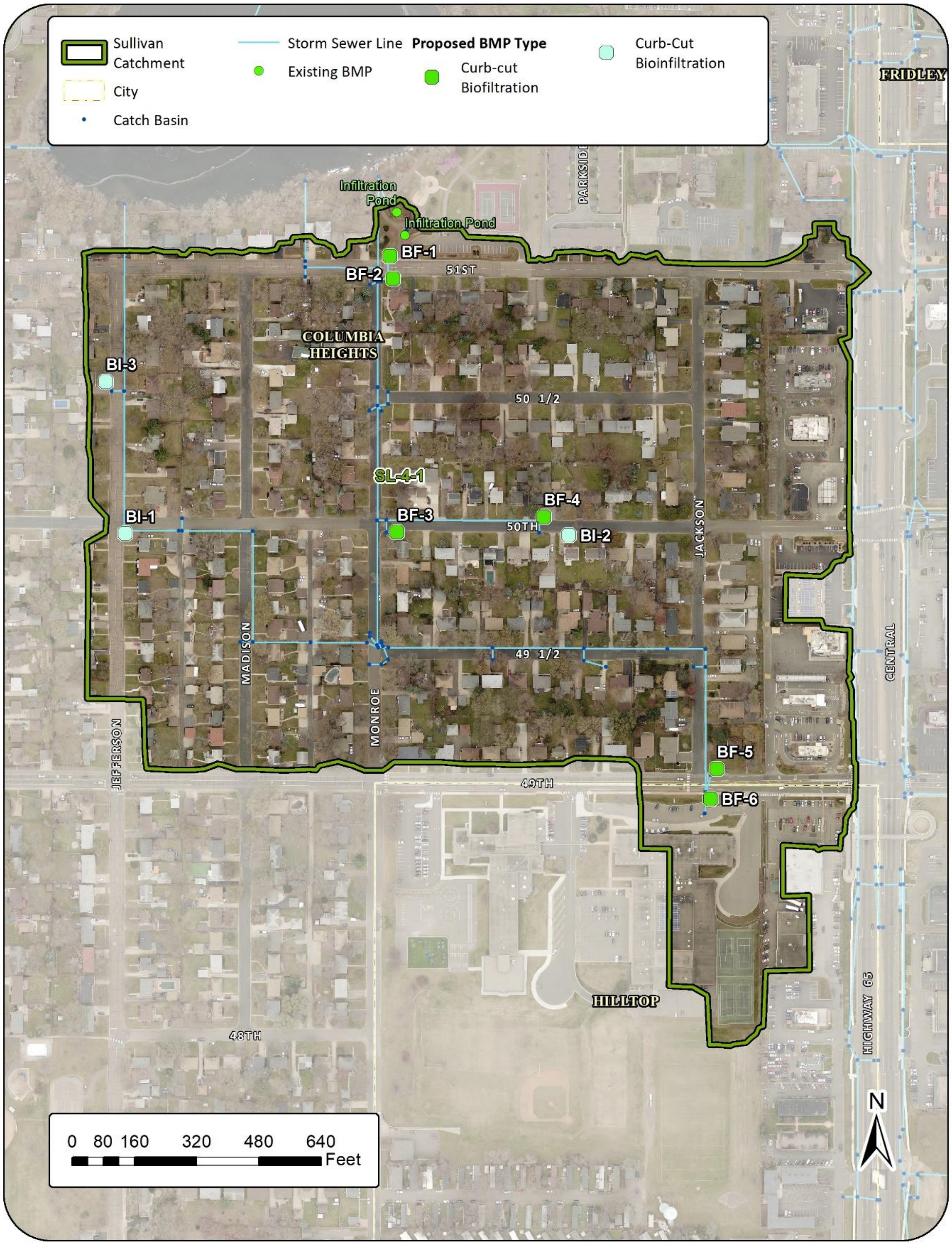
Two infiltration ponds provide water treatment to runoff from the parking lots located within the southern portion of Sullivan Lake Park just north of 51st Ave. NE. The infiltration basins are in-series and outlet to Sullivan Lake. In addition, street cleaning is performed four times per year by the City of Columbia Heights. 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 Pond			
	TP (lb/yr)	50.2	4.5	9%	**45.7**
	TSS (lb/yr)	15,482	1,985	13%	**13,497**
	Volume (acre-feet/yr)	39.3	0.2	0%	**39.1**

RETROFIT RECOMMENDATIONS OVERVIEW

Six biofiltration basins and three bioinfiltration basins were proposed in catchment SL-4. Details are provided in the following project profile pages.

RETROFIT RECOMMENDATIONS



Project ID: SL-4-1 BF-1

Sullivan Lake Park Biofiltration Basin

Drainage Area – 1.1 acres
Location – Northeast corner of intersection between 51st Avenue NE and Monroe Street NE
Property Ownership – Public
Site Specific Information – Stormwater runoff from residential and institutional properties along 51st Avenue NE could be treated using bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	0.4%
	TSS (lb/yr)	66	0.5%
	Volume (acre-feet/yr)	0.05	0.1%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$4,136**	
	30-yr Average Cost/1,000lb-TSS	**$10,027**	
	30-yr Average Cost/ac-ft Vol.	**$14,387**	

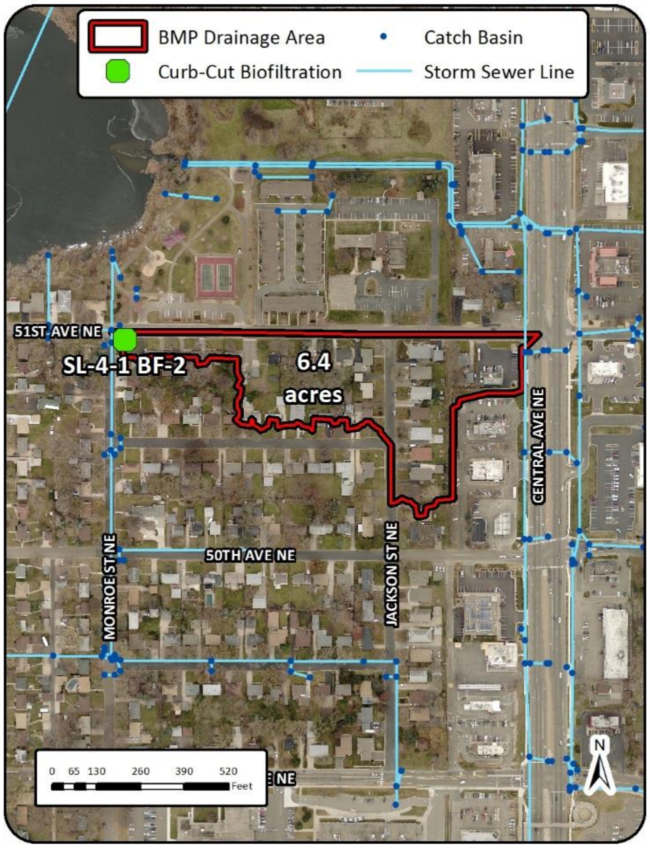
*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-4-1 BF-2

51st Avenue NE
Biofiltration Basin



Drainage Area – 6.4 acres
Location – Southeast corner of intersection between 51st Avenue NE and Monroe Street NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

Curb-Cut Biofiltration			
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	0.5%
	TSS (lb/yr)	81	0.6%
	Volume (acre-feet/yr)	0.07	0.2%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$3,151**	
	30-yr Average Cost/1,000lb-TSS	**$8,170**	
	30-yr Average Cost/ac-ft Vol.	**$9,591**	

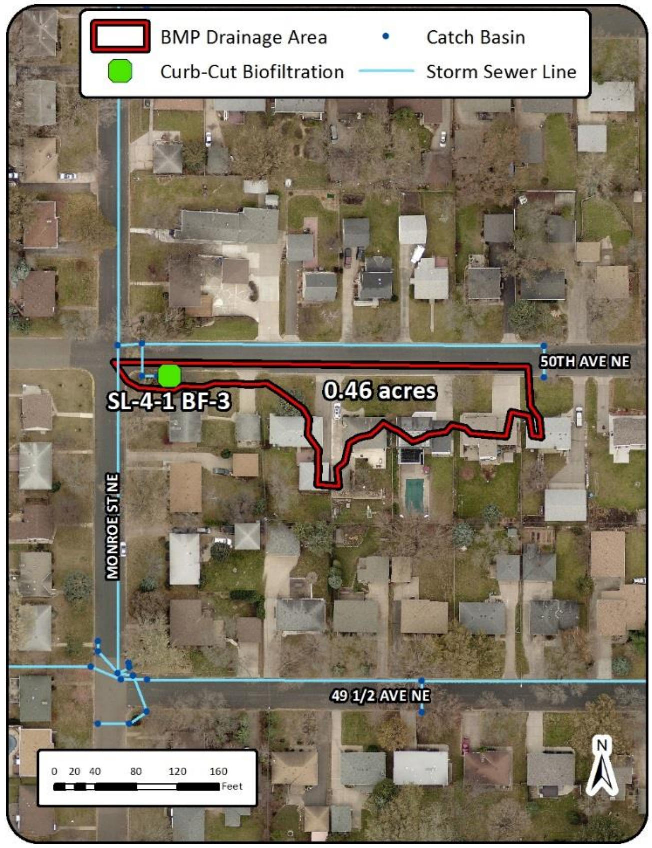
*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-4-1 BF-3

50th Avenue NE
Biofiltration Basin



Drainage Area – 0.5 acres
Location – Southeast corner of intersection between 50th Avenue NE and Monroe Street NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.1	0.3%
	TSS (lb/yr)	37	0.3%
	Volume (acre-feet/yr)	0.02	0.1%
Cost	**Administration & Promotion Costs***	$584	
	Design & Construction Costs**	$10,420	
	Total Estimated Project Cost (2019)	**$11,004**	
	Annual O&M***	$295	
Efficiency	**30-yr Average Cost/lb-TP**	**$5,515**	
	30-yr Average Cost/1,000lb-TSS	**$17,886**	
	30-yr Average Cost/ac-ft Vol.	**$28,774**	

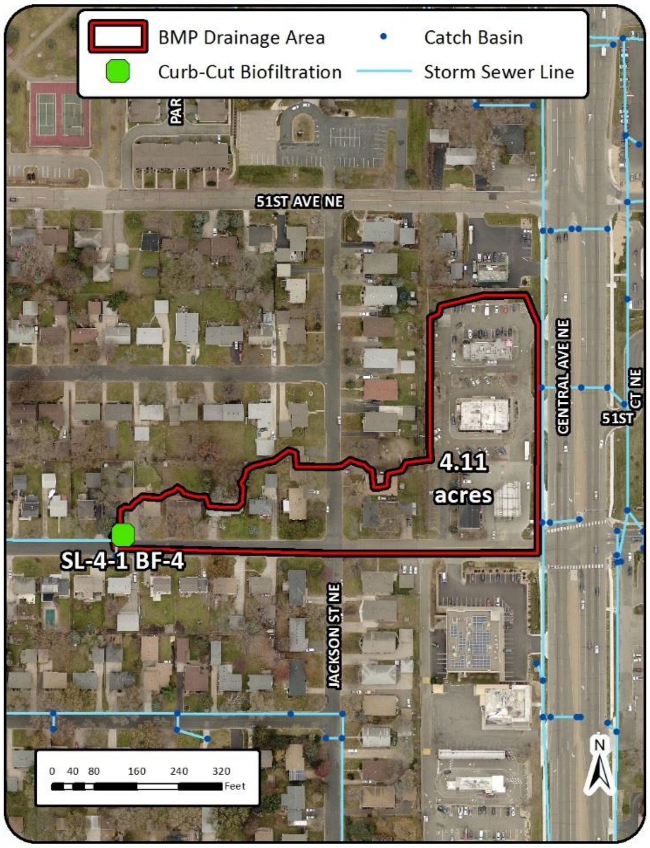
*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-4-1 BF-4

50th Avenue NE
Biofiltration Basin



Drainage Area – 4.1 acres
Location – North side of 50th Avenue NE west of Jackson Street NE
Property Ownership – Private
Site Specific Information – Stormwater runoff from commercial and residential properties could be treated using bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	0.4%
	TSS (lb/yr)	85	0.6%
	Volume (acre-feet/yr)	0.07	0.2%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$3,677**	
	30-yr Average Cost/1,000lb-TSS	**$7,786**	
	30-yr Average Cost/ac-ft Vol.	**$9,591**	

*Indirect Cost: (8 hours at $73/hour base cost)

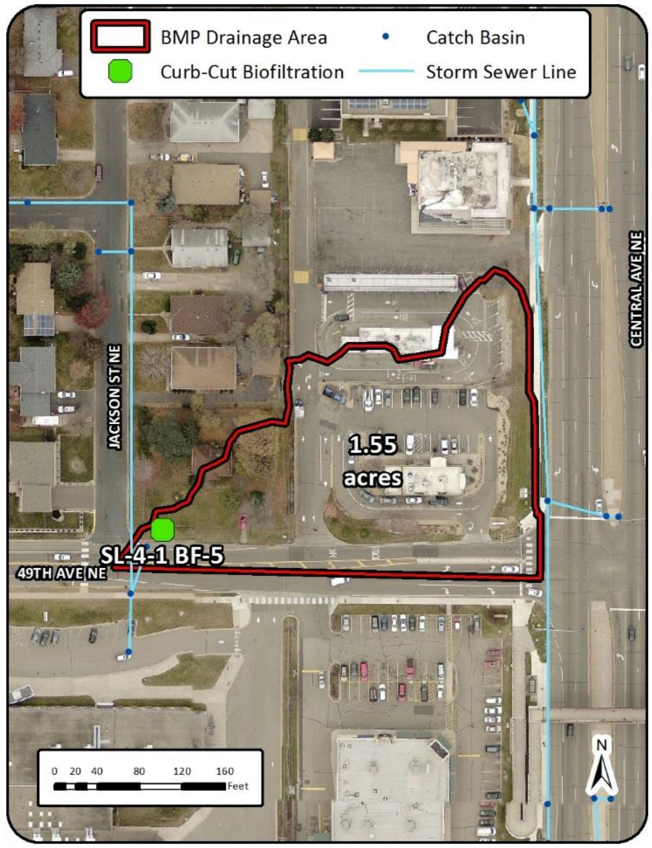
**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-4-1 BF-5

49th Avenue NE
Biofiltration Basin

Drainage Area – 1.6 acres
Location – Northeast corner of intersection between 49th Avenue NE and Jackson Street NE
Property Ownership – Private
Site Specific Information – Stormwater runoff from commercial and residential properties could be treated using bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.



Curb-Cut Biofiltration

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Total Size of BMPs	250	sq-ft
	TP (lb/yr)	0.2	0.4%
	TSS (lb/yr)	78	0.6%
	Volume (acre-feet/yr)	0.07	0.2%
Cost	Administration & Promotion Costs*		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	30-yr Average Cost/lb-TP	**$4,136**	
	30-yr Average Cost/1,000lb-TSS	**$8,485**	
	30-yr Average Cost/ac-ft Vol.	**$9,591**	

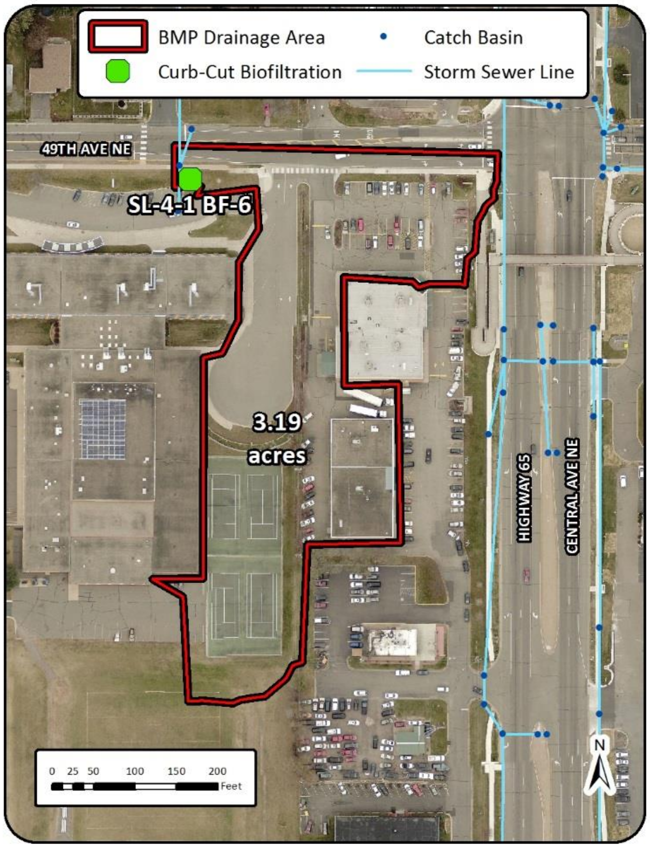
*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-4-1 BF-6

49th Avenue NE
Biofiltration Basin



Drainage Area – 3.2 acres
Location – Southeast corner of intersection between 49th Avenue NE and Jackson Street NE
Property Ownership – Private
Site Specific Information – Stormwater runoff from the Columbia Academy campus and commercial properties along Highway 65 could be treated using bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	0.4%
	TSS (lb/yr)	92	0.7%
	Volume (acre-feet/yr)	0.07	0.2%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$3,483**	
	30-yr Average Cost/1,000lb-TSS	**$7,193**	
	30-yr Average Cost/ac-ft Vol.	**$9,591**	

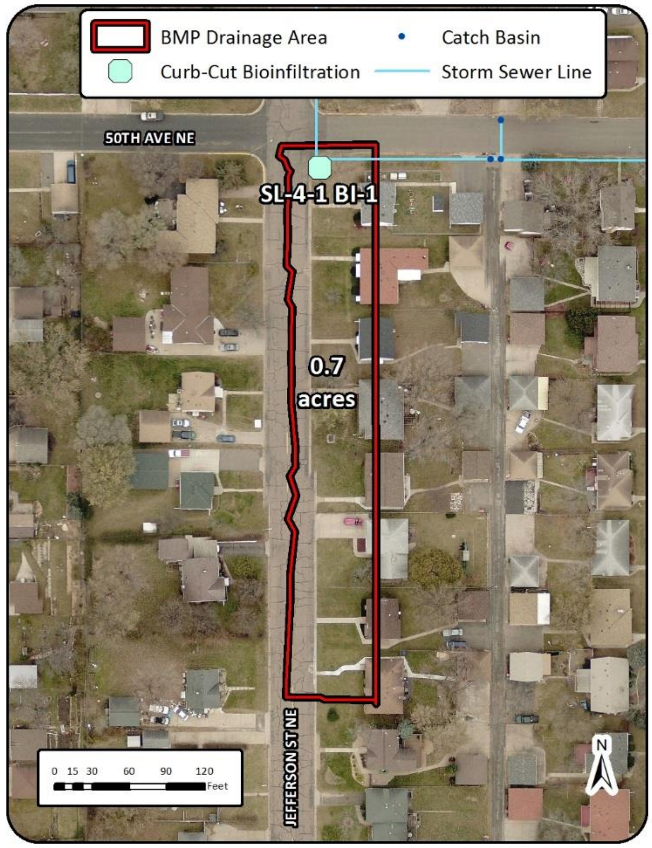
*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: SL-4-1 BI-1

Jefferson Street NE Bioinfiltration Basin



Drainage Area – 0.7 acres
Location – Southeast corner of intersection between 50th Avenue NE and Jefferson Street NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration is preferred. However, optimal sites are not necessarily adjacent to an existing catch basin to serve as the connection point for an underdrain outlet. This basin is proposed to rely on infiltration, and the infiltration rate and ponding depth were adjusted accordingly to reflect the native soil infiltration rates and ensure drawdown in less than 48 hours. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.3	0.6%
	TSS (lb/yr)	83	0.6%
	Volume (acre-feet/yr)	0.23	0.6%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$9,420
	Total Estimated Project Cost (2019)		**$10,004**
	Annual O&M***		$225
Efficiency	**30-yr Average Cost/lb-TP**	**$1,995**	
	30-yr Average Cost/1,000lb-TSS	**$6,729**	
	30-yr Average Cost/ac-ft Vol.	**$2,428**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $73/hour for design)

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

Project ID: SL-4-1 BI-2

50th Avenue NE Bioinfiltration Basin

Drainage Area – 3.6 acres
Location – South side of 50th Avenue NE west of Jackson Street NE
Property Ownership – Private
Site Specific Information – Stormwater runoff from commercial and residential properties could be treated using bioretention. Because of the silty soils in this catchment, biofiltration is preferred. However, optimal sites are not necessarily adjacent to an existing catch basin to serve as the connection point for an underdrain outlet. This basin is proposed to rely on infiltration, and the infiltration rate and ponding depth were adjusted accordingly to reflect the native soil infiltration rates and ensure drawdown in less than 48 hours. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.1	0.3%
	TSS (lb/yr)	52	0.4%
	Volume (acre-feet/yr)	0.16	0.4%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$9,420
	Total Estimated Project Cost (2019)		**$10,004**
	Annual O&M***		$225
Efficiency	**30-yr Average Cost/lb-TP**	**$4,296**	
	30-yr Average Cost/1,000lb-TSS	**$10,740**	
	30-yr Average Cost/ac-ft Vol.	**$3,469**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $73/hour for design)

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

Project ID: SL-4-1 BI-3

Jefferson Street NE Bioinfiltration Basin

Drainage Area – 0.6 acres
Location – West side of Jefferson Street NE south of intersection with 51st Avenue NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration is preferred. However, optimal sites are not necessarily adjacent to an existing catch basin to serve as the connection point for an underdrain outlet. This basin is proposed to rely on infiltration, and the infiltration rate and ponding depth were adjusted accordingly to reflect the native soil infiltration rates and ensure drawdown in less than 48 hours. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.3	0.5%
	TSS (lb/yr)	76	0.6%
	Volume (acre-feet/yr)	0.21	0.5%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$9,420
	Total Estimated Project Cost (2019)		**$10,004**
	Annual O&M***		$225
Efficiency	**30-yr Average Cost/lb-TP**	**$2,234**	
	30-yr Average Cost/1,000lb-TSS	**$7,348**	
	30-yr Average Cost/ac-ft Vol.	**$2,698**	

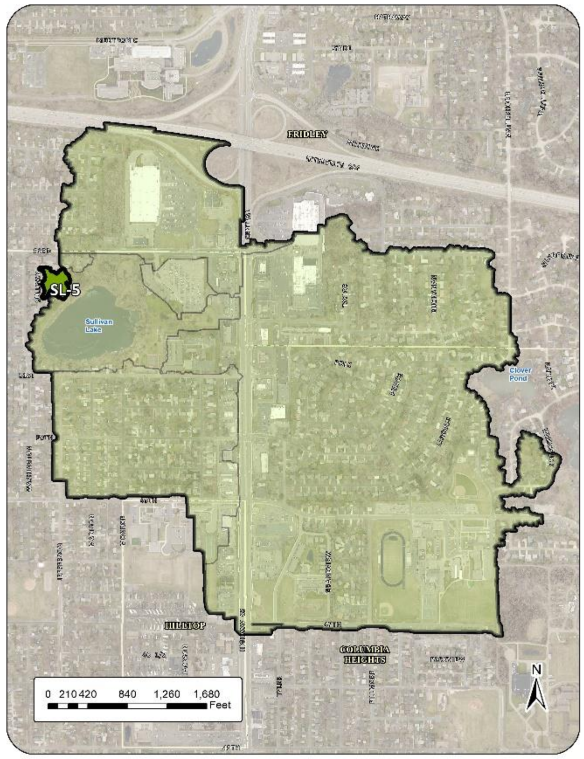
*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $73/hour for design)

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

Catchment SL-5

Existing Catchment Summary	
Acres	1.7
Parcels	21
Land Cover	100% Residential



CATCHMENT DESCRIPTION

This small catchment consists of the backyard areas of the Sullivan Shores Townhomes. Runoff drains to a small depression before entering Sullivan Lake.

EXISTING STORMWATER TREATMENT

Runoff from this catchment drains to a small infiltration basin prior to reaching Sullivan Lake. 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 Pond			
	TP (lb/yr)	1.2	0.1	12%	**1.1**
	TSS (lb/yr)	426	64	15%	**361**
	Volume (acre-feet/yr)	1.3	0.4	33%	**0.9**

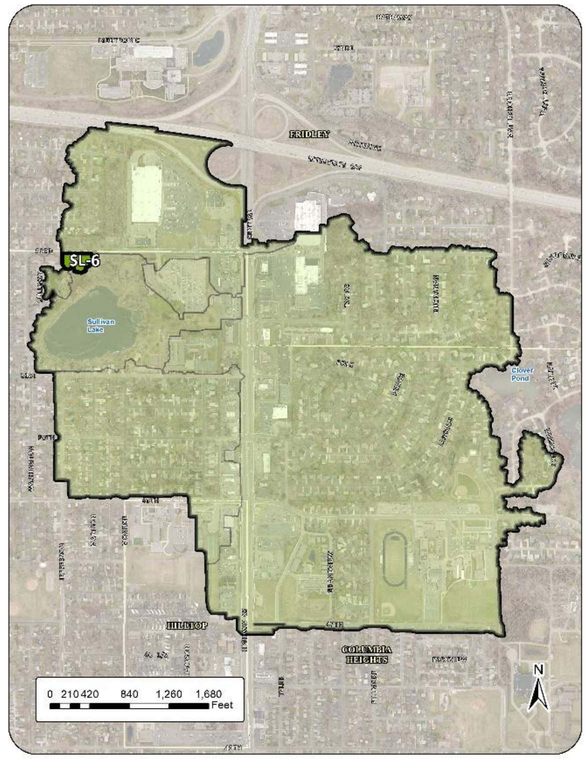
RETROFIT RECOMMENDATIONS OVERVIEW

No retrofits were proposed in catchment SL-5. The entire 1.7-acre drainage area drains to an infiltration basin where it receives water quality treatment. Little opportunity remains for retrofit of an additional stormwater control measure or additional treatment.

RETROFIT RECOMMENDATIONS

Catchment SL-6

Existing Catchment Summary	
Acres	1.3
Parcels	14
Land Cover	100% Residential



CATCHMENT DESCRIPTION

This small catchment also consists entirely of the Sullivan Shores Townhomes. Runoff is piped to a small depression on the north side of Sullivan Lake.

EXISTING STORMWATER TREATMENT

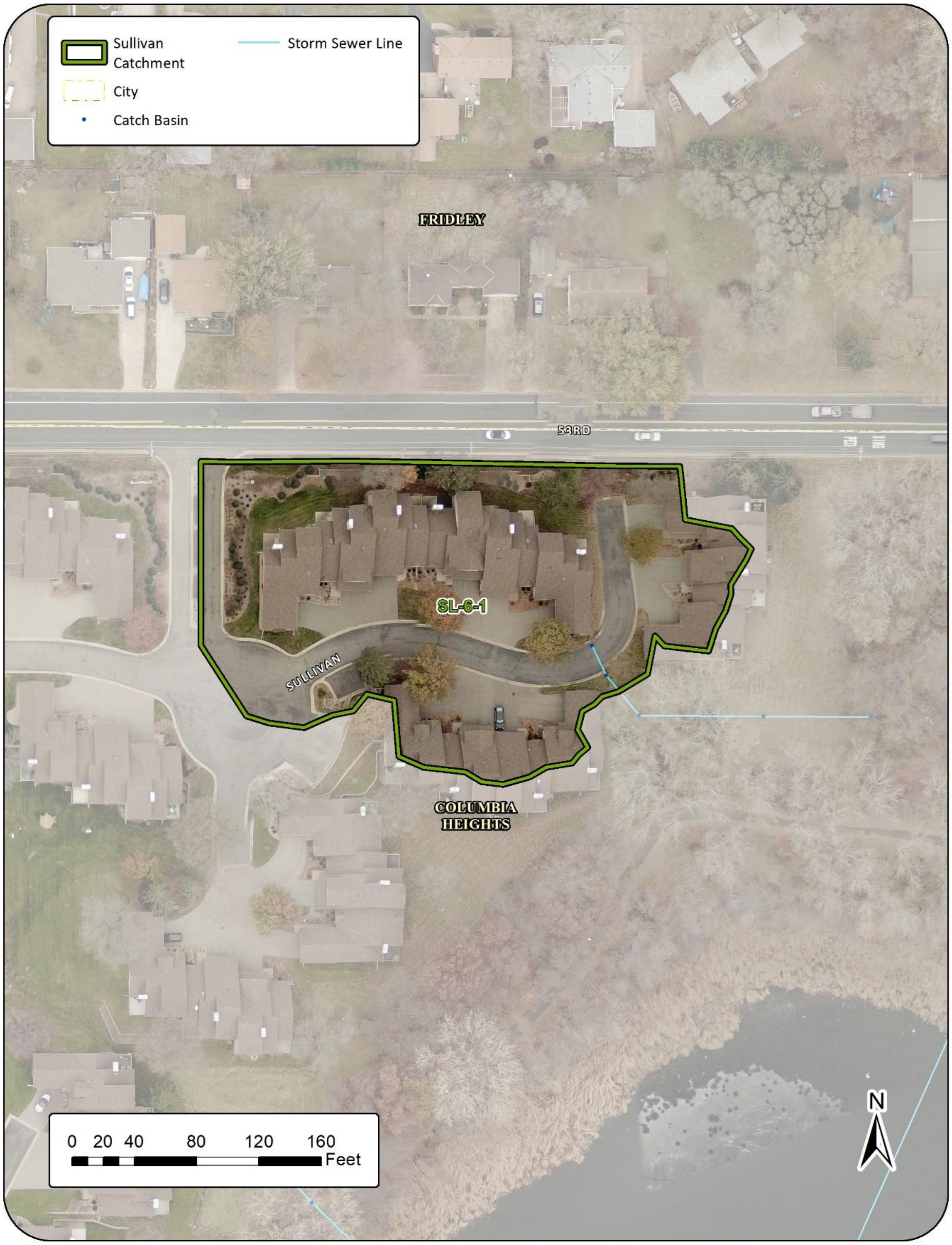
The primary stormwater treatment in the catchment is street cleaning, performed four times per year by the City of Columbia Heights. Present-day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	2			
	BMP Types	Street Cleaning, Infiltration Pond			
	TP (lb/yr)	0.9	0.1	12%	**0.8**
	TSS (lb/yr)	314	47	15%	**267**
	Volume (acre-feet/yr)	1.0	0.0	0%	**1.0**

RETROFIT RECOMMENDATIONS OVERVIEW

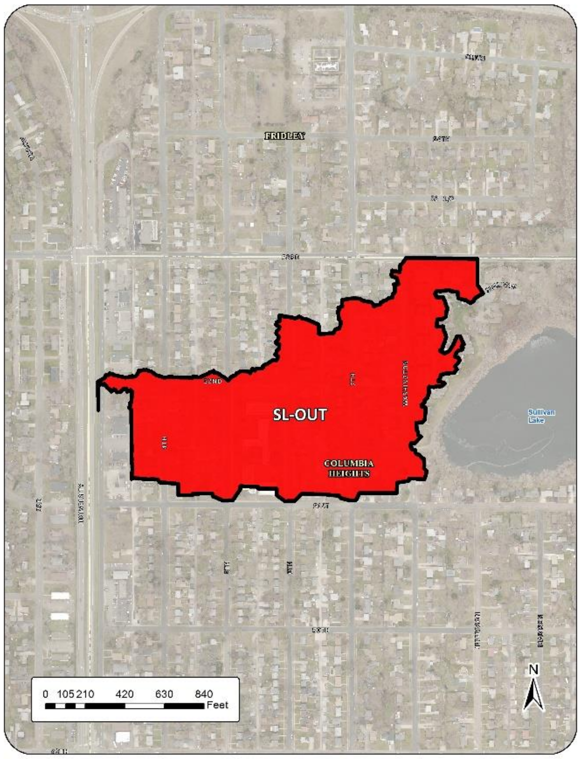
No retrofits were proposed in catchment SL-6. The entire 1.3-acre drainage area drains to an infiltration basin where it receives water quality treatment. Little opportunity remains for retrofit of an additional stormwater control measure or additional treatment.

RETROFIT RECOMMENDATIONS



Catchment SL-OUT

Existing Catchment Summary	
Acres	31.8
Parcels	246
Land Cover	99.9% Residential 0.06% Open Space 0.03% Freeway



CATCHMENT DESCRIPTION

The stormwater infrastructure throughout this catchment is positioned 'downstream' of the Sullivan Lake outlet. Therefore, stormwater conveyed through the storm sewer lines is discharged directly to the Mississippi River. Medium density residential is the primary land use throughout the catchment. The Minnesota Kids campus is located in the south-central area of the catchment, and portions of the Sullivan Shores Townhomes are located in the northeast part of the catchment.

EXISTING STORMWATER TREATMENT

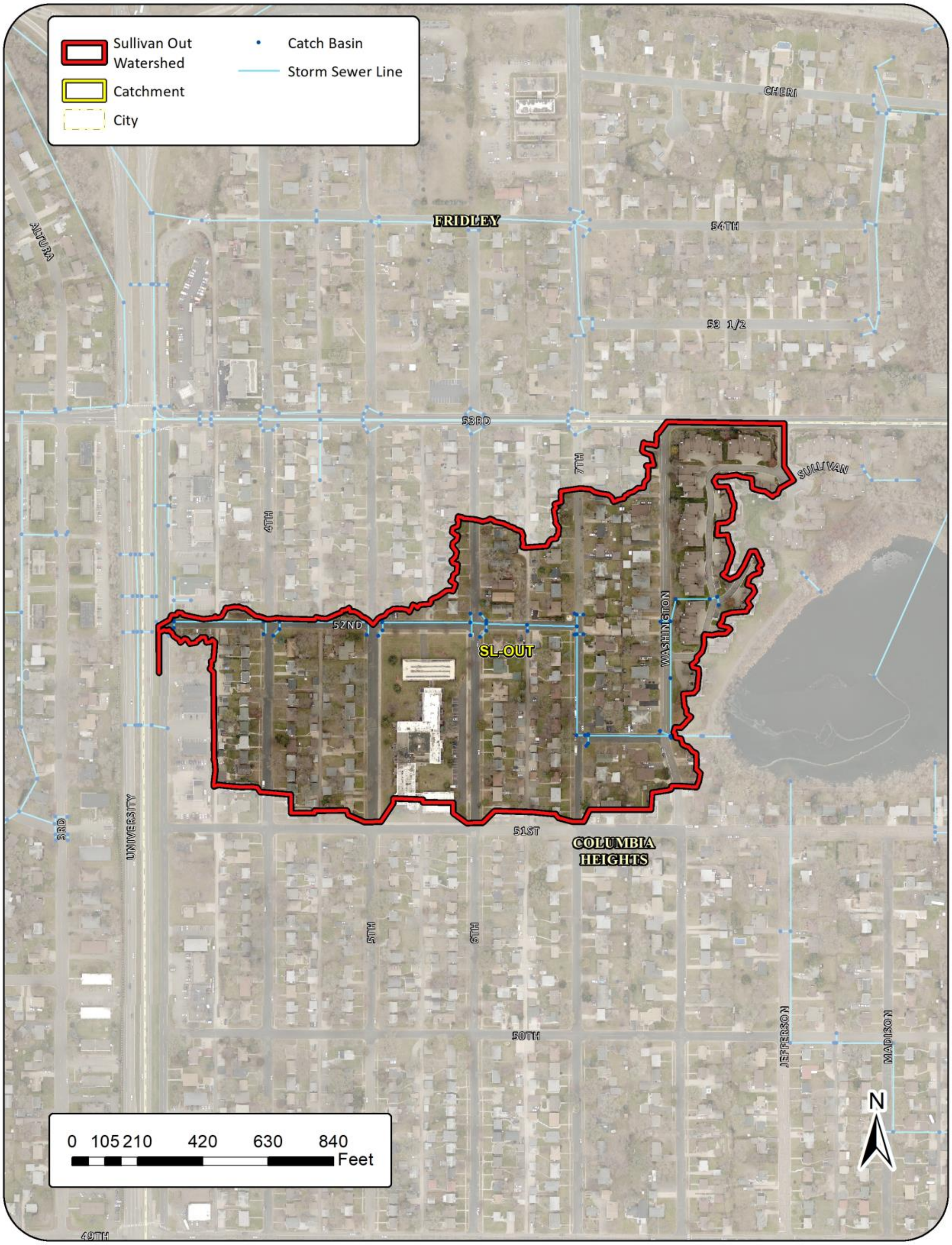
The primary stormwater treatment in the catchment is street cleaning, performed four times per year by the City of Columbia Heights. Present-day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	1			
	BMP Types	Street Cleaning			
	TP (lb/yr)	20.8	2.6	12%	**18.2**
	TSS (lb/yr)	6,951	1,106	16%	**5,845**
	Volume (acre-feet/yr)	18.6	0.0	0%	**18.6**

RETROFIT RECOMMENDATIONS OVERVIEW

Six bioinfiltration basins were proposed in catchment SL-OUT. Details are provided in the following project profile pages.

EXISTING STORMWATER TREATMENT

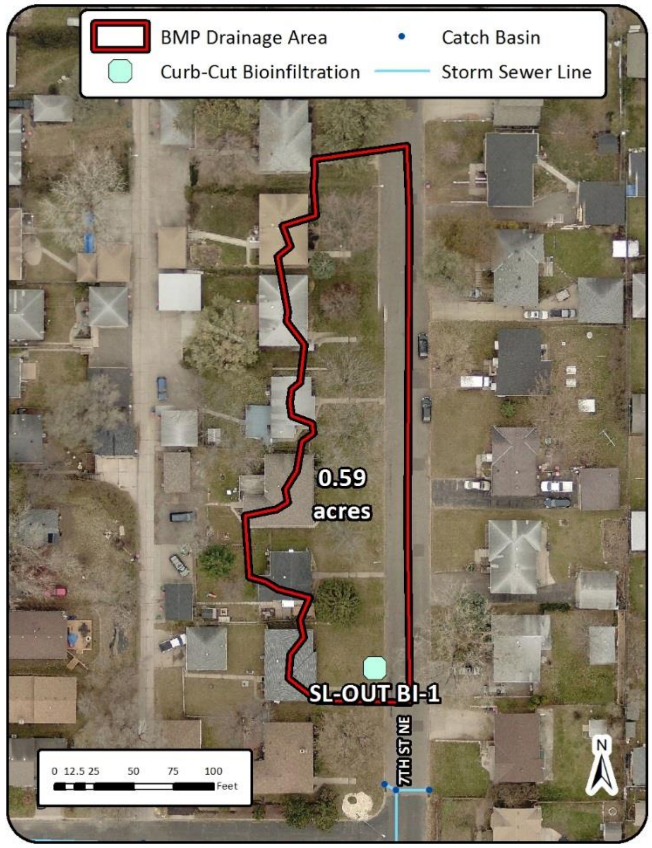


NETWORK RETROFIT RECOMMENDATIONS

Project ID: SL-OUT BI-1

7th Street NE
Bioinfiltration Basin

Drainage Area – 0.6 acres
Location – West side of 7th Street NE north of 52nd Avenue NE
Property Ownership – Private
Site Specific Information – Stormwater runoff from residential properties could be treated using bioretention. Because of the sandy soils in this catchment, bioinfiltration is preferred. The table below provides pollutant removals and estimated costs.



	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.3	1.4%
	TSS (lb/yr)	75	1.3%
	Volume (acre-feet/yr)	0.20	1.1%
Cost	**Administration & Promotion Costs***	$584	
	Design & Construction Costs**	$9,420	
	Total Estimated Project Cost (2019)	**$10,004**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$2,234**	
	30-yr Average Cost/1,000lb-TSS	**$7,446**	
	30-yr Average Cost/ac-ft Vol.	**$2,792**	

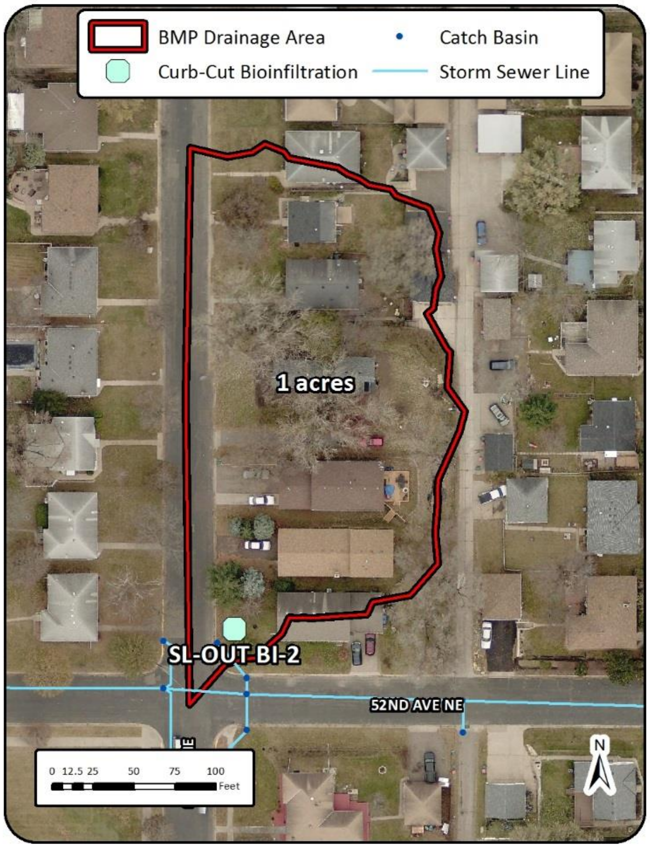
*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $73/hour for design)

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

Project ID: SL-OUT BI-2

6th Street NE
Bioinfiltration Basin



Drainage Area – 1.0 acres
Location – Northeast corner of intersection between 52nd Avenue NE and 6th Street NE
Property Ownership – Private
Site Specific Information – Stormwater runoff from residential properties could be treated using bioretention. Because of the sandy soils in this catchment, bioinfiltration is preferred. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.3	1.9%
	TSS (lb/yr)	102	1.7%
	Volume (acre-feet/yr)	0.27	1.5%
Cost	**Administration & Promotion Costs***	$584	
	Design & Construction Costs**	$9,420	
	Total Estimated Project Cost (2019)	**$10,004**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,643**	
	30-yr Average Cost/1,000lb-TSS	**$5,475**	
	30-yr Average Cost/ac-ft Vol.	**$2,068**	

*Indirect Cost: (8 hours at $73/hour base cost)

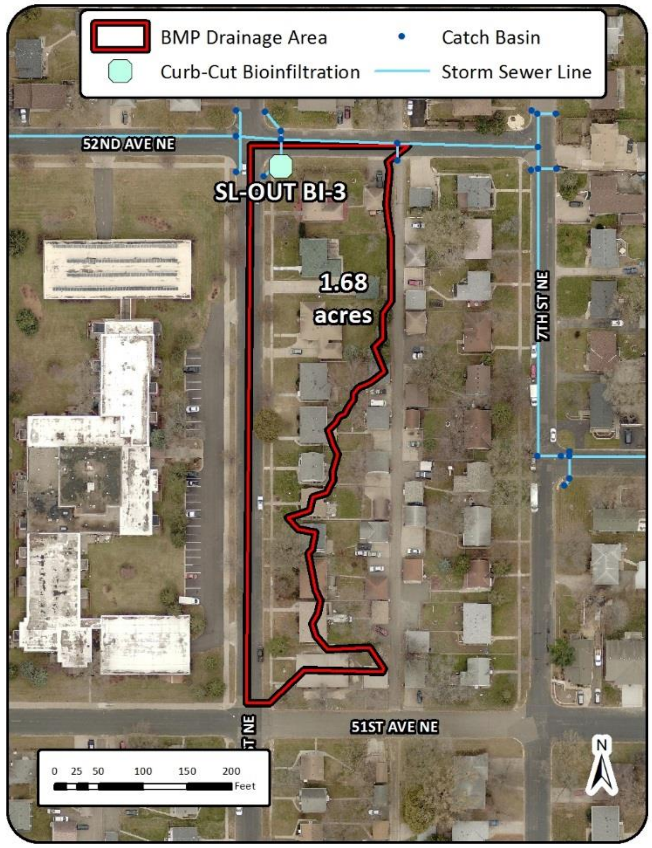
**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $73/hour for design)

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

Project ID: SL-OUT BI-3

6th Street NE
Bioinfiltration Basin

Drainage Area – 1.7 acres
Location – Southeast corner of intersection between 52nd Avenue NE and 6th Street NE
Property Ownership – Private
Site Specific Information – Stormwater runoff from residential properties could be treated using bioretention. Because of the sandy soils in this catchment, bioinfiltration is preferred. The table below provides pollutant removals and estimated costs.



	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.4	2.3%
	TSS (lb/yr)	133	2.3%
	Volume (acre-feet/yr)	0.37	2.0%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$9,420
	Total Estimated Project Cost (2019)		**$10,004**
	Annual O&M***		$225
Efficiency	**30-yr Average Cost/lb-TP**	**$1,330**	
	30-yr Average Cost/1,000lb-TSS	**$4,199**	
	30-yr Average Cost/ac-ft Vol.	**$1,526**	

*Indirect Cost: (8 hours at $73/hour base cost)

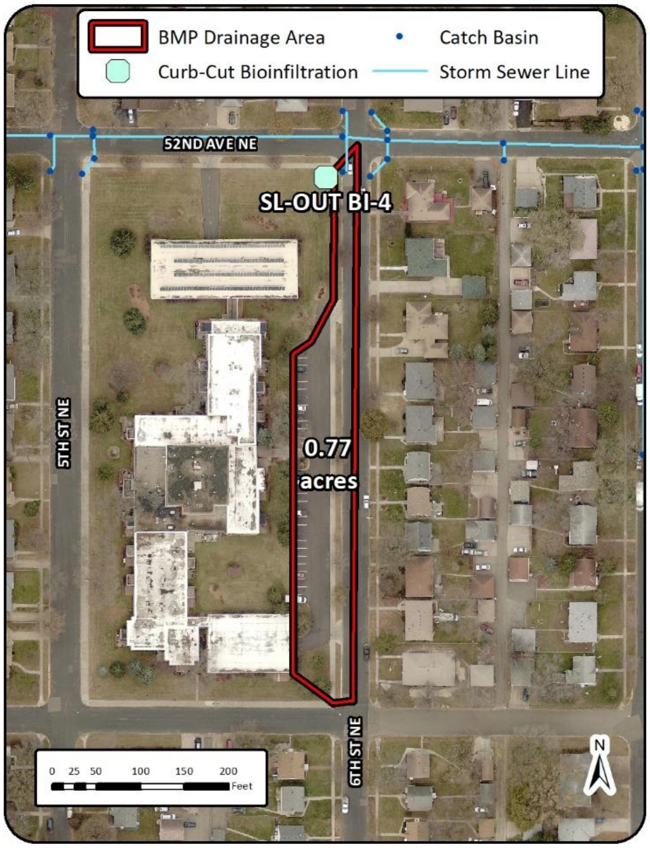
**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $73/hour for design)

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

Project ID: SL-OUT BI-4

6th Street NE Bioinfiltration Basin

Drainage Area – 0.8 acres
Location – Southwest corner of intersection between 52nd Avenue NE and 6th Street NE
Property Ownership – Private
Site Specific Information – Stormwater runoff from residential properties could be treated using bioretention. Because of the sandy soils in this catchment, bioinfiltration is preferred. The table below provides pollutant removals and estimated costs.



	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.3	1.7%
	TSS (lb/yr)	114	2.0%
	Volume (acre-feet/yr)	0.51	2.8%
Cost	**Administration & Promotion Costs***	$584	
	Design & Construction Costs**	$9,420	
	Total Estimated Project Cost (2019)	**$10,004**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,802**	
	30-yr Average Cost/1,000lb-TSS	**$4,899**	
	30-yr Average Cost/ac-ft Vol.	**$1,089**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $73/hour for design)

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

Project ID: SL-OUT BI-5

5th Street NE
Bioinfiltration Basin

Drainage Area – 3.7 acres
Location – Southeast corner of intersection between 52nd Avenue NE and 5th Street NE
Property Ownership – Private
Site Specific Information – Stormwater runoff from the Minnesota Kids campus could be treated using bioretention. Because of the sandy soils in this catchment, bioinfiltration is preferred. The table below provides pollutant removals and estimated costs.

Curb-Cut Bioinfiltration

	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.5	2.5%
	TSS (lb/yr)	168	2.9%
	Volume (acre-feet/yr)	0.51	2.8%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$9,420
	Total Estimated Project Cost (2019)		**$10,004**
	Annual O&M***		$225
Efficiency	**30-yr Average Cost/lb-TP**	**$1,241**	
	30-yr Average Cost/1,000lb-TSS	**$3,324**	
	30-yr Average Cost/ac-ft Vol.	**$1,089**	

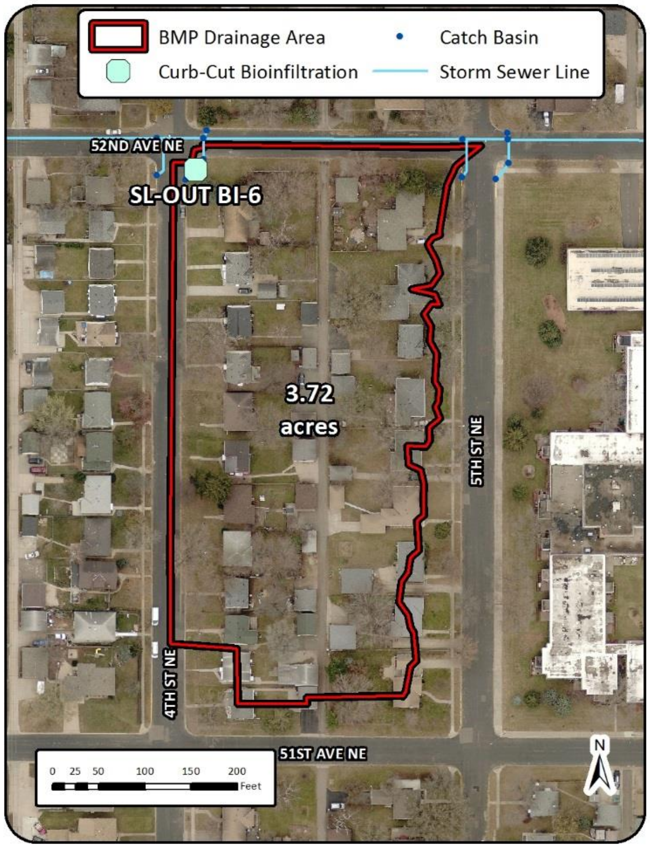
*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $73/hour for design)

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

Project ID: SL-OUT BI-6

4th Street NE Bioinfiltration Basin



Drainage Area – 3.7 acres
Location – Southeast corner of intersection between 52nd Avenue NE and 4th Street NE
Property Ownership – Private
Site Specific Information – Stormwater runoff from residential properties could be treated using bioretention. Because of the sandy soils in this catchment, bioinfiltration is preferred. The table below provides pollutant removals and estimated costs.

Curb-Cut Bioinfiltration

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Total Size of BMPs	250	sq-ft
	TP (lb/yr)	0.6	3.0%
	TSS (lb/yr)	169	2.9%
	Volume (acre-feet/yr)	0.44	2.4%
Cost	Administration & Promotion Costs*		$584
	Design & Construction Costs**		$9,420
	Total Estimated Project Cost (2019)		**$10,004**
	Annual O&M***		$225
Efficiency	30-yr Average Cost/lb-TP	**$1,015**	
	30-yr Average Cost/1,000lb-TSS	**$3,305**	
	30-yr Average Cost/ac-ft Vol.	**$1,257**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $73/hour for design)

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

Clover Pond Drainage Network

Catchment ID	Page
HL-CLOVER-DD	214
HL-CLOVER-1	216

Existing Network Summary	
Acres	10.7
Dominant Land Cover	Park
Volume (ac-ft/yr)	5.1
TP (lb/yr)	8.2
TSS (lb/yr)	1,961

DRAINAGE NETWORK SUMMARY

The Clover Pond drainage network consists of approximately 14 acres divided between two catchments: the shoreline area that drains directly to the pond and a single stormwater pipe inlet in the northeast corner of the pond. Highland Lake also outlets to Clover Pond in the southeast corner of the pond.

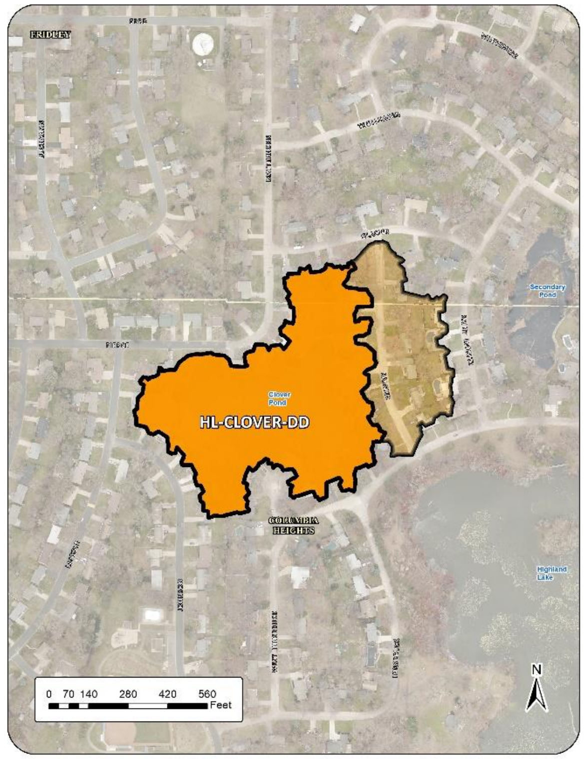
EXISTING STORMWATER TREATMENT

Clover Pond is a stormwater pond and the City of Columbia Heights and City of Fridley conduct street cleaning. Additional detail is provided in the Catchment Profiles.

NETWORK RETROFIT RECOMMENDATIONS

Catchment HL-CLOVER-DD

Existing Catchment Summary	
Acres	6.9
Parcels	32
Land Cover	69.7% Residential 30.3% Open Space



CATCHMENT DESCRIPTION

This catchment consists entirely of medium density residential backyards that drain directly to Clover Pond. Inlets exist on the northeast corner of the pond (Rainier Pass NE storm sewer inlet) and the southeast corner (Highland Lake outlet). A single outlet exists in the northwest corner, which ultimately discharges into Sullivan Lake.

EXISTING STORMWATER TREATMENT

Clover Pond is a stormwater pond. It provides treatment of stormwater for roadway runoff from Rainier Pass NE as well. Water that exits Highland Lake also passes through Clover Pond. 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)	13.9	1.2	8%	**12.7**
	TSS (lb/yr)	3,549	507	14%	**3,042**
	Volume (acre-feet/yr)	7.9	0.0	0%	**7.9**

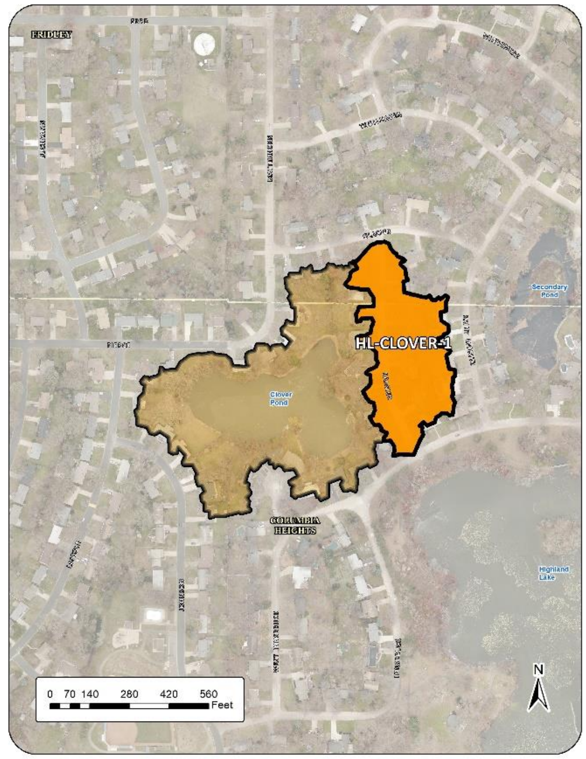
RETROFIT RECOMMENDATIONS OVERVIEW

No retrofits were proposed in catchment HL-CLOVER-DD.

RETROFIT RECOMMENDATIONS

Catchment HL-CLOVER-1

Existing Catchment Summary	
Acres	3.8
Parcels	21
Land Cover	100% Residential



CATCHMENT DESCRIPTION

Highland Lake outlets to Clover Pond. In addition to the nearshore, direct drainage area, HL-CLOVER-1 has a single storm sewer input that directs runoff into the pond from the residential properties along Rainier Pass NE.

EXISTING STORMWATER TREATMENT

The primary stormwater treatment in the catchment is street cleaning, performed four times per year by the City of Columbia Heights and the City of Fridley. In addition, runoff enters Clover Pond, which provides treatment prior to entering storm sewer pipe that ultimately discharges into Sullivan Lake. 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)	3.2	0.3	8%	**2.9**
	TSS (lb/yr)	813	116	14%	**697**
	Volume (acre-feet/yr)	1.8	0.0	0%	**1.8**

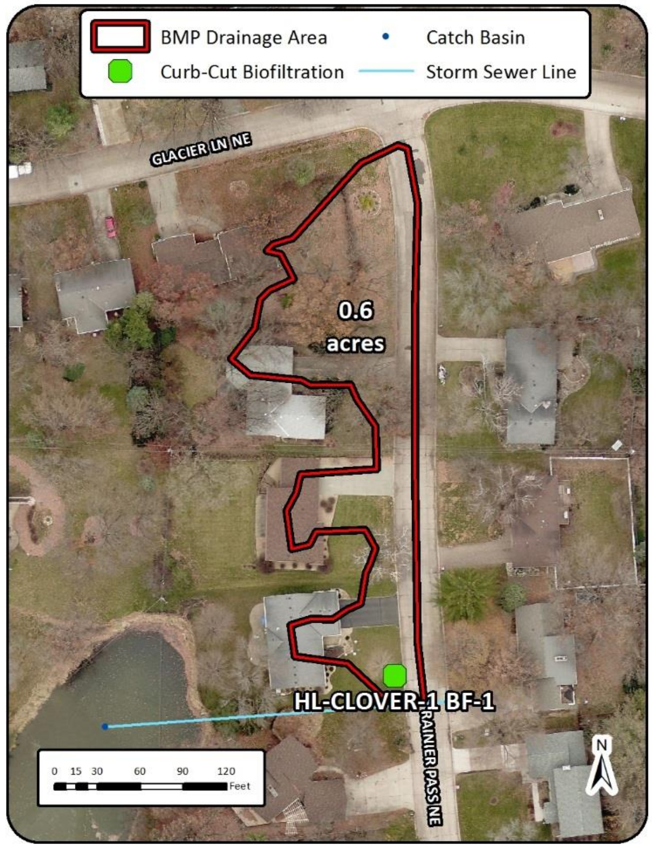
RETROFIT RECOMMENDATIONS OVERVIEW

Three biofiltration basins were proposed in catchment HL-CLOVER-1. Details are provided in the following project profile pages.

RETROFIT RECOMMENDATIONS

Project ID:
HL-CLOVER-1 BF-1
Rainier Pass NE
Biofiltration Basin

Drainage Area – 0.6 acres
Location – West side of Rainier Pass NE south of Glacier Lane NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.



	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq-ft
	TP (lb/yr)	0.13	4.5%
	TSS (lb/yr)	42	6.0%
	Volume (acre-feet/yr)	0.04	2.2%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$5,052**	
	30-yr Average Cost/1,000lb-TSS	**$15,757**	
	30-yr Average Cost/ac-ft Vol.	**$16,545**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID:
HL-CLOVER-1 BF-2
Rainier Pass NE
Biofiltration Basin

Drainage Area – 0.5 acres
Location – West side of Rainier Pass NE north of Innsbruck Parkway NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq-ft
	TP (lb/yr)	0.12	4.3%
	TSS (lb/yr)	40	5.7%
	Volume (acre-feet/yr)	0.04	2.1%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$5,337**	
	30-yr Average Cost/1,000lb-TSS	**$16,545**	
	30-yr Average Cost/ac-ft Vol.	**$17,325**	

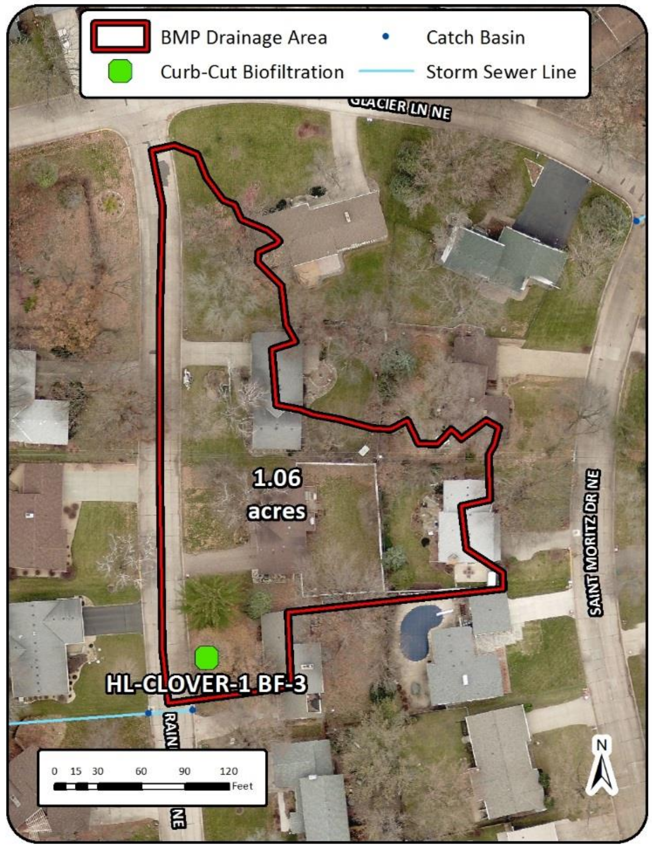
*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID:
HL-CLOVER-1 BF-3
Rainier Pass NE
Biofiltration Basin

Drainage Area – 1.1 acres
Location – East side of Rainier Pass NE south of Glacier Lane NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.



	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq-ft
	TP (lb/yr)	0.17	5.7%
	TSS (lb/yr)	55	7.9%
	Volume (acre-feet/yr)	0.05	2.6%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$3,963**	
	30-yr Average Cost/1,000lb-TSS	**$12,033**	
	30-yr Average Cost/ac-ft Vol.	**$14,214**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Secondary Pond Drainage Network

Catchment ID	Page
HL-SECONDARY-DD	223
HL-SECONDARY-1	225

Existing Network Summary	
Acres	7.9
Dominant Land Cover	Residential
Volume (ac-ft/yr)	3.5
TP (lb/yr)	5.3
TSS (lb/yr)	1,160

DRAINAGE NETWORK SUMMARY

The Secondary Pond drainage network consists of approximately 10 acres divided between two catchments: the shoreline area that drains directly to the pond and a single stormwater pipe inlet on the south side of the pond. Highland Lake also outlets to Clover Pond through that stormwater pipe.

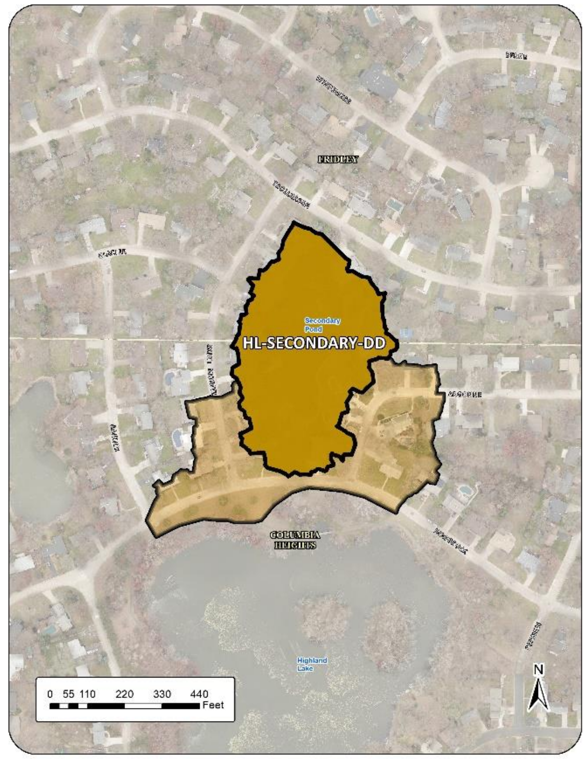
EXISTING STORMWATER TREATMENT

Secondary Pond is a stormwater pond and the City of Columbia Heights conducts street cleaning. Additional detail is provided in the Catchment Profiles.

NETWORK RETROFIT RECOMMENDATIONS

Catchment HL-SECONDARY-DD

Existing Catchment Summary	
Acres	3.3
Parcels	16
Land Cover	61.2% Residential 38.8% Open Space



CATCHMENT DESCRIPTION

This catchment consists of the near-pond areas that discharge directly into Secondary Pond. The pond outlet is located on the north side of the catchment near Trollhagen Drive NE.

EXISTING STORMWATER TREATMENT

Secondary Pond is a stormwater pond. It provides treatment for runoff from Saint Moritz Drive NE, Argonne Drive NE, and Innsbruck Parkway NE. Highland Lake also outlets to Secondary Pond. 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)	2.7	0.5	17%	**2.2**
	TSS (lb/yr)	695	202	29%	**493**
	Volume (acre-feet/yr)	1.5	0.0	0%	**1.5**

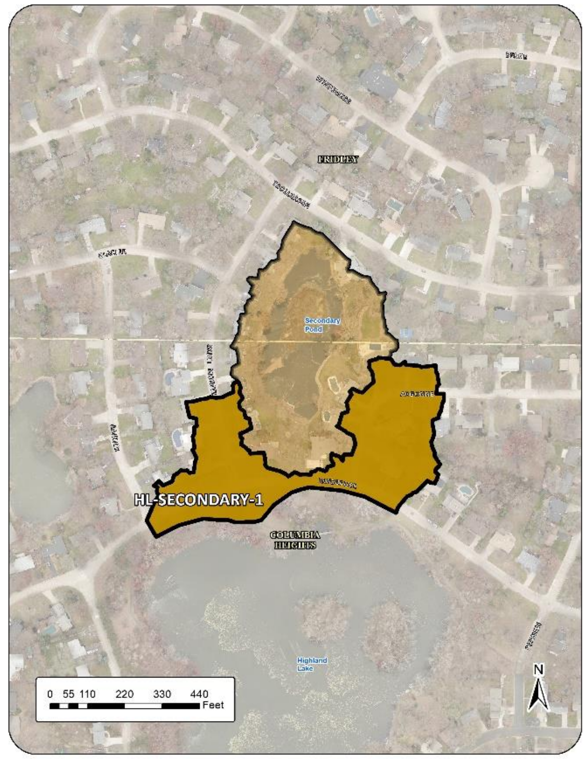
RETROFIT RECOMMENDATIONS OVERVIEW

No retrofits were proposed in catchment HL-SECONDARY-DD.

RETROFIT RECOMMENDATIONS

Catchment HL-SECONDARY-1

Existing Catchment Summary	
Acres	4.6
Parcels	18
Land Cover	80.5% Residential 19.5% Open Space



CATCHMENT DESCRIPTION

This catchment is located just south of Secondary Pond and consists of medium density residential land use. Catch basins along Innsbruck Parkway NE near its intersection with Saint Moritz Drive NE and Argonne Drive NE collect runoff and route it into Secondary Pond via the storm sewer line.

EXISTING STORMWATER TREATMENT

The primary stormwater treatment in the catchment is street cleaning, performed four times per year by the City of Columbia Heights. 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)	3.7	0.6	16%	**3.1**
	TSS (lb/yr)	916	249	27%	**667**
	Volume (acre-feet/yr)	2.0	0.0	0%	**2.0**

RETROFIT RECOMMENDATIONS OVERVIEW

Three biofiltration basins, one bioinfiltration basin, and one hydrodynamic device were proposed in catchment HL-SECONDARY-1. Details are provided on the following project profile pages.

RETROFIT RECOMMENDATIONS

Project ID:
HL-SECONDARY-1 BF-1
Innsbruck Parkway NE
Biofiltration Basin

Drainage Area – 0.6 acres
Location – North side of Innsbruck Parkway east of intersection with Saint Moritz Drive NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq-ft
	TP (lb/yr)	0.11	3.4%
	TSS (lb/yr)	32	4.8%
	Volume (acre-feet/yr)	0.04	2.0%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$6,243**	
	30-yr Average Cost/1,000lb-TSS	**$20,681**	
	30-yr Average Cost/ac-ft Vol.	**$16,969**	

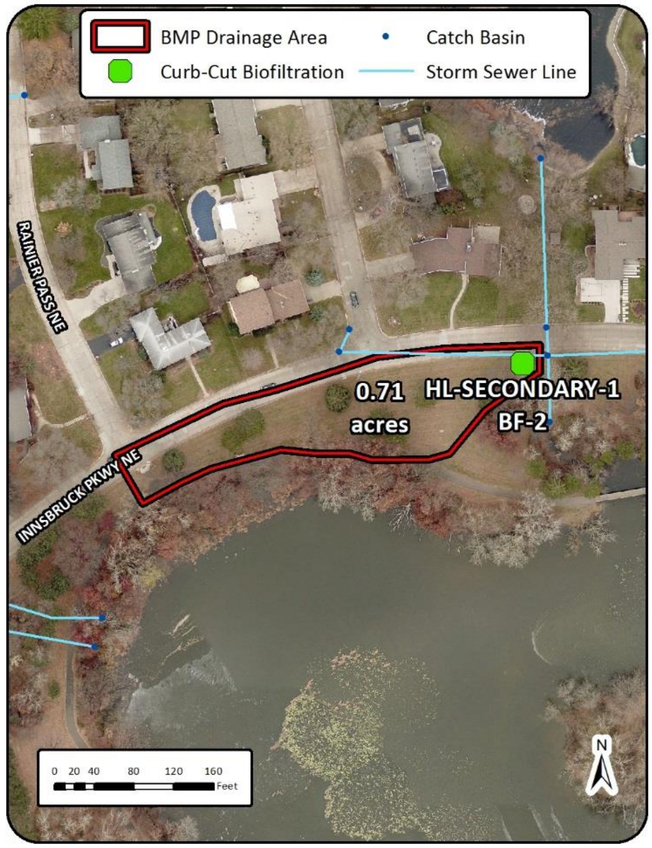
*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID:
HL-SECONDARY-1 BF-2
Innsbruck Parkway NE
Biofiltration Basin

Drainage Area – 0.7 acres
Location – South side of Innsbruck Parkway NE east of intersection with Saint Moritz Drive NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.



	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq-ft
	TP (lb/yr)	0.11	3.7%
	TSS (lb/yr)	32	4.8%
	Volume (acre-feet/yr)	0.03	1.6%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$5,857**	
	30-yr Average Cost/1,000lb-TSS	**$20,681**	
	30-yr Average Cost/ac-ft Vol.	**$20,877**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID:
HL-SECONDARY-1 BF-3
Argonne Drive NE
Biofiltration Basin

Drainage Area – 1.4 acres
Location – Northeast corner of intersection between Innsbruck Parkway NE and Argonne Drive NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq-ft
	TP (lb/yr)	0.15	4.7%
	TSS (lb/yr)	45	6.7%
	Volume (acre-feet/yr)	0.05	2.5%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$4,533**	
	30-yr Average Cost/1,000lb-TSS	**$14,707**	
	30-yr Average Cost/ac-ft Vol.	**$13,115**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID:
HL-SECONDARY-1 BI-1
Argonne Drive NE
Bioinfiltration Basin

Drainage Area – 0.8 acres
Location – Northwest corner of intersection between Innsbruck Parkway NE and Argonne Drive NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration is preferred. However, optimal sites are not necessarily adjacent to an existing catch basin to serve as the connection point for an underdrain outlet. This basin is proposed to rely on infiltration, and the infiltration rate and ponding depth were adjusted accordingly to reflect the native soil infiltration rates and ensure drawdown in less than 48 hours. 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)	0.14	4.6%
	TSS (lb/yr)	36	5.4%
	Volume (acre-feet/yr)	0.12	6.1%
Cost	**Administration & Promotion Costs***	$584	
	Design & Construction Costs**	$9,420	
	Total Estimated Project Cost (2019)	**$10,004**	
	Annual O&M***	$295	
Efficiency	**30-yr Average Cost/lb-TP**	**$4,395**	
	30-yr Average Cost/1,000lb-TSS	**$17,457**	
	30-yr Average Cost/ac-ft Vol.	**$5,151**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID:
HL-SECONDARY-1 HD-1
Innsbruck Parkway NE
Hydrodynamic Device

Drainage Area – 4.6 acres
Location – North side of Innsbruck Parkway NE between Saint Moritz Drive NE and Argonne Drive NE
Property Ownership – Public
Site Specific Information – A hydrodynamic device is proposed in line with the 18" storm sewer line that discharges into the south end of Secondary Pond. A device at this location would provide treatment to runoff 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**	6	ft diameter
	TP (lb/yr)	0.29	9.5%
	TSS (lb/yr)	97	14.5%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***	$3,750	
	Design & Construction Costs**	$27,000	
	Total Estimated Project Cost (2019)	**$30,750**	
	Annual O&M***	$630	
Efficiency	**30-yr Average Cost/lb-TP**	**$5,668**	
	30-yr Average Cost/1,000lb-TSS	**$17,062**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

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

**Direct Cost: ($18,000 for materials) + ($9,000 for labor and installation costs)

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

Tertiary Pond Drainage Network

Catchment ID	Page
HL-TERTIARY-DD	234
HL-TERTIARY-1	236
HL-TERTIARY-2	240
HL-TERTIARY-3	242
HL-TERTIARY-4	247
HL-TERTIARY-4L	256

Existing Network Summary	
Acres	92.1
Dominant Land Cover	Residential
Volume (ac-ft/yr)	42.1
TP (lb/yr)	67.3
TSS (lb/yr)	16,236

DRAINAGE NETWORK SUMMARY

The Tertiary Pond drainage networks is the largest of the three satellite stormwater ponds to Highland Lake (i.e. Clover, Secondary, and Tertiary) with 92.1 acres of contributing drainage area divided among six catchments. Secondary Pond outlets to Tertiary Pond via a storm sewer line located on the west side of Tertiary Pond just east of Saint Imer Drive NE.

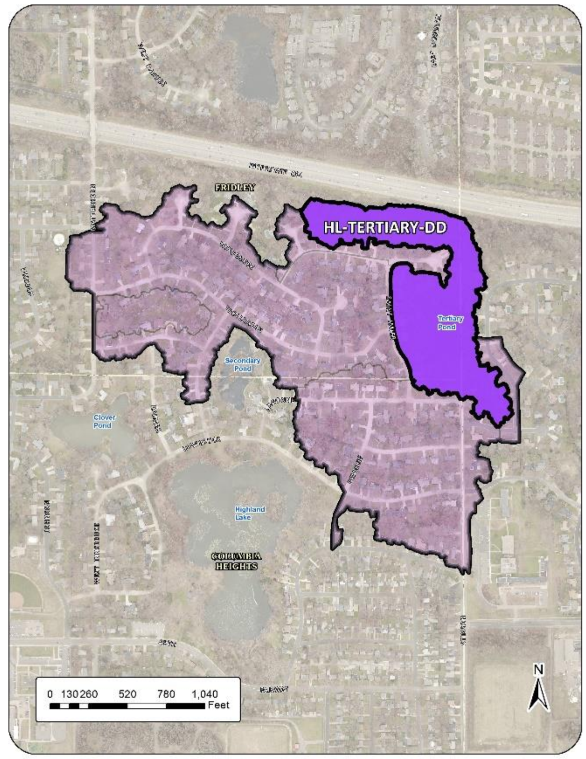
EXISTING STORMWATER TREATMENT

Tertiary Pond is a stormwater pond, and the City of Columbia Heights and the City of Fridley conduct street cleaning. Additional detail is provided in the Catchment Profiles.

NETWORK RETROFIT RECOMMENDATIONS

Catchment HL-TERTIARY-DD

Existing Catchment Summary	
Acres	3.8
Parcels	20
Land Cover	98.1% Residential 1.9% Open Space



CATCHMENT DESCRIPTION

Areas draining directly to Tertiary Pond comprise this catchment. Land use consists of medium density residential (largely backyards) and open space. There are four storm sewer outfalls to Tertiary Pond and there is no mapped outlet structure.

EXISTING STORMWATER TREATMENT

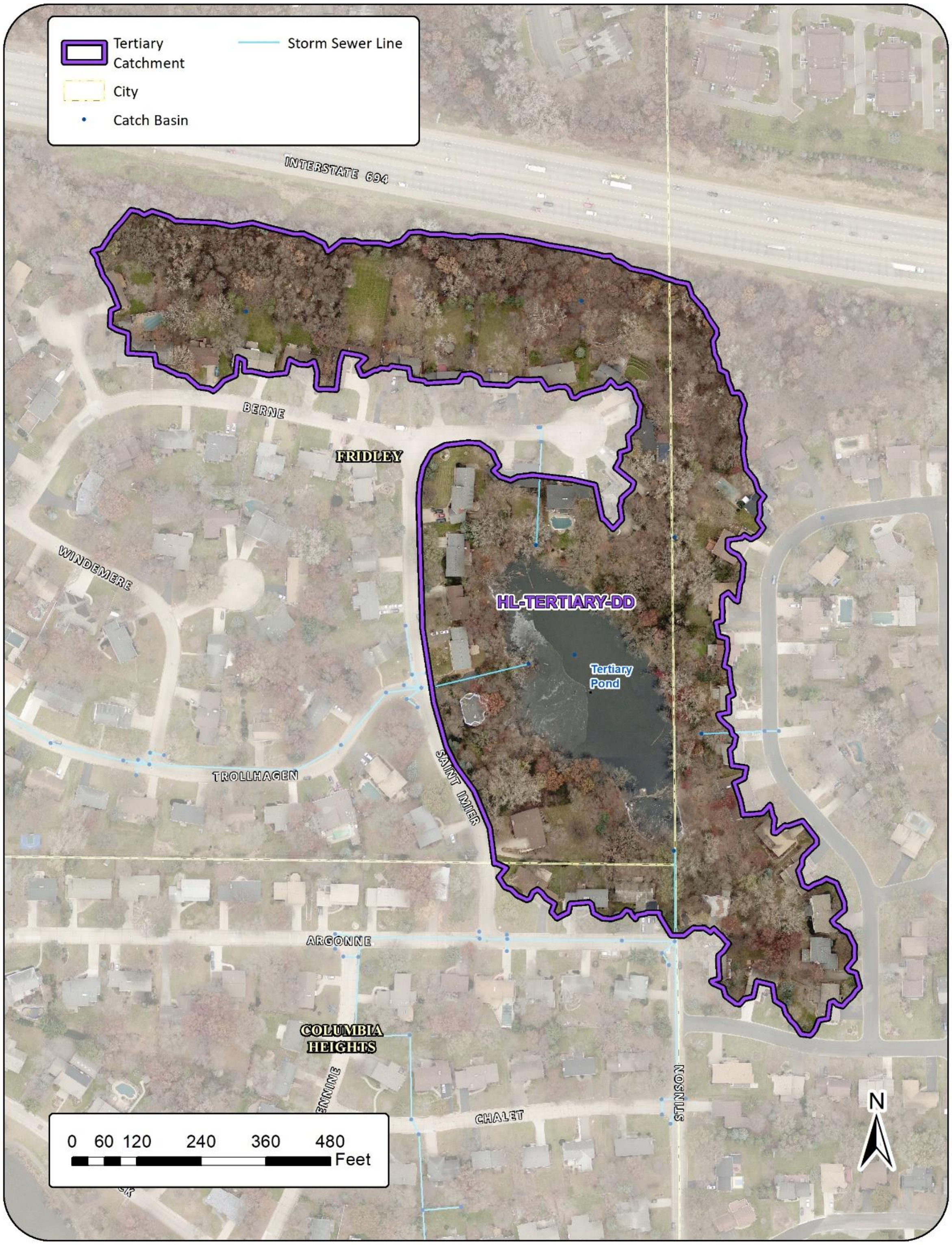
Tertiary Pond is a stormwater pond with no documented outlet. It provides treatment to runoff from two outfalls that enter the pond on the north and west sides. The outfall on the west side also conveys water from the outlet of Secondary Pond. Present-day stormwater pollutant loading and treatment is 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)	13.9	1.2	8%	**12.7**
	TSS (lb/yr)	3,549	507	14%	**3,042**
	Volume (acre-feet/yr)	7.9	0.0	0%	**7.9**

RETROFIT RECOMMENDATIONS OVERVIEW

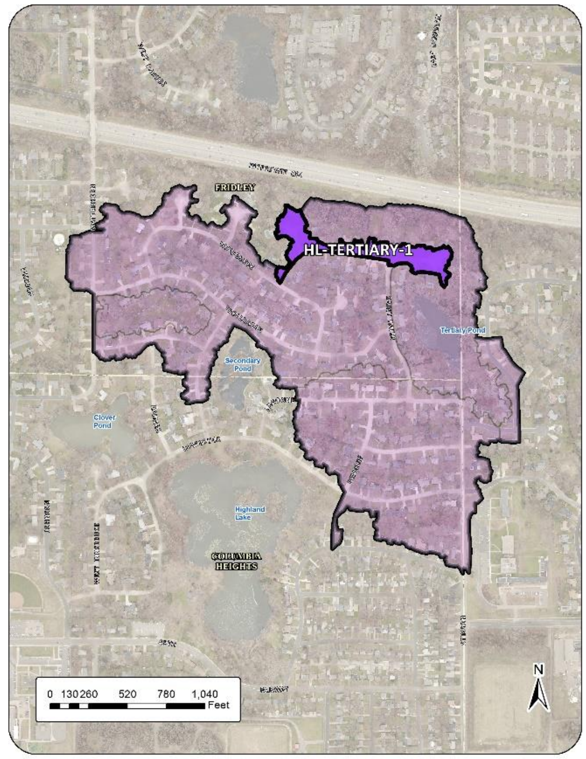
No retrofits were proposed in catchment HL-TERTIARY-DD.

RETROFIT RECOMMENDATIONS



Catchment HL-TERTIARY-1

Existing Catchment Summary	
Acres	3.8
Parcels	20
Land Cover	100% Residential



CATCHMENT DESCRIPTION

This catchment consists of the medium density residential land use located along West Berne Circle NE, Berne Road NE, and East Berne Circle NE. Catch basins near the East Berne Circle NE cul-de-sac collect runoff and route it to the north end of Tertiary Pond.

EXISTING STORMWATER TREATMENT

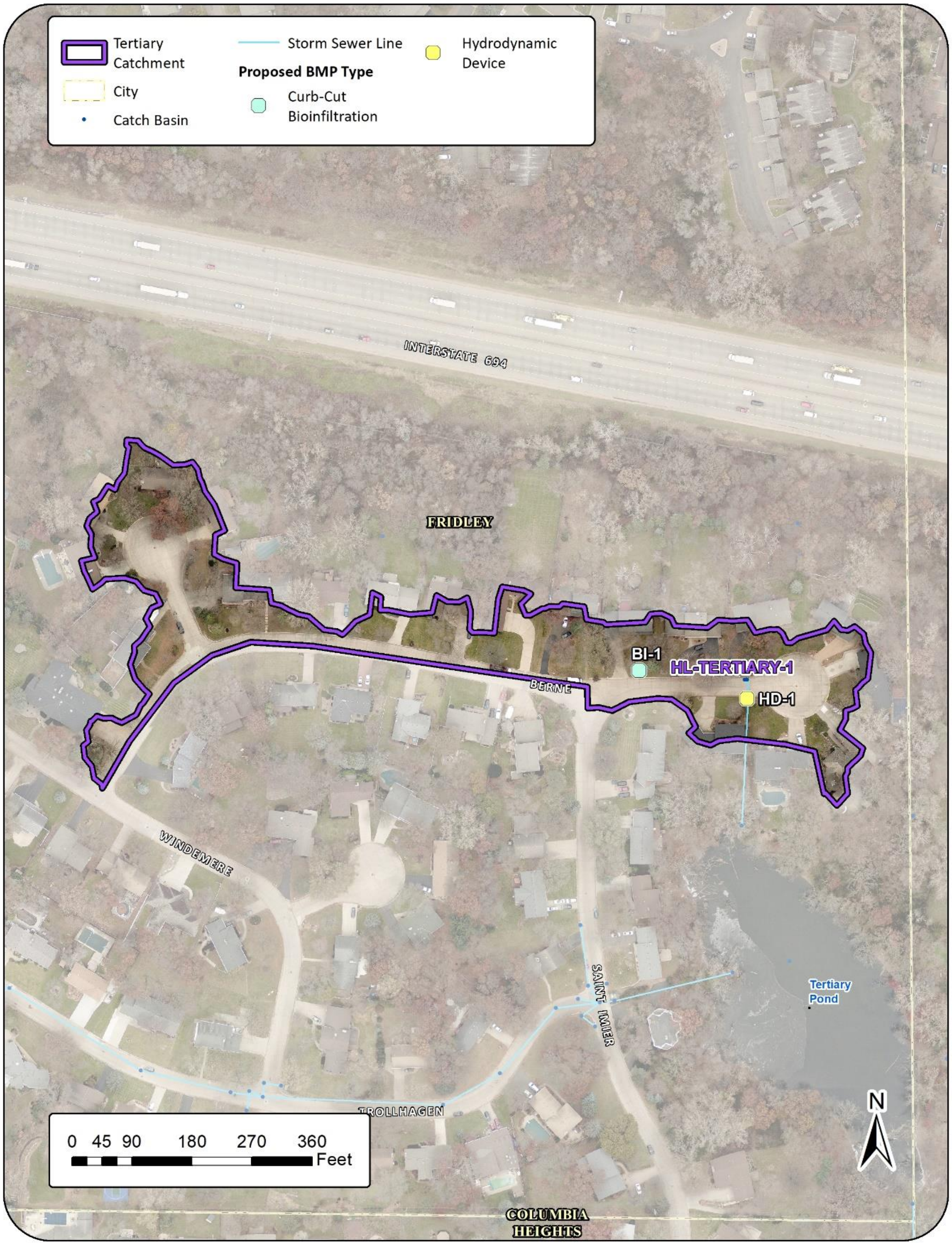
The primary stormwater treatment in the catchment is street cleaning, performed four times per year by the City of Fridley. Present-day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	1			
	BMP Types	Street Cleaning			
	TP (lb/yr)	3.2	0.3	8%	**2.9**
	TSS (lb/yr)	814	116	14%	**698**
	Volume (acre-feet/yr)	1.8	0.0	0%	**1.8**

RETROFIT RECOMMENDATIONS OVERVIEW

One bioinfiltration basin and one hydrodynamic device were proposed in catchment HL-TERTIARY-1. Details are provided in the following project profile pages.

RETROFIT RECOMMENDATIONS



Project ID:
HL-TERTIARY-1 BI-1
East Berne Circle NE
Bioinfiltration Basin

Drainage Area – 2.5 acres
Location – Northeast corner of intersection between East Berne Circle NE and Saint Imer Drive NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration is preferred. However, optimal sites are not necessarily adjacent to an existing catch basin to serve as the connection point for an underdrain outlet. This basin is proposed to rely on infiltration, and the infiltration rate and ponding depth were adjusted accordingly to reflect the native soil infiltration rates and ensure drawdown in less than 48 hours. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	7.2%
	TSS (lb/yr)	56	8.0%
	Volume (acre-feet/yr)	0.16	8.9%
Cost	**Administration & Promotion Costs***	$584	
	Design & Construction Costs**	$9,420	
	Total Estimated Project Cost (2019)	**$10,004**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$2,659**	
	30-yr Average Cost/1,000lb-TSS	**$9,973**	
	30-yr Average Cost/ac-ft Vol.	**$3,475**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $73/hour for design)

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

Project ID:
HL-TERTIARY-1 HD-1
East Berne Circle NE
Hydrodynamic Device

Drainage Area – 3.8 acres
Location – South side of East Berne Circle NE near the cul-de-sac
Property Ownership – Public
Site Specific Information – A hydrodynamic device is proposed in line with the 15" storm sewer line that discharges into the north end of Tertiary Pond. A device at this location would provide treatment to runoff 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 BMPs**	6	ft diameter
	TP (lb/yr)	0.3	10.3%
	TSS (lb/yr)	101	14.5%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***	$3,750	
	Design & Construction Costs**	$27,000	
	Total Estimated Project Cost (2019)	**$30,750**	
	Annual O&M***	$630	
Efficiency	**30-yr Average Cost/lb-TP**	**$5,517**	
	30-yr Average Cost/1,000lb-TSS	**$16,386**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

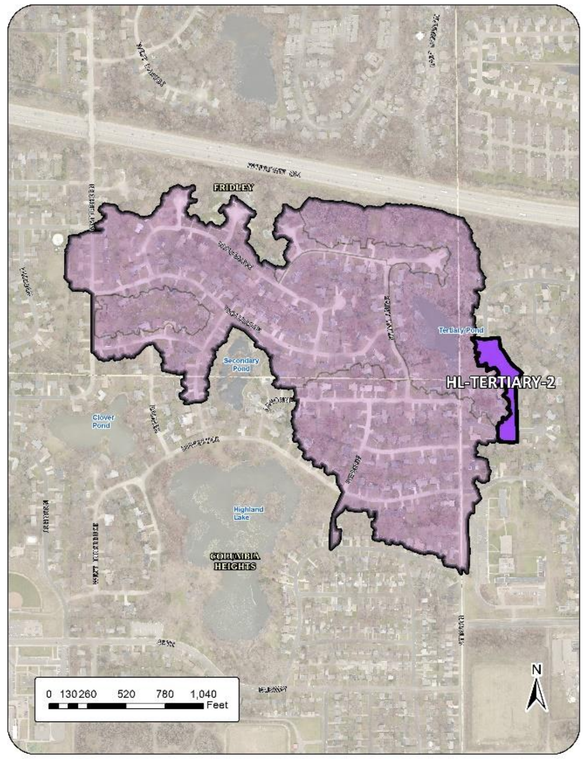
*Indirect Cost: (25 hours at $150/hour)

**Direct Cost: ($18,000 for materials) + ($9,000 for labor and installation costs)

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

Catchment HL-TERTIARY-2

Existing Catchment Summary	
Acres	2.0
Parcels	14
Land Cover	100% Residential



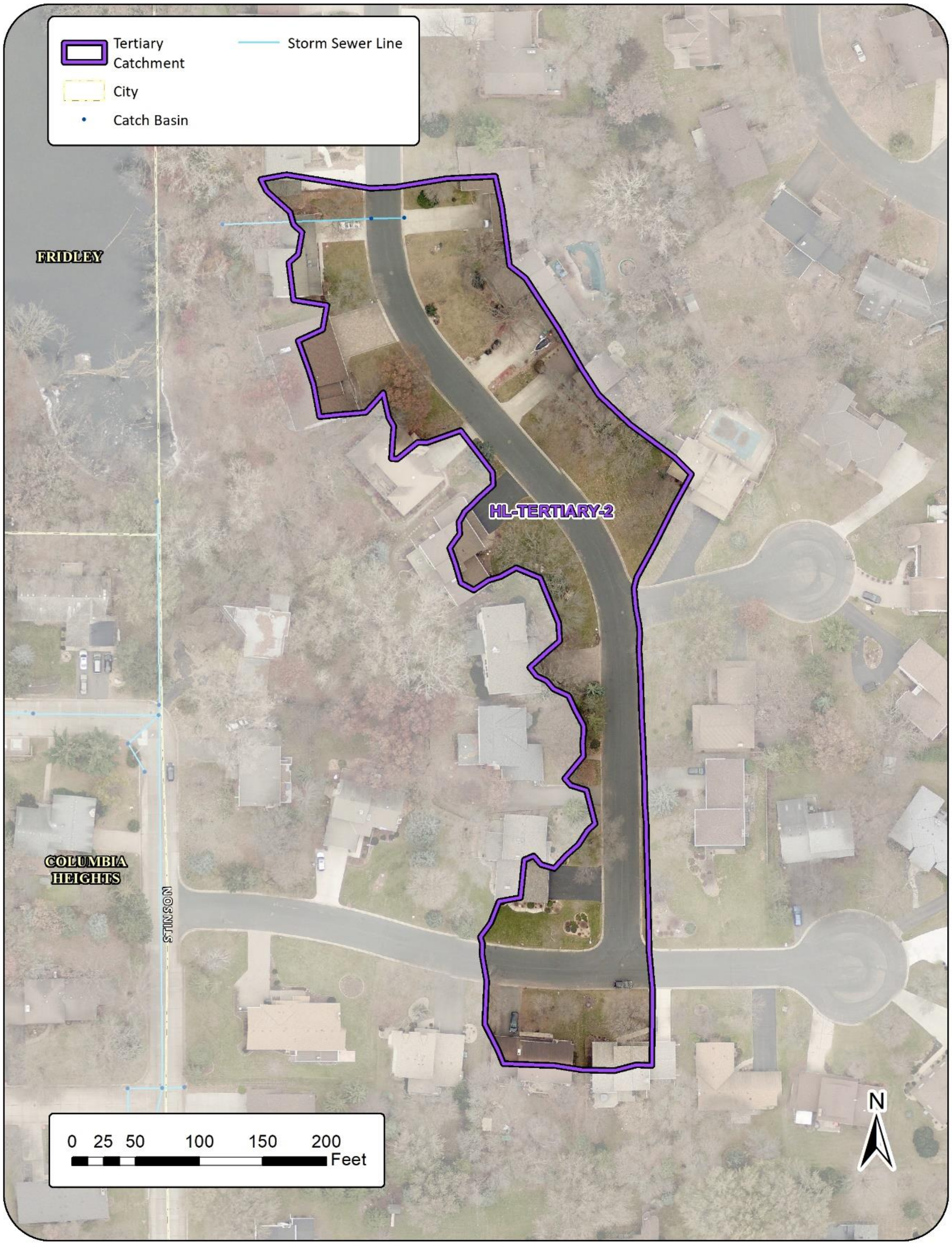
CATCHMENT DESCRIPTION
Located in New Brighton, this small catchment consists of medium density residential land use along Torchwood Drive just east of Tertiary Pond. The catch basins collect runoff and route it into the east side of Tertiary Pond via the storm sewer line.

EXISTING STORMWATER TREATMENT
The primary stormwater treatment in the catchment is street cleaning, performed by the City of New Brighton. The 2.2-acre catchment was modeled with street cleaning performed four times per year. 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)	1.7	0.1	8%	**1.5**
	TSS (lb/yr)	433	62	14%	**371**
	Volume (acre-feet/yr)	1.0	0.0	0%	**1.0**

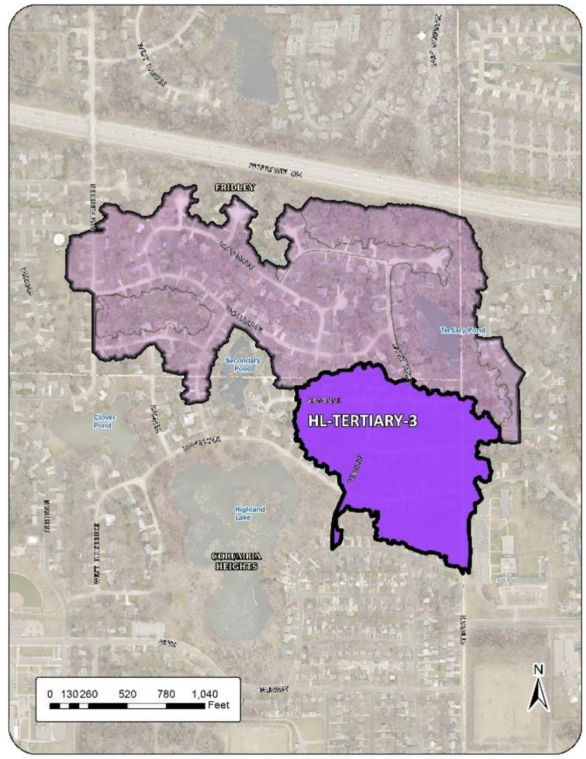
RETROFIT RECOMMENDATIONS OVERVIEW
No retrofits were proposed in catchment HL-TERTIARY-2.

RETROFIT RECOMMENDATIONS



Catchment HL-TERTIARY-3

Existing Catchment Summary	
Acres	27.1
Parcels	87
Land Cover	97.3% Residential 2.7% Institutional



CATCHMENT DESCRIPTION

Similar to the other catchments, medium density residential land use comprises HL-TERTIARY-3. Storm sewer lines convey stormwater runoff into the south end of Tertiary Pond near the point that Stinson Boulevard NE dead ends and meets Argonne Drive NE.

EXISTING STORMWATER TREATMENT

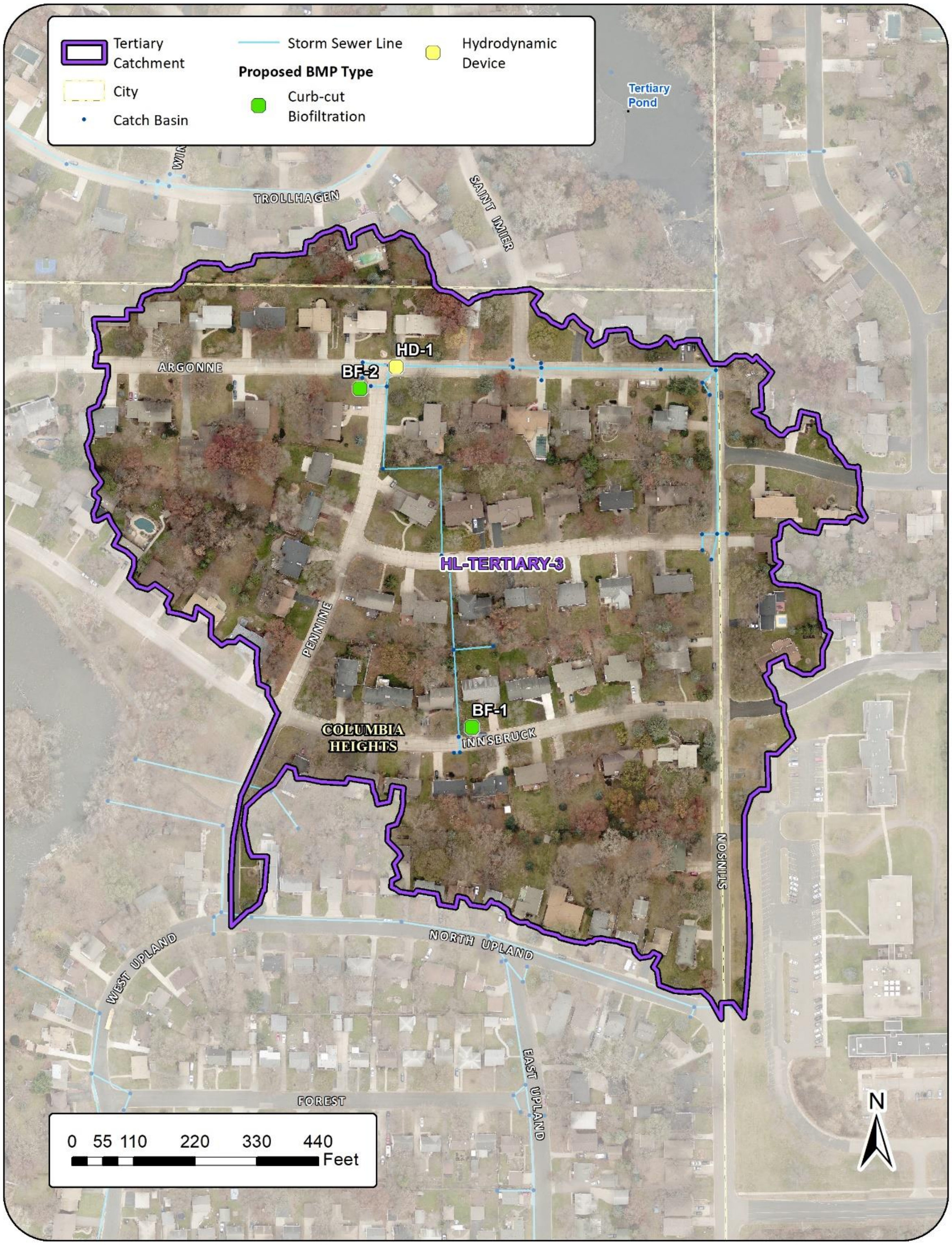
The primary stormwater treatment in the catchment is street cleaning, performed four times per year by the City of Columbia Heights. Present-day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	1			
	BMP Types	Street Cleaning			
	TP (lb/yr)	22.8	1.9	8%	**20.8**
	TSS (lb/yr)	5,944	845	14%	**5,099**
	Volume (acre-feet/yr)	13.2	0.0	0%	**13.2**

RETROFIT RECOMMENDATIONS OVERVIEW

Two biofiltration basins and one hydrodynamic device were proposed in catchment HL-TERTIARY-3. Details are provided in the following project profile pages.

RETROFIT RECOMMENDATIONS



Project ID:
HL-TERTIARY-3 BF-1
Innsbruck Parkway NE
Biofiltration Basin

Drainage Area – 0.7 acres
Location – North side of Innsbruck Parkway NE between Pennine Pass NE and Stinson Boulevard NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

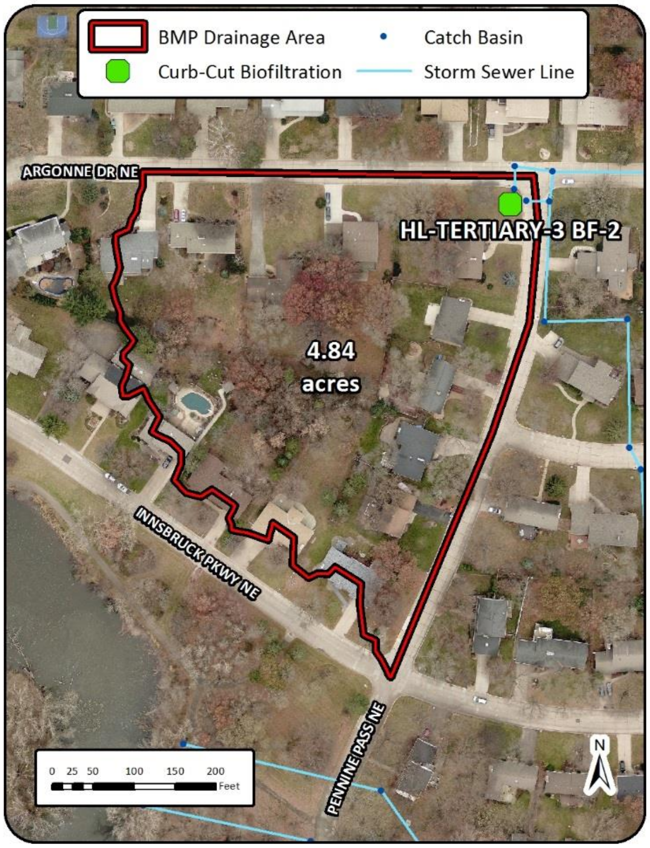
	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq-ft
	TP (lb/yr)	0.15	0.7%
	TSS (lb/yr)	46	0.9%
	Volume (acre-feet/yr)	0.05	0.3%
Cost	**Administration & Promotion Costs***	$584	
	Design & Construction Costs**	$10,420	
	Total Estimated Project Cost (2019)	**$11,004**	
	Annual O&M***	$295	
Efficiency	**30-yr Average Cost/lb-TP**	**$4,412**	
	30-yr Average Cost/1,000lb-TSS	**$14,387**	
	30-yr Average Cost/ac-ft Vol.	**$14,387**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID:
HL-TERTIARY-3 BF-2
Argonne Drive NE
Biofiltration Basin



Drainage Area – 4.8 acres
Location – Southwest corner of intersection between Argonne Drive NE and Pennine Pass NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	Total Size of BMP	250	sq-ft
	TP (lb/yr)	0.26	1.2%
	TSS (lb/yr)	85	1.7%
	Volume (acre-feet/yr)	0.07	0.5%
Cost	Administration & Promotion Costs*	$584	
	Design & Construction Costs**	$10,420	
	Total Estimated Project Cost (2019)	**$11,004**	
	Annual O&M***	$295	
Efficiency	30-yr Average Cost/lb-TP	**$2,545**	
	30-yr Average Cost/1,000lb-TSS	**$7,786**	
	30-yr Average Cost/ac-ft Vol.	**$9,605**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID:

HL-TERTIARY-3 HD-1

Argonne Drive NE
Hydrodynamic Device

Drainage Area – 15.4 acres
Location – East of intersection between Argonne Drive NE and Pennine Pass NE
Property Ownership – Public
Site Specific Information – A hydrodynamic Device is proposed in line with the storm sewer line that runs east west on Argonne Dr. NE. The structure could be placed east of the intersection between Argonne Drive NE and Pennine Pass NE. Placement at this location limits the contributing drainage area to a size that could be treated by a single hydrodynamic device. 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)	1.00	4.8%
	TSS (lb/yr)	346	6.8%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***	$3,750	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2019)	**$111,750**	
	Annual O&M***	$630	
Efficiency	**30-yr Average Cost/lb-TP**	**$4,355**	
	30-yr Average Cost/1,000lb-TSS	**$12,587**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

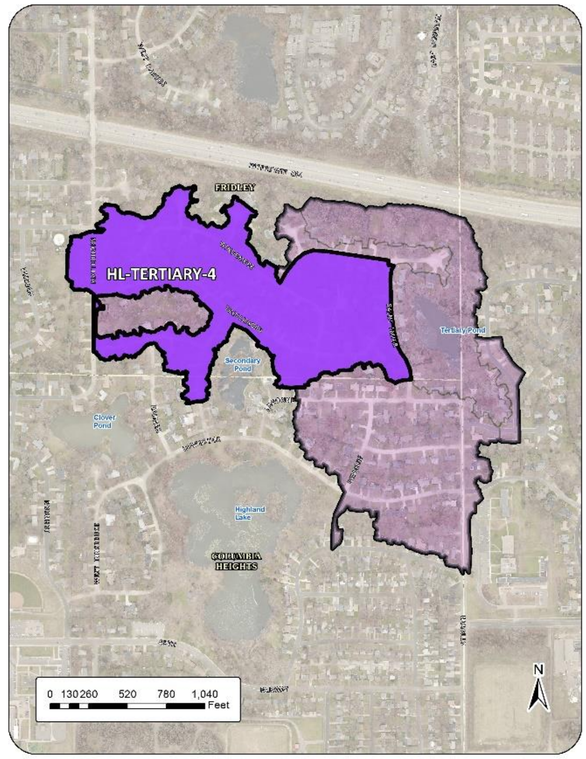
*Indirect Cost: (25 hours at $150/hour)

**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)

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

Catchment HL-TERTIARY-4

Existing Catchment Summary	
Acres	38.3
Parcels	131
Land Cover	100% Residential



CATCHMENT DESCRIPTION

The largest catchment draining to Tertiary Pond is comprised of medium density residential land use. Largely consisting of the streets Berne, Windemere Drive NE, Trollhagen Drive NE, and Glacier Ln. NE, stormwater runoff is routed to the west side of Tertiary Pond via the primary storm sewer line along Trollhagen Drive NE.

EXISTING STORMWATER TREATMENT

The primary stormwater treatment in the catchment is street cleaning, performed four times per year by the City of Fridley. Present-day stormwater pollutant loading and treatment is summarized in the table below.

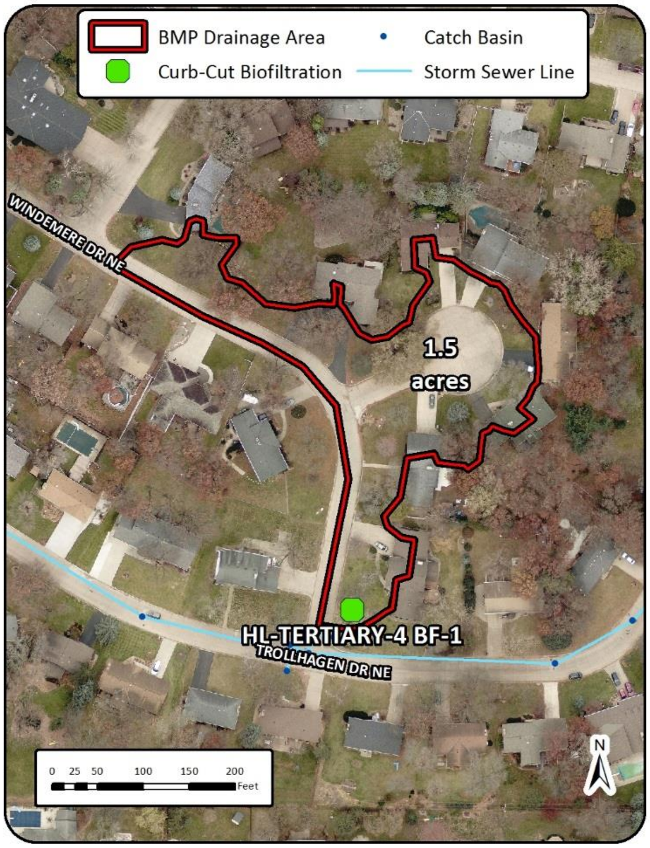
	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	1			
	BMP Types	Street Cleaning			
	TP (lb/yr)	32.0	2.7	8%	**29.3**
	TSS (lb/yr)	8,198	1,172	14%	**7,026**
	Volume (acre-feet/yr)	18.2	0.0	0%	**18.2**

RETROFIT RECOMMENDATIONS OVERVIEW

Four biofiltration basins, two bioinfiltration basins, and one hydrodynamic device were proposed in catchment HL-TERTIARY-4. Details are provided in the following catchment profile pages.

RETROFIT RECOMMENDATIONS

Project ID:
HL-TERTIARY-4 BF-1
Windemere Drive NE
Biofiltration Basin



Drainage Area – 1.5 acres
Location – Northeast corner of intersection between Trollhagen Drive NE and Windemere Drive NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

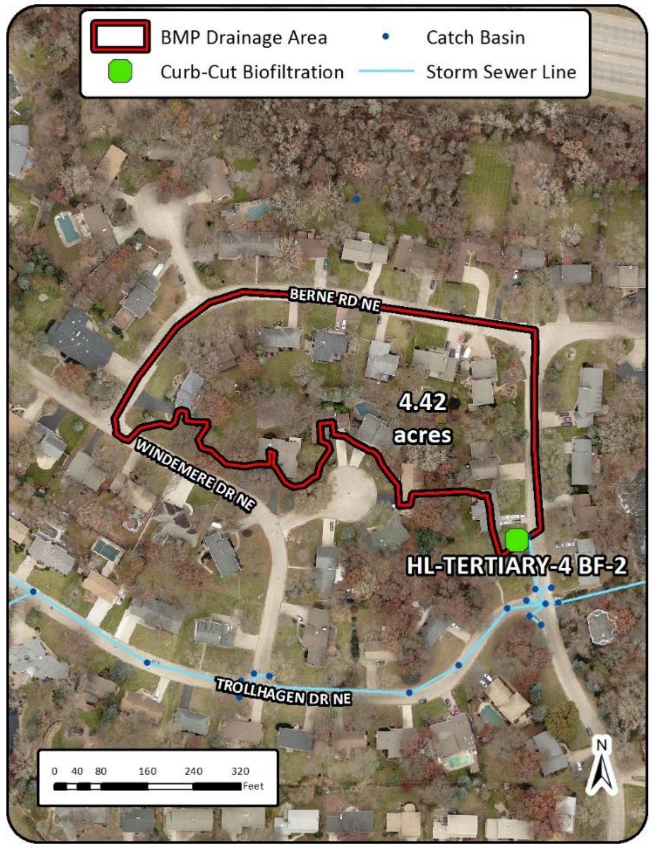
	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq-ft
	TP (lb/yr)	0.20	0.7%
	TSS (lb/yr)	63	0.9%
	Volume (acre-feet/yr)	0.05	0.3%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$3,309**	
	30-yr Average Cost/1,000lb-TSS	**$10,505**	
	30-yr Average Cost/ac-ft Vol.	**$14,387**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID:
HL-TERTIARY-4 BF-2
Saint Imer Drive NE
Biofiltration Basin



Drainage Area – 4.4 acres
Location – West side of Saint Imer Drive NE north of the intersection with Trollhagen Drive NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq-ft
	TP (lb/yr)	0.25	0.9%
	TSS (lb/yr)	84	1.2%
	Volume (acre-feet/yr)	0.07	0.4%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$2,647**	
	30-yr Average Cost/1,000lb-TSS	**$7,879**	
	30-yr Average Cost/ac-ft Vol.	**$9,605**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID:
HL-TERTIARY-4 BF-3
West Windemere Parkway NE
Biofiltration Basin

Drainage Area – 0.9 acres
Location – Northwest corner of intersection between Trollhagen Drive NE and Windemere Drive NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq-ft
	TP (lb/yr)	0.17	0.6%
	TSS (lb/yr)	51	0.7%
	Volume (acre-feet/yr)	0.05	0.3%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$10,420
	Total Estimated Project Cost (2019)		**$11,004**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$3,893**	
	30-yr Average Cost/1,000lb-TSS	**$12,976**	
	30-yr Average Cost/ac-ft Vol.	**$14,387**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID:
HL-TERTIARY-4 BF-4
Trollhagen Drive NE
Biofiltration Basin

Drainage Area – 1.9 acres
Location – Northwest corner of intersection between Trollhagen Drive NE and Windemere Drive NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration was proposed. The potential site for this basin is adjacent to an existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	Total Size of BMP	250	sq-ft
	TP (lb/yr)	0.21	0.7%
	TSS (lb/yr)	68	1.0%
	Volume (acre-feet/yr)	0.07	0.4%
Cost	Administration & Promotion Costs*	$584	
	Design & Construction Costs**	$10,420	
	Total Estimated Project Cost (2019)	**$11,004**	
	Annual O&M***	$295	
Efficiency	**30-yr Average Cost/lb-TP**	**$3,151**	
	30-yr Average Cost/1,000lb-TSS	**$9,732**	
	30-yr Average Cost/ac-ft Vol.	**$9,605**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($30/sq-ft for materials and labor) + (40 hours at $73/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID:
HL-TERTIARY-4 BI-1
Windemere Drive NE
Bioinfiltration Basin

Drainage Area – 1.7 acres
Location – Northwest corner of intersection between Windemere Drive NE and Windemere Circle NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration is preferred. However, optimal sites are not necessarily adjacent to an existing catch basin to serve as the connection point for an underdrain outlet. This basin is proposed to rely on infiltration, and the infiltration rate and ponding depth were adjusted accordingly to reflect the native soil infiltration rates and ensure drawdown in less than 48 hours. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	0.7%
	TSS (lb/yr)	55	0.8%
	Volume (acre-feet/yr)	0.16	0.9%
Cost	**Administration & Promotion Costs***	$584	
	Design & Construction Costs**	$9,420	
	Total Estimated Project Cost (2019)	**$10,004**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$2,659**	
	30-yr Average Cost/1,000lb-TSS	**$10,154**	
	30-yr Average Cost/ac-ft Vol.	**$3,475**	

*Indirect Cost: (8 hours at $73/hour base cost)

**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $73/hour for design)

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

Project ID:
HL-TERTIARY-4 BI-2
Windemere Drive NE
Bioinfiltration Basin

Drainage Area – 0.9 acres
Location – Southwest corner of intersection between Windemere Drive NE and Windemere Circle NE
Property Ownership – Private
Site Specific Information – Single-family residential lots in this catchment provide opportunities for bioretention. Because of the silty soils in this catchment, biofiltration is preferred. However, optimal sites are not necessarily adjacent to an existing catch basin to serve as the connection point for an underdrain outlet. This basin is proposed to rely on infiltration, and the infiltration rate and ponding depth were adjusted accordingly to reflect the native soil infiltration rates and ensure drawdown in less than 48 hours. The table below provides pollutant removals and estimated costs.

	Curb-Cut Bioinfiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	250	sq-ft
	TP (lb/yr)	0.2	0.6%
	TSS (lb/yr)	50	0.7%
	Volume (acre-feet/yr)	0.14	0.8%
Cost	**Administration & Promotion Costs***		$584
	Design & Construction Costs**		$9,420
	Total Estimated Project Cost (2019)		**$10,004**
	Annual O&M***		$225
Efficiency	**30-yr Average Cost/lb-TP**	**$2,939**	
	30-yr Average Cost/1,000lb-TSS	**$11,169**	
	30-yr Average Cost/ac-ft Vol.	**$4,056**	

*Indirect Cost: (8 hours at $73/hour base cost)

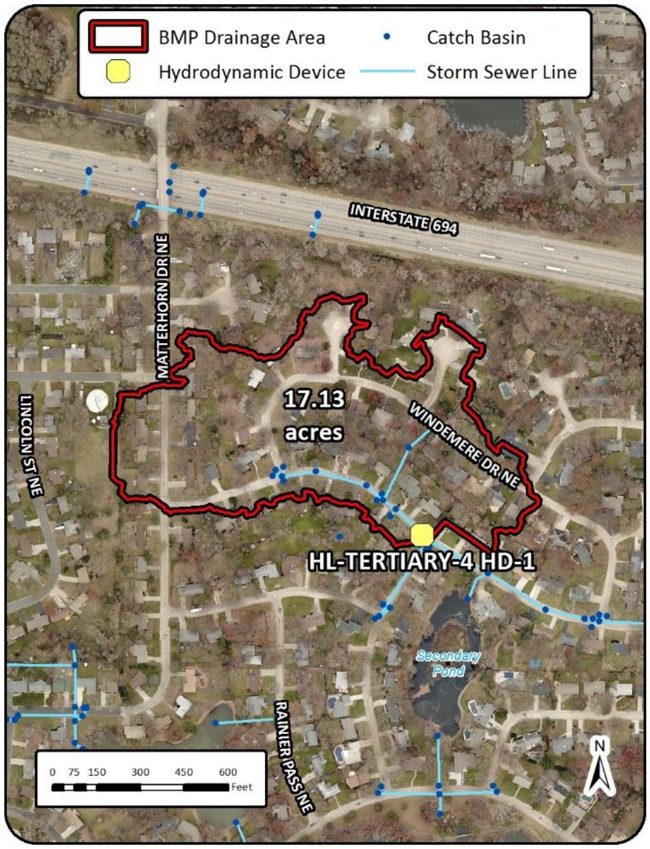
**Direct Cost: ($26/sq-ft for materials and labor) + (40 hours at $73/hour for design)

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

Project ID:

HL-TERTIARY-4 HD-1

Trollhagen Drive NE
Hydrodynamic Device



Drainage Area – 17.1 acres
Location – West of intersection between Trollhagen Drive NE and Saint Moritz Drive NE
Property Ownership – Public
Site Specific Information – A hydrodynamic Device is proposed in line with the 27" storm sewer line that runs east west on Trollhagen Dr. NE. The structure could be placed west of the intersection between Trollhagen Drive NE and Saint Moritz Drive NE. Placement at this location limits the contributing drainage area to a size that could be treated by a single hydrodynamic device. 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)	1.07	3.7%
	TSS (lb/yr)	369	5.3%
	Volume (acre-feet/yr)	0.00	0.0%
Cost	**Administration & Promotion Costs***	$3,750	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2019)	**$111,750**	
	Annual O&M***	$630	
Efficiency	**30-yr Average Cost/lb-TP**	**$4,070**	
	30-yr Average Cost/1,000lb-TSS	**$11,802**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

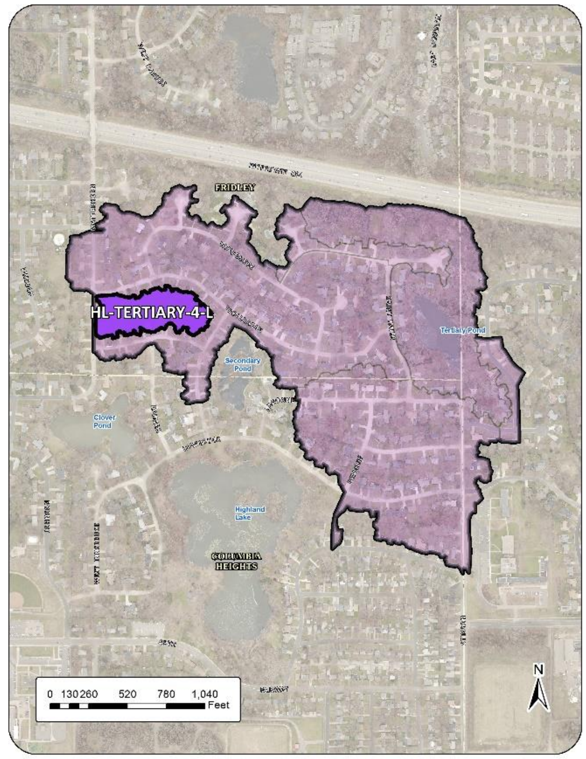
*Indirect Cost: (25 hours at $150/hour)

**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)

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

Catchment HL-TERTIARY-4-L

Existing Catchment Summary	
Acres	4.4
Parcels	17
Land Cover	100% Residential



CATCHMENT DESCRIPTION

This small catchment consists of the backyard areas bounded by Trollhagen Drive NE on the north, Saint Moritz Drive NE on the east, Glacier Lane NE on the south, and Matterhorn Drive NE on the west. The catchment is landlocked as there is no known stormwater infrastructure in the depression.

EXISTING STORMWATER TREATMENT

This landlocked catchment does not have any existing stormwater treatment. Present-day stormwater pollutant loading and treatment is summarized in the table below.

This catchment was not modeled because it is landlocked with no connection to Tertiary Pond. The catchment is residential backyard with no impervious surface.

RETROFIT RECOMMENDATIONS OVERVIEW

No retrofits were proposed in catchment HL-TERTIARY-4-L.

RETROFIT RECOMMENDATIONS

References

Erickson, A.J., and J.S. Gulliver. 2010. *Performance Assessment of an Iron-Enhanced Sand Filtration Trench for Capturing Dissolved Phosphorus*. University of Minnesota St. Anthony Falls Laboratory Engineering, Environmental and Geophysical Fluid Dynamics Project Report No. 549. Prepared for the City of Prior Lake, Prior Lake, MN.

Minnesota Pollution Control Agency (MPCA). 2014. *Design Criteria for Stormwater Ponds*. Web.

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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.

Specification High Performance Modular Biofiltration System (HPMBS). *Material, Performance and Installation Specification.* See Appendix E in this report for the full specification.

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Weiss, P.T., J.S. Gulliver, A.J. Erickson. 2005. The Cost and Effectiveness of Stormwater Management Practices. Minnesota Department of Transportation.

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 10.4.1 was used for this analysis to estimate volume and pollutant loading and reductions. Additional inputs for WinSLAMM are provided in Table 25.

Table 25: General WinSLAMM Model Inputs (i.e. Current File Data)

Parameter	File/Method
Land use acreage	ArcMap, Metropolitan Council 2010 Land Use
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

Infiltration Basin

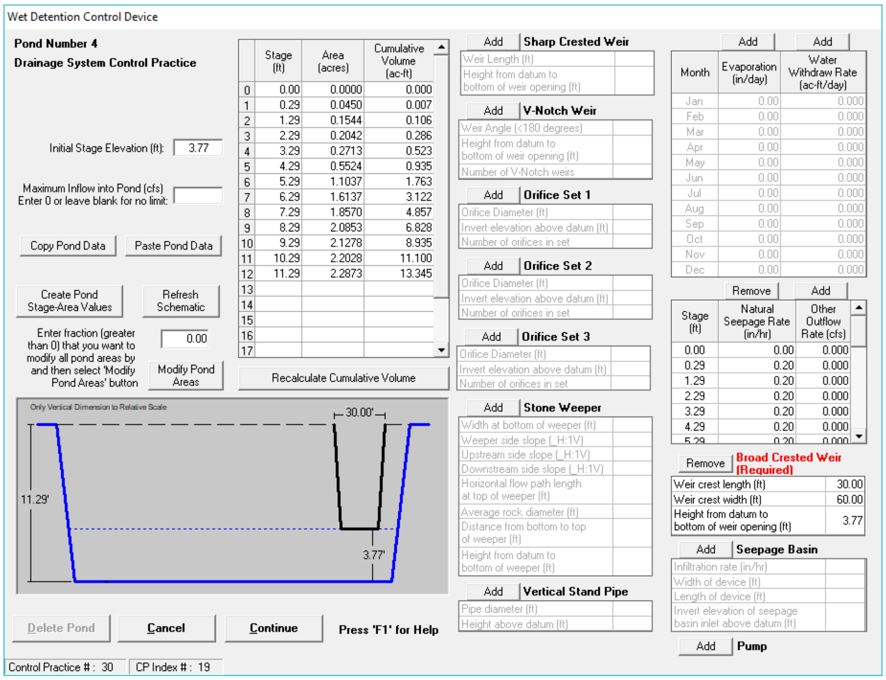

Figure 15: Infiltration Pond at Ramsdell Park (North) – SL-3-4-6 Catchment (WinSLAMM).

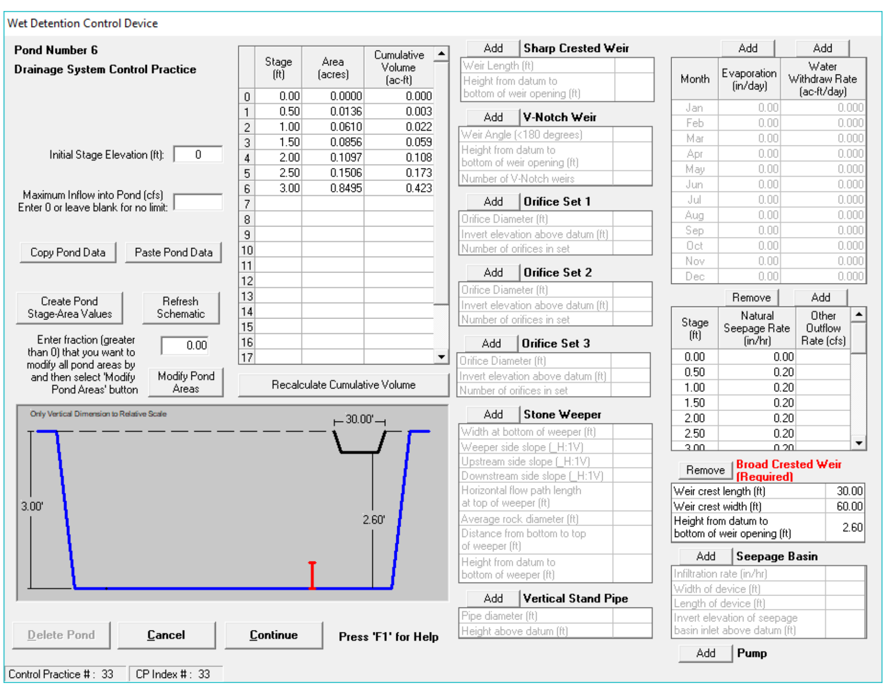

Figure 16: Infiltration Pond at Ramsdell Park (South) – SL-3-4-6 Catchment (WinSLAMM).

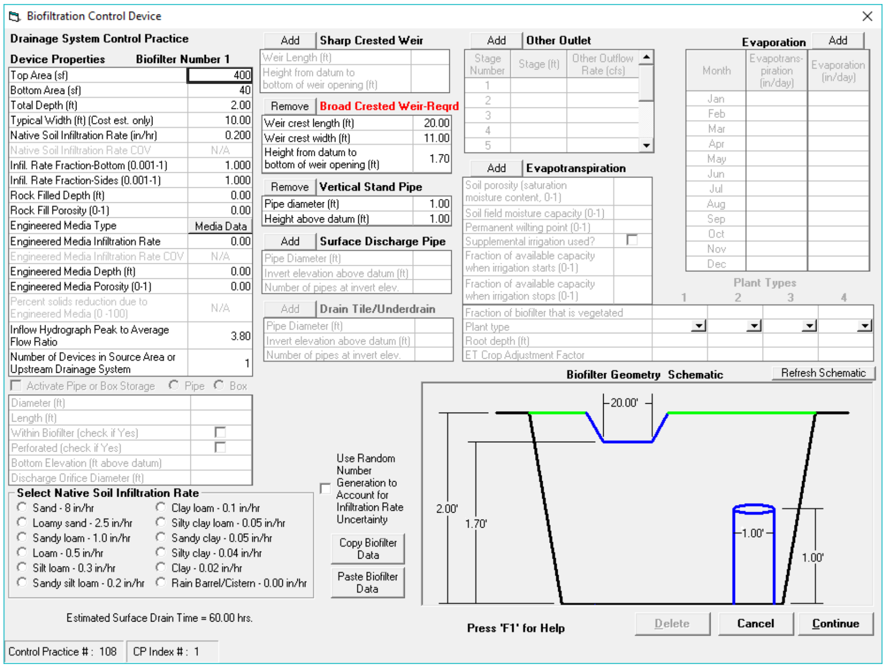

Figure 17: Infiltration Pond at Sullivan Lake Park near 51st Ave. (South) – SL-4-1 Catchment (WinSLAMM).

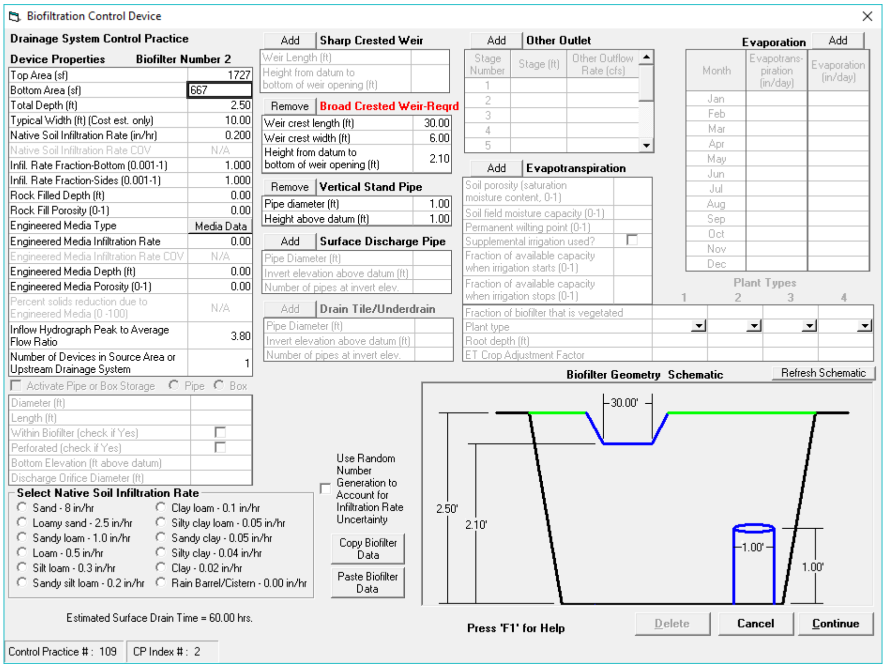

Figure 18: Infiltration Pond at Sullivan Lake Park near 51st Ave. (North) – SL-4-1 Catchment (WinSLAMM).

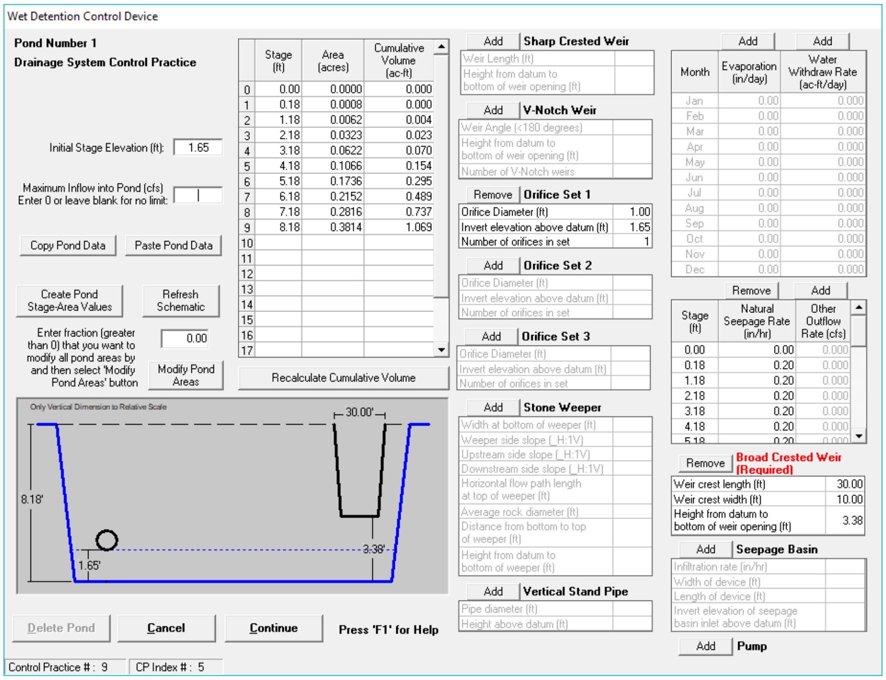

Figure 19: Infiltration Pond near Sullivan Lane – SL-5-1 Catchment (WinSLAMM).

Swale

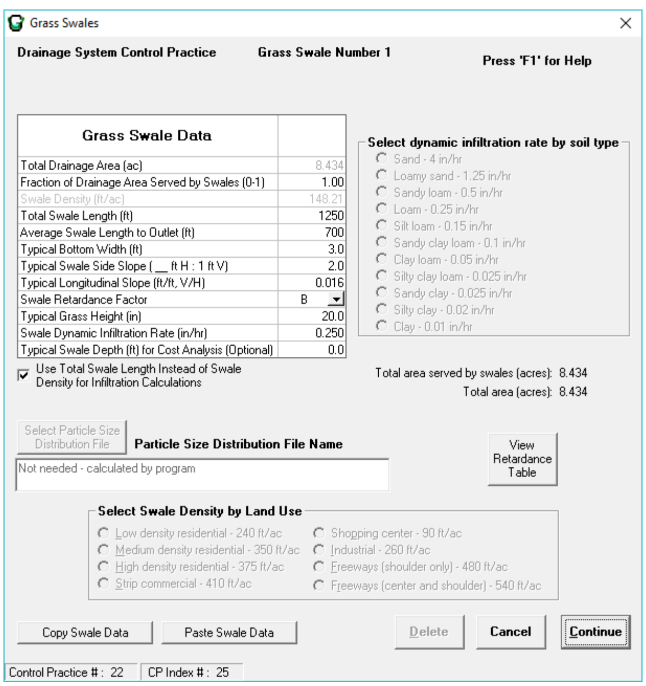

Figure 20: Swale along South side of 694 Off-Ramp – SL-1-2 Catchment (WinSLAMM).

Dry Feature

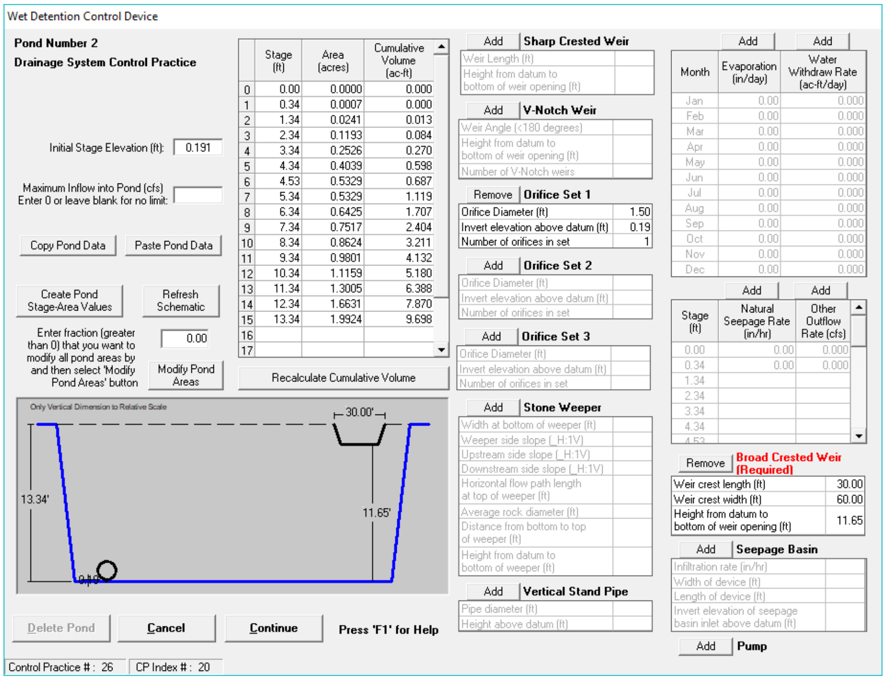

Figure 21: Dry Feature on North side of 694 Off-Ramp – SL-1-2 Catchment (WinSLAMM).

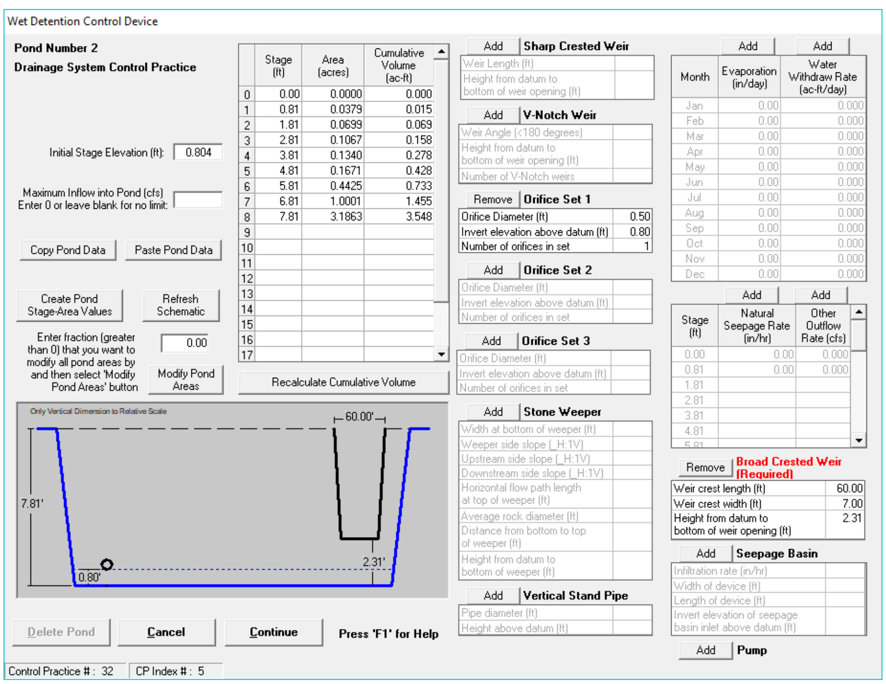

Figure 22: Dry Feature at LivINN Hotel Parking Lot – SL-3-2 Catchment (WinSLAMM).

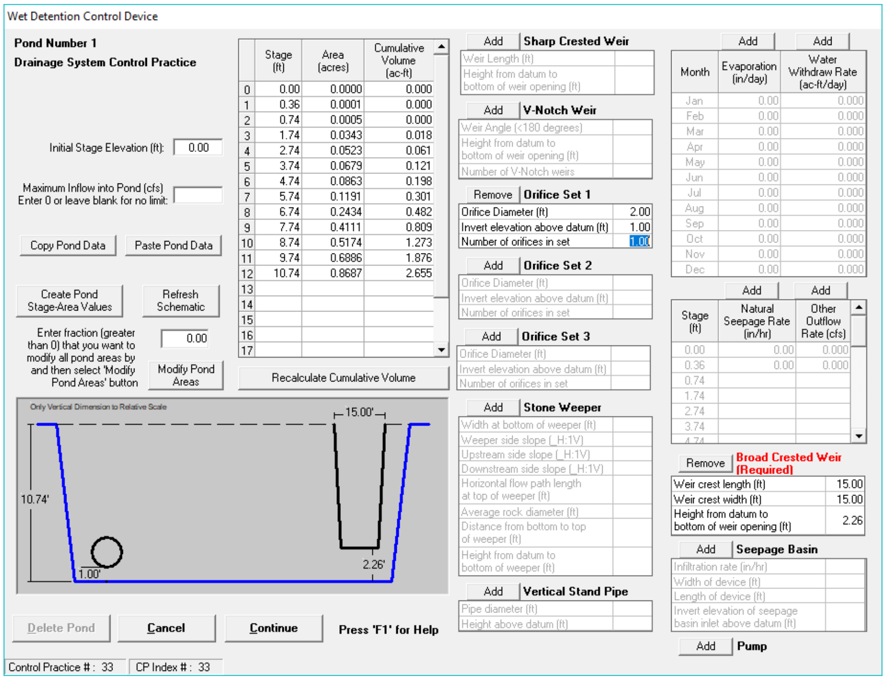

Figure 23: Dry Feature at St. Timothy's Lutheran Church Parking Lot – SL-3-1 Catchment (WinSLAMM).

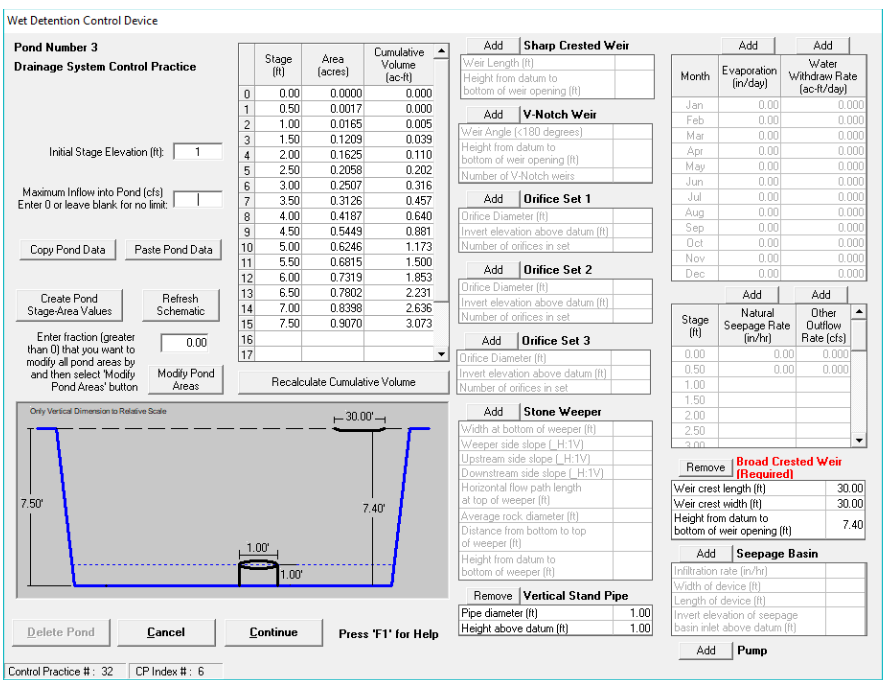

Figure 24: Dry Feature in neighborhood backyards between Lincoln St. and Pierce Terrace – SL-3-3-4 Catchment (WinSLAMM).

Underground Infiltration Device

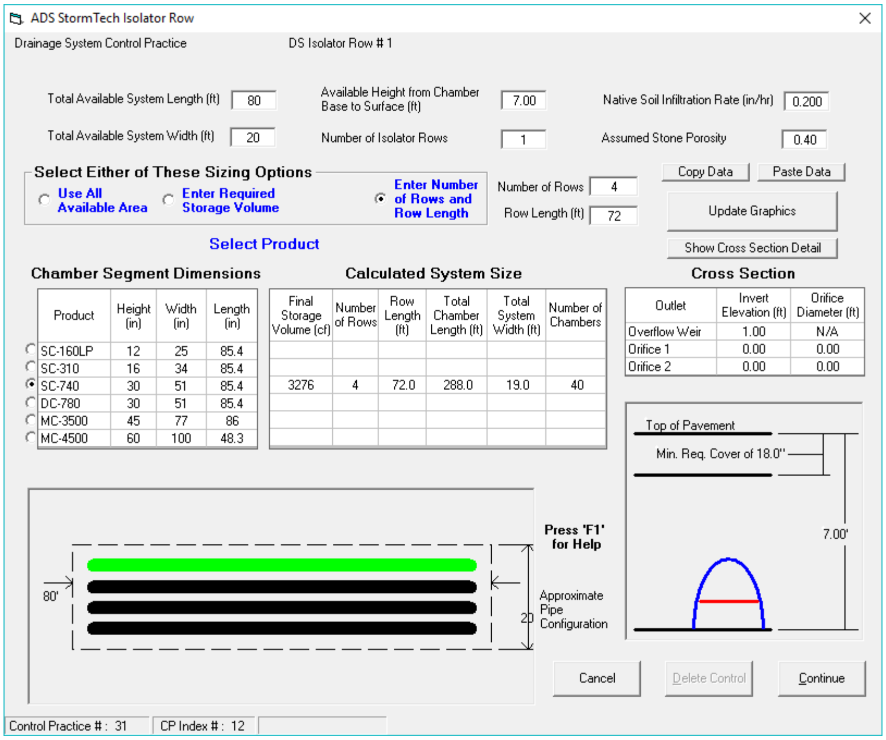

Figure 25: Underground Infiltration Device at Planet Fitness Parking Lot (North) – SL-3-3-1 Catchment (WinSLAMM).

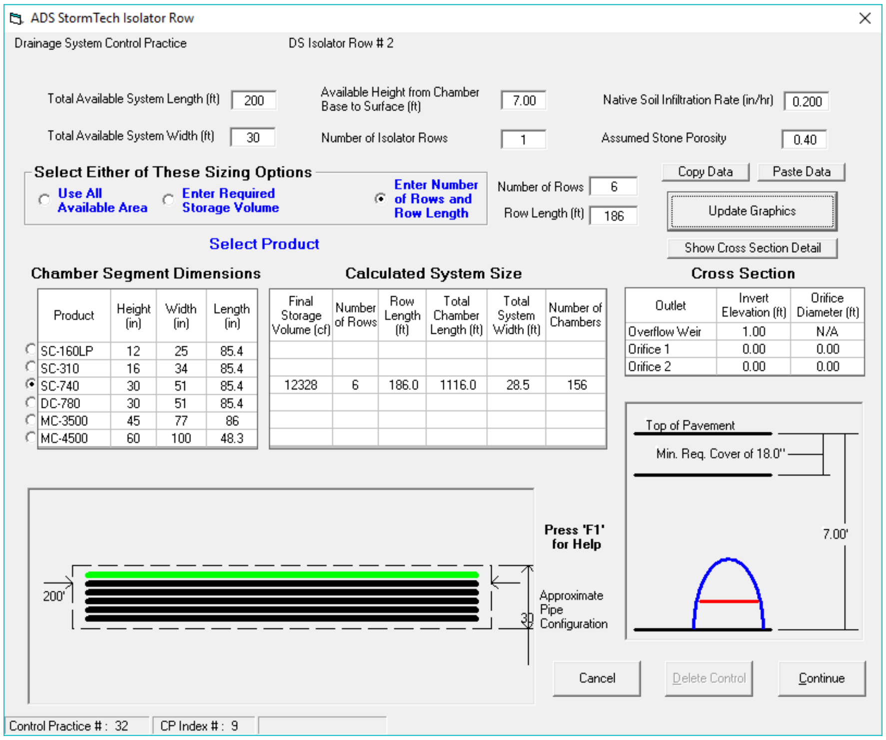

Figure 26: Underground Infiltration Device at Planet Fitness Parking Lot (South) – SL-3-4-1 Catchment (WinSLAMM).

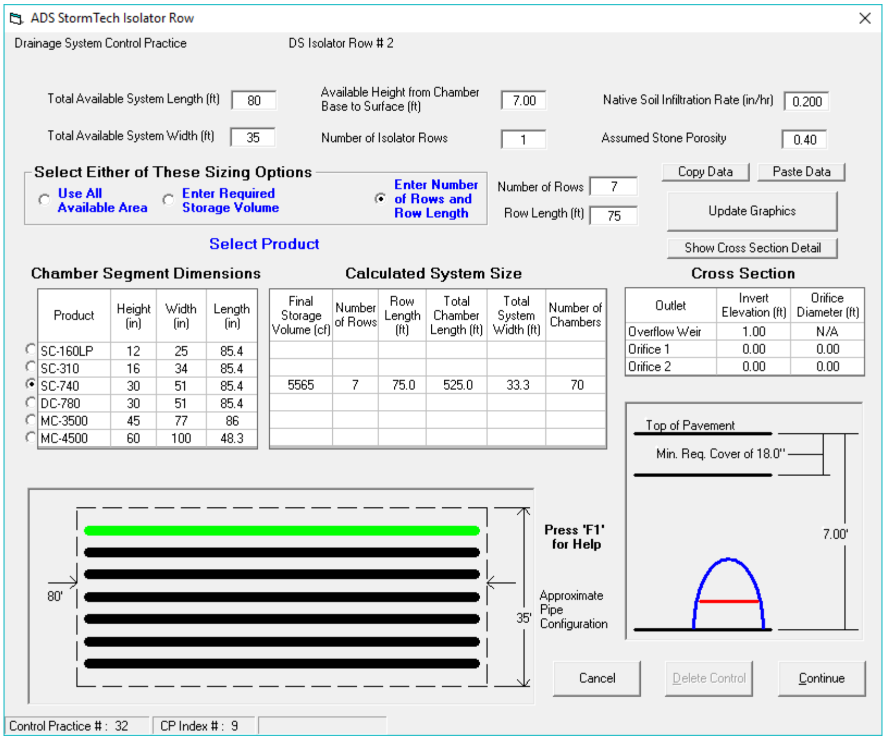

Figure 27: Underground Infiltration Device at Columbia Heights High School Gymnasium – SL-3-4-5 Catchment (WinSLAMM).

Underground Storage Device

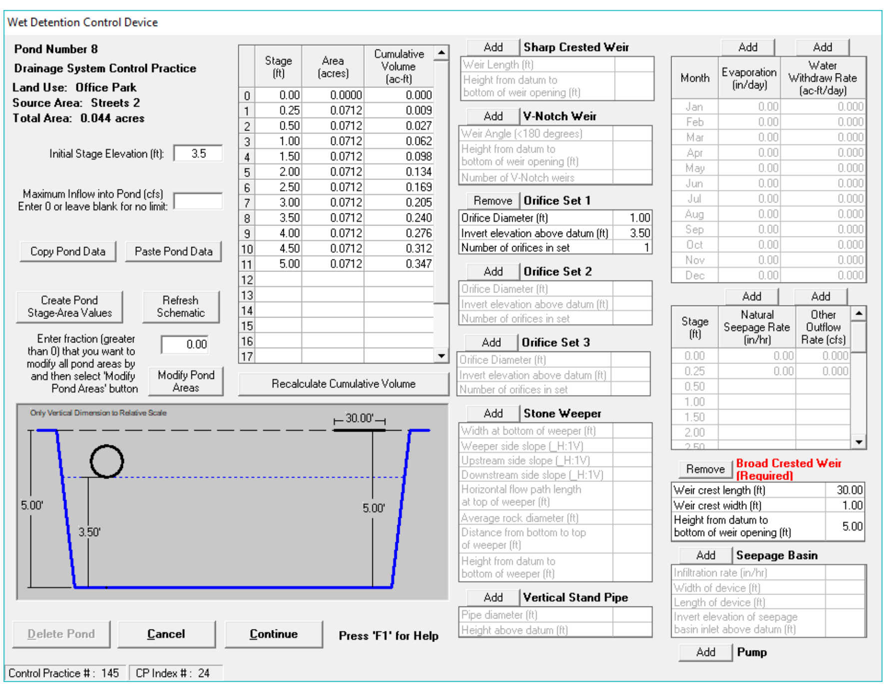

Figure 28: Underground Storage Device at Grand Central Flats – SL 3-5-4 Catchment (WinSLAMM).

Hydrodynamic Device

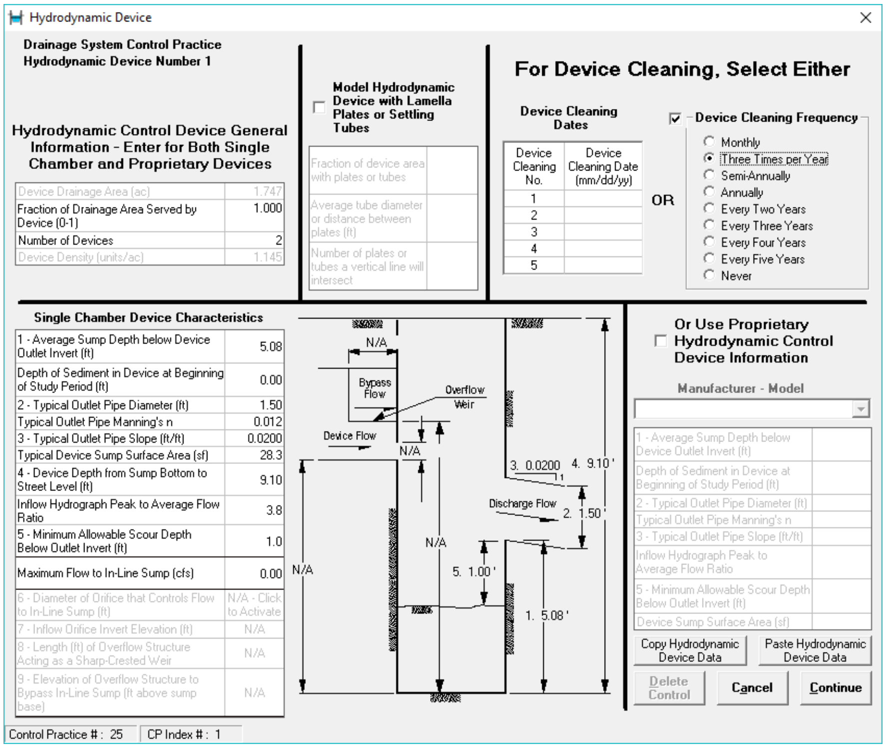

Figure 29: Pair of Hydrodynamic Devices in Petco at 53rd Ave. and Monroe St. – SL-1-1 Catchment (WinSLAMM).

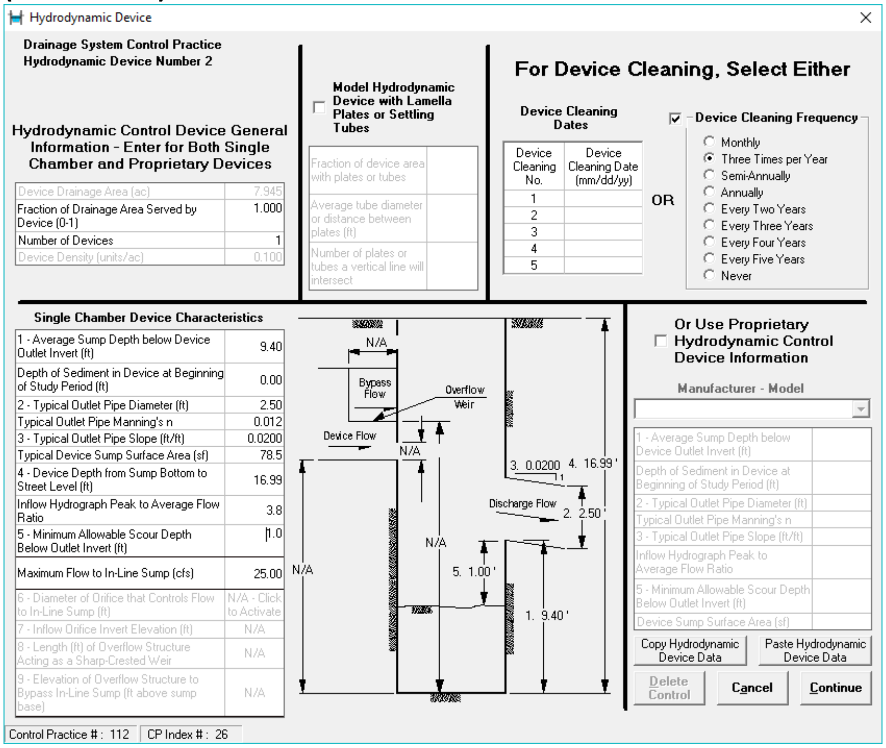

Figure 30: Hydrodynamic Device in Target parking lot - SL-1-1 Catchment (WinSLAMM).

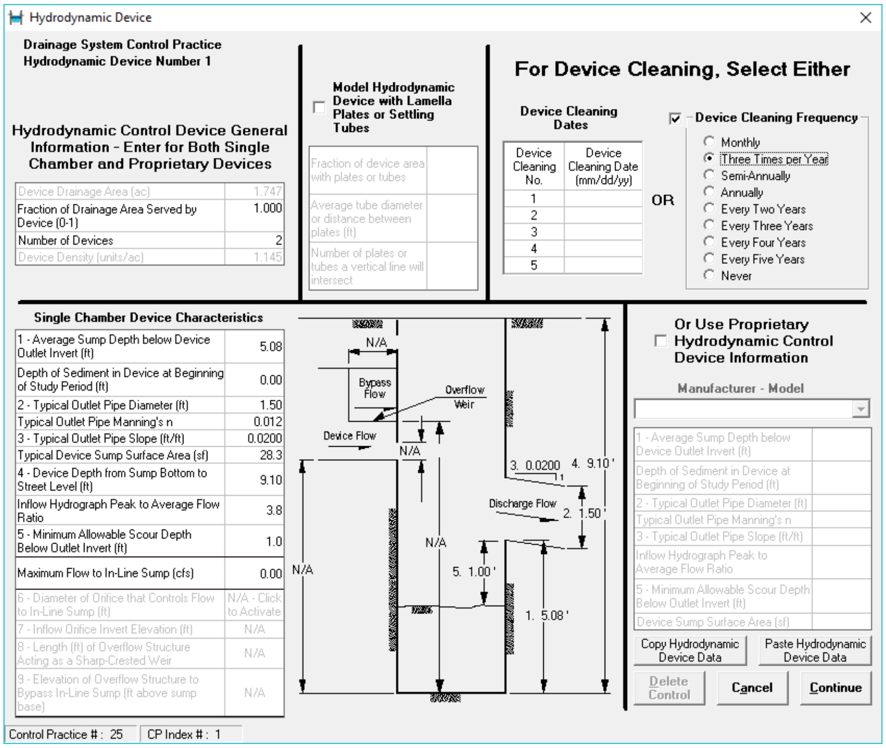

Figure 31: Pair of Hydrodynamic Devices at Applebee's Parking Lot – SL-3-2 Catchment (WinSLAMM).

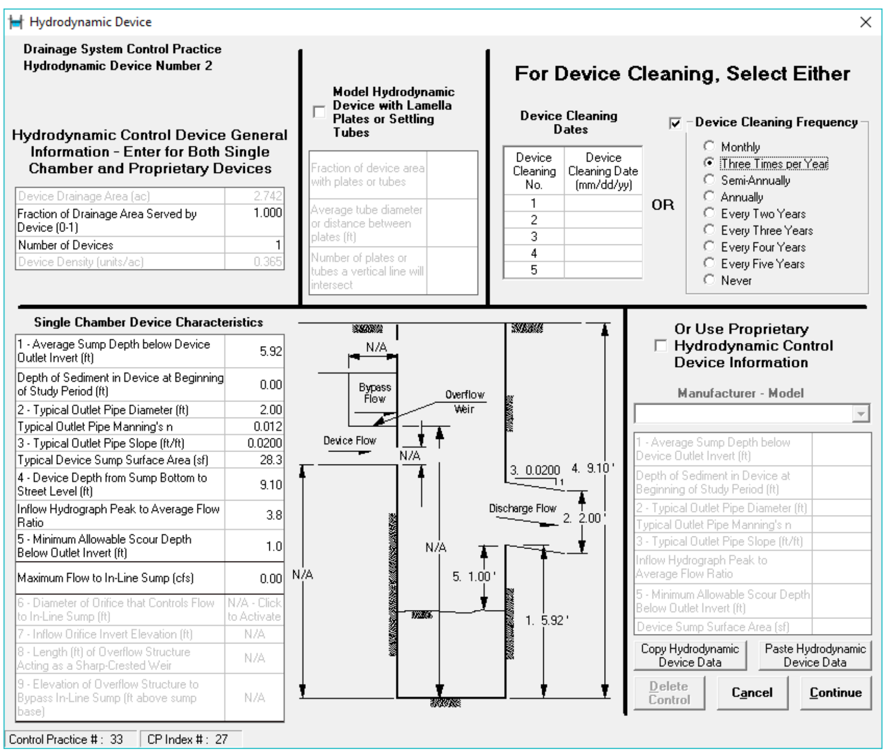

Figure 32: Hydrodynamic Device at Grandview Court – SL-3-5-4 Catchment (WinSLAMM).

Ponds

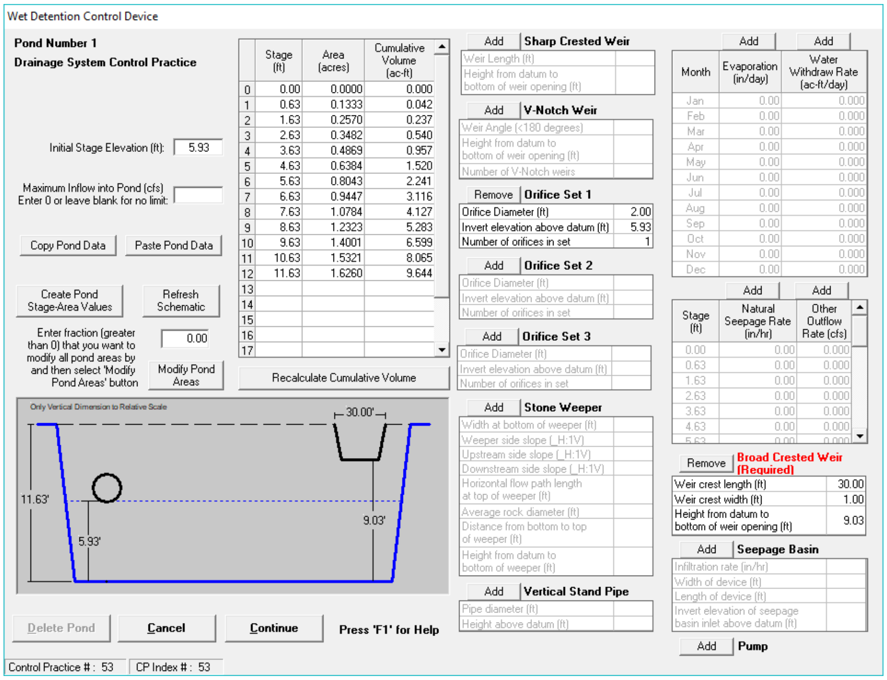

Figure 33: Stormwater Pond at Minneapolis Water Works property on the west side of Chatham Road – HL-4 Catchment (WinSLAMM).

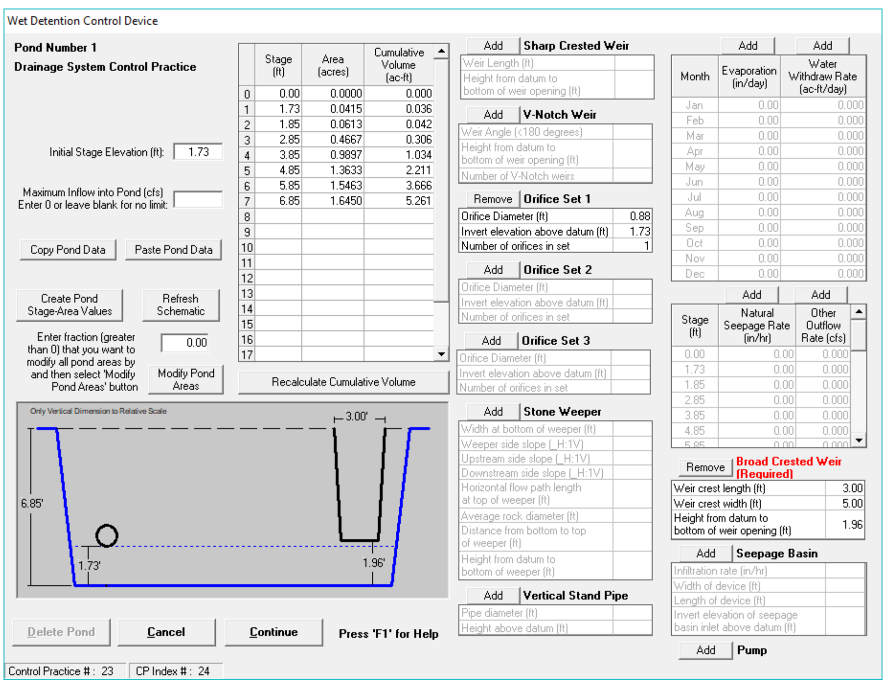

Figure 34: Stormwater Pond at SW Corner of Pawn America Parking Lot – SL-1-1 Catchment (WinSLAMM).

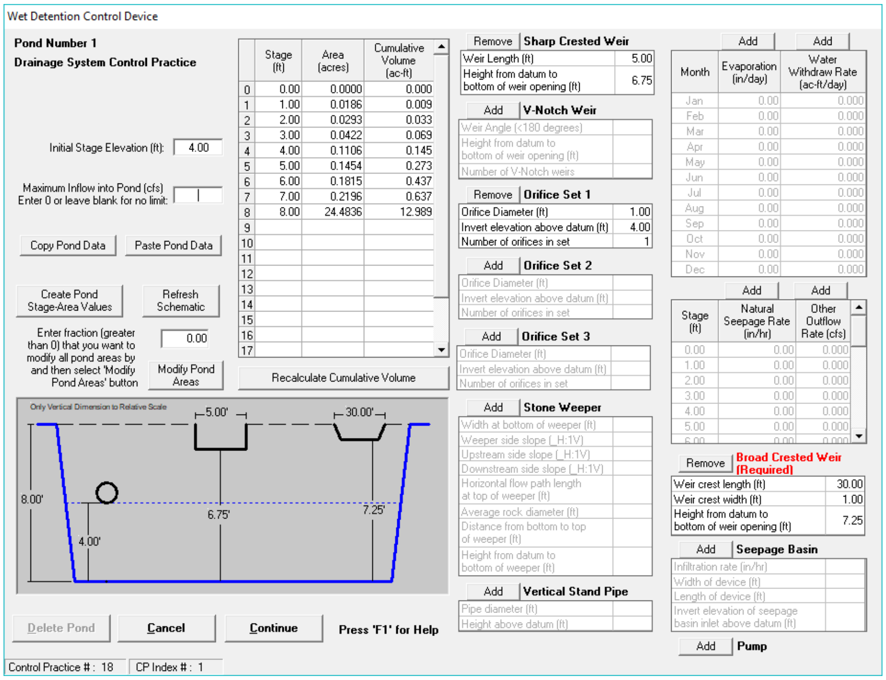

Figure 35: Stormwater Pond at Medtronic Parking Lot – SL-2-1 Catchment (WinSLAMM).

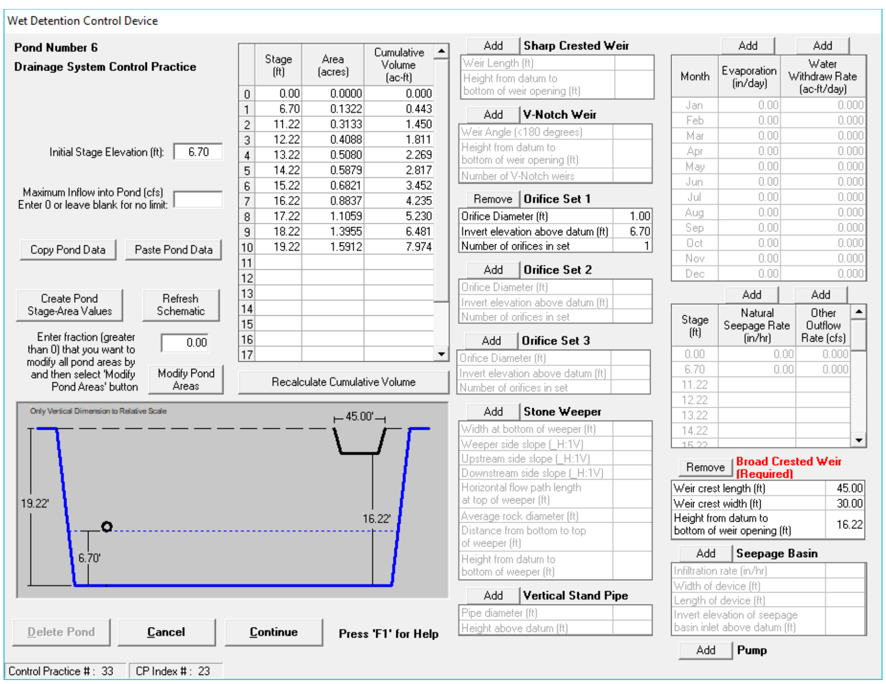

Figure 36: Stormwater Pond at Grandview Court Development Lofts – SL-3-5-3 Catchment (WinSLAMM).

Street Cleaning

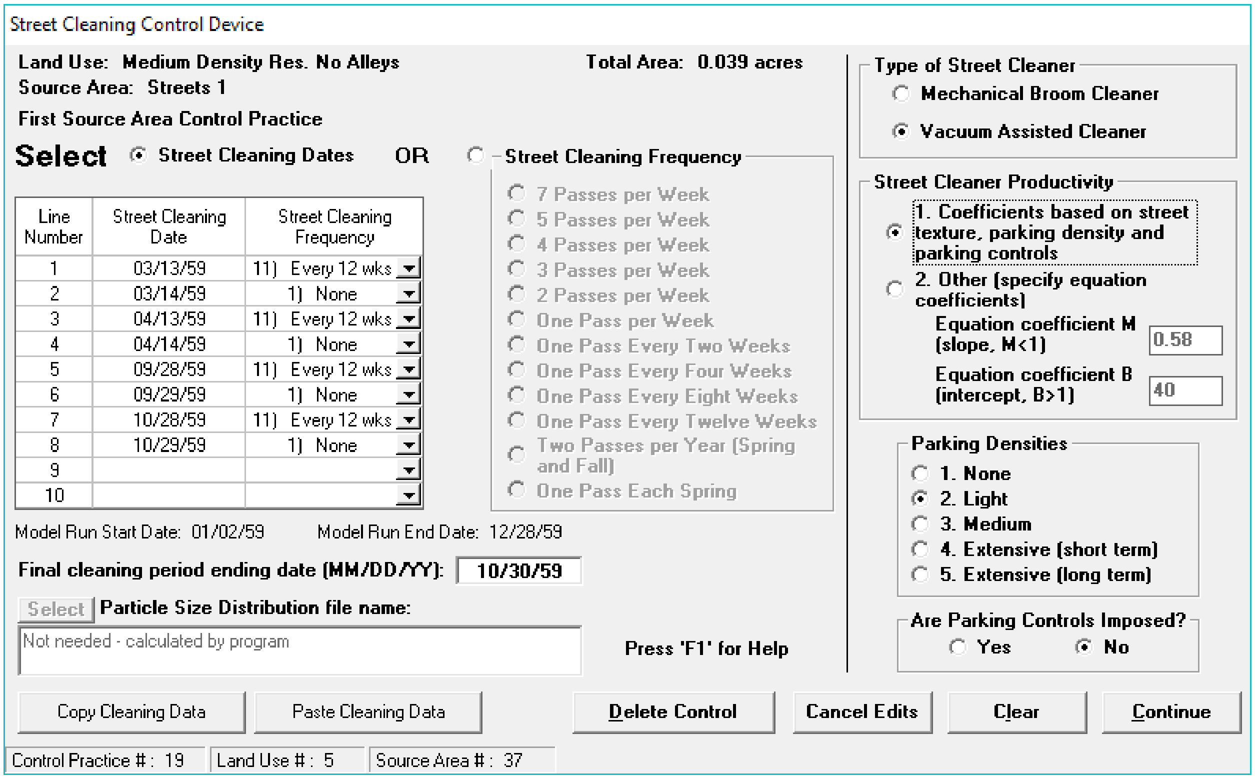

Figure 37: Street cleaning parameters used in all catchments including two spring and two fall cleanings.

Proposed Conditions

Curb-Cut Rain Garden

Curb-cut rain gardens were modeled as drainage area control practices within WinSLAMM. Bioinfiltration basins were modeled without an underdrain and given ponding depths based on available soil information. In sandy areas, a 12-inch ponding depth was applied. In silty areas, a 9” ponding depth was applied to facilitate drainage of the basin within 48 hours of a storm event. Biofiltration basins were modeled in areas with silty soil where an underdrain could be linked to a nearby catch basin with 12-inch ponding depths. All standard bioinfiltration and biofiltration basins were modeled with a 250 sq.-ft. top footprint.

High Performance Modular Bioretention Systems were modeled at parking lot catch basins with underdrains linking to subsurface storm sewer. These basins were modeled with a 100 sq.-ft. top footprint and 12-inch ponding depths.

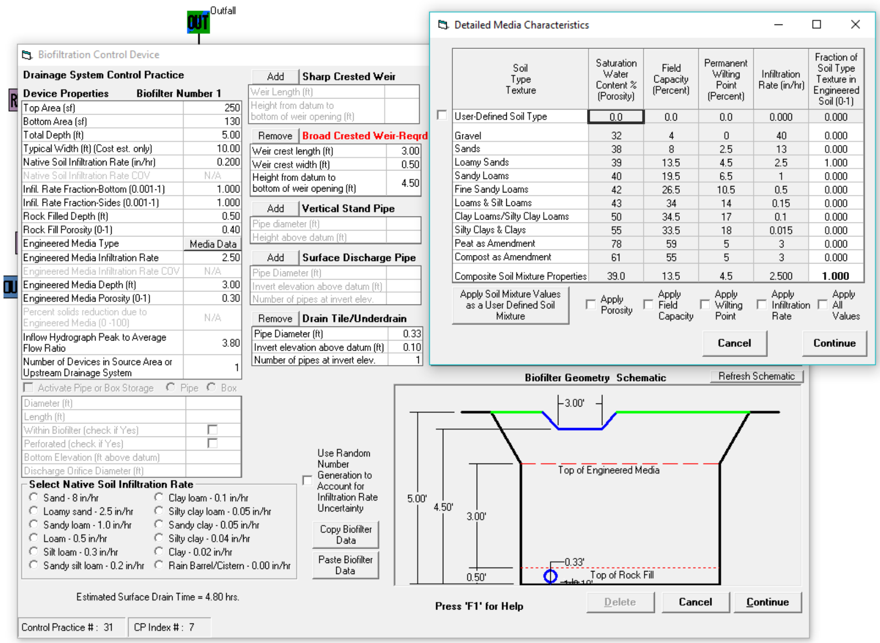

Figure 38: Curb-cut Biofiltration Rain Garden (250 sq.-ft.) with underdrain and amended soils (WinSLAMM).

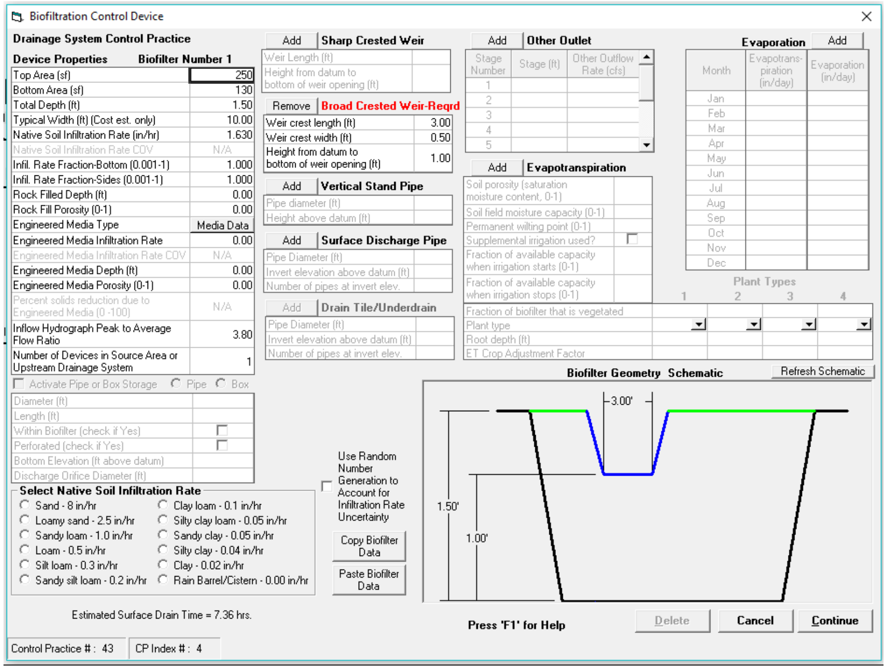

Figure 39: Curb-cut Bioinfiltration Rain Garden (250 sq.-ft.) with 12-inch ponding depth in sandy soils (WinSLAMM).

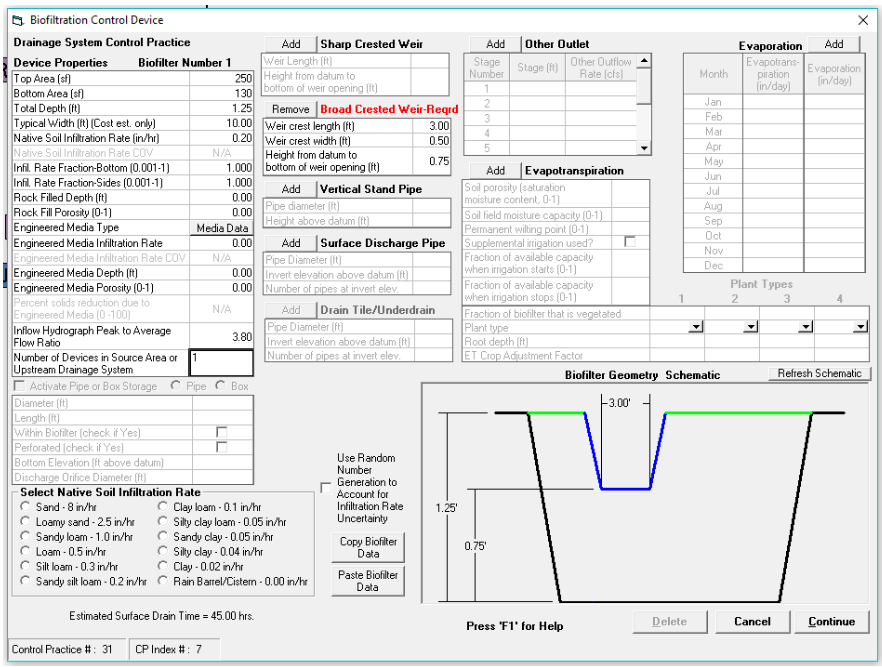

Figure 40: Curb-cut Bioinfiltration Rain Garden (250 sq.-ft.) with 9-inch ponding depth in silty soils (WinSLAMM).

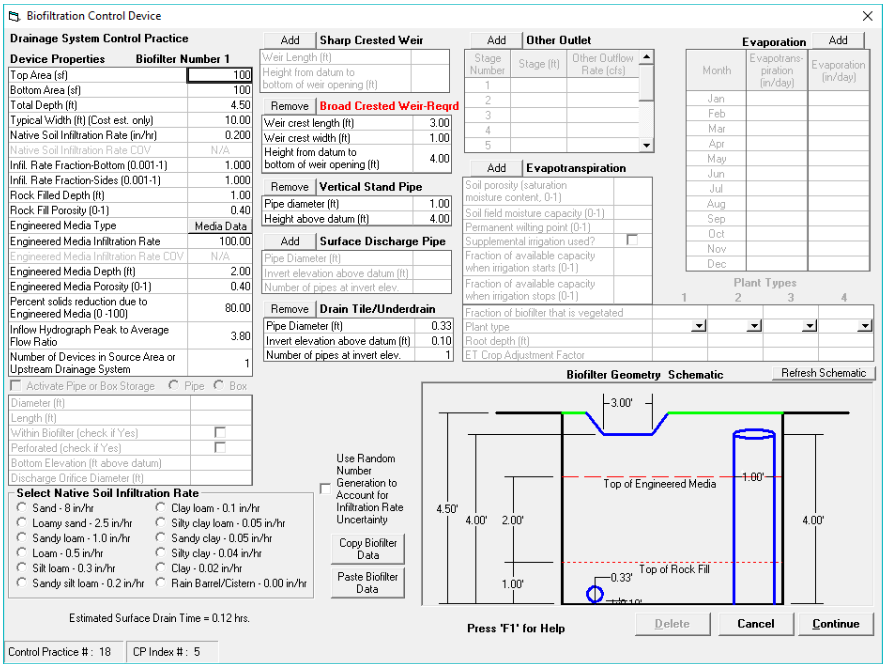

Figure 41: Curb-cut High Performance Modular Biofiltration System (HPMBS) (100 sq.-ft.) with 12-inch ponding depth in parking lot settings (WinSLAMM).

Hydrodynamic Device

Table 26: 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

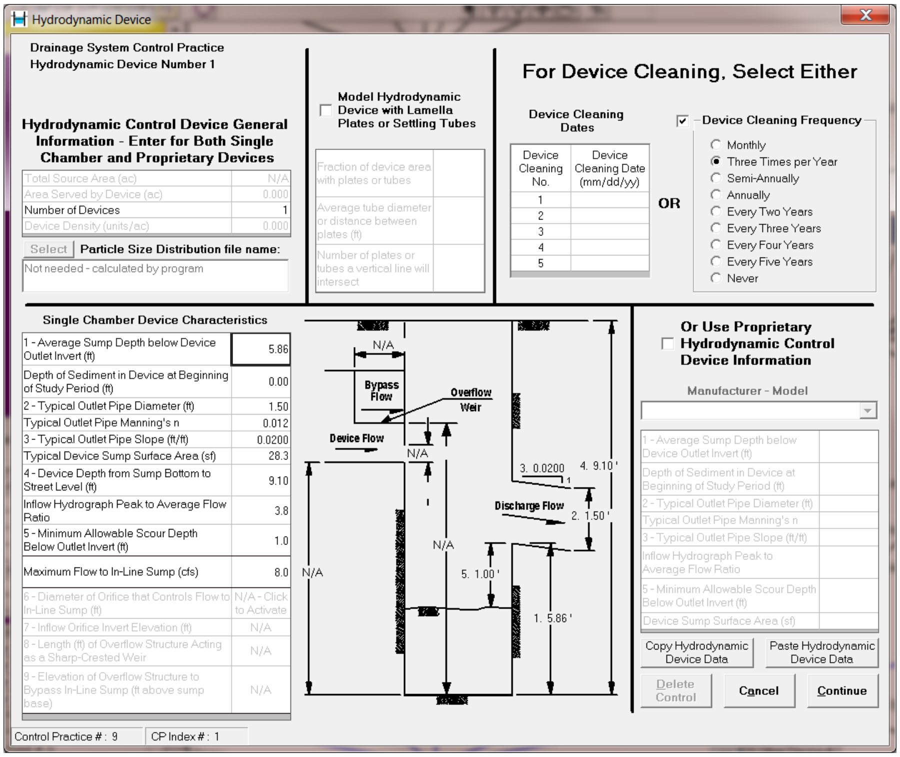

Figure 42: Hydrodynamic Device - 6' diameter (WinSLAMM).

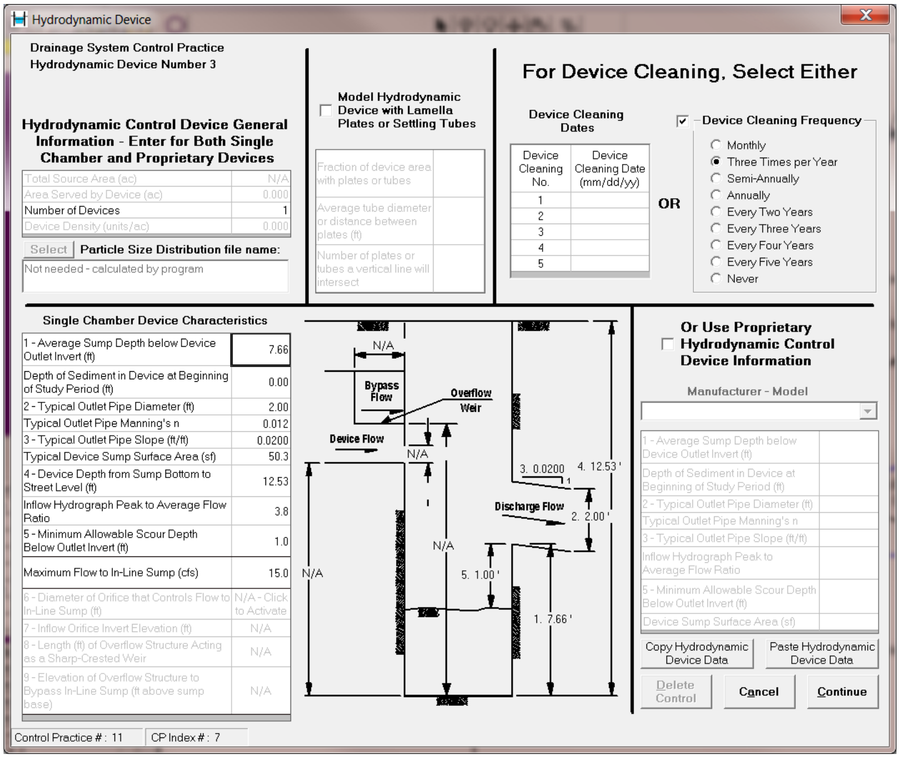

Figure 43: Hydrodynamic Device - 8' diameter (WinSLAMM).

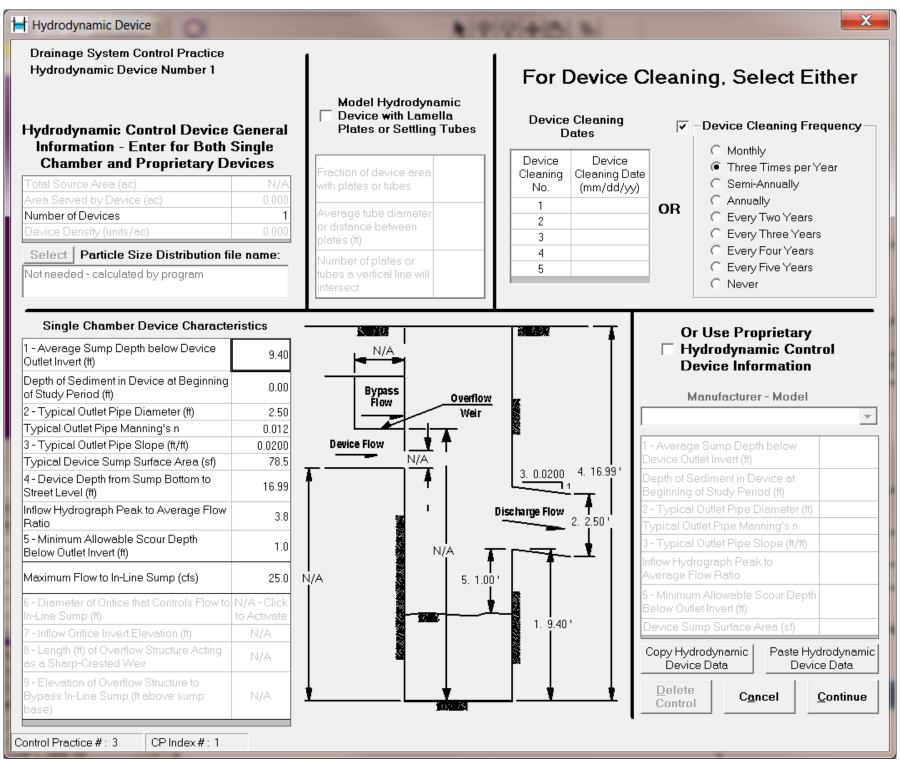

Figure 44: Hydrodynamic Device - 10' diameter (WinSLAMM).

Ponds

Ponds were proposed in the landscape where sufficient drainage area could sustain a permanent pool of water. Ponds were proposed following guidance from the Minnesota Pollution Control Agency, in which depths are equal to or less than 8-10’ to prohibit stratification and at least 1,800 cu-ft. of pond storage is available for each acre of drainage area.

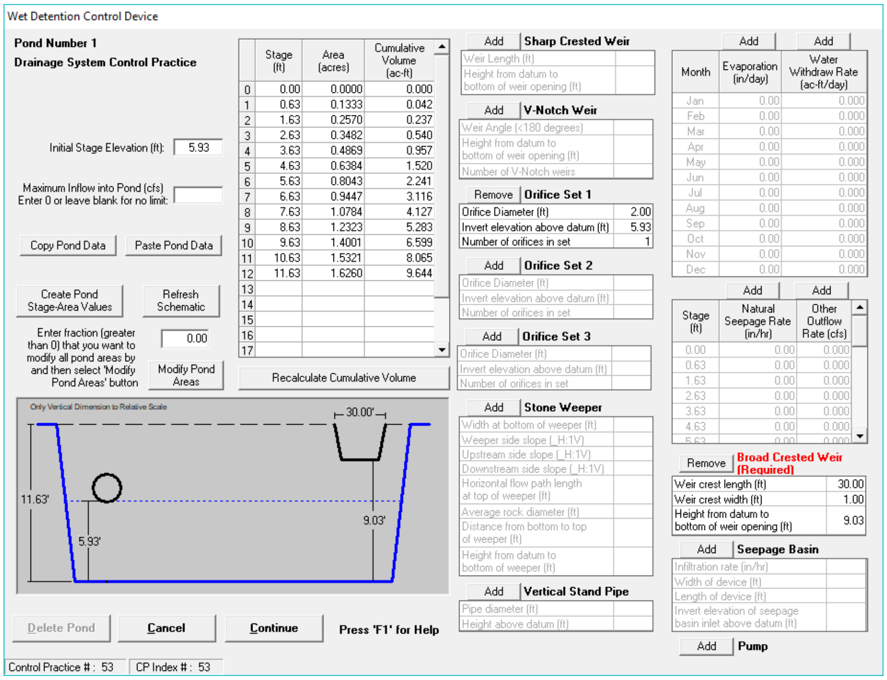

Figure 45: HL-4 SP-1 Stormwater Pond at Minneapolis Water Works property on the west side of Chatham Road (WinSLAMM).

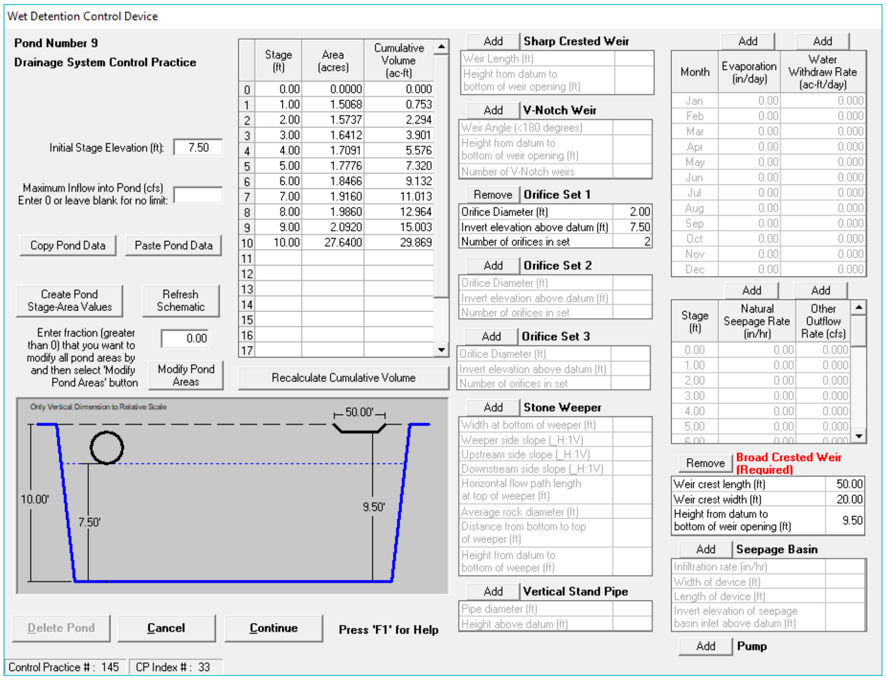

Figure 46: SL-REGIONAL-SP-1 Stormwater Pond South of Medtronic Parking Lot (treats all of SL-3 and portions of SL-2-1 and SL-DD) (WinSLAMM).

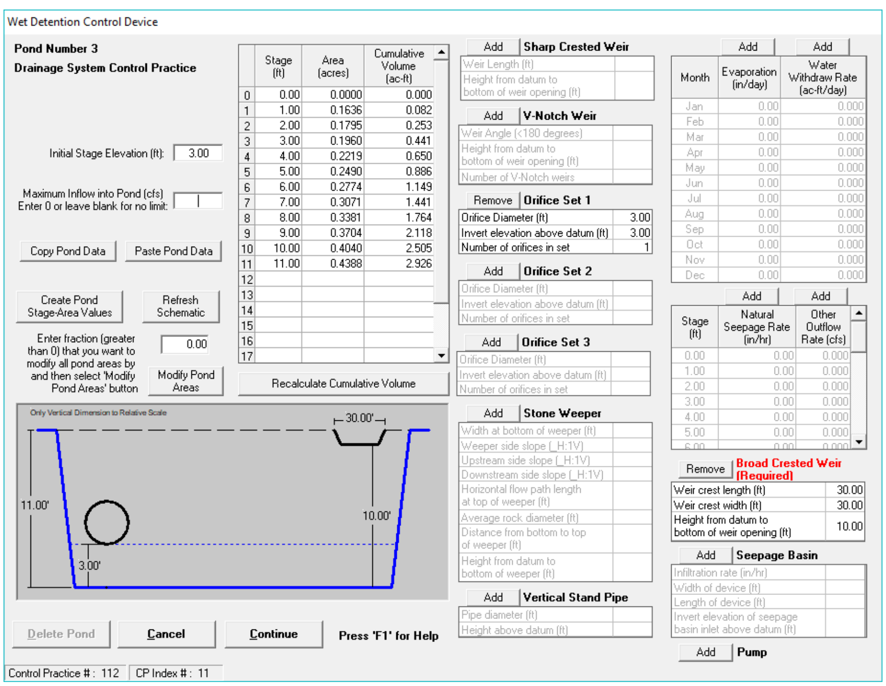

Figure 47: SL-1-1 SP-1 Stormwater Pond at Target Parking Lot (WinSLAMM).

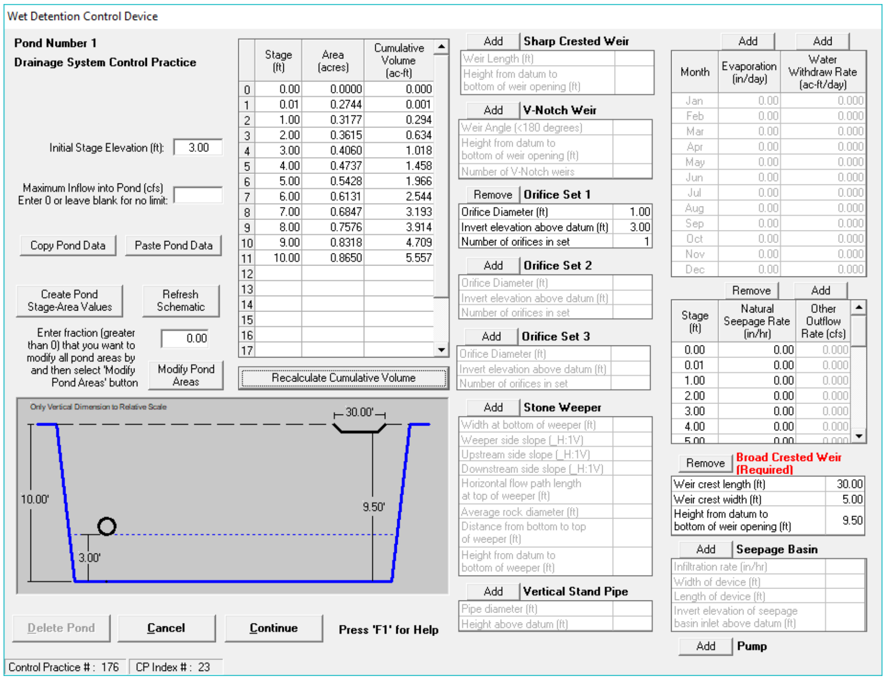

Figure 48: SL-3-4-6 SP-2 Stormwater Pond at Ramsdell Park (WinSLAMM)

Iron Enhanced Sand Filter

Wet ponds, by design, allow for sediments and other bound pollutants to drop out of suspension. This practice, though, often allows dissolved pollutants to advect through the system untreated. Iron-enhanced sand filters (IESF) can be retrofitted to or installed with wet ponds to treat this dissolved load.

A pump controlled IESF is installed apart from the stormwater pond rather than within the pond's flood basin like a passive IESF bench. Pumps pull water from within the stormwater pond after the particulate matter has settled out, pump it over the IESF bed allowing for infiltration of the water through its iron rich media, where dissolved pollutants (particularly dissolved phosphorus (DP)) adsorb to the iron filings. DP is then retained within the media while the infiltrated water seeps into an underdrain. Lastly, the underdrain discharges downstream of the wet pond and IESF. IESFs can be installed without ponds, although it is recommended that some form of pretreatment is available to remove sediment, which can deposit within the pore space of the filter and clog the practice over time.

There is currently no drainage practice input for these features in WinSLAMM. As they behave similarly to a bioretention cell, they can be modeled as such. However, as they often operate in tandem with stormwater ponds, estimating when and how much water and pollutants they will receive can be problematic. WinSLAMM was utilized to estimate the particulate and dissolved phosphorus concentration as well as the particulate solids concentration of water in the proposed regional pond after treatment by the pond. These concentrations were then applied to the volume of water that could be pumped through a 0.1-acre, 0.2-acre, and 0.3-acre IESF bench installed near the pond. Pollutant treatment by the device is a function of total area, media depth, infiltration rate, and engineered media characteristics.

Field tests of installed sand trenches conducted by the University of Minnesota concluded that a sand media mixed with 5% - 8% iron filings is capable of retaining 80% (or more) of the DP load of stormwater flowing through the media (Erickson and Gulliver, 2010). It is assumed that 100% of particulate phosphorus (PP) and TSS are captured by the IESF media. Thus, pollutant retention by the IESF can be estimated by the following equations,

$$DP_{RET} = 0.8 * [DP_{IN}] * q_t$$

$$PP_{RET} = [PP_{IN}] * q_t$$

$$TSS_{RET} = [TSS_{IN}] * q_t$$

where X_{RET} is the pollutant load removed by the IESF, $[X_{IN}]$ is the concentration of the pollutant input, and q_t is the volume of water pumped over and passing through the IESF over a given time period. The 0.8 multiplier assumes the IESF removes 80% of the DP load.

DP retention potential over the effective life of the IESF is ultimately determined by the total iron filing content at installation. As DP adsorbs to the iron filings, the remaining potential for DP retention decreases. The goal was to design the IESF bench and regulate the pumping rate so that binding sites are exhausted at 30 years after installation. For the three bench size options, a 12-inch deep media bed was assumed. IESF media can cake and clog at the surface unless the media is periodically tilled up as part of the required maintenance. Beds deeper than 12-inches can be difficult to till fully. The iron filing concentration was fixed at 6.5%, in the middle of the 5% - 8% concentration range used in testing. The following process was used to determine pollutant removal by the IESF sizes proposed:

Process

- Utilized WinSLAMM to determine concentration of DP at pond outlet
- Determined space available for potential IESF bed

- Used assumptions/calculations outlined below to determine IESF treatment capacity by water volume
- Converted volume to pollutant removal efficiency

Assumptions:

- 6.5% iron concentration by weight
- Available binding potential of media at 6.5% Fe = 33.018 lbs DP/ 1,000 CF media
- DP concentration at pond outlet = 0.1072 mg/L
- IESF is 80% effective at removing DP
- Only DP occupies iron-binding sites, particulate phosphorus is removed by filtering through the sand matrix.
- Number of pumping days per year = 200, pumps run on cycle of 32 hours on, eight hours off.

For example, assuming a 0.1-acre IESF bed, below is the process for determining the pounds of phosphorus treated and the pump size necessary.

- 0.1 acres * 1' media = 4,356 CF of IESF media
- 1,000 CF of IESF media has a holding capacity of 33.018 lbs of phosphorus
- Therefore, 4,356 CF of IESF media has sufficient binding sites to hold 143.83 lbs of phosphorus
- Assuming an 80% DP removal effectiveness of the IESF media, 179.79 lbs of DP must pass through the filter over 30 years to exhaust the available binding sites
- This results in 5.99 lbs-DP/year that must pass through the filter
- The DP concentration at the pond outlet is 0.1072 mg/L
- 1 mg/L is equivalent to 2.71936 lbs/ac-ft
- Therefore, the DP concentration at the pond outlet is 0.2915 lbs/ac-ft
- To pass 5.99 lbs-DP/year through the filter using water with a DP concentration of 0.2915 lbs/ac-ft, 20.56 ac-ft of water must be passed through the filter
- 20.56 ac-ft is equivalent to 6,699,114 gallons
- 160 days of pumping per year (i.e. 200 days with pumps running for 32 hours and off for 8 hours), is equivalent to 230,400 minutes of pumping per year
- Therefore, 29.07 gallons per minute must be pumped to the filter during the pumping time (i.e. 6,699,114 gallons/230,400 minutes = 29.07 gal/min)
- A 30 gallon per minute pump was recommended

Appendix B – Project Cost Estimates

Introduction

The 'Cost Estimates' section explains the elements of cost that were considered and the amounts and assumptions that were used. In addition, each project type concludes with budget assumptions listed in the footnotes. This appendix is a compilation of tables that shows in greater detail the calculations made and quantities used to arrive at the cost estimates for practices where the information provided elsewhere in the document is insufficient to reconstruct the budget. This section includes ponds, iron enhanced sand filters, and stormwater reuse.

Ponds

Table 27: HL-4 SP-1 Stormwater Pond at Minneapolis Water Works property on the west side of Chatham Road (WinSLAMM).

Activity	Units	Unit Price	Quantity	Unit Price
Design	Each	$ 20,000	1	$ 20,000
Mobilization	Each	$ 10,000	1	$ 10,000
Inlet/Outlet Storm Sewer Tie-in	Each	$ 25,000	2	$ 50,000
Site Restoration/Revegetation	Each	$ 5,000	1	$ 5,000
		Total for project =		$ 85,000

Table 28: SL-REGIONAL-SP-1 Stormwater Pond South of Medtronic Parking Lot (treats all of SL-3 and portions of SL-2-1 and SL-DD) (WinSLAMM).

Activity	Units	Unit Price	Quantity	Unit Price
Design	Each	$ 100,000	1	$ 100,000
Mobilization	Each	$ 50,000	1	$ 50,000
Site Prep	Each	$ 50,000	1	$ 50,000
Excavation	cu-yards	$ 30	25,813	$ 774,400
Inlet/Outlet Storm Sewer Tie-in	Each	$ 25,000	2	$ 50,000
Site Restoration/Revegetation	Each	$ 30,000	1	$ 30,000
Land Purchase	Acres	$ 142,440	3	$ 484,296
		Total for project =		$ 1,538,696

Table 29: SL-1-1 SP-1 Stormwater Pond at Target Parking Lot (WinSLAMM).

Activity	Units	Unit Price	Quantity	Unit Price
Design	Each	$ 50,000	1	$ 50,000
Mobilization	Each	$ 30,000	1	$ 30,000
Excavation	cu-yards	$ 30	4,721	$ 141,630
Inlet/Outlet Storm Sewer Tie-in	Each	$ 15,000	2	$ 30,000
Site Restoration/Revegetation	Each	$ 10,000	1	$ 10,000
		Total for project =		$ 261,630

Table 30: SL-3-4-6 SP-2 Stormwater Pond at Ramsdell Park (WinSLAMM)

Activity	Units	Unit Price	Quantity	Unit Price
Design	Each	$ 50,000	1	$ 50,000
Mobilization	Each	$ 30,000	1	$ 30,000
Site Prep	Each	$ 20,000	1	$ 20,000
Excavation	cu-yards	$ 30	6,073	$ 182,178
Inlet/Outlet Storm Sewer Tie-in	Each	$ 10,000	2	$ 20,000
Site Restoration/Revegetation	Each	$ 10,000	1	$ 10,000
		Total for project =		$ 312,178

Iron Enhanced Sand Filters

Table 31: 0.1 Acre Pump-Controlled IESF Bench at SL-REGIONAL-SP-1 Stormwater Pond South of Medtronic Parking Lot (treats all of SL-3 and portions of SL-2-1 and SL-DD) (WinSLAMM).

Item	Est. Qty	Unit	Unit Cost	Total
PROJECT ADMINISTRATION	1	EACH	$ 5,000.00	$ 5,000.00
PROJECT DEVELOPMENT	1	EACH	$ 15,000.00	$ 15,000.00
PROJECT DESIGN (ENGINEERING ASSISTANCE)	1	EACH	$ 50,000.00	$ 50,000.00
MOBILIZATION	1	EACH	$ 30,000.00	$ 30,000.00
CLEARING & GRUBBING	1	EACH	$ 10,000.00	$ 10,000.00
COMMON EXCAVATION AND DISPOSAL	322.29	CU YD	$ 30.00	$ 9,668.82
6” SOLID-WALL CPEP	200	LIN FT	$ 20.00	$ 4,000.00
6" DRAINTILE, CPEP	500	LIN FT	$ 15.00	$ 7,500.00
6" PVC CLEANOUT RISER W/CAP	10	EACH	$ 250.00	$ 2,500.00
COARSE FILTER AGGREGATE (CV)	53.72	CU YD	$ 70.00	$ 3,760.10
FINE FILTER AGGREGATE (CV) (P)*	153.76	CU YD	$ 45.00	$ 6,919.07
IRON FILINGS (P)*	14.96	TON	$ 1,500.00	$ 22,446.89
POWER TO SITE	1	EACH	$ 25,000.00	$ 25,000.00
PUMP, CONTROLS, DEWATERING, LIFT STATION MANHOLE	1	EACH	$ 50,000.00	$ 50,000.00
VALVES, CONTROLS, WIRING	1	EACH	$ 10,000.00	$ 10,000.00
4" FORCE MAIN	1	EACH	$ 35,000.00	$ 35,000.00
12" INTAKE LINE	1	EACH	$ 30,000.00	$ 30,000.00
BIT. TRAIL RESTORATION	1	EACH	$ 1,000.00	$ 1,000.00
SEED MIX & EROSION CONTROL BLANKET	1	EACH	$ 7,500.00	$ 7,500.00
SPLIT-RAIL FENCE	300	LIN FT	$ 25.00	$ 7,500.00
SUBTOTAL				$ 332,794.87
10% CONTINGENCY				$ 33,279.49
TOTAL				$ 366,074.36

Table 32: 0.2 Acre Pump-Controlled IESF Bench at SL-REGIONAL-SP-1 Stormwater Pond South of Medtronic Parking Lot (treats all of SL-3 and portions of SL-2-1 and SL-DD) (WinSLAMM).

Item	Est. Qty	Unit	Unit Cost	Total
PROJECT ADMINISTRATION	1	EACH	$ 5,000.00	$ 5,000.00
PROJECT DEVELOPMENT	1	EACH	$ 15,000.00	$ 15,000.00
PROJECT DESIGN (ENGINEERING ASSISTANCE)	1	EACH	$ 50,000.00	$ 50,000.00
MOBILIZATION	1	EACH	$ 30,000.00	$ 30,000.00
CLEARING & GRUBBING	1	EACH	$ 10,000.00	$ 10,000.00
COMMON EXCAVATION AND DISPOSAL	644.59	CU YD	$ 30.00	$ 19,337.64
6” SOLID-WALL CPEP	250	LIN FT	$ 20.00	$ 5,000.00
6" DRAINTILE, CPEP	500	LIN FT	$ 15.00	$ 7,500.00
6" PVC CLEANOUT RISER W/CAP	15	EACH	$ 250.00	$ 3,750.00
COARSE FILTER AGGREGATE (CV)	107.43	CU YD	$ 70.00	$ 7,520.19
FINE FILTER AGGREGATE (CV) (P)*	307.51	CU YD	$ 45.00	$ 13,838.14
IRON FILINGS (P)*	29.93	TON	$ 1,500.00	$ 44,893.78
POWER TO SITE	1	EACH	$ 25,000.00	$ 25,000.00
PUMP, CONTROLS, DEWATERING, LIFT STATION MANHOLE	1	EACH	$ 50,000.00	$ 50,000.00
VALVES, CONTROLS, WIRING	1	EACH	$ 10,000.00	$ 10,000.00
4" FORCE MAIN	1	EACH	$ 35,000.00	$ 35,000.00
12" INTAKE LINE	1	EACH	$ 30,000.00	$ 30,000.00
BIT. TRAIL RESTORATION	1	EACH	$ 1,000.00	$ 1,000.00
SEED MIX & EROSION CONTROL BLANKET	1	EACH	$ 7,500.00	$ 7,500.00
SPLIT-RAIL FENCE	450	LIN FT	$ 25.00	$ 11,250.00
SUBTOTAL				$ 381,589.75
10% CONTINGENCY				$ 38,158.97
TOTAL				$ 419,748.72

Table 33: 0.3 Acre Pump-Controlled IESF Bench at SL-REGIONAL-SP-1 Stormwater Pond South of Medtronic Parking Lot (treats all of SL-3 and portions of SL-2-1 and SL-DD) (WinSLAMM).

Item	Est. Qty	Unit	Unit Cost	Total
PROJECT ADMINISTRATION	1	EACH	$ 5,000.00	$ 5,000.00
PROJECT DEVELOPMENT	1	EACH	$ 15,000.00	$ 15,000.00
PROJECT DESIGN (ENGINEERING ASSISTANCE)	1	EACH	$ 50,000.00	$ 50,000.00
MOBILIZATION	1	EACH	$ 30,000.00	$ 30,000.00
CLEARING & GRUBBING	1	EACH	$ 10,000.00	$ 10,000.00
COMMON EXCAVATION AND DISPOSAL	966.88	CU YD	$ 30.00	$ 29,006.46
6” SOLID-WALL CPEP	300	LIN FT	$ 20.00	$ 6,000.00
6" DRAINTILE, CPEP	600	LIN FT	$ 15.00	$ 9,000.00
6" PVC CLEANOUT RISER W/CAP	20	EACH	$ 250.00	$ 5,000.00
COARSE FILTER AGGREGATE (CV)	161.15	CU YD	$ 70.00	$ 11,280.29
FINE FILTER AGGREGATE (CV) (P)*	461.27	CU YD	$ 45.00	$ 20,757.21
IRON FILINGS (P)*	44.89	TON	$ 1,500.00	$ 67,340.67
POWER TO SITE	1	EACH	$ 25,000.00	$ 25,000.00
PUMP, CONTROLS, DEWATERING, LIFT STATION MANHOLE	1	EACH	$ 50,000.00	$ 50,000.00
VALVES, CONTROLS, WIRING	1	EACH	$ 10,000.00	$ 10,000.00
4" FORCE MAIN	1	EACH	$ 35,000.00	$ 35,000.00
12" INTAKE LINE	1	EACH	$ 30,000.00	$ 30,000.00
BIT. TRAIL RESTORATION	1	EACH	$ 1,000.00	$ 1,000.00
SEED MIX & EROSION CONTROL BLANKET	1	EACH	$ 7,500.00	$ 7,500.00
SPLIT-RAIL FENCE	600	LIN FT	$ 25.00	$ 15,000.00
SUBTOTAL				$ 431,884.62
10% CONTINGENCY				$ 43,188.46
TOTAL				$ 475,073.09

Appendix C – Soil Information

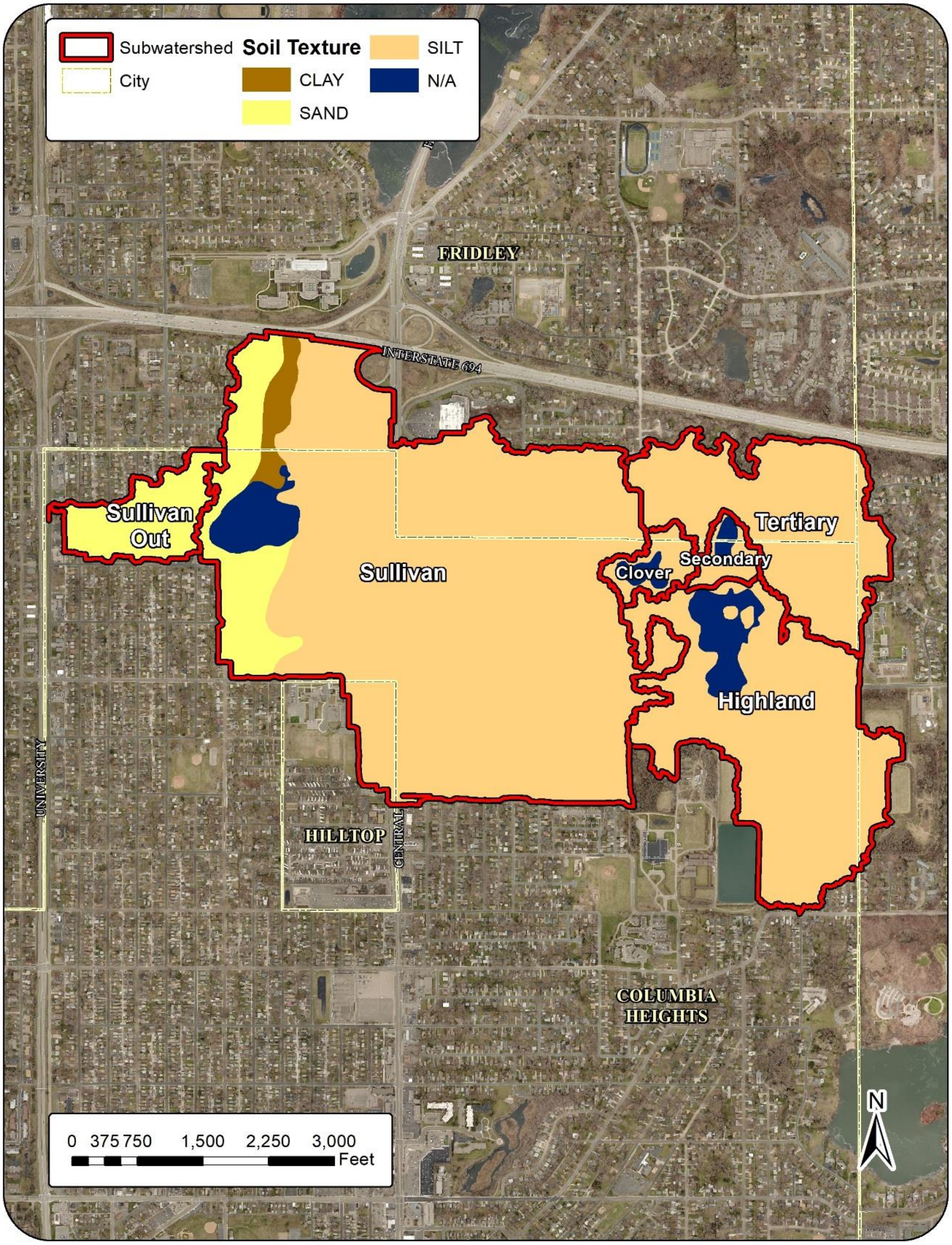

Figure 49: Soil texture used for WinSLAMM model.

Appendix D –Wellhead Protection Areas

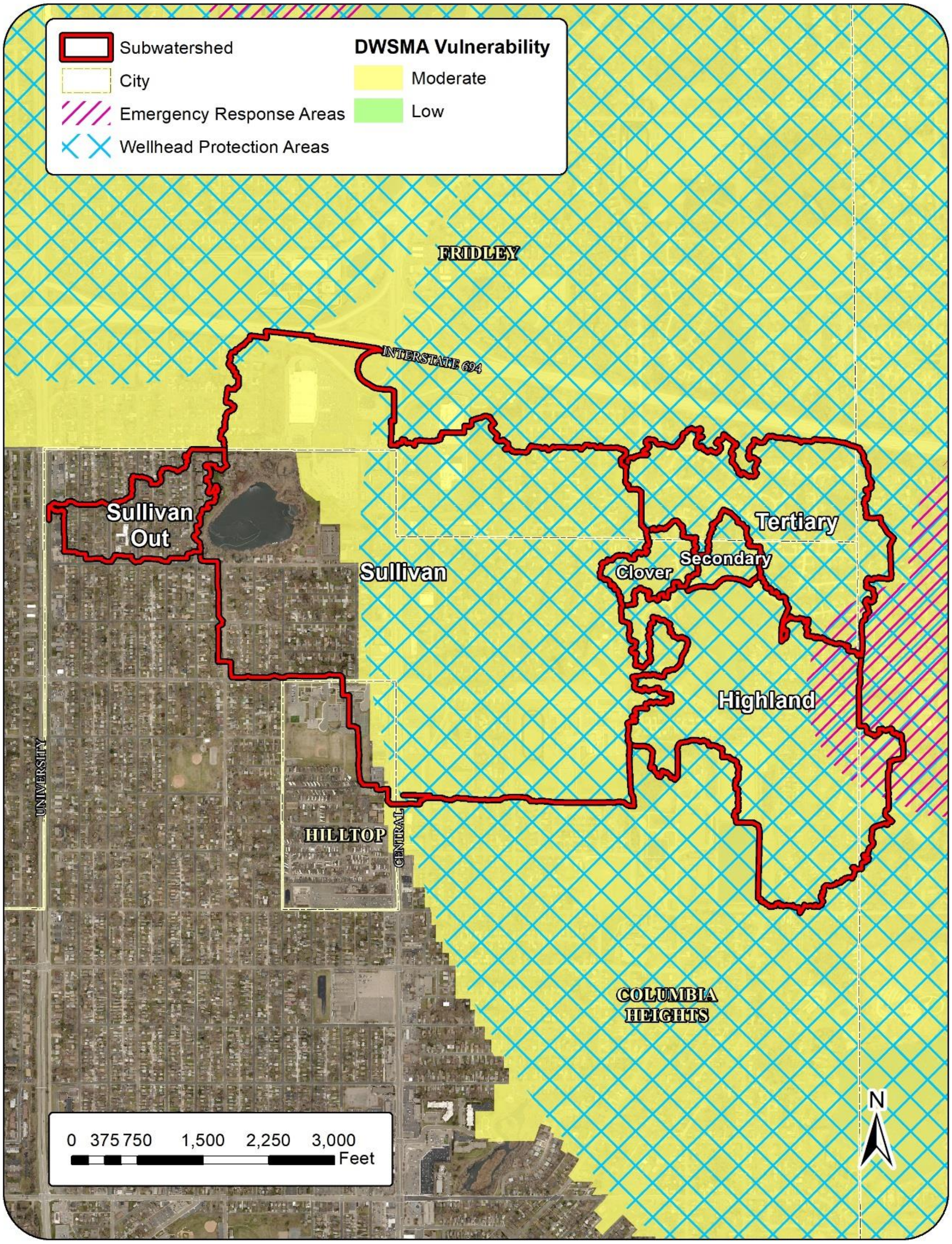

Figure 50: Wellhead protection areas and Drinking Water Supply Management Area (DWSMA) vulnerability.

Appendix E –High Performance Modular Biofiltration System (HPMBS) Specification

SPECIFICATION
HIGH PERFORMANCE MODULAR BIOFILTRATION SYSTEM (HPMBS)
Material, Performance and Installation Specification

I. Summary

The following general specifications describe the components and installation requirements for a volume based High Performance Modular Biofiltration System (HPMBS) that utilizes physical, chemical and biological mechanisms of a soil, plant and microbe complex to remove pollutants typically found in urban storm water runoff. The modular treatment system in which the biologically active biofiltration media is used shall be a complete, integrated system designed to be placed in Square Foot or Linear Foot increments per the approved drawings to treat contaminated runoff from impervious surfaces.

The High Performance Modular Biofiltration System (HPMBS) is comprised of the following components:

A. Plant Component

1. Supplier shall provide a regionalized list of acceptable plants.
2. Plants, as specified in the approved drawings/supplier's plant list, shall be installed at the time the HPMBS is commissioned for use.
3. Plants and planting are typically included in landscape contract.

B. Biofilter Component

1. This component employs a high performance cross-section in which each element is highly dependent on the others to meet the performance specification for the complete system. It is important that this entire cross-section be provided as a complete system, and installed as such.

2. As indicated in the approved drawings, the elements of the Biofilter include:

   A. *A <u>mulch protective layer</u> (if specified).*

   B. *An advanced <u>high infiltration rate biofiltration planting media bed</u> which utilizes physical, chemical and biological mechanisms of the soil, plant, and microbe complex, to remove pollutants found in storm water runoff.*

   C. *A <u>separation layer which utilizes the concept of 'bridging'</u> to separate the biofiltration media from the underdrain without the use of geotextile fabrics.*

D. *A* *<u>wide aperture mesh layer</u>* *utilized to prevent bridging stone from entering the underdrain/storage element.*

E. *A* *<u>modular, high infiltration rate 'flat pipe'</u>* *style underdrain/storage system which is designed to directly infiltrate or exfiltrate water through its surface. The modular underdrain must provide a minimum of 95% void space.*

C. Energy Dissipation Component

1. An Energy Dissipation Component is typically specified to slow and spread out water as it enters the system. This component is dependent upon the design in the approved drawings, but typically consists of a rock gabion, rock filter dam or dense vegetation element, such as native grasses, either surrounding the Biofiltration Component or located immediately upstream of it.

D. Pretreatment Component

1. Pretreatment, when specified, is typically accomplished by locating the Biofiltration Component within a traditional vegetated BMP such as a vegetated swale, vegetated depression, traditional bioretention system, vegetated filter strip, sediment forebay, etc. These BMPs provide primary TSS removal when desirable.

E. Observation and Maintenance Component

1. An Observation and Maintenance Port shall be installed per the approved drawings to provide for easy inspection of the underdrain/storage element, and cleanout access if needed.

F. Extreme Event Overflow (by others)

1. An Extreme Event Overflow should be located external to, but near the Biofiltration element to provide bypass when needed. This may be an overland flow bypass structure, beehive overflow grate structure, or equivalent that serves the purpose. If a beehive overflow structure is utilized it should include a removable filter insert to provide for effective control of gross pollutants, trash and floatables.

II. Quality Assurance and Performance Specifications

The quality and composition of all system components and all other appurtenances and their assembly process shall be subject to inspection upon delivery of the system to the work site.

Installation is to be performed only by skilled work people with satisfactory record of performance on earthworks, pipe, chamber, or pond/landfill construction projects of comparable size and quality.

A. Plants

1. Plants must be compatible with the HPMBS media and the associated highly variable hydrologic regime. Plants are typically facultative with fibrous roots systems such a native grasses and shrubs.

2. Supplier shall provide a regionalized list of acceptable plants.

3. All plant material shall comply with the type and size required by the approved drawings and shall be alive and free of obvious signs of disease.

B. Mulch

1. Mulch, typically double shredded hardwood (non-floatable), shall comply with the type and size required by the approved drawings, and shall be screened to minimize fines.

C. Biofiltration Media

1. Biologically active biofiltration media shall be visually inspected to ensure appropriate volume, texture and consistency with the approved drawings, and must bear a batch number marking from the supplier which certifies performance testing of the batch to meet or exceed the required infiltration rate (100 in/hr). A third party laboratory test must be provided to certify the 100 in/hr rate.

2. Within 90 days after project completion, the infiltration rate shall be confirmed at the supplier's expense, by a wetted condition hydraulic conductivity test.

    a. *Failure to pass this test will result in removal and replacement of all media in the system at no cost to the project owner/operator.*

    b. *Test must utilize the equipment and follow the standard operating procedures found in the Harris County Texas manual entitled, Low Impact Development & Green Infrastructure Design Criteria for Storm Water Management (2011).*

    c. *Replacement media, if required, must be taken from a different batch than the original.*

3. Supplier shall provide, at no additional cost to the project owner/operator, maintenance of the biofiltration system for a period of one year.

4. Pollutant Removal performance, composition and characteristics of the Biofiltration Media must meet or exceed the following minimum standards as

demonstrated by testing acceptable to the project engineer:

Pollutant	**Removal Efficiency**
TSS	> 80%
Phosphorus	≥ 60%
Nitrogen	≥ 48%
Composition and Characteristics	
Sand - Fine	< 5%
Sand – Medium	10% - 15%
Sand – Coarse	15% - 25%
Sand – Very Coarse	40% - 45%
Gravel	10% - 20%
Infiltration Rate	>100 inches per hour
Peat Moss*	5% - 15%
*** Peat Moss Specification**	
Listed by Organic Materials Review Institute 100% natural peat (no composted, sludge, yard or leaf waste) Total Carbon >85% Carbon to Nitrogen Ratio 15:1 to 23:1 Lignin Content 49% to 52% Humic Acid >18% pH 6.0 to 7.0 Moisture Content 30% to 50% 95% to 100% passing 2.0mm sieve > 80% passing 1.0mm sieve	

D. Underdrain/Storage System

1. Underdrain/storage components shall be manufactured in an ISO certified facility and be manufactured from at least 90% post consumer recycled materials.

2. Underdrain/storage components shall meet or exceed the following characteristics:

Property	Value
Surface Void Area	≥ 85%
Unit Weight	3.25 lbs/cf
Service Temperature	-14° to 167°
Unconfined Crush Strength	32.48 psi
180 Day Creep Test	
Load Applied – Initial and Sustained	11.16 psi
• Creep Sustained – After 180 Days	0.20 inches
• Creep Sustained – After 180 Days	1.13 %
• Projected Creep – 40 years	1.72%

E. Separation Mesh

1. Separation Mesh shall be composed of high-tenacity monofilament polypropylene yarns that are woven together to produce an open mesh geotextile which shall be inert to biological degradation and resistant to naturally encountered chemicals, alkalis and acids. The mesh shall meet or exceed the following characteristics:

Properties	Test Method	Unit	Min Ave Roll Value	
			MD	CD
Tensile Strength	ASTM D4595	kN/m (lbs/ft)	21 (1440)	25.3 (1733)
Creep Reduced Strength	ASTM D5262	kN/m (lbs/ft)	6.9 (471)	8.3 (566)
Long Term Allowable Design Load	GRI GG-4	kN/m (lbs/ft)	5.9 (407)	7.2 (490)
UV Resistance (at 500 hours)	-	% strength retained	90	
Aperture Size (machine direction)	-	mm (in)	2 (0.08)	
Aperture Size (cross machine direction)	-	mm (in)	2 (0.08)	
Mass/Unit Area	ASTM D5261	g/m^2 (oz/yd^2)	197 (5.8)	

F. Bridging Stone

1. Bridging Stone shall be 3/8" pea gravel, or other diameter sized to prevent migration of filter media, as specified by supplier.

2. Stone must be washed and free from sediment, soil and contaminants.

III. Delivery, Storage and Handling

A. Protect all materials from damage during delivery and store UV sensitive materials under tarp to protect from sunlight including all plastics, when time from delivery to installation exceeds one week. Storage should occur on smooth surfaces, free from dirt, mud and debris.

B. Biofiltration media shall be segregated from any other aggregate materials and shall be protected against contamination, including contamination from any stormwater runoff from areas of the site which are not stabilized.

IV. Submittals

A. Product Data

1. Submit supplier's product data and approved Installation Manual as well as supplier's Operations and Maintenance Manual for the system. It will be the responsibility of the system owner/operator or their contractor to ensure the system is operated and maintained in accordance with the manual.

B. Certification

1. Supplier shall submit a letter of certification that the complete system meets or exceeds all technical and packaging requirements. Biofiltration media packaging must bear a batch number marking from the supplier which matches a letter from the supplier certifying performance testing of the batch to meet or exceed the required infiltration rate.

C. Drawings

1. Supplier shall provide dimensional drawings including details for construction, materials, specifications and pipe connections.

D. Warranty

1. Supplier shall provide a warranty for all components of the HPMBS for a period of one year provided the unit is installed, operated and maintained in accordance with the manual. Improper operation, maintenance or accidental or illegal activities (i.e. dumping of pollutants, vandalism, etc.) will void the warranty. Biofiltration media shall be warranted to pass the post-installation infiltration test described in this document.

E. Design Computations

1. The HPMBS must be sized using a volume based sizing criteria and demonstrate, using a SCS stormwater modeling software/spreadsheet calculator that the required water quality volume (defined by the Engineer of Record) passes through the HPMBS prior to activation of the overflow device (set no lower higher than six (6) inches above the top elevation of the HPMBS (typically defined as top of mulch)). Design computations must be provided as part of the submittal process. Sizing based solely on a filter surface area to drainage area ratio method will not be accepted.

F. Substitutions

1. Any proposed equal alternative product substitution to this specification must be submitted for review and approved prior to bid opening. Review package should include third party reviewed performance data of the biofiltration media that includes saturated conductivity measurements and pollutant removal efficiency. Pollutant removal data must follow specified protocols. All components must meet or exceed Quality Assurance and Performance Criteria indicated herein.

V. Project Conditions

A. Review supplier's recommended installation procedures and coordinate installation with other work affected, such as grading, excavation, utilities, construction access and erosion control to prevent all non- installation related construction traffic over the completed HPMBS.

B. Cold Weather

1. Do not use frozen materials or materials mixed or coated with ice or frost.

2. Do not build on frozen ground or wet, saturated or muddy subgrade.

3. Care must be taken when handling plastics when air temperature is at 40 degrees or below as plastic becomes brittle.

C. Protect partially completed installation against damage from other construction traffic when work is in progress and following completion of backfill by establishing a perimeter with highly visible construction tape, fencing, or other means until construction is complete.

D. Soil stabilization of the surrounding site must be complete before the Biofiltration System can be brought online. Soil stabilization occurs when 90% of the site has been paved or vegetated. Temporary erosion control and/or sedimentation prevention measures shall be implemented to reduce the possibility of sediments being transported into the Biofiltration System prior to full stabilization of the site. Significant sediment loads can damage the HPBMS and lead to failure if not prevented or remediated promptly.

VI. PRODUCTS

A. Acceptable HPBMS

FocalPoint High Performance Biofiltration System

B. Acceptable Beehive Overflow Grate Structure (Optional)

Beehive Overflow Grate Structure with removable StormSack

C. Acceptable System Supplier

Convergent Water Technologies, Inc.
(800) 711-5428
www.convergentwater.com

D. **Authorized Value Added Reseller**

ACF Environmental
2831 Cardwell Road
Richmond, VA 23234
(800 448-3636
www.acfenvironmental.com

VII. Packaging

A. HPMBS is assembled on site.

B. Modular underdrain/storage unit is shipped flat and modules are assembled prior to installation.

C. Biofiltration media is delivered in one ton super sacks each labeled with supplier's batch number and/or in bulk with accompanying supplier's certification.

D. Other components are delivered in bulk or super sacks

VIII. Execution

A. Excavation and Backfill

1. Base of excavation shall be smooth, level and free of lumps or debris, and compacted unless infiltration of storm water into subgrade is desired. A thin layer (3") of compacted base material is recommended to establish a level working platform (may not be needed in sandy soils). If the base of the excavation is pumping or appears excessively soft, a geotechnical engineer should be consulted for advice. In many cases, a stabilization geotextile and 6" of compactable material that drains well will be sufficient to amend the bearing capacity of the soil.

2. Most applications require 8 oz Non-Woven Geotextile or equivalent nonwoven geotextile with a nominal weight of 8 oz per square yard to line the excavation to separate in situ soils and the HPMBS. (Applications requiring water to infiltrate the in situ sub-soils should use a bridging stone rather than geotextile to provide a separation layer between the HPMBS and the in situ soils). Geotextile, when utilized, should be placed on the bottom and up the sides of the excavation. Absolutely no geotextiles should be used in the water column. If an impermeable liner is specified, it shall be installed according to supplier's instructions and recommendations.

3. Specified backfill material must be free from lumps, debris and any sharp objects that could penetrate the geotextile. Material is used for backfill along the sides of the system as indicated in engineering detail drawings.

B. Inspection

1. Examine prepared excavation for smoothness, compaction and level. Check for presence of high water table, which must be kept at levels below the bottom of the under drain structure at all times. If the base is pumping or appears excessively soft, a geotechnical engineer should be consulted for advice.

2. Installation commencement constitutes acceptance of existing conditions and responsibility for satisfactory performance. If existing conditions are found to be unsatisfactory, contact Project Manager or Engineer for resolution prior to installation.

IX. Cleanup and Protection during Ongoing Construction Activity

A. Perform cleaning during the installation and upon completion of the work.

B. Remove from site all excess materials, debris, and equipment. Repair any damage to adjacent materials and surfaces resulting from installation.

C. If surrounding drainage area is not fully stabilized, a protective covering of geotextile fabric should be securely placed to protect the Biofiltration Media.

D. Construction phase erosion and sedimentation controls shall be placed to protect the inlet(s) to the Biofiltration System. Excessive sedimentation, particularly prior to establishment of plants may damage the HPMBS.

E. Strictly follow supplier's guidelines with respect to protection of the HPMBS between Installation and Commissioning phases.

X. Commissioning

A. Commissioning should only be carried out once the contributing drainage area is fully stabilized. If Commissioning must be carried out sooner, it is imperative that appropriate erosion and sediment controls be placed to prevent the entry of excessive sediment/pollutant loads into the system.

B. Commissioning entails removing the protective covering from the Biofiltration Media, planting the plant material in accordance with the approved drawings, and placing mulch if specified.

1. Dig planting holes the depth of the root ball and two to three times as wide as the root ball. Wide holes encourage horizontal root growth that plants naturally produce.

2. With trees, you must ensure you are not planting too deep. Don't dig holes deeper than root balls. The media should be placed at the root collar, not above the root collar. Otherwise the stem will be vulnerable to disease.

3. Strictly follow supplier's planting guidance.

C. Cover the exposed root ball top with mulch. Mulch should not touch the plant base because it can hold too much moisture and invite disease and insects. Evenly place 3 inches of double-shredded hardwood mulch (if specified) on the surface of the media.

D. Plantings shall be watered-in at installation and temporary irrigations shall be provided, if specified.

XI. Using the HPMBS

A. Maintenance Requirements

1. Each correctly installed HPMBS is to be maintained by the supplier for a minimum period of one year. The cost of this service is to be included in the supplier's price of the system.

2. Annual maintenance consists of two (2) scheduled visits unless otherwise specified.

3. Each maintenance visit consists of the following:

    1. *Complete system inspection*
    2. *Removal of foreign debris, silt, plant material, trash and mulch (if needed)*
    3. *Evaluation of biofiltration media*
    4. *Evaluation of plant health*
    5. *Inspection of underdrain/storage system via Observation/Maintenance Port*
    6. *Properly dispose of all maintenance refuse items (trash, mulch, etc.)*
    7. *Take photographs documenting plant growth and general system health*
    8. *Update and store maintenance records*
    9. *To ensure long term performance of the HPMBS, continuing annual maintenance should be performed per the supplier's Operations and Maintenance Manual.*

4. If sediment accumulates beyond an acceptable level in the underdrain/storage system, it will be necessary to flush the underdrain. This can be done by pumping

water into the Observation/Maintenance Port or adjacent overflow structure, allowing the turbulent flows through the underdrain to re- suspend the fine sediments. If multiple Observation/Maintenance Ports have been installed, water should be pumped into each port to maximize flushing efficiency.

Sediment-laden water can be pumped out and either captured for disposal or filtered through a Dirtbag filter bag, if permitted by the locality.

XII. Measurement and Payment

Given the integrated nature of the HPMBS, measurement and payment will be based not on the individual component prices, but on the size of the Biofiltration Media bed. The external dimension as indicated in the approved plans and executed in the installation will be measured in Square Feet and payment will be made per HPMBS system.

Measurement and payment of beehive overflow grate structure with removable filter insert will be based on per unit price.