Springbrook
Stormwater Retrofit Analysis

Prepared by:

ANOKA CONSERVATION DISTRICT

for the

COON CREEK WATERSHED DISTRICT

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Cover photo: The confluence of Springbrook with the Mississippi River south of 79th Way NE in Fridley.

Disclaimer: This report identifies and ranks identified BMPs for the Springbrook subwatershed at the time of printing. 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 Coon Creek Watershed District.

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Executive Summary

This study provides recommendations for cost effectively improving treatment of stormwater draining to Ditch 17, known locally as Springbrook. Springbrook is located within the Coon Creek Watershed District, and flows through portions of the Cities of Blaine, Coon Rapids, Spring Lake Park, and Fridley. The creek serves as drainage for a 2,702 acre area, and is the primary stormwater conveyance through this urban landscape. Both because of its own importance, and because it discharges into the Mississippi River, water quality in Springbrook is a priority. Improved stormwater treatment is a means for significant water quality improvement in the waterbody.

Springbrook is designated as a Minnesota state "impaired" water for failing to meet invertebrate biota expectations. The stream also has other water quality concerns that have not yet resulted in state impairment designations, including high dissolved pollutants and suspended solids. Phosphorus also approaches the state water quality standard during storms. *E. coli* appears to be elevated, but only a limited number of samples have been taken.

This report presents stormwater retrofitting projects that will improve water quality, and ranks projects in order of cost effectiveness. Stormwater retrofitting refers to adding stormwater treatment to an already built-up area, where little open land exists. This process is investigative and creative. Stormwater retrofitting success is sometimes improperly judged by the number of projects installed or by comparing costs alone. Those approaches neglect to consider how much pollution is removed per dollar spent. In this stormwater analysis we estimated both costs and pollutant reductions, and used them to calculate cost effectiveness of each possible project.

This report's modeling and numeric pollutant reduction results focus on phosphorus, specifically total phosphorus (TP), with secondary analysis of total suspended solids (TSS) and volume. Dissolved pollutants and *E. coli* are also of importance but were considered in non-numeric ways. Robust computer models for suspended solids and phosphorus exist. Models are weak at estimating bacterial and dissolved pollutant reductions. Although selected stormwater treatment practices are effective at treating these pollutants, numeric reductions cannot be presented with high confidence. The report contains discussion throughout about why certain retrofits are recommended for multi-pollutant treatment.

Monitoring data was examined to gain a sense of the magnitude of pollutant reductions needed to meet state water quality standards. Preliminary analysis based on in-stream water quality monitoring at the confluence of Springbrook with the Mississippi River found that a 24.0% reduction in TP and a 4.6% reduction in TSS would bring water quality samples found to be in exceedance of the state standard to below the standard. These percentages were set as the reduction goal for these pollutants across the subwatershed. Based on WinSLAMM loading estimates from existing conditions, including present-day land use and installed stormwater BMPs, these percentages correspond to required annual loading reductions of 212.5 lbs-TP and 9,840 lbs-TSS. No numeric goals were proposed for bacteria, but infiltration practices, known to be the most effective at removing bacteria, were targeted above other practices where possible. Adaptive management, where plans are revised after each round of projects, is appropriate.

This report is organized by stormwater catchment or drainage area. There are 17 neighborhood-level catchments discussed. For each, the water quality modeling software WinSLAMM was used to estimate volume and pollutant runoff from the landscape in three scenarios: base (no stormwater treatment), existing (present-day structural stormwater treatment) and proposed (with proposed stormwater retrofits). The 2,702 acres draining to Springbrook contribute an estimated 1,620 ac-ft. of stormwater runoff, 885 lbs-TP, and 213,918 lbs-TSS annually (WinSLAMM model estimates).

An additional 143 acres exist within the Springbrook subwatershed, which are not hydrologically connected to the waterbody. This area is distributed across two catchments (SP-14 and SP-17) which convey stormwater through storm sewer pipes directly to the Mississippi River. Projects were proposed in these catchments but were not included in the ranking tables with projects benefiting Springbrook. Ranking tables for these projects are listed separately in *Appendix C* and are not discussed outside of the *Catchment Profile* pages for catchments SP-14 and SP-17.

A variety of stormwater retrofit approaches were identified. They included:

- Maintenance of, or alterations to, existing stormwater treatment,
- Curb-cut rain gardens,
- Hydrodynamic devices,
- Infiltration basins,
- Iron-enhanced sand filter pond benches,
- Permeable asphalt,
- Permeable check dams, and
- Streambank stabilizations.

When considering treatment train effects, the three projects listed below represent the most cost-effective combination to achieve both pollutant reduction goals of 212.5 lbs-TP and 9,840 lbs-TSS.

Table 1: Projects to meet the proposed TP and TSS goals

Project Rank	Project ID	Page Number	Retrofit Type and Detail	Retrofit Location	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Probable Project Cost (2015 Dollars)	Estimated Annual Operations & Maintenance (2015 Dollars)	Estimated cost/ lb-TP/year (30-year)[1]
1	16-E	155	0.5 acre IESF bench with 0.25 acre sedimentation basin	Subcatchment 16-12	SP-16	114.5	17,921	$948,000	$11,500	$376
2	15-G	145	0.5 acre IESF Bench	Subcatchment 15-5	SP-15	54.1	0	$832,000	$11,000	$716
3	9-B	105	8,200 sq-ft IESF Bench	Subcatchment 9-18	SP-9	48.1	0	$422,800	$7,882	$457

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

Installing all three of these projects would result in 216.7 lbs-TP and 17,921 lbs-TSS removal, thereby achieving the goals. Direct (design and construction) and indirect (promotion and administration) costs for these projects are proposed to be $2,202,800, with an additional $30,382 per year in estimated operations and maintenance costs. Assuming a 30-year project lifetime for each of these projects, total cost (excluding inflation) is expected to be approximately $3,114,000.

The large-scale projects in Table 1 are driven by the need to reduce TP by 212.5 lbs-TP annually and may prove to be infeasible or cost-prohibitive. Alternatively, the TSS goal alone could be achieved through the installation of a single project; a streambank stabilization project in Catchment 16 (Project 16-F, page 157) could reduce TSS by 15,000 lbs/yr.

This report provides conceptual sketches or photos of these and other recommended stormwater retrofitting projects. The intent 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. wet ponds and iron-enhanced sand filter benches) will require feasibility studies 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 tables on the next pages summarize potential projects. Potential projects are organized from most cost effective to least, based on cost per pound of TP removed. Installation of projects in series, such as those listed in Table 1, will result in lower total treatment than the simple sum of treatment across the individual projects due to treatment train effects. The projects identified in Table 1 were included in a single, comprehensive WinSLAMM model to estimate treatment train effects. This is why projects listed in Table 1 have lower pollutant reduction values than what is listed in their project ID pages. 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 unfeasible due to prohibitive size, number, or were too expensive to justify installation were not included in this report.

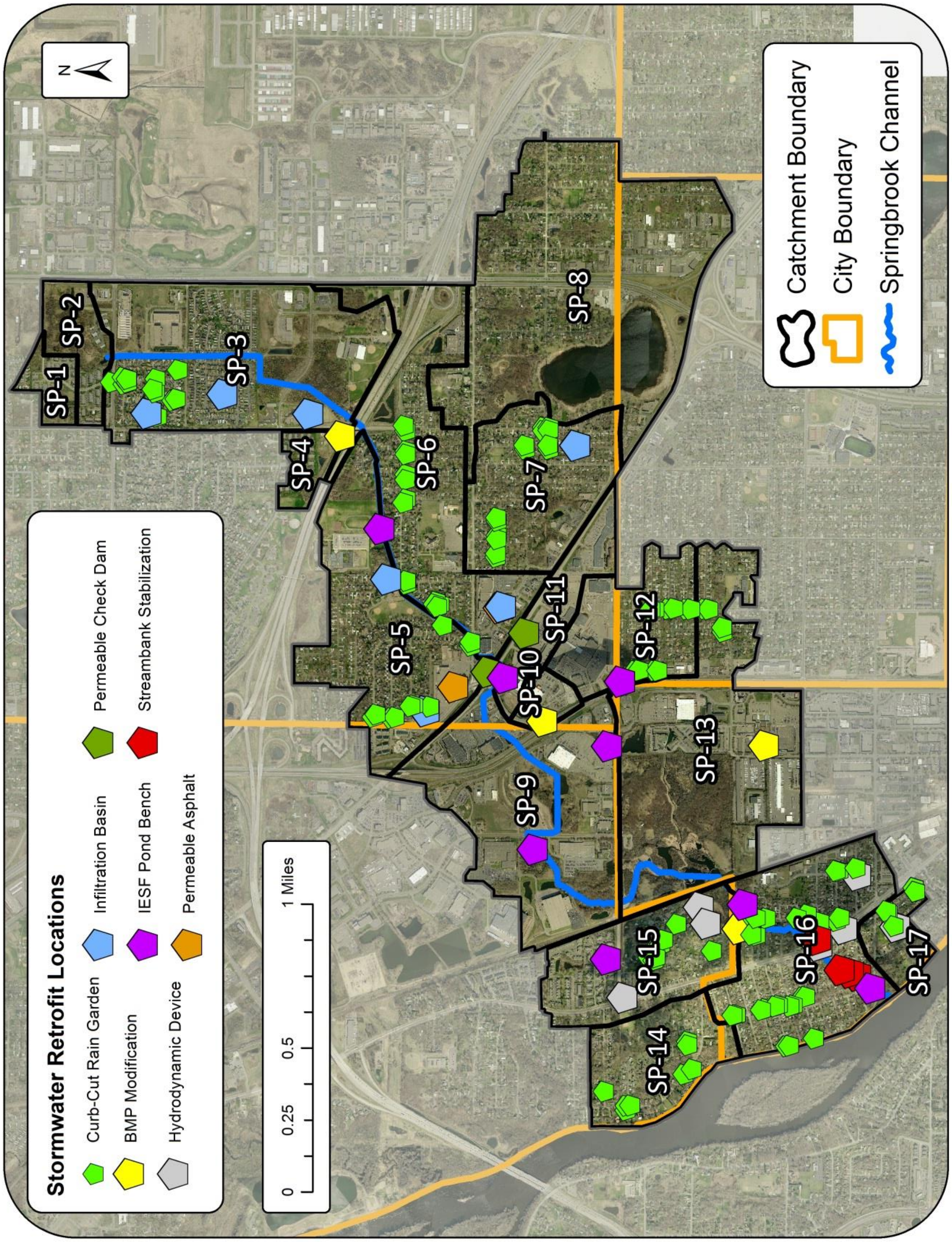


Figure 1: Subwatershed-wide map showing all proposed retrofits included in this report.

Table 2: Cost-effectiveness of retrofits with respect to TP reduction. Projects 1 - 14. 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	Retrofit Location	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost (2015 Dollars)	Estimated Annual Operations & Maintenance (2015 Dollars)	Estimated cost/ lb-TP/year (30-year)[1]
1	16-F	157	Streambank Stabilization	Multiple	SP-16	12.0	15,000	0.0	$37,920	$500	$147
2	16-E	155	IESF Bench	Subcatchment 16-12	SP-16	69.7-137.7	0	0.0	$448,230-$948,000	$8,500-$11,500	$286-$336
3	15-G	145	IESF Bench	Subcatchment 15-5	SP-15	66.5-94.5	0	0.0	$548,230-$832,000	$8,500-$11,000	$403-$410
4	9-B	105	IESF Bench	Subcatchment 9-18	SP-9	48.1	0	0.0	$422,800	$7,882	$457
5	11-A	115	Permeable Check Dam	Subcatchment 11-1	SP-11	1.5	434	1.5	$15,448	$365	$587
6	16-G	158	Streambank Stabilization	Multiple	SP-16	3.0	3,750	0.0	$37,920	$500	$588
7	16-A	151	Curb-Cut Rain Gardens	Multiple	SP-16	6.5-14.2	1,912-4,336	5.2-10.4	$73,608-$143,128	$1,800-$4,050	$621-$654
8	15-A	138	Curb-Cut Rain Gardens	Multiple	SP-15	3.5-5.8	1,102-1,807	2.3-3.7	$40,600-$73,608	$900-$1,800	$644-$733
9	5-D	81	Infiltration Basin	Subcatchment 5-9	SP-5	2.7-3.1	659-766	4.1-4.8	$48,796-$63,796	$275	$704-$775
10	5-F	83	Permeable Check Dam	Subcatchment 5-10	SP-5	1.1	378	1.1	$15,448	$365	$800
11	7-B	96	Infiltration Basin	Subcatchment 7-1	SP-7	1.6	376	2.3	$33,796	$275	$876
12	3-C	66	Infiltration Basin	Subcatchment 3-4	SP-3	1.2-1.3	277-314	2.5-3.0	$27,796-$35,796	$275	$1,001-$1,129
13	3-B	65	Infiltration Basin	Subcatchment 3-4	SP-3	0.8-1.0	155-211	1.4-1.8	$18,796-$23,796	$275	$1,068-$1,127
14	16-H	159	Streambank Stabilization	Multiple	SP-16	1.1	1,350	0.0	$27,920	$300	$1,119

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

Table 3: Cost-effectiveness of retrofits with respect to TP reduction. Projects 15 - 28. 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	Retrofit Location	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost (2015 Dollars)	Estimated Annual Operations & Maintenance (2015 Dollars)	Estimated cost/ lb-TP/year (30-year)[1]
15	6-C	90	Infiltration Basin	Subcatchment 6-16	SP-6	1.1-1.5	395-554	3.0-3.9	$28,696-$48,796	$275	$1,120-$1,268
16	3-D	67	Infiltration Basin	Subcatchment 3-4	SP-3	0.8	160	0.9	$19,796	$275	$1,169
17	12-A	121	Curb-Cut Rain Gardens	Multiple	SP-12	1.8-3.2	457-761	3.2-5.3	$40,600-$73,608	$900-$1,800	$1,252-$1,329
18	13-A	127	Curb-Cut Rain Gardens	Multiple	SP-13	1.0-1.7	206-357	1.8-3.0	$24,096-$40,600	$450-$900	$1,253-$1,325
19	16-I	160	Streambank Stabilization	Multiple	SP-16	0.7	900	0.0	$22,920	$200	$1,377
T20	6-A	88	Curb-Cut Rain Gardens	Multiple	SP-6	1.8-3.5	378-767	2.5-5.5	$57,104-$90,112	$1,350-$2,250	$1,467-$1,807
T20	7-A	95	Curb-Cut Rain Gardens	Multiple	SP-7	1.9-3.6	455-810	3.4-6.4	$57,104-$90,112	$1,350-$2,250	$1,467-$1,712
22	3-A	64	Curb-Cut Rain Gardens	Multiple	SP-3	1.2-2.8	243-560	1.6-3.9	$40,600-$73,608	$900-$1,800	$1,519-$1,878
23	5-A	78	Curb-Cut Rain Gardens	Multiple	SP-5	1.2-2.5	268-554	1.8-3.9	$40,600-$73,608	$900-$1,800	$1,701-$1,878
24	4-A	72	BMP Modification	Subcatchment 4-2	SP-4	0.9	731	0.0	$27,650	$700	$1,802
25	12-B	122	IESF Bench	Subcatchment 12-1	SP-12	6.0	0	0.0	$282,955	$1,607	$1,840
26	5-C	80	Infiltration Basin	Subcatchment 5-4	SP-5	0.6	119	0.7	$26,296	$275	$1,919
27	15-B	139	IESF Bench	Subcatchment 15-3	SP-15	2.4	0	0.0	$143,315	$459	$2,182
28	15-D	141	Hydrodynamic Device	Subcatchment 15-5	SP-15	1.9	715	0.0	$109,752	$840	$2,368

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

Table 4: Cost-effectiveness of retrofits with respect to TP reduction. Projects 29 - 41. 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	Retrofit Location	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost (2015 Dollars)	Estimated Annual Operations & Maintenance (2015 Dollars)	Estimated cost/ lb-TP/year (30-year)[1]
29	16-D	154	Hydrodynamic Device	Subcatchment 16-8	SP-16	1.6	617	0.0	$109,752	$840	$2,812
30	5-B	79	IESF Bench	Subcatchment 5-3	SP-5	2.0	0	0.0	$152,400	$505	$2,884
31	11-B	116	IESF Bench	Subcatchment 11-2	SP-11	2.0	0	0.0	$189,195	$918	$3,612
32	10-A	110	BMP Modification	Subcatchment 10-1	SP-10	0.8	271	1.8	$80,920	$275	$3,715
33	15-C	140	Hydrodynamic Device	Subcatchment 15-4	SP-15	1.2	517	0.0	$109,752	$840	$3,749
34	16-B	152	Hydrodynamic Device	Subcatchment 16-7	SP-16	1.1	431	0.0	$109,752	$840	$4,089
35	15-E	142	Hydrodynamic Device	Subcatchment 15-5	SP-15	0.6	252	0.0	$109,752	$840	$4,497
36	9-A	104	IESF Bench	Subcatchment 9-11	SP-9	1.7	0	0.0	$224,195	$918	$4,936
37	16-C	153	Hydrodynamic Device	Subcatchment 16-8	SP-16	0.9	393	0.0	$109,752	$840	$4,998
38	15-F	143	BMP Modification	Subcatchment 15-5	SP-15	0.6-1.1	232-446	0.0	$108,840-$215,840	$900	$5,086-$9,047
39	13-B	128	BMP Modification	Subcatchment 13-17	SP-13	0.4	376	0.0	$150,840-$250,840	$900	$14,820-$23,153
40	6-B	89	Permeable Asphalt	Subcatchment 6-16	SP-6	0.8	347	2.3	$439,396	$32,670	$59,146
41	5-E	82	Permeable Asphalt	Subcatchment 5-10	SP-5	0.4	175	1.4	$221,596	$16,335	$59,304

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

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 *Appendices A* and *B* for additional detail on modeling methodology.

Project Ranking and Selection

The *Project Ranking and Selection* section describes the methods and rationale for how projects were chosen and 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 volume or pollutant removed by each project over its given lifetime, usually 30 years. The final cost per unit 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 lists provided in this report are merely a starting point.

Lastly, water quality goals are detailed in this section, as well as a project list capable of reaching any proposed goals.

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 Springbrook subwatershed was divided into 17 stormwater catchments which were assigned a unique identification number (i.e. SP-1 through SP-17) and further subdivided into 144 subcatchments for modeling purposes. For each catchment, the following information is detailed:

Catchment Description

Within each catchment profile is a table that summarizes basic catchment information including acres, dominant land cover, and parcels. A second table lists the estimated annual pollutant and volume loads under base and existing conditions. Existing conditions included notable stormwater treatment practices for which information was available from the Cities of Blaine, Coon Rapids, Spring Lake Park, and 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.

Potential Retrofits

Potential retrofits are presented for each catchment and include a description of the proposed BMP, a 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.

Abbreviations

Listed below are some abbreviations used frequently throughout the text:

ACD: Anoka Conservation District
BMP: Best Management Practice
CCWD: Coon Creek Watershed District
DP: Dissolved Phosphorus
GIS: Geographic Information Systems
HD: Hydrodynamic Device
IB: Infiltration Basin
IESF: Iron-Enhanced Sand Filter
MNDOT or DOT: Minnesota Department of Transportation
MPCA: Minnesota Pollution Control Agency
MS4: Municipal Separate Storm Sewer System
NPDES: National Pollutant Discharge Elimination System
TP: Total Phosphorus
TSS: Total Suspended Solids
WinSLAMM: Source Loading and Management Model for Windows
WP: Wet (Retention) Pond

Background

The history of the Springbrook subwatershed follows much of the history of development in the northern suburbs of the Twin Cities. The area was predominantly agrarian through the 1930's. By this time, historical aerials show Springbrook to be a channelized ditch draining fields north and east of the Burlington Northern Railroad tracks. By the 1960's much of the watershed had been developed into single-family neighborhoods with exception to an area between Co. Highway 10 and the Burlington Northern Railroad tracks, where a large wetland complex still existed. This complex was soon lost, as commercial and industrial properties moved into the region, although part of it was saved in the form of the Springbrook Nature Center.

Present-day conditions show an area nearly completely developed with a mix of land uses, including residential (46.7% of subwatershed area), commercial (14.1%), open land (8.7%; primarily along the stream corridor), industrial (8.6%), freeway (8.1%), parkland (7.9%), open water (3.0%), and institutional (2.8%). Stormwater generated within the subwatershed has very limited overland flow as it is quickly intercepted by catch basins and conveyed via municipal storm sewers to either a stormwater pond or directly into the creek. There are a total of 58 wet retention ponds currently within the subwatershed. These, along with eleven additional structural BMPs including seven infiltration basins, three natural wetlands, and one hydrodynamic device, provide treatment to much of the subwatershed. Five of these ponds, along with the Springbrook Nature Center wetland, are in-line with the creek and provide some treatment to all upstream areas.

Springbrook is currently designated as an "impaired" waterbody for failing to meet invertebrate biota expectations. The stream also has other water quality concerns including high dissolved pollutants, suspended solids, and *E. coli* that have not yet been designated by the State as "impairments." Conductivity (which is a measure of the concentration of ions in the water) and chloride measurements are continually some of the highest for streams measured within Anoka County (ACD 2014). Based on the most recent data available, median values for TSS and TP are below proposed state standards of 30 mg/L and 100 µg/L, respectively, but during storm events these values often exceed standards (ACD 2014).

The Coon Creek Watershed District (CCWD) contracted the Anoka Conservation District (ACD) to complete this stormwater retrofit analysis for the purpose of identifying and analyzing projects to reduce pollutant loading to the creek. Overall subwatershed loading of TSS, TP, and stormwater volume were estimated for subdivided drainage areas within the subwatershed. Potential 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 volume or 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, 2014).

Scoping and Reduction Goals determine 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 area was all areas that drain to Springbrook and ultimately discharge to the Mississippi River. Included are areas of residential, commercial, industrial, institutional, and freeway land uses. The subwatershed was divided into 17 catchments using a combination of existing subwatershed mapping data, stormwater infrastructure maps, and observed topography.

Targeted pollutants in this study (Table 5) were determined by reviewing the most recent monitoring data available for Springbrook, sampled near its confluence with the Mississippi River at 79th Way NE in Fridley. Water quality samples found to be in exceedance of state standards were evaluated to determine the percent reduction needed to bring each sample into compliance. These individual reductions were then averaged within each flow regime of the flow duration curve (as exceedance was most often found outside baseflow and small storm events). Finally, a reduction percentage across all storm events was estimated by weighting each flow regime to flow frequency and then summing across all flow regimes. This analysis found that TP and TSS loading to the creek would need to be reduced by 24.0% and 4.6%, respectively, to comply with standards. Projects were analyzed based on their ability to cost-effectively treat either TP or TSS. Volume reductions were also investigated as in-stream erosion from high volume inputs also likely contributes to TSS and TP loading.

Table 5: 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.

Desktop analysis involves computer-based scanning of the subwatershed for potential retrofit catchments and/or specific sites. This step also identifies areas that don't need to be analyzed because of existing stormwater infrastructure or disconnection from the target water body. Accurate geographic information systems (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 are verified to the maximum extent practicable. 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. The newest version of WinSLAMM (version 10.1), which allows routing of multiple catchments and stormwater treatment practices, was used for this analysis because of the unique connectivity amongst the catchments identified in the Springbrook subwatershed. Areas throughout the subwatershed are routed through multiple catchments before being discharged to the Mississippi River. This creates a network of stormwater treatment. Therefore, estimated volume and pollutant loads to the Mississippi River from any given catchment must take into consideration other treatment practices within the same network.

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 wasteload 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*.

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. To accurately model the land uses in each catchment, manual drainage area delineations were completed using GIS. The drainage areas were consolidated into seventeen catchments using GIS (specifically, ArcMap). Catchments were further subdivided into 144 subcatchments for modeling purposes. Land use data (based on 2010 Metropolitan Council land use file) were used to calculate acreages of each land use type within each catchment. Soil types throughout the subwatershed were modeled as both sand and silt based on available soils information. This process 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 was available from the Cities of Blaine, Coon Rapids, Spring Lake Park, and Fridley (Figure 2). This included 69 total structural stormwater practices such as retention ponds, natural wetlands, and hydrodynamics devices. WinSLAMM input for each of these existing BMPs are listed in *Appendix A*.

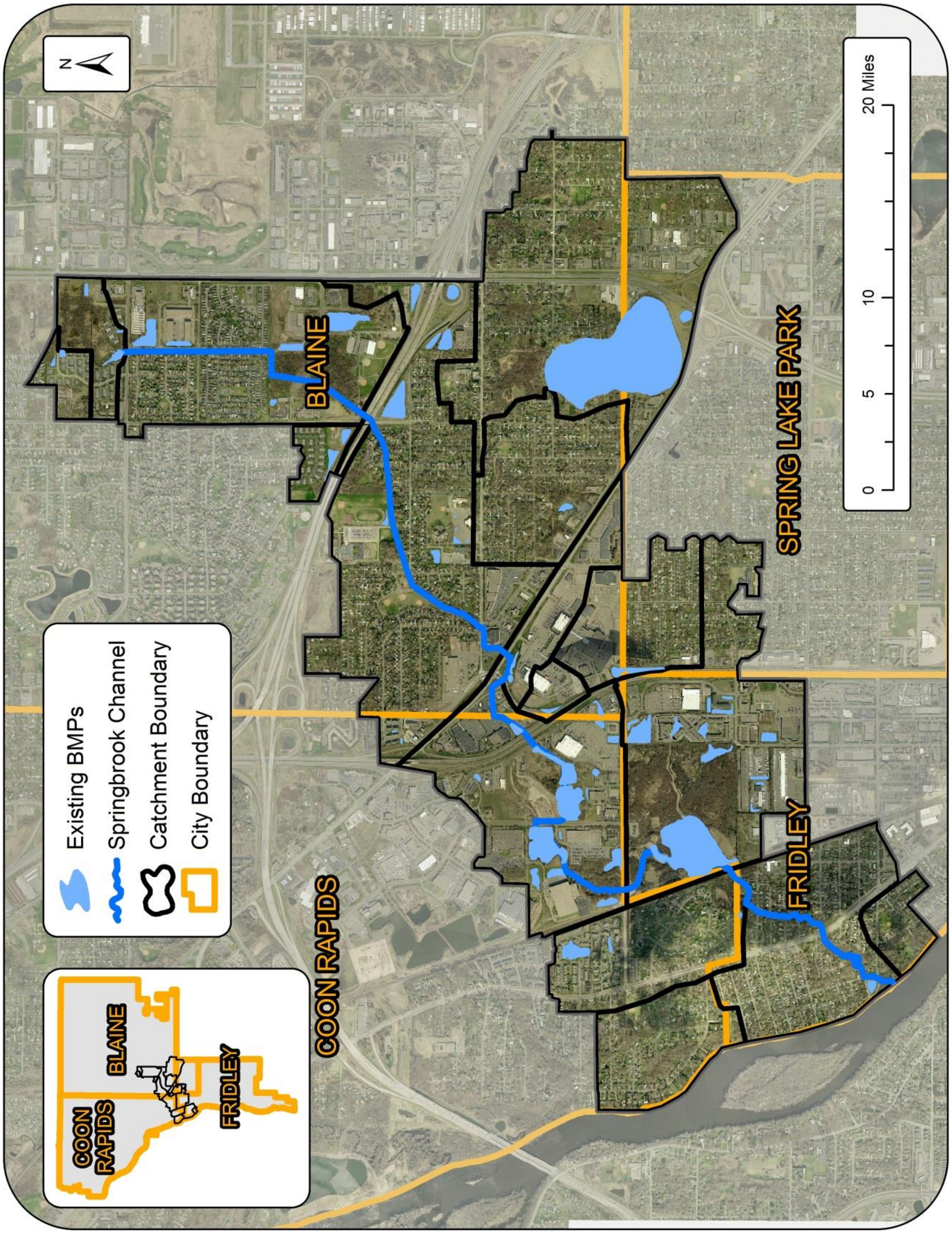


Figure 2: Subwatershed-wide map showing existing BMPs included in the WinSLAMM model.

Finally, each potential 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 for proposed BMPs can also be found in *Appendix A*.

Street cleaning, a practice employed by each of the four municipalities within the Springbrook subwatershed, was not included in the water quality modeling in this analysis. Due to modeling constraints within WinSLAMM, street cleaning could not be included subwatershed-wide while still modeling existing and proposed conditions at the subcatchment scale. Existing and proposed conditions were both modeled without street cleaning to ensure pollutant loading in each case is comparable. This is paramount to determining proposed BMP functionality and cost-effectiveness.

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 2015 dollars. Costs throughout this report were estimated using a multitude of sources. Costs were derived from The Center for Watershed Protection's Urban Subwatershed Restoration Manuals (Schueler & Kitchell, 2005 and Schueler et al., 2007), recent installation costs, and cost estimates provided to 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.

Project ranking is essential to identify which projects may be pursued to achieve water quality goals. Project ranking tables are presented based on acre-feet of volume reduced, cost per pound of TP removed, and cost 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.

Project Ranking and Selection

The intent of this analysis is to provide the information necessary to enable local natural resource managers to successfully 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 (Figure 3), significant pollution reduction could be accomplished for both Springbrook and the Mississippi River. However, funding limitations and landowner interest will be a limiting factor in implementation. The tables on the following pages rank all modeled projects by cost-effectiveness.

Catchments SP-14 and SP-17 are not hydrologically connected to Springbrook as they drain to storm sewer catch basins which discharge directly to the Mississippi River. These were included in this analysis as they are still part of the historical Springbrook subwatershed. Projects proposed in these catchments (Figure 3) were ranked separately and are listed in *Appendix A*.

Projects proposed in catchments draining directly to Springbrook (located in catchments SP-1 to SP-13, SP-15, and SP-16) were ranked in three ways:

1) Cost per pound of TP removed (Table 6 - Table 8),
2) Cost per 1,000 pounds of TSS removed (Table 9 - Table 11), and
3) Cost per acre-foot of volume reduced (Table 12 - Table 14).

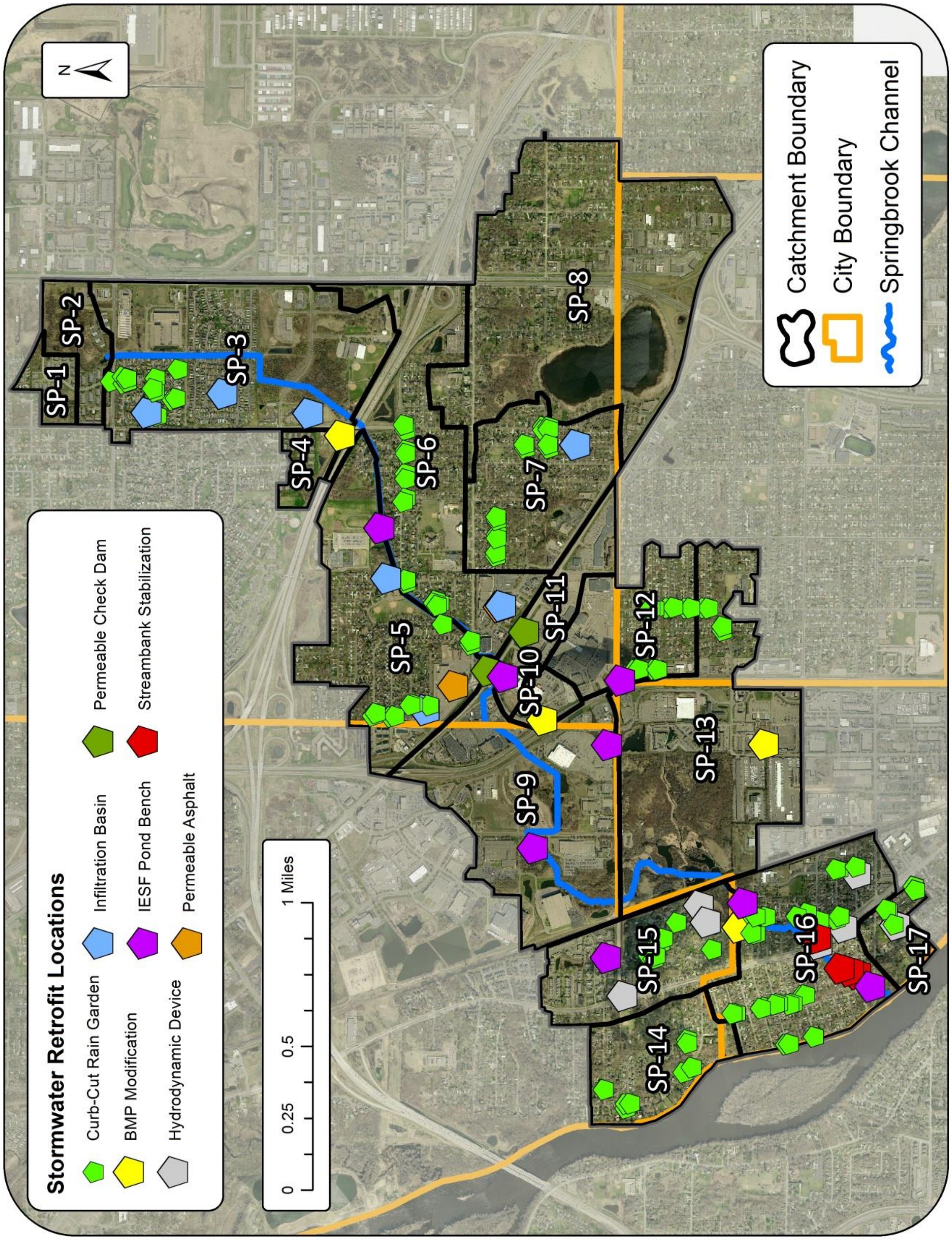


Figure 3: Subwatershed-wide map showing all proposed retrofits included in this report.

Table 6: Cost-effectiveness of retrofits with respect to TP reduction. Projects 1 - 14. 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	Retrofit Location	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost (2015 Dollars)	Estimated Annual Operations & Maintenance (2015 Dollars)	Estimated cost/ lb-TP/year (30-year)[1]
1	16-F	157	Streambank Stabilization	Multiple	SP-16	12.0	15,000	0.0	$37,920	$500	$147
2	16-E	155	IESF Bench	Subcatchment 16-12	SP-16	69.7-137.7	0	0.0	$448,230-$948,000	$8,500-$11,500	$286-$336
3	15-G	145	IESF Bench	Subcatchment 15-5	SP-15	66.5-94.5	0	0.0	$548,230-$832,000	$8,500-$11,000	$403-$410
4	9-B	105	IESF Bench	Subcatchment 9-18	SP-9	48.1	0	0.0	$422,800	$7,882	$457
5	11-A	115	Permeable Check Dam	Subcatchment 11-1	SP-11	1.5	434	1.5	$15,448	$365	$587
6	16-G	158	Streambank Stabilization	Multiple	SP-16	3.0	3,750	0.0	$37,920	$500	$588
7	16-A	151	Curb-Cut Rain Gardens	Multiple	SP-16	6.5-14.2	1,912-4,336	5.2-10.4	$73,608-$143,128	$1,800-$4,050	$621-$654
8	15-A	138	Curb-Cut Rain Gardens	Multiple	SP-15	3.5-5.8	1,102-1,807	2.3-3.7	$40,600-$73,608	$900-$1,800	$644-$733
9	5-D	81	Infiltration Basin	Subcatchment 5-9	SP-5	2.7-3.1	659-766	4.1-4.8	$48,796-$63,796	$275	$704-$775
10	5-F	83	Permeable Check Dam	Subcatchment 5-10	SP-5	1.1	378	1.1	$15,448	$365	$800
11	7-B	96	Infiltration Basin	Subcatchment 7-1	SP-7	1.6	376	2.3	$33,796	$275	$876
12	3-C	66	Infiltration Basin	Subcatchment 3-4	SP-3	1.2-1.3	277-314	2.5-3.0	$27,796-$35,796	$275	$1,001-$1,129
13	3-B	65	Infiltration Basin	Subcatchment 3-4	SP-3	0.8-1.0	155-211	1.4-1.8	$18,796-$23,796	$275	$1,068-$1,127
14	16-H	159	Streambank Stabilization	Multiple	SP-16	1.1	1,350	0.0	$27,920	$300	$1,119

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

Table 7: Cost-effectiveness of retrofits with respect to TP reduction. Projects 15 - 28. 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	Retrofit Location	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost (2015 Dollars)	Estimated Annual Operations & Maintenance (2015 Dollars)	Estimated cost/ lb-TP/year (30-year)[1]
15	6-C	90	Infiltration Basin	Subcatchment 6-16	SP-6	1.1-1.5	395-554	3.0-3.9	$28,696-$48,796	$275	$1,120-$1,268
16	3-D	67	Infiltration Basin	Subcatchment 3-4	SP-3	0.8	160	0.9	$19,796	$275	$1,169
17	12-A	121	Curb-Cut Rain Gardens	Multiple	SP-12	1.8-3.2	457-761	3.2-5.3	$40,600-$73,608	$900-$1,800	$1,252-$1,329
18	13-A	127	Curb-Cut Rain Gardens	Multiple	SP-13	1.0-1.7	206-357	1.8-3.0	$24,096-$40,600	$450-$900	$1,253-$1,325
19	16-I	160	Streambank Stabilization	Multiple	SP-16	0.7	900	0.0	$22,920	$200	$1,377
T20	6-A	88	Curb-Cut Rain Gardens	Multiple	SP-6	1.8-3.5	378-767	2.5-5.5	$57,104-$90,112	$1,350-$2,250	$1,467-$1,807
T20	7-A	95	Curb-Cut Rain Gardens	Multiple	SP-7	1.9-3.6	455-810	3.4-6.4	$57,104-$90,112	$1,350-$2,250	$1,467-$1,712
22	3-A	64	Curb-Cut Rain Gardens	Multiple	SP-3	1.2-2.8	243-560	1.6-3.9	$40,600-$73,608	$900-$1,800	$1,519-$1,878
23	5-A	78	Curb-Cut Rain Gardens	Multiple	SP-5	1.2-2.5	268-554	1.8-3.9	$40,600-$73,608	$900-$1,800	$1,701-$1,878
24	4-A	72	BMP Modification	Subcatchment 4-2	SP-4	0.9	731	0.0	$27,650	$700	$1,802
25	12-B	122	IESF Bench	Subcatchment 12-1	SP-12	6.0	0	0.0	$282,955	$1,607	$1,840
26	5-C	80	Infiltration Basin	Subcatchment 5-4	SP-5	0.6	119	0.7	$26,296	$275	$1,919
27	15-B	139	IESF Bench	Subcatchment 15-3	SP-15	2.4	0	0.0	$143,315	$459	$2,182
28	15-D	141	Hydrodynamic Device	Subcatchment 15-5	SP-15	1.9	715	0.0	$109,752	$840	$2,368

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

Table 8: Cost-effectiveness of retrofits with respect to TP reduction. Projects 29 - 41. 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	Retrofit Location	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost (2015 Dollars)	Estimated Annual Operations & Maintenance (2015 Dollars)	Estimated cost/ lb-TP/year (30-year)[1]
29	16-D	154	Hydrodynamic Device	Subcatchment 16-8	SP-16	1.6	617	0.0	$109,752	$840	$2,812
30	5-B	79	IESF Bench	Subcatchment 5-3	SP-5	2.0	0	0.0	$152,400	$505	$2,884
31	11-B	116	IESF Bench	Subcatchment 11-2	SP-11	2.0	0	0.0	$189,195	$918	$3,612
32	10-A	110	BMP Modification	Subcatchment 10-1	SP-10	0.8	271	1.8	$80,920	$275	$3,715
33	15-C	140	Hydrodynamic Device	Subcatchment 15-4	SP-15	1.2	517	0.0	$109,752	$840	$3,749
34	16-B	152	Hydrodynamic Device	Subcatchment 16-7	SP-16	1.1	431	0.0	$109,752	$840	$4,089
35	15-E	142	Hydrodynamic Device	Subcatchment 15-5	SP-15	0.6	252	0.0	$109,752	$840	$4,497
36	9-A	104	IESF Bench	Subcatchment 9-11	SP-9	1.7	0	0.0	$224,195	$918	$4,936
37	16-C	153	Hydrodynamic Device	Subcatchment 16-8	SP-16	0.9	393	0.0	$109,752	$840	$4,998
38	15-F	143	BMP Modification	Subcatchment 15-5	SP-15	0.6-1.1	232-446	0.0	$108,840-$215,840	$900	$5,086-$9,047
39	13-B	128	BMP Modification	Subcatchment 13-17	SP-13	0.4	376	0.0	$150,840-$250,840	$900	$14,820-$23,153
40	6-B	89	Permeable Asphalt	Subcatchment 6-16	SP-6	0.8	347	2.3	$439,396	$32,670	$59,146
41	5-E	82	Permeable Asphalt	Subcatchment 5-10	SP-5	0.4	175	1.4	$221,596	$16,335	$59,304

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

Table 9: Cost-effectiveness of retrofits with respect to TSS reduction. Projects 1 - 14. 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	Retrofit Location	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost (2015 Dollars)	Estimated Annual Operations & Maintenance (2015 Dollars)	Estimated cost/ 1,000lb-TSS/year (30-year)[1]
1	16-F	157	Streambank Stabilization	Multiple	SP-16	12.0	15,000	0.0	$37,920	$500	$118
2	16-G	158	Streambank Stabilization	Multiple	SP-16	3.0	3,750	0.0	$37,920	$500	$470
3	16-H	159	Streambank Stabilization	Multiple	SP-16	1.1	1,350	0.0	$27,920	$300	$912
4	16-I	160	Streambank Stabilization	Multiple	SP-16	0.7	900	0.0	$22,920	$200	$1,017
5	11-A	115	Permeable Check Dam	Subcatchment 11-1	SP-11	1.5	434	1.5	$15,448	$365	$2,027
6	16-A	151	Curb-Cut Rain Gardens	Multiple	SP-16	6.5-14.2	1,912-4,336	5.2-10.4	$73,608-$143,128	$1,800-$4,050	$2,034-$2,225
7	15-A	138	Curb-Cut Rain Gardens	Multiple	SP-15	3.5-4.8	1,102-1,807	2.3-3.7	$40,600-$73,608	$900-$1,800	$2,045-$2,354
8	4-A	72	BMP Modification	Subcatchment 4-2	SP-4	0.9	731	0.0	$27,650	$700	$2,218
9	5-F	83	Permeable Check Dam	Subcatchment 5-10	SP-5	1.1	378	1.1	$15,448	$365	$2,328
10	5-D	81	Infiltration Basin	Subcatchment 5-9	SP-5	2.7-3.1	659-766	4.1-4.8	$48,796-$63,796	$275	$2,885-$3,135
11	6-C	90	Infiltration Basin	Subcatchment 6-16	SP-6	1.1-1.5	395-554	3.0-3.9	$28,696-$48,796	$275	$3,118-$3,432
12	7-B	96	Infiltration Basin	Subcatchment 7-1	SP-7	1.6	376	2.3	$33,796	$275	$3,727
13	3-C	66	Infiltration Basin	Subcatchment 3-4	SP-3	1.2-1.3	277-314	2.5-3.0	$27,796-$35,796	$275	$4,338-$4,676
14	12-A	121	Curb-Cut Rain Gardens	Multiple	SP-12	1.8-3.2	457-761	3.2-5.3	$40,600-$73,608	$900-$1,800	$4,931-$5,589

[1] [(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TSS Reduction/1,000)]

Table 10: Cost-effectiveness of retrofits with respect to TSS reduction. Projects 15 - 28. 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	Retrofit Location	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost (2015 Dollars)	Estimated Annual Operations & Maintenance (2015 Dollars)	Estimated cost/ 1,000lb-TSS/year (30-year)[1]
15	3-B	65	Infiltration Basin	Subcatchment 3-4	SP-3	0.8-1.0	155-211	1.4-1.8	$18,796-$23,796	$275	$5,063-$5,816
16	3-D	67	Infiltration Basin	Subcatchment 3-4	SP-3	0.8	160	0.9	$19,796	$275	$5,843
17	13-A	127	Curb-Cut Rain Gardens	Multiple	SP-13	1.0-1.7	206-357	1.8-3.0	$24,096-$40,600	$450-$900	$6,083-$6,312
18	15-D	141	Hydrodynamic Device	Subcatchment 15-5	SP-15	1.9	715	0.0	$109,752	$840	$6,291
19	7-A	95	Curb-Cut Rain Gardens	Multiple	SP-7	1.9-3.6	455-810	3.4-6.4	$57,104-$90,112	$1,350-$2,250	$6,377-$7,150
20	6-A	88	Curb-Cut Rain Gardens	Multiple	SP-6	1.8-3.5	378-767	2.5-5.5	$57,104-$90,112	$1,350-$2,250	$6,730-$8,607
21	16-D	154	Hydrodynamic Device	Subcatchment 16-8	SP-16	1.6	617	0.0	$109,752	$840	$7,291
22	3-A	64	Curb-Cut Rain Gardens	Multiple	SP-3	1.2-2.8	243-560	1.6-3.9	$40,600-$73,608	$900-$1,800	$7,596-$9,273
23	5-A	78	Curb-Cut Rain Gardens	Multiple	SP-5	1.2-2.5	268-554	1.8-3.9	$40,600-$73,608	$900-$1,800	$7,678-$8,408
24	15-C	140	Hydrodynamic Device	Subcatchment 15-4	SP-15	1.2	517	0.0	$109,752	$840	$8,701
25	5-C	80	Infiltration Basin	Subcatchment 5-4	SP-5	0.6	119	0.7	$26,296	$275	$9,677
26	16-B	152	Hydrodynamic Device	Subcatchment 16-7	SP-16	1.1	431	0.0	$109,752	$840	$10,437
27	15-E	142	Hydrodynamic Device	Subcatchment 15-5	SP-15	0.6	252	0.0	$109,752	$840	$10,708
28	10-A	110	BMP Modification	Subcatchment 10-1	SP-10	0.8	271	1.8	$80,920	$275	$10,968

[1] [(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TSS Reduction/1,000)]

Table 11: Cost-effectiveness of retrofits with respect to TSS reduction. Projects 29- 41. 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	Retrofit Location	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost (2015 Dollars)	Estimated Annual Operations & Maintenance (2015 Dollars)	Estimated cost/ 1,000lb-TSS/year (30-year)[1]
29	16-C	153	Hydrodynamic Device	Subcatchment 16-8	SP-16	0.9	393	0.0	$109,752	$840	$11,446
30	15-F	143	BMP Modification	Subcatchment 15-5	SP-15	0.6-1.1	232-446	0.0	$108,840-$215,840	$900	$12,544-$23,397
31	13-B	128	BMP Modification	Subcatchment 13-17	SP-13	0.4	376	0.0	$150,840-$250,840	$900	$15,766-$24,631
32	5-E	82	Permeable Asphalt	Subcatchment 5-10	SP-5	0.4	175	1.4	$221,596	$16,355	$135,552
33	6-B	89	Permeable Asphalt	Subcatchment 6-16	SP-6	0.8	347	2.3	$439,396	$32,670	$136,359
34	5-B	79	IESF Bench	Subcatchment 5-3	SP-5	2.0	0	0.0	$152,400	$505	N/A
35	9-A	104	IESF Bench	Subcatchment 9-11	SP-9	1.7	0	0.0	$224,195	$918	N/A
36	9-B	105	IESF Bench	Subcatchment 9-18	SP-9	48.1	0	0.0	$422,800	$7,882	N/A
37	11-B	116	IESF Bench	Subcatchment 11-2	SP-11	2.0	0	0.0	$189,195	$918	N/A
38	12-B	122	IESF Bench	Subcatchment 12-1	SP-12	6.0	0	0.0	$282,955	$1,607	N/A
39	15-B	139	IESF Bench	Subcatchment 15-3	SP-15	2.4	0	0.0	$143,315	$459	N/A
40	15-G	145	IESF Bench	Subcatchment 15-5	SP-15	66.5-94.5	0	0.0	$548,230-$832,000	$8,500-$11,000	N/A
41	16-E	155	IESF Bench	Subcatchment 16-12	SP-16	69.7-137.7	0	0.0	$448,230-$948,000	$8,500-$11,500	N/A

[1] [(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TSS Reduction/1,000)]

Table 12: Cost-effectiveness of retrofits with respect to volume reduction. Projects 1 - 14. TP and TSS 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	Retrofit Location	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost (2015 Dollars)	Estimated Annual Operations & Maintenance (2015 Dollars)	Estimated cost/ ac-ft Vol./year (30-year)
1	6-C	90	Infiltration Basin	Subcatchment 6-16	SP-6	1.1-1.5	395-554	3.0-3.9	$28,696-$48,796	$275	$411-$488
2	3-C	66	Infiltration Basin	Subcatchment 3-4	SP-3	1.2-1.3	277-314	2.5-3.0	$27,796-$35,796	$275	$481-$489
3	5-F	83	Permeable Check Dam	Subcatchment 5-10	SP-5	1.1	378	1.1	$15,448	$365	$587
4	3-B	65	Infiltration Basin	Subcatchment 3-4	SP-3	0.8-1.0	155-211	1.4-1.8	$18,796-$23,796	$275	$593-$644
5	7-B	96	Infiltration Basin	Subcatchment 7-1	SP-7	1.6	376	2.3	$33,796	$275	$609
6	15-A	138	Curb-Cut Rain Gardens	Multiple	SP-15	3.5-4.8	1,102-1,807	2.3-3.7	$40,600-$73,608	$900-$1,800	$644-$733
7	13-A	127	Curb-Cut Rain Gardens	Multiple	SP-13	1.0-1.7	206-357	1.8-3.0	$24,096-$40,600	$450-$900	$696-$751
T8	12-A	121	Curb-Cut Rain Gardens	Multiple	SP-12	1.8-3.2	457-761	3.2-5.3	$40,600-$73,608	$900-$1,800	$704-$803
T8	5-D	81	Infiltration Basin	Subcatchment 5-9	SP-5	2.7-3.1	659-766	4.1-4.8	$48,796-$63,796	$275	$704-$775
10	11-A	115	Permeable Check Dam	Subcatchment 11-1	SP-11	1.5	434	1.5	$15,448	$365	$800
11	7-A	95	Curb-Cut Rain Gardens	Multiple	SP-7	1.9-3.6	455-810	3.4-6.4	$57,104-$90,112	$1,350-$2,250	$803-$957
12	16-A	151	Curb-Cut Rain Gardens	Multiple	SP-16	6.5-14.2	1,912-4,336	5.2-10.4	$73,608-$143,128	$1,800-$4,050	$818-$881
13	6-A	88	Curb-Cut Rain Gardens	Multiple	SP-6	1.8-3.5	378-767	2.5-5.5	$57,104-$90,112	$1,350-$2,250	$945-$1,301
14	3-A	64	Curb-Cut Rain Gardens	Multiple	SP-3	1.2-2.8	243-560	1.6-3.9	$40,600-$73,608	$900-$1,800	$1,084-$1,408

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

Table 13: Cost-effectiveness of retrofits with respect to volume reduction. Projects 15 - 28. TP and TSS 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	Retrofit Location	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost (2015 Dollars)	Estimated Annual Operations & Maintenance (2015 Dollars)	Estimated cost/ ac-ft Vol./year (30-year)
15	5-A	78	Curb-Cut Rain Gardens	Multiple	SP-5	1.2-2.5	268-554	1.8-3.9	$40,600-$73,608	$900-$1,800	$1,091-$1,301
16	3-D	67	Infiltration Basin	Subcatchment 3-4	SP-3	0.8	160	0.9	$19,796	$275	$1,169
17	5-C	80	Infiltration Basin	Subcatchment 5-4	SP-5	0.6	119	0.7	$26,296	$275	$1,919
18	5-E	82	Permeable Asphalt	Subcatchment 5-10	SP-5	0.4	175	1.4	$221,596	$16,355	$16,944
19	6-B	89	Permeable Asphalt	Subcatchment 6-16	SP-6	0.8	347	2.3	$439,396	$32,670	$20,572
T20	4-A	72	BMP Modification	Subcatchment 4-2	SP-4	0.9	731	0.0	$27,650	$700	N/A
T20	5-B	79	IESF Bench	Subcatchment 5-3	SP-5	2.0	0	0.0	$152,400	$505	N/A
T20	9-A	104	IESF Bench	Subcatchment 9-11	SP-9	1.7	0	0.0	$224,195	$918	N/A
T20	9-B	105	IESF Bench	Subcatchment 9-18	SP-9	48.1	0	0.0	$422,800	$7,882	N/A
T20	10-A	110	BMP Modification	Subcatchment 10-1	SP-10	0.8	271	1.8	$80,920	$275	N/A
T20	11-B	116	IESF Bench	Subcatchment 11-2	SP-11	2.0	0	0.0	$189,195	$918	N/A
T20	12-B	122	IESF Bench	Subcatchment 12-1	SP-12	6.0	0	0.0	$282,955	$1,607	N/A
T20	13-B	128	BMP Modification	Subcatchment 13-17	SP-13	0.4	376	0.0	$150,840-$250,840	$900	N/A
T20	15-B	139	IESF Bench	Subcatchment 15-3	SP-15	2.4	0	0.0	$143,315	$459	N/A

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

Table 14: Cost-effectiveness of retrofits with respect to volume reduction. Projects 29 - 41. TP and TSS 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	Retrofit Location	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost (2015 Dollars)	Estimated Annual Operations & Maintenance (2015 Dollars)	Estimated cost/ ac-ft Vol./year (30-year)
T20	15-C	140	Hydrodynamic Device	Subcatchment 15-4	SP-15	1.2	517	0.0	$109,752	$840	N/A
T20	15-D	141	Hydrodynamic Device	Subcatchment 15-5	SP-15	1.9	715	0.0	$109,752	$840	N/A
T20	15-E	142	Hydrodynamic Device	Subcatchment 15-5	SP-15	0.6	252	0.0	$109,752	$840	N/A
T20	15-F	143	BMP Modification	Subcatchment 15-5	SP-15	0.6-1.1	232-446	0.0	$108,840-$215,840	$900	N/A
T20	15-G	145	IESF Bench	Subcatchment 15-5	SP-15	66.5-94.5	0	0.0	$548,230-$832,000	$8,500-$11,000	N/A
T20	16-B	152	Hydrodynamic Device	Subcatchment 16-7	SP-16	1.1	431	0.0	$109,752	$840	N/A
T20	16-C	153	Hydrodynamic Device	Subcatchment 16-8	SP-16	0.9	393	0.0	$109,752	$840	N/A
T20	16-D	154	Hydrodynamic Device	Subcatchment 16-8	SP-16	1.6	617	0.0	$109,752	$840	N/A
T20	16-E	155	IESF Bench	Subcatchment 16-12	SP-16	69.7-137.7	0	0.0	$448,230-$948,000	$8,500-$11,500	N/A
T20	16-F	157	Streambank Stabilization	Multiple	SP-16	12.0	15,000	0.0	$37,920	$500	N/A
T20	16-G	158	Streambank Stabilization	Multiple	SP-16	3.0	3,750	0.0	$37,920	$500	N/A
T20	16-H	159	Streambank Stabilization	Multiple	SP-16	1.1	1,350	0.0	$27,920	$300	N/A
T20	16-I	160	Streambank Stabilization	Multiple	SP-16	0.7	900	0.0	$22,920	$200	N/A

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

Project Selection

The combination of projects selected for pursuit could strive to achieve volume, TSS, and/or 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

To determine which projects to pursue, CCWD analyzed water quality samples taken in Springbrook to establish which pollutants needed to be addressed. This methodology is listed in detail in the *Analytical Process and Elements* section. Results of this analysis set the TP goal to 24.0% and TSS goal to 4.6% of total stormwater loading. Using WinSLAMM model results based on existing conditions, the estimated annual reductions are 212.5 lbs for TP and 9,840 lbs for TSS. Stormwater retrofit opportunities were then individually modeled in WinSLAMM to determine their pollutant retention potential and ranked by their effectiveness to remove a particular pollutant per dollar spent (Tables Table 6 to Table 14). The most cost-effective projects were then included in a subwatershed model to determine which suite of projects were needed to meet the pollutant reduction goals of 212.5 lbs-TP and 9,840 lbs-TSS. The project suite is listed in the table below.

Table 15: Projects needed to reach the proposed TP and TSS goals.

Project Rank	Project ID	Page Number	Retrofit Type and Detail	Retrofit Location	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Probable Project Cost (2015 Dollars)	Estimated Annual Operations & Maintenance (2015 Dollars)	Estimated cost/ lb-TP/year (30-year)[1]
1	16-E	151	0.5 acre IESF bench with 0.25 acre sedimentation basin	Subcatchment 16-12	SP-16	114.5	17,921	$948,000	$11,500	$376
2	15-G	141	0.5 acre IESF Bench	Subcatchment 15-5	SP-15	54.1	0	$832,000	$11,000	$716
3	9-B	101	8,200 sq-ft IESF Bench	Subcatchment 9-18	SP-9	48.1	0	$422,800	$7,882	$457

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

Installing all three of these projects would result in 216.7 lbs-TP and 17,921 lbs-TSS removal. Direct (design and construction) and indirect (promotion and administration) costs for these projects are proposed to be $2,202,800, with an additional $30,382 per year in estimated operations and maintenance costs. Assuming a 30-year project lifetime for each of these projects, total cost (excluding inflation) is expected to be approximately $3,114,000.

Please note that the TP reduction for projects 16-E and 15-G are lower than those listed in the *Catchment Profiles* pages. This is because these projects are installed in-line and downstream of project 9-B. Upstream projects remove pollutants which may have otherwise been treated by downstream BMPs, thereby reducing the treatment efficiencies of any downstream practices. This is reflected in the higher cost-effectiveness values for projects 16-E and 15-G.

Project 16-E is able to solely reach the TSS goal, but may be infeasible based on site limitations. Another project which could reach the TSS goal of 9,840 lbs-TSS is project 16-F, a streambank stabilization within catchment SP-16. This project is expected to remove 15,000 lbs-TSS and has the lowest cost effectiveness of all projects found in this analysis.

BMP Descriptions

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

Project types included in the following sections are:

- Bioretention
- Hydrodynamic device
- Iron-enhanced sand filter pond bench
- Modification to an existing BMP
- Permeable asphalt
- Permeable check dam
- Streambank stabilization

Bioretention

Bioretention is a BMP that uses soil and vegetation to treat stormwater runoff from roads, driveways, roof tops, 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 16).

Table 16: 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 fully estimate the 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

Curb-cut rain gardens capture stormwater that is in roadside gutters and redirect 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 up-gradient of a catch basin serving a large drainage area. Bioinfiltration was solely proposed (as opposed to biofiltration) as the available soil information suggested infiltration rates could be sufficient to allow complete draw-down within 24-48 hours following a storm event (Figure 4).

Figure 4: Rain garden before/after and during a rainfall event

All curb-cut rain gardens were presumed to have a 12" ponding depth, 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 garden 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.

Infiltration Basin

Infiltration basins function identically to the curb-cut rain gardens previously described in this bioretention section. However, these basins are proposed in locations where a large amount of space is available. This presents an opportunity to construct a large-scale (i.e. > 500 sq-ft.) infiltration basin. This would allow stormwater runoff to fill the basin and be filtered by the soil and vegetation.

Probable project cost includes installation of the project as well as promotion, administrative, and design costs, all in 2015 dollars. A reduced construction cost (i.e. \$15 to \$20 per ft.^{2}) relative to other bioretention practices was proposed for the infiltration basin because of assumed cost savings with a larger project. Furthermore, the large open spaces available at each of the proposed project locations could allow the basins to be constructed without retaining walls, which would result in a significant cost savings. Maintenance was assumed to be completed by city public works crews. Maintenance costs were also included for rehabilitation of the basin every 10 years for the life of the project.

Many projects assumed storm sewer pipes could be daylighted into an infiltration basin. For these projects it is paramount that the depths to pipe inverts are determined immediately as this will greatly impact project feasibility.

Hydrodynamic Devices

In heavily urbanized settings such as the cities within the Springbrook subwatershed, stormwater is immediately intercepted along 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 alternative is the hydrodynamic device (Figure 5). These are installed in-line with the existing storm sewer network and can provide treatment for up to 10-15 acres of upland drainage. 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 stormwater retrofit analyses. 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.

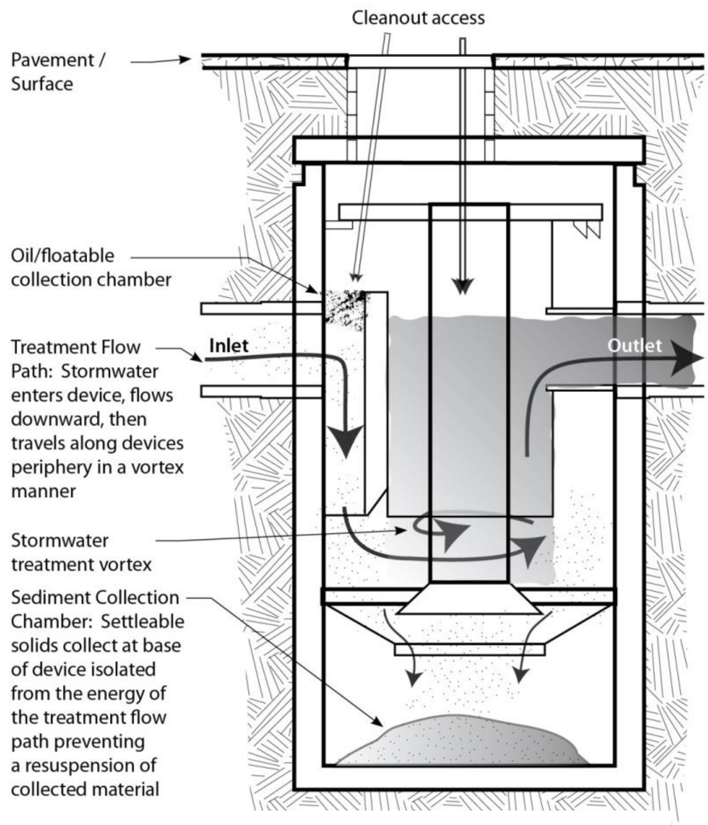


Figure 5: Schematic of a typical hydrodynamic device

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

Iron-Enhanced Sand Filter Pond Bench

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. 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 (DP) 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 DP is a readily available nutrient for algal uptake in waterbodies and can be a main cause for nutrient eutrophication.

To augment DP retention in existing stormwater ponds, an iron-enhanced sand filter (IESF) bench can be retrofit along the pond bank nearest the outlet. The IESF bench relies on the properties of iron to bind DP as it passes through an iron-rich medium. Depending on topographic characteristics of the installation site, IESF benches can rely on gravitational flow and natural water level fluctuation, or water pumping to hydrate the IESF. IESF benches 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 DP 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 bench, a ferric-chloride injection system could be installed to bind DP into a flocculent, which would settle in the bottom of the new pond.

Figure 6 shows an IESF bench 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 bench. 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 bench's capacity would exit the pond via the existing outlet.

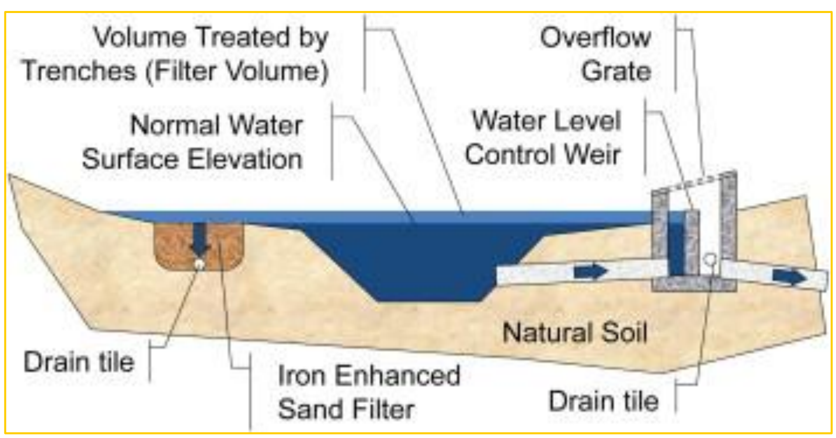


Figure 6: Iron-Enhanced Sand Filter Concept (Erickson & Gulliver, 2010)

Benefits for stormwater ponds were modeled utilizing WinSLAMM. WinSLAMM is able to calculate flow through constructed features such as rain gardens with underdrains, soil amendments, and controlled overflow elevations. An IESF bench works much the same way. Storm event based discharge volumes and DP concentrations estimated by WinSLAMM after construction of the pond were entered into WinSLAMM as inputs into the IESF bench (baseflow, if pond is installed in-line, was discounted as it would bypass the IESF). Various iterations of IESF benches were modeled to identify an optimal treatment level compared to construction costs. A detailed account of the methodologies used is included in *Appendix A*. To account for the DP treated by the IESF bench, an additional 80% DP removal was assumed for each IESF bench 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 bench 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.

Modification to an Existing BMP

Retention Ponds

Developments prior to enactment of contemporary stormwater rules often included wet detention ponds which were frequently designed exclusively 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 greatly 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 five strategies which 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
- 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. One proposed modification, excavating the pond bottom to increase storage, often has a very wide range in expected cost due to the nature of the excavated soil. If the soil has been contaminated and requires landfilling, the cost for disposal can quickly lead to a doubling in project cost. For this reason, projects which include the excavation of ponds have been priced based on the following criteria:

- Management Level 1: Dredged pond soil is suitable for use or reuse on properties with a residential or recreational use
- Management Level 2: Dredged pond soil is suitable for use or reuse on properties with an industrial use
- Management Level 3: Dredged pond soil is considered significantly contaminated and must be managed specifically for the contaminants present

Costs within each of these levels can even range widely, but were estimated to be $20/cu-yd., $35/cu-yd., and $50/cu-yd. for levels 1, 2, and 3, respectively. Additional costs associated with specific projects are listed in Appendix B.

Infiltration Basins

Similar to retention ponds, existing infiltration basins provide cost-effective opportunities to increase pollutant retention in a catchment. These sites already have the necessary easement/land ownership and stormwater infrastructure that often contributes heavily to most new installation costs. Oftentimes, simple maintenance can rejuvenate a struggling site back to its design capacity. In other cases, changes to the surrounding landscape require increases to the design capacity to treat growing imperviousness in upstream drainage areas.

Within the Springbrook subwatershed one site was investigated near the Northtown Mall on University Avenue. Ponding depth could be increased to one foot provided a soil investigation confirms sufficient soil infiltration rates.

Permeable Asphalt

Relatively flat, low traffic areas provide the perfect location for diverting stormwater runoff from impervious surfaces to porous pavement. Void space between concrete pavers or within permeable asphalt and concrete allow water to percolate through the surface to an underlying layer(s) of coarse aggregate rock (Figure 7). This aggregate can act as a reservoir, providing water quality and quantity benefits by filtering the stormwater and creating storage. From there water can either be stored temporarily or can infiltrate into the ground to recharge local groundwater aquifers. Many designs include permeable geotextile fabric to separate the uncompacted soil subgrade from the coarse aggregate and to facilitate infiltration. If soils don't allow for infiltration, a liner can be installed with an underdrain attached to nearby storm sewers or additional stormwater BMPs. This still allows for filtration through the pavement and aggregate and reduces the peak discharge from the site.

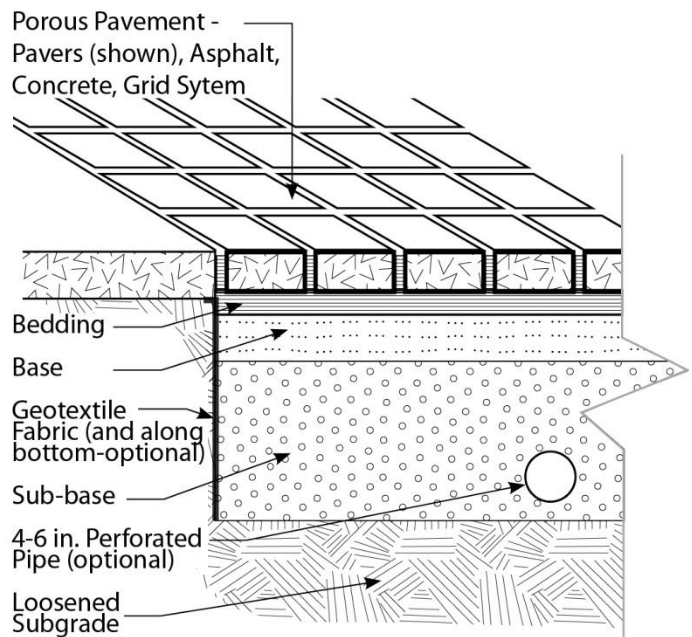


Figure 7: Schematic of typical permeable asphalt and subgrade

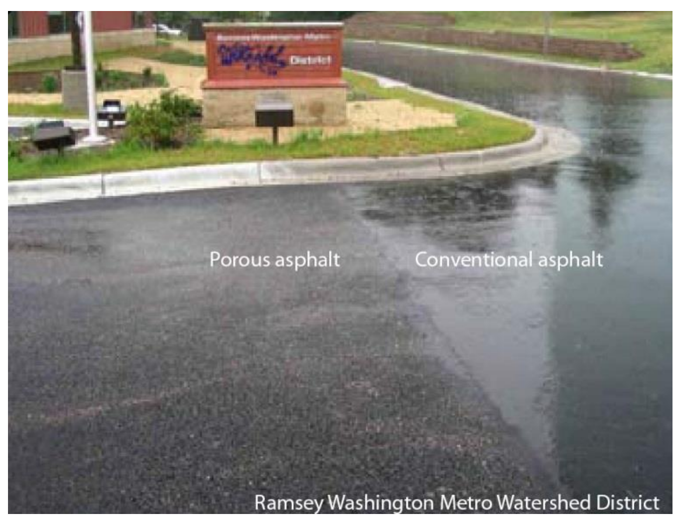


Figure 8: Photo comparing conventional and permeable asphalt

This practice is ideally suited for small drainage areas flowing to low traffic pavement surfaces (Figure 8). For a residential property, roof runoff can be diverted via rain leaders to a permeable driveway. On a commercial property, parking spaces within a large parking lot could be converted to permeable pavement to capture runoff from the parking lot, sidewalks, and any buildings on the property. On a residential roadway, parking spaces on either side of the street could be converted to permeable asphalt. In this case the practice could treat not just the roadway but multiple properties along the street. Permeable asphalt can be used for many other scenarios in areas where soil type, seasonal water table, and frost line allow for groundwater recharge.

The capacity for this practice is completely dependent on the reservoir size within the aggregate and whether or not infiltration can occur on the site. In most cases the permeable asphalt treats stormwater received from just the surface itself and adjacent impervious surfaces. A general design guideline used in this analysis is a ratio between the permeable asphalt surface area and the area of the impervious surface draining to the practice of 1:4. Besides reservoir capacity, this ratio also depends on the infiltration rate (in the case that the BMP allows for infiltration) or drainage time (if an underdrain is installed) and how well the practice is maintained as clogging can greatly decrease the ability of the practice to capture runoff.

The pollutant removal potential of permeable asphalt was estimated using WinSLAMM. In order to calculate cost-benefit, the cost of each project had to be estimated. To fully estimate the cost of project installation, labor costs for project outreach, promotion, design, administration, and maintenance over the anticipated life of the practice were considered in addition to actual construction costs. Load reduction estimates for these projects are noted in the *Catchment Profiles* section.

Permeable Check Dams

Permeable check dams provide additional treatment for pollutants within ditches and grassed waterways through two processes. First, the dams act as a barrier to flow through the channel, allowing sediment and particulate pollutants to drop out of solution upstream of the dam. This promotes infiltration and evaporation of stormwater as well. Second, any water retained behind the dam can seep through a sand filter located within the rock dam. The sand, mixed with iron filings (similar to an IESF pond bench), creates an opportunity for dissolved pollutant species to be filtered out of the stormwater runoff.

Figure 9: Rock check dams in a small ditch (www.casfm.org/stormwater_committee/LID-Summary.htm)

These practices are often installed in a series, from two to a dozen practices depending on the length and slope of the ditch or waterway (Figure 9). For short ditch lengths a single check dam is often sufficient. The dams include an inner sand filter mixed with iron filings. The ratio of iron filings to sand should be between 5-8% by weight and these should be mixed thoroughly prior to installation. The sand-iron mix should be encased within a permeable membrane allowing for flow in and out of the filter. This filter is surrounded by rocks to promote settling and inhibit clogging of the filter.

It is recommended that these dams are installed such that the buried rock toe of the upstream dam is at the same elevation as top of any downstream dams (Figure 10). This reduces the likelihood of scouring downstream of dams as water flowing over the dam intercepts ponded water rather than erodible soil. Also, the top of the most upstream dam should be installed below the outlet elevation of any pipe draining to the practice to ensure water does not back up into the upstream storm sewer infrastructure.

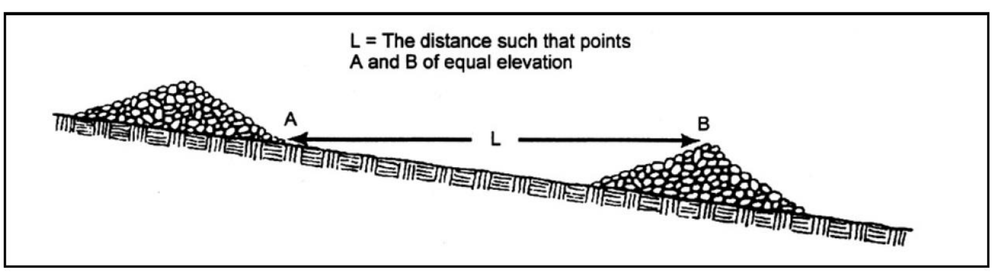


Figure 10: Check dam schematic (MPCA 2000)

The pollutant removal potential of permeable check dams was estimated using WinSLAMM. The ponding volume behind the dams was determined using LIDAR. Based on results of other IESFs, it was assumed that 80% of DP flowing through the dam was retained (Erickson & Gulliver, 2010). In order to calculate cost-benefit, the cost of each project had to be estimated. To fully estimate the cost of project installation, labor costs for project outreach, promotion, design, administration, and maintenance over the anticipated life of the practice were considered in addition to actual construction costs. Load reduction estimates for these projects are noted in the *Catchment Profiles* section.

Streambank Stabilizations

Increasing impervious surface in the upstream drainage areas of a watershed can cause higher peak flows which threaten the stability of downstream bank channels. High flows which sustain over time lead to unstable banks with toe erosion and bank sloughing. The sediment lost from the bank is carried downstream, bringing with it nutrients such as phosphorus as well as other pollutants commonly found in soil. Streambank stabilizations are projects which focus on ensuring that both (i) the toe of the slope is reinforced to ensure undercutting no longer occurs and (ii) upland bank sloughing is repaired and protected from future erosion.

Streambank stabilization designs vary greatly depending on the location and severity of erosion, soil texture, vegetative cover, contributing watershed size, slope and land use characteristics, site access, and cultural features. The first element of a streambank stabilization is to secure the toe of the slope. This is often done using large boulder or rip rap, often buried into the soil to prohibit downcutting. Above the creek channel additional actions can be taken to ensure bank structure, including erosion control mats/fabric and the planting of deep-rooted vegetation. Other in-channel stream restoration structures can also be included in the design to provide grade stabilization or to divert flow from a cut bank to the main channel. Grade stabilization structures include cross vanes and w-weirs. Restoration structures which divert flow velocity from the bank to the main channel include rock vanes, bendway weirs, J-hooks, and root wads among others.

Engineered designs are critical to ensure the practices are suitable for anticipated water velocities and volumes, soil types, and other characteristics previously mentioned. Costs vary greatly depending on the engineered practice as well as site access, regulatory requirements, and the size of the treatment area.

A ditch inspection of Springbrook was completed by CCWD in December 2011. This inspection identified four reaches of the creek illustrating erosion that needed to be addressed in the near future. These sites were evaluated in this analysis to determine their pollutant contribution to Springbrook, the cost to complete and maintain the project, and the cost-effectiveness of the effort.

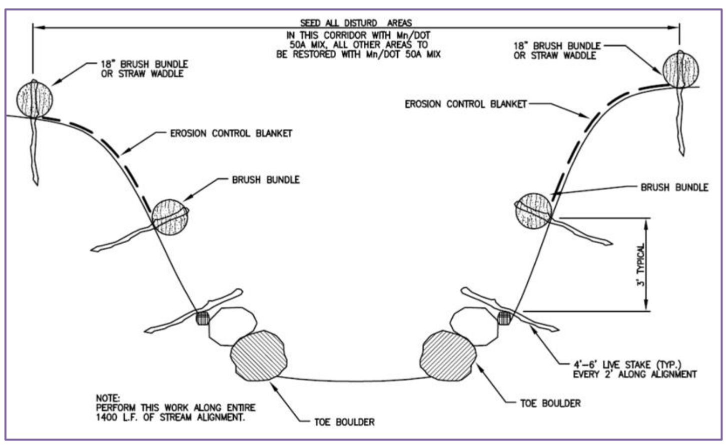


Figure 11: Various Stabilization Practices Cross Section

Instances of erosion were classified according to severity along each distinct stream segment. Erosion severity determinations and voided soil volumes were estimated utilizing RAP-M (Windhorn, R. D., 2000). TSS and TP reduction estimates were based upon the Board of Water and Soil Resources Pollution Reduction Estimator which estimates loading based upon a correlation between voided sediment volume and type with soil density averages and phosphorus concentrations. *Appendix A* includes more detail on modeling methods.

To estimate overall project cost and impact, cost-benefit, installation cost, annual maintenance, as well as project promotion, design, and administration were all determined. Installation cost was estimated at $500.00 per linear foot, which includes costs for mobilization, clearing, grubbing, common excavation and disposal, stabilization of channel and bank, water control, and site restoration. All streambank stabilization projects are assumed to include Class 3 rip rap in the channel and erosion control fabric along the upper bank. This estimate does not include any costs for in-stream structures for flow diversion or grade control. The estimate also ignores any costs to acquire the land, either through an easement or an outright sale, as landowner participation in the project is expected based on prior experience in this neighborhood. Total cost over the 30-year anticipated project life was divided by the total reduction in stormwater pollutants over the same time span.

Catchment Profiles

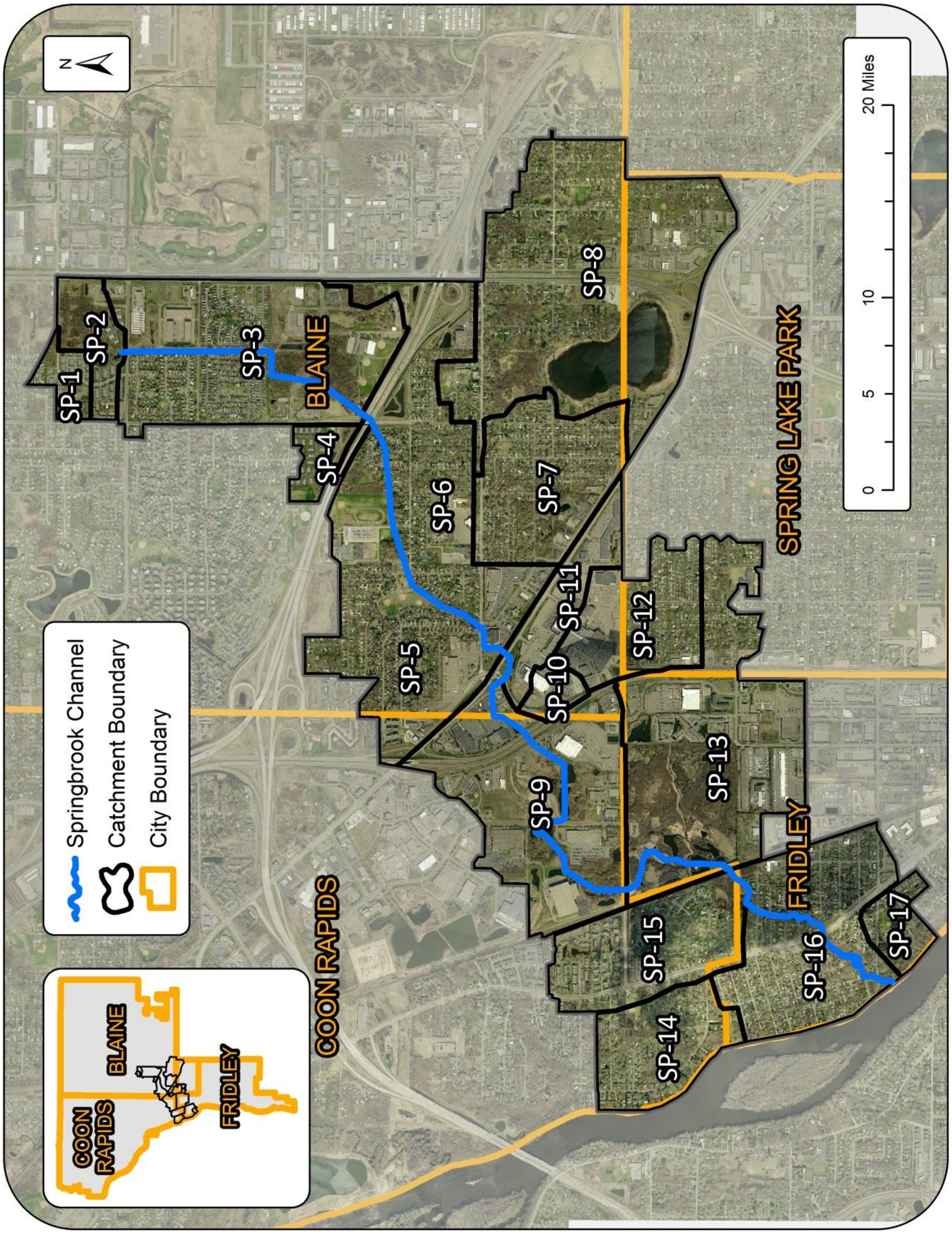
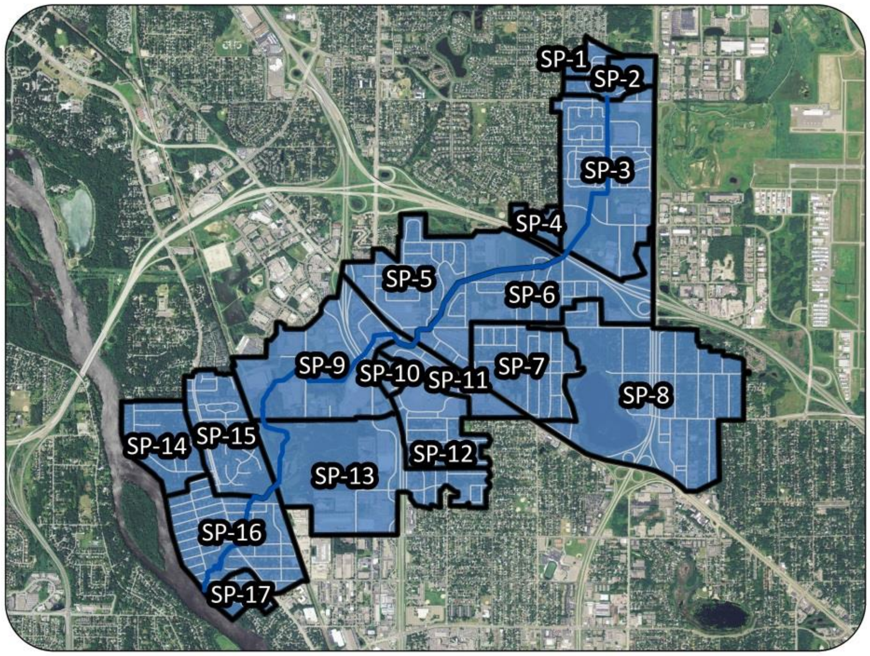


Figure 12: The Springbrook subwatershed was divided into 17 catchments for this analysis. Catchment profiles on the following pages provide additional information.

Subwatershed-Wide Summary



SUBWATERSHED DRAINAGE SUMMARY

The Springbrook subwatershed is comprised of seventeen catchments (SP-1 through SP-17). Catchments SP-1 through SP-8, SP-10, and SP-11 are located primarily within in the City of Blaine. Catchments SP-9, SP-14, and SP-15 are primarily within the City of Coon Rapids. Catchments SP-13, SP-16, and SP-17 are primarily within the City of Fridley. Lastly, catchment SP-12 straddles the municipal boundary between the Cities of Blaine and Spring Lake Park. Based on total land cover, the subwatershed lies mostly within the City of Blaine (52.5%), followed by the Cities of Fridley (18.8%), Coon Rapids (18.5%), and Spring Lake Park (10.2%). Stormwater runoff generated in the subwatershed largely flows from northeast to southwest where it discharges into the Mississippi River. Springbrook is primarily an open channel, except where it is piped below commercial developments between County Road 10 and State Highway 47. Land use throughout the subwatershed is predominantly single-family residential (41.0% by area), followed by commercial (14.1%), undeveloped open space (8.7%), light industrial (8.6%), major highways (8.1%), parks (7.9%), multi-family residential (5.7%), and various others.

EXISTING STORMWATER TREATMENT

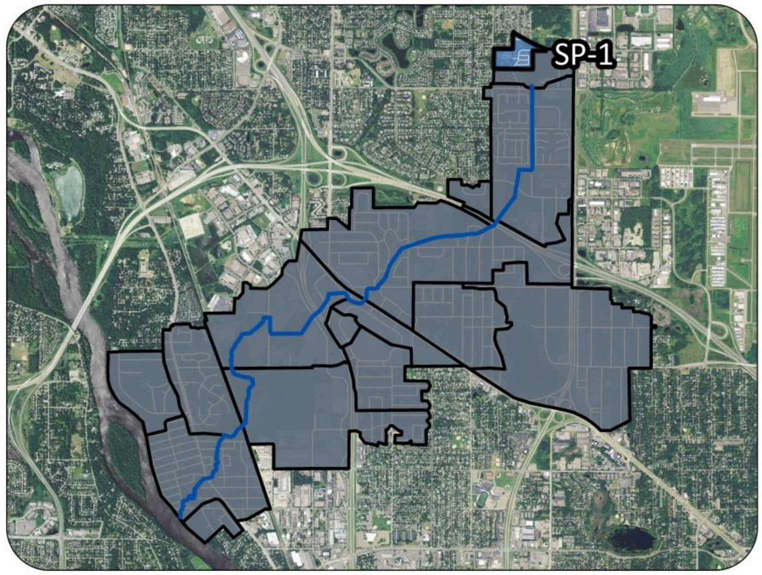
Stormwater runoff in the Springbrook subwatershed has limited overland flow paths due to the large network of storm sewers throughout the Cities of Blaine, Coon Rapids, and Fridley. In many cases water intercepted by the storm sewer system discharges into a stormwater BMP prior to reaching the creek. A total of 69 structural stormwater BMPs are scattered throughout the subwatershed and were significant enough in size to be modeled within this analysis. Of these, 58 are stormwater retention ponds, seven are infiltration basins, three are natural wetlands, and one is a hydrodynamic device. Additional information on each of these BMPs is listed in the “Existing Stormwater Treatment” segment of the

Catchment Profiles pages. More specific information on the practices are listed in the appendices, including WinSLAMM model input screens, which provide great detail on the character, size, and function of each of the practices.

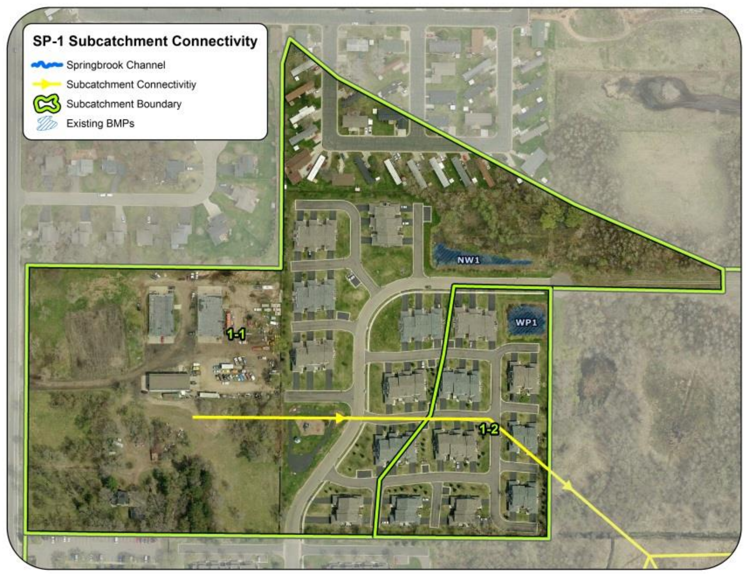
Street cleaning is also performed at least twice per year by each of the municipalities within the subwatershed. This BMP was not modeled in WinSLAMM due to model constraints. More detail on this is given in the *Modeling* portion of the *Analytical Process and Elements* section.

Catchment SP-1

Existing Catchment Summary	
Acres	26.8
Dominant Land Cover	Residential
Parcels	99



CATCHMENT DESCRIPTION
Catchment SP-1 consists primarily of multi-family townhomes and a mobile home park. Much of the western portion of the catchment is parkland or large lots with limited impervious cover.



EXISTING STORMWATER TREATMENT
Stormwater runoff in the catchment drains from west to east to two separate BMP's. The first is a natural wetland (NW1) located in the northeastern corner of the catchment along 101st Ave. NE in subcatchment 1-1. Overflow from the wetland drains south via a culvert under 101st Ave. NE to a stormwater pond (WP1) in subcatchment 1-2. This pond is well sized for the drainage area and has over 0.4 ac-ft. of storage volume below its outlet elevation. Historical aerials and field evidence verify that the pond is often below its outlet elevation, allowing for greater rate control in addition to other water quality benefits. All stormwater runoff generated within the catchment is treated by this wet pond.

Listed below are network-level base and existing loading for catchments SP-1 to SP-13. Each of these catchments drain to the three in-line ponds in SP-9 and the Springbrook Nature Center wetland in SP-13, These waterbodies supply stormwater treatment to over 2,300 acres of the Springbrook subwatershed.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	64			
	BMP Types	stormwater retention ponds, infiltration basins, natural wetlands, hydrodynamic device			
	TP (lb/yr)	1,874.0	1,206.1	64%	**667.9**
	TSS (lb/yr)	731,718	582,303	80%	**149,415**
	Volume (acre-feet/yr)	1,541.8	97.6	6%	**1,444.2**

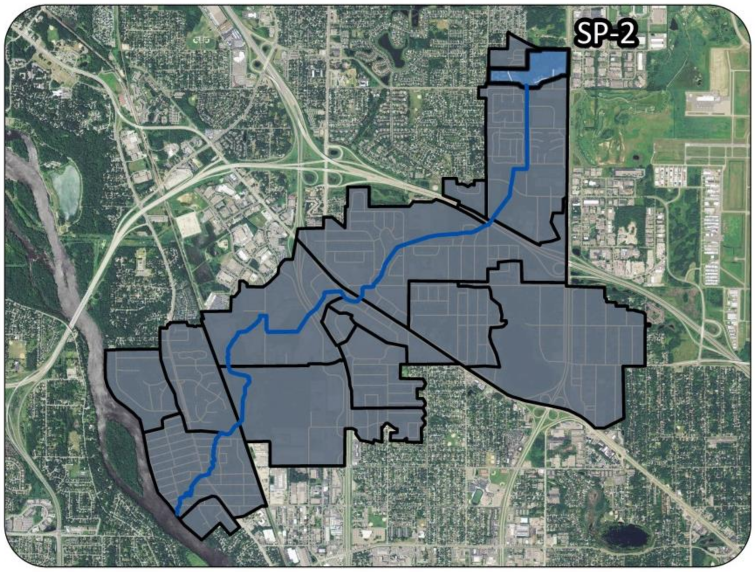
PROPOSED RETROFITS OVERVIEW

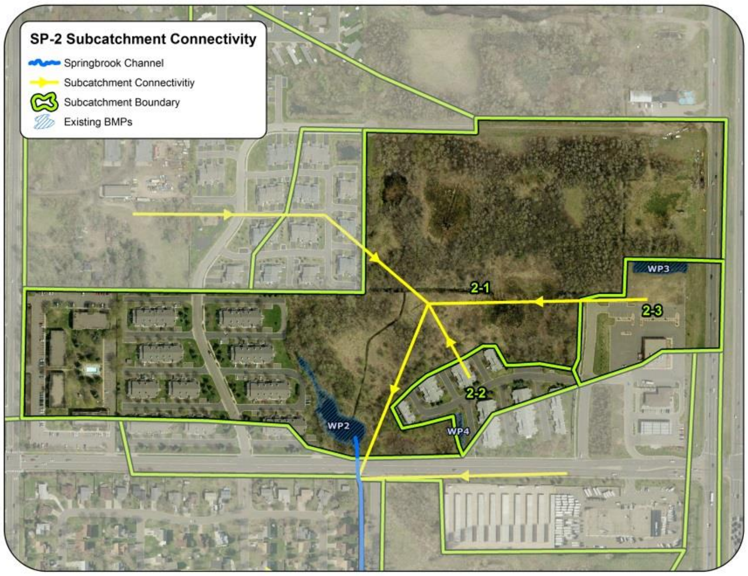
The wetland and stormwater pond that receive runoff from catchment SP-1 are sufficiently sized to treat drainage from this catchment. In addition, there is another stormwater pond treating overflow from these structures downstream in catchment SP-2. Therefore, no retrofit projects were proposed in catchment SP-1.

CURRENT STORMWATER INFRASTRUCTURE AND BMPS

Catchment SP-2

Existing Catchment Summary	
Acres	48.9
Dominant Land Cover	Residential
Parcels	144





CATCHMENT DESCRIPTION
This catchment is comprised of multi-family apartments and townhomes in the west and a wetland complex through the central and eastern portions of the catchment. Overflow from this wetland is directed into a culvert and conveyed under 99th Ave. NE into Springbrook south of the roadway. Soils are generally hydric within and near the wetland, with sandy soils to the east and west of the wetland.

EXISTING STORMWATER TREATMENT
Very little of the stormwater runoff generated within the catchment is piped, with most flowing overland towards the wetland complex in subcatchment 2-1. A pond (WP2) located just north of 99th Ave. NE at Buchanan St. NE drains the wetland.

Two other ponds treat runoff upstream of the wetland. The first (WP3) accepts runoff from a portion of Central Ave. NE and businesses on the western side of the highway in subcatchment 2-3. The second (WP4) accepts runoff from townhomes along 99th Court NE in the southern portion of subcatchment 2-2. Both are well-sized for their drainage areas (1.23 ac-ft. and 0.25 ac-ft. of storage, respectively) and appear to only overflow during spring snowmelt and large precipitation events.

Listed below are network-level base and existing loading for catchments SP-1 to SP-13. Each of these catchments drain to the three in-line ponds in SP-9 and the Springbrook Nature Center wetland in SP-13, These waterbodies supply stormwater treatment to over 2,300 acres of the Springbrook subwatershed.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	64			
	BMP Types	stormwater retention ponds, infiltration basins, natural wetlands, hydrodynamic device			
	TP (lb/yr)	1,874.0	1,206.1	64%	**667.9**
	TSS (lb/yr)	731,718	582,303	80%	**149,415**
	Volume (acre-feet/yr)	1,541.8	97.6	6%	**1,444.2**

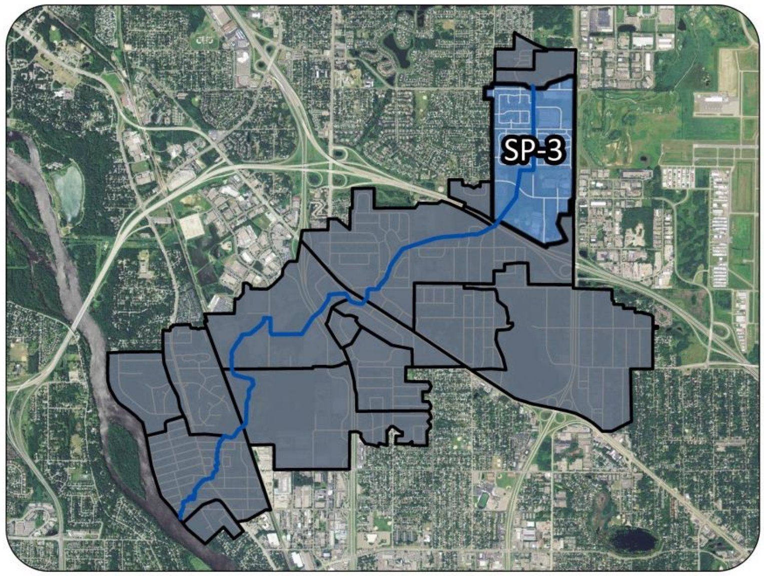
PROPOSED RETROFITS OVERVIEW

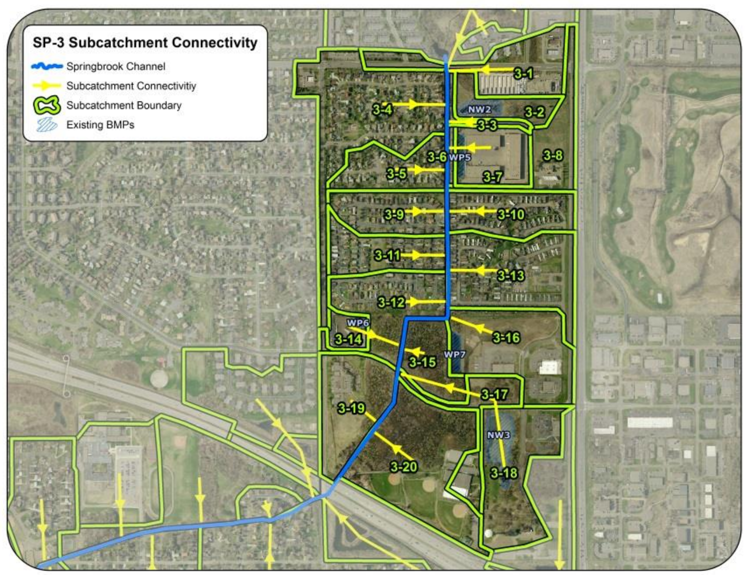
Due to the well-sized ponds and abundant pervious cover, no retrofits were proposed in this catchment. However, several retrofit options were considered before determining the catchment currently receives sufficient treatment. One curb-cut rain garden within the multi-family townhome complex could provide additional volume reduction and pollutant treatment. Modifications to the stormwater pond (e.g. increased ponding depth and/or pond area) adjacent to 99th Ave. NE could increase treatment and provide rate control before runoff enters Springbrook south of 99th Ave NE. The relatively small contributing drainage area and limited elevation difference between the current outlet invert and 99th Ave. NE resulted in the exclusion of these retrofits.

CURRENT STORMWATER INFRASTRUCTURE AND BMPS

Catchment SP-3

Existing Catchment Summary	
Acres	298.6
Dominant Land Cover	Residential
Parcels	225





CATCHMENT DESCRIPTION
Land use varies widely in this catchment, including single-family and multi-family residential lots, mobile homes, and parks, as well as commercial, industrial, and undeveloped properties. Springbrook bisects the catchment, running from north to south. The stream exits the catchment at its intersection with State Highway 10. SP-3 is bounded by University Ave. NE to the west and Central Ave. NE to the east. Soils are generally hydric along an approximately 600 ft. wide stream corridor. Sandy soils prevail along the eastern and western boundaries.

EXISTING STORMWATER TREATMENT
Stormwater infrastructure within the catchment is piecemeal, with stormwater BMPs generally only treating the properties they were installed with. This is the case for ponds built on the J.J Vanderson & Co. (WP5; subcatchment 3-7), Teamster's Local 120 (WP7; subcatchment 3-16), and Cloverleaf Courts properties (WP6; subcatchment 3-14). Two wetlands also exist along Buchanan St. NE (NW2; subcatchment 3-2) and Cloverleaf Parkway (NW3; subcatchment 3-18). Both, along with the undeveloped stream corridor in subcatchments 3-15, 3-17, 3-19, and 3-20, are holdovers from what was once a much larger wetland complex prior to development in the area. No treatment exists for the single-family residential and mobile home lots. Runoff from these properties enters storm sewer lines and discharges directly into Springbrook.

Listed below are network-level base and existing loading for catchments SP-1 to SP-13. Each of these catchments drain to the three in-line ponds in SP-9 and the Springbrook Nature Center wetland in SP-13, These waterbodies supply stormwater treatment to over 2,300 acres of the Springbrook subwatershed.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	64			
	BMP Types	stormwater retention ponds, infiltration basins, natural wetlands, hydrodynamic device			
	TP (lb/yr)	1,874.0	1,206.1	64%	**667.9**
	TSS (lb/yr)	731,718	582,303	80%	**149,415**
	Volume (acre-feet/yr)	1,541.8	97.6	6%	**1,444.2**

PROPOSED RETROFITS OVERVIEW

Proposed retrofits within catchment SP-3 are focused on the currently untreated stormwater runoff from the single-family residential and mobile home areas in the northern half of the catchment. Curb-cut rain gardens and an infiltration basin were proposed to treat runoff in the single-family residential neighborhood in the northwestern corner of the catchment.

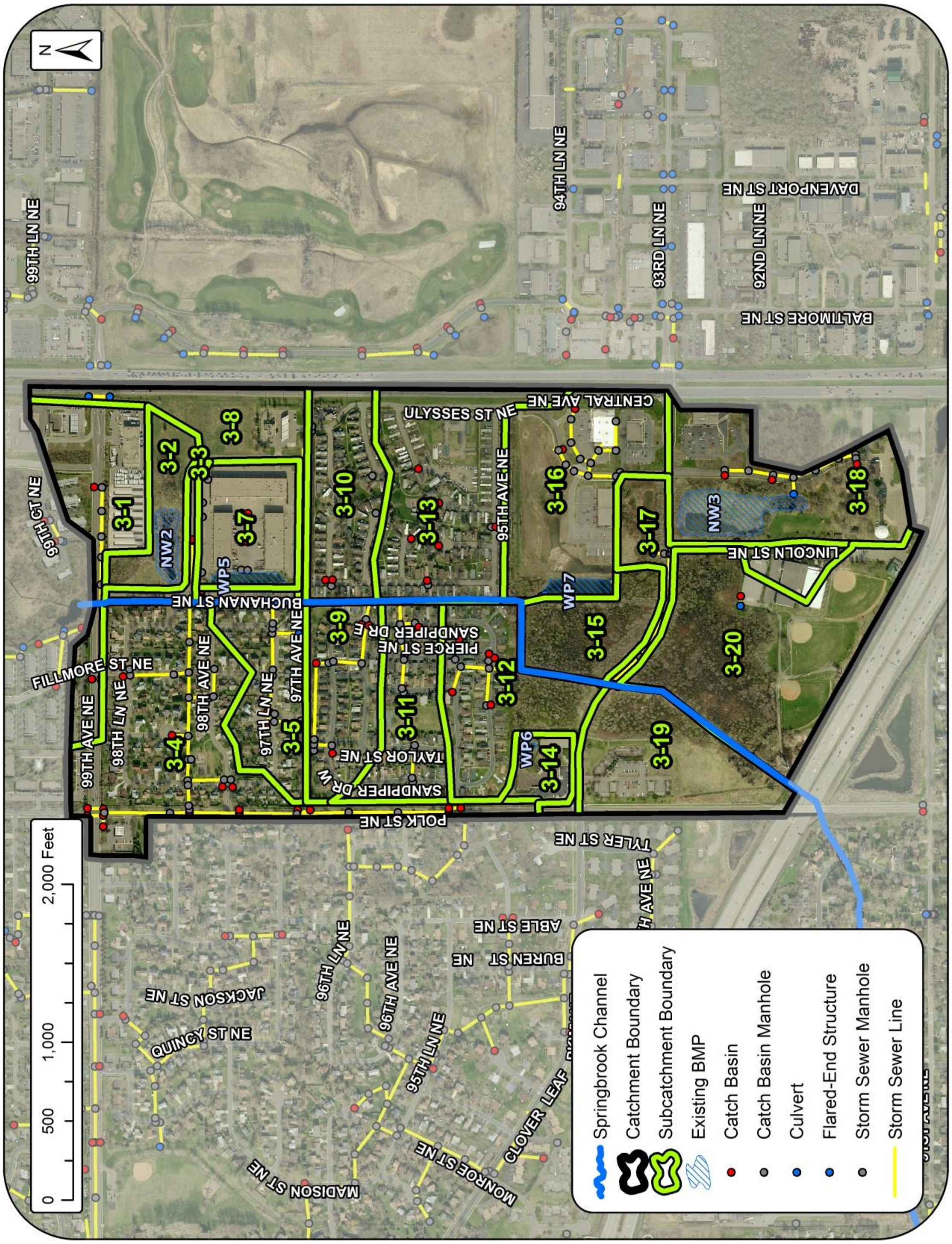
The central reach of Springbrook within catchment SP-3 is bordered on the east and west by mobile home parks, which often provide too little space on the property for a rain garden. A single infiltration basin was proposed within a large common space in the center of the western mobile home park. The storm sewer line passes through this common space, and an in-line infiltration basin could be installed that would daylight the pipe and provide both aesthetic value to the open space as well as stormwater treatment.

Runoff generated from the southern half of catchment SP-3 passes through a number of property-specific stormwater treatment ponds as well as a substantial wetland area that borders both the east and west side of Springbrook. Only one feasible retrofit was found in this area: a new stormwater infiltration basin accepting runoff from the Cloverleaf Park Apartments.

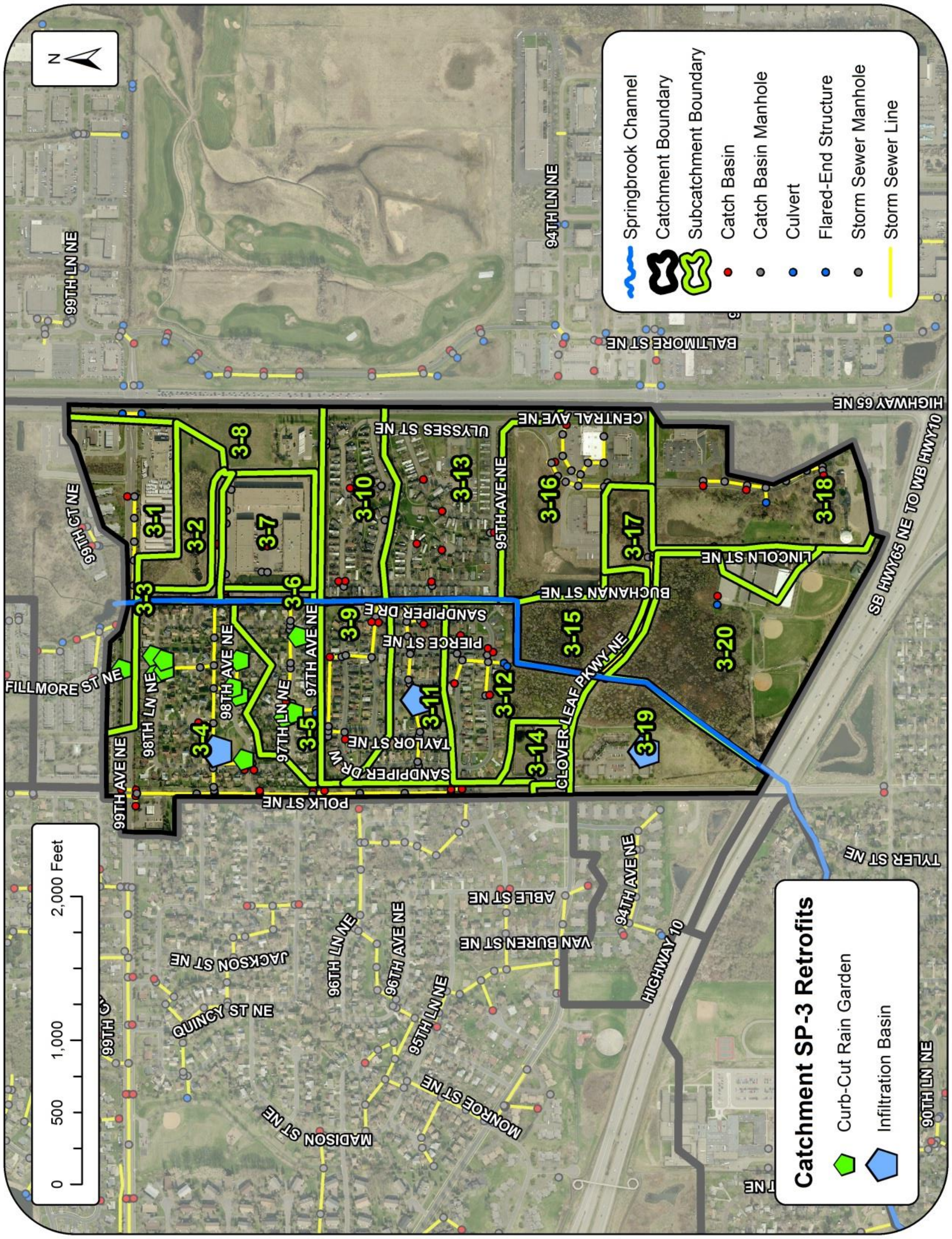
PROPOSED RETROFITS CONSIDERED BUT REJECTED

Eight optimal sites were located for hydrodynamic devices throughout the catchment. WinSLAMM model results found none of the devices removed more than 25 lbs-TSS/year or 0.2 lbs-TP/year above what downstream in-line ponds and the Springbrook Nature Center wetland were already treating. Considering their cost, such little pollutant retention made these devices cost-prohibitive. Therefore, they were removed from the proposed suite of projects.

CURRENT STORMWATER INFRASTRUCTURE AND BMPS



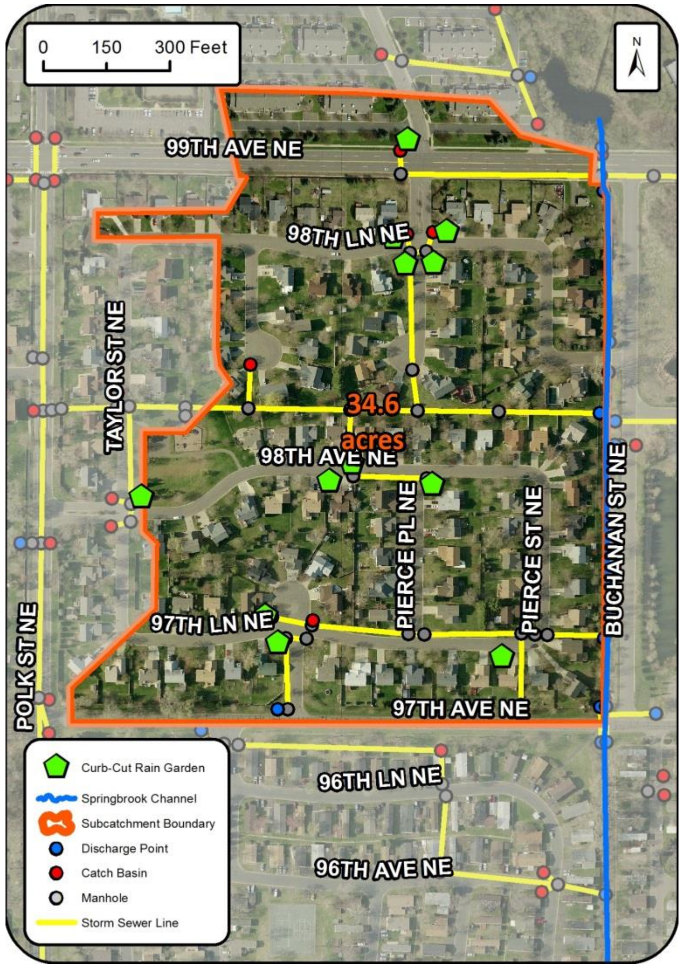
POTENTIAL RETROFITS



Project ID: 3-A

Curb-Cut Rain Gardens
Catchment SP-3

Drainage Area – Varies
Location – Throughout catchment SP-3
Property Ownership – Private
Site Specific Information – Single-family lots in catchment SP-3, specifically within subcatchments 3-4 and 3-5, provide various locations for curb-cut rain gardens to treat stormwater pollutants from private property. Up to 12 optimal sites were found through desktop analysis. Considering typical landowner participation rates, scenarios with 4, 6, and 8 rain gardens were analyzed. Note that some proposed garden sites are located near or within wellhead protection areas. Infiltration on these sites should be evaluated using the procedure established by the Minnesota Department of Health (MDH, 2007; *Appendix D*).



	Curb-Cut Rain Garden						
	Cost/Removal Analysis	**New Treatment**	**% Reduction**	**New Treatment**	**% Reduction**	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	4		6		8	
	Total Size of BMPs	1,000	sq-ft	1,500	sq-ft	2,000	sq-ft
	TP (lb/yr)	1.2	0.2%	2.1	0.3%	2.8	0.4%
	TSS (lb/yr)	243	0.2%	419	0.3%	560	0.4%
	Volume (acre-feet/yr)	1.6	0.1%	3.0	0.2%	3.9	0.3%
Cost	**Administration & Promotion Costs***		$11,096		$12,848		$14,600
	Design & Construction Costs**		$29,504		$44,256		$59,008
	Total Estimated Project Cost (2015)		**$40,600**		**$57,104**		**$73,608**
	Annual O&M***		$900		$1,350		$1,800
Efficiency	**30-yr Average Cost/lb-TP**	**$1,878**		**$1,549**		**$1,519**	
	30-yr Average Cost/1,000lb-TSS	**$9,273**		**$7,765**		**$7,596**	
	30-yr Average Cost/ac-ft Vol.	**$1,408**		**$1,084**		**$1,091**	

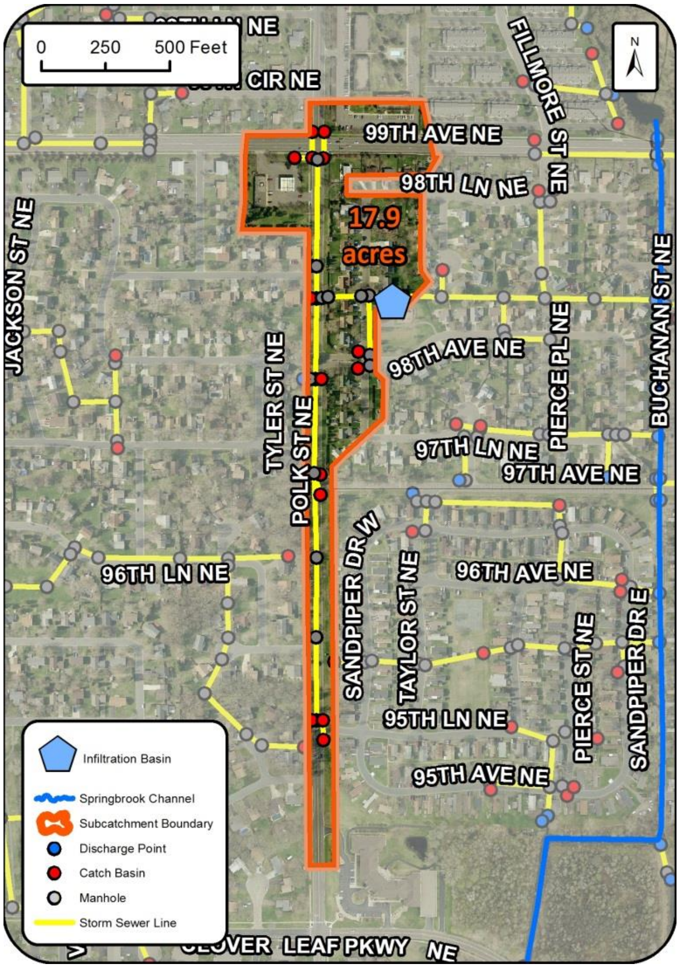
*Indirect Cost: (104 hours at $73/hour base cost) + (12 hours/BMP at $73/hour)

**Direct Cost: ($26/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)

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

Project ID: 3-B

Infiltration Basin
Subcatchment 3-4



Drainage Area – 17.9 acres
Location – North end of Olympia Park
Property Ownership – Public (City of Blaine)
Site Specific Information – Open space is available within Olympia Park for the installation of an infiltration basin. A 33” storm sewer line running the length of the park could be daylighted to provide for treatment of TSS and TP. *Prior to pursuing this project, the depth to the storm sewer line must be determined to gauge project feasibility.* Pollutant reduction values in the table below are listed for either a 6” or 12” deep basin. Both sizes were modeled as native soils are silty. Soil infiltration tests should be performed prior to installation to determine what the deepest ponding depth is that still ensures complete infiltration within 48 hours.

Infiltration Basin

	Cost/Removal Analysis	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	Ponding Depth of BMP	6 inches		12 inches	
	Total Size of BMP	1,000	sq-ft	1,000	sq-ft
	TP (lb/yr)	0.8	0.1%	1.0	0.1%
	TSS (lb/yr)	155	0.1%	211	0.1%
	Volume (acre-feet/yr)	1.4	0.1%	1.8	0.1%
Cost	Administration & Promotion Costs*	$2,920		$2,920	
	Design & Construction Costs**	$15,876		$20,876	
	Total Estimated Project Cost (2015)	**$18,796**		**$23,796**	
	Annual O&M***	$275		$275	
Efficiency	30-yr Average Cost/lb-TP	**$1,127**		**$1,068**	
	30-yr Average Cost/1,000lb-TSS	**$5,816**		**$5,063**	
	30-yr Average Cost/ac-ft Vol.	**$644**		**$593**	

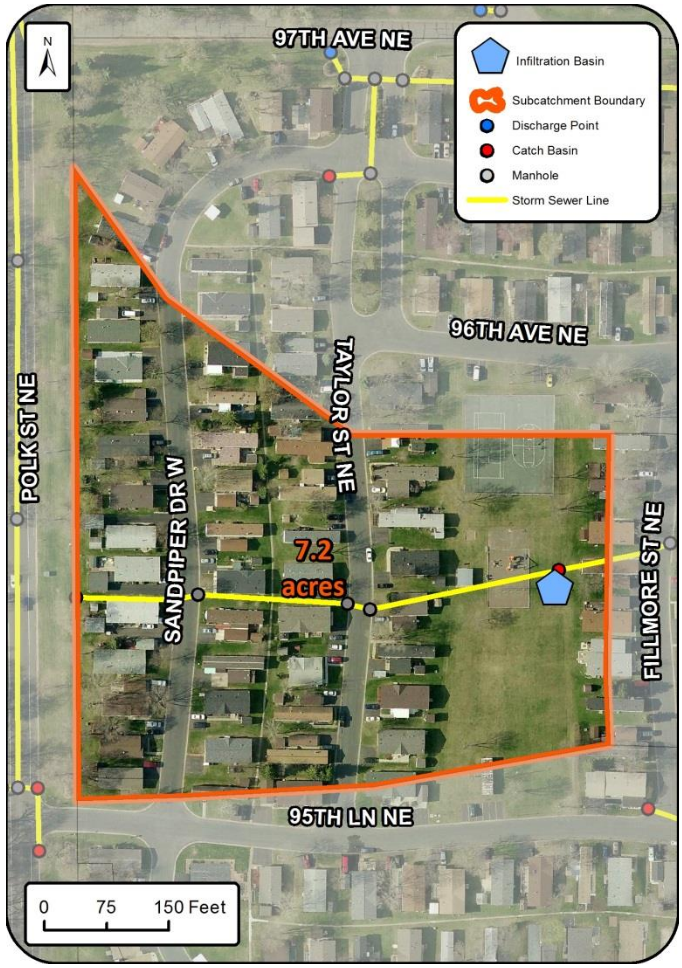
*Indirect Cost: 40 hours at $73/hour

**Direct Cost: ($20/sq-ft for materials and labor) + (12 hours at $73/hour for design) for 12" depth
($15/sq-ft for materials and labor) + (12 hours at $73/hour for design) for 6" depth

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

Project ID: 3-C

Infiltration Basin
Subcatchment 3-11



Drainage Area – 7.2 acres
Location – East of playground within mobile home park common space
Property Ownership – Private
Site Specific Information –A private storm sewer line draining about seven acres of mobile home properties could be daylighted within open space in the mobile home park. *Prior to pursuing this project, the depth to the storm sewer line must be determined to gauge project feasibility.* Pollutant reduction values in the table below are listed for either a 6" or 12" deep basin. Both sizes were modeled as hydric soils are located in the vicinity of the project site. Soil infiltration tests should be performed prior to installation to determine what the deepest ponding depth is which still ensures complete infiltration within 48 hours.

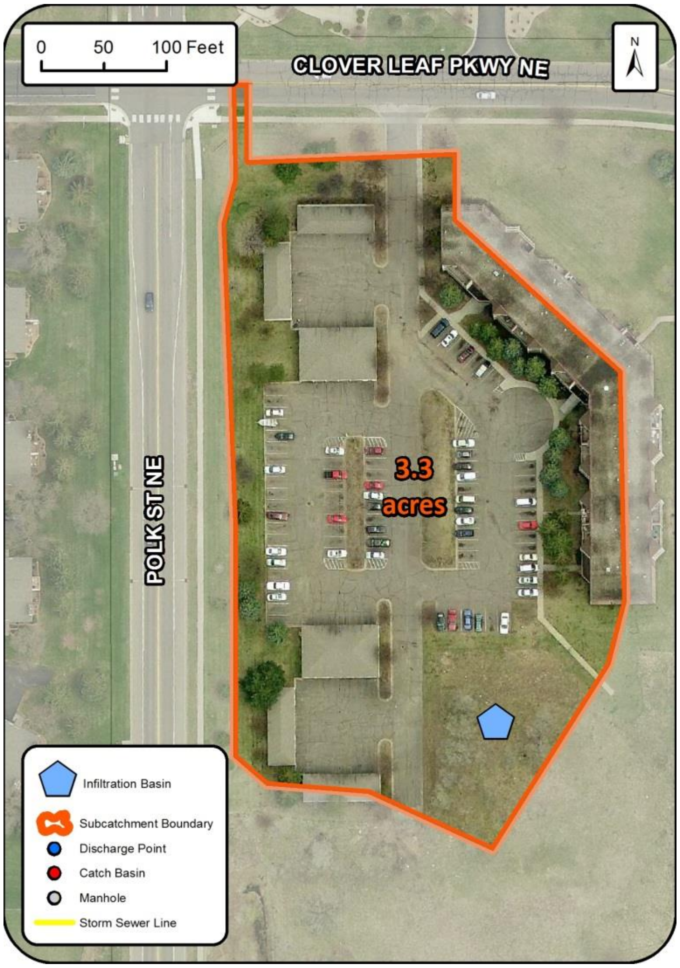
Infiltration Basin

	Cost/Removal Analysis	**New Treatment**	**% Reduction**	**New Treatment**	**% Reduction**
Treatment	**Ponding Depth of BMP**	6 inches		12 inches	
	Total Size of BMP	1,600	sq-ft	1,600	sq-ft
	TP (lb/yr)	1.2	0.2%	1.3	0.2%
	TSS (lb/yr)	277	0.2%	314	0.2%
	Volume (acre-feet/yr)	2.5	0.2%	3.0	0.2%
Cost	**Administration & Promotion Costs***		$2,920		$2,920
	Design & Construction Costs**		$24,876		$32,876
	Total Estimated Project Cost (2015)		**$27,796**		**$35,796**
	Annual O&M***		$275		$275
Efficiency	**30-yr Average Cost/lb-TP**	**$1,001**		**$1,129**	
	30-yr Average Cost/1,000lb-TSS	**$4,338**		**$4,676**	
	30-yr Average Cost/ac-ft Vol.	**$481**		**$489**	

*Indirect Cost: 40 hours at $73/hour
**Direct Cost: ($20/sq-ft for materials and labor) + (12 hours at $73/hour for design) for 12" depth
($15/sq-ft for materials and labor) + (12 hours at $73/hour for design) for 6" depth
***($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: 3-D

Infiltration Basin
Subcatchment 3-19



Drainage Area – 3.3 acres
Location – South of the Cloverleaf Park Apartments parking lot
Property Ownership – Private
Site Specific Information – Currently, stormwater runoff generated on this site is captured in parking lot catch basins and discharged untreated into Springbrook. An infiltration basin is proposed to accept stormwater from the apartment complex. Catch basins already exist on the site, so project installation should utilize the existing infrastructure (i.e. catch basins and storm sewer lines) to keep project cost low. Costs in the table below assume this.

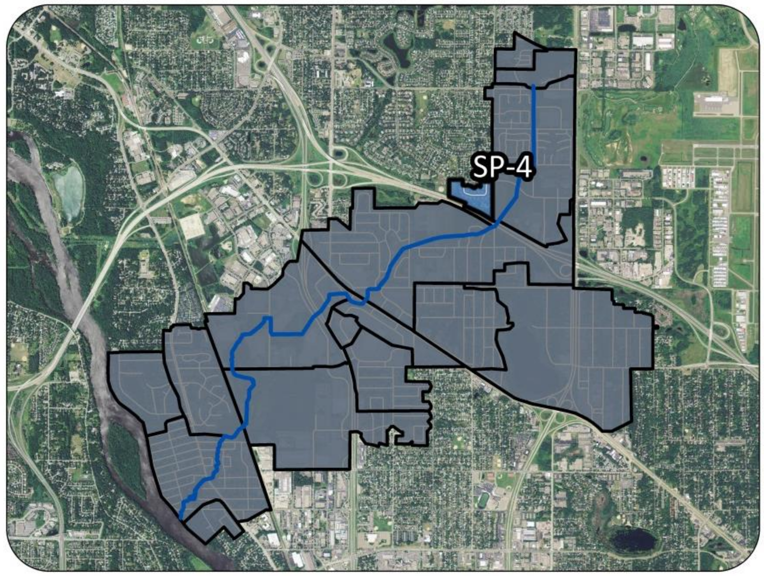
Infiltration Basin

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Ponding Depth of BMP	12 inches	
	Total Size of BMP	800	sq-ft
	TP (lb/yr)	0.8	0.1%
	TSS (lb/yr)	160	0.1%
	Volume (acre-feet/yr)	0.9	0.1%
Cost	Administration & Promotion Costs*	$2,920	
	Design & Construction Costs**	$16,876	
	Total Estimated Project Cost (2015)	**$19,796**	
	Annual O&M***	$275	
Efficiency	30-yr Average Cost/lb-TP	**$1,169**	
	30-yr Average Cost/1,000lb-TSS	**$5,843**	
	30-yr Average Cost/ac-ft Vol.	**$1,039**	

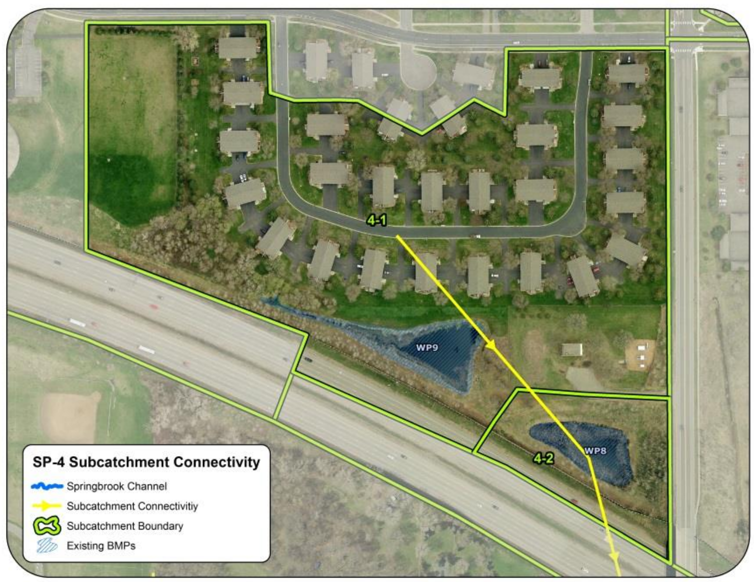
*Indirect Cost: 40 hours at $73/hour
**Direct Cost: ($20/sq-ft for materials and labor) + (12 hours at $73/hour for design)
***($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Catchment SP-4

Existing Catchment Summary	
Acres	26.9
Dominant Land Cover	Residential
Parcels	105



CATCHMENT DESCRIPTION
This catchment is bounded by the State Highway 10 corridor to the south, Polk St. NE to the east, and portions of Clover Leaf Parkway NE to the north. The catchment is split nearly equally by a city park and multi-family residential lots. The southeastern portion of the catchment contains a natural gas utility and two MNDOT stormwater ponds.



EXISTING STORMWATER TREATMENT
Stormwater runoff collected within the multi-family parcels flows into a storm sewer network and discharges into two in-line MNDOT stormwater ponds (WP8 and WP9), These ponds are ultimately connected to Springbrook via a 15“ RCP running through the State Highway 10 corridor. Similarly, runoff generated within the park flows overland into the ponds.

Listed below are network-level base and existing loading for catchments SP-1 to SP-13. Each of these catchments drain to the three in-line ponds in SP-9 and the Springbrook Nature Center wetland in SP-13, These waterbodies supply stormwater treatment to over 2,300 acres of the Springbrook subwatershed.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	**Number of BMPs**	64			
	BMP Types	stormwater retention ponds, infiltration basins, natural wetlands, hydrodynamic device			
	TP (lb/yr)	1,874.0	1,206.1	64%	**667.9**
	TSS (lb/yr)	731,718	582,303	80%	**149,415**
	Volume (acre-feet/yr)	1,541.8	97.6	6%	**1,444.2**

PROPOSED RETROFITS OVERVIEW

A pond modification was proposed for WP8 in subcatchment 4-2. This project proposes deepening the permanent pool depth from 2 ft. to 4ft.

PROPOSED RETROFITS CONSIDERED BUT REJECTED

A single hydrodynamic device was proposed within the catchment, located at the intersection of 94th Ave. NE and Van Buren St. NE, but was not pursued as WinSLAMM model results found the device only removed 17 lbs-TSS/year and 0.1 lbs-TP/year above what is already removed by in-line treatment downstream. Considering the potential cost of the project, such little pollutant retention made installation cost-prohibitive.

Infiltration practices were not pursued in this catchment due to the presence of (i) hydric and (ii) silty, non-hydric soils in the most opportune BMP locations.

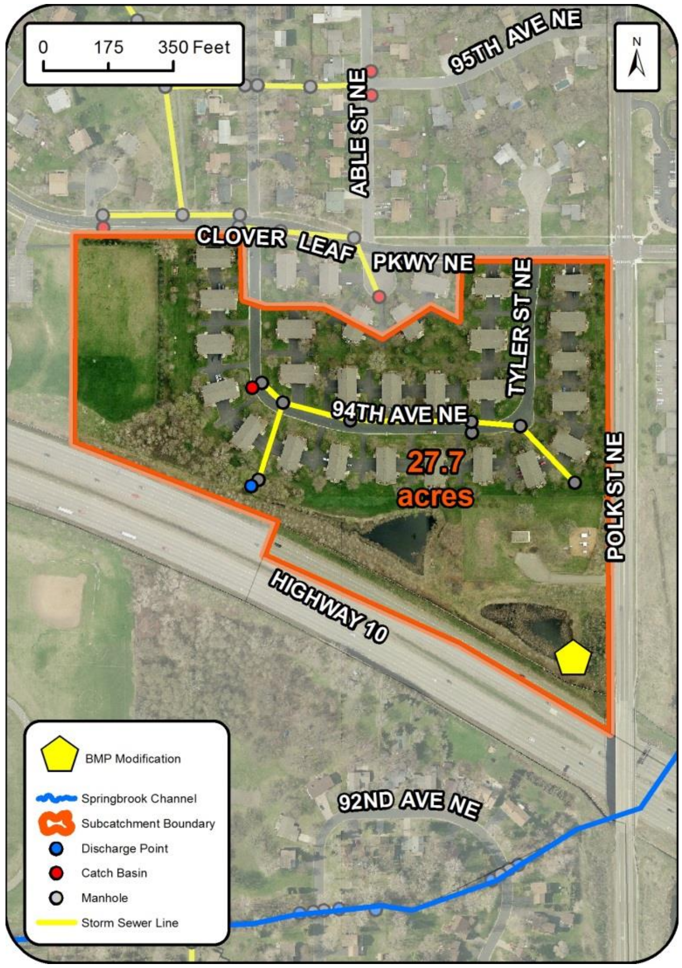
CURRENT STORMWATER INFRASTRUCTURE AND BMPS

POTENTIAL RETROFITS

Project ID: 4-A

BMP Modification
Subcatchment 4-2

Drainage Area – 27.7 acres
Location – Wet pond 8 (WP8)
Property Ownership – Public (MNDOT)
Site Specific Information – Based on current MNDOT drainage plans, WP8 in subcatchment 4-2 only ponds water to 2 ft., a depth which may not prohibit the resuspension of sediments. A pond modification is proposed that would increase permanent pool ponding depth from 2 ft. to 4 ft. This practice is expected to increase pollutant and volume retention upstream of Springbrook. No additional excavation is proposed with this practice, only a change to the outlet structure. Therefore, proposed costs below only include changes to the outlet structure.



Pond Modification

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMPs	0.7	acres
	TP (lb/yr)	0.9	0.1%
	TSS (lb/yr)	731	0.5%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	Administration & Promotion Costs*		$3,650
	Design & Construction Costs**		$24,000
	Total Estimated Project Cost (2015)		**$27,650**
	Annual O&M***		$700
Efficiency	30-yr Average Cost/lb-TP	**$1,802**	
	30-yr Average Cost/1,000lb-TSS	**$2,218**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

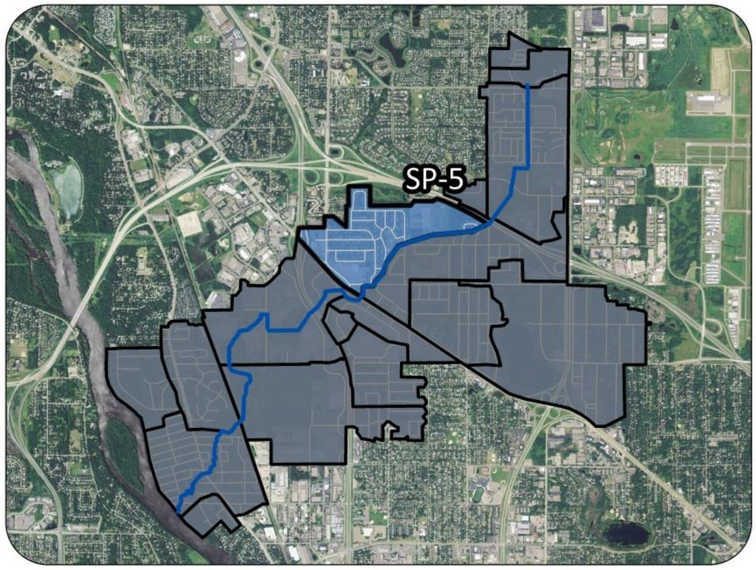
*Indirect Cost: 50 hours at $73/hour

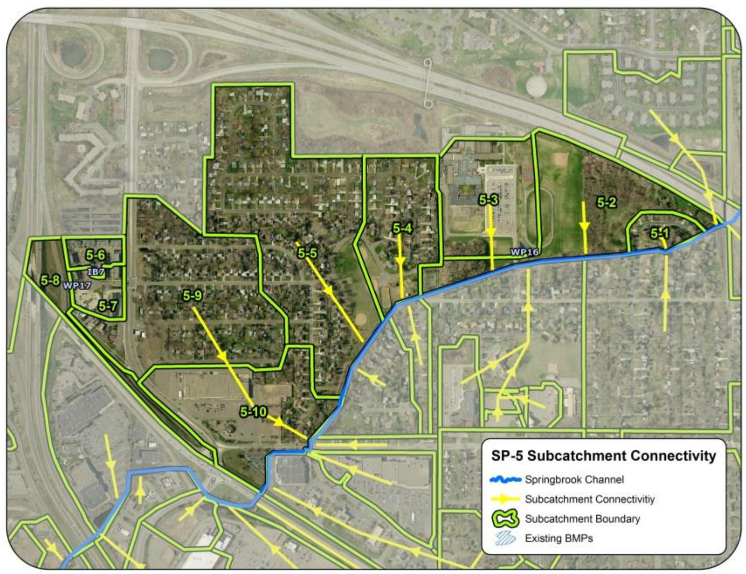
**Direct Cost: See Appendix B for detailed cost information

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

Catchment SP-5

Existing Catchment Summary	
Acres	192.7
Dominant Land Cover	Industrial
Parcels	380





CATCHMENT DESCRIPTION

Catchment SP-5 consists primarily of single-family residential lots, along with multi-family townhomes, commercial business along County Road 10, Westwood middle and intermediate schools, and Aurelia Park. The catchment is bounded by Springbrook to the east, the State Highway 10 corridor to the north, and County Road 10 to the south. Stormwater runoff generated within the catchment enters Springbrook through ditching along County Road 10 or through storm sewer lines throughout the catchment.

EXISTING STORMWATER TREATMENT

In subcatchment 5-3, stormwater runoff collected within the Westwood schools' property is conveyed from the impervious building and parking lot to a grass swale. This swale discharges into a stormwater pond (WP16) less than 100 ft. from Springbrook.

The multi-family townhomes in subcatchments 5-6 and 5-7 drain first to an infiltration basin (IB7; subcatchment 5-6), then to a wet pond (WP17; subcatchment 5-7), before finally discharging into the ditching system running parallel to County Road 10 (subcatchment 5-8). Based on stormwater infrastructure information received by the City of Coon Rapids and verified through desktop analysis it does not appear these subcatchments are hydrologically connected to Springbrook.

Single-family residential lots catchment-wide and commercial properties along County Road 10 currently receive no water quality treatment outside of street cleaning (not modeled for this analysis). Stormwater runoff generated in the residential neighborhoods is immediately intercepted by stormwater catch basins and routed directly into the creek. Commercial businesses along County Road

10 in subcatchment 5-10 release stormwater into a ditch running parallel to the road. This ditch subsequently drains into the creek.

Listed below are network-level base and existing loading for catchments SP-1 to SP-13. Each of these catchments drain to the three in-line ponds in SP-9 and the Springbrook Nature Center wetland in SP-13, These waterbodies supply stormwater treatment to over 2,300 acres of the Springbrook subwatershed.

	Existing Conditions	**Base Loading**	**Treatment**	**Net Treatment %**	**Existing Loading**
Treatment	**Number of BMPs**	64			
	BMP Types	stormwater retention ponds, infiltration basins, natural wetlands, hydrodynamic device			
	TP (lb/yr)	1,874.0	1,206.1	64%	**667.9**
	TSS (lb/yr)	731,718	582,303	80%	**149,415**
	Volume (acre-feet/yr)	1,541.8	97.6	6%	**1,444.2**

PROPOSED RETROFITS OVERVIEW

A variety of practices have been proposed in this catchment, including curb-cut rain gardens, infiltration basins, permeable asphalt, an IESF bench to the existing Westwood school retention pond, and a permeable check dam. Upland soils in this catchment are generally sandy and well-drained (Sartell and Zimmerman soils), which is favorable for infiltration practices such as curb-cut rain gardens, infiltration basins, and permeable asphalt. The single-family residential neighborhood bounded by Westwood Schools and University Ave. NE has front yards with a large elevation grade which limits opportunities for cost-effective rain gardens, particularly in subcatchments 5-4 and 5-5. Even so, a handful of sites have been located which could accommodate a rain garden. Two infiltration basins have also been proposed, one in Aurelia Park and a second at the corner of 3rd St. NE and 90th Ave. NE within a currently undeveloped property.

In the northeast portion of the catchment, changes to existing stormwater infrastructure may provide cost-effective opportunities to enhance stormwater treatment. The Westwood pond currently provides treatment for much of the school property, including the building, parking lot, and portions of the track and tennis courts. An IESF bench could be installed just south of the pond to treat overflow for DP.

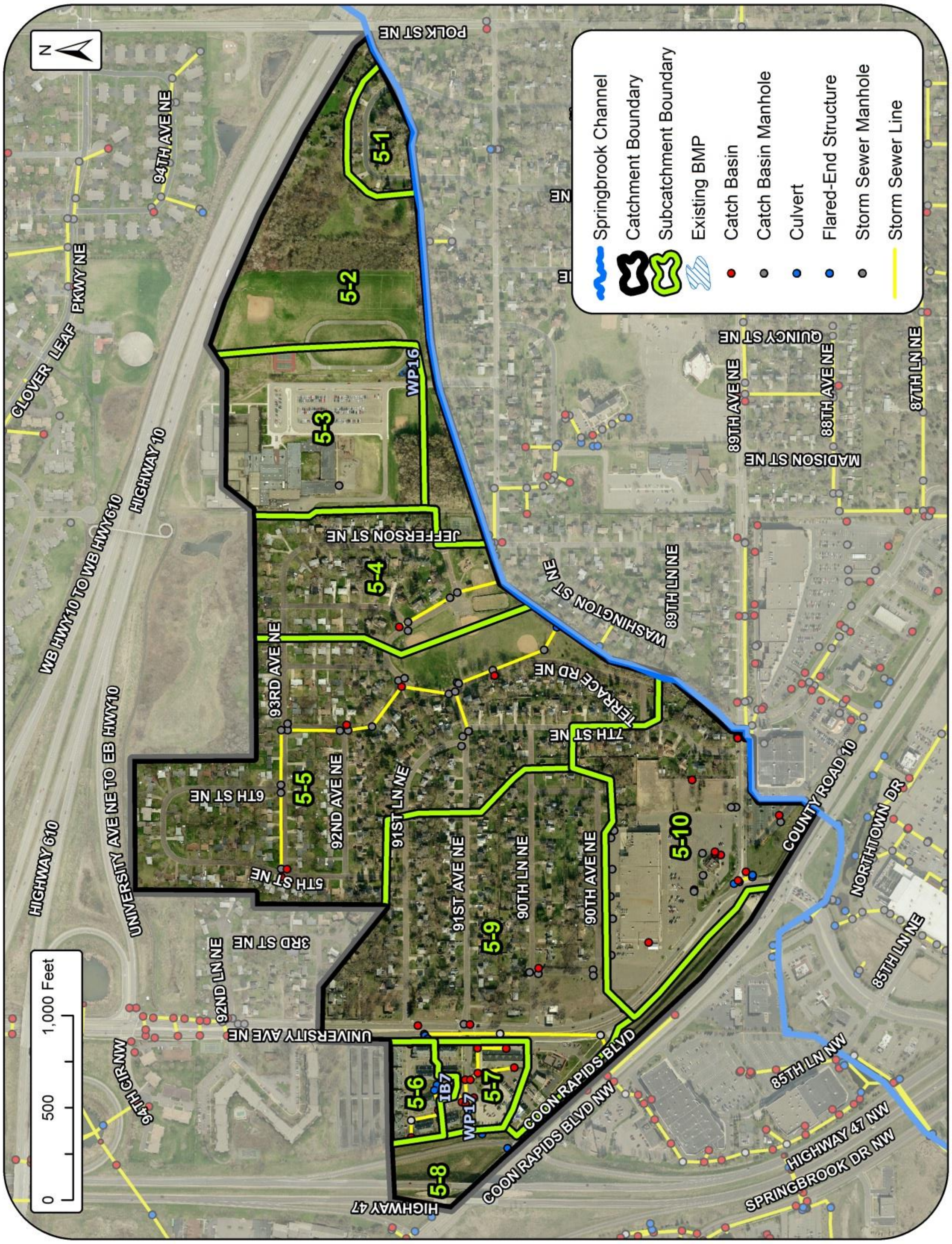
For the commercial properties along County Road 10, two distinct opportunities were found. The first treats a portion of the large K-Mart parking lot, which currently flows untreated directly into Springbrook. Permeable asphalt would be installed along low-traffic areas in the parking lot, allowing water to infiltrate into soils rather than being immediately intercepted in catch basins. The second practice, a permeable check dam located in the ditch along the north side of County Road 10, utilizes iron-enhanced sand to increase retention of dissolved constituents.

PROPOSED RETROFITS CONSIDERED BUT REJECTED

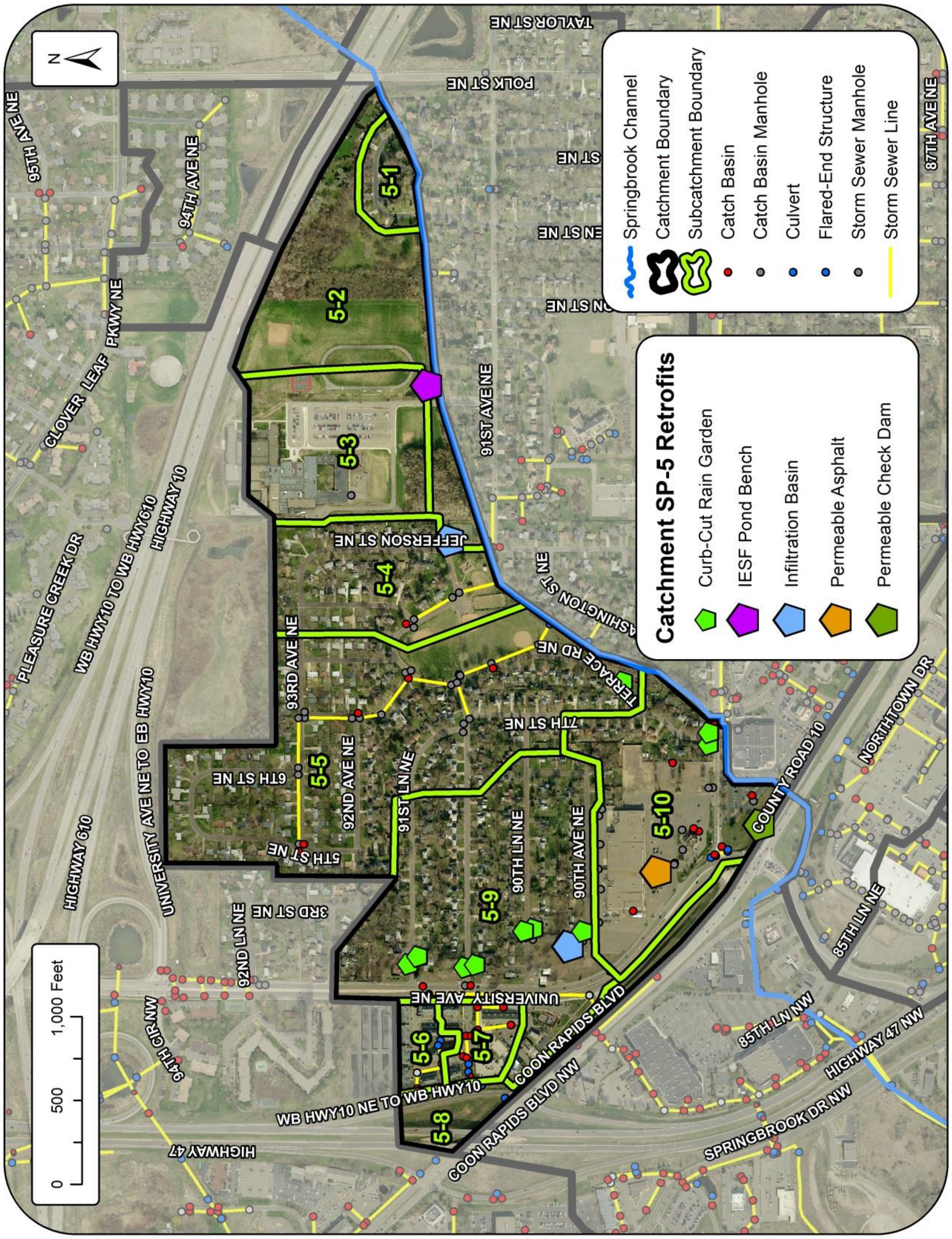
Three sites were located for hydrodynamic devices treating primarily single-family residential runoff in subcatchments 5-4 and 5-5. WinSLAMM model results found none of the devices removed more than 20 lbs-TSS/year or 0.2 lbs-TP/year above what downstream in-line ponds and the Springbrook Nature Center wetland were already treating. Considering their cost, such little pollutant retention made these devices cost-prohibitive. Therefore, no hydrodynamic devices were proposed as retrofits in catchment SP-5.

An underground storage tank in Aurelia Park was also explored as a proposed retrofit. This tank would have accepted runoff from the residential properties and roadways within the catchment, and would have used this water to irrigate the park property. This project was not included as a proposed retrofit as the park is not currently irrigated.

CURRENT STORMWATER INFRASTRUCTURE AND BMPS

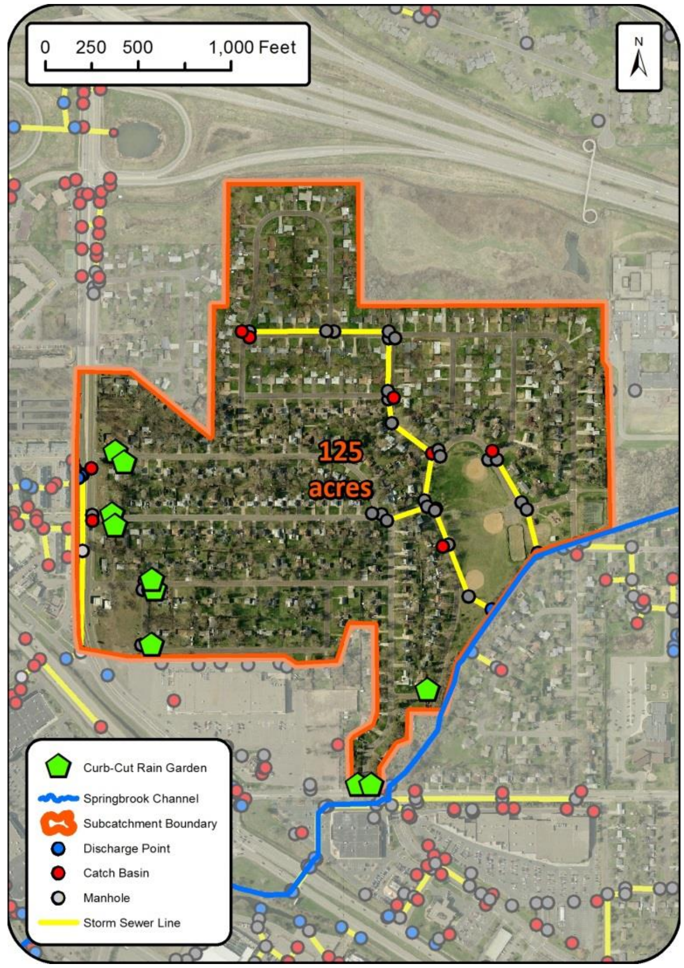


POTENTIAL RETROFITS



Project ID: 5-A

Curb-cut Rain Gardens
Catchment SP-5



Drainage Area – Varies
Location – Throughout catchment SP-5
Property Ownership – Private
Site Specific Information – Single-family lots in catchment SP-5, specifically within subcatchments 5-9 and 5-10, provide various locations for curb-cut rain gardens to treat stormwater pollutants from private property. Up to 10 optimal sites were found through desktop analysis. Considering typical landowner participation rates, scenarios with 4, 6, and 8 rain gardens were analyzed. Potential rain garden sites may also available in subcatchments 5-4 and 5-5 but could potentially be more expensive per sq-ft. due to steeper front yards (and therefore more cost for excavation and retaining wall block).

Curb-Cut Rain Garden

	Cost/Removal Analysis	New Treatment	% Reduction	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	Number of BMPs	4		6		8	
	Total Size of BMPs	1,000	sq-ft	1,500	sq-ft	2,000	sq-ft
	TP (lb/yr)	1.2	0.2%	1.8	0.3%	2.5	0.4%
	TSS (lb/yr)	268	0.2%	388	0.3%	554	0.4%
	Volume (acre-feet/yr)	1.8	0.1%	2.5	0.2%	3.9	0.3%
Cost	Administration & Promotion Costs*		$11,096		$12,848		$14,600
	Design & Construction Costs**		$29,504		$44,256		$59,008
	Total Estimated Project Cost (2015)		**$40,600**		**$57,104**		**$73,608**
	Annual O&M***		$900		$1,350		$1,800
Efficiency	30-yr Average Cost/lb-TP	**$1,878**		**$1,807**		**$1,701**	
	30-yr Average Cost/1,000lb-TSS	**$8,408**		**$8,385**		**$7,678**	
	30-yr Average Cost/ac-ft Vol.	**$1,252**		**$1,301**		**$1,091**	

*Indirect Cost: (104 hours at $73/hour base cost) + (12 hours/BMP at $73/hour)

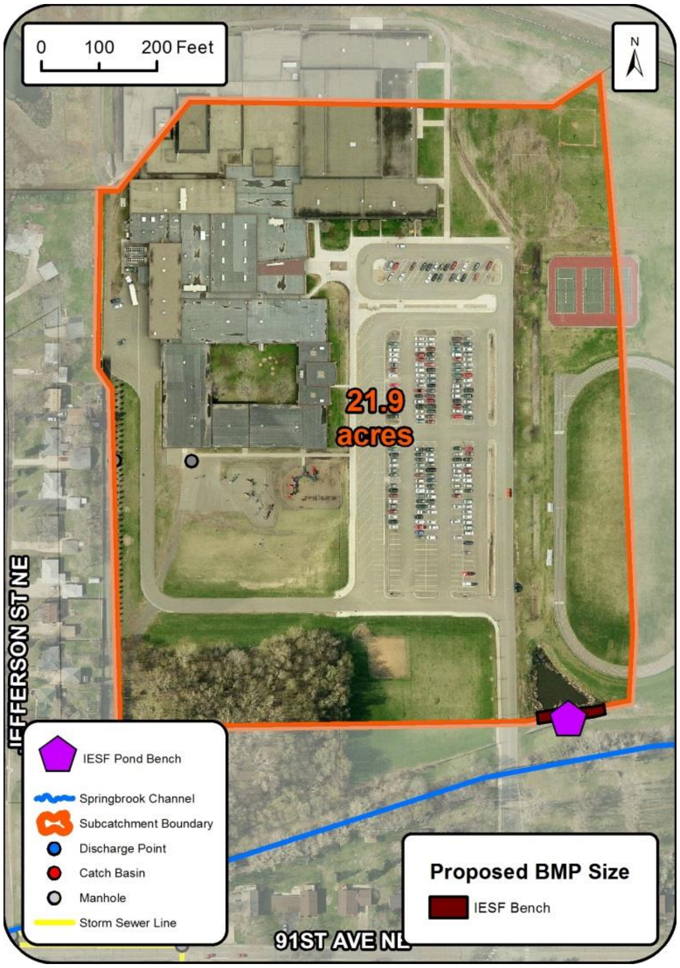
**Direct Cost: ($26/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)

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

Project ID: 5-B

IESF Bench
Subcatchment 5-3

Drainage Area – 21.9 acres
Location – Along southern bank of wet pond 16 (WP16)
Property Ownership – Public (Spring Lake Park School District)
Site Specific Information – Publically-owned space is available south of WP16 for a 20 ft. by 110 ft. IESF bench. This practice will supplement the pond by better treating outflow for DP, which can often advect through wet retention systems untreated. Some pond dredging may be needed to ensure sufficient storage for settling of particulates, as these can reduce IESF efficiency if not removed within the pond.



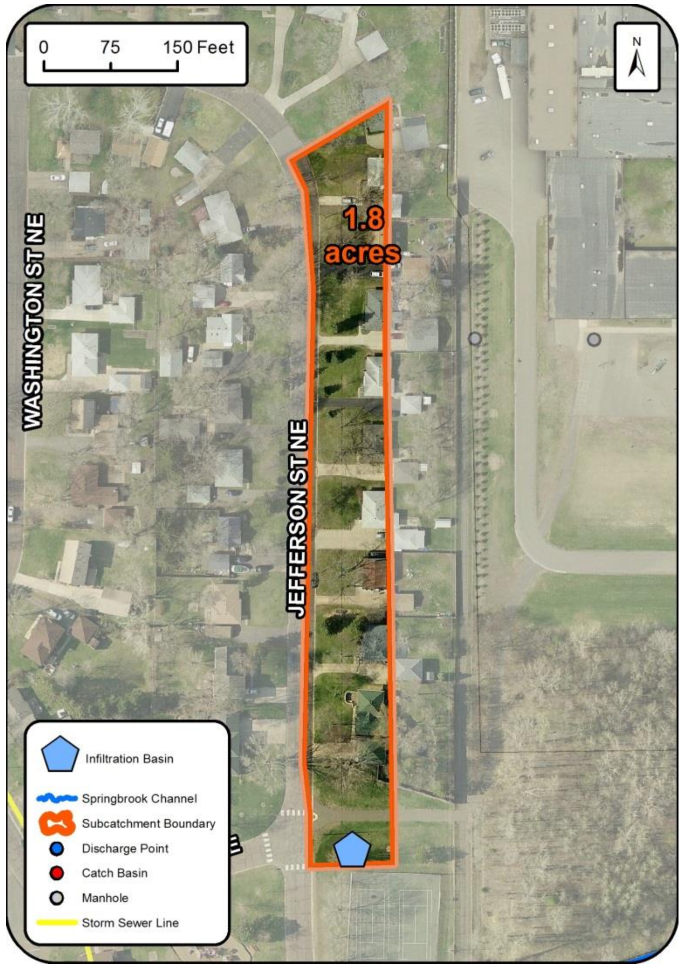
IESF Bench

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMPs	2,200	sq-ft
	TP (lb/yr)	2.0	0.3%
	TSS (lb/yr)	0	0.0%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	Administration & Promotion Costs*	$5,475	
	Design & Construction Costs**	$152,400	
	Total Estimated Project Cost (2015)	**$157,875**	
	Annual O&M***	$505	
Efficiency	30-yr Average Cost/lb-TP	**$2,884**	
	30-yr Average Cost/1,000lb-TSS	**N/A**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

*Indirect Cost: 75 hours at $73/hour
**Direct Cost: See Appendix B for detailed cost information
***$10,000/acre for IESF

Project ID: 5-C

Infiltration Basin
Subcatchment 5-4



Drainage Area – 1.8 acres
Location – Northwest corner of Aurelia Park
Property Ownership – Public (City of Blaine)
Site Specific Information – –An infiltration basin is proposed within Aurelia Park to treat single-family residential and park land. Hydric soils exist along low areas in the Springbrook corridor, and the site of basin installation should be chosen such that (i) the basin is installed on the most well-drained, sandy soils and (ii) the basin location is as far downstream (further south along Jefferson St. NE) as possible to maximize the drainage area upstream of the garden. Due to silty soils within the park, this garden was modeled with a 6” ponding depth. Soil infiltration tests should be performed prior to installation to determine what the deepest ponding depth is which still ensures complete infiltration within 48 hours.

Infiltration Basin

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Ponding Depth of BMP	6 inches	
	Total Size of BMP	1,500	sq-ft
	TP (lb/yr)	0.6	0.1%
	TSS (lb/yr)	119	0.1%
	Volume (acre-feet/yr)	0.7	0.0%
Cost	Administration & Promotion Costs*	$2,920	
	Design & Construction Costs**	$23,376	
	Total Estimated Project Cost (2015)	**$26,296**	
	Annual O&M***	$275	
Efficiency	30-yr Average Cost/lb-TP	**$1,919**	
	30-yr Average Cost/1,000lb-TSS	**$9,677**	
	30-yr Average Cost/ac-ft Vol.	**$1,645**	

*Indirect Cost: 40 hours at $73/hour

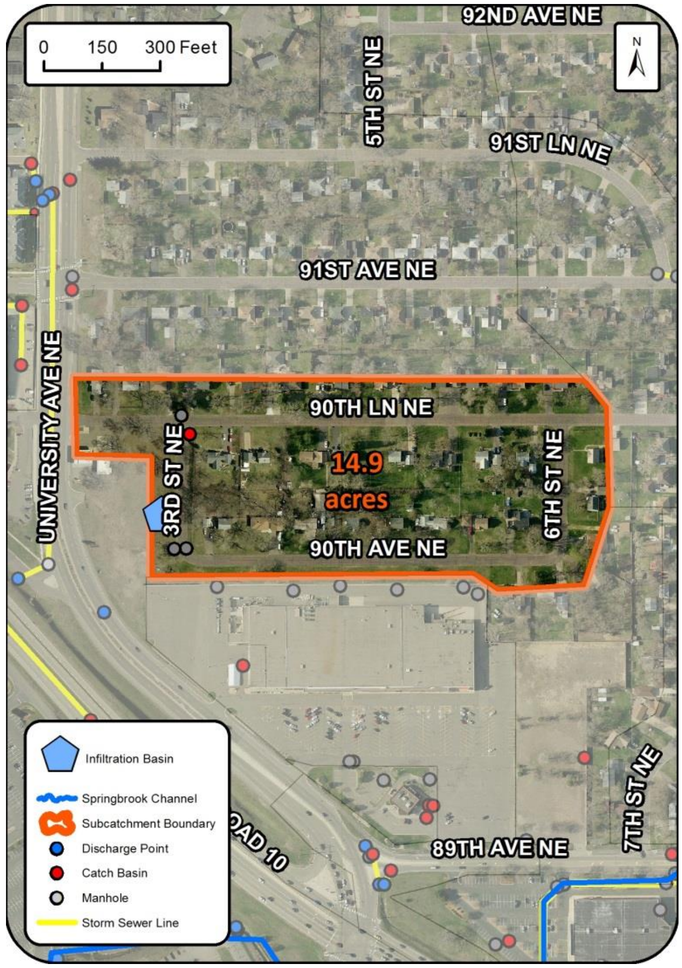
**Direct Cost: ($15/sq-ft for materials and labor) + (12 hours at $73/hour for design)

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

Project ID: 5-D

Infiltration Basin
Subcatchment 5-9

Drainage Area – 14.9 acres
Location – Near intersection of 3rd St. NE and 90th Ave. NE
Property Ownership – Blaine Economic Development Authority
Site Specific Information – Undeveloped space is available along University Ave. NE to treat residential runoff from a nearly 15 acre drainage area. Catch basins at the intersection of 90th Ave. NE and 3rd St. NE could be removed or diverted to a 3,000 sq-ft. infiltration basin. Due to the prevalence of silty soils near the proposed site this garden was modeled with either a 6” or 12” ponding depth. Soil infiltration tests should be performed prior to installation to determine what the deepest ponding depth is which still ensures complete infiltration within 48 hours.



Infiltration Basin

	Cost/Removal Analysis	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	Ponding Depth of BMP	6 inches		12 inches	
	Total Size of BMP	3,000	sq-ft	3,000	sq-ft
	TP (lb/yr)	2.7	0.4%	3.1	0.5%
	TSS (lb/yr)	659	0.4%	766	0.5%
	Volume (acre-feet/yr)	4.1	0.3%	4.8	0.3%
Cost	Administration & Promotion Costs*	$2,920		$2,920	
	Design & Construction Costs**	$45,876		$60,876	
	Total Estimated Project Cost (2015)	**$48,796**		**$63,796**	
	Annual O&M***	$275		$275	
Efficiency	30-yr Average Cost/lb-TP	**$704**		**$775**	
	30-yr Average Cost/1,000lb-TSS	**$2,885**		**$3,135**	
	30-yr Average Cost/ac-ft Vol.	**$464**		**$500**	

*Indirect Cost: 40 hours at $73/hour
**Direct Cost: ($20/sq-ft for materials and labor) + (12 hours at $73/hour for design) for 12" depth
($15/sq-ft for materials and labor) + (12 hours at $73/hour for design) for 6" depth
***($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: 5-E

Permeable Asphalt
Subcatchment 5-10

Drainage Area – 2.0 acres
Location – Kmart parking Lot
Property Ownership – Private
Site Specific Information – Only 2 of the 10.5 acre Kmart parking property incorporated into the permeable asphalt drainage area to keep overall project cost down. To treat this area, 0.5 acres (21,780 sq-ft.) of permeable asphalt is proposed. A much larger portion of the 10.5 acre Kmart property could potentially be treated using permeable asphalt as most of the property drains to its parking lot. Cost-efficiencies similar to those in the table could be used to estimate pollutant reductions for that larger project.

Permeable Asphalt			
	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMP	21,780	sq-ft
	TP (lb/yr)	0.4	0.1%
	TSS (lb/yr)	175	0.1%
	Volume (acre-feet/yr)	1.4	0.1%
Cost	Administration & Promotion Costs*	$2,920	
	Design & Construction Costs**	$218,676	
	Total Estimated Project Cost (2015)	**$221,596**	
	Annual O&M***	$16,335	
Efficiency	30-yr Average Cost/lb-TP	**$59,304**	
	30-yr Average Cost/1,000lb-TSS	**$135,552**	
	30-yr Average Cost/ac-ft Vol.	**$16,944**	

*Indirect Cost: 40 hours at $73/hour

**Direct Cost: ($10/sq-ft for materials and labor) + (12 hours at $73/hour for design)

***($0.75/sq-ft for routine maintenance)

Project ID: 5-F

Permeable Check Dam
Subcatchment 5-10

Drainage Area – 3.3 acres
Location – Within county ditch north of County Road 10
Property Ownership – Public (Anoka County)
Site Specific Information – Stormwater generated on commercial properties along University Ave. NE and 89th Ave NE drains to the ditch north of County Road 10. This ditch flows east and directly into Springbrook. A permeable check dam is proposed along the ditch to promote sediment and debris accumulation upstream of the dam and dissolved pollutant retention within the dam. A check dam modeled for this location was 2' high (on average), 4' long, and 20' in width to span the ditch.

Permeable Check Dam

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMP	208	cu-ft
	TP (lb/yr)	1.1	0.2%
	TSS (lb/yr)	378	0.3%
	Volume (acre-feet/yr)	1.1	0.1%
Cost	Administration & Promotion Costs*	$2,920	
	Design & Construction Costs**	$12,528	
	Total Estimated Project Cost (2015)	**$15,448**	
	Annual O&M***	$365	
Efficiency	30-yr Average Cost/lb-TP	**$800**	
	30-yr Average Cost/1,000lb-TSS	**$2,328**	
	30-yr Average Cost/ac-ft Vol.	**$800**	

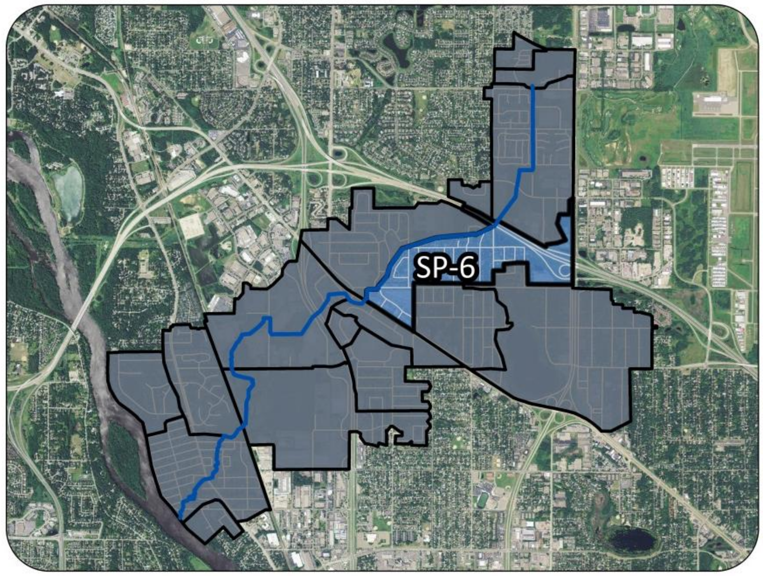
*Indirect Cost: 40 hours at $73/hour

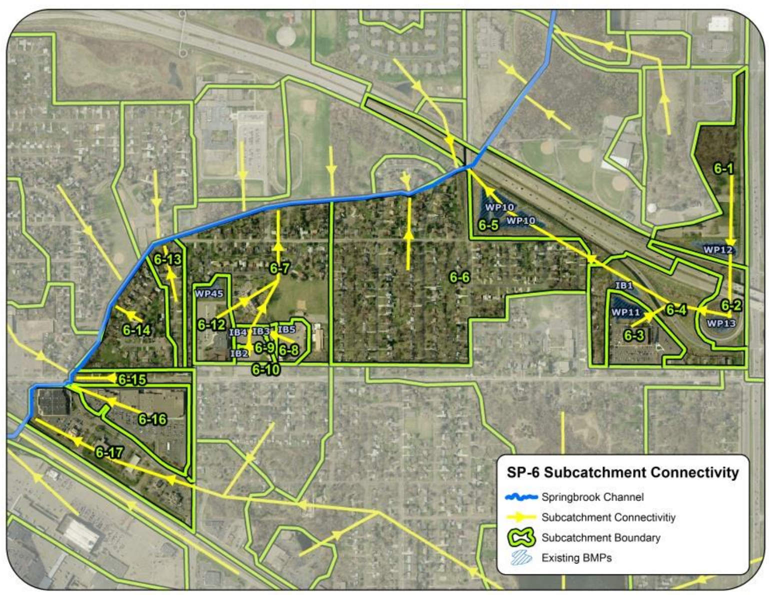
**Direct Cost: See Appendix B for detailed cost information

***(5 hours for each dam at $73/hour for cleaning sediment/debris and maintenance)

Catchment SP-6

Existing Catchment Summary	
Acres	242.6
Dominant Land Cover	Residential
Parcels	317





CATCHMENT DESCRIPTION

Land use within catchment SP-6 is dominated by single-family residential lots. Also within the catchment are the Church of St. Timothy, Calvin Christian School, Anoka County Judicare, and numerous commercial businesses in the southwest. The western boundary of the catchment is Springbrook, while the southern boundary is either County Road 10 or 89th Ave NE. The eastern boundary is Central Ave. NE.

EXISTING STORMWATER TREATMENT

Numerous stormwater treatment ponds exist throughout the catchment. Beginning in the east, a series of stormwater ponds and an infiltration basin along State Highway 10 treat runoff from the freeway and commercial properties west of Central Ave. NE: WP12 in subcatchment 6-1, WP13 in subcatchment 6-2, IB1 in subcatchment 6-4, and WP10 in subcatchment 6-5. Anoka County Judicare also has a treatment pond (WP11) located near the northern extent of its campus in subcatchment 6-3. In the west, the Christ Lutheran Church has a pond (WP45) treating runoff generated within the property (subcatchment 6-12). Church of St. Timothy, following a recent parking lot renovation, installed four infiltration basins to treat runoff generated from its building and parking lot (IB1 through IB4 in subcatchments 6-8 through 6-11).

Outside of the subcatchments noted above, stormwater runoff from the residential lots within the central portion of the catchment flows untreated to Springbrook. Runoff from the commercial land use in the southwest is conveyed into a ditch running along County Road 10 (subcatchment 6-17). This ditch discharges directly into Springbrook.

Listed below are network-level base and existing loading for catchments SP-1 to SP-13. Each of these catchments drain to the three in-line ponds in SP-9 and the Springbrook Nature Center wetland in SP-13, These waterbodies supply stormwater treatment to over 2,300 acres of the Springbrook subwatershed.

	Existing Conditions	**Base Loading**	**Treatment**	**Net Treatment %**	**Existing Loading**
Treatment	**Number of BMPs**	64			
	BMP Types	stormwater retention ponds, infiltration basins, natural wetlands, hydrodynamic device			
	TP (lb/yr)	1,874.0	1,206.1	64%	**667.9**
	TSS (lb/yr)	731,718	582,303	80%	**149,415**
	Volume (acre-feet/yr)	1,541.8	97.6	6%	**1,444.2**

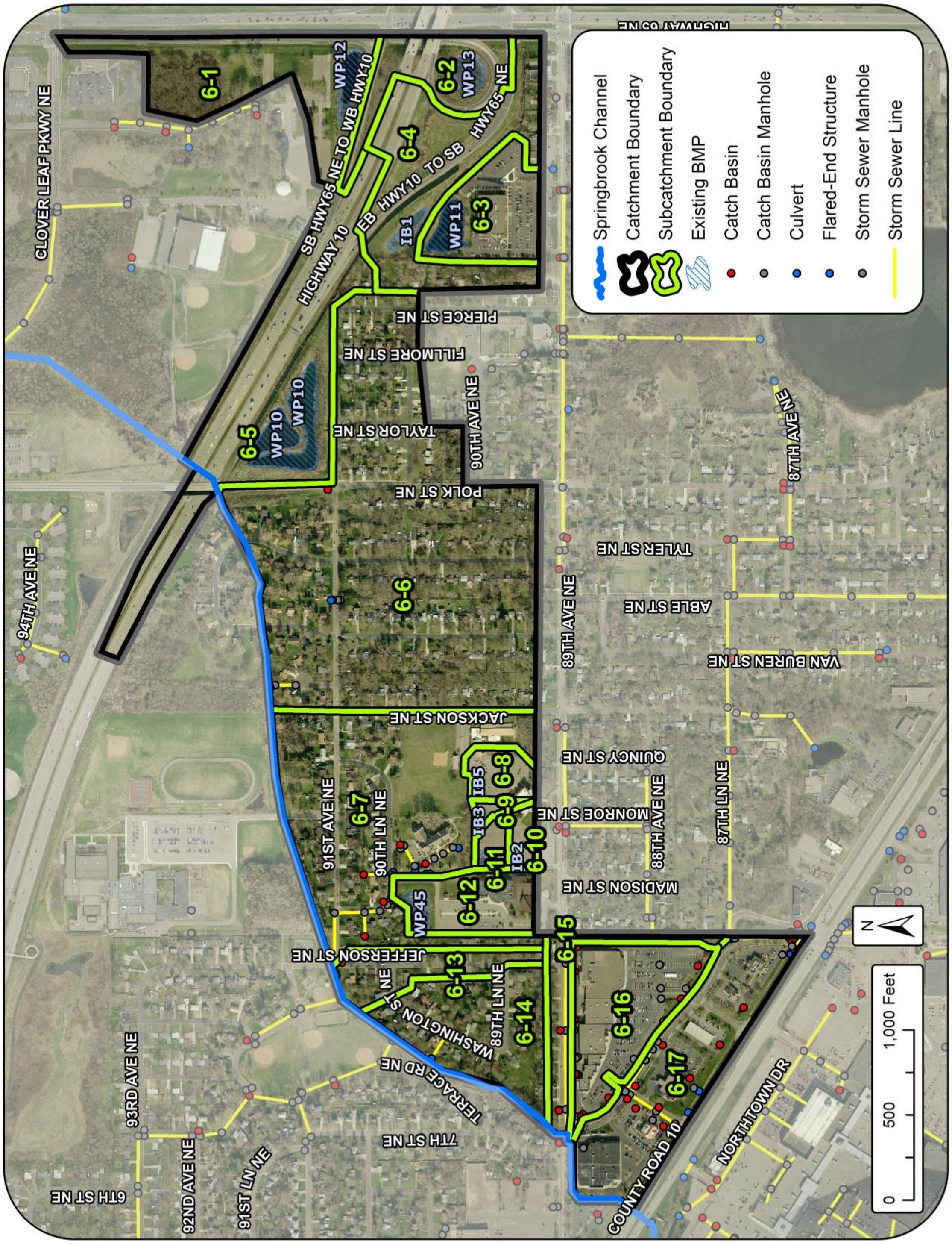
PROPOSED RETROFITS OVERVIEW

Practices proposed in this catchment focus on the residential and commercial areas that discharge to Springbrook without treatment. Curb-cut rain gardens were proposed in the single-family residential neighborhoods, especially along 91st Ave. NE. Permeable asphalt was proposed to treat the strip mall and its parking lot along 89th Ave. NE. Lastly, an infiltration basin was also explored on the strip mall property within a median south of the parking lot.

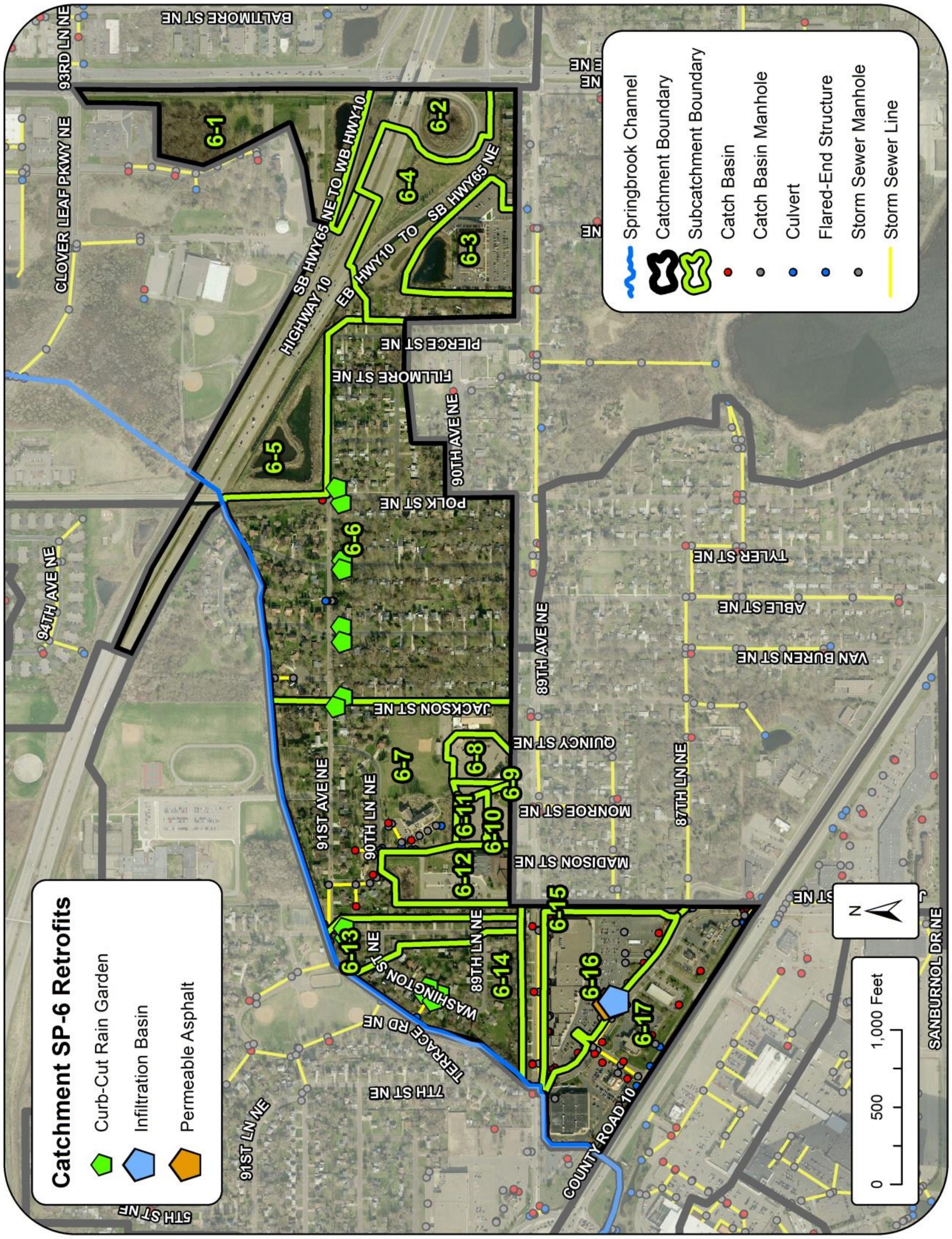
PROPOSED RETROFITS CONSIDERED BUT REJECTED

Five sites were chosen for hydrodynamic devices treating both single-family residential in subcatchments 6-13 and 6-14 and commercial runoff in subcatchments 6-15, 6-16, and 6-17. WinSLAMM model results found none of the devices removed more than 20 lbs-TSS/year or 0.2 lbs-TP/year above what downstream in-line ponds and the Springbrook Nature Center wetland were already treating. Considering their cost, such little pollutant retention made these devices cost-prohibitive. Therefore, no hydrodynamic devices were proposed as retrofits in catchment SP-6.

CURRENT STORMWATER INFRASTRUCTURE AND BMPS

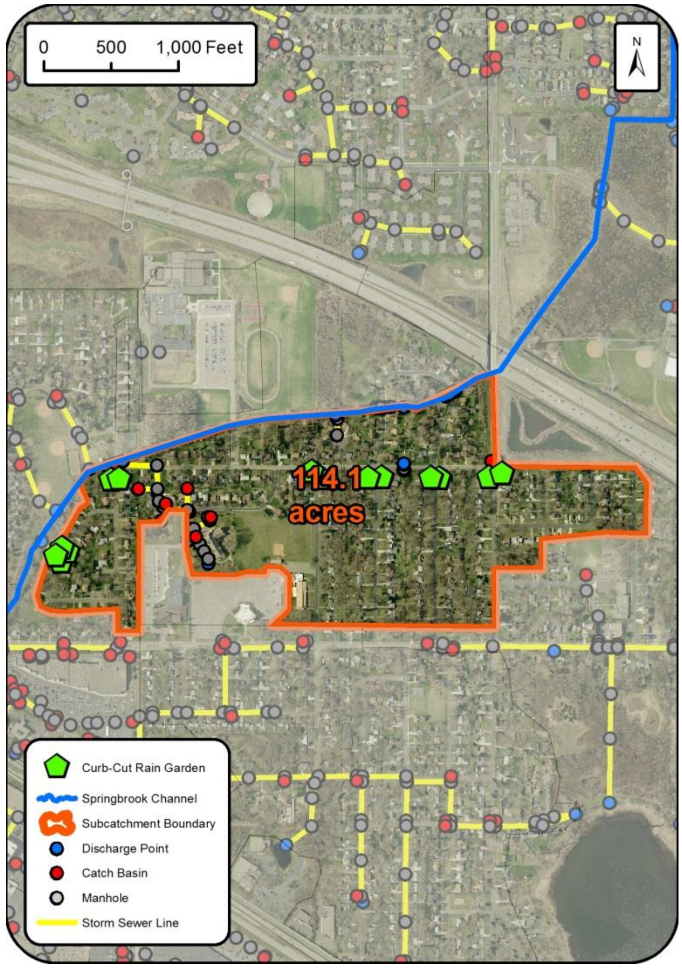


POTENTIAL RETROFITS



Project ID: 6-A

Curb-cut Rain Gardens
Catchment SP-6



Drainage Area – Varies
Location – Throughout catchment SP-6
Property Ownership – Private
Site Specific Information – Single-family lots in catchment SP-6, specifically within subcatchments 6-6, 6-7, 6-13, and 6-14, provide various locations for curb-cut rain gardens to treat stormwater pollutants from private property. Up to 14 optimal sites were found through desktop analysis. Considering typical landowner participation rates, scenarios with 6, 8, and 10 rain gardens were analyzed.

Curb-Cut Rain Garden

	Cost/Removal Analysis	New Treatment	% Reduction	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	Number of BMPs	6		8		10	
	Total Size of BMPs	1,500	sq-ft	2,000	sq-ft	2,500	sq-ft
	TP (lb/yr)	1.8	0.3%	2.9	0.4%	3.5	0.5%
	TSS (lb/yr)	378	0.3%	632	0.4%	767	0.5%
	Volume (acre-feet/yr)	2.5	0.2%	4.5	0.3%	5.5	0.4%
Cost	Administration & Promotion Costs*	$12,848		$14,600		$16,352	
	Design & Construction Costs**	$44,256		$59,008		$73,760	
	Total Estimated Project Cost (2015)	**$57,104**		**$73,608**		**$90,112**	
	Annual O&M***	$1,350		$1,800		$2,250	
Efficiency	30-yr Average Cost/lb-TP	**$1,807**		**$1,467**		**$1,501**	
	30-yr Average Cost/1,000lb-TSS	**$8,607**		**$6,730**		**$6,850**	
	30-yr Average Cost/ac-ft Vol.	**$1,301**		**$945**		**$955**	

*Indirect Cost: (104 hours at $73/hour base cost) + (12 hours/BMP at $73/hour)

**Direct Cost: ($26/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)

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

Project ID: 6-B

Permeable Asphalt
Subcatchment 6-16

Drainage Area – 4.0 acres
Location – 87th Ln. NE strip mall
Property Ownership – Private
Site Specific Information – The large parking lot within the strip mall property provides an opportunity for the installation of permeable asphalt within the low-traffic areas of the lot. Up to 1 acre of permeable asphalt is proposed to treat this drainage area. A smaller area of asphalt could be proposed treating a smaller drainage area as well if project and operations costs as proposed in the table below are too high. Similar cost-efficiencies could be used if the project were to be downsized from what is proposed in the table below.

	Permeable Asphalt		
	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMP	43,560	sq-ft
	TP (lb/yr)	0.8	0.1%
	TSS (lb/yr)	347	0.2%
	Volume (acre-feet/yr)	2.3	0.2%
Cost	Administration & Promotion Costs*	$2,920	
	Design & Construction Costs**	$436,476	
	Total Estimated Project Cost (2015)	**$439,396**	
	Annual O&M***	$32,670	
Efficiency	30-yr Average Cost/lb-TP	**$59,146**	
	30-yr Average Cost/1,000lb-TSS	**$136,359**	
	30-yr Average Cost/ac-ft Vol.	**$20,572**	

*Indirect Cost: 40 hours at $73/hour

**Direct Cost: ($10/sq-ft for materials and labor) + (12 hours at $73/hour for design)

***($0.75/sq-ft for routine maintenance)

Project ID: 6-C

Infiltration Basin
Subcatchment 6-16

Drainage Area – 4.0 acres
Location – 87th Ln. NE strip mall
Property Ownership – Private
Site Specific Information – Space is available along the boulevard between the strip mall parking lot and 87th Ln. NE for an infiltration basin to treat parking lot and roof runoff from the property. A basin which ponds water to 6" was proposed based on the silty soils in the region. A deeper basin could be installed if infiltration rates determined at the site allow for it. Two distinct sizes were modeled (shown in the table below), both achieving similar cost-efficiencies.

Infiltration Basin

	Cost/Removal Analysis	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	Ponding Depth of BMP	6 inches		6 inches	
	Total Size of BMP	1,660	sq-ft	3,000	sq-ft
	TP (lb/yr)	1.1	0.2%	1.5	0.2%
	TSS (lb/yr)	395	0.3%	554	0.4%
	Volume (acre-feet/yr)	3.0	0.2%	3.9	0.3%
Cost	Administration & Promotion Costs*	$2,920		$2,920	
	Design & Construction Costs**	$25,776		$45,876	
	Total Estimated Project Cost (2015)	**$28,696**		**$48,796**	
	Annual O&M***	$275		$275	
Efficiency	30-yr Average Cost/lb-TP	**$1,120**		**$1,268**	
	30-yr Average Cost/1,000lb-TSS	**$3,118**		**$3,432**	
	30-yr Average Cost/ac-ft Vol.	**$411**		**$488**	

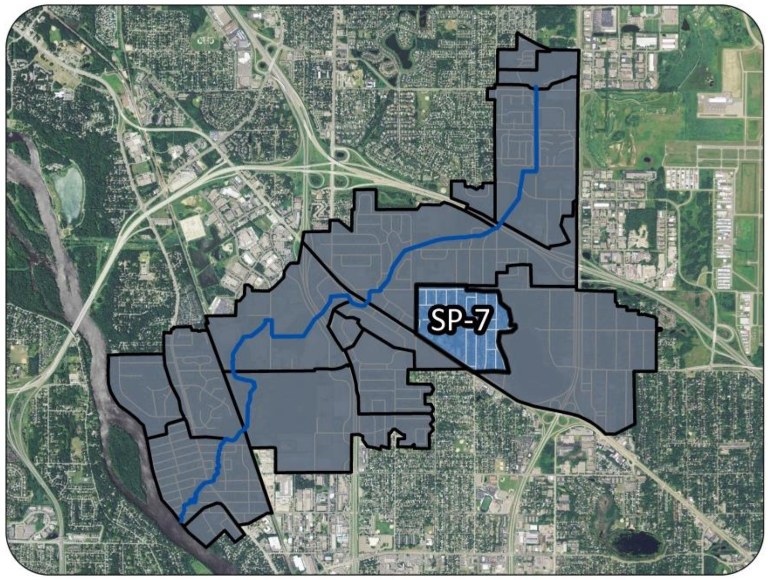
*Indirect Cost: 40 hours at $73/hour

**Direct Cost: ($15/sq-ft for materials and labor) + (12 hours at $73/hour for design)

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

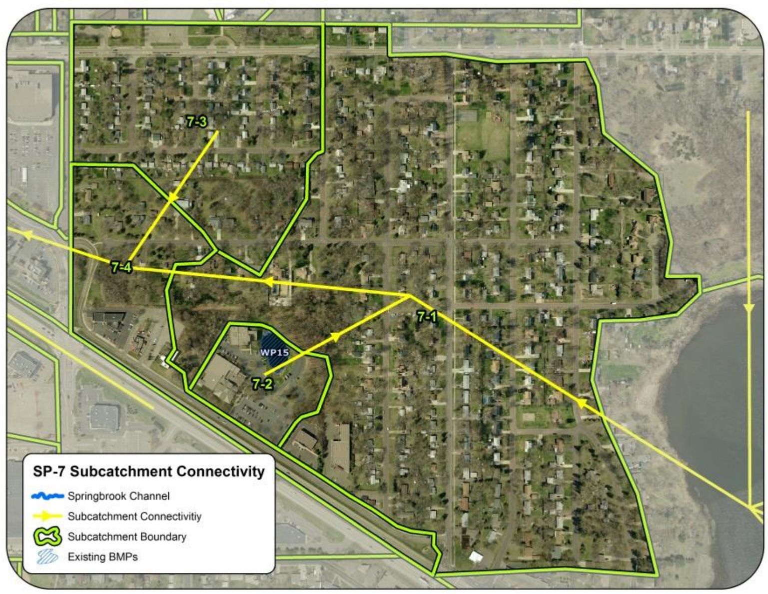
Catchment SP-7

Existing Catchment Summary	
Acres	242.6
Dominant Land Cover	Residential
Parcels	360



CATCHMENT DESCRIPTION

This catchment is largely single-family residential lots, with an exception being businesses along County Road 10 in the southwest. Runoff in this catchment drains to a storm sewer line running from east to west along 87th Ave. NE and 87th Ln. NE. This storm sewer line also drains Laddie Lake and discharges into the ditch along County Road 10.



EXISTING STORMWATER TREATMENT

This catchment has just one structural stormwater BMP, a wet pond (WP15) for the Anoka County Library in subcatchment 7-2. This pond accepts runoff generated within the library property and overflows into the 87th Ave. NE storm sewer line.

Listed below are network-level base and existing loading for catchments SP-1 to SP-13. Each of these catchments drain to the three in-line ponds in SP-9 and the Springbrook Nature Center wetland in SP-13, These waterbodies supply stormwater treatment to over 2,300 acres of the Springbrook subwatershed.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	64			
	BMP Types	stormwater retention ponds, infiltration basins, natural wetlands, hydrodynamic device			
	TP (lb/yr)	1,874.0	1,206.1	64%	**667.9**
	TSS (lb/yr)	731,718	582,303	80%	**149,415**
	Volume (acre-feet/yr)	1,541.8	97.6	6%	**1,444.2**

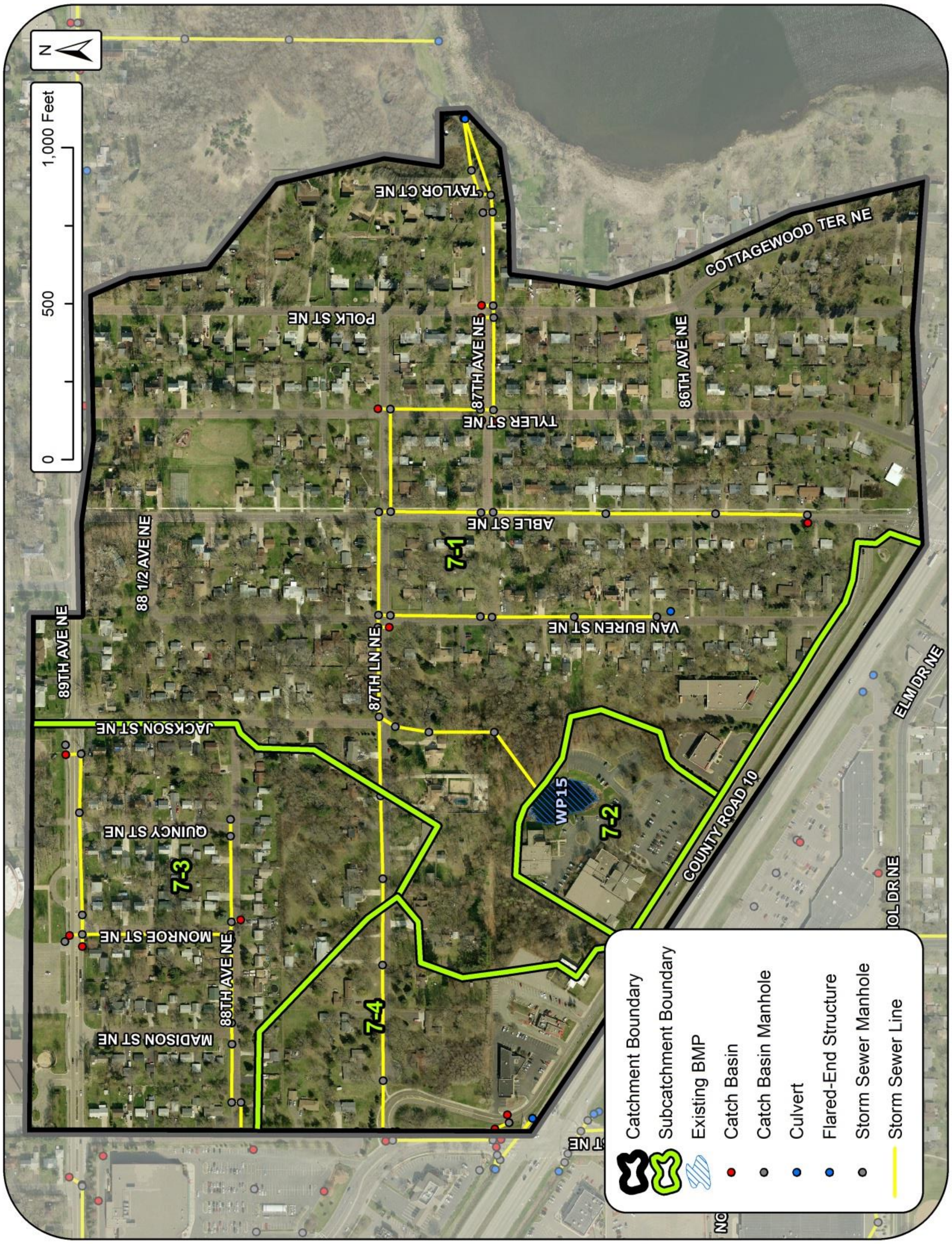
PROPOSED RETROFITS OVERVIEW

Soils in this catchment are generally well-drained Zimmerman soils conducive to infiltration practices. Curb-cut rain gardens have been proposed for residential properties throughout the catchment and an infiltration basin has been proposed for Little Bit Park. This basin is intended to act as an oversized, vegetated rain garden accepting runoff from the park and surrounding residential properties.

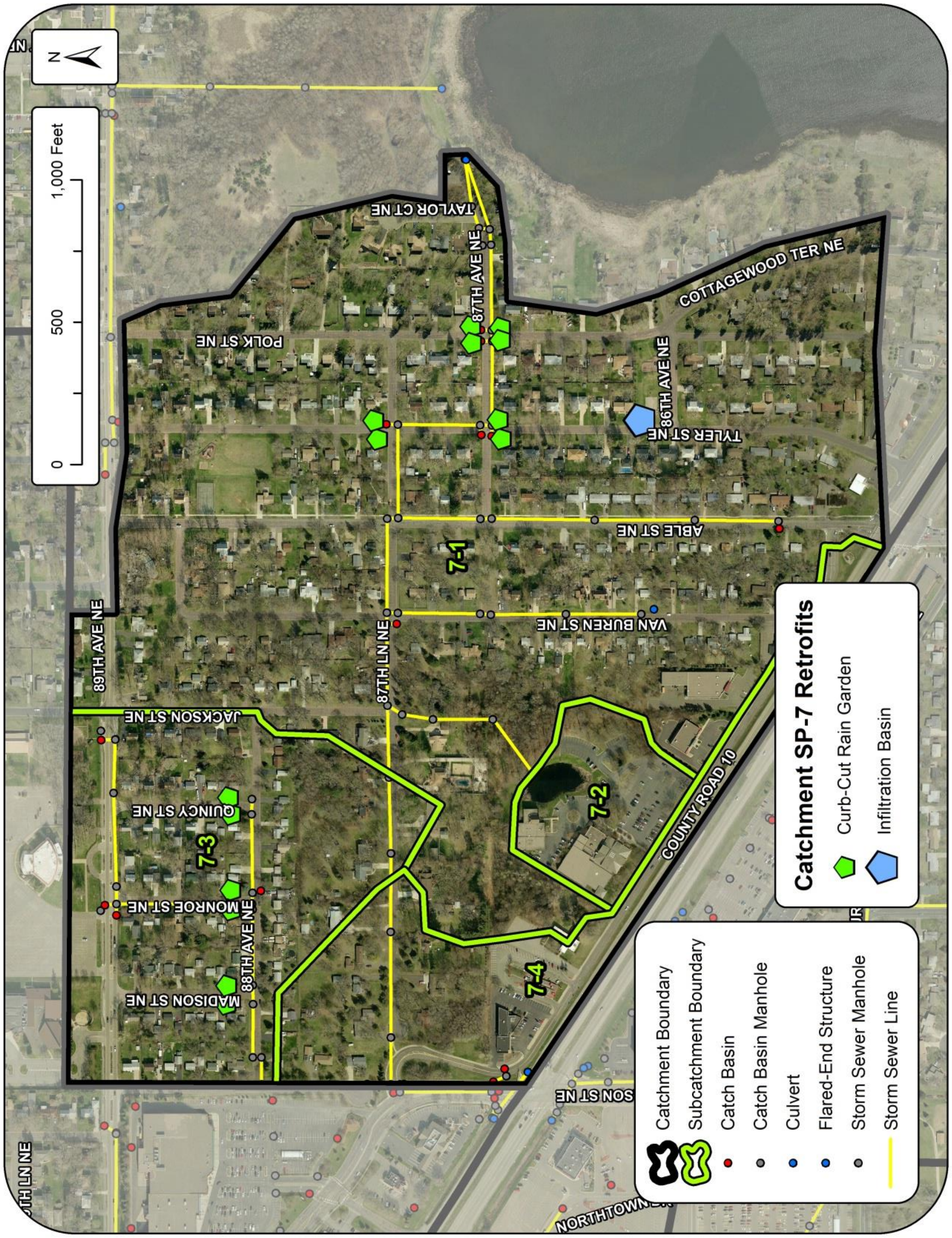
PROPOSED RETROFITS CONSIDERED BUT REJECTED

Hydrodynamic devices were initially proposed along 88th Ave. NE in subcatchment 7-3 and Able St. NE in subcatchment 7-1. WinSLAMM model results found neither of the devices removed more than 15 lbs-TSS/year or 0.2 lbs-TP/year above what downstream in-line ponds and the Springbrook Nature Center wetland were already treating. Considering their cost, such little pollutant retention made these devices cost-prohibitive. Therefore, no hydrodynamic devices were proposed as retrofits in catchment SP-7.

CURRENT STORMWATER INFRASTRUCTURE AND BMPS



POTENTIAL RETROFITS



Project ID: 7-A

Curb-cut Rain Gardens
Catchment SP-7

Drainage Area – Varies
Location – Throughout catchment SP-7
Property Ownership – Private
Site Specific Information – Single-family lots in catchment SP-7, specifically within subcatchments 7-1 and 7-3, provide various locations for curb-cut rain gardens to treat stormwater pollutants from private property. Up to 14 optimal sites were found through desktop analysis. Considering typical landowner participation rates, scenarios with 6, 8, and 10 rain gardens were analyzed.

Curb-Cut Rain Garden

	Cost/Removal Analysis	New Treatment	% Reduction	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	Number of BMPs	6		8		10	
	Total Size of BMPs	1,500	sq-ft	2,000	sq-ft	2,500	sq-ft
	TP (lb/yr)	1.9	0.3%	2.9	0.4%	3.6	0.5%
	TSS (lb/yr)	455	0.3%	667	0.4%	810	0.5%
	Volume (acre-feet/yr)	3.4	0.2%	5.3	0.4%	6.4	0.4%
Cost	Administration & Promotion Costs*	$12,848		$14,600		$16,352	
	Design & Construction Costs**	$44,256		$59,008		$73,760	
	Total Estimated Project Cost (2015)	**$57,104**		**$73,608**		**$90,112**	
	Annual O&M***	$1,350		$1,800		$2,250	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,712**		**$1,467**		**$1,459**	
	30-yr Average Cost/1,000lb-TSS	**$7,150**		**$6,377**		**$6,486**	
	30-yr Average Cost/ac-ft Vol.	**$957**		**$803**		**$821**	

*Indirect Cost: (104 hours at $73/hour base cost) + (12 hours/BMP at $73/hour)

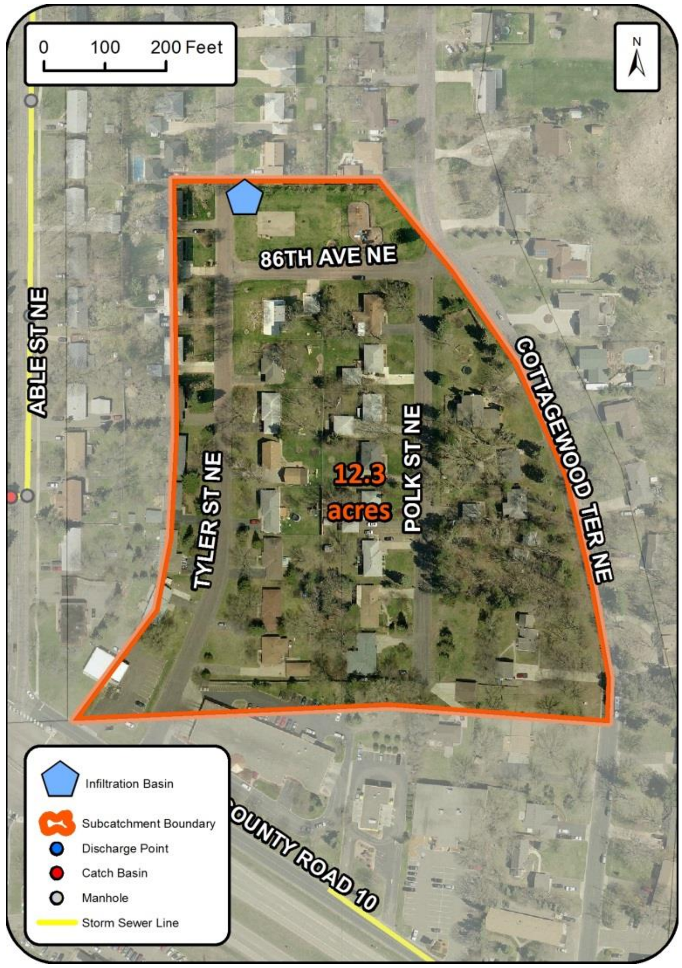
**Direct Cost: ($26/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)

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

Project ID: 7-B

Infiltration Basin
Subcatchment 7-1

Drainage Area – 12.3 acres
Location – Little Bit Park
Property Ownership – Public (City of Blaine)
Site Specific Information – Residential stormwater runoff from Tyler St. NE, Polk St. NE, and 86th Ave. NE. flows north along Tyler St. NE past Little Bit Park. An infiltration basin could be installed in the northwest corner of the park to treat runoff from these roadways. A 1,500 sq-ft., 1 ft. deep basin was proposed based on the space available between the basketball court and Tyler St. NE.



	Infiltration Basin		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Ponding Depth of BMP**	12 inches	
	Total Size of BMP	1,500	sq-ft
	TP (lb/yr)	1.6	0.2%
	TSS (lb/yr)	376	0.3%
	Volume (acre-feet/yr)	2.3	0.2%
Cost	**Administration & Promotion Costs***	$2,920	
	Design & Construction Costs**	$30,876	
	Total Estimated Project Cost (2015)	**$33,796**	
	Annual O&M***	$275	
Efficiency	**30-yr Average Cost/lb-TP**	**$876**	
	30-yr Average Cost/1,000lb-TSS	**$3,727**	
	30-yr Average Cost/ac-ft Vol.	**$609**	

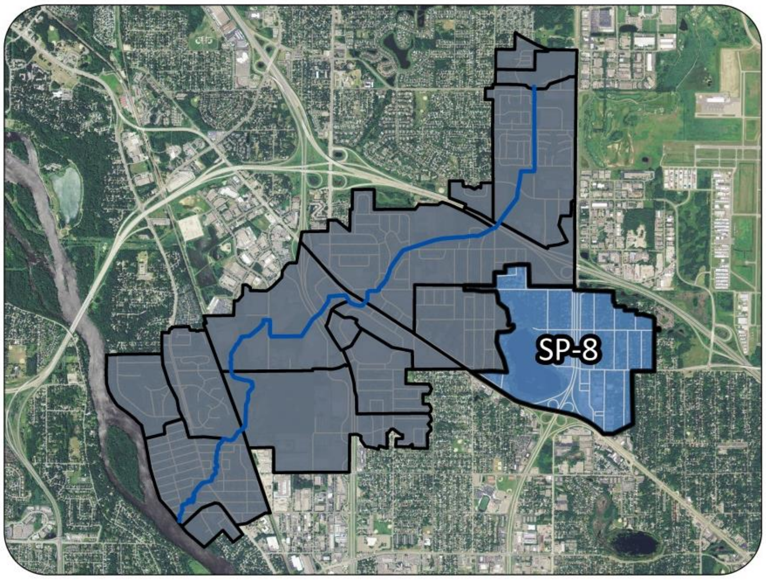
*Indirect Cost: 40 hours at $73/hour

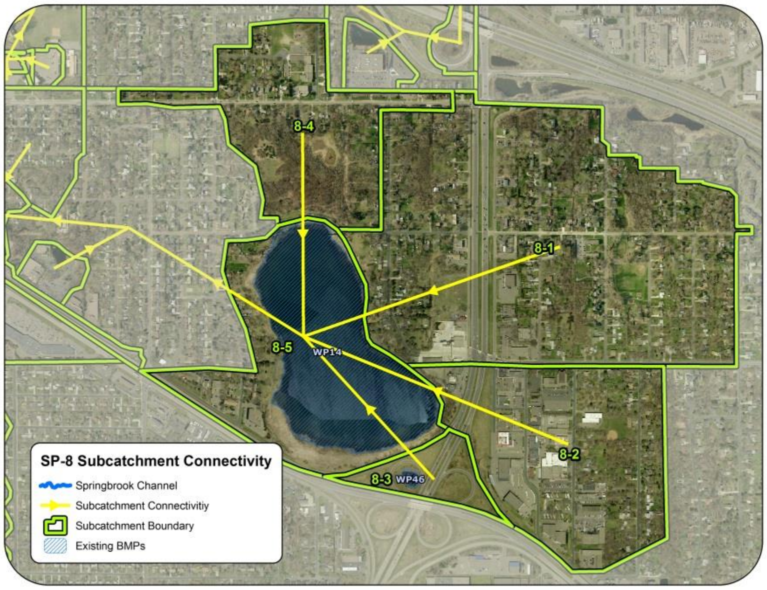
**Direct Cost: ($20/sq-ft for materials and labor) + (12 hours at $73/hour for design)

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

Catchment SP-8

Existing Catchment Summary	
Acres	405.4
Dominant Land Cover	Residential
Parcels	537





CATCHMENT DESCRIPTION

This is the easternmost catchment in the Springbrook subwatershed. Properties in the catchment north of 85th Ave. NE are in the City of Blaine and those south of 85th Ave. NE are in the City of Spring Lake Park. The entire catchment drains to Laddie Lake, and is bounded by Hastings St. NE and the City of Mounds View to the east and County Road 10 to the south. Central Ave. NE bisects the catchment. Land use is predominantly single-family residential, with commercial and industrial properties along Central Ave. NE and County Road 10. This catchment also has a greater proportion of pervious space compared to many other catchments, with undeveloped properties and parks dotting the landscape.

EXISTING STORMWATER TREATMENT

All stormwater generated within this catchment flows to Laddie Lake, which was considered a stormwater pond for this analysis as it provides treatment to upstream properties draining to it (WP14; subcatchment 8-5). This lake is quite shallow, with a maximum depth of just 4 ft. Even so this lake seldom overflows and provides adequate storage for the catchment.

One other BMP upstream of Laddie Lake in catchment SP-8 is a small pond (WP46) which treats roadway runoff from the Central Ave. NE/County Road 10 interchange in subcatchment 8-3.

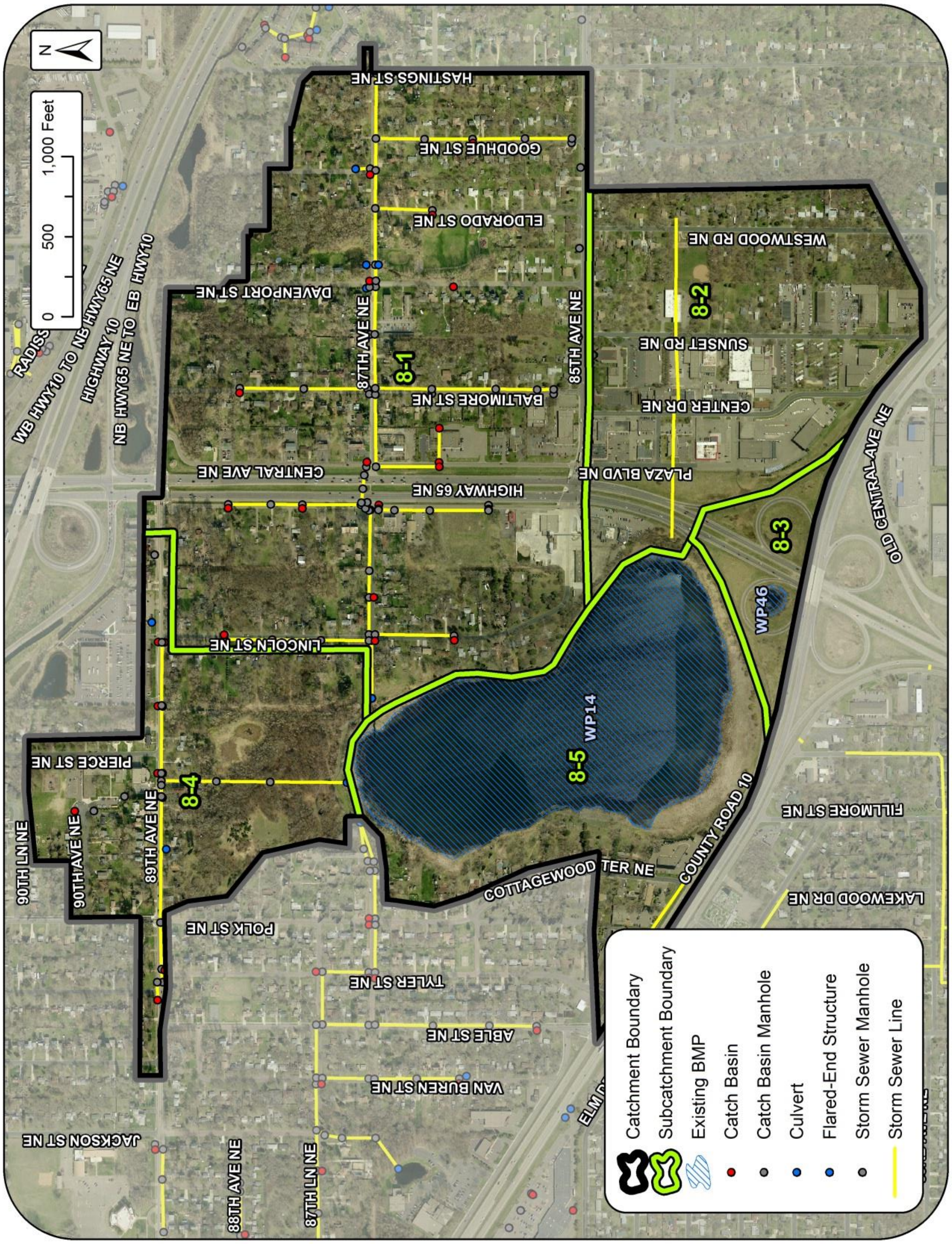
Listed below are network-level base and existing loading for catchments SP-1 to SP-13. Each of these catchments drain to the three in-line ponds in SP-9 and the Springbrook Nature Center wetland in SP-13, These waterbodies supply stormwater treatment to over 2,300 acres of the Springbrook subwatershed.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	64			
	BMP Types	stormwater retention ponds, infiltration basins, natural wetlands, hydrodynamic device			
	TP (lb/yr)	1,874.0	1,206.1	64%	**667.9**
	TSS (lb/yr)	731,718	582,303	80%	**149,415**
	Volume (acre-feet/yr)	1,541.8	97.6	6%	**1,444.2**

PROPOSED RETROFITS CONSIDERED BUT REJECTED

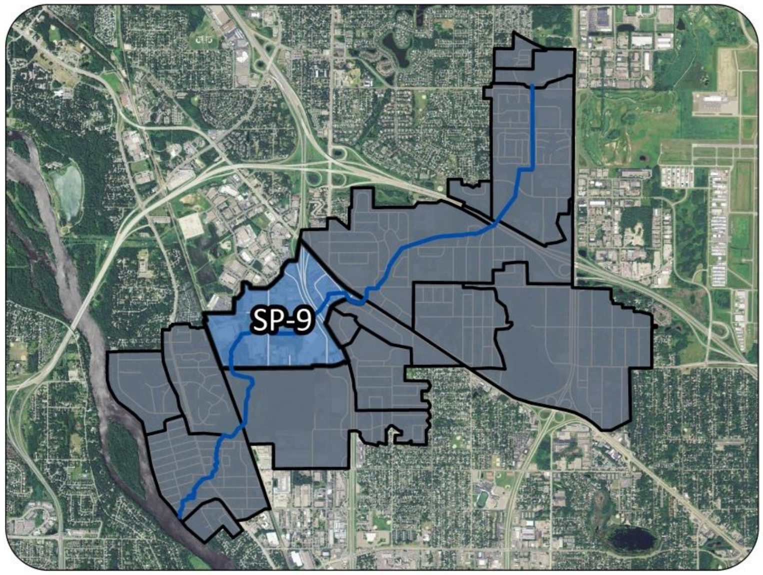
A variety of stormwater BMPs were modeled for this catchment, including hydrodynamic devices, new ponds, infiltration basins, curb-cut rain gardens, and a stormwater diversion. None of these items were found to be cost-effective as Laddie Lake (WP14) adequately treats the catchment. The lake seldom overflows into the Springbrook storm sewers, except during large storm events. As only these events would be treated above what Laddie Lake currently treats, BMPs installed here couldn't provide enough additional treatment to benefit Springbrook.

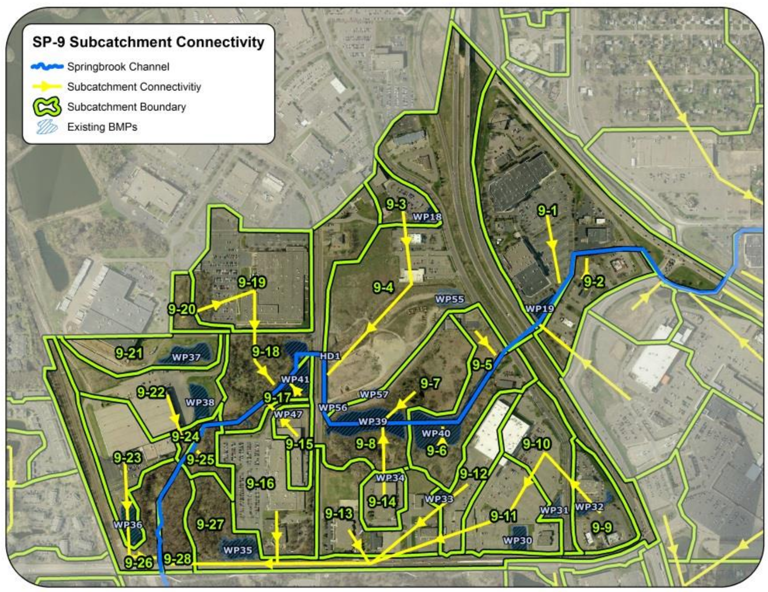
CURRENT STORMWATER INFRASTRUCTURE AND BMPS



Catchment SP-9

Existing Catchment Summary	
Acres	257.5
Dominant Land Cover	Commercial
Parcels	79





CATCHMENT DESCRIPTION
This catchment is dominated by large commercial and industrial properties, as well as undeveloped properties along the Springbrook stream corridor. The catchment is bounded by University Ave. NE and County Road 10 to the east, 85th Ave. NE to the south, and the Burlington Northern railroad tracks to the west. Springbrook runs from east to west through much of the catchment, turning south as it nears the Springbrook Nature Center downstream in catchment SP-13.

EXISTING STORMWATER TREATMENT
Fifteen stormwater ponds are distributed throughout the catchment, most of which treat the properties they were built upon. Exceptions to this are:

1. Ponds WP32, WP31, and WP30 in subcatchments 9-9, 9-10, and 9-11, respectively, which are in-line with one another and treat commercial properties west of County Road 10 and north of 85th Ave. NE. WP30 in subcatchment 9-11 overflows into a ditch north of 85th Ave. NE and subsequently drains to pond WP35 in subcatchment 9-27. Overflow from pond WP35 is maintained by a discharge control structure.
2. Ponds in-line with Springbrook, including ponds along the boundaries of subcatchments 9-5/9-6 (WP40), 9-7/9-8 (WP39), and 9-17/9-18 (WP41), which provide treatment to their respective subcatchments and to all areas upstream.

Listed below are network-level base and existing loading for catchments SP-1 to SP-13. Each of these catchments drain to the three in-line ponds in SP-9 and the Springbrook Nature Center wetland in SP-13, These waterbodies supply stormwater treatment to over 2,300 acres of the Springbrook subwatershed.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	64			
	BMP Types	stormwater retention ponds, infiltration basins, natural wetlands, hydrodynamic device			
	TP (lb/yr)	1,874.0	1,206.1	64%	**667.9**
	TSS (lb/yr)	731,718	582,303	80%	**149,415**
	Volume (acre-feet/yr)	1,541.8	97.6	6%	**1,444.2**

PROPOSED RETROFITS OVERVIEW

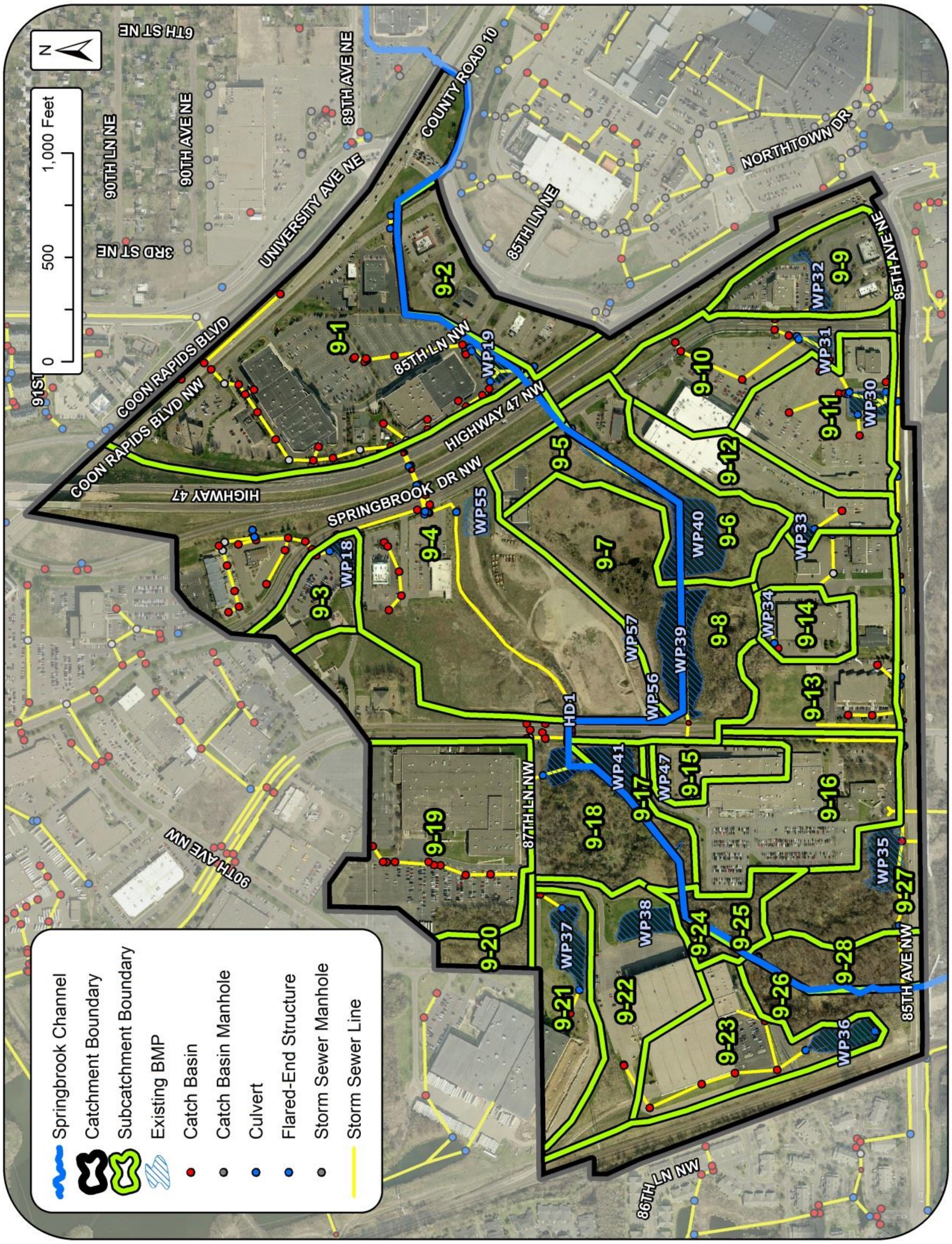
Proposed retrofits in this catchment target areas that have an opportunity to have existing treatment enhanced to better meet the needs of the contributing drainage area. New practices include IESF benches for two retention ponds. Within subcatchment 9-11, an IESF bench could be installed along pond WP30 to better treat phosphorus (particularly in dissolved form). A similar (but possibly much larger) structure could be installed along the western bank of pond WP41 in subcatchment 9-18.

PROPOSED RETROFITS CONSIDERED BUT REJECTED

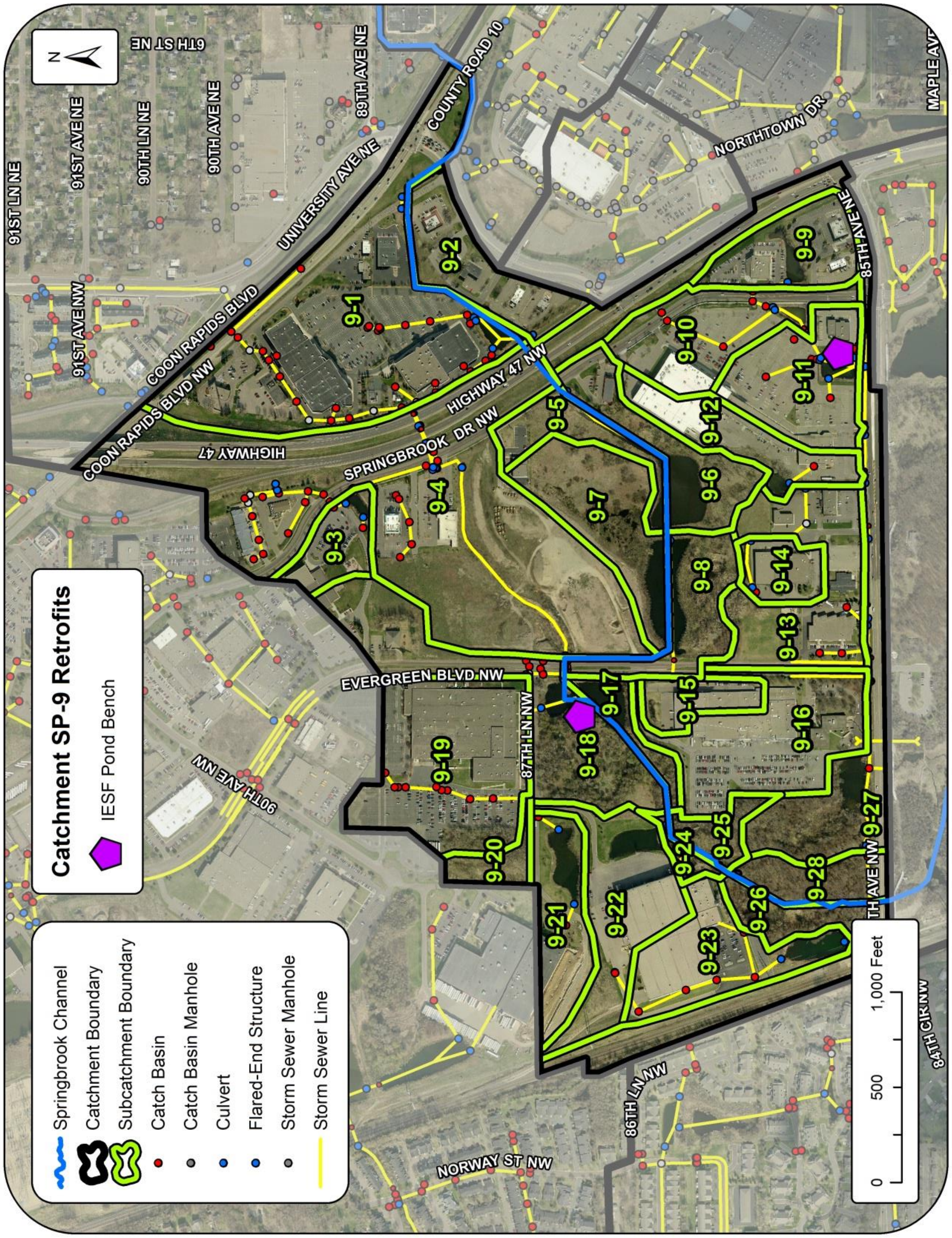
A hydrodynamic device was initially proposed along Springbrook Dr. NW in subcatchment 9-4 to treat runoff from commercial properties west of State Highway 47. WinSLAMM model results found the device removed less than 20 lbs-TSS/year and 0.2 lbs-TP/year above what downstream in-line ponds in the catchment and the Springbrook Nature Center wetland in catchment SP-13 wetland were already treating. Considering the cost of the project, such little pollutant retention made this device cost-prohibitive. Therefore, the hydrodynamic device was not proposed as a retrofit.

Also, permeable asphalt was investigated within the large parking area of the Honeywell Aerospace factory in subcatchment 9-19, but found to be cost-prohibitive based on low pollutant removal values and high installation cost.

CURRENT STORMWATER INFRASTRUCTURE AND BMPS



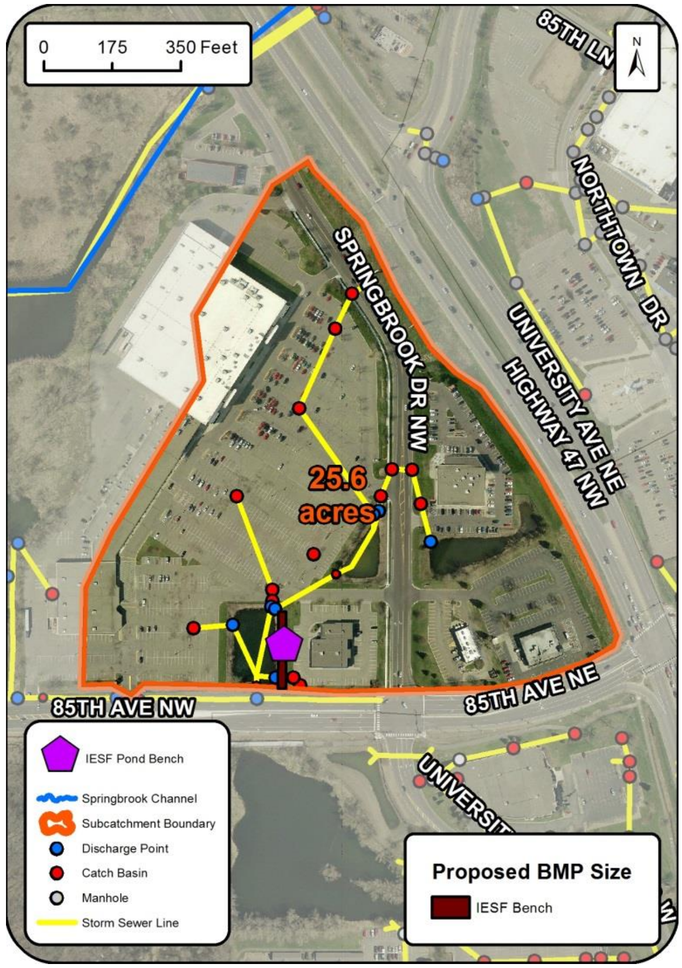
POTENTIAL RETROFITS



Project ID: 9-A

IESF Bench

Subcatchment 9-11



Drainage Area – 25.6 acres

Location – East of retention pond 30 (WP30)

Property Ownership – Private

Site Specific Information – WP30 provides treatment to over 25 acres of predominantly paved, commercial properties. Although WP30 and its in-line, upstream ponds provide sufficient treatment for particulate pollutants through settling, dissolved pollutants can easily advect through them without treatment. Space is available along the pond's eastern shore for installation of an IESF bench to better provide treatment for dissolved constituents, mainly phosphorus. Although WP30 is deep enough for an IESF now it is rather shallow (~3 ft. deep on average), and sediment accumulation in the pond should be tracked to ensure enough settling occurs in the pond to not compromise IESF function by clogging the filter. If average pond depth is below 3 ft., pond excavation should also be considered prior to installation of the IESF.

	IESF Bench		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	4,000	sq-ft
	TP (lb/yr)	1.7	0.3%
	TSS (lb/yr)	0	0.0%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$5,475	
	Design & Construction Costs**	$218,720	
	Total Estimated Project Cost (2015)	**$224,195**	
	Annual O&M***	$918	
Efficiency	**30-yr Average Cost/lb-TP**	**$4,936**	
	30-yr Average Cost/1,000lb-TSS	**N/A**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

*Indirect Cost: 75 hours at $73/hour

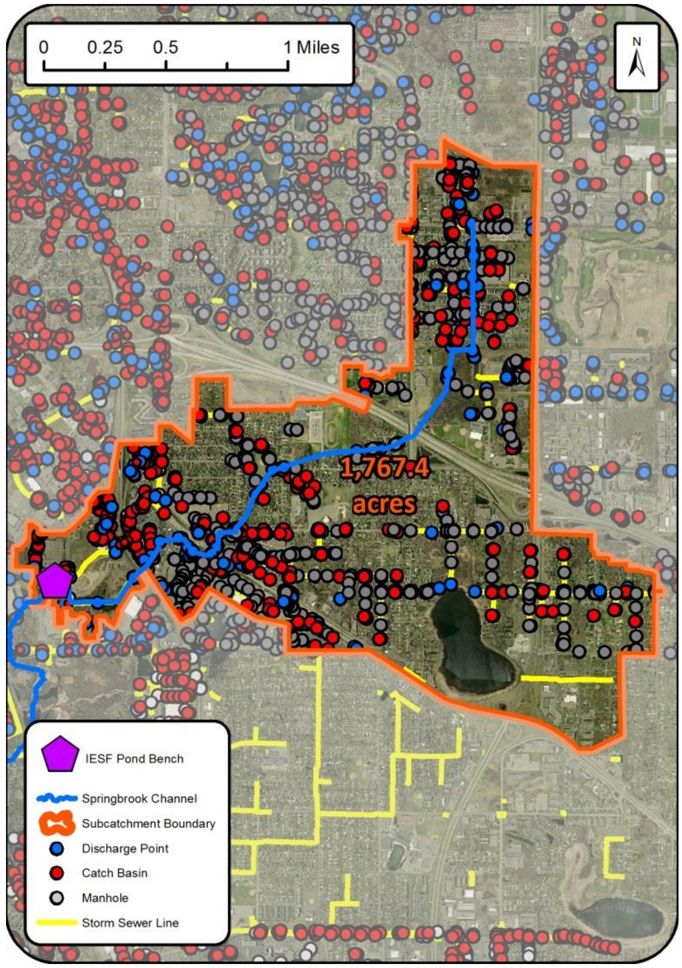
**Direct Cost: See Appendix B for detailed cost information

***$10,000/acre for IESF

Project ID: 9-B

IESF Bench
Subcatchment 9-18

Drainage Area – 1,767.4 acres (including all upstream subcatchments)
Location – Southwest of wet pond 41 (WP41)
Property Ownership – Private
Site Specific Information – WP41 provides treatment to catchments SP-1 through SP-8, SP-10, SP-11, and portions of SP-9, totaling 1,767 acres. This pond and in-line ponds WP39 and WP40 provide some treatment through settling. An IESF could be installed just upstream of the outlet control structure southwest of WP41 to better treat for dissolved pollutant species, specifically phosphorus. The project was proposed to impact as little of the wetland along WP41 as possible, with the IESF (as proposed in the map to the right) running adjacent to the Springbrook channel on either bank.



IESF Bench

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
Treatment	Total Size of BMPs	8,200	sq-ft
Treatment	TP (lb/yr)	48.1	7.2%
Treatment	TSS (lb/yr)	0	0.0%
Treatment	Volume (acre-feet/yr)	0.0	0.0%
Cost	Administration & Promotion Costs*	$7,300	
Cost	Design & Construction Costs**	$415,500	
Cost	Total Estimated Project Cost (2015)	**$422,800**	
Cost	Annual O&M***	$7,882	
Efficiency	30-yr Average Cost/lb-TP	**$457**	
Efficiency	30-yr Average Cost/1,000lb-TSS	**N/A**	
Efficiency	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
***($10,000/acre for IESF) + ($6,000 for annual lift station maintenance and calibration

Catchment SP-10

Existing Catchment Summary	
Acres	20.4
Dominant Land Cover	Commercial
Parcels	10

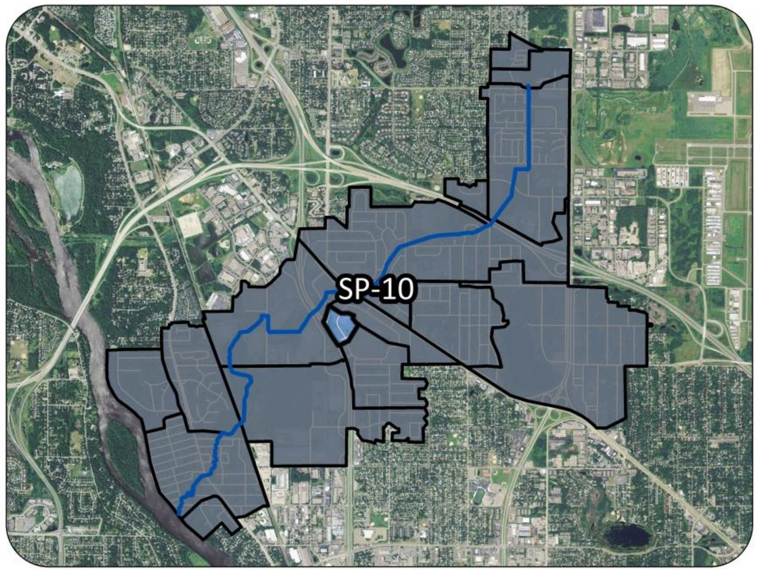
CATCHMENT DESCRIPTION

This is the smallest catchment in this analysis, and contains portions of University Ave. NE and State Highway 47 as well as the businesses immediately east of the highways.

EXISTING STORMWATER TREATMENT

All runoff generated within the catchment is intercepted in parking lot catch basins and discharged into an infiltration basin (IB6) east of the intersection between University Ave. NE and State Highway 47. Overflow from the basin flows west to a ditch along State Highway 47 and subsequently discharges into Springbrook.

Listed below are network-level base and existing loading for catchments SP-1 to SP-13. Each of these catchments drain to the three in-line ponds in SP-9 and the Springbrook Nature Center wetland in SP-13, These waterbodies supply stormwater treatment to over 2,300 acres of the Springbrook subwatershed.

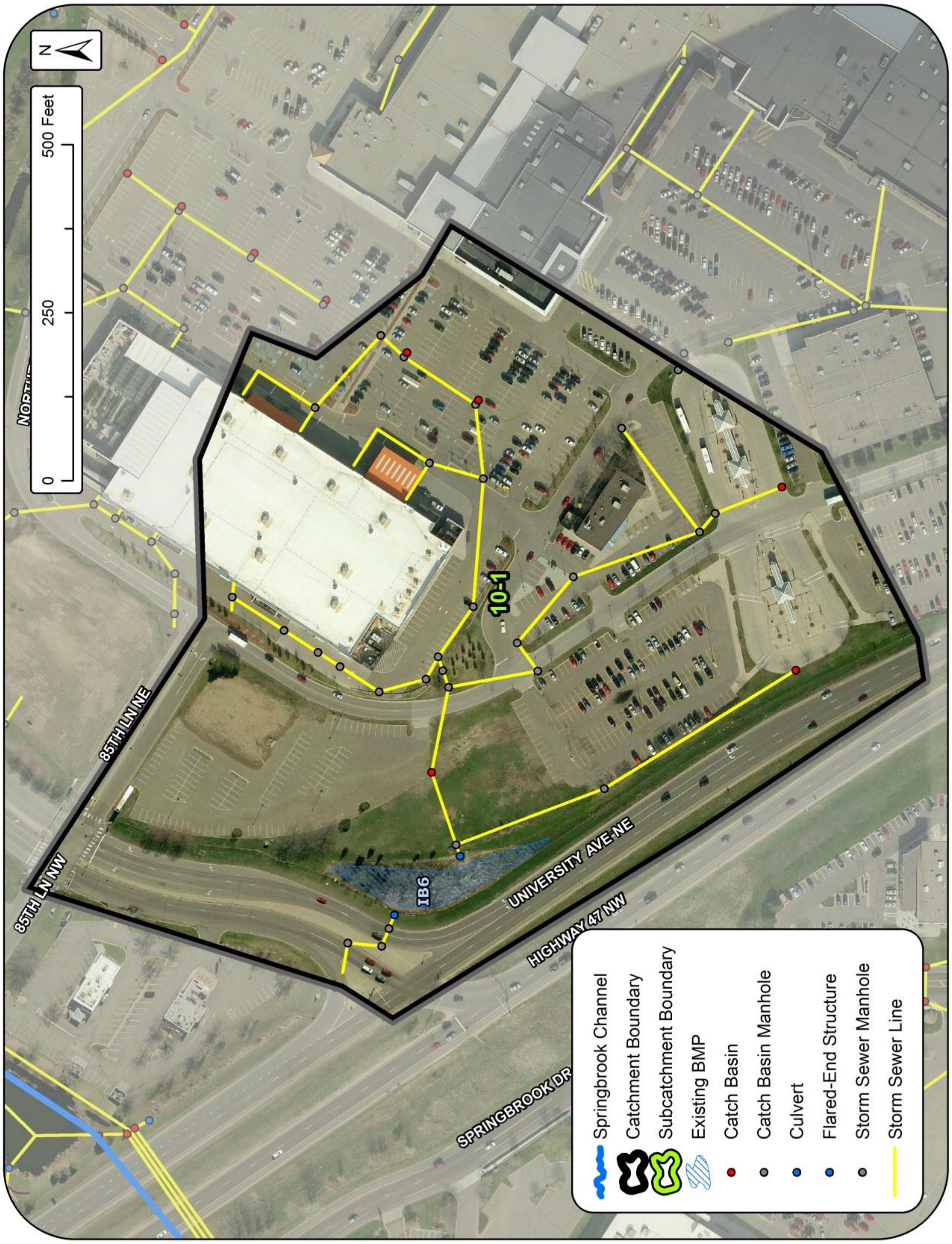


	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	64			
	BMP Types	stormwater retention ponds, infiltration basins, natural wetlands, hydrodynamic device			
	TP (lb/yr)	1,874.0	1,206.1	64%	**667.9**
	TSS (lb/yr)	731,718	582,303	80%	**149,415**
	Volume (acre-feet/yr)	1,541.8	97.6	6%	**1,444.2**

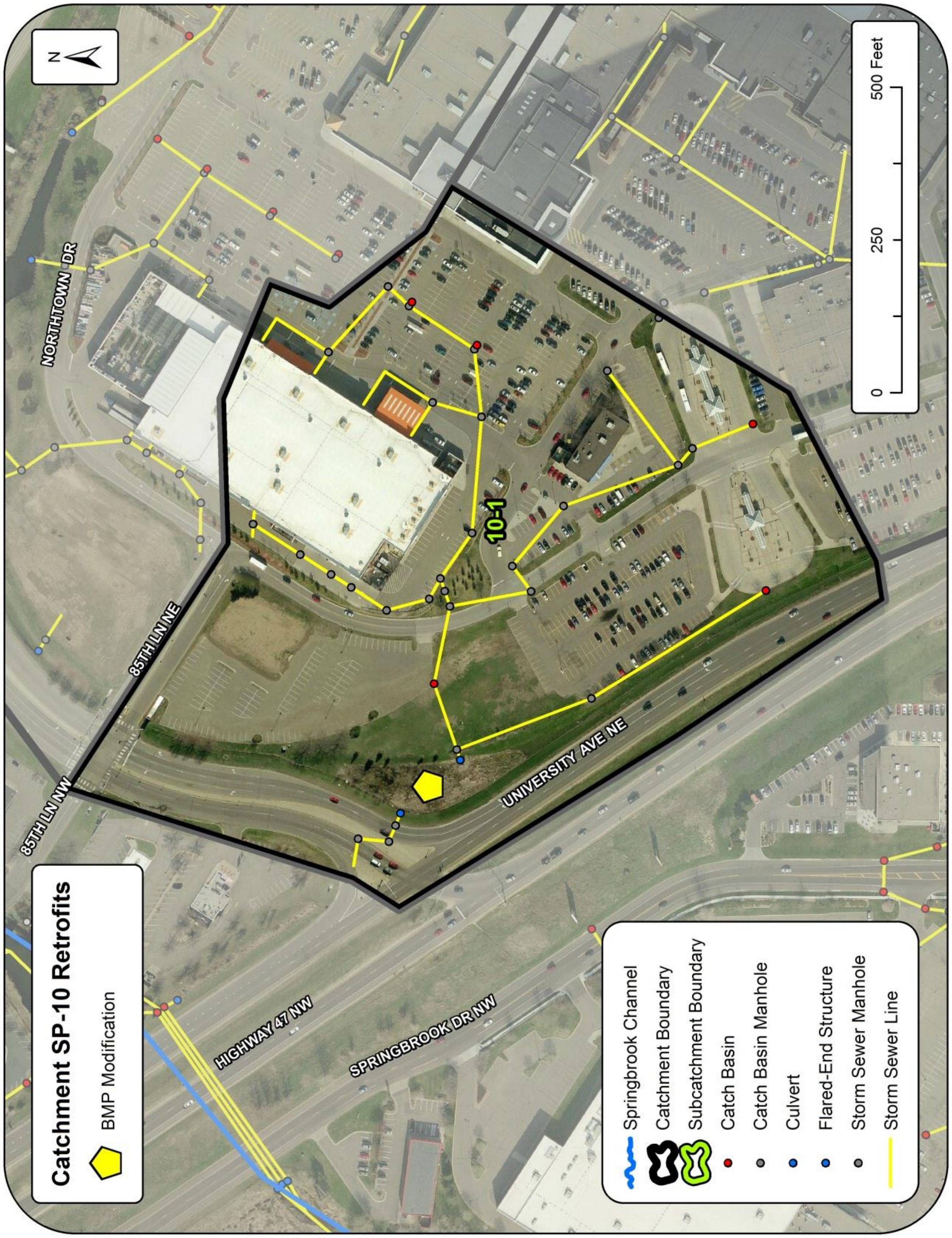
PROPOSED RETROFITS OVERVIEW

The infiltration basin located east of the intersection between University Ave. NE and State Highway 47 can be expanded and dredged to allow for a greater ponding depth, increased sedimentation, and increased infiltration of stormwater.

CURRENT STORMWATER INFRASTRUCTURE AND BMPS

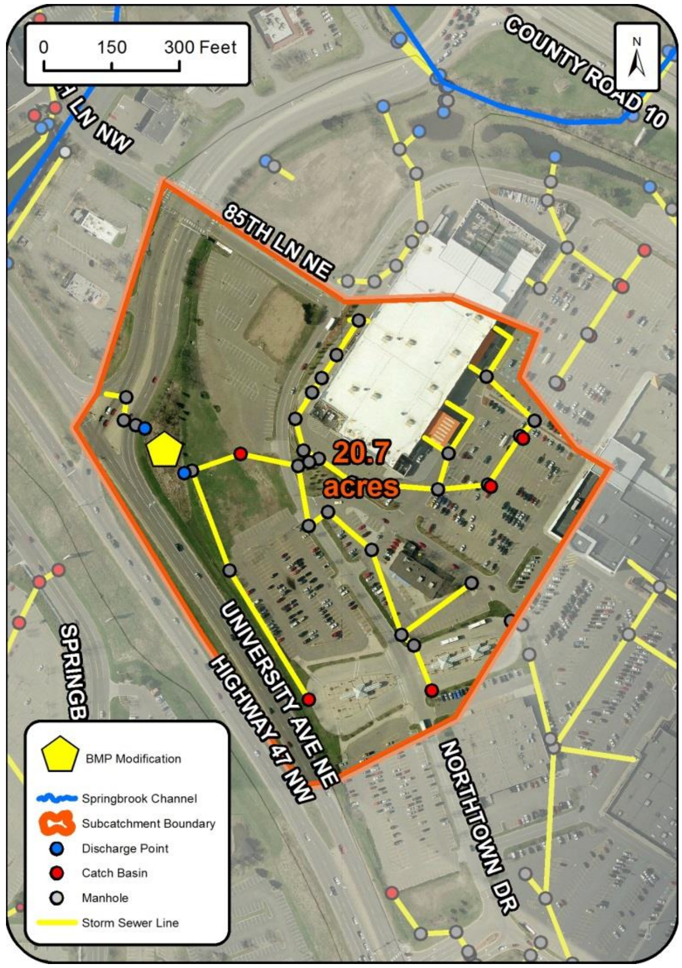


POTENTIAL RETROFITS



Project ID: 10-A

BMP Modification
Subcatchment 10-1



Drainage Area – 20.7 acres
Location – Infiltration basin 6 (IB6)
Property Ownership – Private
Site Specific Information – IB6 currently treats runoff from commercial properties between 85th Ln. NE and University Ave. NE. The basin is rather shallow, averaging less than 6" of depth throughout the basin below the inlet elevation of the drainage pipe. Soils in the region are generally sandy, and could allow excavation for an additional 6" of ponding depth. This increase would achieve an additional 10,780 cu-ft. of storage. Similarly, undeveloped space exists to the east of the BMP to up to double the size of the practice. Expanding the size of the basin, while still retaining a 6" depth, could potentially reach the same pollutant goal as excavation of the existing basin geometry.

	BMP Modification		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Ponding Depth of BMP**	12 inches	
	Total Size of BMP	21,570	sq-ft
	TP (lb/yr)	0.8	0.1%
	TSS (lb/yr)	271	0.2%
	Volume (acre-feet/yr)	1.8	0.1%
Cost	**Administration & Promotion Costs***	$2,920	
	Design & Construction Costs**	$78,000	
	Total Estimated Project Cost (2015)	**$80,920**	
	Annual O&M***	$275	
Efficiency	**30-yr Average Cost/lb-TP**	**$3,715**	
	30-yr Average Cost/1,000lb-TSS	**$10,968**	
	30-yr Average Cost/ac-ft Vol.	**$1,651**	

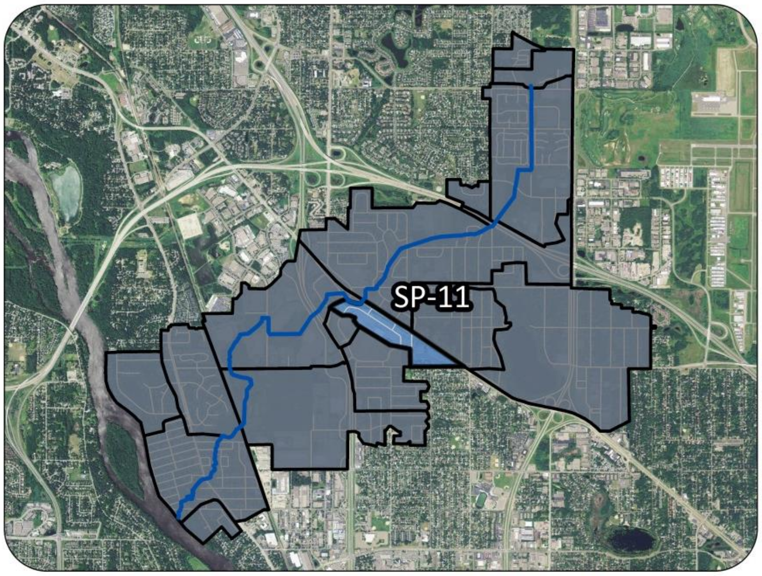
*Indirect Cost: 40 hours at $73/hour

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

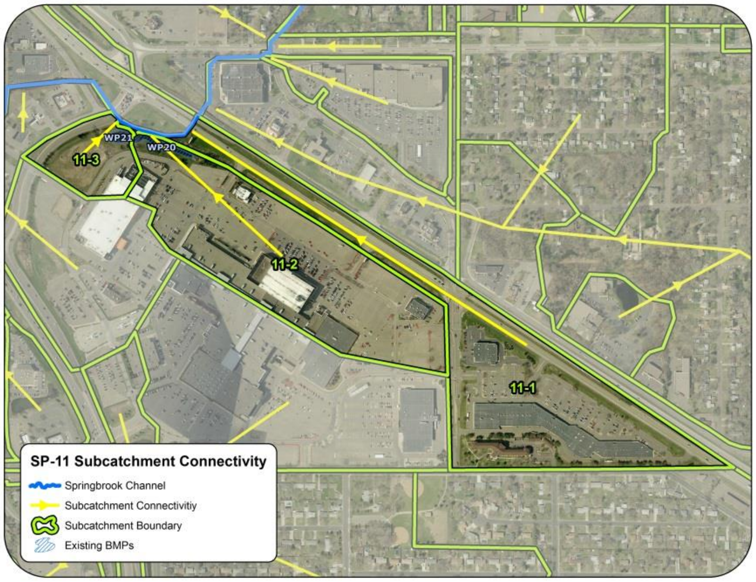
***($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Catchment SP-11

Existing Catchment Summary	
Acres	68.1
Dominant Land Cover	Commercial
Parcels	12



CATCHMENT DESCRIPTION
This catchment is exclusively commercial, including various properties along County Road 10 such as portions of the Northtown Mall and Home Depot. The catchment has the highest percentage of impervious surface of all catchments (77% of total area) in the Springbrook subwatershed. Springbrook is conveyed under County Road 10 via two 36” RCPs and daylights in the ditch southeast of the intersection between County Road 10 and University Ave. NE.



EXISTING STORMWATER TREATMENT
Runoff generated within this catchment flows quickly over paved surfaces to either (i) the ditch south of County Road 10 (subcatchment 11-1) for businesses east of Jefferson St. NE or (ii) ponds in subcatchments 11-2 (WP20) and 11-3 (WP21) for businesses west of Jefferson St. NE. Both the ponds and ditch discharge directly to Springbrook.

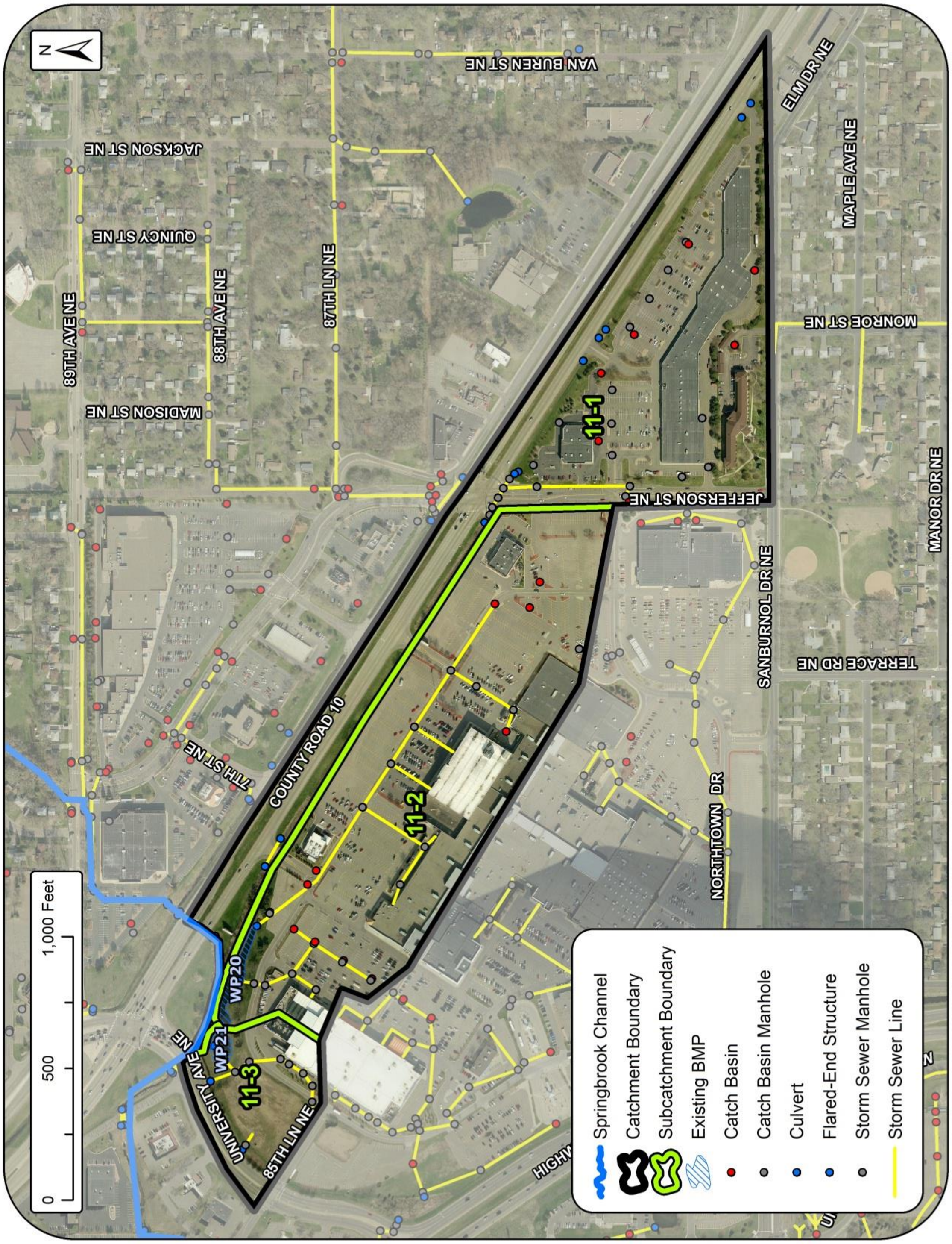
Listed below are network-level base and existing loading for catchments SP-1 to SP-13. Each of these catchments drain to the three in-line ponds in SP-9 and the Springbrook Nature Center wetland in SP-13, These waterbodies supply stormwater treatment to over 2,300 acres of the Springbrook subwatershed.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	64			
	BMP Types	stormwater retention ponds, infiltration basins, natural wetlands, hydrodynamic device			
	TP (lb/yr)	1,874.0	1,206.1	64%	**667.9**
	TSS (lb/yr)	731,718	582,303	80%	**149,415**
	Volume (acre-feet/yr)	1,541.8	97.6	6%	**1,444.2**

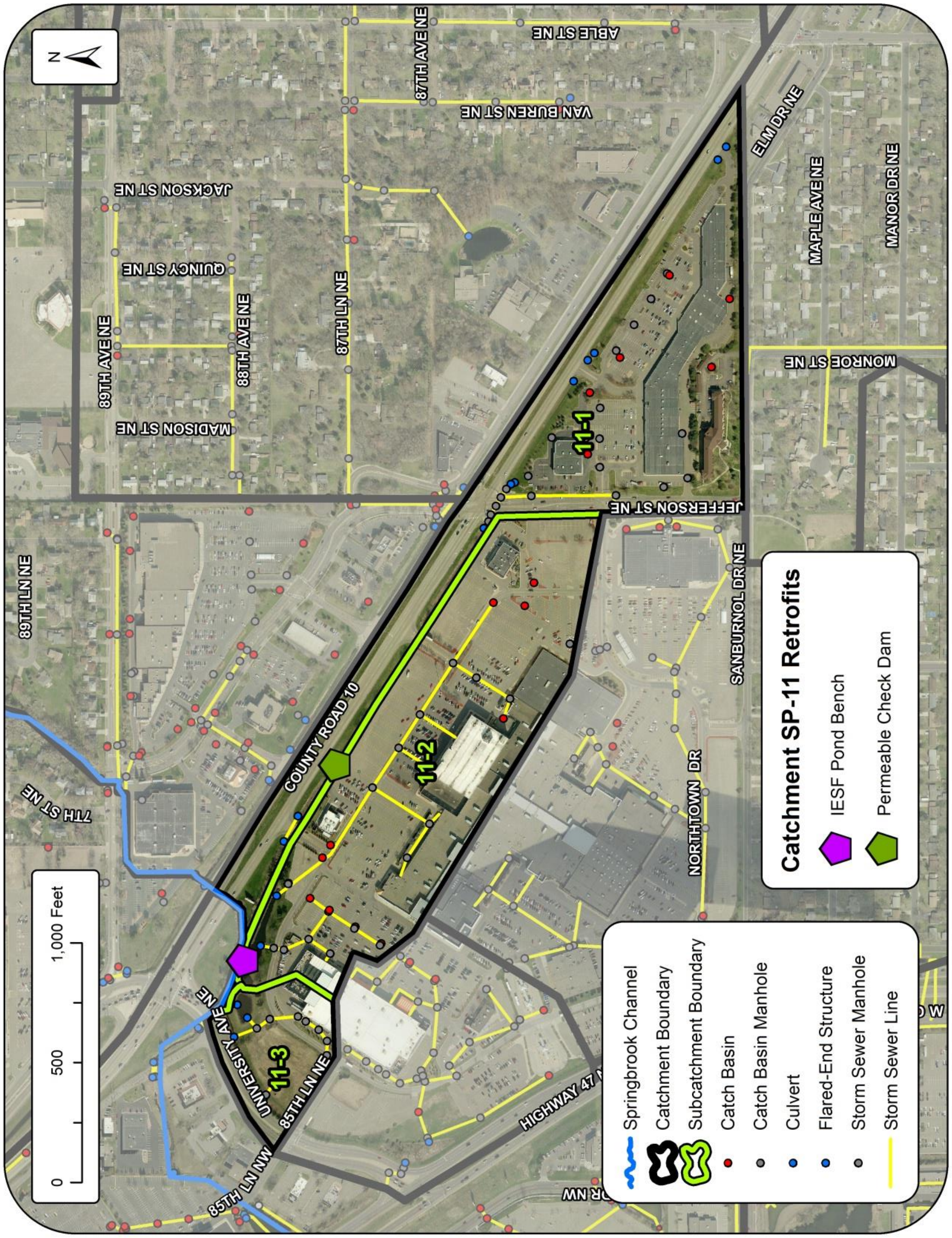
PROPOSED RETROFITS OVERVIEW

Two retrofits are proposed in this catchment. The first is a permeable check dam in the ditch south of County Road 10. This practice would treat properties east of Jefferson St. NE through the deposition of sediment and debris behind the dam and through filtration via an iron-enhanced sand medium within the dam. The second proposed practice is an IESF pond bench located on the northern bank of pond WP20. The bench would be designed to treat dissolved pollutant species that would have exited the pond through its overflow structure and discharged directly into Springbrook.

CURRENT STORMWATER INFRASTRUCTURE AND BMPS

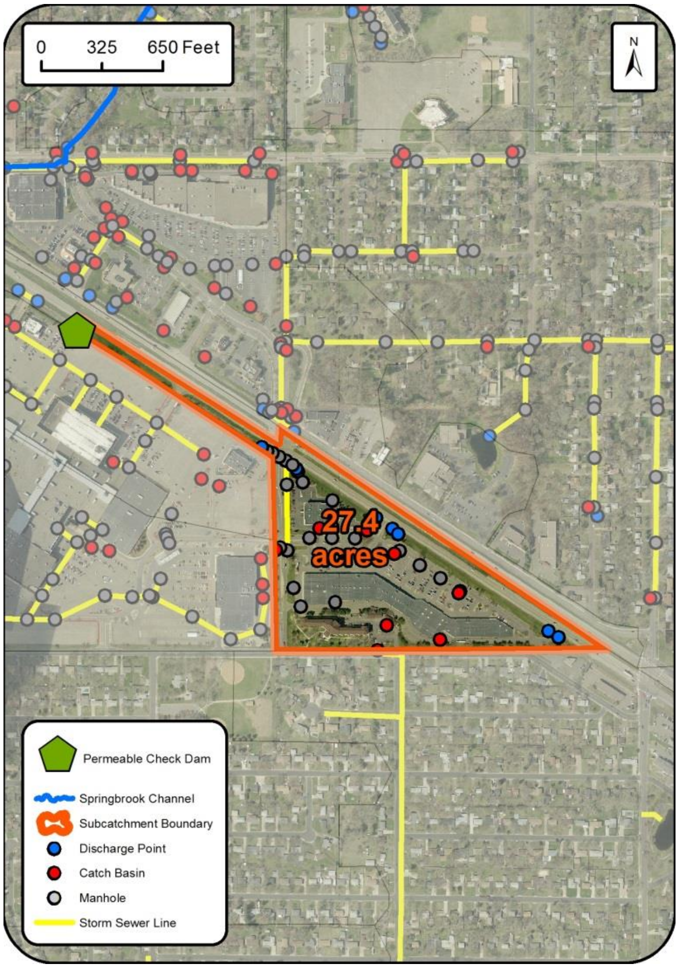


POTENTIAL RETROFITS



Project ID: 11-A

Permeable Check Dam
Subcatchment 11-1



Drainage Area – 27.4 acres
Location – Ditch south of County Road 10
Property Ownership – Public (Anoka County)
Site Specific Information – A mowed ditch between the Northtown Mall and County Road 10 conveys stormwater discharge from the mall parking lot and businesses flanking Jefferson St. NE. This ditch flows west and directly into Springbrook. A permeable check dam is proposed along the ditch to promote sediment and debris accumulation upstream of the dam and dissolved pollutant retention within the dam. A check dam modeled for this location was 2' high (on average), 4' long, and 16'-20' in width to span the ditch.

Permeable Check Dam

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMP	208	cu-ft
	TP (lb/yr)	1.5	0.2%
	TSS (lb/yr)	434	0.3%
	Volume (acre-feet/yr)	1.5	0.1%
Cost	Administration & Promotion Costs*		$2,920
	Design & Construction Costs**		$12,528
	Total Estimated Project Cost (2015)		**$15,448**
	Annual O&M***		$365
Efficiency	30-yr Average Cost/lb-TP	**$587**	
	30-yr Average Cost/1,000lb-TSS	**$2,027**	
	30-yr Average Cost/ac-ft Vol.	**$587**	

*Indirect Cost: 40 hours at $73/hour

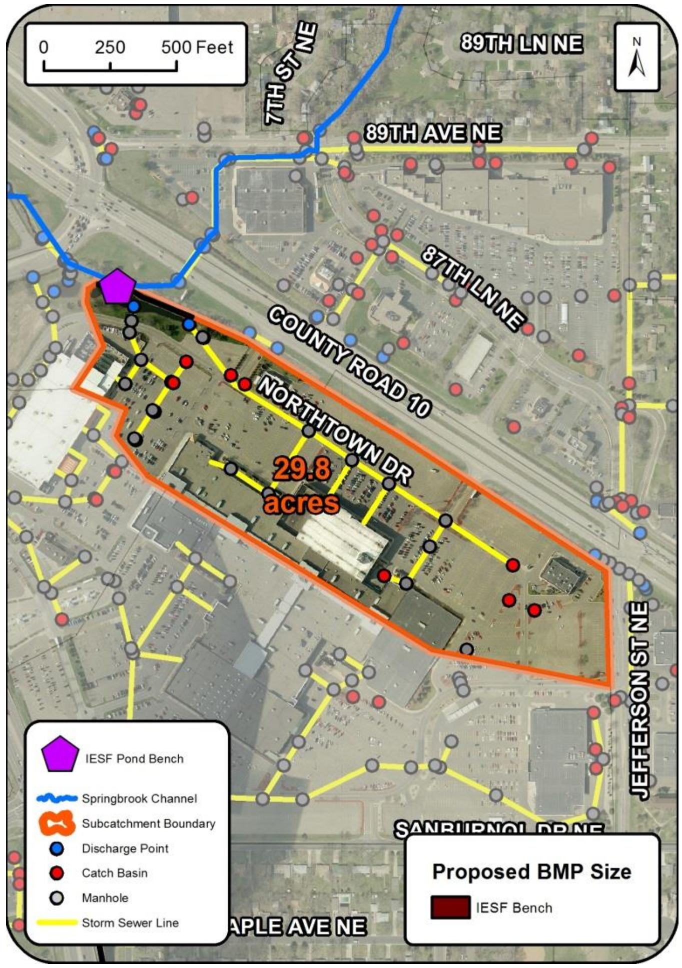
**Direct Cost: See Appendix B for detailed cost information

***(5 hours for each dam at $73/hour for cleaning sediment/debris and maintenance)

Project ID: 11-B

IESF Bench

Subcatchment 11-2



Drainage Area – 29.8 acres
Location – North of retention pond 20 (WP20)
Property Ownership – Public (Anoka County)
Site Specific Information – WP20 provides treatment to nearly 30 acres of predominantly paved, commercial properties. Although WP20 provides sufficient treatment for particulate pollutants through settling, dissolved pollutants can easily advect through the pond without treatment. Space is available along the pond's northern shore for installation of an IESF bench (see map to the lower right) to better provide treatment for dissolved constituents, mainly phosphorus. The IESF outlet structure should tie in directly to the ditch to the north just upstream of Springbrook.

	IESF Bench		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	4,000	sq-ft
	TP (lb/yr)	2.0	0.3%
	TSS (lb/yr)	0	0.0%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$5,475	
	Design & Construction Costs**	$183,720	
	Total Estimated Project Cost (2015)	**$189,195**	
	Annual O&M***	$918	
Efficiency	**30-yr Average Cost/lb-TP**	**$3,612**	
	30-yr Average Cost/1,000lb-TSS	**N/A**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

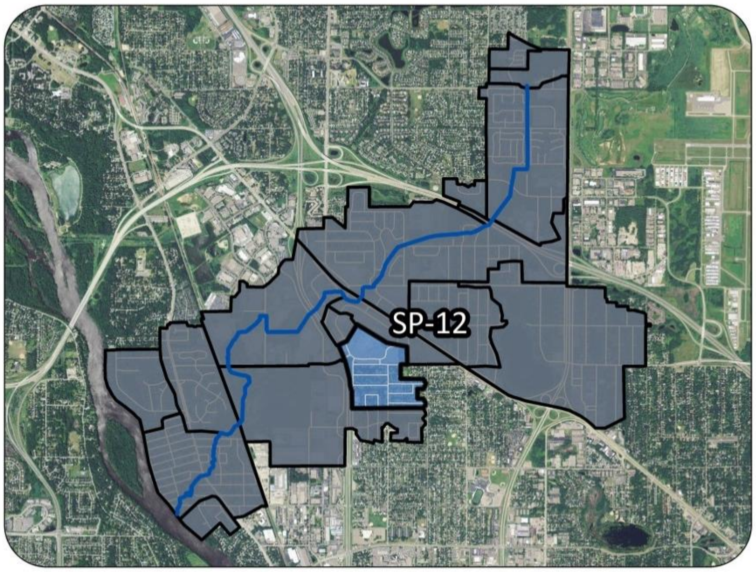
*Indirect Cost: 75 hours at $73/hour

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

***$10,000/acre for IESF

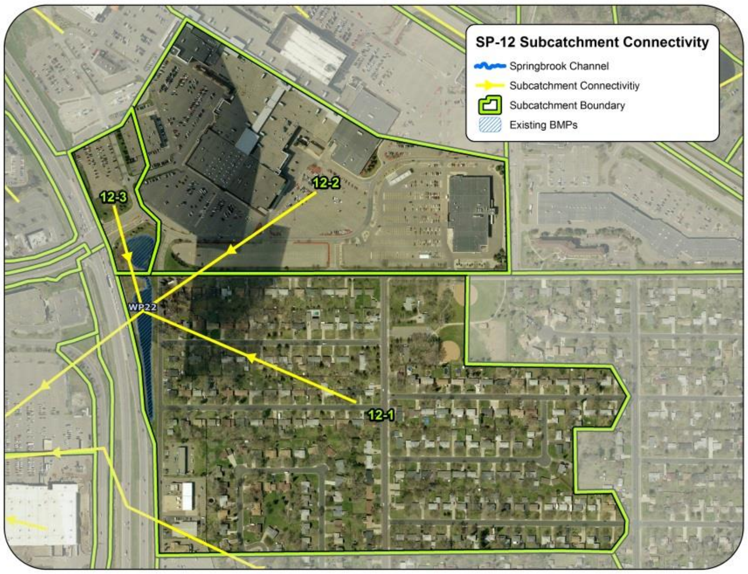
Catchment SP-12

Existing Catchment Summary	
Acres	116.8
Dominant Land Cover	Residential
Parcels	216



CATCHMENT DESCRIPTION

Catchment SP-12 straddles the municipal boundary between the Cities of Blaine and Spring Lake Park. Land use in the catchment is exclusively commercial north of Sanburnol Dr. NE in Blaine and a mix of residential and commercial south of Sanburnol Dr. NE in Spring Lake Park. The commercial properties in Spring Lake Park are along University Ave. NE. A portion of Sanburnol Park is also within the catchment in the City of Spring Lake Park.



EXISTING STORMWATER TREATMENT

All stormwater generated within the catchment flows to pond WP22 in subcatchments 12-1 and 12-3. In the City of Blaine stormwater is quickly intercepted by catch basins and conveyed via storm sewers to the pond. In Spring Lake Park, stormwater primarily travels overland to catch basins located on Lund Ave. NE, Manor Dr. NE, and Maple Ave. NE. Overflow from the pond is piped under University Ave. NE and subsequently to Springbrook within the Springbrook Nature Center.

Listed below are network-level base and existing loading for catchments SP-1 to SP-13. Each of these catchments drain to the three in-line ponds in SP-9 and the Springbrook Nature Center wetland in SP-13, These waterbodies supply stormwater treatment to over 2,300 acres of the Springbrook subwatershed.

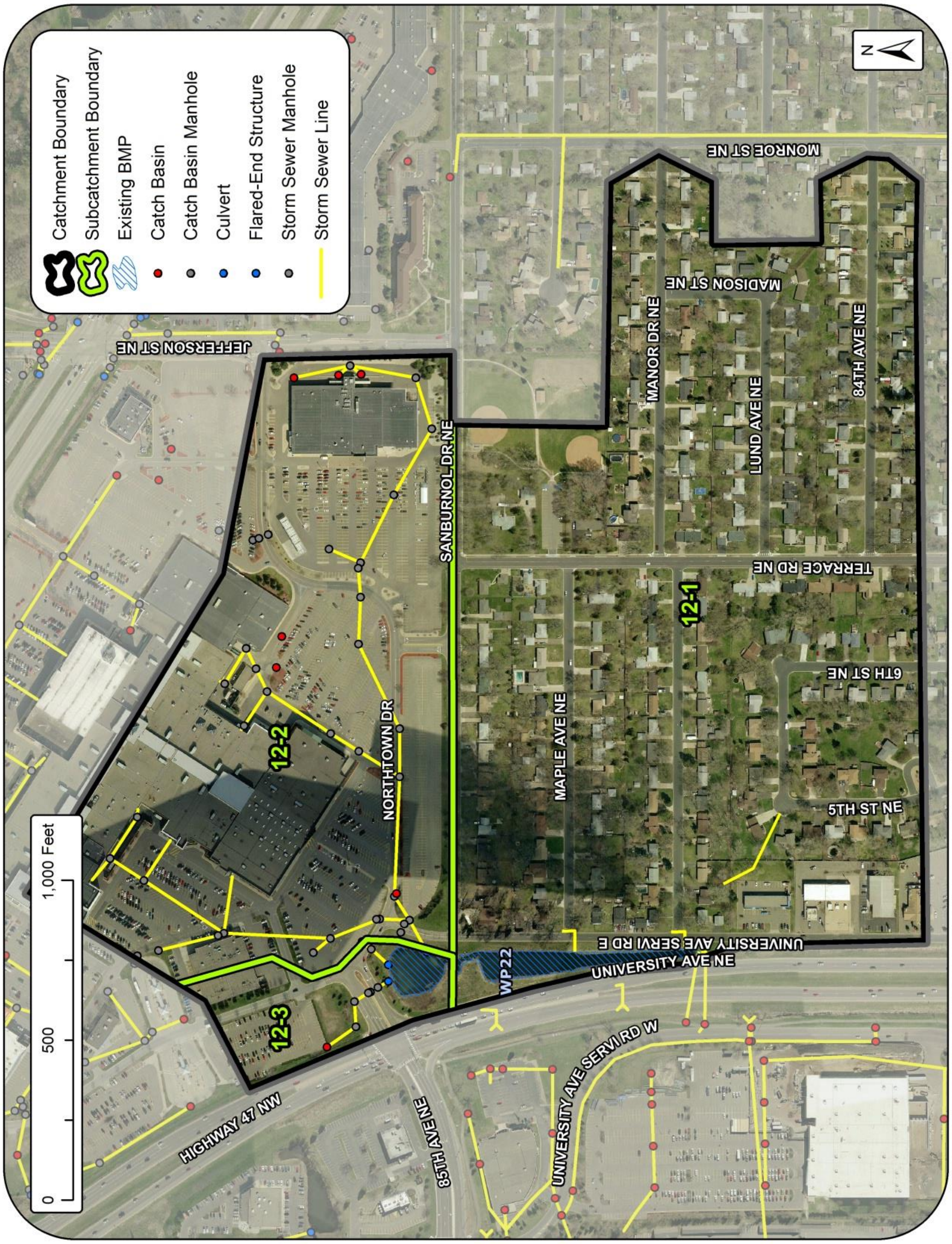
	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	64			
	BMP Types	stormwater retention ponds, infiltration basins, natural wetlands, hydrodynamic device			
	TP (lb/yr)	1,874.0	1,206.1	64%	**667.9**
	TSS (lb/yr)	731,718	582,303	80%	**149,415**
	Volume (acre-feet/yr)	1,541.8	97.6	6%	**1,444.2**

PROPOSED RETROFITS OVERVIEW

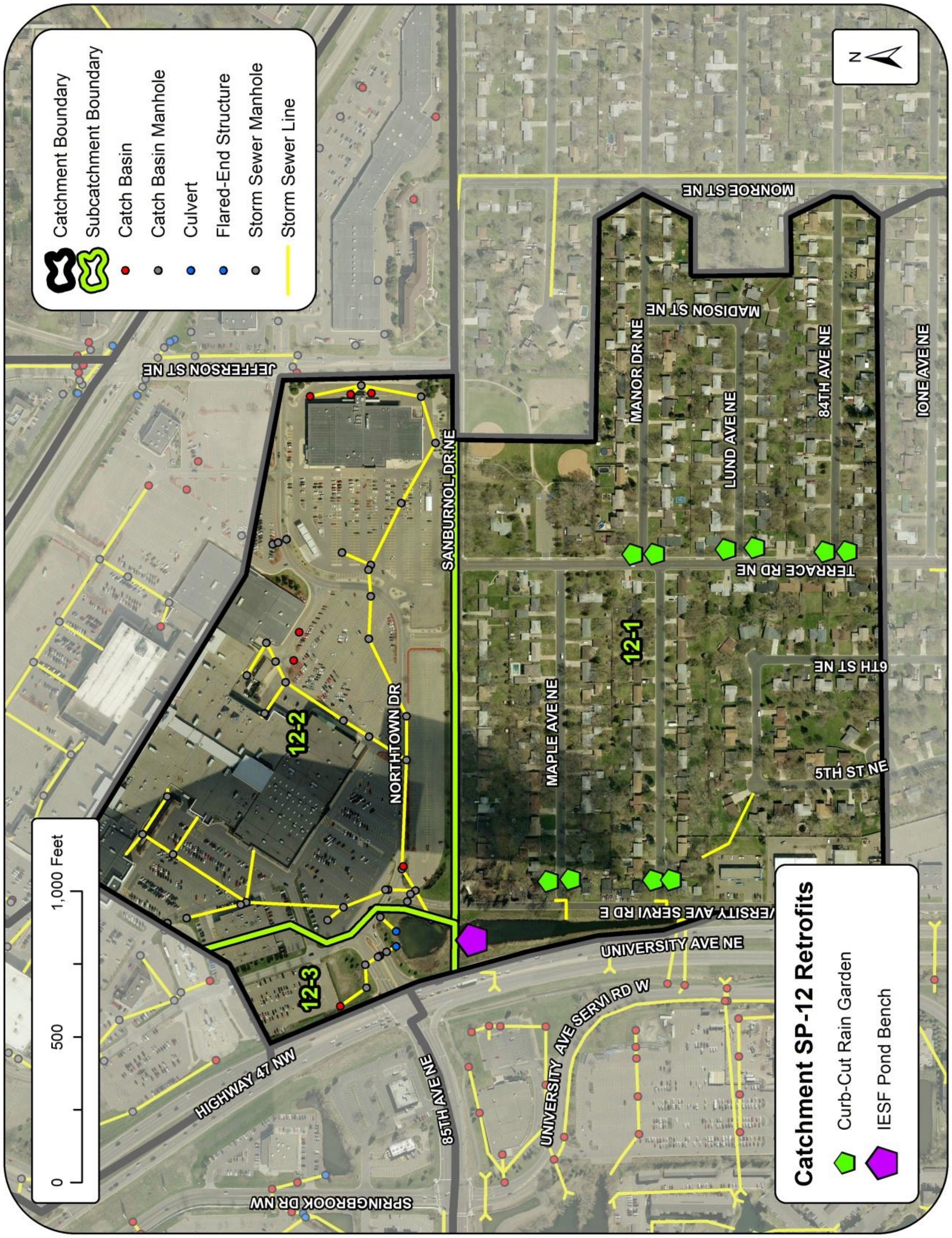
Curb-cut rain gardens were proposed for the residential neighborhoods in Spring Lake Park. These practices have particular use in this neighborhood as overland flow distance is large and rain gardens could potentially decrease roadway flooding.

An IESF pond bench was also proposed along the western bank of pond WP22 to better treat dissolved pollutant species within the pond.

CURRENT STORMWATER INFRASTRUCTURE AND BMPS



POTENTIAL RETROFITS



Project ID: 12-A

Curb-cut Rain Gardens
Subcatchment 12-1

Drainage Area – Varies
Location – Throughout subcatchment 12-1
Property Ownership – Private
Site Specific Information – Single-family lots in subcatchment 12-1 provide various locations for curb-cut rain gardens to treat stormwater pollutants from private property. The lack of stormwater infrastructure in the subcatchment increases overland flowpaths, thereby potentially increasing drainage areas to gardens as well. Up to 10 optimal sites were found through desktop analysis. Considering typical landowner participation rates, scenarios with 4, 6, and 8 rain gardens were analyzed.

Curb-Cut Rain Garden

	Cost/Removal Analysis	New Treatment	% Reduction	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	Number of BMPs	4		6		8	
	Total Size of BMPs	1,000	sq-ft	1,500	sq-ft	2,000	sq-ft
	TP (lb/yr)	1.8	0.3%	2.5	0.4%	3.2	0.5%
	TSS (lb/yr)	457	0.3%	612	0.4%	761	0.5%
	Volume (acre-feet/yr)	3.2	0.2%	4.4	0.3%	5.3	0.4%
Cost	Administration & Promotion Costs*	$11,096		$12,848		$14,600	
	Design & Construction Costs**	$29,504		$44,256		$59,008	
	Total Estimated Project Cost (2015)	**$40,600**		**$57,104**		**$73,608**	
	Annual O&M***	$900		$1,350		$1,800	
Efficiency	30-yr Average Cost/lb-TP	**$1,252**		**$1,301**		**$1,329**	
	30-yr Average Cost/1,000lb-TSS	**$4,931**		**$5,316**		**$5,589**	
	30-yr Average Cost/ac-ft Vol.	**$704**		**$739**		**$803**	

*Indirect Cost: (104 hours at $73/hour base cost) + (12 hours/BMP at $73/hour)

**Direct Cost: ($26/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)

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

Project ID: 12-B

IESF Bench

Subcatchments 12-1 and 12-3

Drainage Area – 118.3 acres (including all upstream subcatchments)
Location – West of wet pond 22 (WP22)
Property Ownership – Public (MNDOT)
Site Specific Information – WP22 provides treatment to all subcatchment in catchment 12. The pond sufficiently treats this area for particulates. Dissolved species, on the other hand, more easily escape the pond untreated. An IESF bench could be installed on the western shore of the pond to better treat dissolved constituents. The bench would need to be installed such that it could easily tie into the outlet structure on the south side of the pond. A 7,000 sq-ft. bench is proposed based on space available between the pond and State Highway 47.

IESF Bench

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMPs	7,000	sq-ft
	TP (lb/yr)	6.0	0.9%
	TSS (lb/yr)	0	0.0%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	Administration & Promotion Costs*		$5,475
	Design & Construction Costs**		$277,480
	Total Estimated Project Cost (2015)		**$282,955**
	Annual O&M***		$1,607
Efficiency	30-yr Average Cost/lb-TP	**$1,840**	
	30-yr Average Cost/1,000lb-TSS	**N/A**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

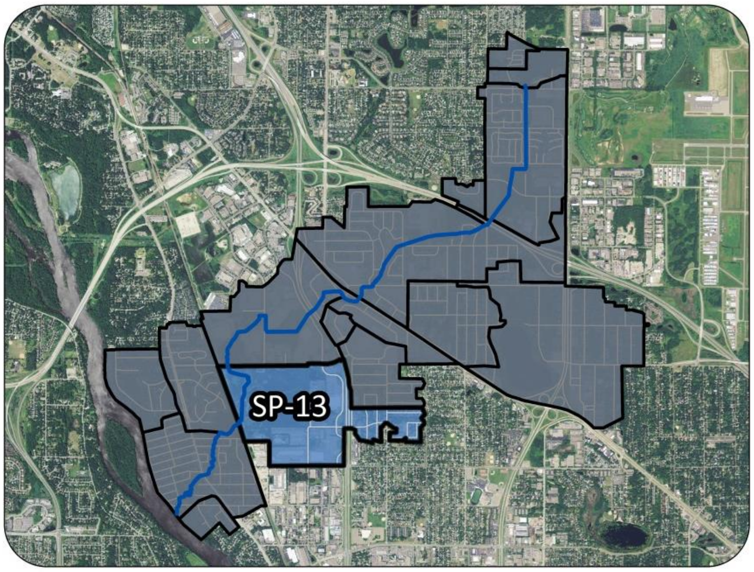
*Indirect Cost: 75 hours at $73/hour

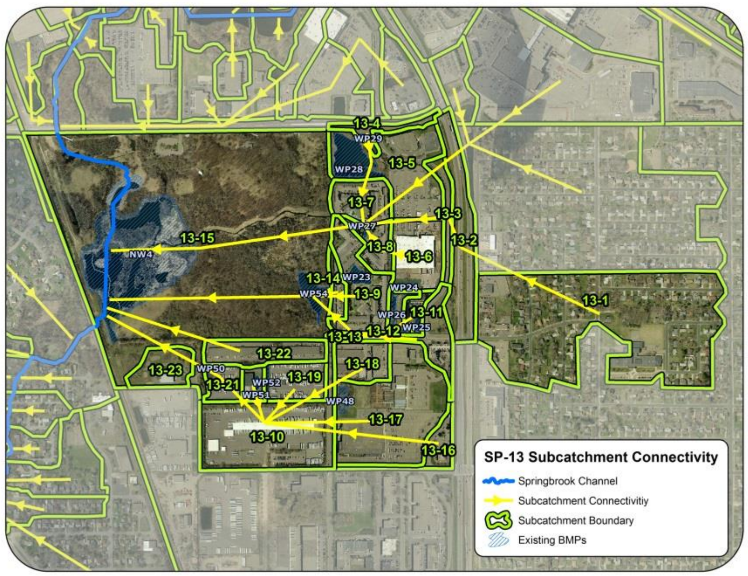
**Direct Cost: See Appendix B for detailed cost information

***$10,000/acre for IESF

Catchment SP-13

Existing Catchment Summary	
Acres	305.3
Dominant Land Cover	Commercial
Parcels	160





CATCHMENT DESCRIPTION

This catchment can be categorized by three distinct areas,

1. Eastern portion of the catchment (east of University Ave. NE): primarily residential with commercial properties along University Ave. NE and Park Terrace Elementary School.
2. Central portion of the catchment (west of University Ave.NE): commercial properties along University Ave. NE with industrial properties between Hickory St. NE and Main St. NE.
3. Western portion of the catchment (Springbrook Nature Center): nature preserve with native prairie, forests, and wetlands.

Springbrook flows through the Nature Center's wetland complex.

EXISTING STORMWATER TREATMENT

Stormwater flows from east to west towards the Springbrook Nature Center wetland. Most stormwater is conveyed through the storm sewer network to at least one wet pond prior to entering the Nature Center. In total, twelve stormwater ponds treat runoff within the catchment, many of which are in-line to one another. See *Appendix A* for details on each pond.

Listed below are network-level base and existing loading for catchments SP-1 to SP-13. Each of these catchments drain to the three in-line ponds in SP-9 and the Springbrook Nature Center wetland in SP-13, These waterbodies supply stormwater treatment to over 2,300 acres of the Springbrook subwatershed.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	64			
	BMP Types	stormwater retention ponds, infiltration basins, natural wetlands, hydrodynamic device			
	TP (lb/yr)	1,874.0	1,206.1	64%	**667.9**
	TSS (lb/yr)	731,718	582,303	80%	**149,415**
	Volume (acre-feet/yr)	1,541.8	97.6	6%	**1,444.2**

PROPOSED RETROFITS OVERVIEW

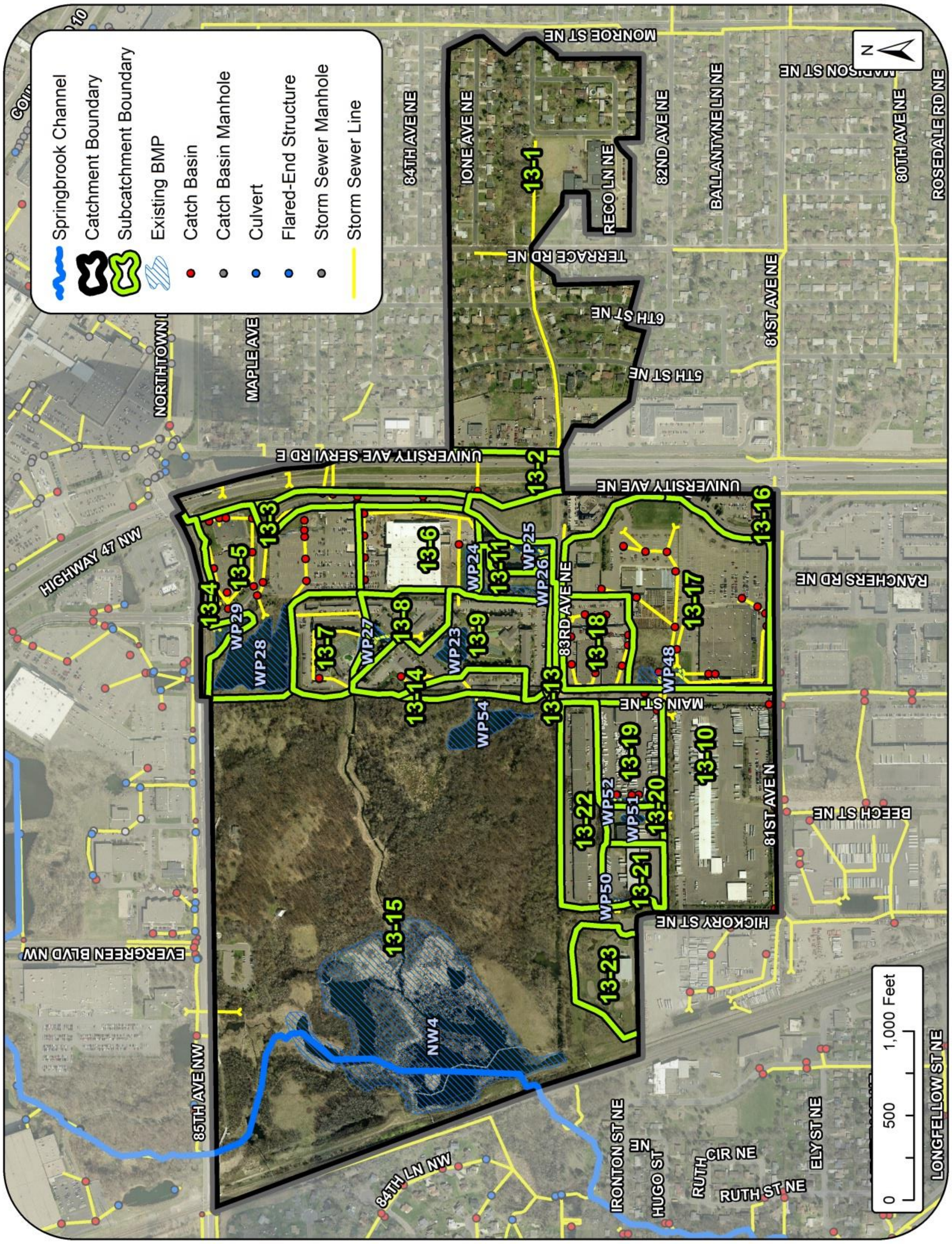
Curb-cut rain gardens were proposed for the residential neighborhood east of University Ave. NE. A modification to the pond in subcatchment 13-17 was also proposed to increase pond size and depth, better utilizing the space available for a practice at this site.

PROPOSED RETROFITS CONSIDERED BUT REJECTED

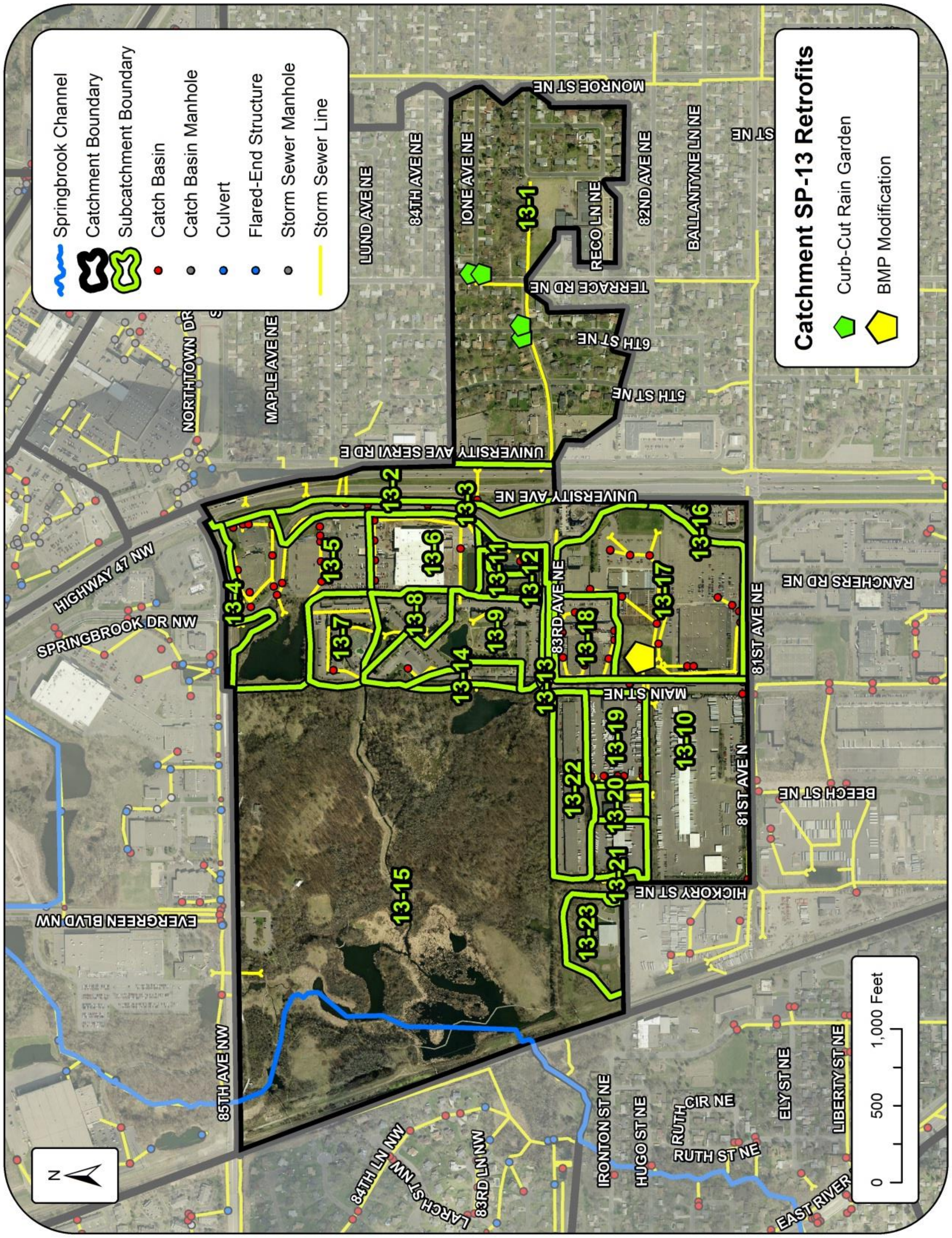
An underground storage tank was initially proposed for Park Terrace Elementary School. This practice would have intercepted stormwater from the northern portion of the school property, as well as residential runoff upstream along 83rd Ave. NE, Jefferson St. NE, and Madison St. NE, and stored it for irrigating green space on the school property. This practice was not proposed in the final report as the area draining to the practice location did not generate enough stormwater to necessitate a practice of this size.

No projects outside of the BMP modification to WP48 were proposed in the commercial and industrial properties west of University Ave NE. as all of the existing stormwater ponds within the catchment provide sufficient treatment to stormwater in the area.

CURRENT STORMWATER INFRASTRUCTURE AND BMPS



POTENTIAL RETROFITS



Project ID: 13-A

Curb-cut Rain Gardens
Subcatchment 13-1

Drainage Area – Varies
Location – Throughout subcatchment 13-1
Property Ownership – Private
Site Specific Information – Single-family lots in subcatchment 13-1 provide various locations for curb-cut rain gardens to treat stormwater pollutants from private property. Up to 4 optimal sites were found through desktop analysis. Considering typical landowner participation rates, scenarios with 2 and 4 rain gardens were analyzed. Due to similarities in landscape, proximity, and cost-effectiveness, this project could be completed with project 12-A, curb-cut rain gardens in subcatchment 12-1.

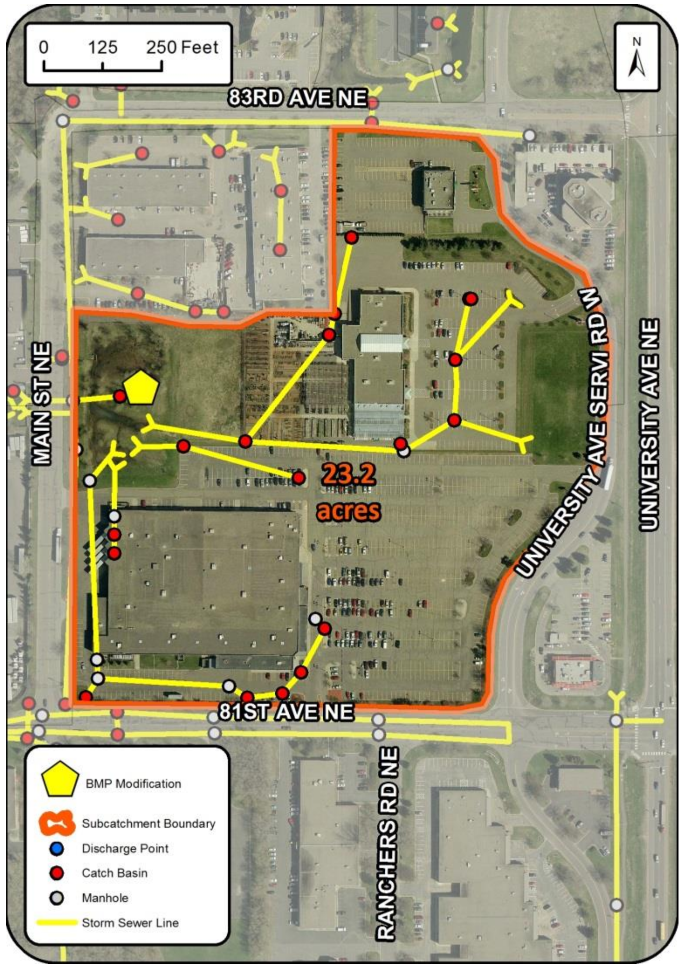
Curb-Cut Rain Garden

	Cost/Removal Analysis	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	Number of BMPs	2		4	
	Total Size of BMPs	500	sq-ft	1,000	sq-ft
	TP (lb/yr)	1.0	0.1%	1.7	0.3%
	TSS (lb/yr)	206	0.1%	357	0.2%
	Volume (acre-feet/yr)	1.8	0.1%	3.0	0.2%
Cost	Administration & Promotion Costs*	$9,344		$11,096	
	Design & Construction Costs**	$14,752		$29,504	
	Total Estimated Project Cost (2015)	**$24,096**		**$40,600**	
	Annual O&M***	$450		$900	
Efficiency	30-yr Average Cost/lb-TP	**$1,253**		**$1,325**	
	30-yr Average Cost/1,000lb-TSS	**$6,083**		**$6,312**	
	30-yr Average Cost/ac-ft Vol.	**$696**		**$751**	

*Indirect Cost: (104 hours at $73/hour base cost) + (12 hours/BMP at $73/hour)
**Direct Cost: ($26/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)
***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: 13-B

BMP Modification
Subcatchment 13-17



Drainage Area – 23.2 acres
Location – Wet pond 48 (WP48) east of Main St. NE
Property Ownership – Private
Site Specific Information – Stormwater runoff from the Sam's Club and Bachman's furniture commercial properties is conveyed via storm sewer pipes to a pond (WP48) behind Sam's Club. This pond has not been well maintained. The skimmer structure is no longer functional and the pond has silted in due to a lack of maintenance. A BMP modification is proposed, which includes increasing the depth of the pond through modifications to the inlet and outlet control structures. Some excavation will be needed (estimated to be about 3,000 cu-yards), but a large depression already exists on the site such that excavation costs could likely be minimized. The cost-benefit table below lists costs based on management level. Additional information on these costs can be found in the *BMP Descriptions* section and in *Appendices B* and *C*.

	BMP Modification						
	Cost/Removal Analysis	New Treatment	% Reduction	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	Pond Management Level	1		2		3	
	Amount of Soil Excavated	3,000	cu-yards	3,000	cu-yards	3,000	cu-yards
	TP (lb/yr)	0.4	0.1%	0.4	0.1%	0.4	0.1%
	TSS (lb/yr)	376	0.3%	376	0.3%	376	0.3%
	Volume (acre-feet/yr)	0.0	0.0%	0.0	0.0%	0.0	0.0%
Cost	Administration & Promotion Costs*	$5,840		$5,840		$5,840	
	Design & Construction Costs**	$145,000		$190,000		$245,000	
	Total Estimated Project Cost (2015)	**$150,840**		**$195,840**		**$250,840**	
	Annual O&M***	$900		$900		$900	
Efficiency	30-yr Average Cost/lb-TP	**$14,820**		**$18,570**		**$23,153**	
	30-yr Average Cost/1,000lb-TSS	**$15,766**		**$19,755**		**$24,631**	
	30-yr Average Cost/ac-ft Vol.	**N/A**		**N/A**		**N/A**	

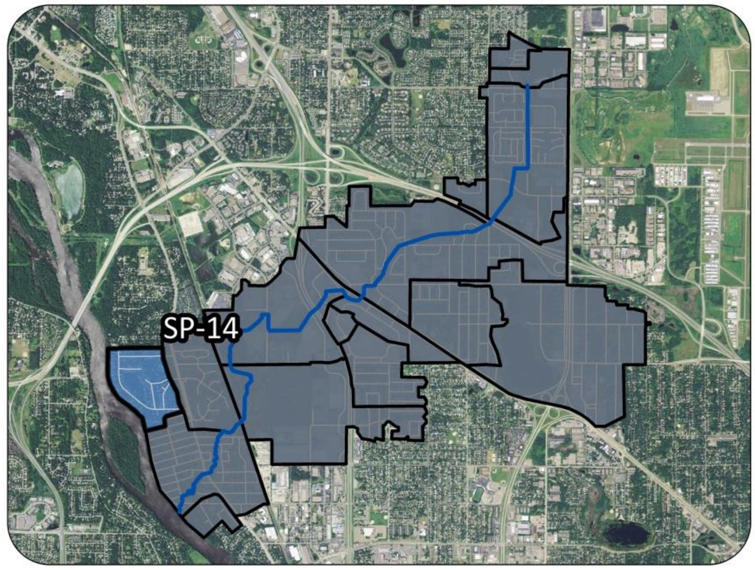
*Indirect Cost: 80 hours at $73/hour

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

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

Catchment SP-14

Existing Catchment Summary	
Acres	106.6
Dominant Land Cover	Residential
Parcels	161



CATCHMENT DESCRIPTION
SP-14 contains exclusively single-family residential lots between East River Road NW and the Mississippi River. There is a large grade change across the catchment, with an 80 ft. drop in elevation between the highest point in the catchment and the surface of the Mississippi River. Stormwater runoff flows to storm sewer lines on Mississippi Blvd. NW and discharges into the Mississippi River. ***This catchment is not hydrologically connected to Springbrook.***

EXISTING STORMWATER TREATMENT
No structural stormwater BMPs exist within this catchment.

Listed below are base and existing loading for catchment SP-14.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	0			
	BMP Types	N/A			
	TP (lb/yr)	64.2	0.0	0%	**64.2**
	TSS (lb/yr)	18,478	0	0%	**18,478**
	Volume (acre-feet/yr)	42.4	0.0	0%	**42.4**

PROPOSED RETROFITS OVERVIEW
Curb-cut rain gardens were proposed at ideal locations near storm sewer catch basins. Soils are favorable for infiltration practices throughout the catchment, but a lack of usable open space and public land likely means residential rain gardens are the best option.

As stormwater runoff from this catchment is discharged directly to the Mississippi River, and is not hydrologically connected to Springbrook, pollutant reductions ***would solely benefit the Mississippi River***.

CURRENT STORMWATER INFRASTRUCTURE AND BMPS

POTENTIAL RETROFITS

Project ID: 14-A

Curb-cut Rain Gardens
Catchment 14

Drainage Area – Varies
Location – Throughout catchment 14
Property Ownership – Private
Site Specific Information – Single-family lots in catchment 14 provide various locations for curb-cut rain gardens to treat stormwater pollutants from private property. Up to 8 optimal sites were found through desktop analysis. Considering typical landowner participation rates, scenarios with 4, 6, and 8 rain gardens were analyzed.

	Curb-Cut Rain Garden						
	Cost/Removal Analysis	New Treatment	% Reduction	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	Number of BMPs	4		6		8	
	Total Size of BMPs	1,000	sq-ft	1,500	sq-ft	2,000	sq-ft
	TP (lb/yr)	4.3	6.7%	6.1	9.5%	7.9	12.3%
	TSS (lb/yr)	1,363	7.4%	1,951	10.6%	2,509	13.6%
	Volume (acre-feet/yr)	2.8	6.6%	4.0	9.4%	5.1	12.0%
Cost	Administration & Promotion Costs*	$11,096		$12,848		$14,600	
	Design & Construction Costs**	$29,504		$44,256		$59,008	
	Total Estimated Project Cost (2015)	**$40,600**		**$57,104**		**$73,608**	
	Annual O&M***	$900		$1,350		$1,800	
Efficiency	30-yr Average Cost/lb-TP	**$524**		**$533**		**$538**	
	30-yr Average Cost/1,000lb-TSS	**$1,653**		**$1,668**		**$1,695**	
	30-yr Average Cost/ac-ft Vol.	**$805**		**$813**		**$834**	

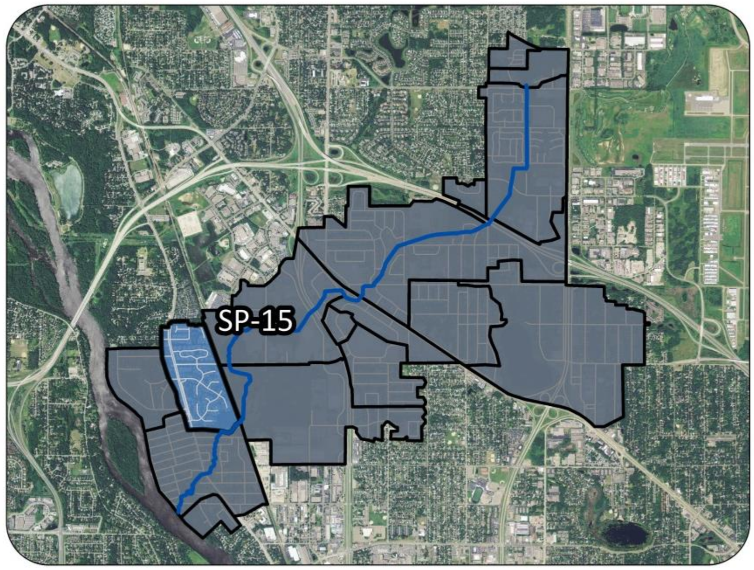
*Indirect Cost: (104 hours at $73/hour base cost) + (12 hours/BMP at $73/hour)

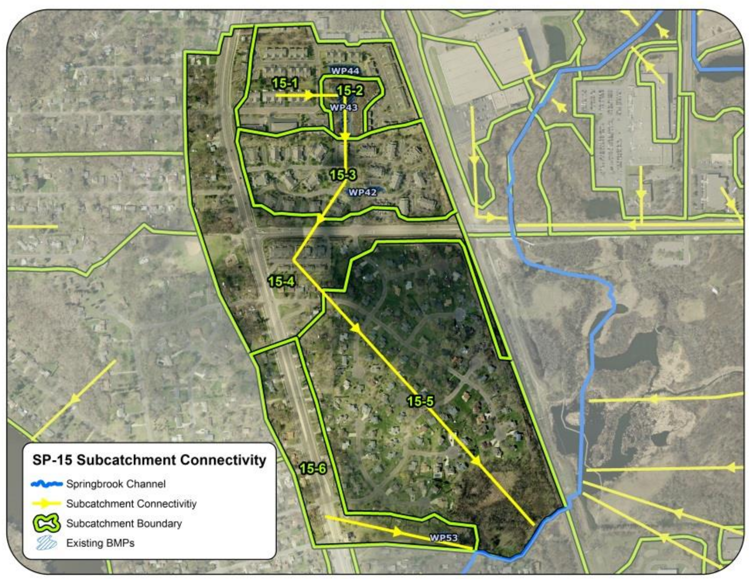
**Direct Cost: ($26/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)

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

Catchment SP-15

Existing Catchment Summary	
Acres	144.4
Dominant Land Cover	Residential
Parcels	485





CATCHMENT DESCRIPTION

This catchment is split between single- and multi-family residential land uses. Multi-family units are primarily located north of 85th Ave. NW and east of East River Road NW. Stormwater generated in the northern portion of the catchment flows to ditching along 85th Ave. NW and along the eastern boundary of the catchment west of the Burlington Northern railroad tracks. In the southern half of the catchment, stormwater is conveyed via pipes and discharged directly into Springbrook.

EXISTING STORMWATER TREATMENT

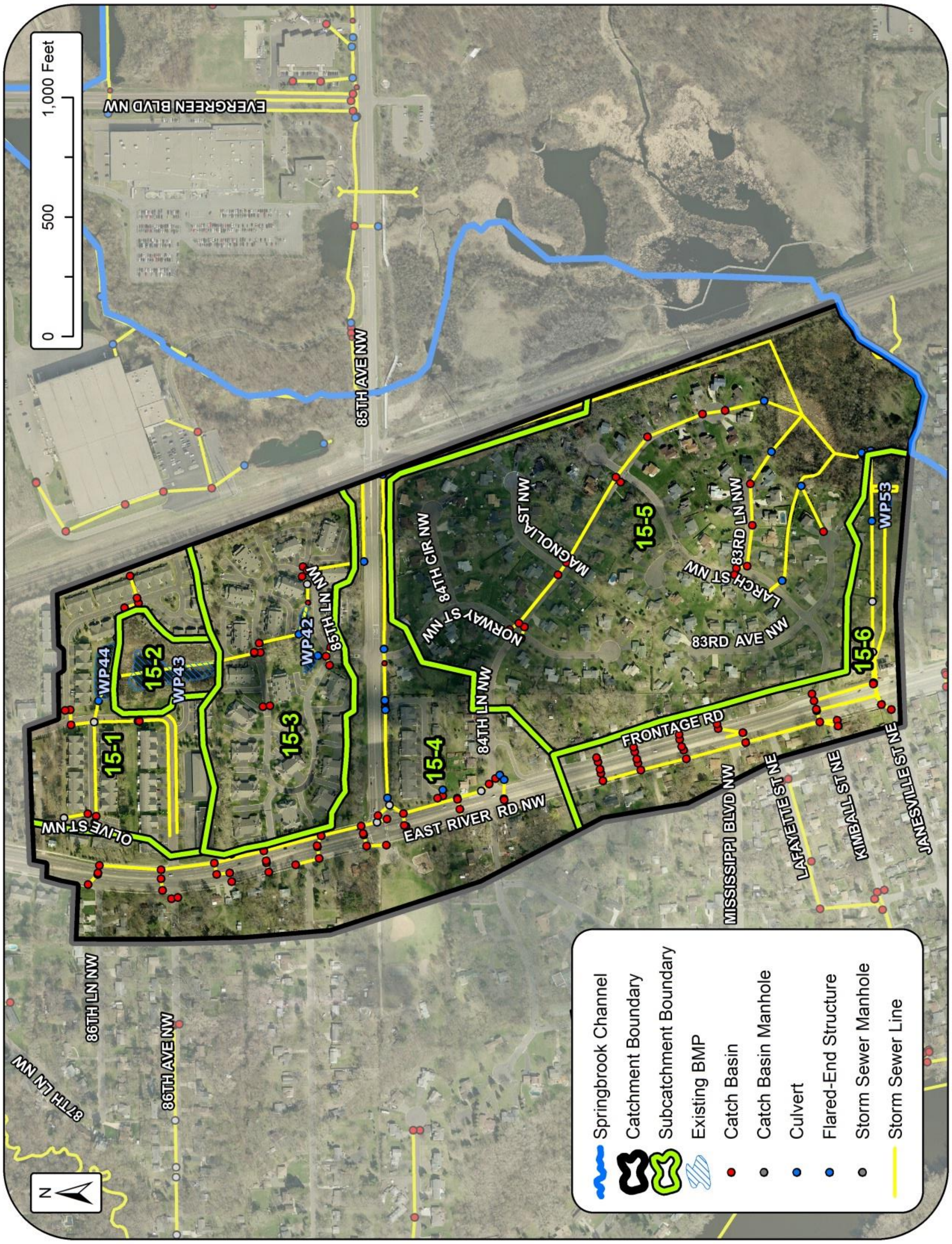
Four stormwater ponds treat runoff throughout the catchment. Three (WP42, WP43, and WP44) are located north of 85th Ave. NW and treat the multi-family townhomes east of East River Road NW. These ponds are in-line and are well-sized to treat particulate pollutants generated within their drainage area. The fourth pond (WP53) accepts runoff from East River Road NW and residences on either side of the road. This pond is less than 200 ft. northwest of Springbrook and discharges into the creek. Listed below are base and existing loading for catchment SP-15.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	4			
	BMP Types	stormwater retention ponds			
	TP (lb/yr)	98.5	15.6	16%	**82.9**
	TSS (lb/yr)	29,591	6,373	22%	**23,218**
	Volume (acre-feet/yr)	77.4	0.5	1%	**76.9**

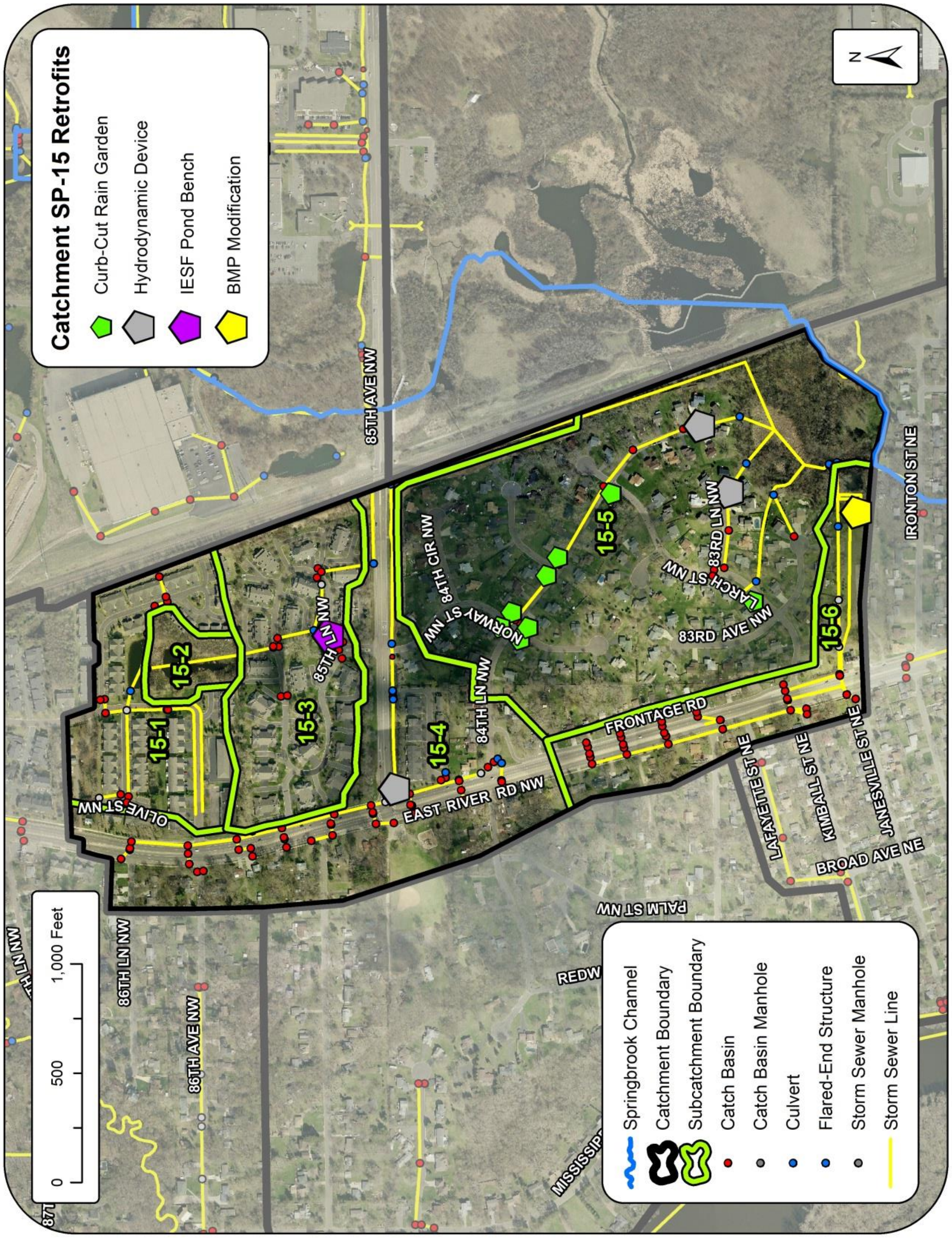
PROPOSED RETROFITS OVERVIEW

Curb-cut rain gardens were proposed in the southern half of the catchment where single-family residential lots with sandy soils favor infiltration practices. Hydrodynamic devices were proposed along East River Road NW at 85th Ave. NW and along storm sewer lines in the southeastern portion of the catchment to better treat particulate pollutants downstream of the in-line ponds in upstream catchments. An IESF bench was proposed for pond WP42 to treat dissolved pollutant species from that pond and the two ponds upstream. Lastly, a modification to pond WP53 was proposed, including expanding the pond size to better accommodate the fifteen acre drainage area.

CURRENT STORMWATER INFRASTRUCTURE AND BMPS



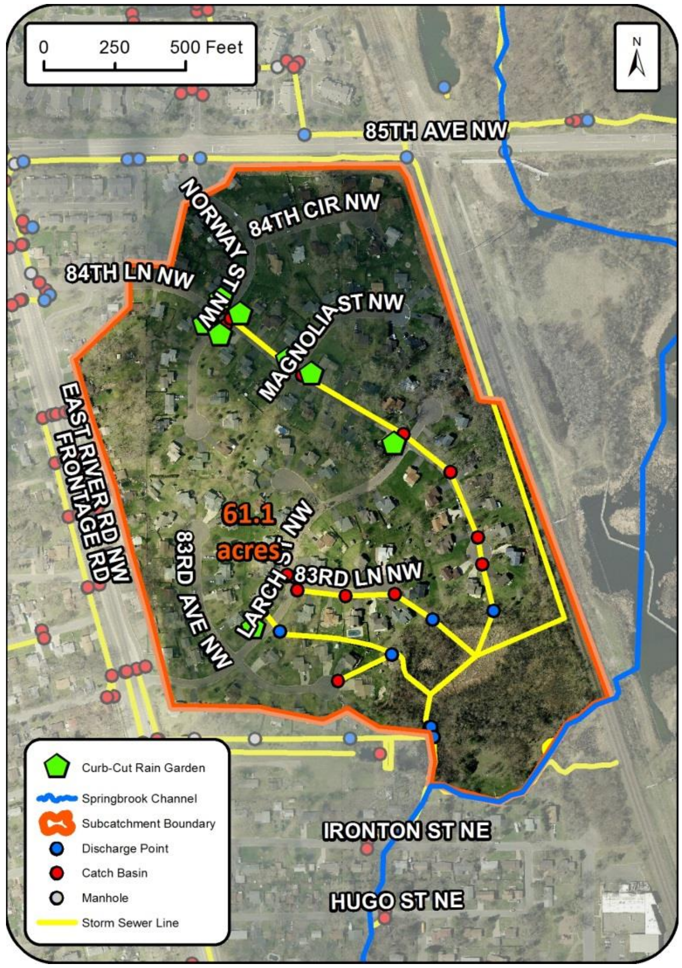
POTENTIAL RETROFITS



Project ID: 15-A

Curb-cut Rain Gardens
Subcatchment 15-5

Drainage Area – Varies
Location – Throughout subcatchment 15-5
Property Ownership – Private
Site Specific Information – Single-family lots in subcatchment 15-5 provide various locations for curb-cut rain gardens to treat stormwater pollutants from private property. Up to 8 optimal sites were found through desktop analysis. Considering typical landowner participation rates, scenarios with 4, 6, and 8 rain gardens were analyzed. Large slopes across many front yards in the neighborhood may limit rain garden opportunities within the subcatchment.



	Curb-Cut Rain Garden						
	Cost/Removal Analysis	New Treatment	% Reduction	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	Number of BMPs	4		6		8	
	Total Size of BMPs	1,000	sq-ft	1,500	sq-ft	2,000	sq-ft
	TP (lb/yr)	3.5	4.2%	4.8	5.8%	5.8	7.0%
	TSS (lb/yr)	1,102	4.7%	1,487	6.4%	1,807	7.8%
	Volume (acre-feet/yr)	2.3	3.0%	3.0	3.9%	3.7	4.8%
Cost	Administration & Promotion Costs*	$11,096		$12,848		$14,600	
	Design & Construction Costs**	$29,504		$44,256		$59,008	
	Total Estimated Project Cost (2015)	**$40,600**		**$57,104**		**$73,608**	
	Annual O&M***	$900		$1,350		$1,800	
Efficiency	30-yr Average Cost/lb-TP	**$644**		**$678**		**$733**	
	30-yr Average Cost/1,000lb-TSS	**$2,045**		**$2,188**		**$2,354**	
	30-yr Average Cost/ac-ft Vol.	**$980**		**$1,084**		**$1,150**	

*Indirect Cost: (104 hours at $73/hour base cost) + (12 hours/BMP at $73/hour)

**Direct Cost: ($26/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)

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

Project ID: 15-B

IESF Bench
Subcatchment 15-3

Drainage Area – 36.2 acres
Location – Southern shore of wet retention pond 42 (WP42)
Property Ownership – N/A (no information available for this parcel)
Site Specific Information – WP42 provides treatment to over 36 acres of predominantly paved, commercial properties. Although WP42 and its in-line, upstream ponds provide sufficient treatment for particulate pollutants through settling, dissolved pollutants can easily advect through them without treatment. Space is available along the pond's southern shore for installation of an IESF bench (see map to the lower right) to better provide treatment for dissolved constituents, mainly phosphorus.

	IESF Bench		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	2,000	sq-ft
	TP (lb/yr)	2.4	2.9%
	TSS (lb/yr)	0	0.0%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$5,475	
	Design & Construction Costs**	$137,840	
	Total Estimated Project Cost (2015)	**$143,315**	
	Annual O&M***	$459	
Efficiency	**30-yr Average Cost/lb-TP**	**$2,182**	
	30-yr Average Cost/1,000lb-TSS	**N/A**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

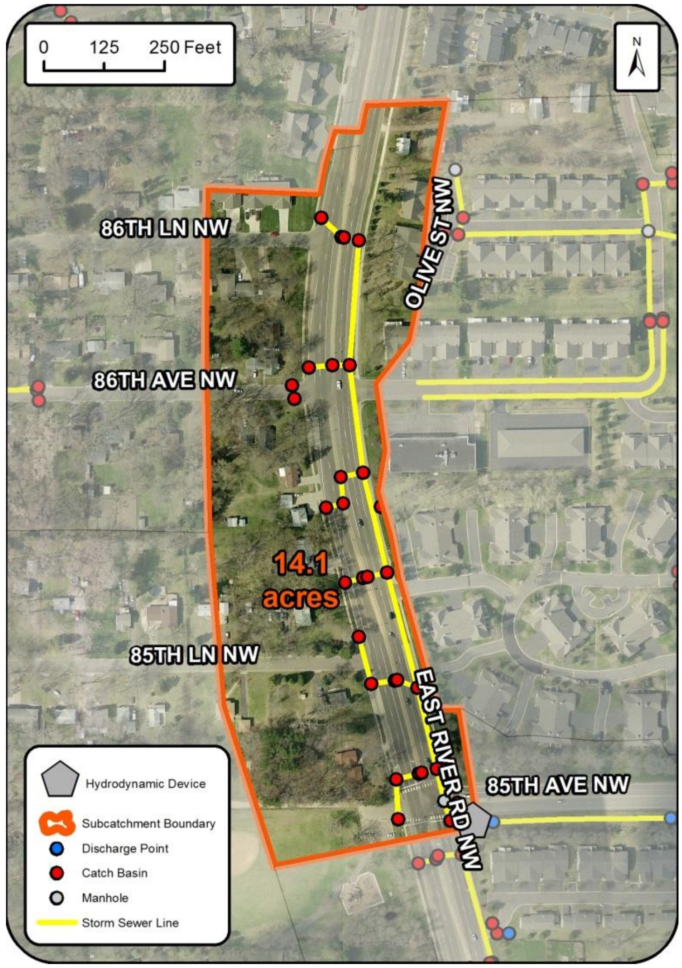
*Indirect Cost: 75 hours at $73/hour

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

***$10,000/acre for IESF

Project ID: 15-C

Hydrodynamic Device
Subcatchment 15-4



Drainage Area – 14.1 acres
Location – Intersection of East River Road NW and 85th Ave. NW
Property Ownership – Public (City of Coon Rapids)
Site Specific Information – A hydrodynamic device could be installed to accept runoff from stormwater catch basins draining East River Road NW and the single-family and multi-family properties surrounding it.

	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	10	ft diameter
	TP (lb/yr)	1.2	1.4%
	TSS (lb/yr)	517	2.2%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2015)	**$109,752**	
	Annual O&M***	$840	
Efficiency	**30-yr Average Cost/lb-TP**	**$3,749**	
	30-yr Average Cost/1,000lb-TSS	**$8,701**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

*Indirect Cost: (24 hours at $73/hour)

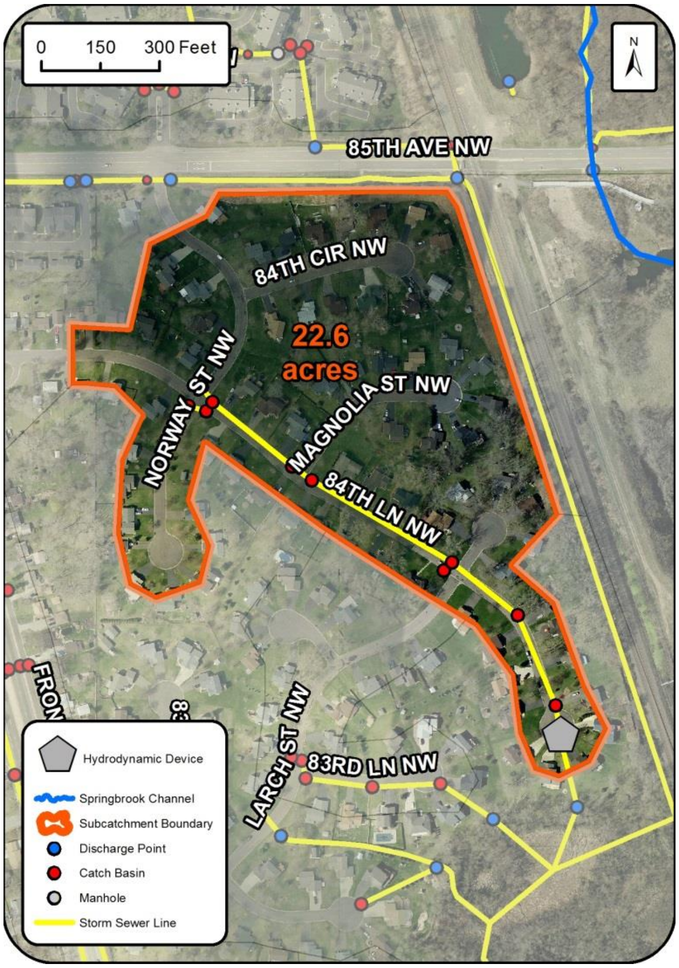
**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)

***Per BMP: (4 cleanings/year)*(3 hours/cleaning)*($70/hour)

Project ID: 15-D

Hydrodynamic Device
Subcatchment 15-5

Drainage Area – 22.6 acres
Location – Along 84th Ln NW
Property Ownership – Public (City of Coon Rapids)
Site Specific Information – A hydrodynamic device could be installed along the 84th Ln. NW storm sewer line to accept runoff from single-family properties draining to catch basins on 84th Ln. NW. The device was proposed (as shown on the map to the right) at the furthest downstream catch basin along 84th Ln. NW. The device may need to be moved upstream to ensure peak flows to the device are minimized to reduce resuspension.



	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	10	ft diameter
	TP (lb/yr)	1.9	2.3%
	TSS (lb/yr)	715	3.1%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2015)	**$109,752**	
	Annual O&M***	$840	
Efficiency	**30-yr Average Cost/lb-TP**	**$2,368**	
	30-yr Average Cost/1,000lb-TSS	**$6,291**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

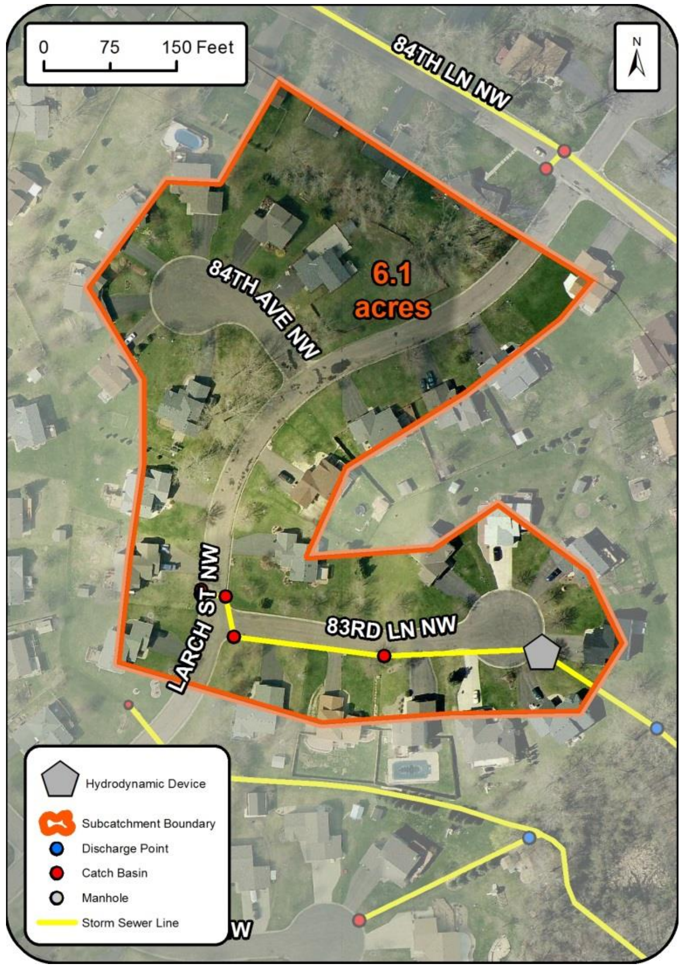
*Indirect Cost: (24 hours at $73/hour)

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

***Per BMP: (4 cleanings/year)*(3 hours/cleaning)*($70/hour)

Project ID: 15-E

Hydrodynamic Device
Subcatchment 15-5



Drainage Area – 6.1 acres
Location – Along 83rd Ln. NW
Property Ownership – Public (City of Coon Rapids)
Site Specific Information – A hydrodynamic device could be installed along the 83rd Ln. NW storm sewer line to accept runoff from single-family properties draining to catch basins on Larch St. NW and 83rd Ln. NW. The device should be installed as far down the 83rd Ln. NW storm sewer line as possible, maximizing the drainage area to the practice. Modeling results as noted in the table below assume all catch basins along 83rd Ln. NW drain to the proposed practice.

Hydrodynamic Device			
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	8	ft diameter
	TP (lb/yr)	0.6	0.7%
	TSS (lb/yr)	252	1.1%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$54,000	
	Total Estimated Project Cost (2015)	**$55,752**	
	Annual O&M***	$840	
Efficiency	**30-yr Average Cost/lb-TP**	**$4,497**	
	30-yr Average Cost/1,000lb-TSS	**$10,708**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

*Indirect Cost: (24 hours at $73/hour)

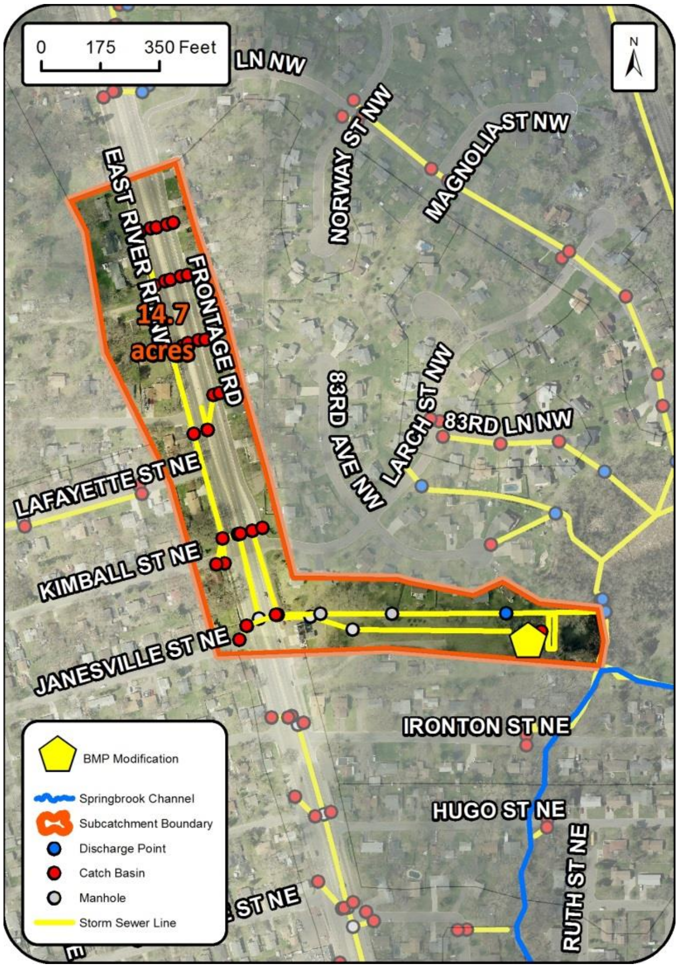
**Direct Cost: ($36,000 for materials) + ($18,000 for labor and installation costs)

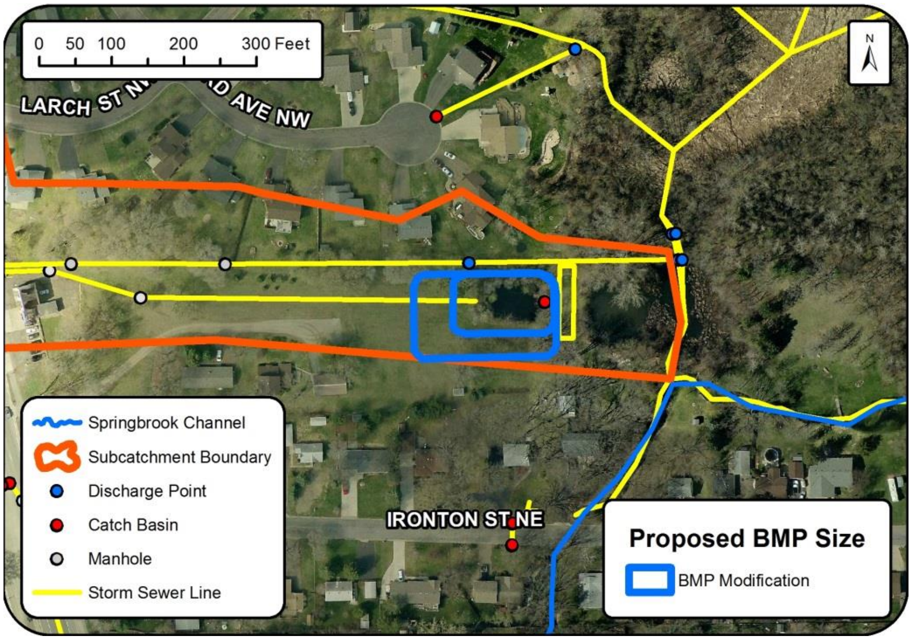
***Per BMP: (4 cleanings/year)*(3 hours/cleaning)*($70/hour)

Project ID: 15-F

BMP Modification
Subcatchment 15-5

Drainage Area – 14.7 acres
Location – On existing wet retention pond 53 (WP53) site
Property Ownership – Private
Site Specific Information – An existing pond (WP53) treats predominantly residential runoff from along East River Road NW. The pond is currently undersized for this drainage area. A modification to this pond is proposed, expanding the area and deepening the BMP. The pond property is also privately owned, likely requiring a stormwater easement or potential outright purchase of the property for any stormwater treatment improvements. The map to the lower right illustrates two potential pond sizes. The smaller blue oval estimates pond expansion to 0.25 acres. The larger blue oval estimates pond expansion to 0.50 acres. The tables on the next page list proposed pollutant reductions from each of these pond sizes. Detailed pond specifications, including new stage-storage relationships, are noted in *Appendix B*.





Proposed pollutant reductions from a 0.25 acre pond, requiring excavation of an estimated 900 cu-yards of soil,

	BMP Modification						
	Cost/Removal Analysis	**New Treatment**	**% Reduction**	**New Treatment**	**% Reduction**	**New Treatment**	**% Reduction**
Treatment	**Pond Management Level**	1		2		3	
	Amount of Soil Excavated	900	cu-yards	900	cu-yards	900	cu-yards
	TP (lb/yr)	0.6	0.7%	0.6	0.7%	0.6	0.7%
	TSS (lb/yr)	232	1.0%	232	1.0%	232	1.0%
	Volume (acre-feet/yr)	0.0	0.0%	0.0	0.0%	0.0	0.0%
Cost	**Administration & Promotion Costs***	$5,840		$5,840		$5,840	
	Design & Construction Costs**	$103,000		$116,500		$130,000	
	Total Estimated Project Cost (2015)	**$108,840**		**$122,340**		**$135,840**	
	Annual O&M***	$900		$900		$900	
Efficiency	**30-yr Average Cost/lb-TP**	**$7,547**		**$8,297**		**$9,047**	
	30-yr Average Cost/1,000lb-TSS	**$19,517**		**$21,457**		**$23,397**	
	30-yr Average Cost/ac-ft Vol.	**N/A**		**N/A**		**N/A**	

*Indirect Cost: 80 hours at $73/hour

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

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

Proposed pollutant reductions from a 0.50 acre pond, requiring excavation of an estimated 2,500 cu-yards of soil,

	BMP Modification						
	Cost/Removal Analysis	**New Treatment**	**% Reduction**	**New Treatment**	**% Reduction**	**New Treatment**	**% Reduction**
Treatment	**Pond Management Level**	1		2		3	
	Amount of Soil Excavated	2,500	cu-yards	2,500	cu-yards	2,500	cu-yards
	TP (lb/yr)	1.1	1.3%	1.1	1.3%	1.1	1.3%
	TSS (lb/yr)	446	1.9%	446	1.9%	446	1.9%
	Volume (acre-feet/yr)	0.0	0.0%	0.0	0.0%	0.0	0.0%
Cost	**Administration & Promotion Costs***	$5,840		$5,840		$5,840	
	Design & Construction Costs**	$135,000		$172,500		$210,000	
	Total Estimated Project Cost (2015)	**$140,840**		**$178,340**		**$215,840**	
	Annual O&M***	$900		$900		$900	
Efficiency	**30-yr Average Cost/lb-TP**	**$5,086**		**$6,222**		**$7,359**	
	30-yr Average Cost/1,000lb-TSS	**$12,544**		**$15,347**		**$18,149**	
	30-yr Average Cost/ac-ft Vol.	**N/A**		**N/A**		**N/A**	

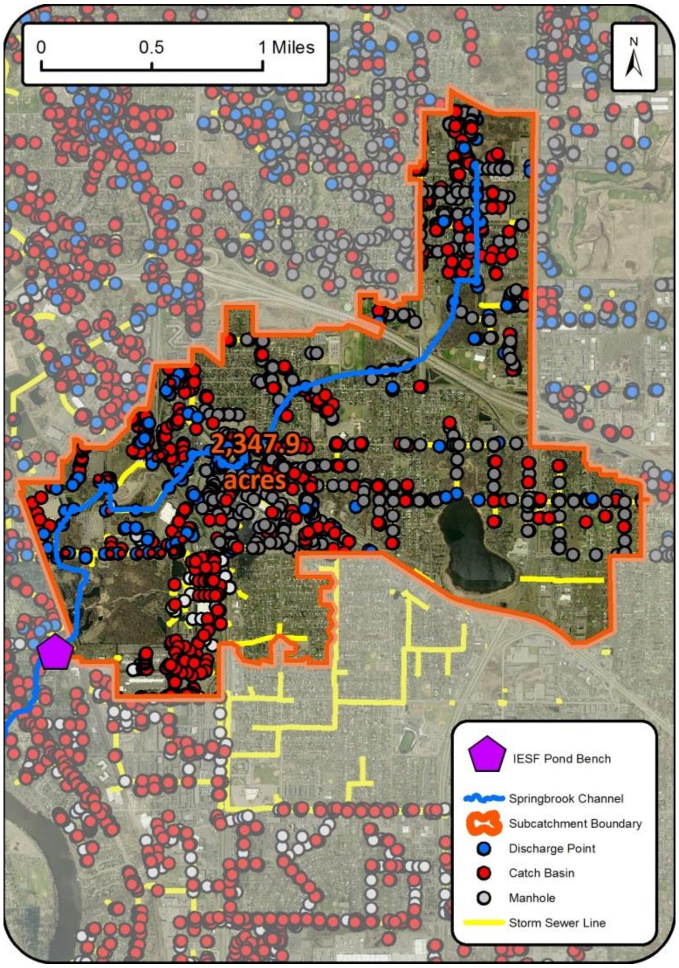
*Indirect Cost: 80 hours at $73/hour

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

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

Project ID: 15-G

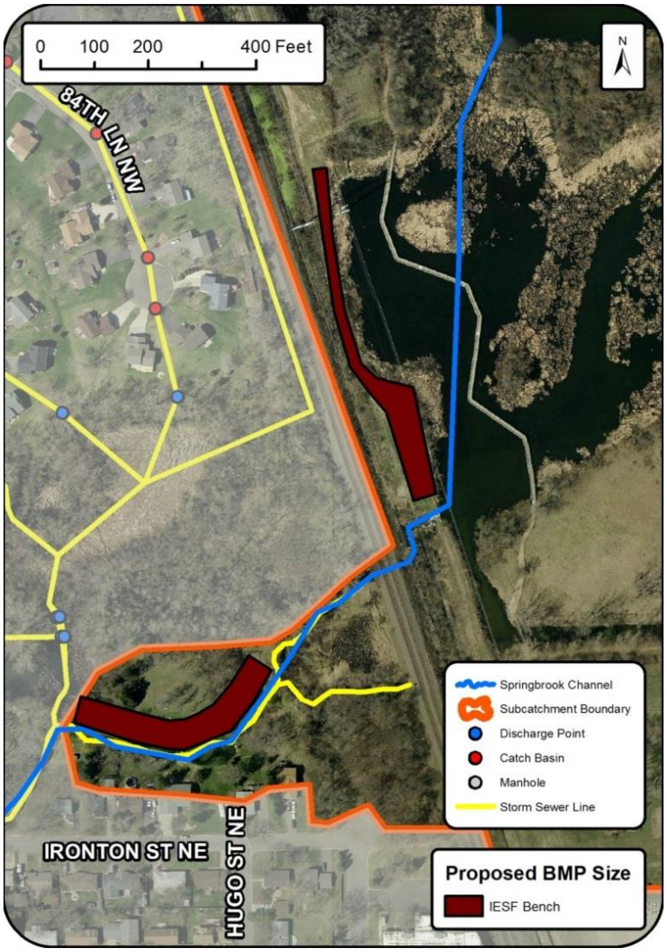
IESF Bench
Subcatchment 15-5



Drainage Area – 2,347.9 acres
Location – Along northern banks of Springbrook north of Ironton St NE
Property Ownership – Private
Site Specific Information – Undeveloped space is available adjacent to the creek channel for an IESF bench to treat all of the drainage from catchments SP-1 through SP-13. The Springbrook Nature Center wetland likely provides sufficient pretreatment of particulates such that the bench can accept inflow directly from the creek. The property north of the creek, where the practice is proposed, is predominantly owned by a single homeowner. If a large practice is pursued, though, additional homeowners will also need to be included in the discussion. A lift station and pump are proposed with this practice to ensure a steady input of water into the IESF bench (although a gravity-fed IESF bench could also be pursued). The table below lists pollutant reduction values and cost-effectiveness for two IESF bench sizes, 0.25 acres and 0.50 acres.

A second project site is also available pending the feasibility of this site. A similar IESF bench could be installed within the Springbrook Nature Center property east of the Burlington Northern railroad tracks. The bench would be situated between the access road along the property boundary and the extent of the wetland north of the weir draining the park. The bench would fill as the water level in the wetland grew and drain through the sand filter into an underdrain tied to the weir system. This project treats a very similar drainage area as the proposed project site just downstream, so the pollutant reduction values in the table below could be used for either site (although costs and cost-effectiveness may differ). Also, the Nature Center wetland is infrequently drained to promote plant germination when the emergent plant community begins to recede. This can often lead to complete drainage of the wetland for a year or more, thereby removing any stormwater pollutant treatment the waterbody provides. This must be taken into account when determining feasibility of this second potential site for an IESF bench.

The photo below shows both potential sites, the northern one within the Springbrook Nature Center and the southern one along the creek north of Ironton St. NE. As noted in the photo, the storm sewer lines conveying flow from SP-15 are downstream of the potential site. So, although this practice is within SP-15 subwatershed, it would treat very little of the drainage generated within the subwatershed.



IESF Bench					
	Cost/Removal Analysis	**New Treatment**	**% Reduction**	**New Treatment**	**% Reduction**
Treatment	Number of BMPs	1		1	
	Total Size of BMPs	10,890	sq-ft	21,780	sq-ft
	TP (lb/yr)	66.5	10.0%	94.5	14.1%
	TSS (lb/yr)	0	0.0%	0	0.0%
	Volume (acre-feet/yr)	0.0	0.0%	0.0	0.0%
Cost	Administration & Promotion Costs*	$7,300		$7,300	
	Design & Construction Costs**	$540,930		$824,700	
	Total Estimated Project Cost (2015)	**$548,230**		**$832,000**	
	Annual O&M***	$8,500		$11,000	
Efficiency	30-yr Average Cost/lb-TP	**$403**		**$410**	
	30-yr Average Cost/1,000lb-TSS	**N/A**		**N/A**	
	30-yr Average Cost/ac-ft Vol.	**N/A**		**N/A**	

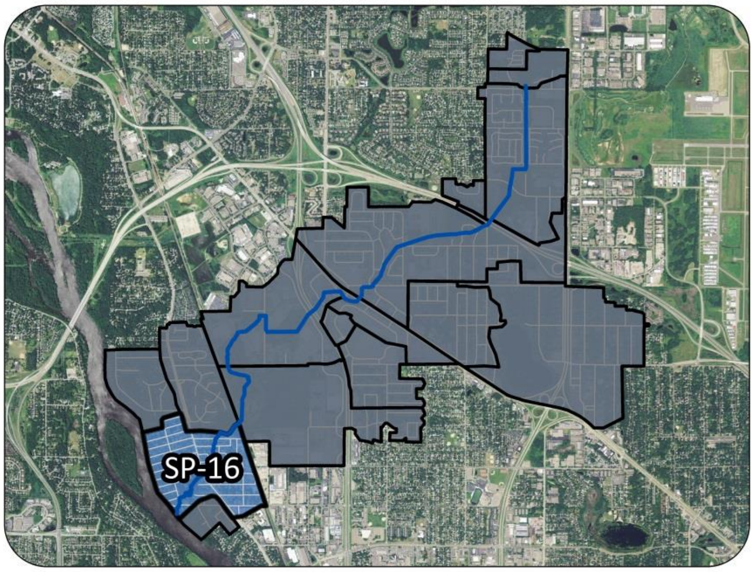
*Indirect Cost: 100 hours at $73/hour

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

***($10,000/acre for IESF) + ($6,000 for annual lift station maintenance and calibration)

Catchment SP-16

Existing Catchment Summary	
Acres	144.4
Dominant Land Cover	Residential
Parcels	642



CATCHMENT DESCRIPTION
Catchment SP-16 is bounded by East River Road NW to the east and the Mississippi River to the west. Springbrook bisects the catchment, running from the northeast to southwest corner. Land use is mostly single-family residential, with multi-family and commercial properties along East River Road NW and parks dotting the landscape throughout the catchment.

EXISTING STORMWATER TREATMENT
Only one structural BMP lies within the catchment, a typically dry detention pond located in the southeastern corner of subcatchment 16-13 (WP49). The practice was designed primarily to supply additional storage for backflow from the Mississippi River during high flow periods. In addition to this it provides some treatment to its drainage area (subcatchment 16-13).

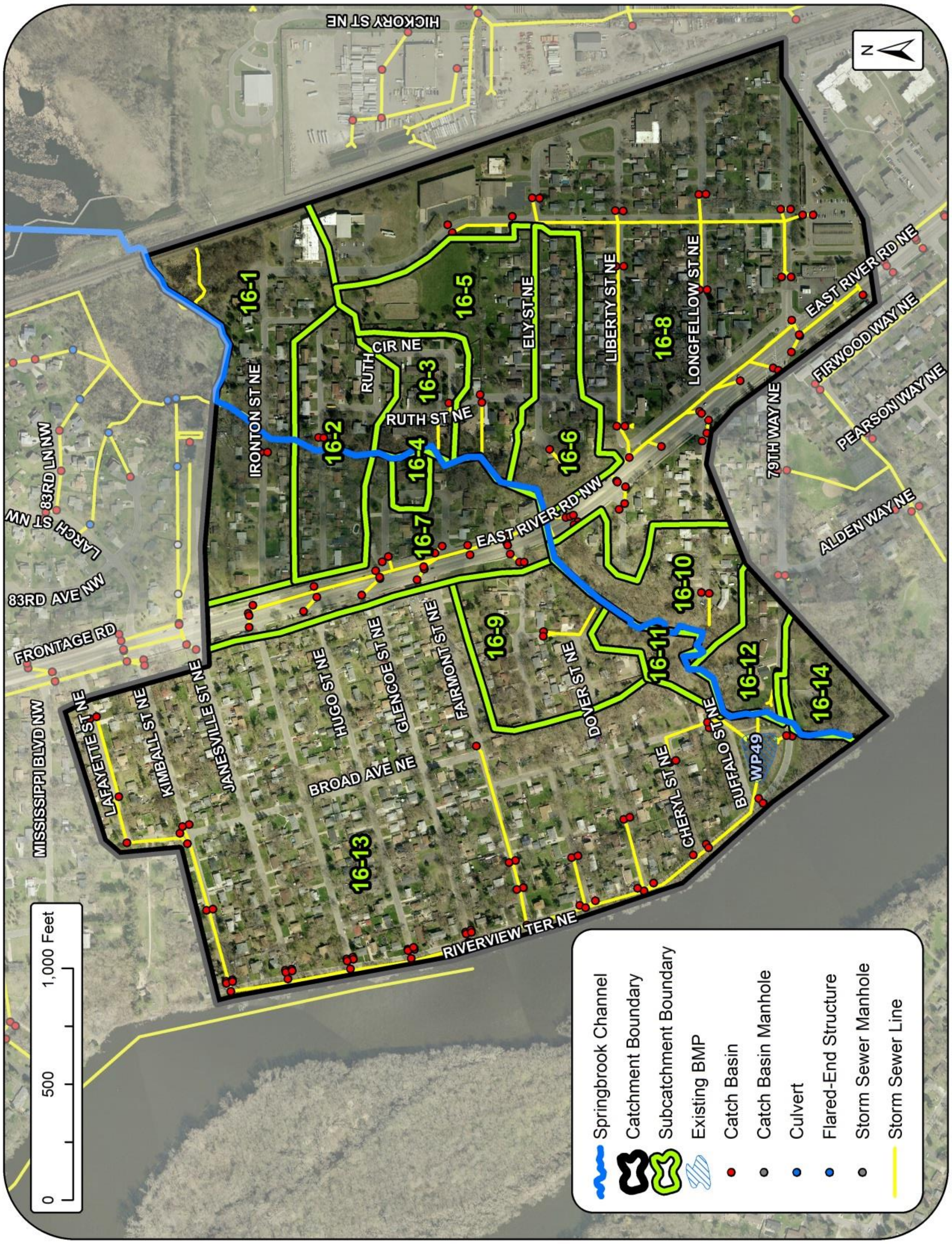
Listed below are base and existing loading for catchment SP-16.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	1			
	BMP Types	stormwater retention pond			
	TP (lb/yr)	140.9	6.4	5%	**134.5**
	TSS (lb/yr)	43,769	2,484	6%	**41,285**
	Volume (acre-feet/yr)	99.0	0.3	0%	**98.7**

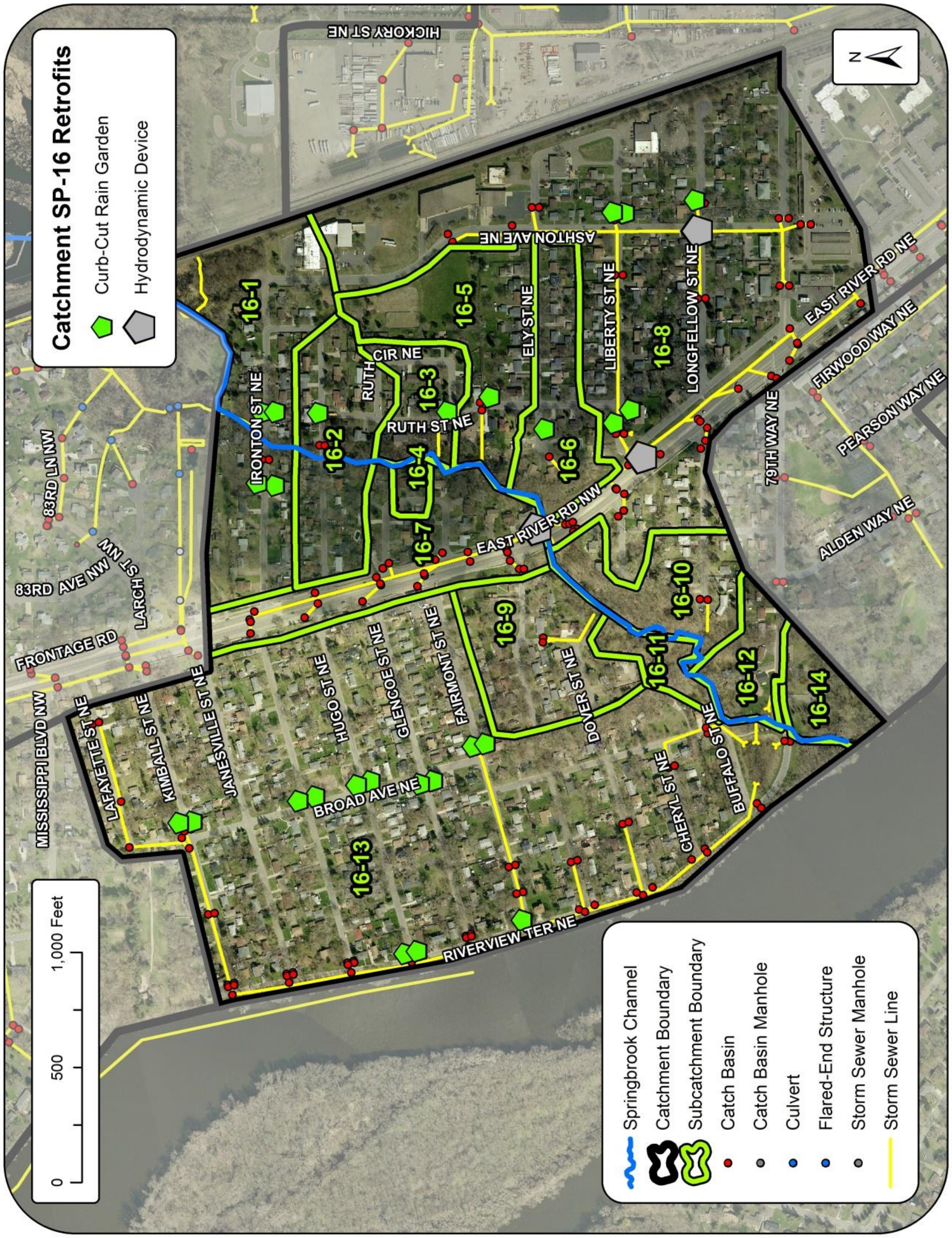
PROPOSED RETROFITS OVERVIEW

The generally sandy, well-drained soils and predominantly single-family residential land use throughout the catchment favor curb-cut rain gardens. In addition, two hydrodynamic devices were proposed in the southeastern portion of the catchment.

CURRENT STORMWATER INFRASTRUCTURE AND BMPS

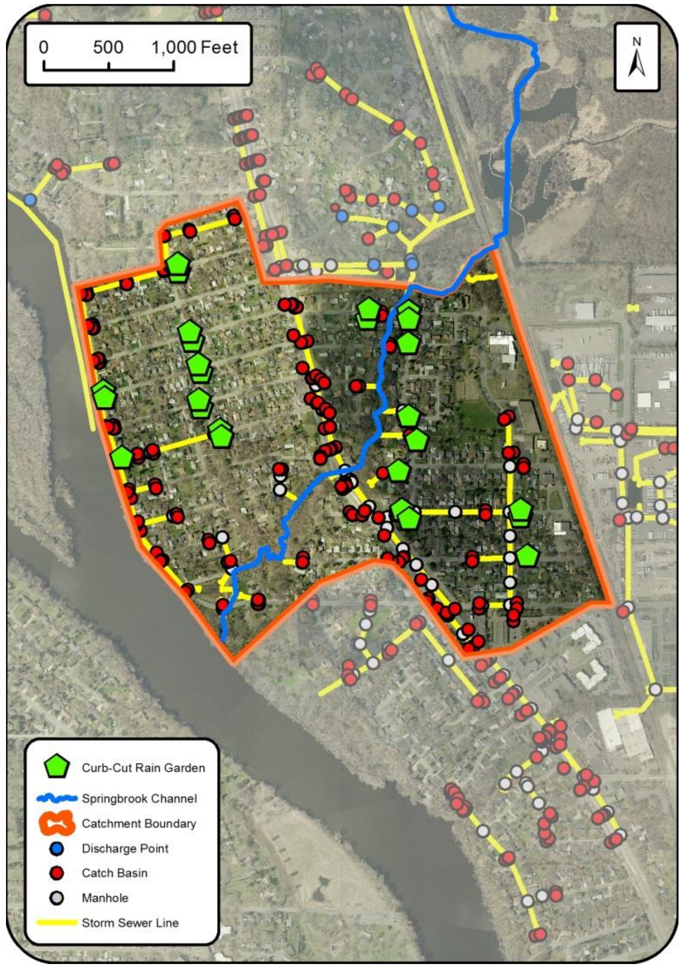


POTENTIAL RETROFITS



Project ID: 16-A

Curb-cut Rain Gardens
Catchment 16



Drainage Area – Varies
Location – Throughout catchment SP-16
Property Ownership – Private
Site Specific Information – Single-family lots in catchment SP-16 provide various locations for curb-cut rain gardens to treat stormwater pollutants from private property. Up to 26 optimal sites were found through desktop analysis. Considering typical landowner participation rates, scenarios with 8, 12, and 18 rain gardens were analyzed. Large slopes across many front yards in the neighborhood may also limit rain garden opportunities within the subcatchment.

Curb-Cut Rain Garden

	Cost/Removal Analysis	New Treatment	% Reduction	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	Number of BMPs	8		12		18	
	Total Size of BMPs	2,000	sq-ft	3,000	sq-ft	4,000	sq-ft
	TP (lb/yr)	6.5	4.8%	9.6	7.1%	14.2	10.6%
	TSS (lb/yr)	1,912	4.6%	2,916	7.1%	4,336	10.5%
	Volume (acre-feet/yr)	5.2	5.3%	7.1	7.2%	10.4	10.5%
Cost	Administration & Promotion Costs*	$14,600		$18,104		$23,360	
	Design & Construction Costs**	$59,008		$88,512		$119,768	
	Total Estimated Project Cost (2015)	**$73,608**		**$106,616**		**$143,128**	
	Annual O&M***	$1,800		$2,700		$4,050	
Efficiency	30-yr Average Cost/lb-TP	**$654**		**$651**		**$621**	
	30-yr Average Cost/1,000lb-TSS	**$2,225**		**$2,145**		**$2,034**	
	30-yr Average Cost/ac-ft Vol.	**$818**		**$881**		**$848**	

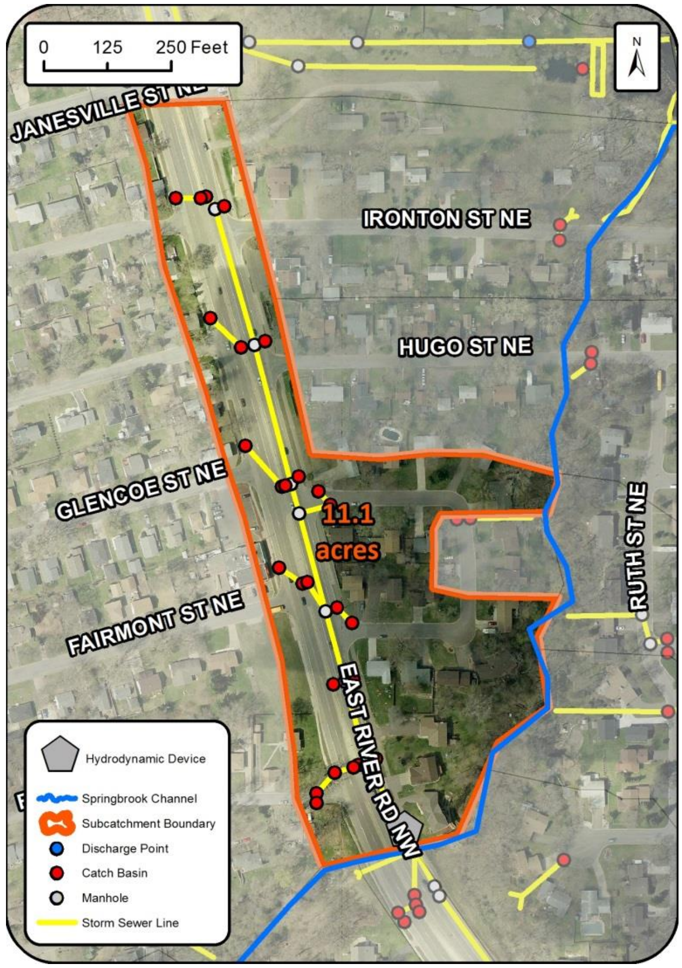
*Indirect Cost: (104 hours at $73/hour base cost) + (12 hours/BMP at $73/hour)

**Direct Cost: ($26/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)

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

Project ID: 16-B

Hydrodynamic Device
Subcatchment 16-7



Drainage Area – 11.1 acres
Location – North of intersection between East River Road NW and Springbrook
Property Ownership – Public (City of Fridley)
Site Specific Information – A hydrodynamic device could be installed to accept runoff from stormwater catch basins draining directly to Springbrook from East River Road NW. The device should be installed as far down the East River Road NW storm sewer line as possible to maximize the drainage area treated by the device.

Hydrodynamic Device

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMPs	10	ft diameter
	TP (lb/yr)	1.1	0.8%
	TSS (lb/yr)	431	1.0%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	Administration & Promotion Costs*	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2015)	**$109,752**	
	Annual O&M***	$840	
Efficiency	30-yr Average Cost/lb-TP	**$4,089**	
	30-yr Average Cost/1,000lb-TSS	**$10,437**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

*Indirect Cost: (24 hours at $73/hour)

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

***Per BMP: (4 cleanings/year)*(3 hours/cleaning)*($70/hour)

Project ID: 16-C

Hydrodynamic Device
Subcatchment 16-8

Drainage Area – 7.4 acres
Location –Intersection of East River Road NW and Liberty St. NE
Property Ownership – Public (City of Fridley)
Site Specific Information – A hydrodynamic device could be installed to accept runoff from stormwater catch basins draining East River Road NW and the residential and commercial properties flanking it. The device was proposed further upstream the East River Road NW storm sewer line to minimize the overall drainage area to the practice, thereby decreasing peak discharge and resuspension of particulates within the device.

	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	10	ft diameter
	TP (lb/yr)	0.9	0.7%
	TSS (lb/yr)	393	1.0%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2015)	**$109,752**	
	Annual O&M***	$840	
Efficiency	**30-yr Average Cost/lb-TP**	**$4,998**	
	30-yr Average Cost/1,000lb-TSS	**$11,446**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

*Indirect Cost: (24 hours at $73/hour)

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

***Per BMP: (4 cleanings/year)*(3 hours/cleaning)*($70/hour)

Project ID: 16-D

Hydrodynamic Device
Subcatchment 16-8

Drainage Area – 16.5 acres
Location – Intersection of Longfellow St. NE and Ashton Ave. NE
Property Ownership – Public (City of Fridley)
Site Specific Information – A hydrodynamic device could be installed to accept runoff from stormwater catch basins draining single-family and multi-family residences on Longfellow St. NE, 79th Way NE, Lincoln St. NE, and Ashton Ave. NE.

	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	10	ft diameter
	TP (lb/yr)	1.6	1.2%
	TSS (lb/yr)	617	1.5%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2015)	**$109,752**	
	Annual O&M***	$840	
Efficiency	**30-yr Average Cost/lb-TP**	**$2,812**	
	30-yr Average Cost/1,000lb-TSS	**$7,291**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

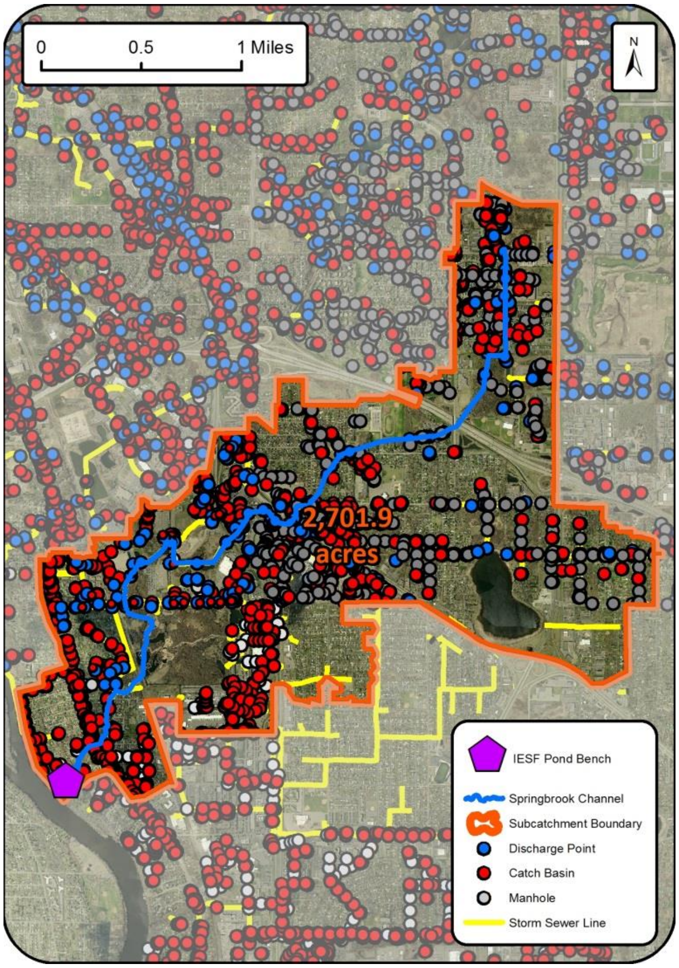
*Indirect Cost: (24 hours at $73/hour)

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

***Per BMP: (4 cleanings/year)*(3 hours/cleaning)*($70/hour)

Project ID: 16-E

IESF Bench
Subcatchment 16-12

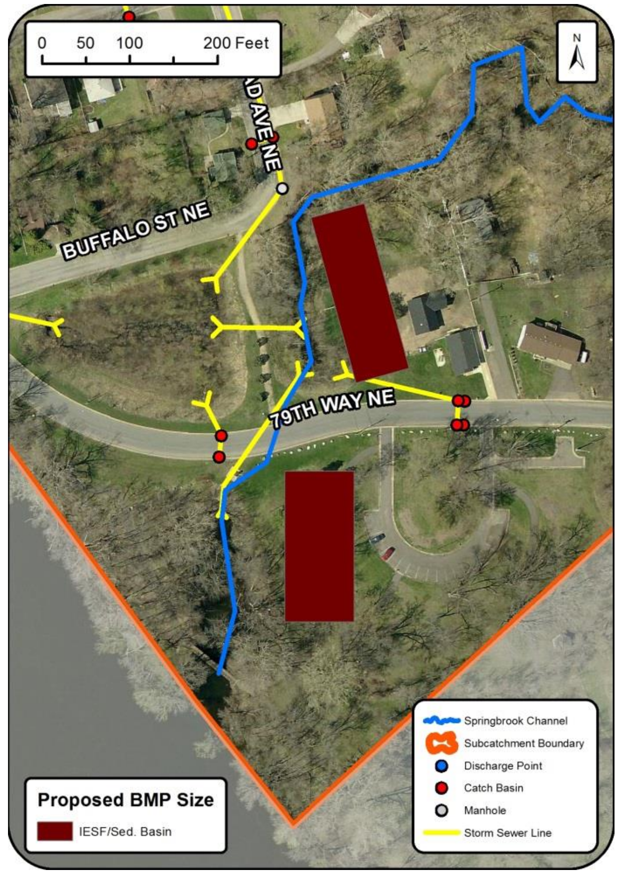


Drainage Area – 2,701.9 acres
Location – City-owned property north of 79th Way and just east of the creek channel
Property Ownership – City of Fridley
Site Specific Information – Undeveloped space is available adjacent to the creek channel and within Riverview Heights Park for an IESF bench and sedimentation basin to treat drainage from most of the Springbrook subwatershed. The sites, just east of the channel on city-owned property, flank 79th Way NE (see photo below). The northern site abuts private property.

The most feasible location is the northern site, which could be excavated to allow for gravitational input into an IESF bench installed adjacent to the creek. That strategy, though, may be unfeasible for two reasons. First, little head loss is available between this site and the creek upstream of 79th Way to allow for gravitational draining of the filter. Second, backwater from the Mississippi during high flow periods could inundate the filter, releasing phosphorus bound to iron in the media. For these reasons a list station is proposed for any IESF at this site. Potential benefits from a single project (0.25 acre IESF without a sedimentation basin) proposed at this site are noted in the first column of the table below.

City-owned property also exists within Riverview Heights Park south of 79th Way NE. A second practice in-line to one installed north of 79th Way NE could provide significant treatment to over 2,700 acres of upstream drainage. The most effective option would include a sedimentation basin north of 79th Way NE and an IESF south of 79th Way NE. The sedimentation basin would provide pretreatment to the filter, settling sediments and phosphorus-laden particulates upstream of the practice. The filter could provide treatment for dissolved constituents, specifically phosphorus, before outletting into Springbrook just upstream of its confluence with the Mississippi River. The site of this IESF south of 79th Way NE, shown in the figure below, is currently about 10 ft. above the water level of the Mississippi River under normal conditions and about 4 ft. above the site north of 79th Way NE. It is recommended excavation here be limited to ensure encroachment from the Mississippi River during high flows is prevented but that gravitational flow from the sedimentation basin upstream is still possible. A second lift station may be needed if high water from the Mississippi River requires a higher elevation for the IESF drain field at the site south of 79th Way. Costs in the table below assume two lift stations will be required.

Whichever project is pursued, a feasibility study is required due to the high complexity of these practices and sites.



IESF Bench

	Cost/Removal Analysis	New Treatment	% Reduction	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	With or Without Sed. Basin	w/out Sed. Basin		w/ Sed. Basin		w/ Sed. Basin	
Treatment	Total Size of IESF	10,890	sq-ft	10,890	sq-ft	21,780	sq-ft
Treatment	TP (lb/yr)	69.7	7.9%	107.8	12.2%	137.7	15.6%
Treatment	TSS (lb/yr)	0	0.0%	14,962	7.0%	14,962	7.0%
Treatment	Volume (acre-feet/yr)	0.0	0.0%	0.0	0.0%	0.0	0.0%
Cost	Administration & Promotion Costs*	$7,300		$7,300		$7,300	
Cost	Design & Construction Costs**	$440,930		$646,930		$940,700	
Cost	**Total Estimated Project Cost (2015)**	**$448,230**		**$654,230**		**$948,000**	
Cost	Annual O&M***	$8,500		$9,000		$11,500	
Efficiency	30-yr Average Cost/lb-TP	**$336**		**$286**		**$313**	
Efficiency	30-yr Average Cost/1,000lb-TSS	**N/A**		**$2,059**		**$2,881**	
Efficiency	30-yr Average Cost/ac-ft Vol.	**N/A**		**N/A**		**N/A**	

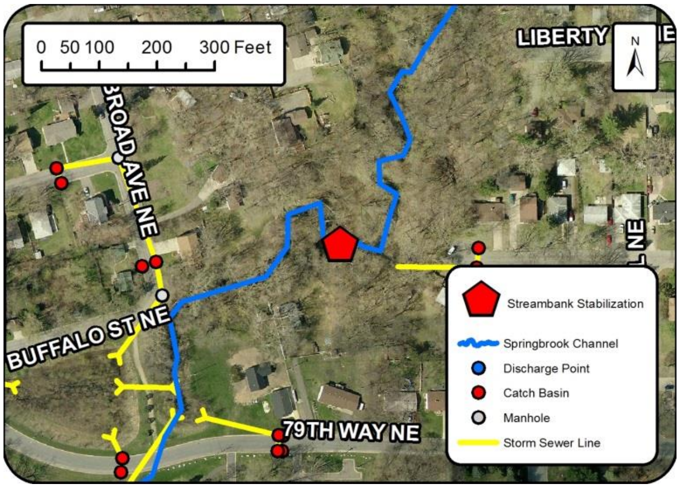
*Indirect Cost: 100 hours at $73/hour

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

***($10,000/acre for IESF) + ($2,000/acre for sed. basin) + $6,000 for annual lift station maintenance and calibration

Project ID: 16-F

Streambank Stabilization
Ditch Inspection Station
11+00



Drainage Area – 2,701.9 acres
Location – Ditch inspection station 11+00
Property Ownership – Private
Information – During the 2011 ditch inspection significant erosion was found along the streambank at station 11+00 (see photo to right). A project is proposed to stabilize the bank and toe of the slope with rip rap and erosion control blankets. Pollutant reduction estimates are listed in the table below. Percent reductions are based on subwatershed-wide pollutant inputs to the creek. Eroding face height was estimated to be 10 ft. on average across the project reach. The recession rate was estimated to be 0.3 ft/yr.

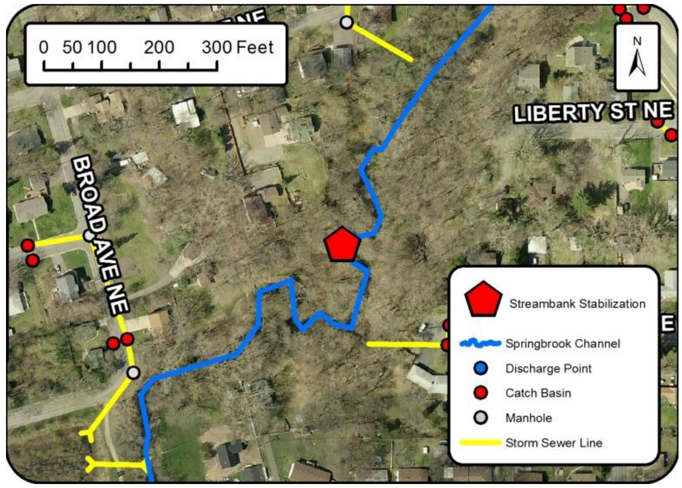
Streambank Stabilization

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Estimated Length of Stabilization	50	ft
	TP (lb/yr)	12.0	1.4%
	TSS (lb/yr)	15,000	7.0%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	Administration & Promotion Costs*	$2,920	
	Design & Construction Costs**	$35,000	
	Total Estimated Project Cost (2015)	**$37,920**	
	Annual O&M***	$500	
Efficiency	30-yr Average Cost/lb-TP	**$147**	
	30-yr Average Cost/1,000lb-TSS	**$118**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

*Indirect Cost: 40 hours at $73/hour
**Direct Cost: ($500/linear-ft for materials and labor) + ($10,000 for design)
***$10/linear-ft - Annual inspection and regular maintenance

Project ID: 16-G

Streambank Stabilization
Ditch Inspection Station
12+00



Drainage Area – 2,701.9 acres
Location – Ditch inspection station 12+00
Property Ownership – Private
Information – During the 2011 ditch inspection significant erosion was found along the streambank at station 12+00 (see photo to right). A project is proposed to stabilize the bank and toe of the slope with rip rap and erosion control blankets. Pollutant reduction estimates are listed in the table below. Percent reductions are based on subwatershed-wide pollutant inputs to the creek. Eroding face height was estimated to be 5 ft. on average across the project reach. The recession rate was estimated to be 0.15 ft/yr.

Streambank Stabilization

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Estimated Length of Stabilization	50	ft
	TP (lb/yr)	3.0	0.3%
	TSS (lb/yr)	3,750	1.8%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	Administration & Promotion Costs*		$2,920
	Design & Construction Costs**		$35,000
	Total Estimated Project Cost (2015)		**$37,920**
	Annual O&M***		$500
Efficiency	30-yr Average Cost/lb-TP	**$588**	
	30-yr Average Cost/1,000lb-TSS	**$470**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

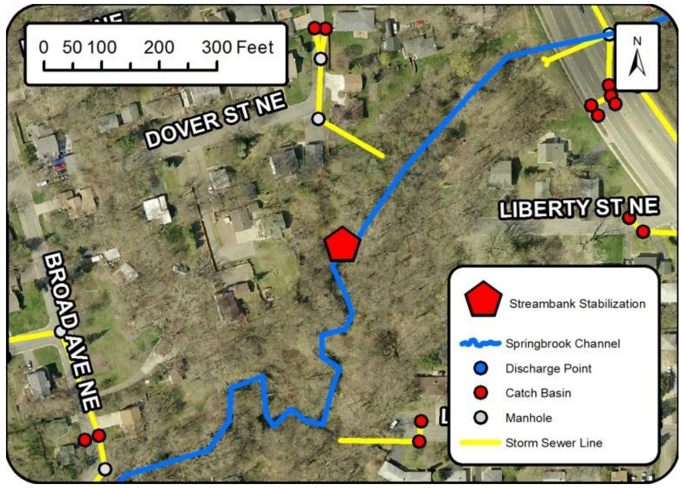
*Indirect Cost: 40 hours at $73/hour

**Direct Cost: ($500/linear-ft for materials and labor) + ($10,000 for design)

***$10/linear-ft - Annual inspection and regular maintenance

Project ID: 16-H

Streambank Stabilization
Ditch Inspection Station
15+00



Drainage Area – 2,701.9 acres
Location – Ditch inspection station 15+00
Property Ownership – Private
Information – During the 2011 ditch inspection significant erosion was found along the streambank at station 15+00 (see photo to right). A project is proposed to stabilize the bank and toe of the slope with rip rap and erosion control blankets. Pollutant reduction estimates are listed in the table below. Percent reductions are based on subwatershed-wide pollutant inputs to the creek. Eroding face height was estimated to be 3 ft. on average across the project reach. The recession rate was estimated to be 0.15 ft/yr.

	Streambank Stabilization		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Estimated Length of Stabilization	30	ft
	TP (lb/yr)	1.1	0.1%
	TSS (lb/yr)	1,350	0.6%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$2,920	
	Design & Construction Costs**	$25,000	
	Total Estimated Project Cost (2015)	**$27,920**	
	Annual O&M***	$300	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,119**	
	30-yr Average Cost/1,000lb-TSS	**$912**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

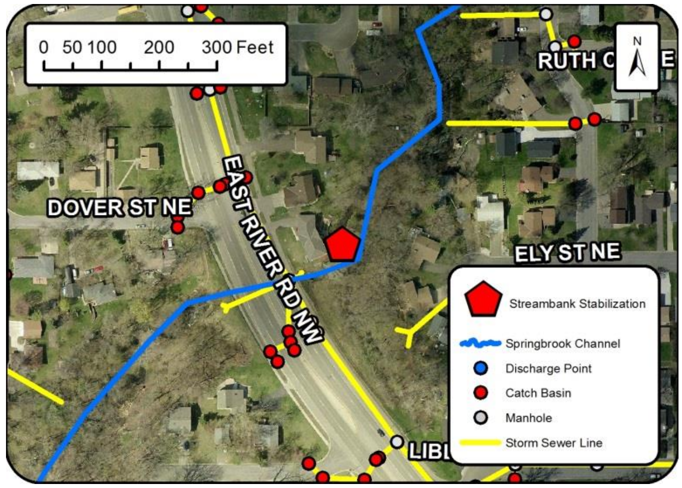
*Indirect Cost: 40 hours at $73/hour

**Direct Cost: ($500/linear-ft for materials and labor) + ($10,000 for design)

***$10/linear-ft - Annual inspection and regular maintenance

Project ID: 16-I

Streambank Stabilization
Ditch Inspection Station
23+00



Drainage Area – 2,701.9 acres
Location – Ditch inspection station 23+00
Property Ownership – Private
Information – During the 2011 ditch inspection significant erosion was found along the streambank at station 23+00 (see photo to right). A project is proposed to stabilize the bank and toe of the slope with rip rap and erosion control blankets. Pollutant reduction estimates are listed in the table below. Percent reductions are based on subwatershed-wide pollutant inputs to the creek. Eroding face height was estimated to be 3 ft. on average across the project reach. The recession rate was estimated to be 0.15 ft/yr.

	Streambank Stabilization		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Estimated Length of Stabilization	20	ft
	TP (lb/yr)	0.7	0.1%
	TSS (lb/yr)	900	0.4%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$2,920	
	Design & Construction Costs**	$20,000	
	Total Estimated Project Cost (2015)	**$22,920**	
	Annual O&M***	$200	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,377**	
	30-yr Average Cost/1,000lb-TSS	**$1,071**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

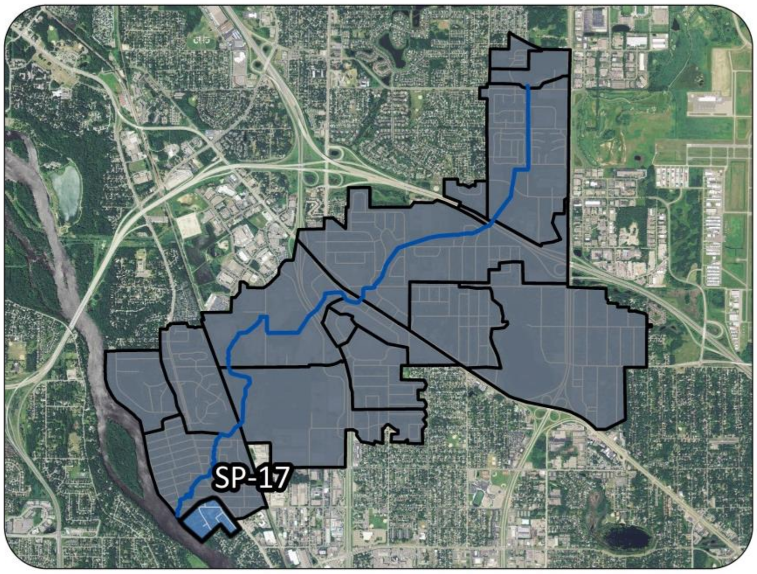
*Indirect Cost: 40 hours at $73/hour

**Direct Cost: ($500/linear-ft for materials and labor) + ($10,000 for design)

***$10/linear-ft - Annual inspection and regular maintenance

Catchment SP-17

Existing Catchment Summary	
Acres	144.4
Dominant Land Cover	Residential
Parcels	71



CATCHMENT DESCRIPTION
Catchment SP-17 is primarily single-family residential lots. Other land uses in the catchment include multi-family townhomes along East River Road NE, Craig Park in the central portion of the catchment, and Riverview Heights Park along the Mississippi River.

Stormwater runoff generated within the catchment flows to storm sewer lines running from Pearson Way NE to Bellaire Way NE and discharges directly to the Mississippi River within Riverview Heights Park. ***This catchment, similar to SP-14, is not hydrologically connected to Springbrook.***

EXISTING STORMWATER TREATMENT
No structural stormwater BMPs exist within this catchment.

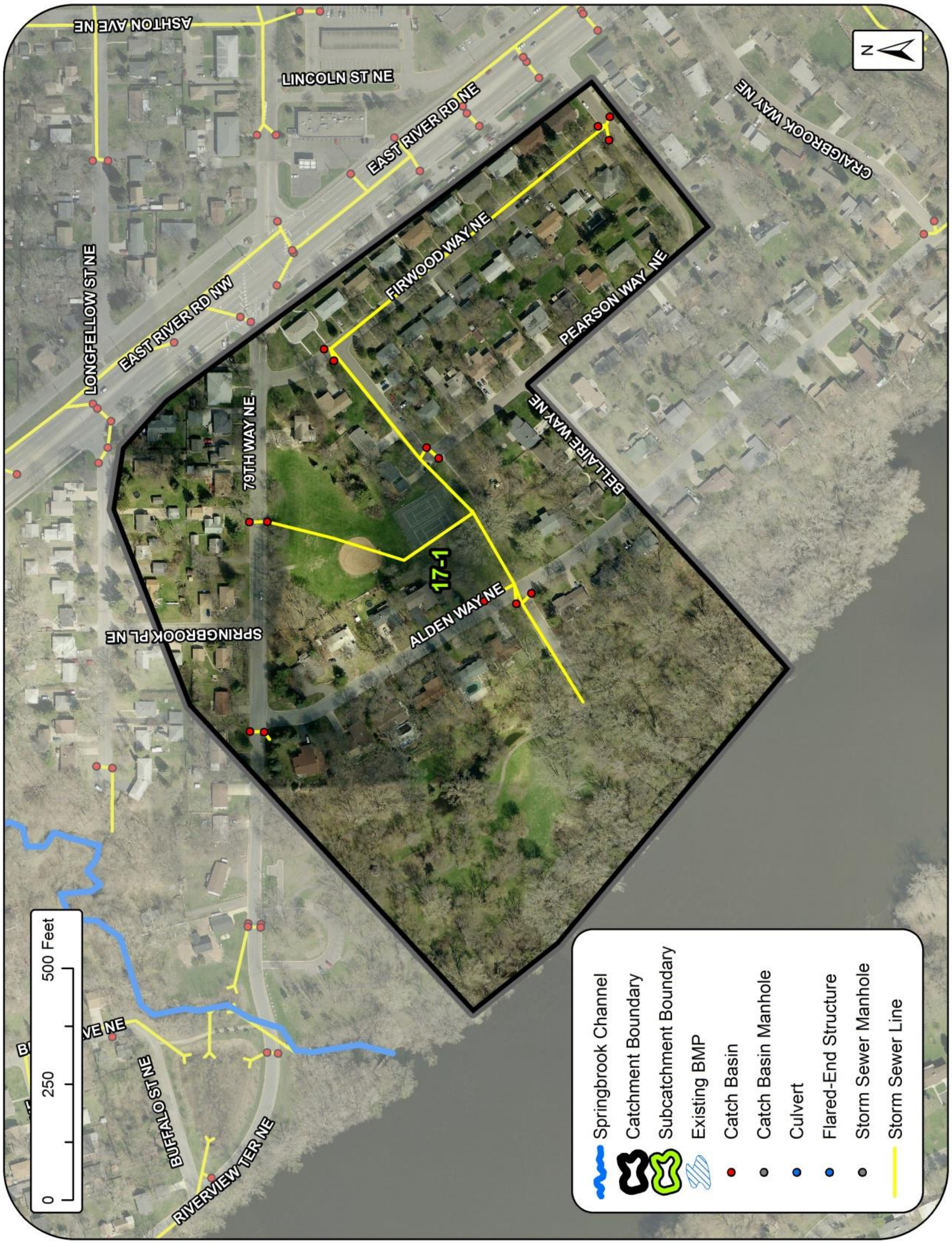
Listed below are base and existing loading for catchment SP-17.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	0			
	BMP Types	N/A			
	TP (lb/yr)	21.3	0.0	0%	**21.3**
	TSS (lb/yr)	5,891	0	0%	**5,891**
	Volume (acre-feet/yr)	13.4	0.0	0%	**13.4**

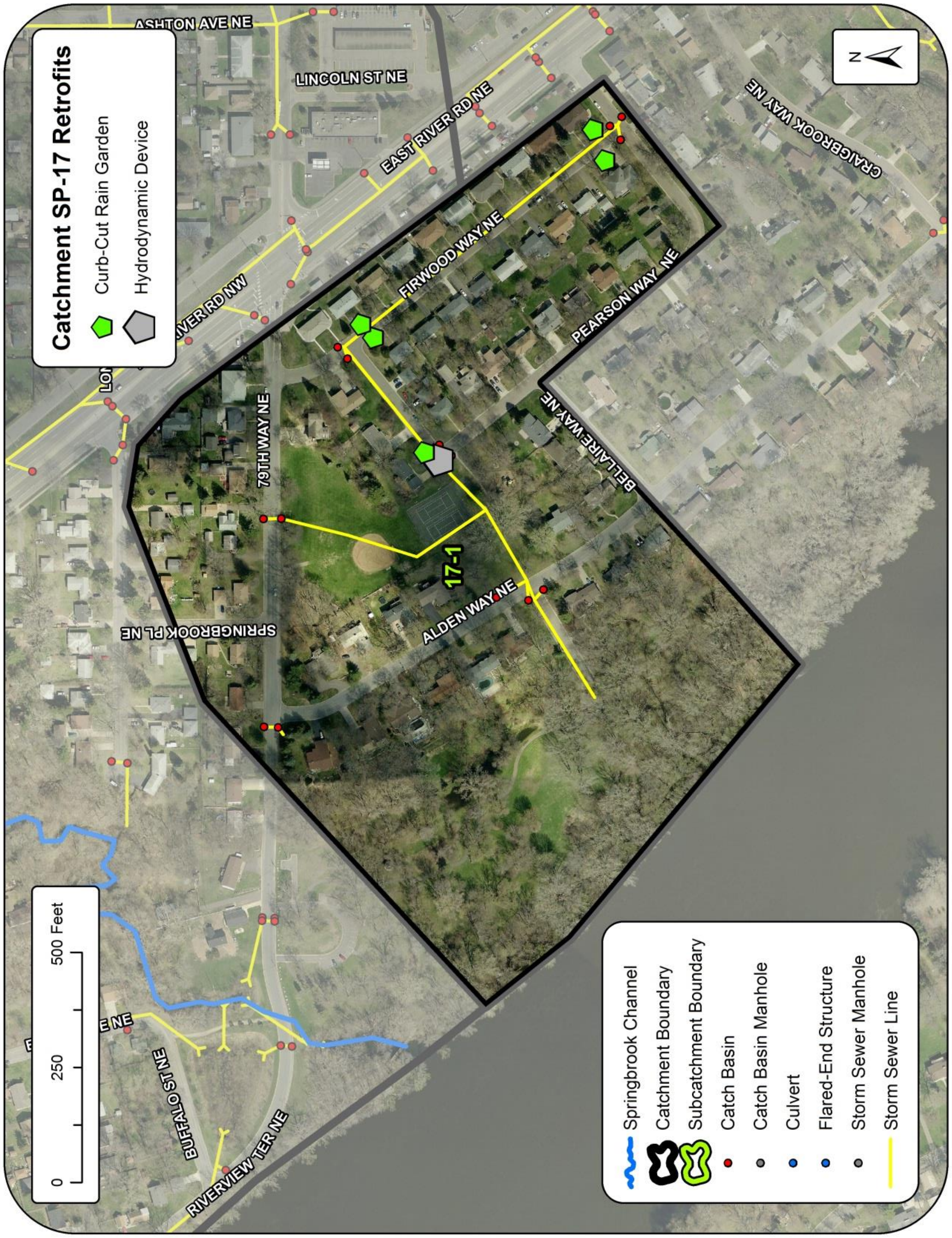
PROPOSED RETROFITS OVERVIEW
Curb-cut rain gardens were proposed along Firwood Way NE and Pearson Way NE, east of Craig Park. A hydrodynamic device was also proposed along Pearson Way NE at the intersection of the existing storm sewer line with a trail leading to Craig Park.

As stormwater runoff from this catchment is discharged directly to the Mississippi River, and is not hydrologically connected to Springbrook, pollutant reductions ***would solely benefit the Mississippi River***.

CURRENT STORMWATER INFRASTRUCTURE AND BMPS



POTENTIAL RETROFITS



Project ID: 17-A

Curb-cut Rain Gardens
Catchment 17

Drainage Area – Varies
Location – Throughout catchment SP-17
Property Ownership – Private
Site Specific Information – Single-family lots in catchment SP-17 provide various locations for curb-cut rain gardens to treat stormwater pollutants from private property. Five optimal sites were found through desktop analysis. Considering typical landowner participation rates, scenarios with 2 and 4 rain gardens were analyzed. Large slopes across many front yards for properties west of East River Road NE may also limit rain garden opportunities within the subcatchment.

Curb-Cut Rain Garden

	Cost/Removal Analysis	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	Number of BMPs	2		4	
	Total Size of BMPs	500	sq-ft	1,000	sq-ft
	TP (lb/yr)	1.5	7.0%	2.4	11.3%
	TSS (lb/yr)	487	8.3%	792	13.4%
	Volume (acre-feet/yr)	1.1	8.2%	1.8	13.4%
Cost	Administration & Promotion Costs*	$9,344		$11,096	
	Design & Construction Costs**	$14,752		$29,504	
	Total Estimated Project Cost (2015)	**$24,096**		**$40,600**	
	Annual O&M***	$450		$900	
Efficiency	30-yr Average Cost/lb-TP	**$835**		**$939**	
	30-yr Average Cost/1,000lb-TSS	**$2,573**		**$2,845**	
	30-yr Average Cost/ac-ft Vol.	**$1,139**		**$1,252**	

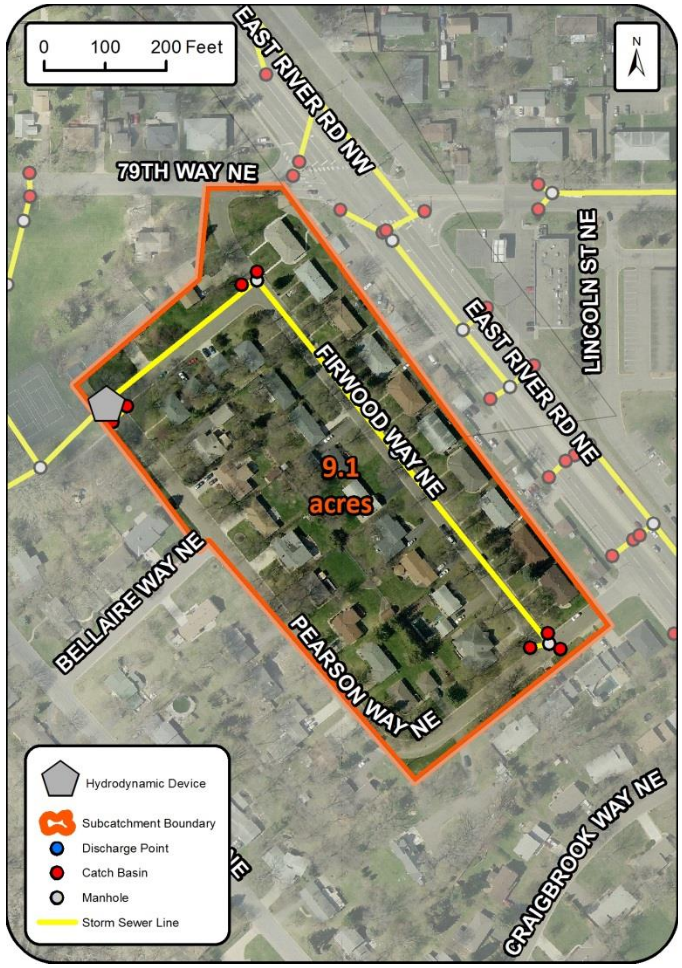
*Indirect Cost: (104 hours at $73/hour base cost) + (12 hours/BMP at $73/hour)

**Direct Cost: ($26/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)

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

Project ID: 17-B

Hydrodynamic Device
Subcatchment 17-1



Drainage Area – 9.1 acres
Location – Along Pearson Way NE east of Craig Park
Property Ownership – Public (City of Fridley)
Site Specific Information – A hydrodynamic device could be installed to accept runoff from stormwater catch basins draining single-family residences along Pearson Way NE and Firwood Way NE. The table below assumes the device is installed such that it accepts runoff from each catch basin on the roadways east of the park and west of East River Road NE.

Hydrodynamic Device

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMPs	10	ft diameter
	TP (lb/yr)	0.9	4.2%
	TSS (lb/yr)	384	6.5%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	Administration & Promotion Costs*	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2015)	**$109,752**	
	Annual O&M***	$840	
Efficiency	30-yr Average Cost/lb-TP	**$4,998**	
	30-yr Average Cost/1,000lb-TSS	**$11,715**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

*Indirect Cost: (24 hours at $73/hour)

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

***Per BMP: (4 cleanings/year)*(3 hours/cleaning)*($70/hour)

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Appendix A – Modeling Methods

The following sections include WinSLAMM model details for each type of best management practice modeled for this analysis. The sections are separated into general WinSLAMM model inputs, existing conditions, and proposed conditions.

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 10.1.1 was used for this analysis to estimate volume and pollutant loading and reductions. Additional inputs for WinSLAMM are provided in Table 17.

Table 17: 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 from state (MNDOT), county (Anoka County), and local (CCWD, municipalities of Blaine, Coon Rapids, Fridley, and Spring Lake Park) entities. The practices listed below were included in the existing conditions model.

Hydrodynamic Devices

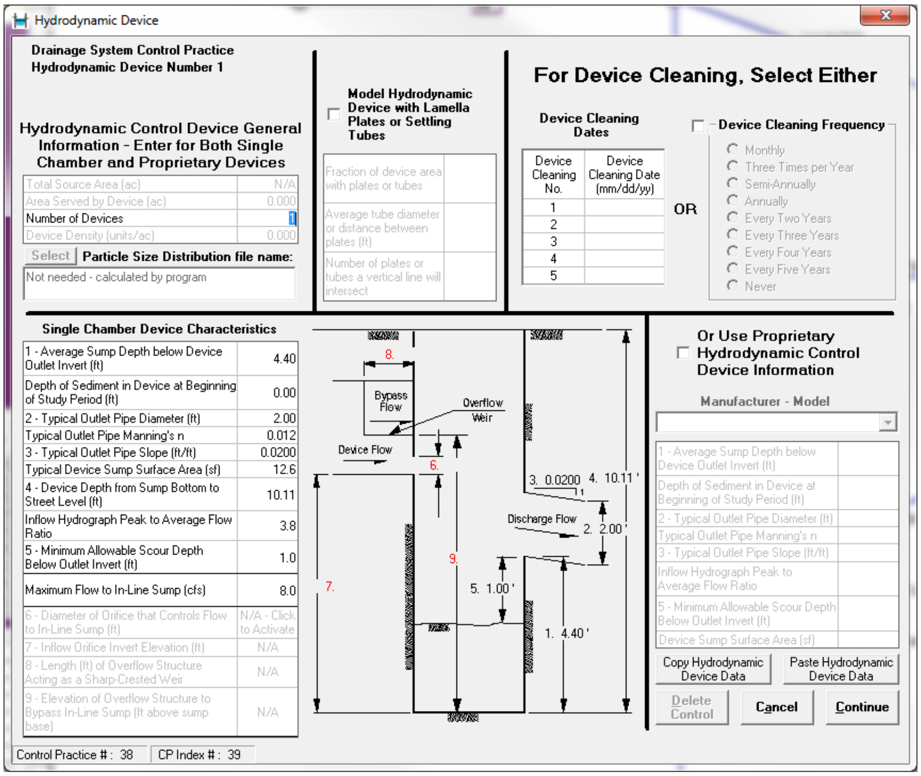

Figure 13: WinSLAMM model inputs for hydrodynamic device 1 (HD1) in Catchment SP-9

Infiltration Basins

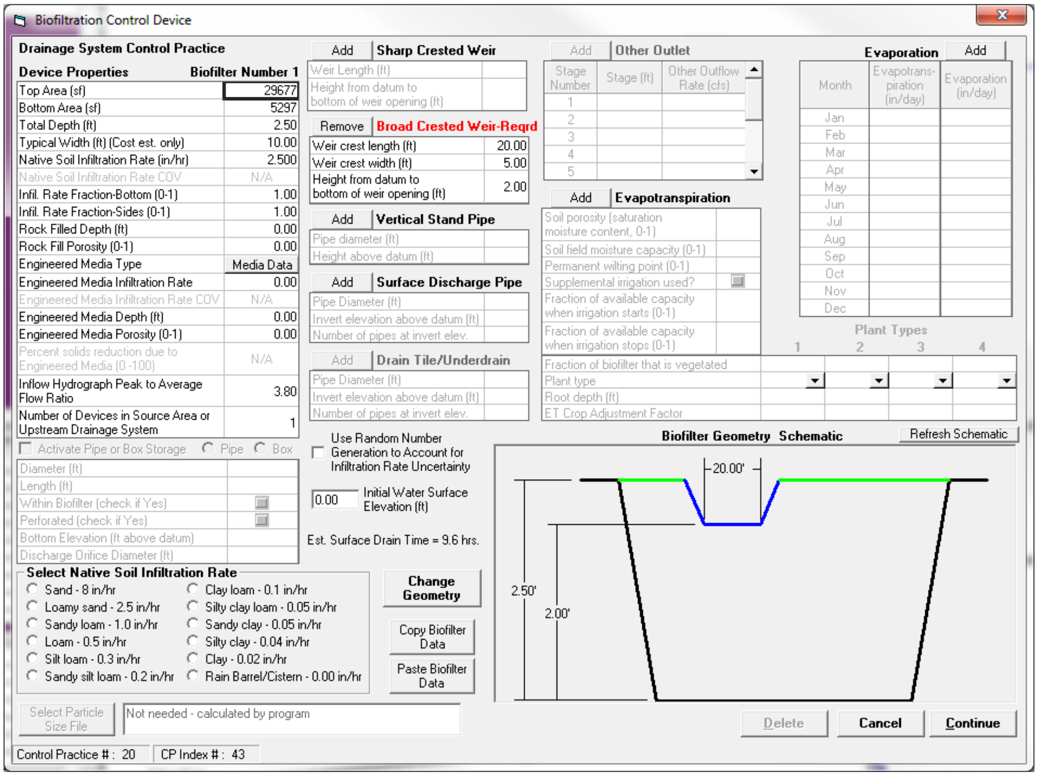

Figure 14: WinSLAMM model inputs for infiltration basin 1 (IB1) in Catchment SP-6

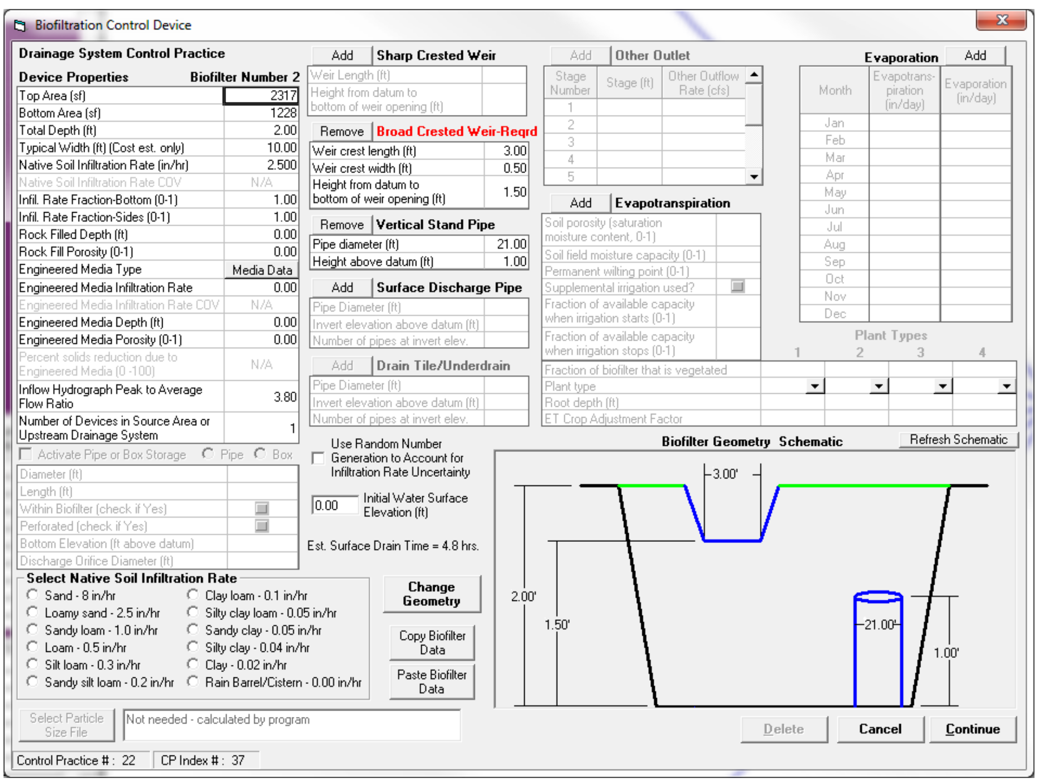

Figure 15: WinSLAMM model inputs for infiltration basin 2 (IB2) in Catchment SP-6

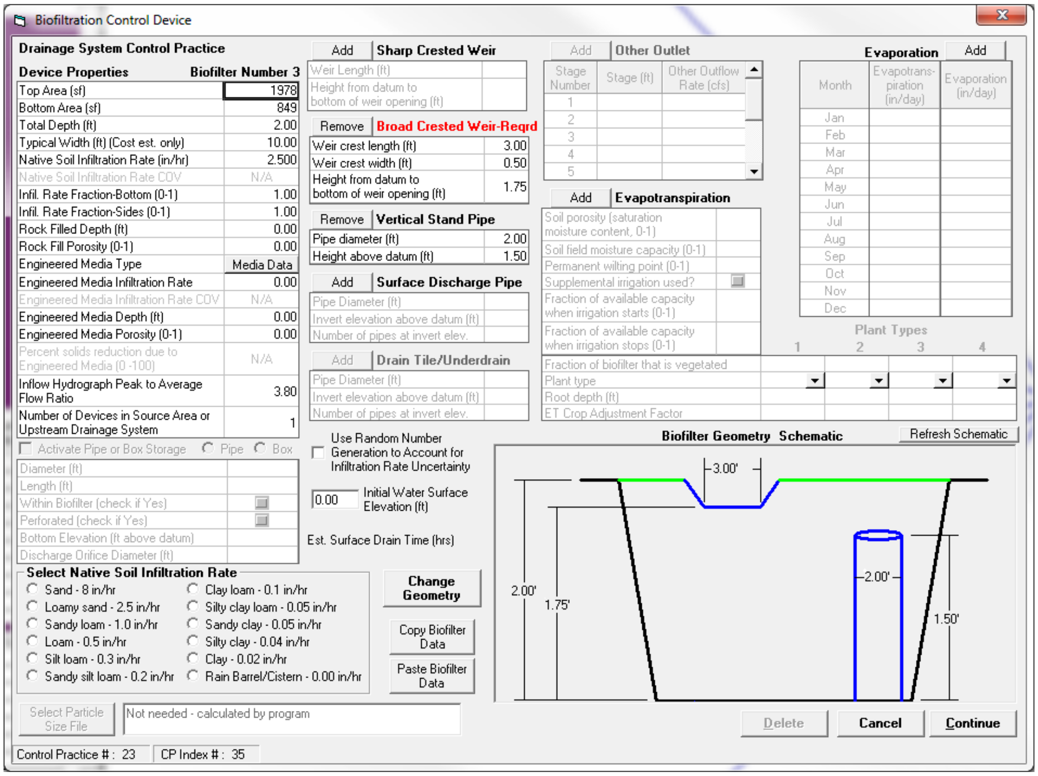

Figure 16: WinSLAMM model inputs for infiltration basin 3 (IB3) in Catchment SP-6

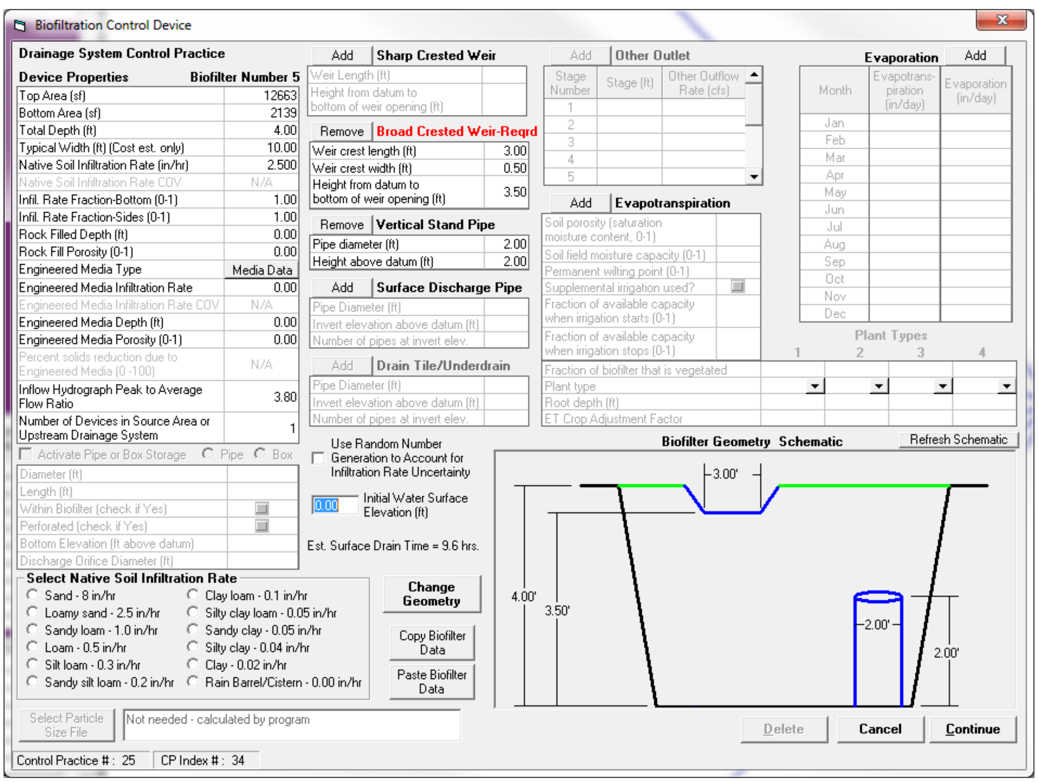

Figure 17: WinSLAMM model inputs for infiltration basin 4 (IB4) in Catchment SP-6

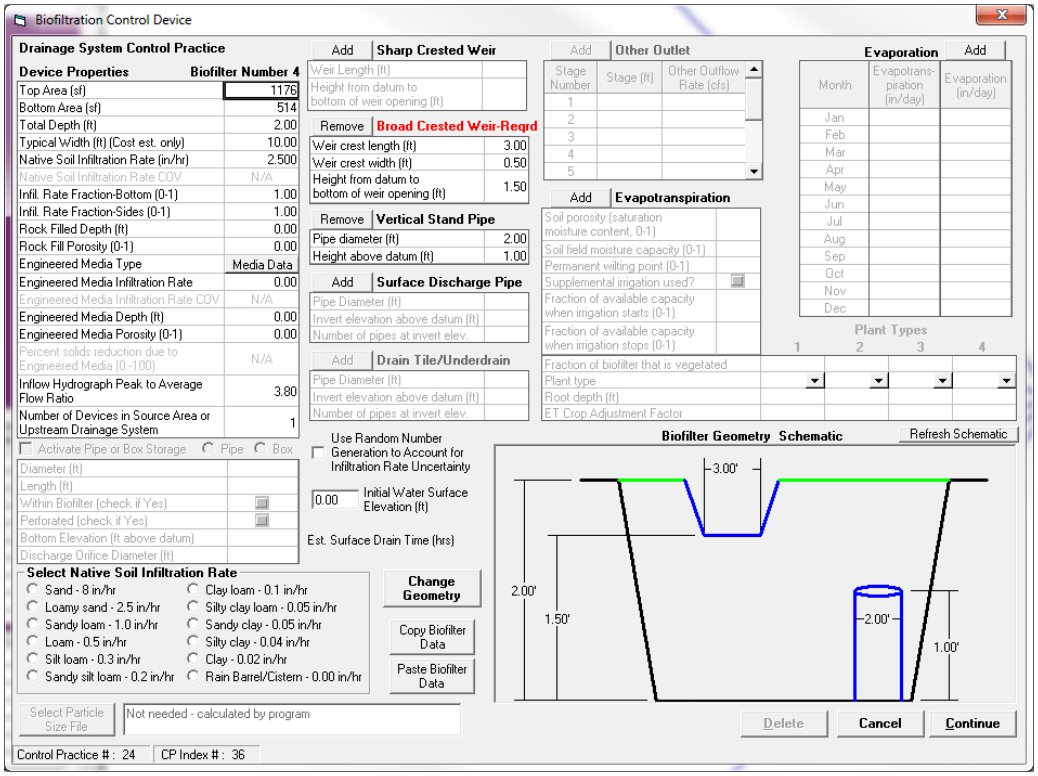

Figure 18: WinSLAMM model inputs for infiltration basin 5 (IB5) in Catchment SP-6

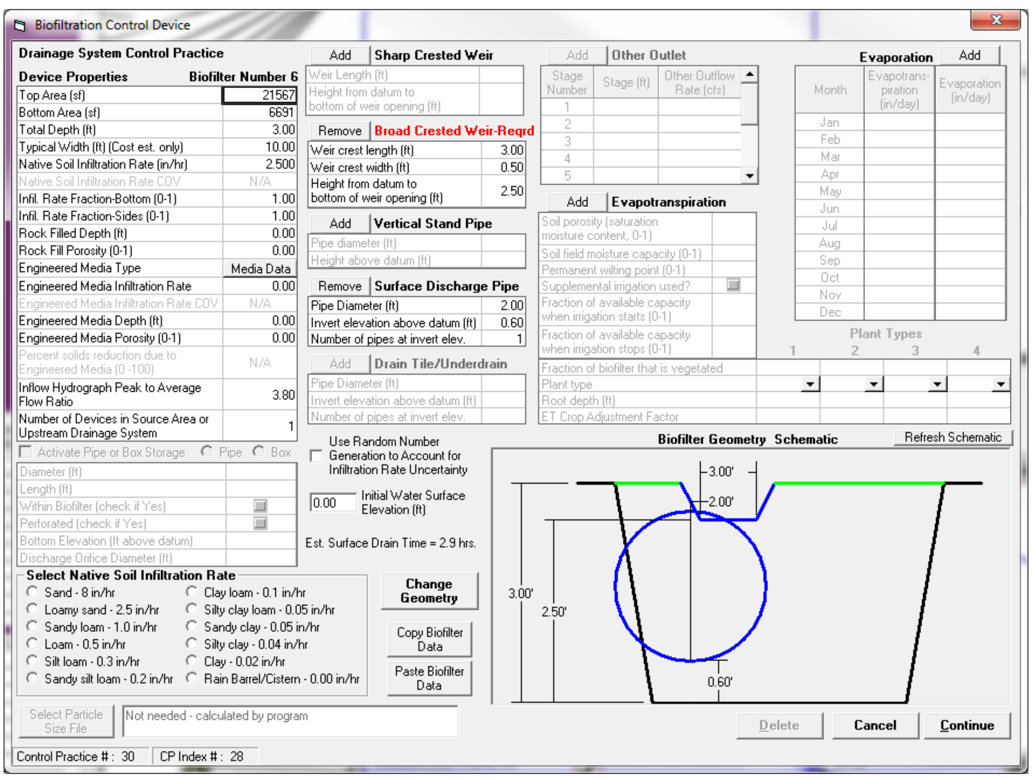

Figure 19: WinSLAMM model inputs for infiltration basin 6 (IB6) in Catchment SP-10

Natural Wetlands

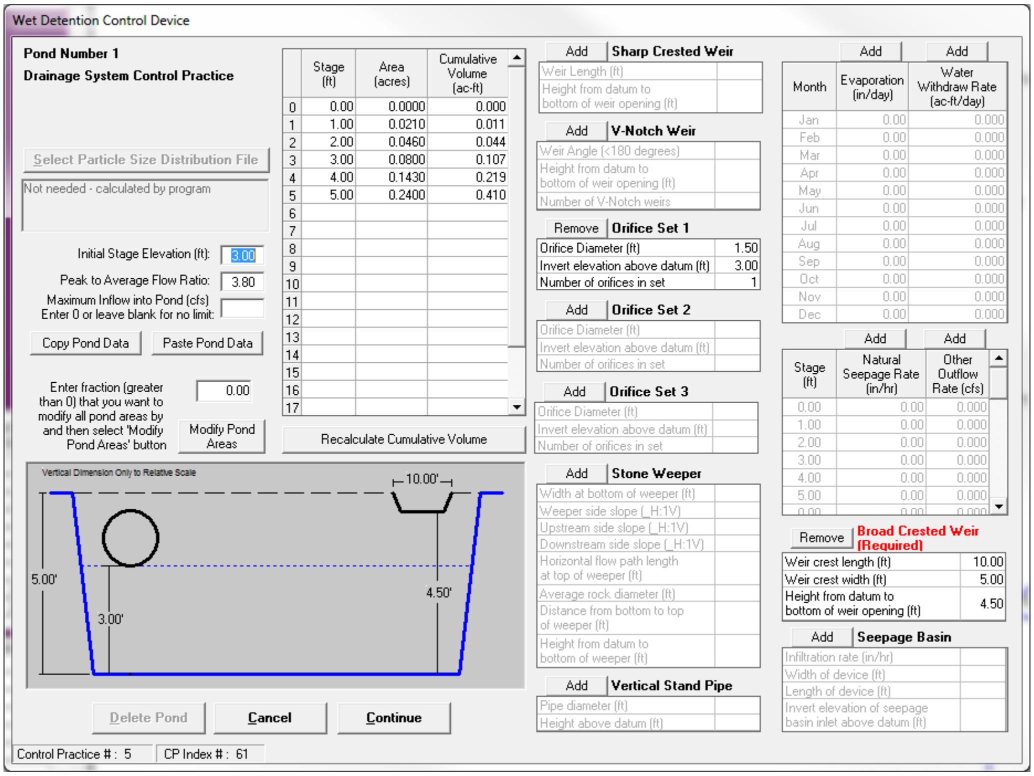

Figure 20: WinSLAMM model inputs for natural wetland 1 (NW1) in Catchment SP-1

Natural wetland 2 (NW2) was not modeled within WinSLAMM as it is hydrologically disconnected from the surrounding Springbrook subwatershed.

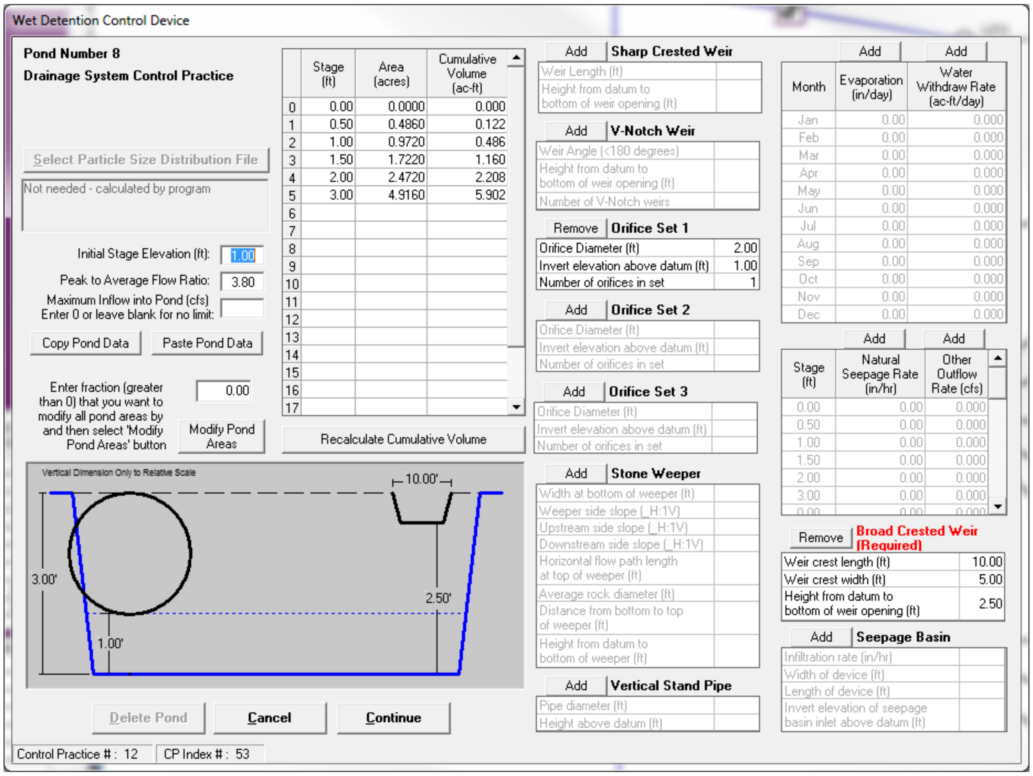

Figure 21: WinSLAMM model inputs for natural wetland 3 (NW3) in Catchment SP-3

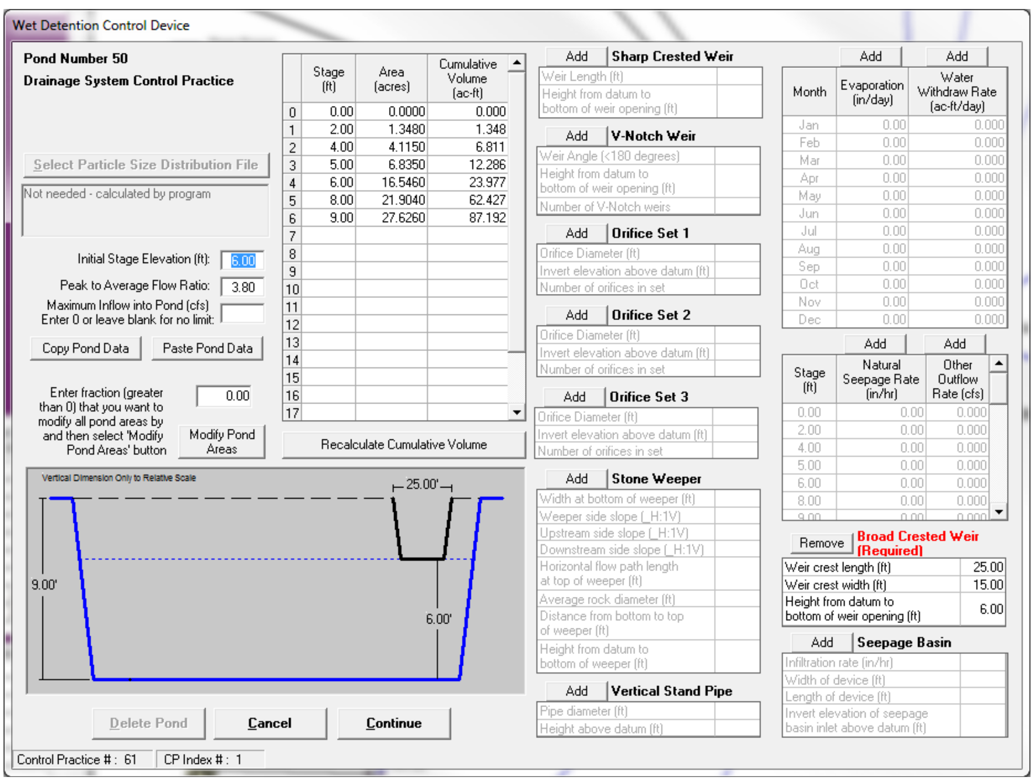

Figure 22: WinSLAMM model inputs for natural wetland 4 (NW4) in Catchment SP-13

Stormwater Ponds

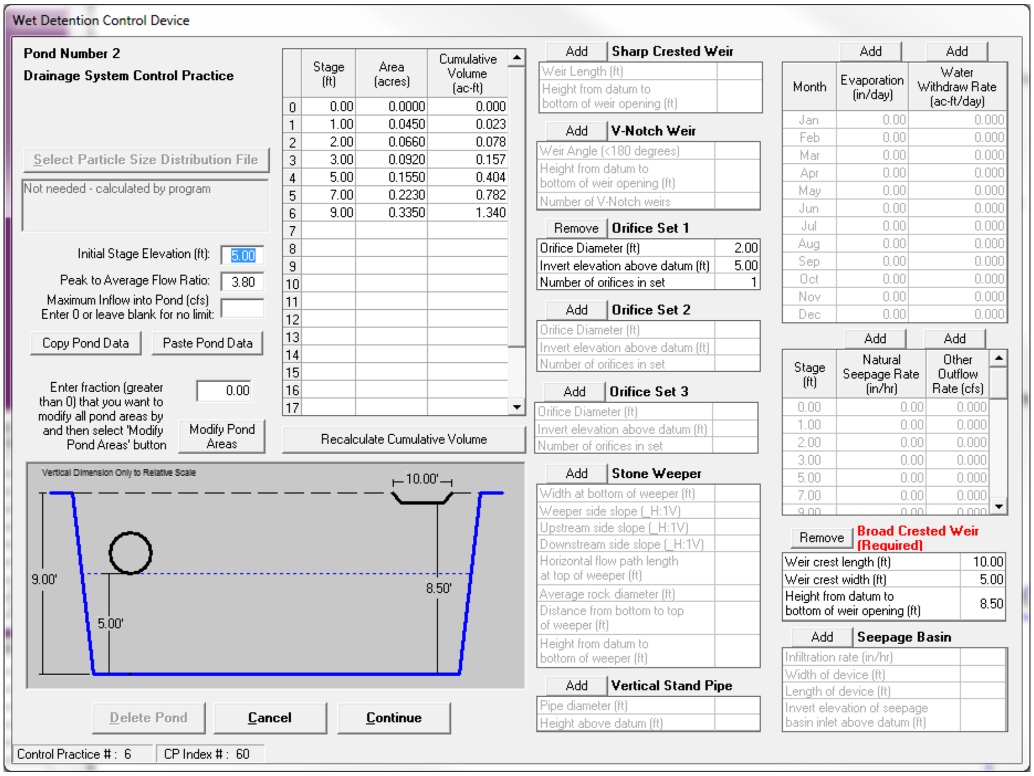

Figure 23: WinSLAMM model inputs for wet retention pond 1 (WP1) in Catchment SP-1

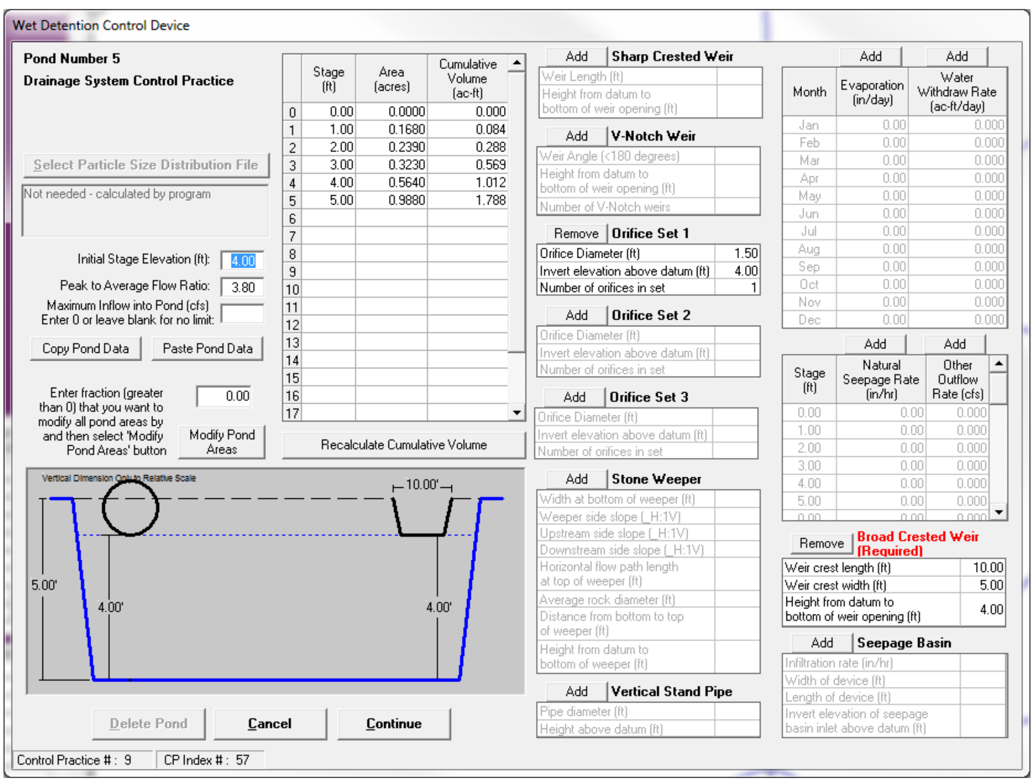

Figure 24: WinSLAMM model inputs for wet retention pond 2 (WP2) in Catchment SP-2

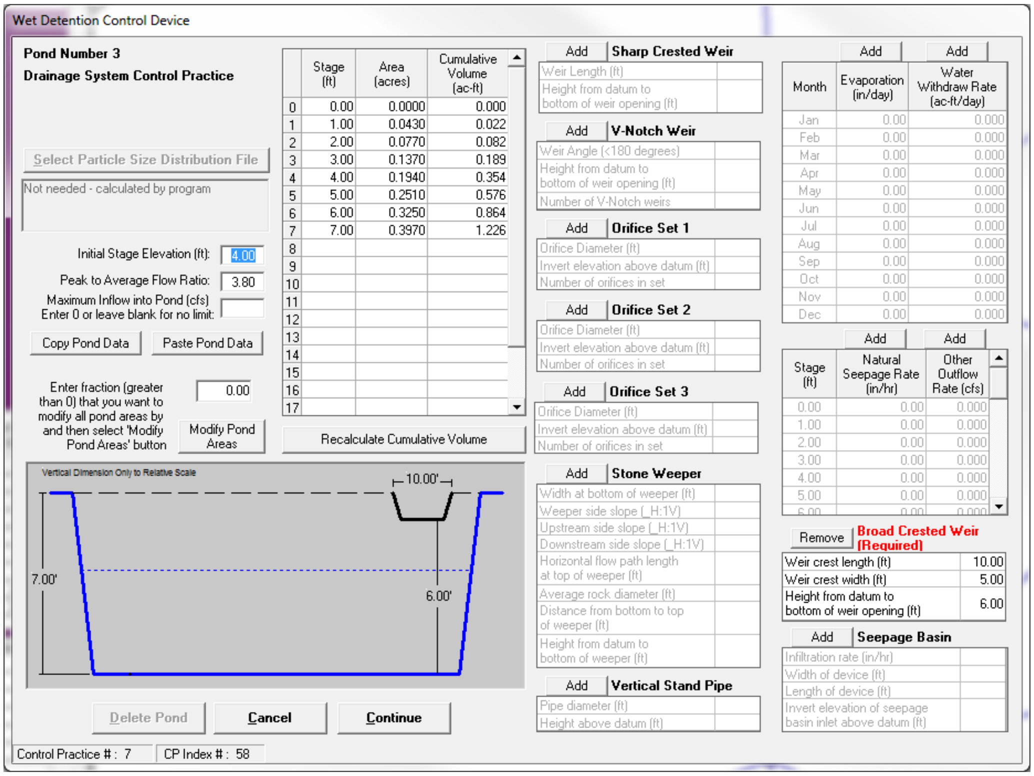

Figure 25: WinSLAMM model inputs for wet retention pond 3 (WP3) in Catchment SP-2

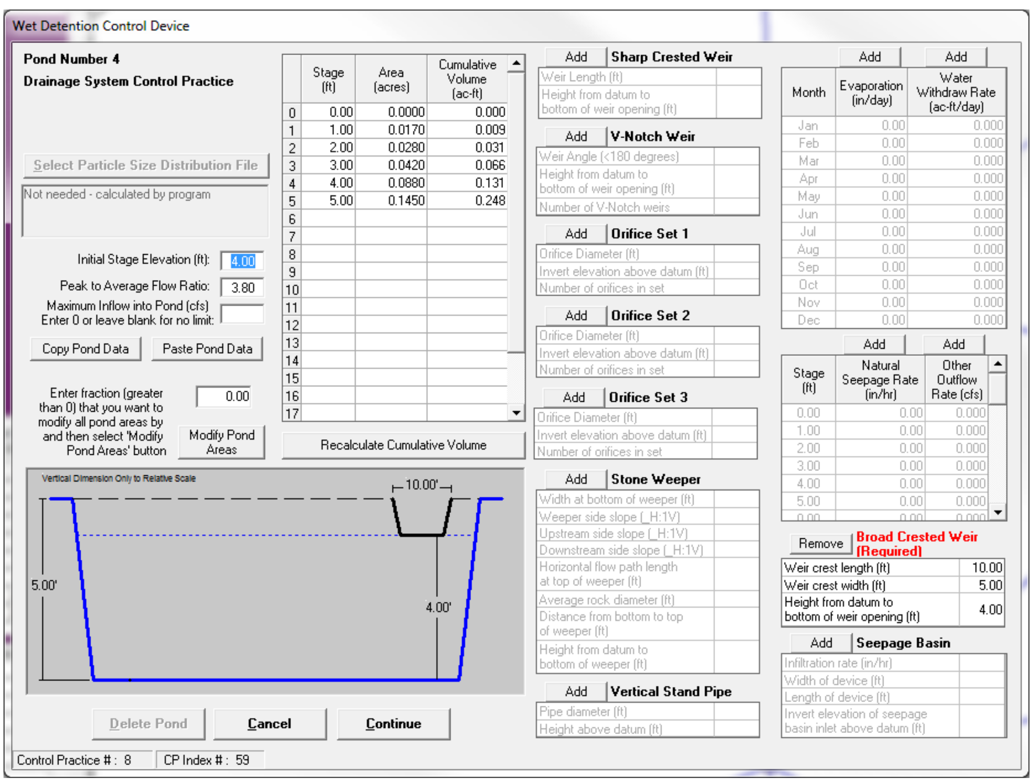

Figure 26: WinSLAMM model inputs for wet retention pond 4 (WP4) in Catchment SP-2

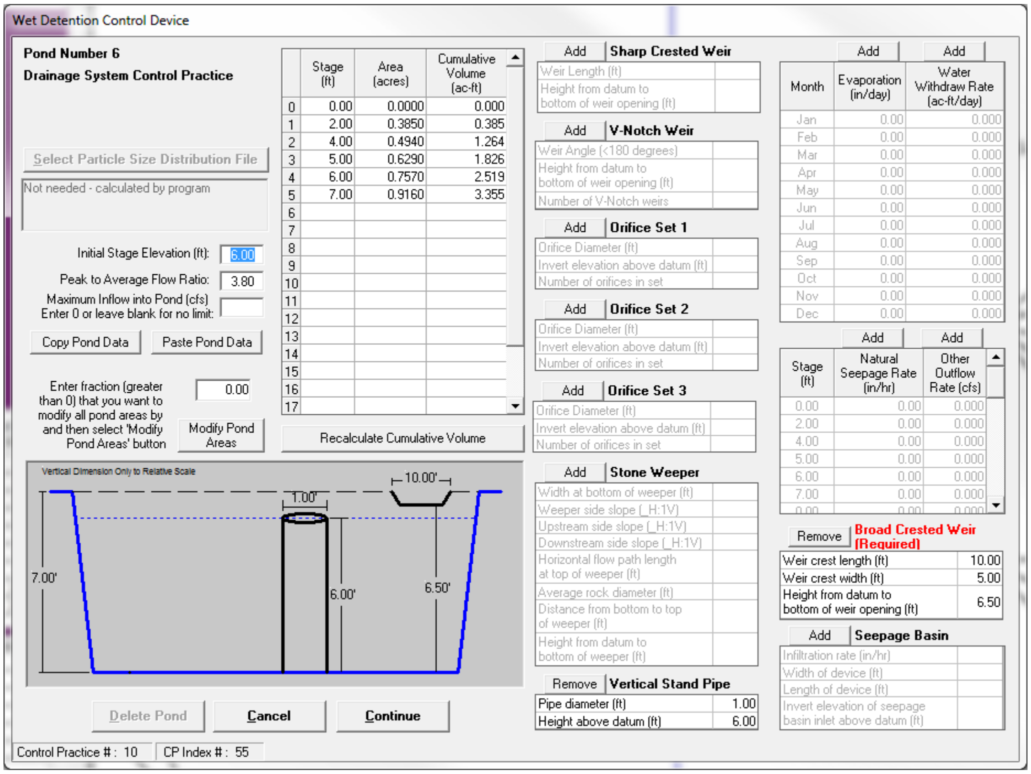

Figure 27: WinSLAMM model inputs for wet retention pond 5 (WP5) in Catchment SP-3

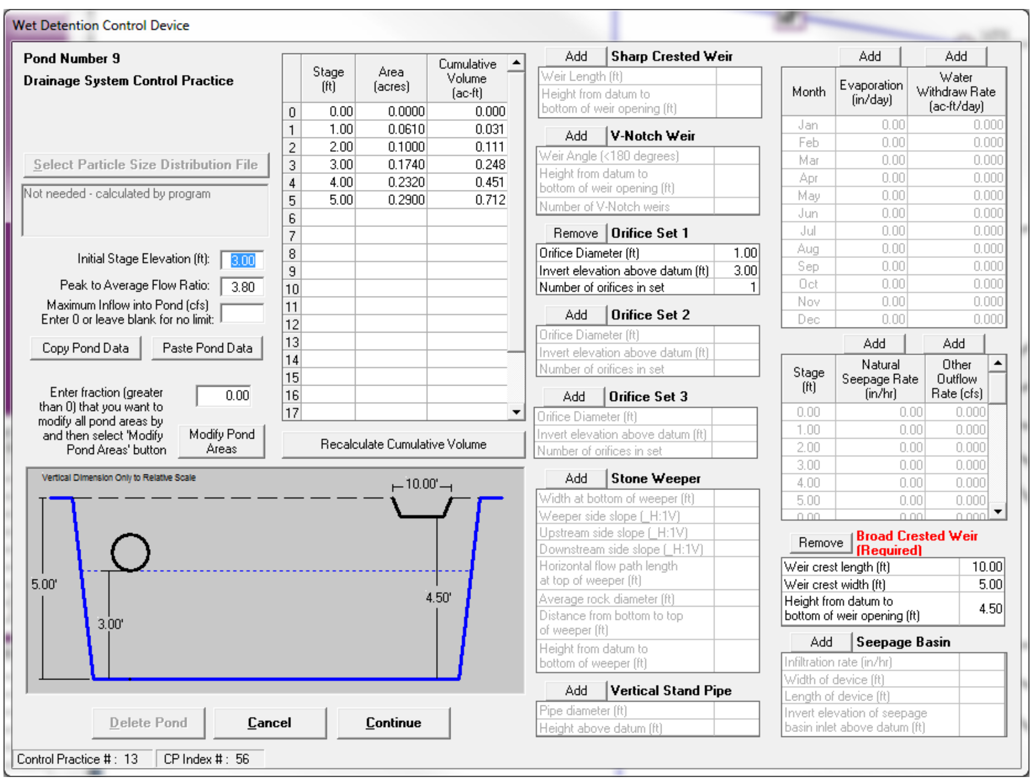

Figure 28: WinSLAMM model inputs for wet retention pond 6 (WP6) in Catchment SP-3

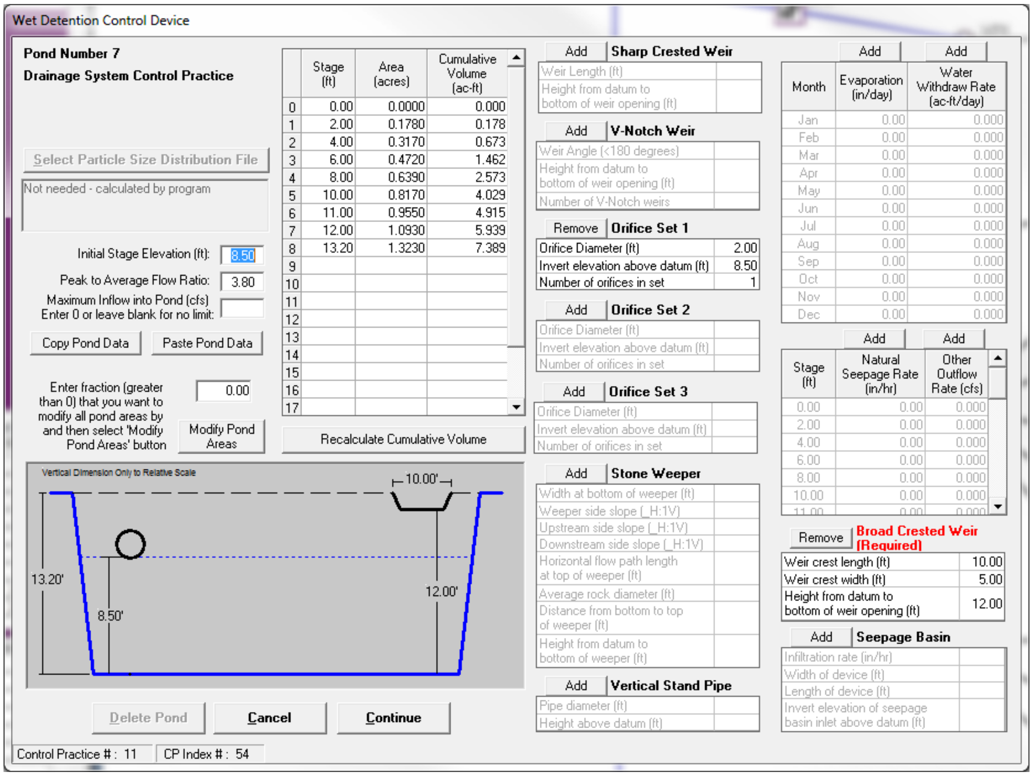

Figure 29: WinSLAMM model inputs for wet retention pond 7 (WP7) in Catchment SP-3

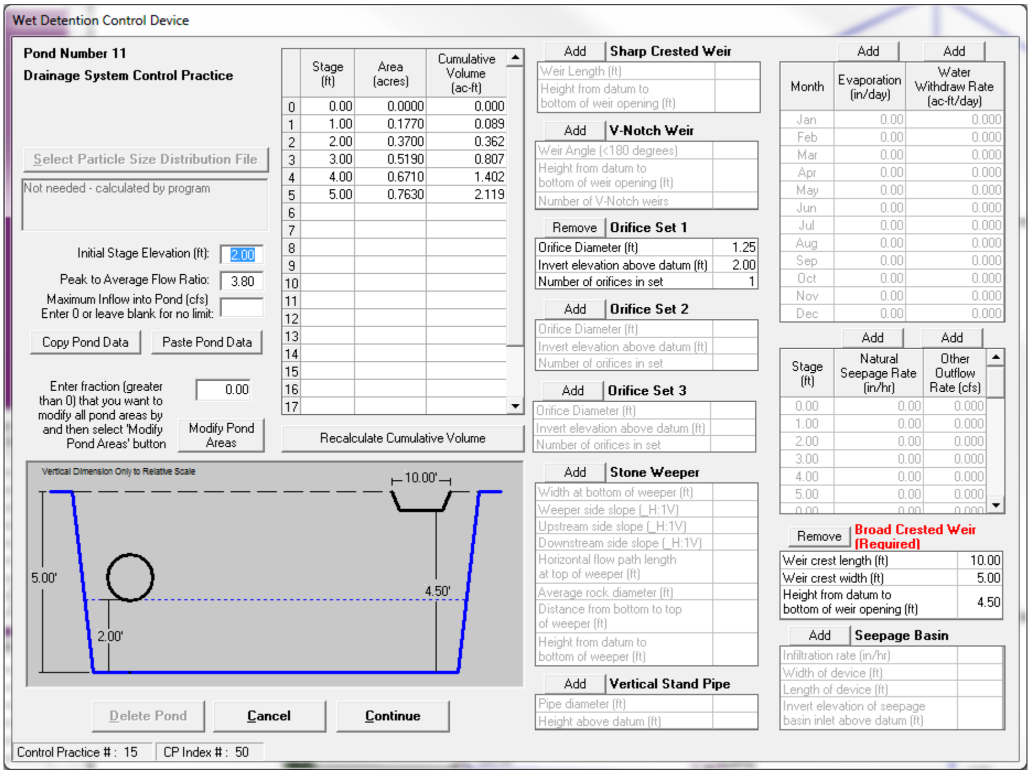

Figure 30: WinSLAMM model inputs for wet retention pond 8 (WP8) in Catchment SP-4

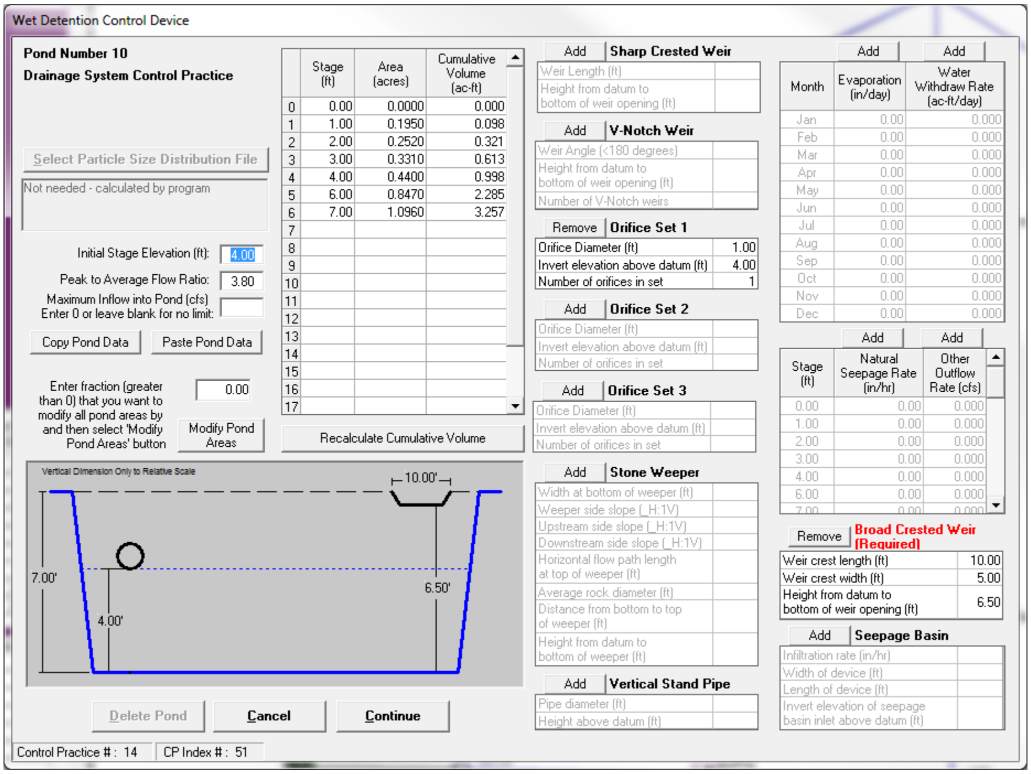

Figure 31: WinSLAMM model inputs for wet retention pond 9 (WP9) in Catchment SP-4

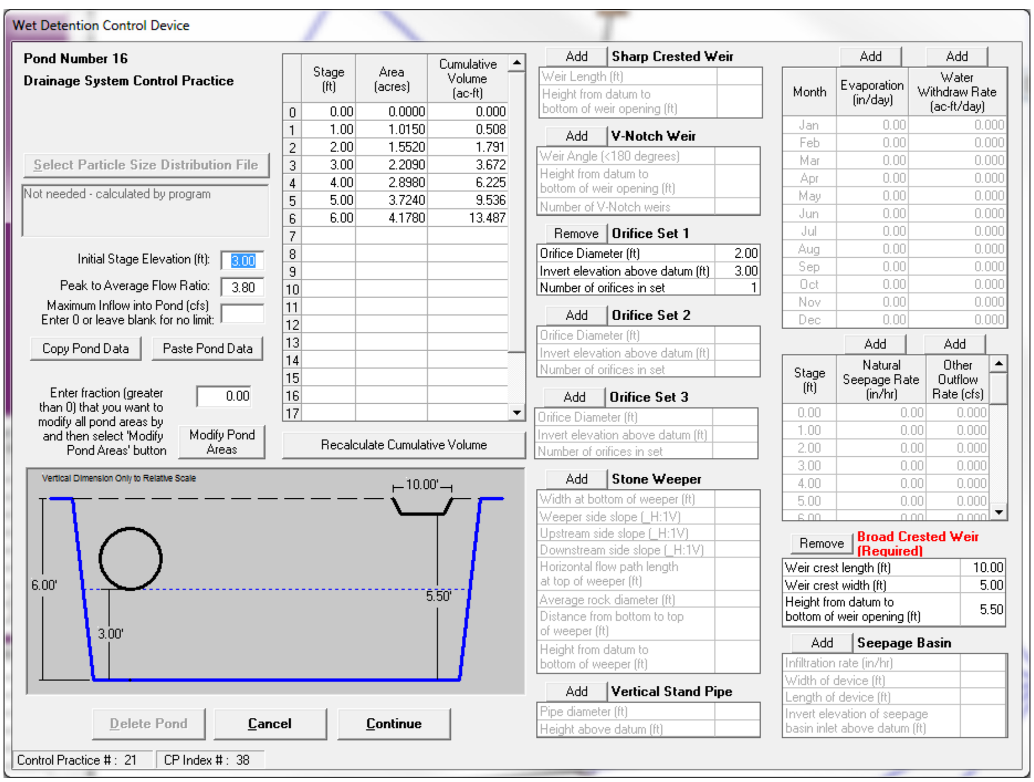

Figure 32: WinSLAMM model inputs for wet retention pond 10 (WP10) in Catchment SP-6

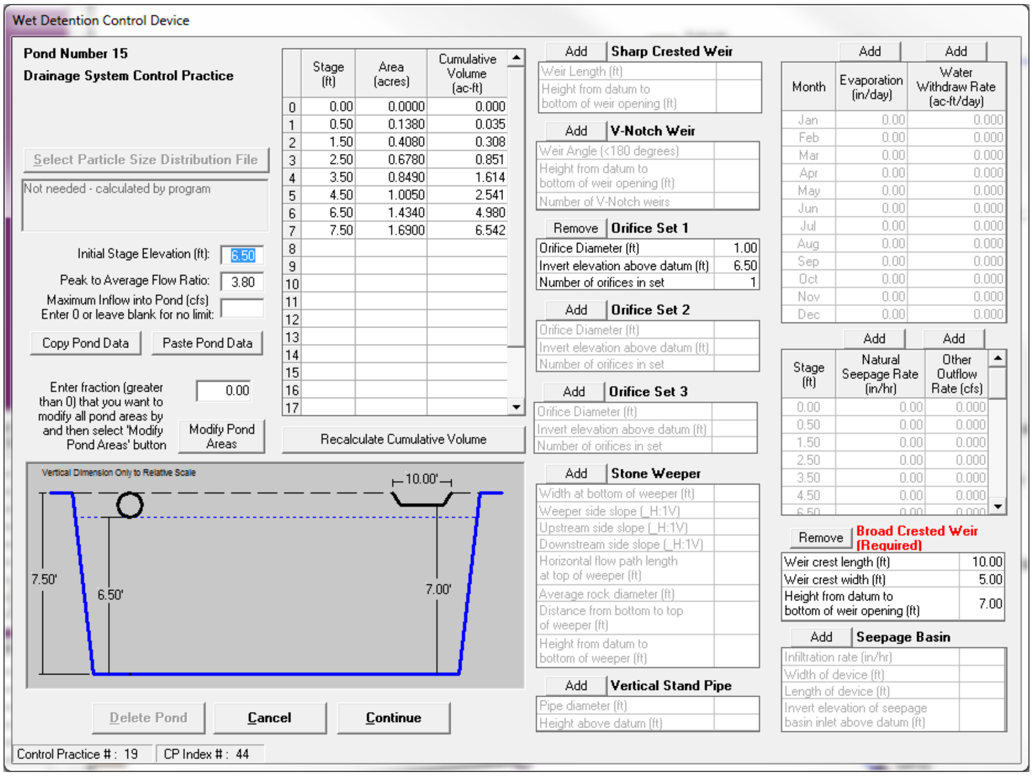

Figure 33: WinSLAMM model inputs for wet retention pond 11 (WP11) in Catchment SP-6

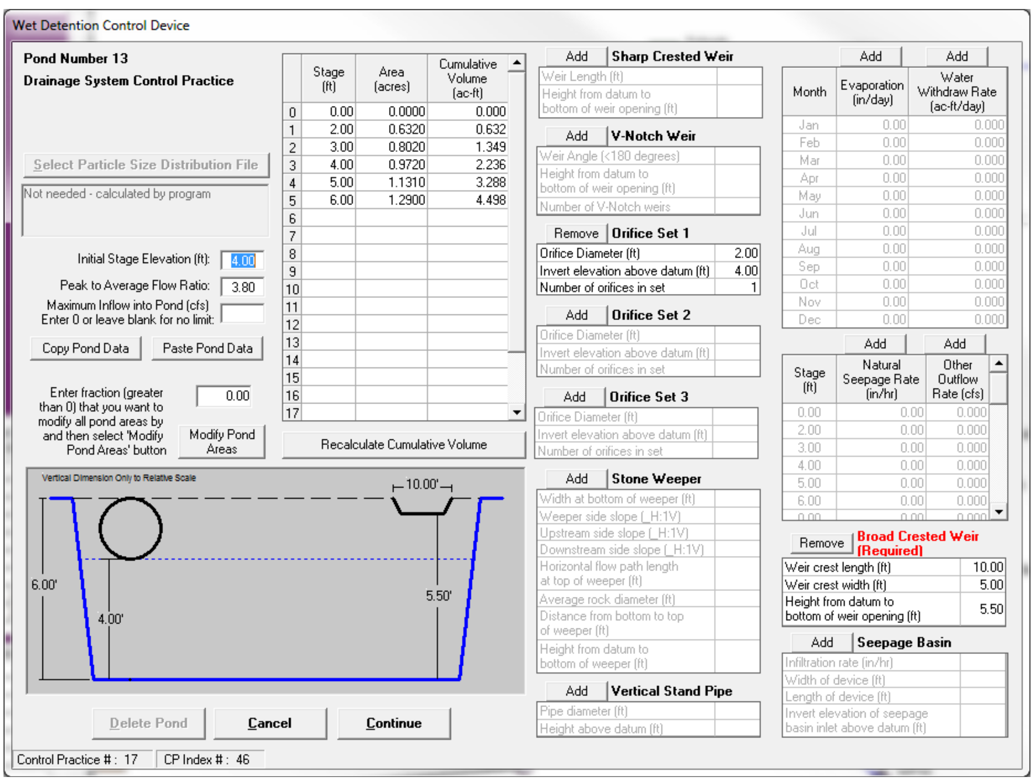

Figure 34: WinSLAMM model inputs for wet retention pond 12 (WP12) in Catchment SP-6

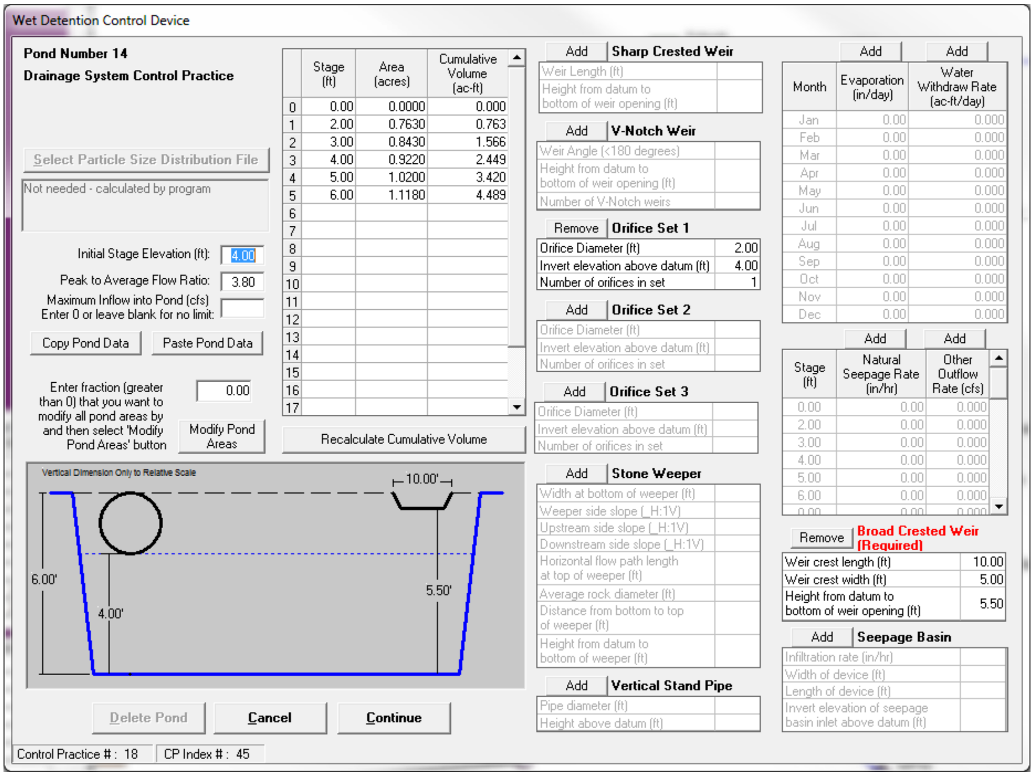

Figure 35: WinSLAMM model inputs for wet retention pond 13 (WP13) in Catchment SP-6

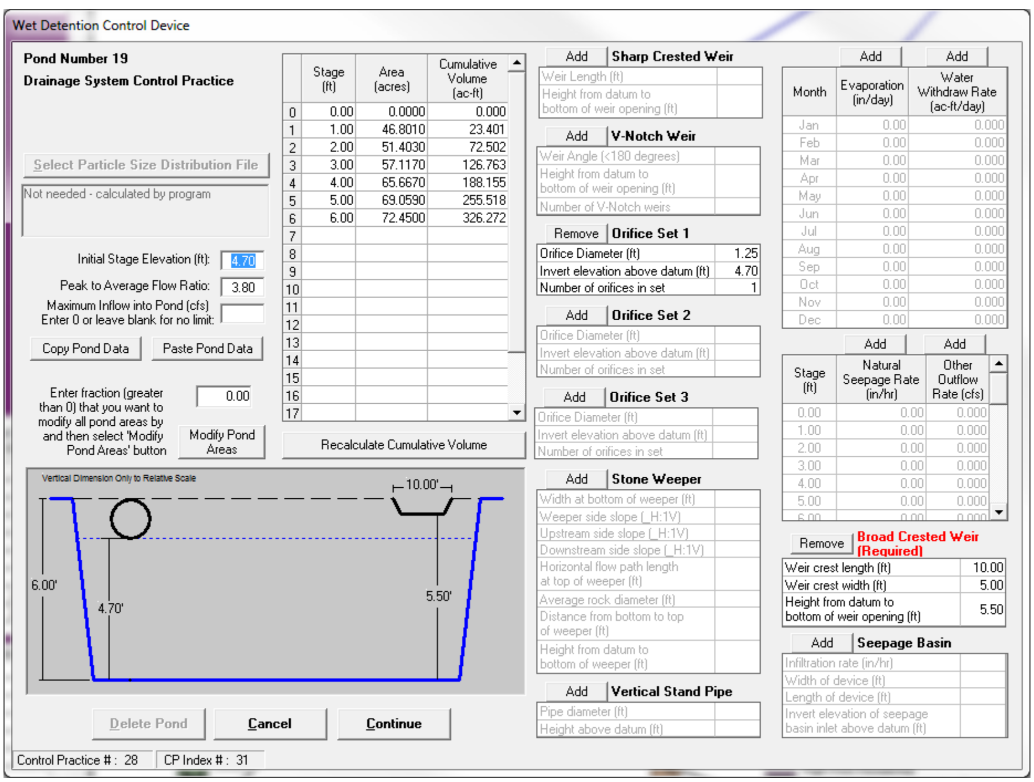

Figure 36: WinSLAMM model inputs for wet retention pond 14 (WP14) in Catchment SP-8

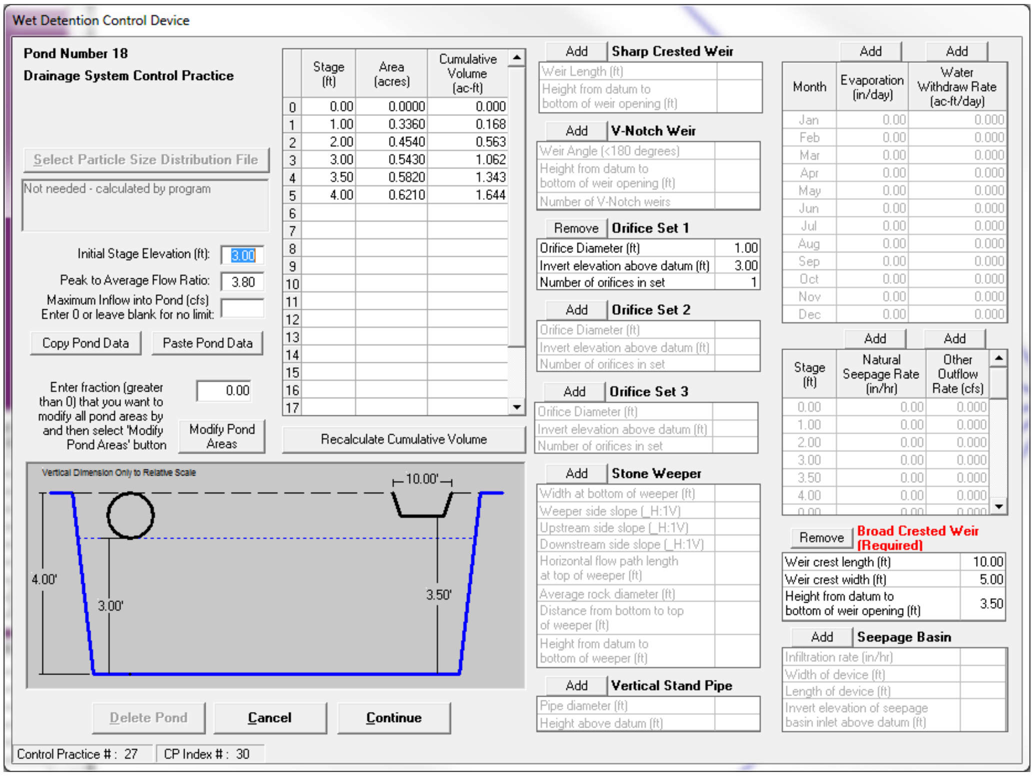

Figure 37: WinSLAMM model inputs for wet retention pond 15 (WP15) in Catchment SP-7

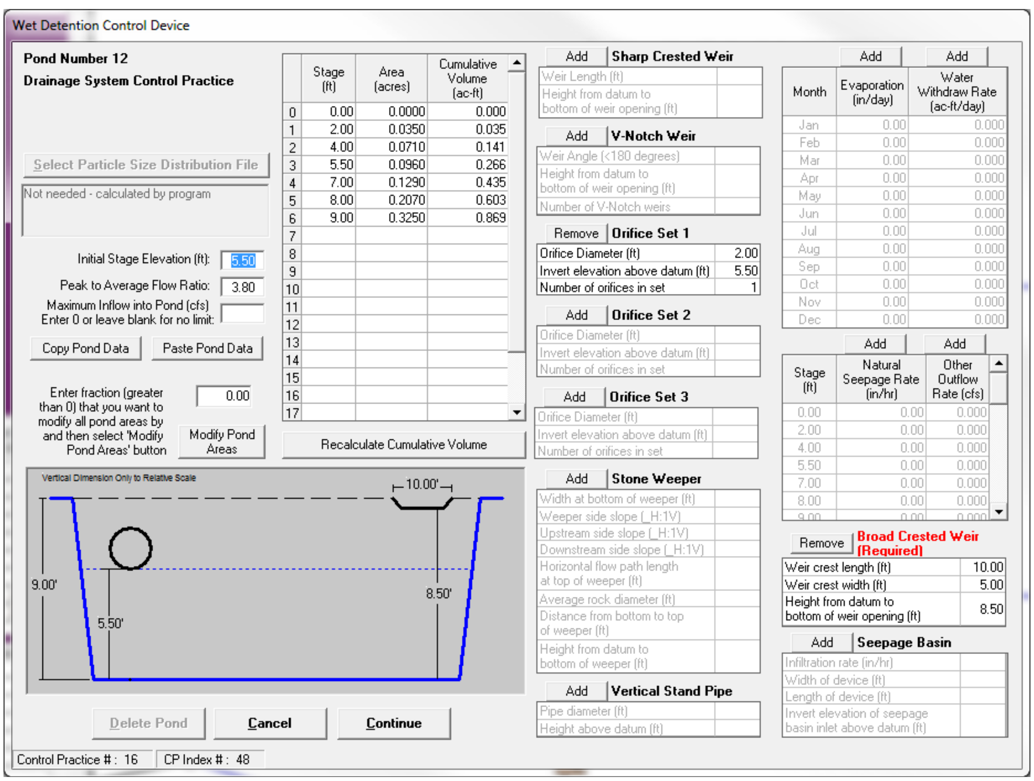

Figure 38: WinSLAMM model inputs for wet retention pond 16 (WP16) in Catchment SP-5

WP17 and IB7 were deemed disconnected in all but very large storm events based on storage available. These BMPs were not modeled in WinSLAMM as part of this analysis.

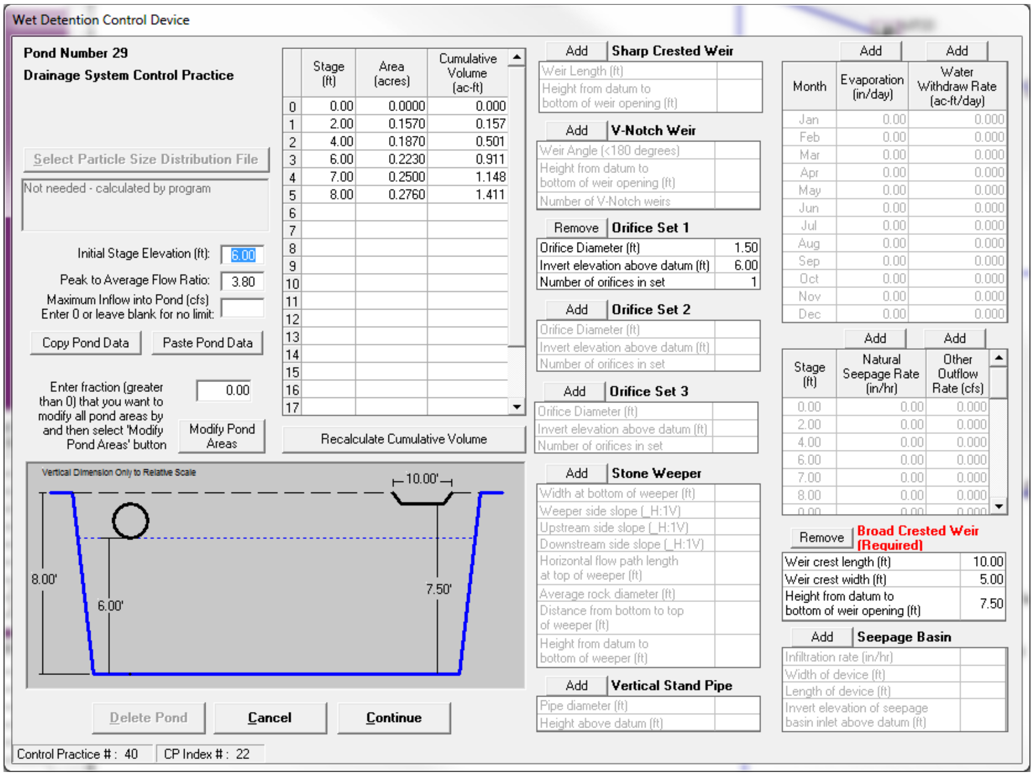

Figure 39: WinSLAMM model inputs for wet retention pond 18 (WP18) in Catchment SP-9

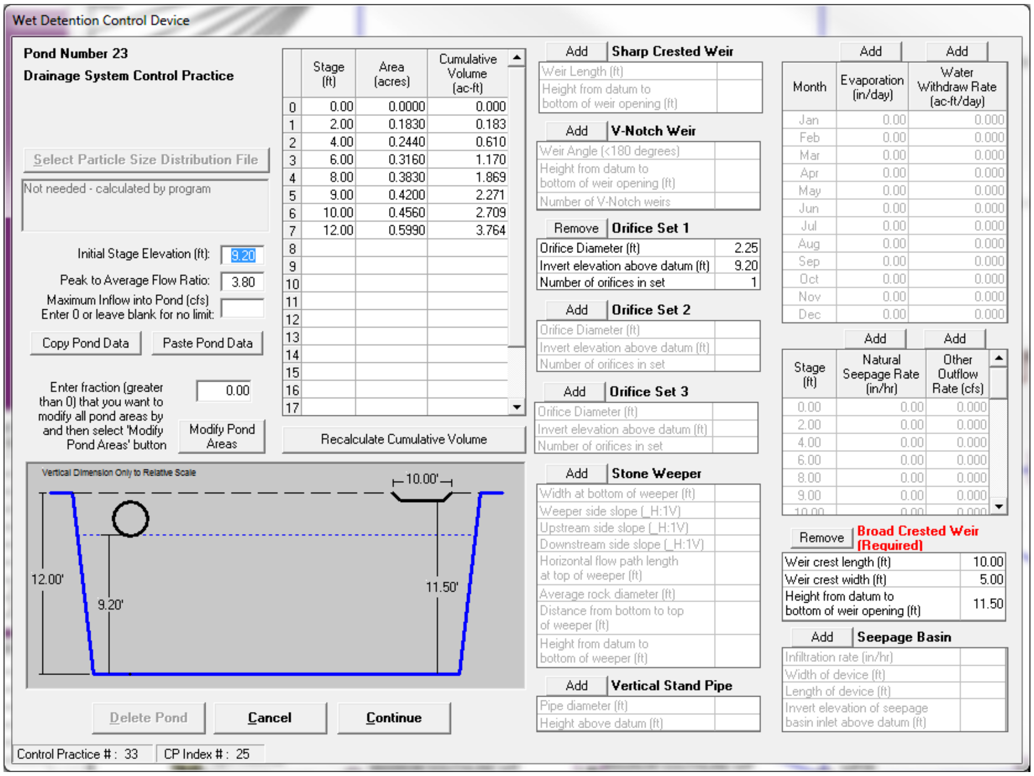

Figure 40: WinSLAMM model inputs for wet retention pond 19 (WP19) in Catchment SP-9

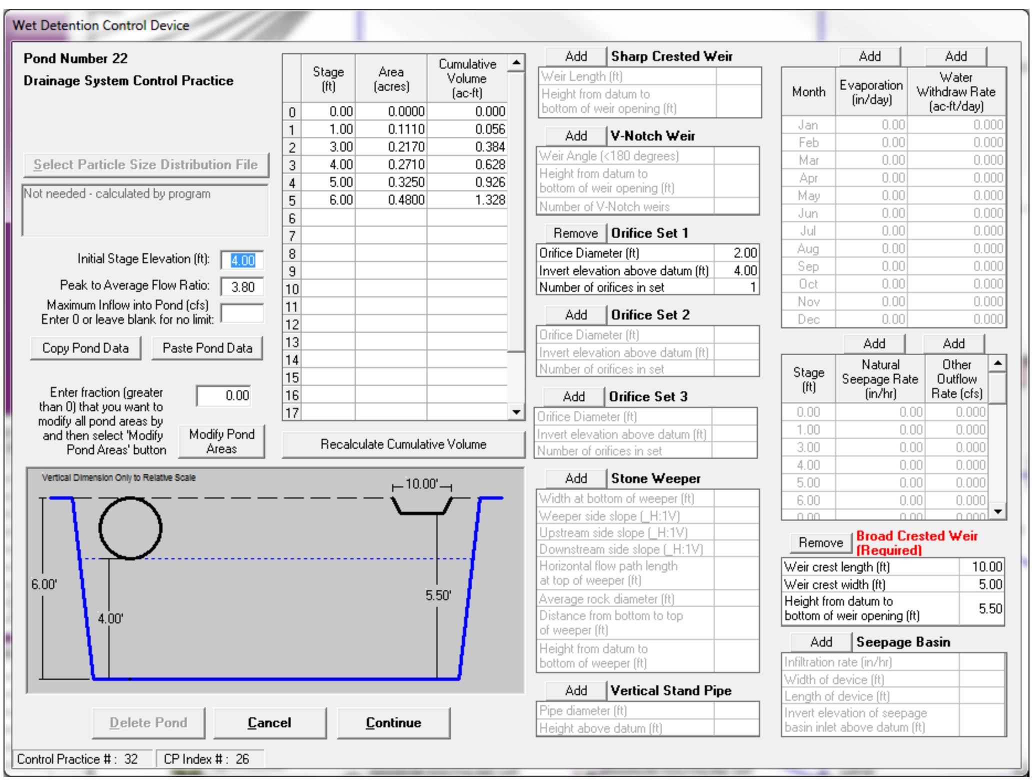

Figure 41: WinSLAMM model inputs for wet retention pond 20 (WP20) in Catchment SP-11

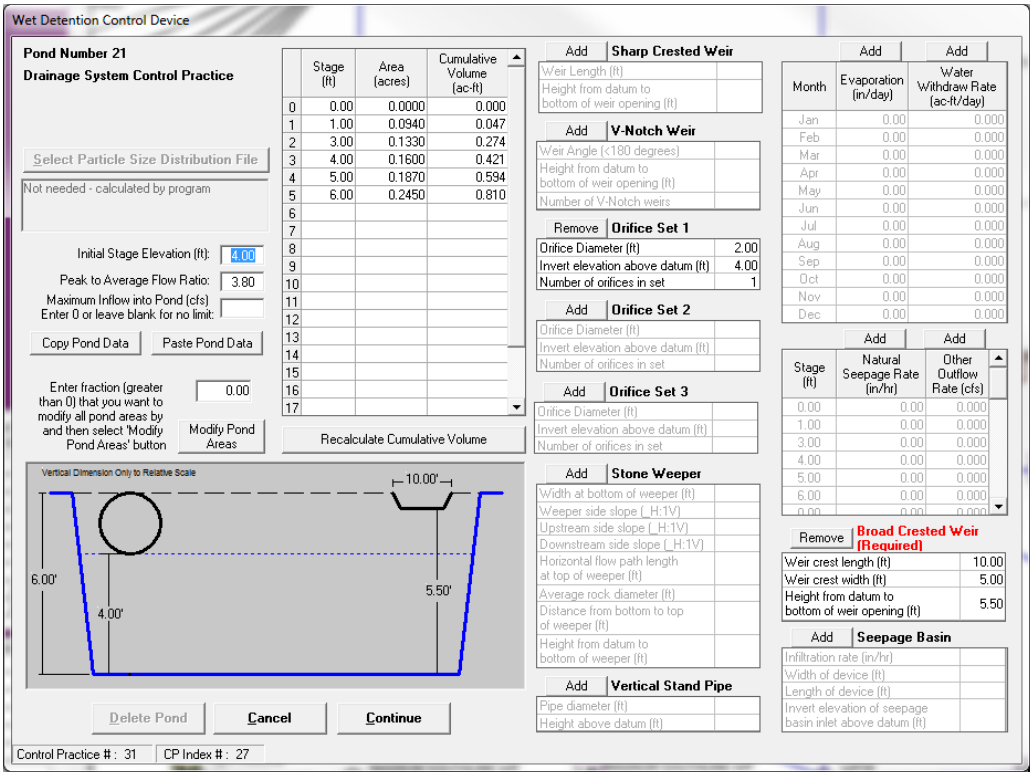

Figure 42: WinSLAMM model inputs for wet retention pond 21 (WP21) in Catchment SP-11

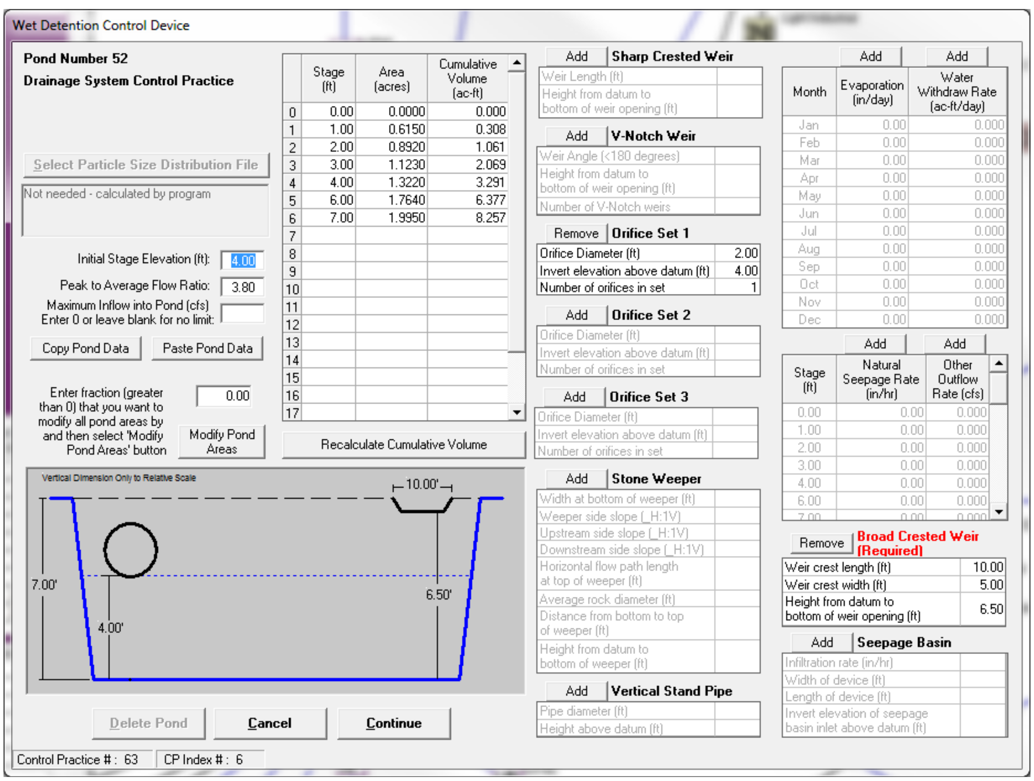

Figure 43: WinSLAMM model inputs for wet retention pond 22 (WP22) in Catchment SP-12

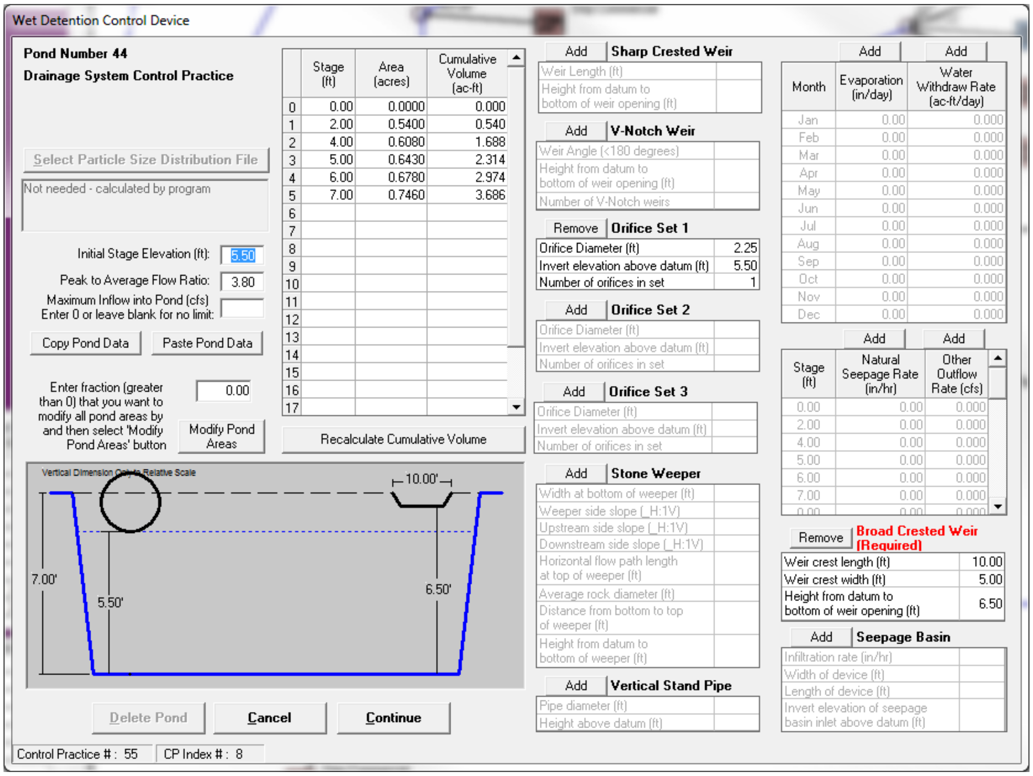

Figure 44: WinSLAMM model inputs for wet retention pond 23 (WP23) in Catchment SP-13

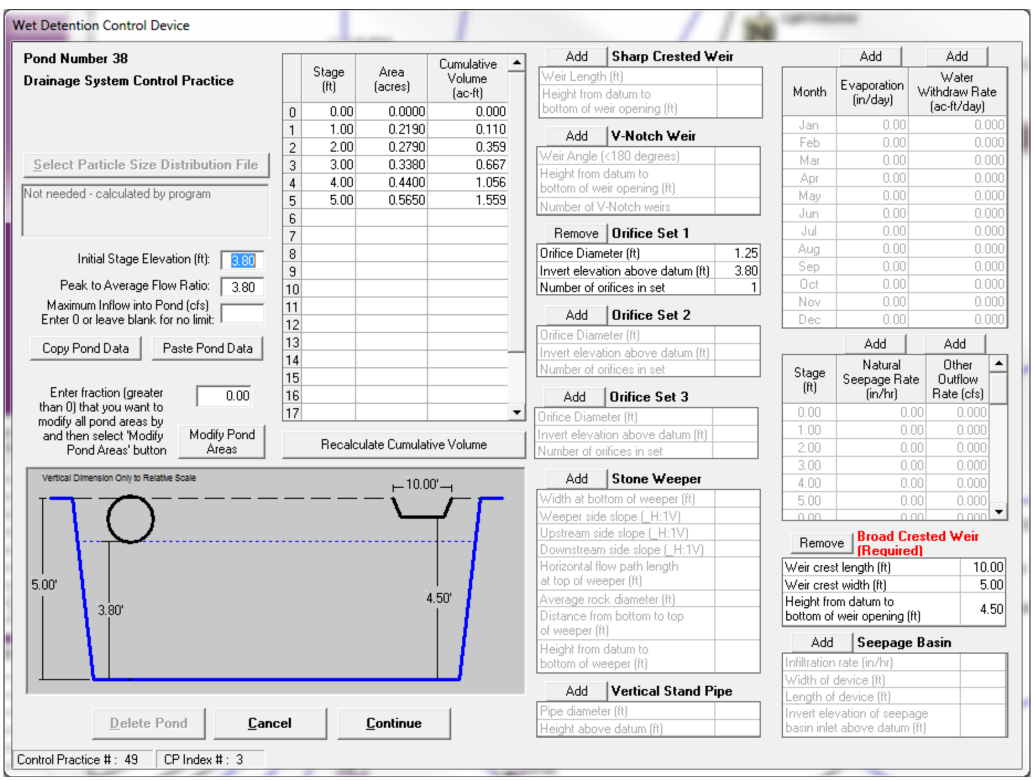

Figure 45: WinSLAMM model inputs for wet retention pond 24 (WP24) in Catchment SP-13

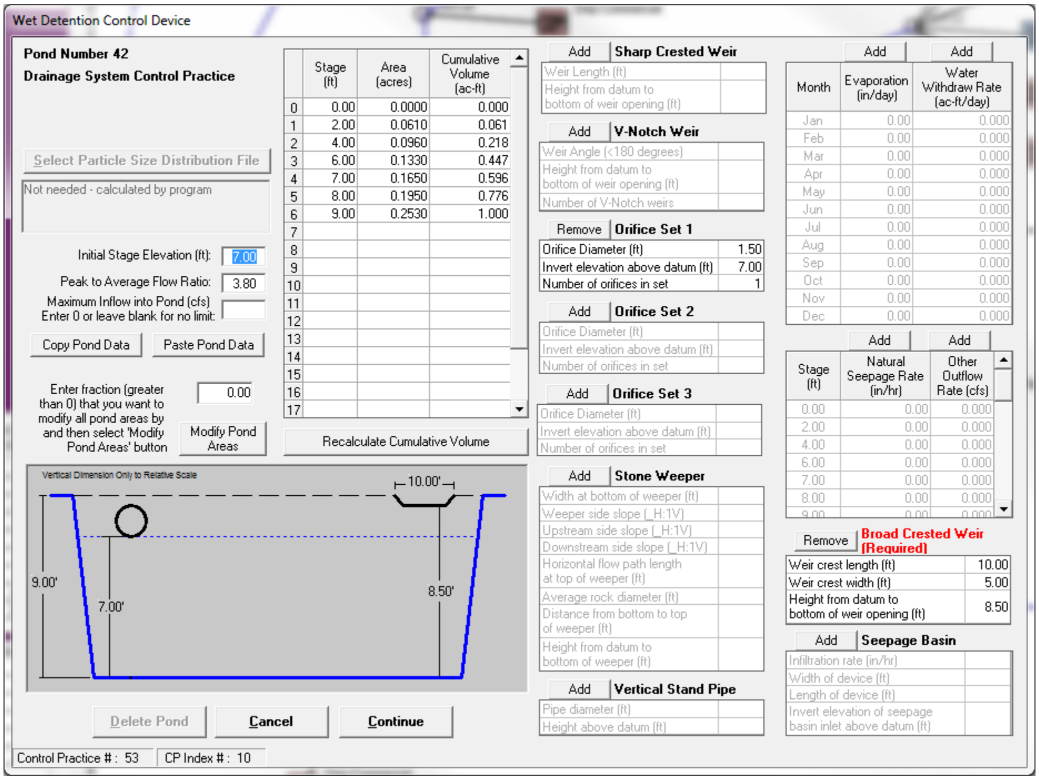

Figure 46: WinSLAMM model inputs for wet retention pond 25 (WP25) in Catchment SP-13

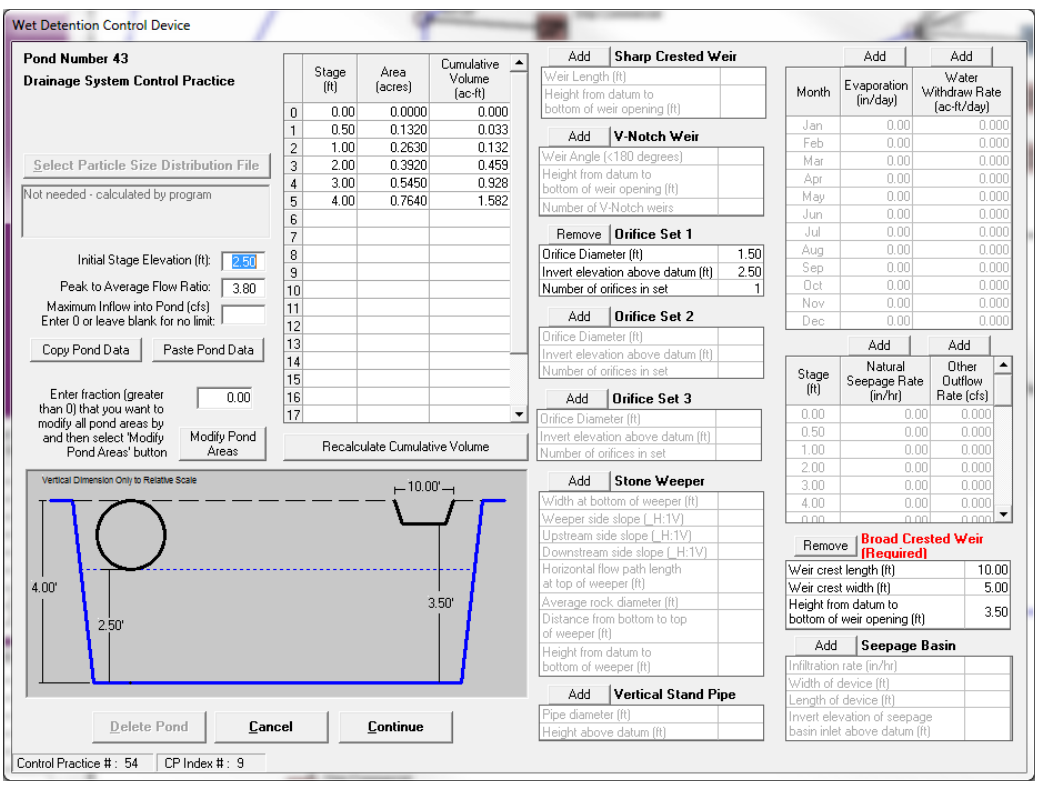

Figure 47: WinSLAMM model inputs for wet retention pond 26 (WP26) in Catchment SP-13

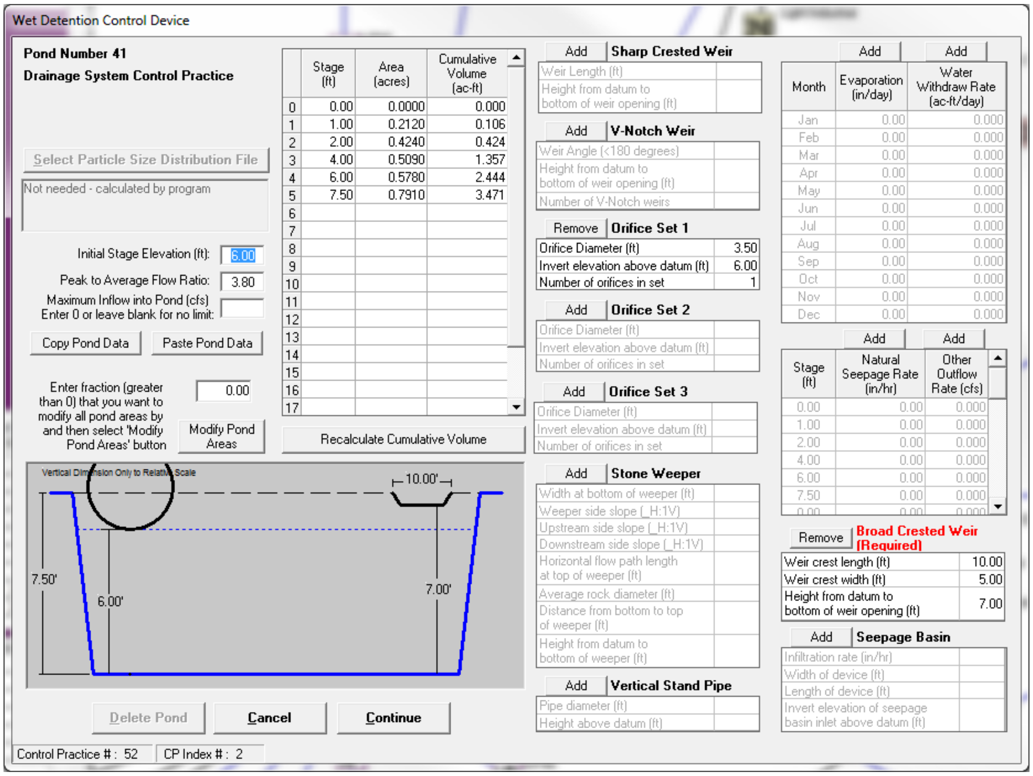

Figure 48: WinSLAMM model inputs for wet retention pond 27 (WP27) in Catchment SP-13

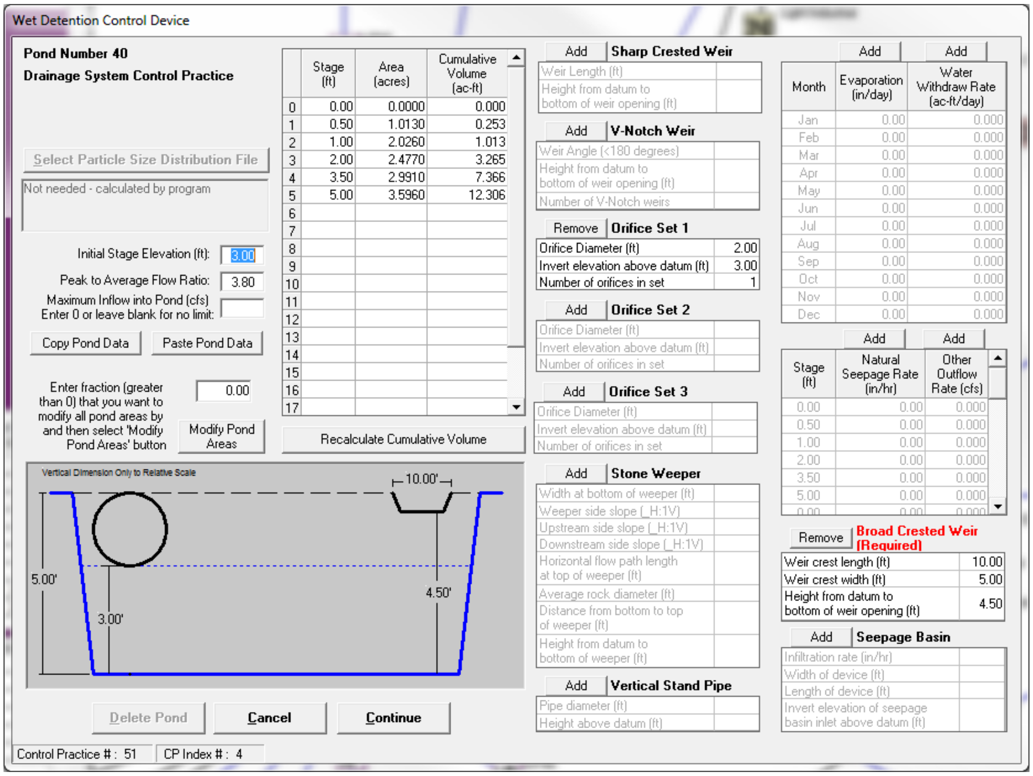

Figure 49: WinSLAMM model inputs for wet retention pond 28 (WP28) in Catchment SP-13

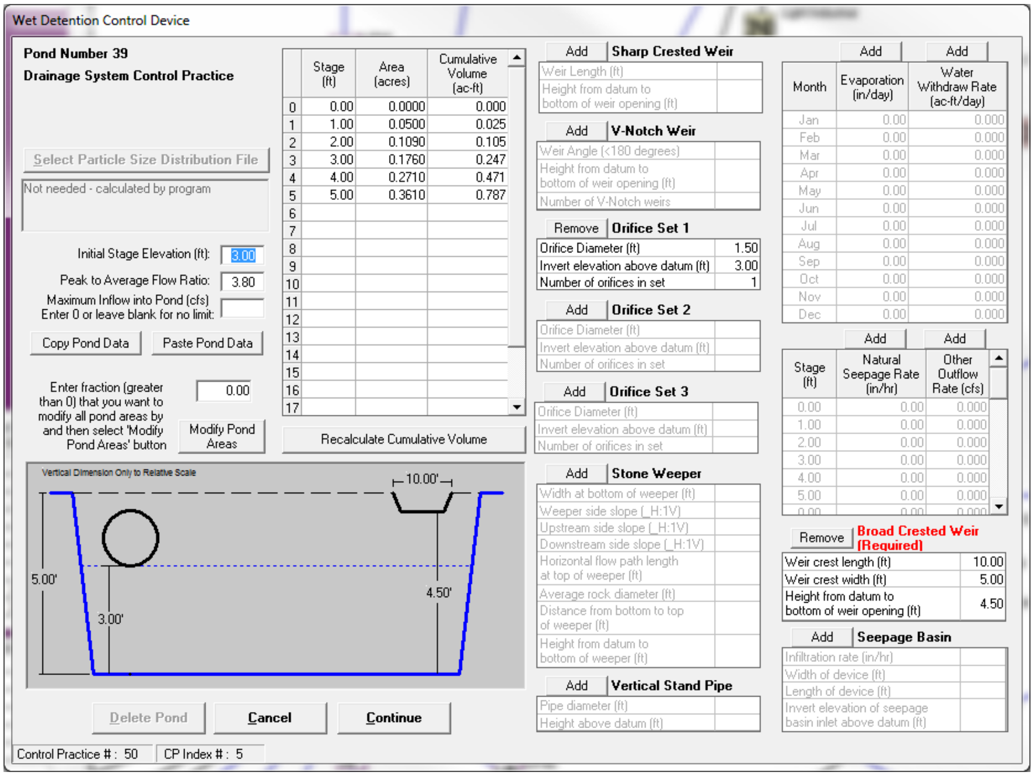

Figure 50: WinSLAMM model inputs for wet retention pond 29 (WP29) in Catchment SP-13

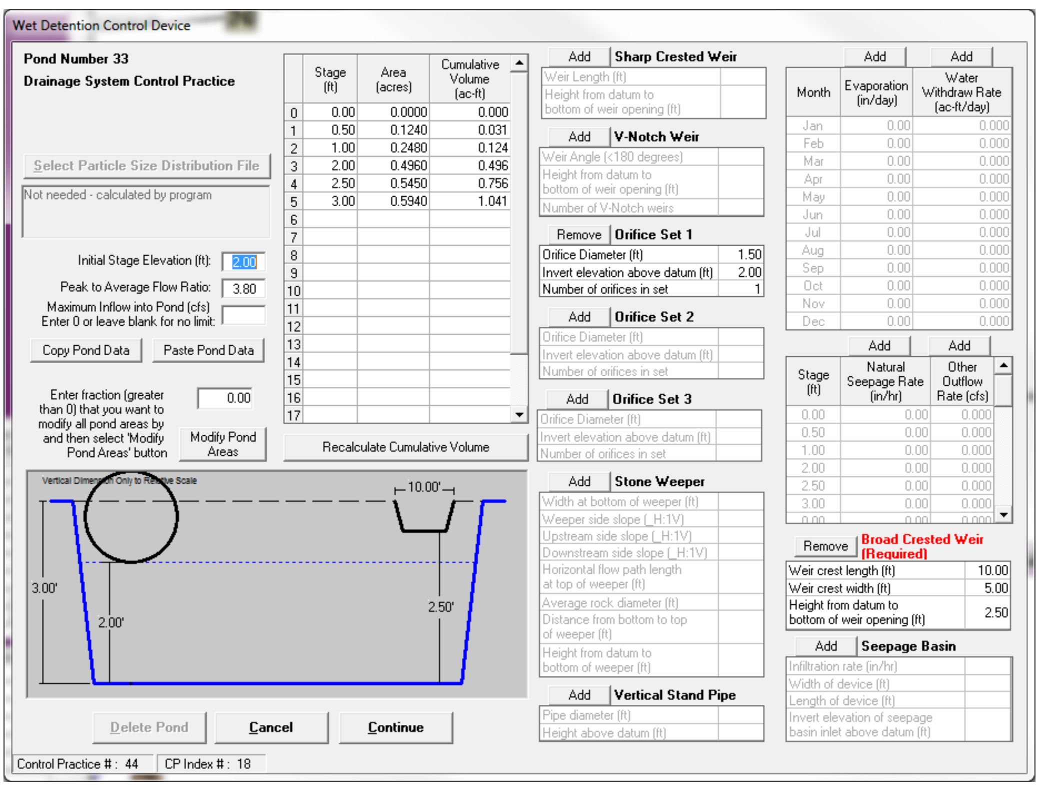

Figure 51: WinSLAMM model inputs for wet retention pond 30 (WP30) in Catchment SP-9

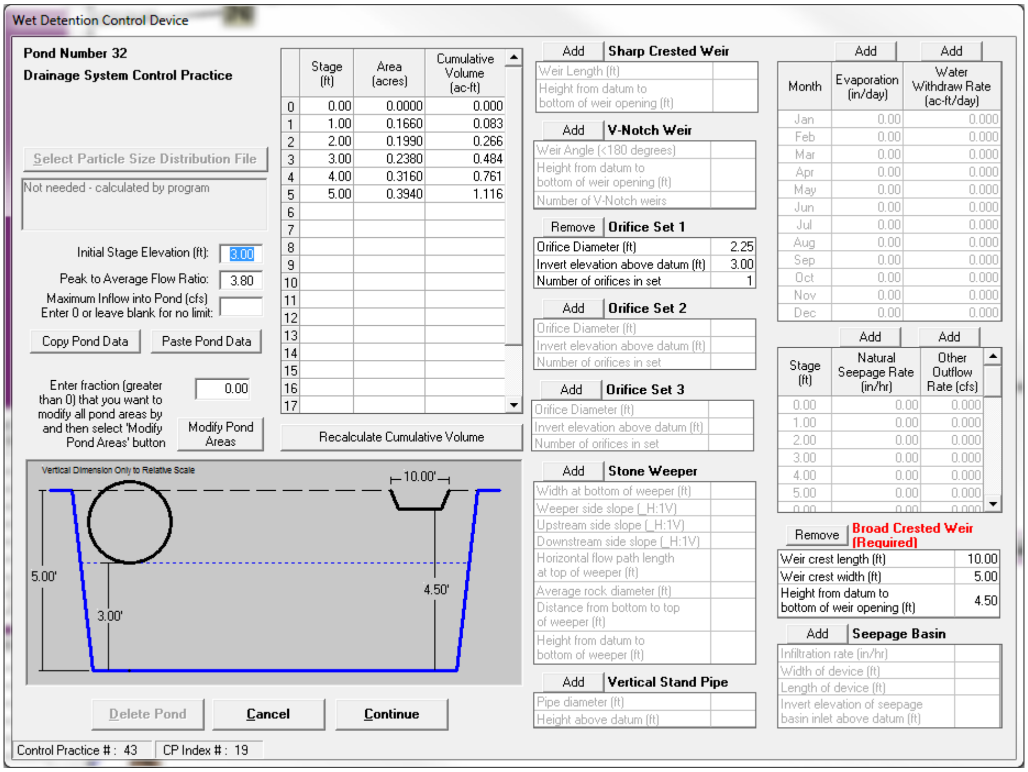

Figure 52: WinSLAMM model inputs for wet retention pond 31 (WP31) in Catchment SP-9

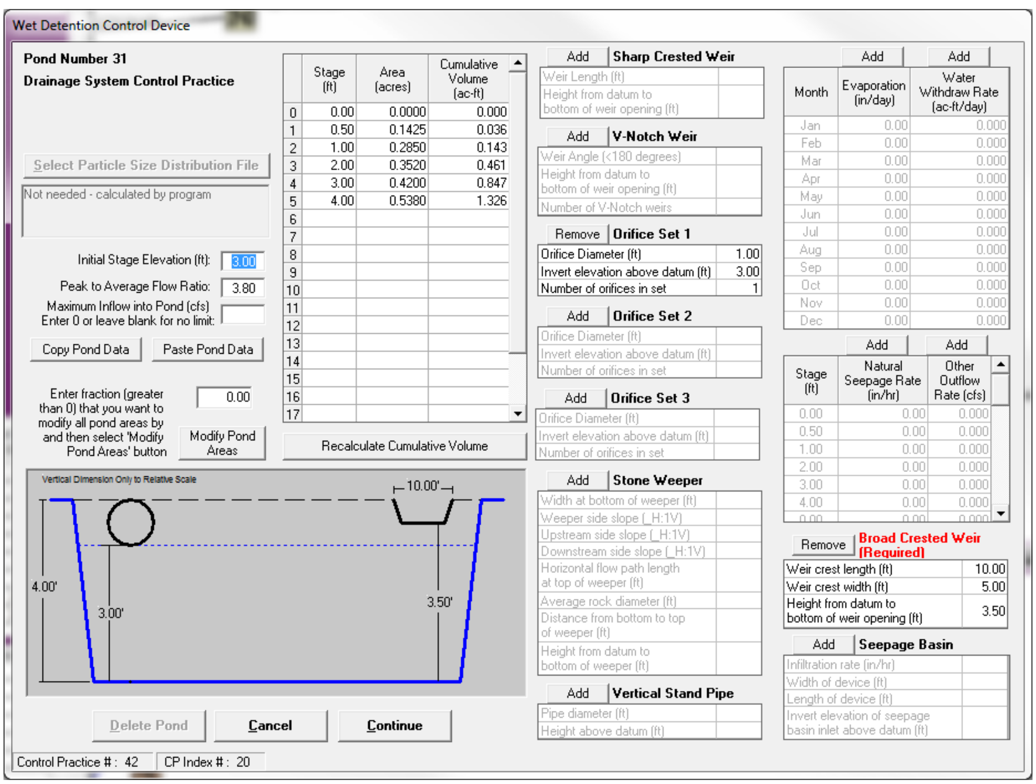

Figure 53: WinSLAMM model inputs for wet retention pond 32 (WP32) in Catchment SP-9

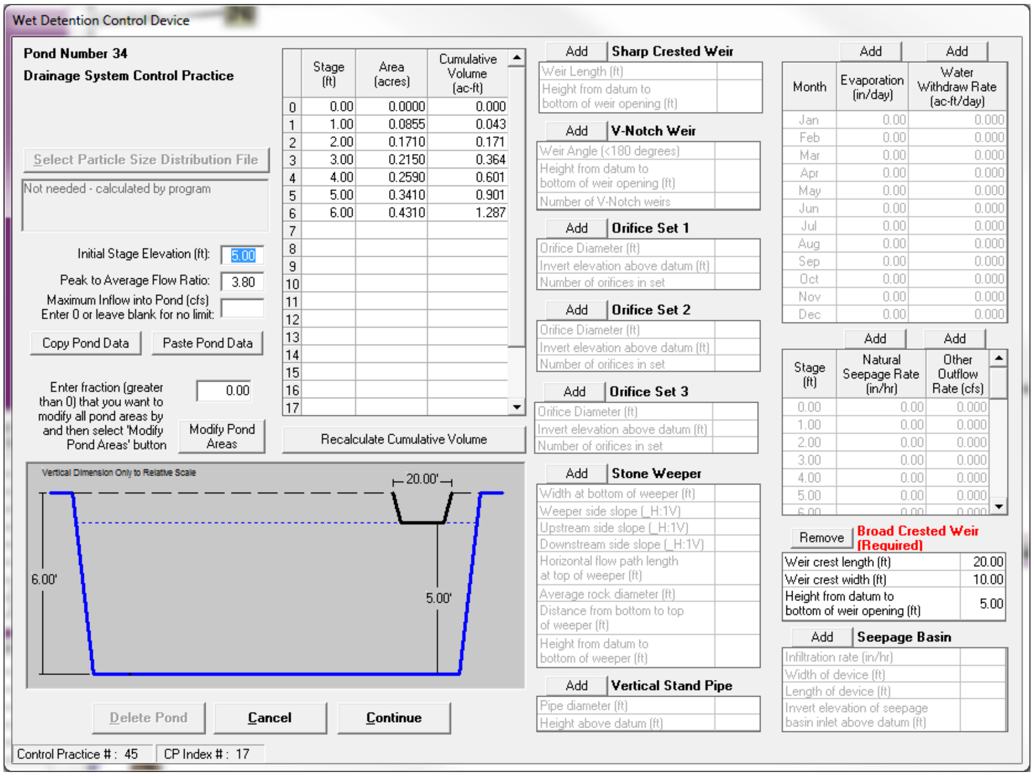

Figure 54: WinSLAMM model inputs for wet retention pond 33 (WP33) in Catchment SP-9

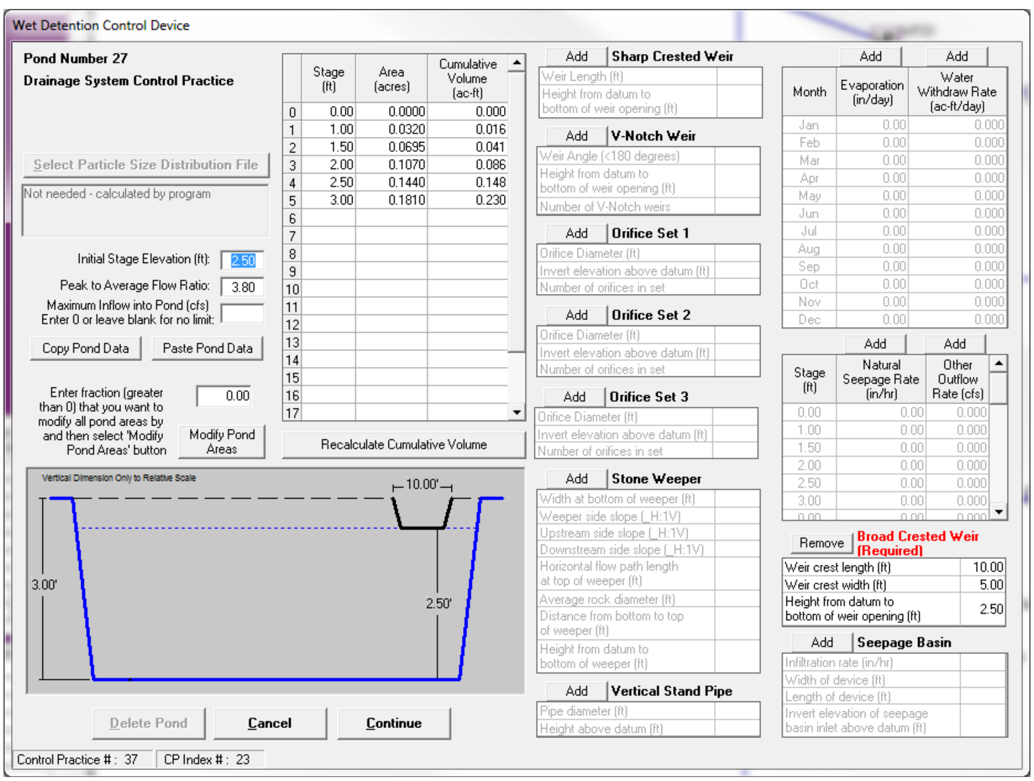

Figure 55: WinSLAMM model inputs for wet retention pond 34 (WP34) in Catchment SP-9

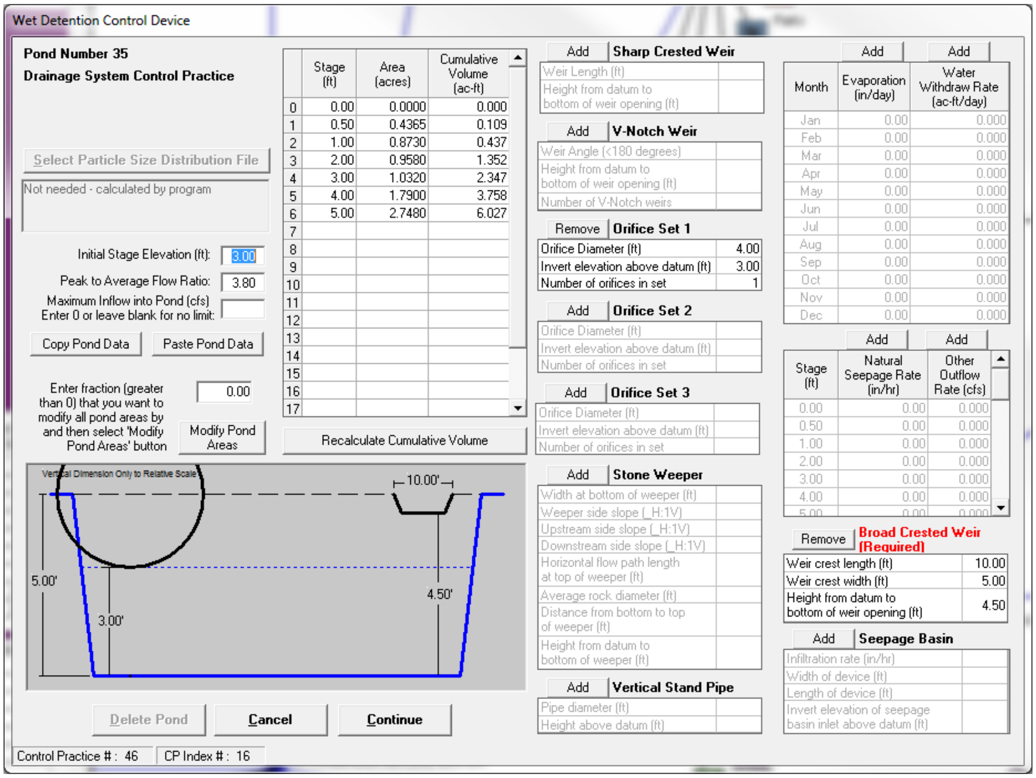

Figure 56: WinSLAMM model inputs for wet retention pond 35 (WP35) in Catchment SP-9

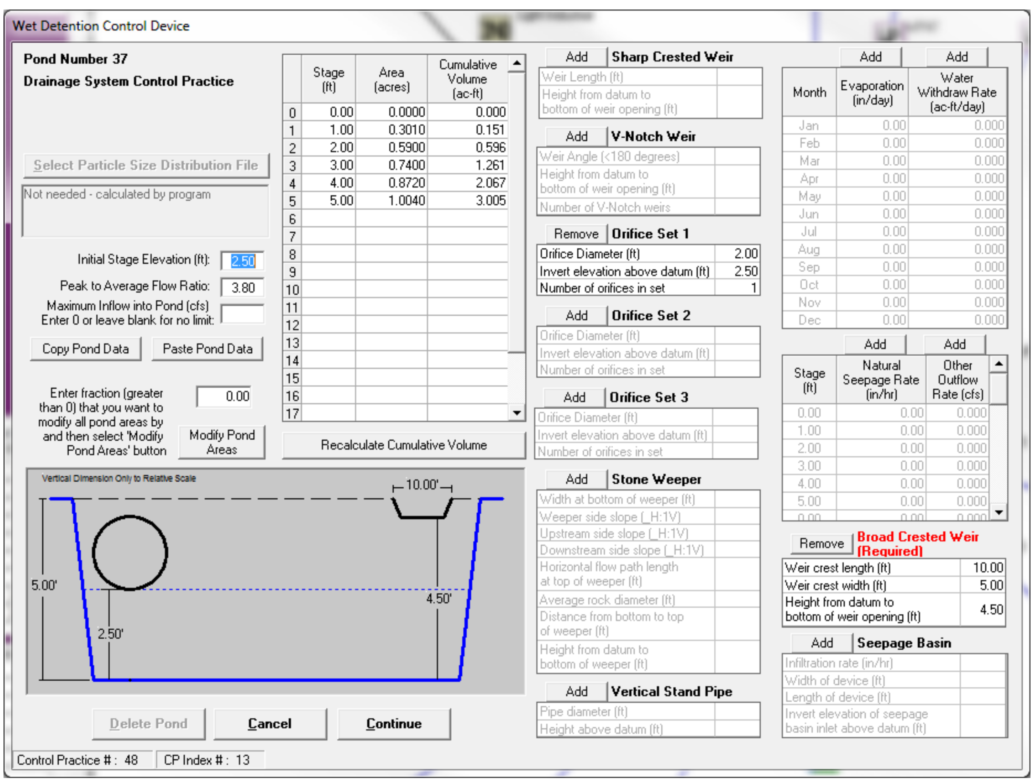

Figure 57: WinSLAMM model inputs for wet retention pond 36 (WP36) in Catchment SP-9

WP37 was deemed disconnected in all but very large storm events based on storage available. This BMP was not modeled in WinSLAMM as part of this analysis.

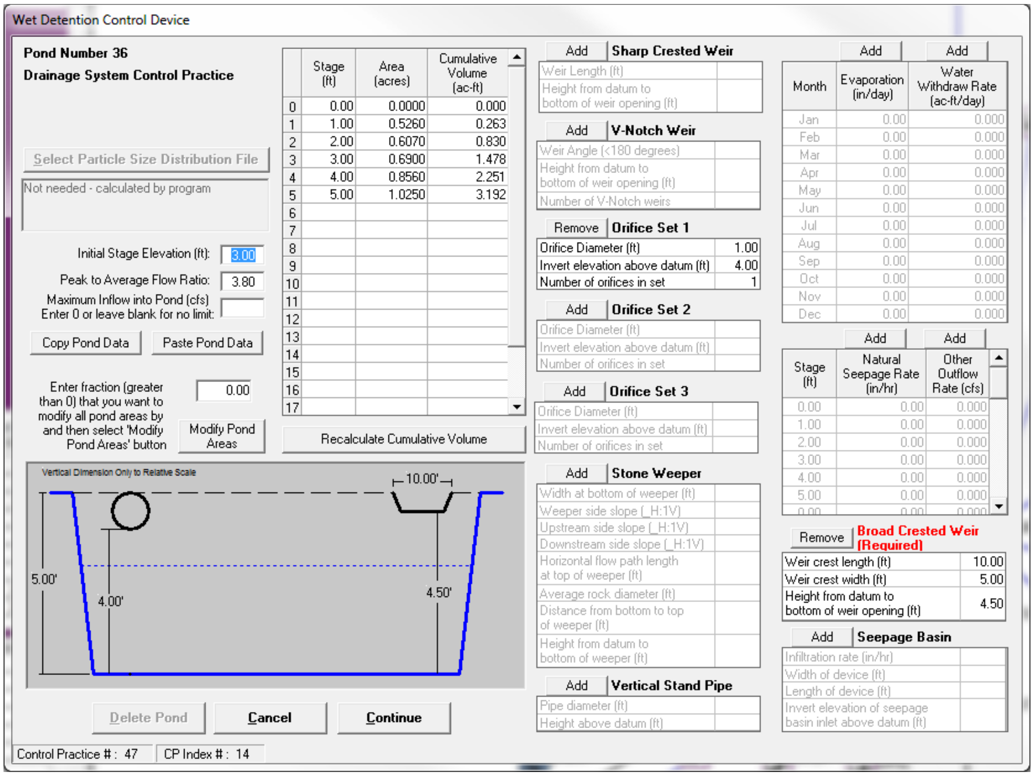

Figure 58: WinSLAMM model inputs for wet retention pond 38 (WP38) in Catchment SP-9

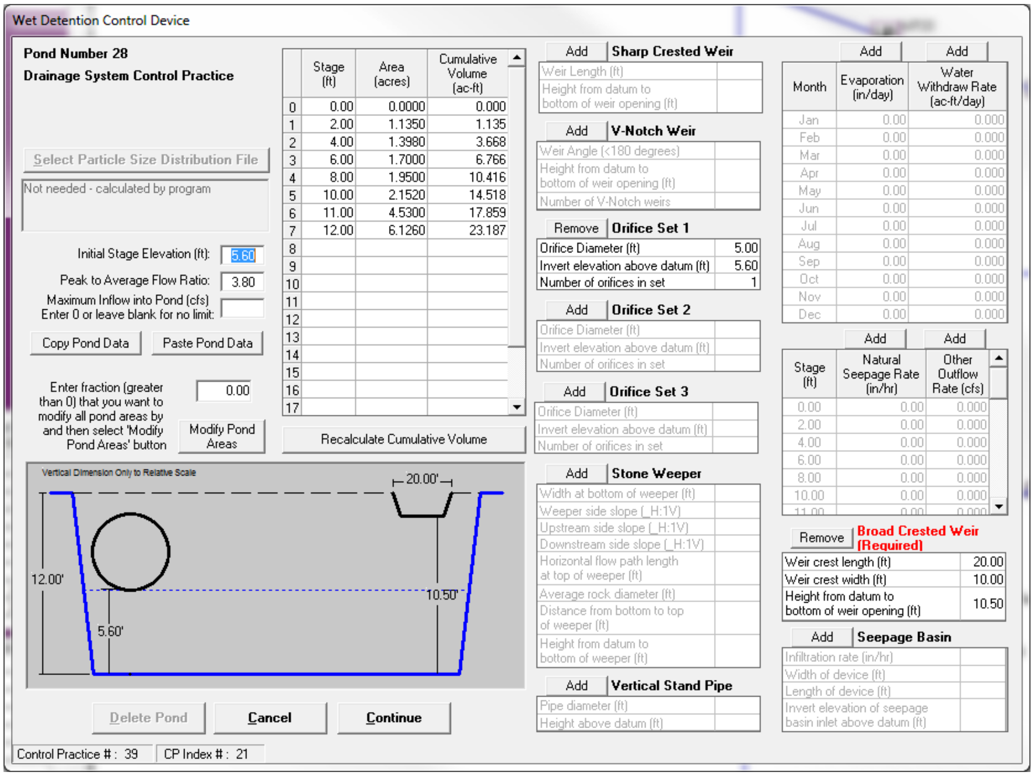

Figure 59: WinSLAMM model inputs for wet retention pond 39 (WP39) in Catchment SP-9

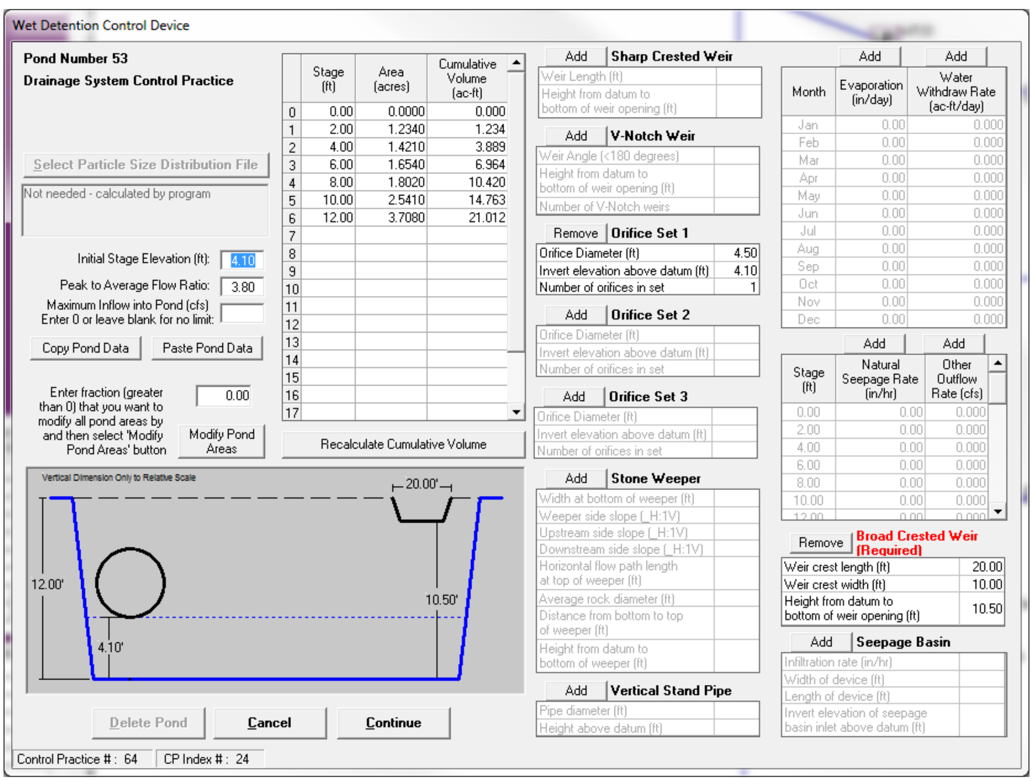

Figure 60: WinSLAMM model inputs for wet retention pond 40 (WP40) in Catchment SP-9

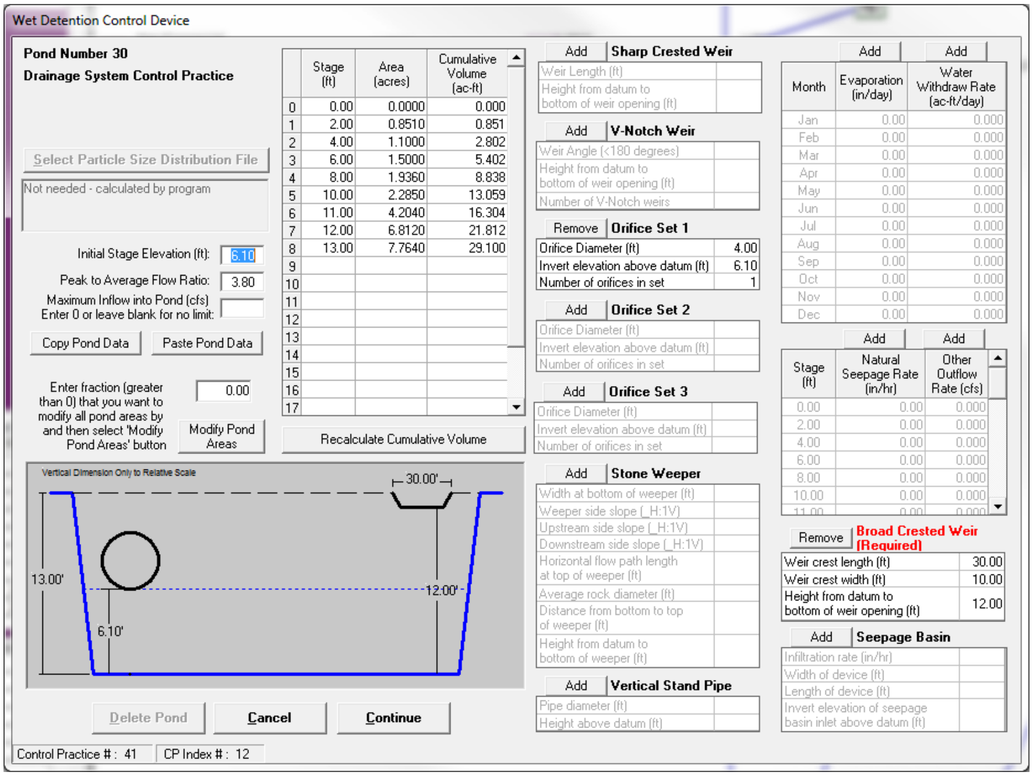

Figure 61: WinSLAMM model inputs for wet retention pond 41 (WP41) in Catchment SP-9

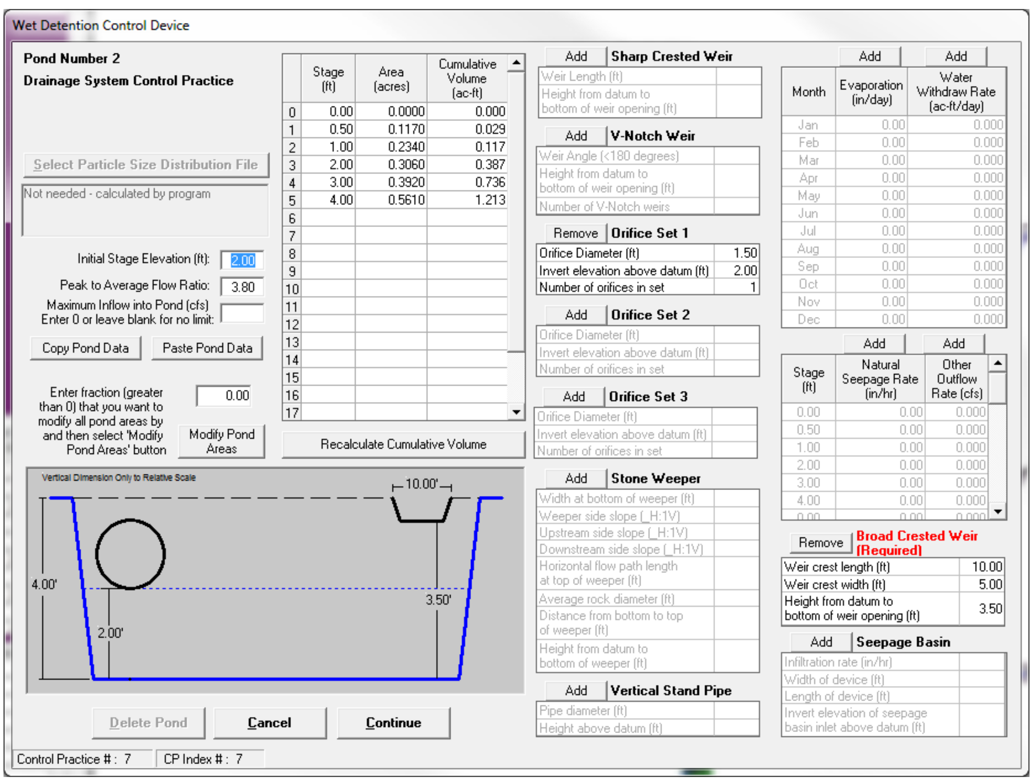

Figure 62: WinSLAMM model inputs for wet retention pond 42 (WP42) in Catchment SP-15

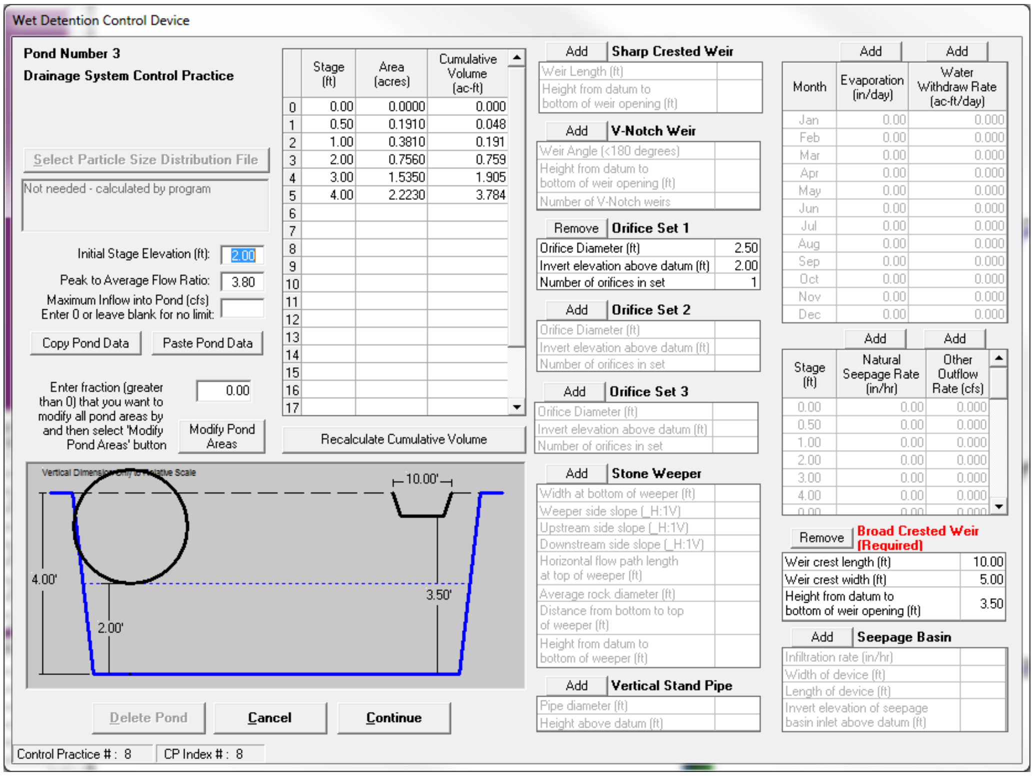

Figure 63: WinSLAMM model inputs for wet retention pond 43 (WP43) in Catchment SP-15

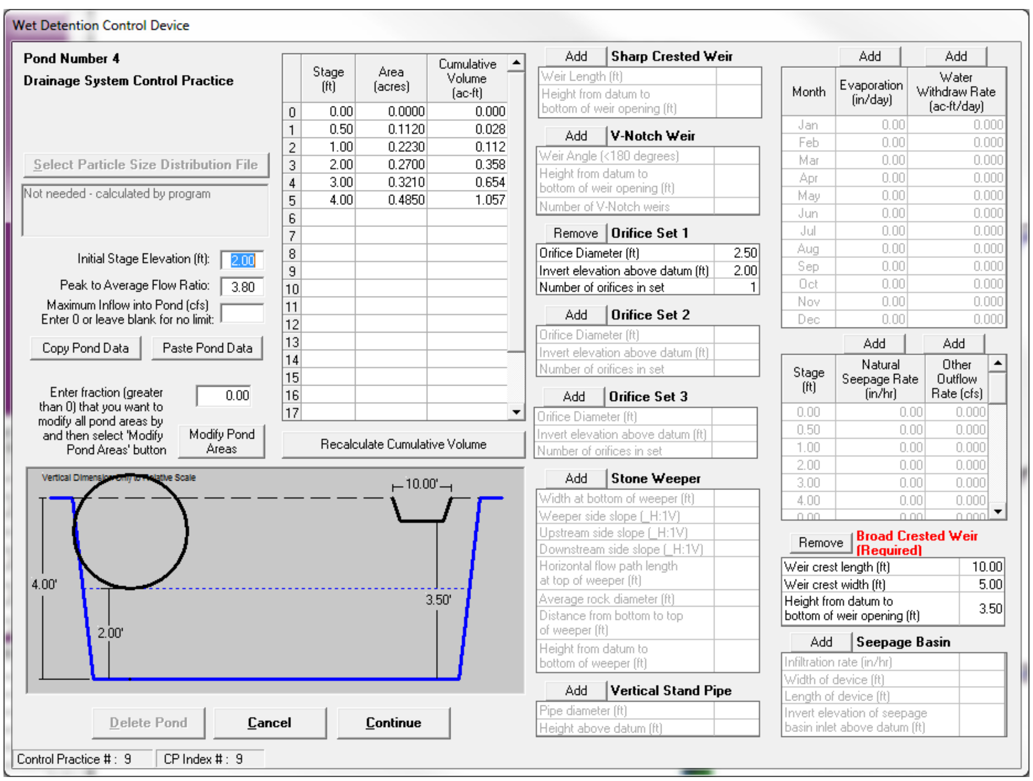

Figure 64: WinSLAMM model inputs for wet retention pond 44 (WP44) in Catchment SP-15

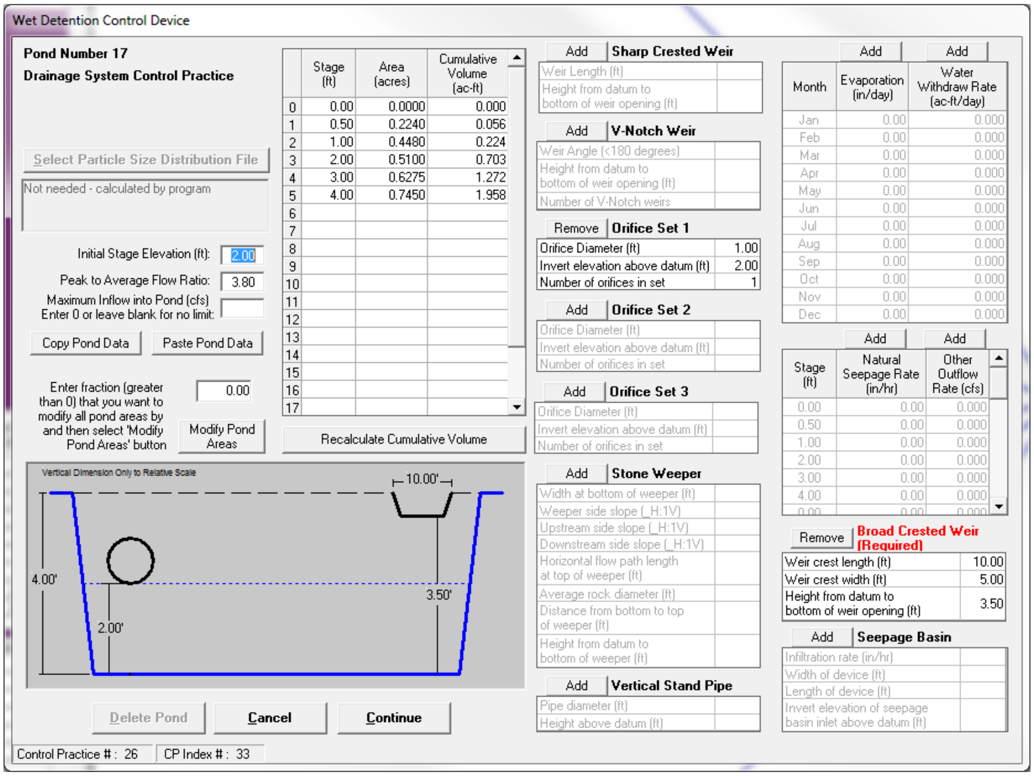

Figure 65: WinSLAMM model inputs for wet retention pond 45 (WP45) in Catchment SP-6

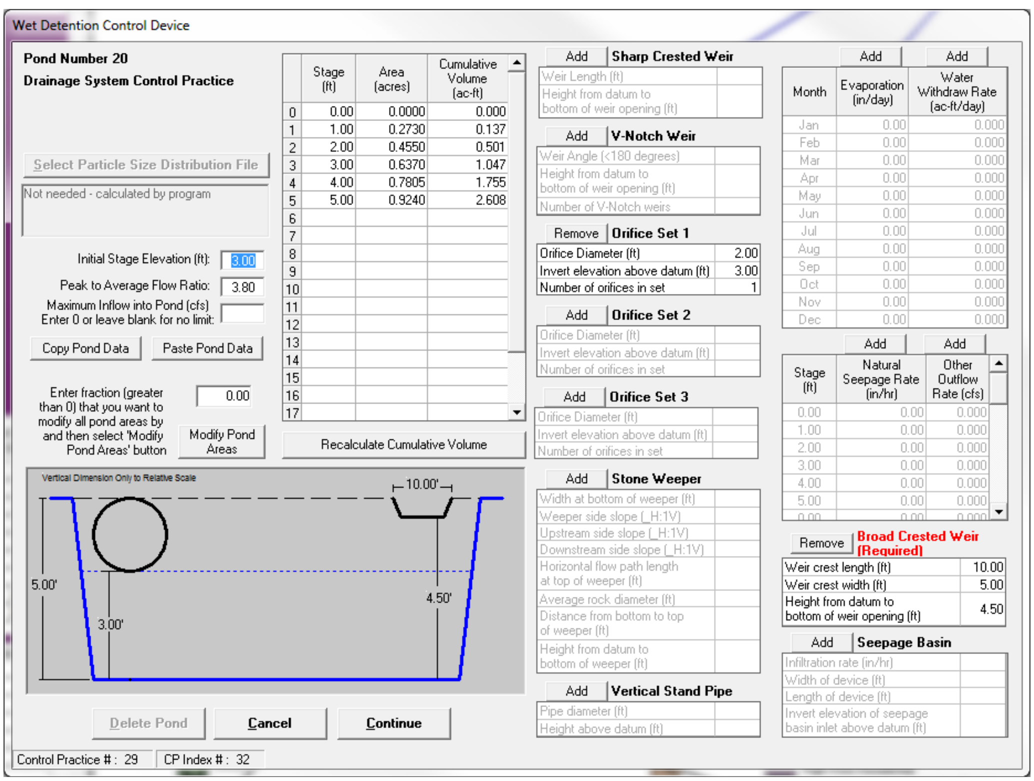

Figure 66: WinSLAMM model inputs for wet retention pond 46 (WP46) in Catchment SP-8

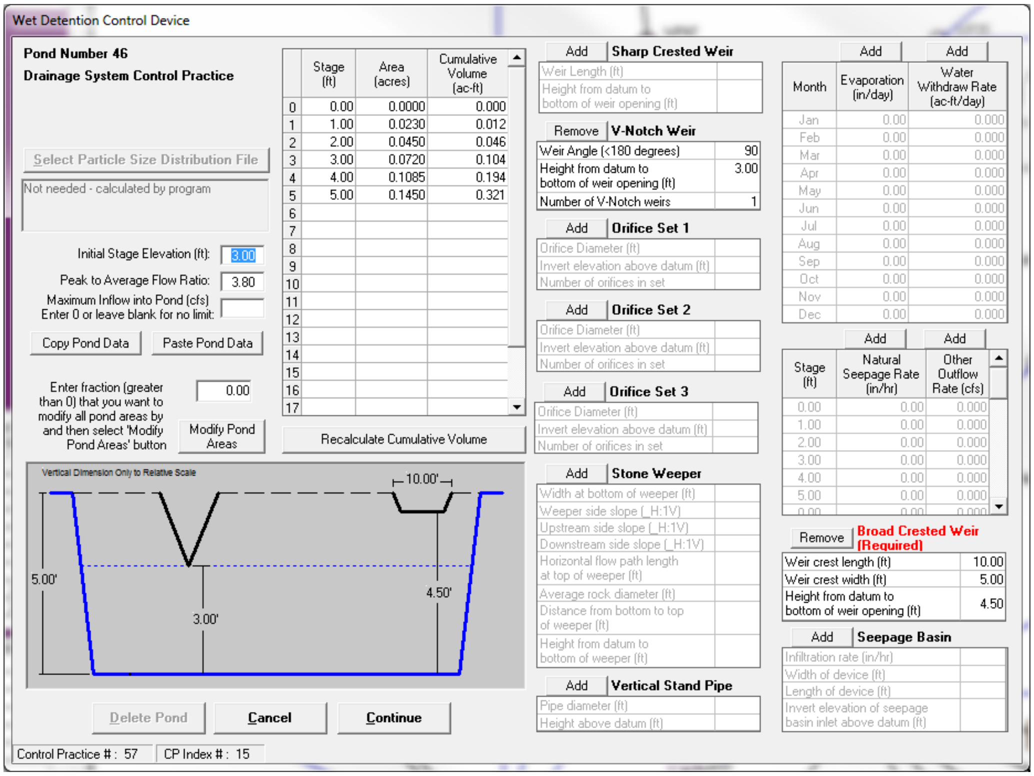

Figure 67: WinSLAMM model inputs for wet retention pond 47 (WP47) in Catchment SP-9

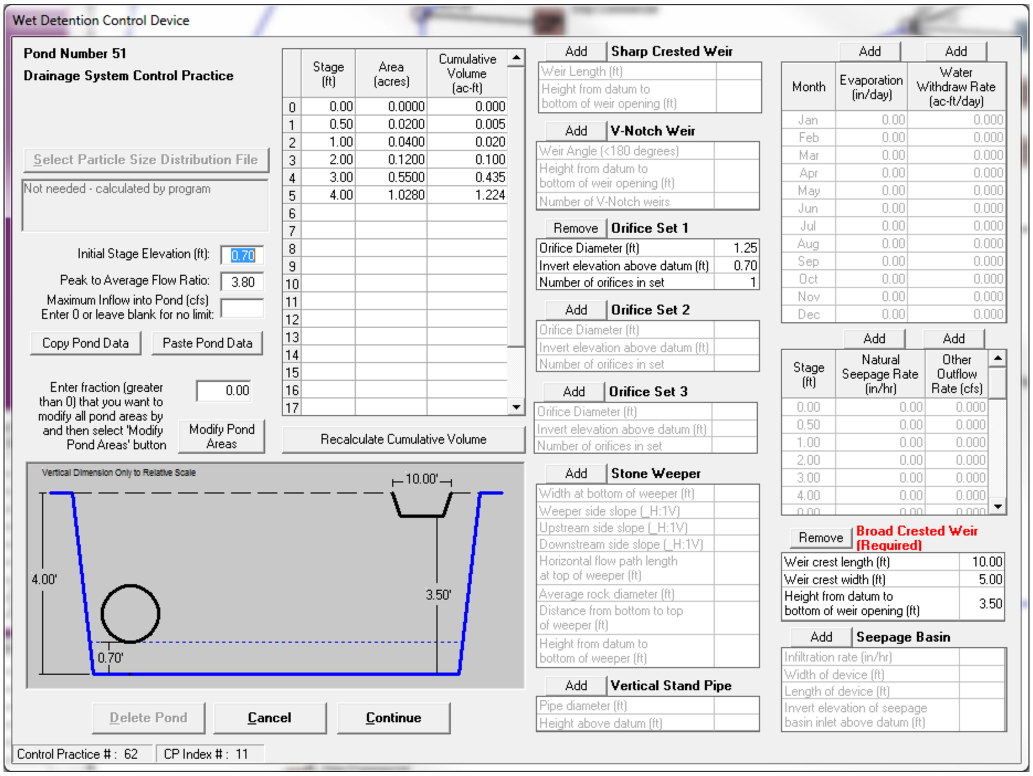

Figure 68: WinSLAMM model inputs for wet retention pond 48 (WP48) in Catchment SP-13

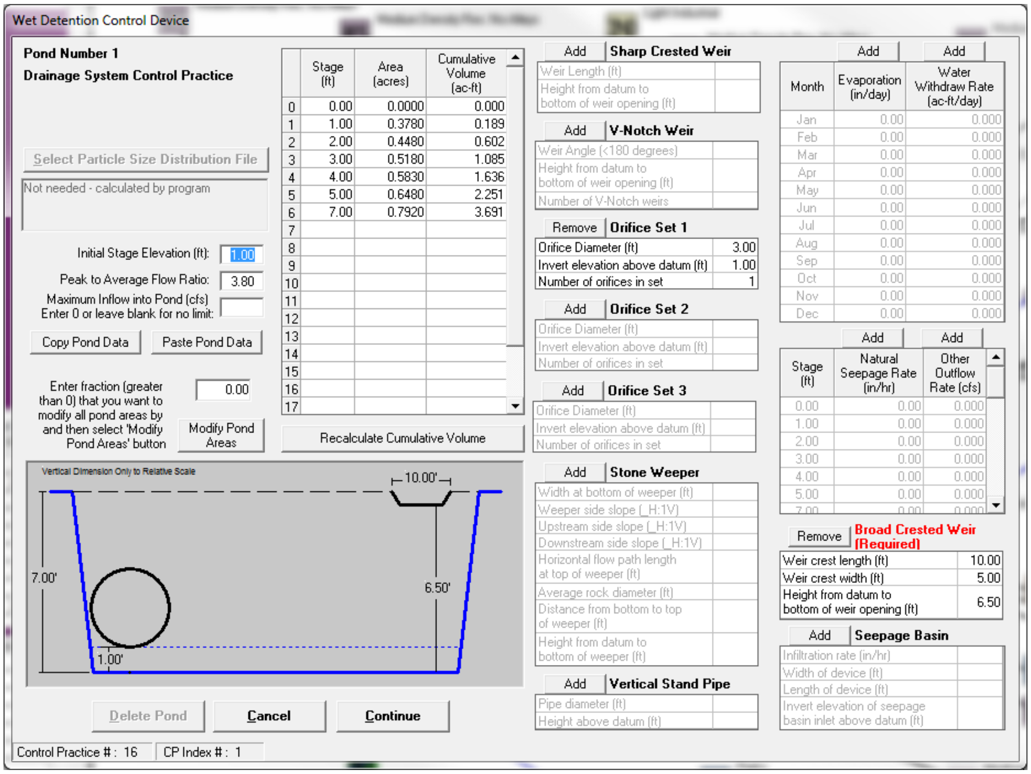

Figure 69: WinSLAMM model inputs for wet retention pond 49 (WP49) in Catchment SP-16

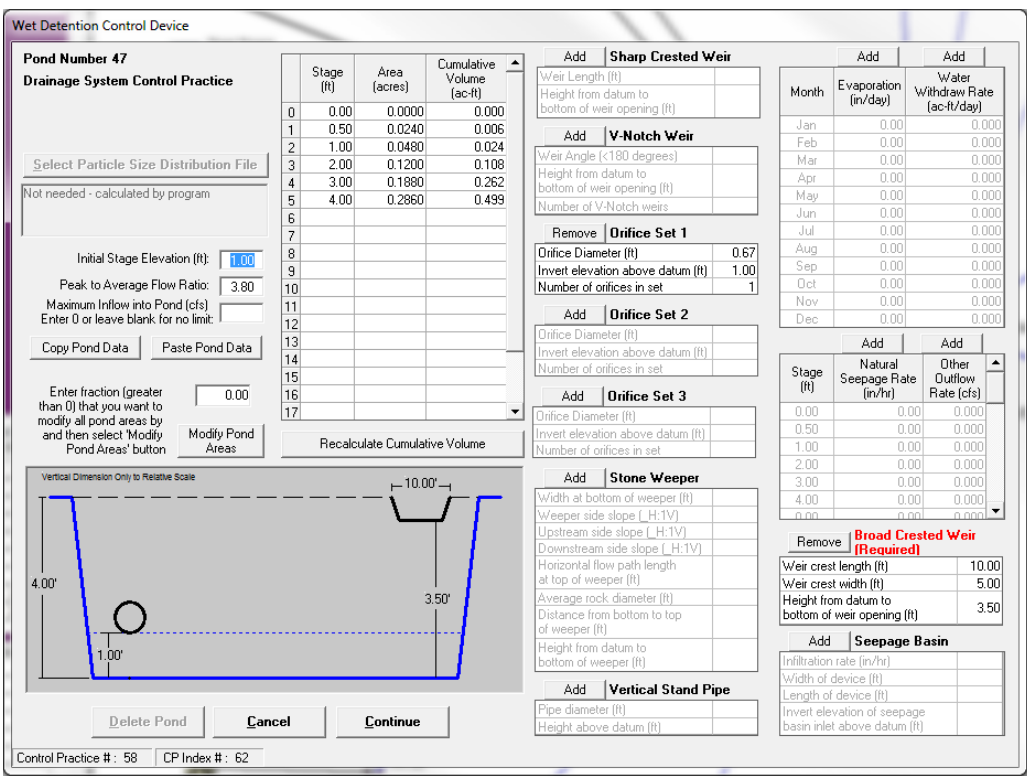

Figure 70: WinSLAMM model inputs for wet retention pond 50 (WP50) in Catchment SP-13

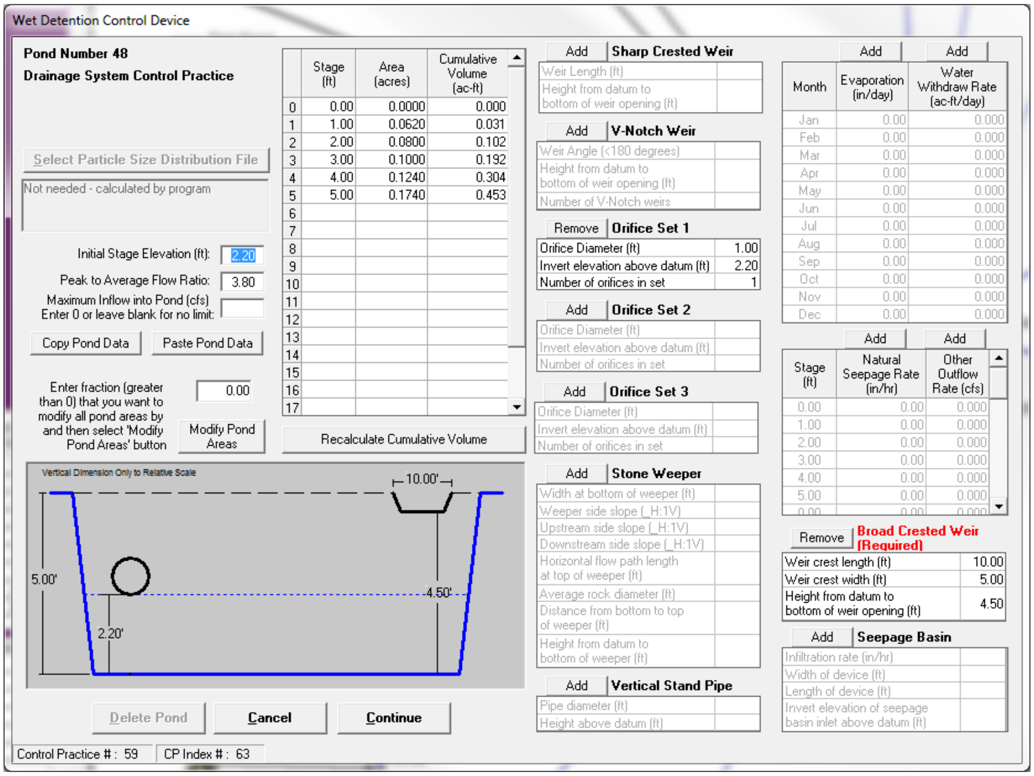

Figure 71: WinSLAMM model inputs for wet retention pond 51 (WP51) in Catchment SP-13

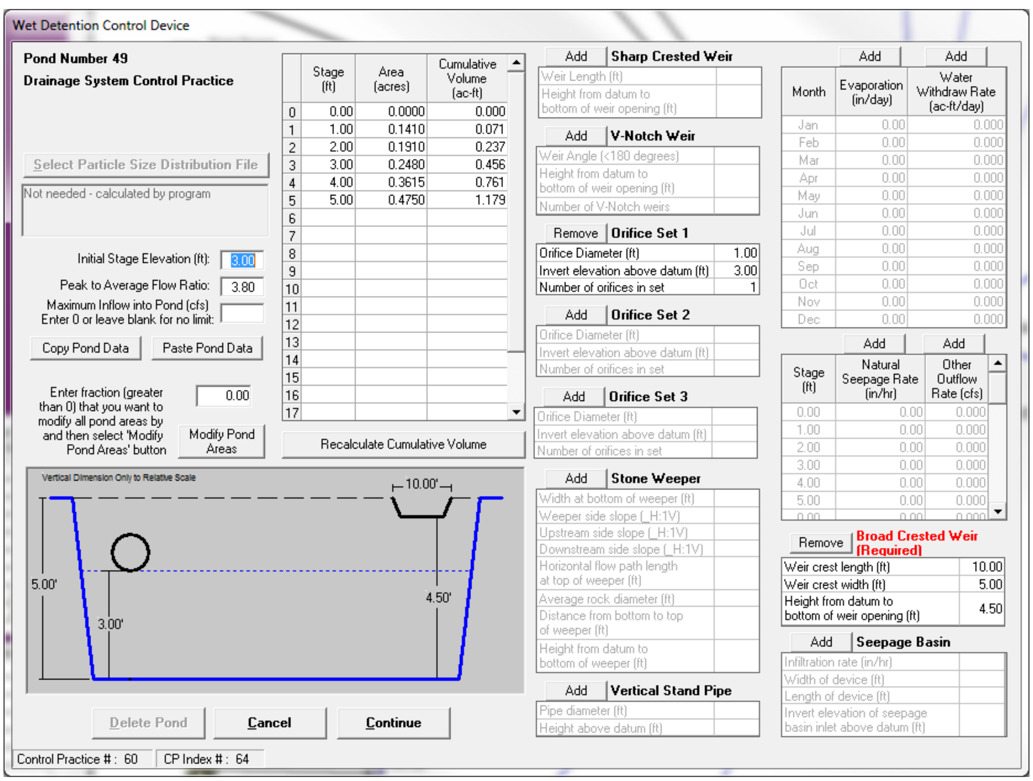

Figure 72: WinSLAMM model inputs for wet retention pond 52 (WP52) in Catchment SP-13

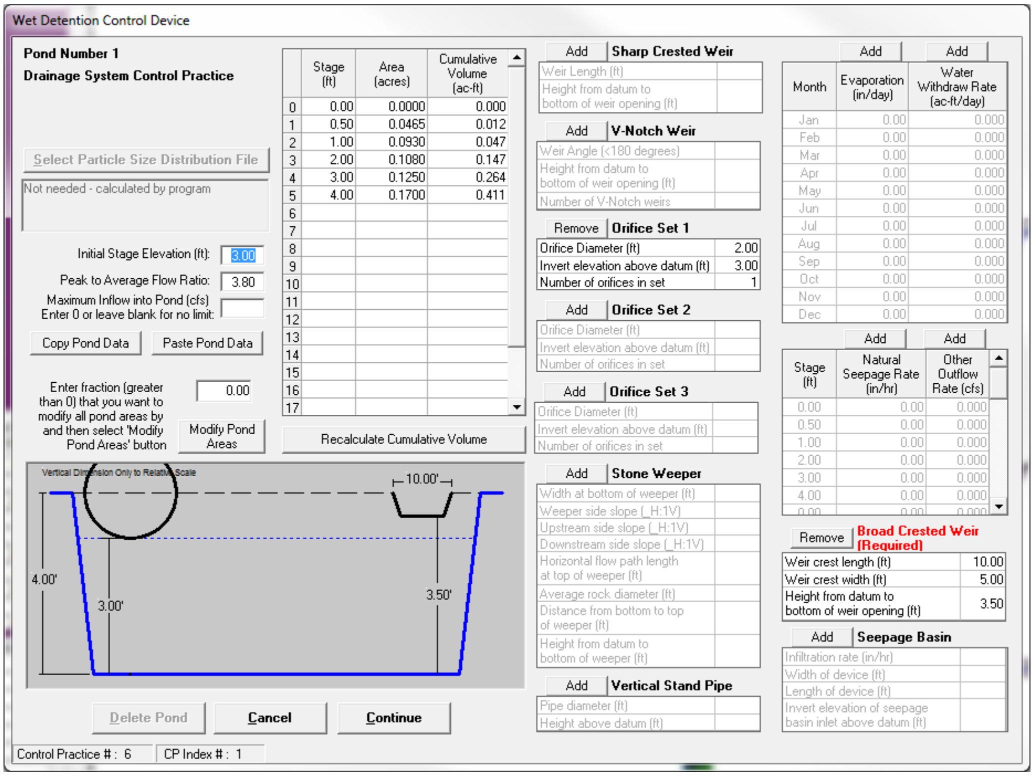

Figure 73: WinSLAMM model inputs for wet retention pond 53 (WP53) in Catchment SP-15

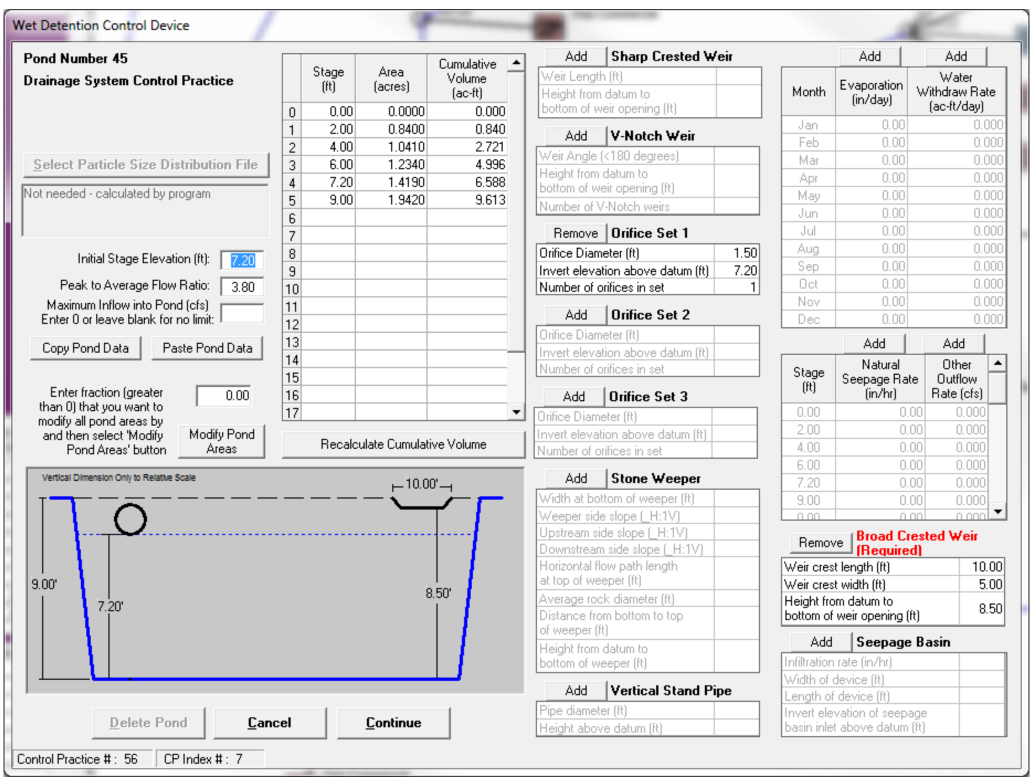

Figure 74: WinSLAMM model inputs for wet retention pond 54 (WP54) in Catchment SP-13

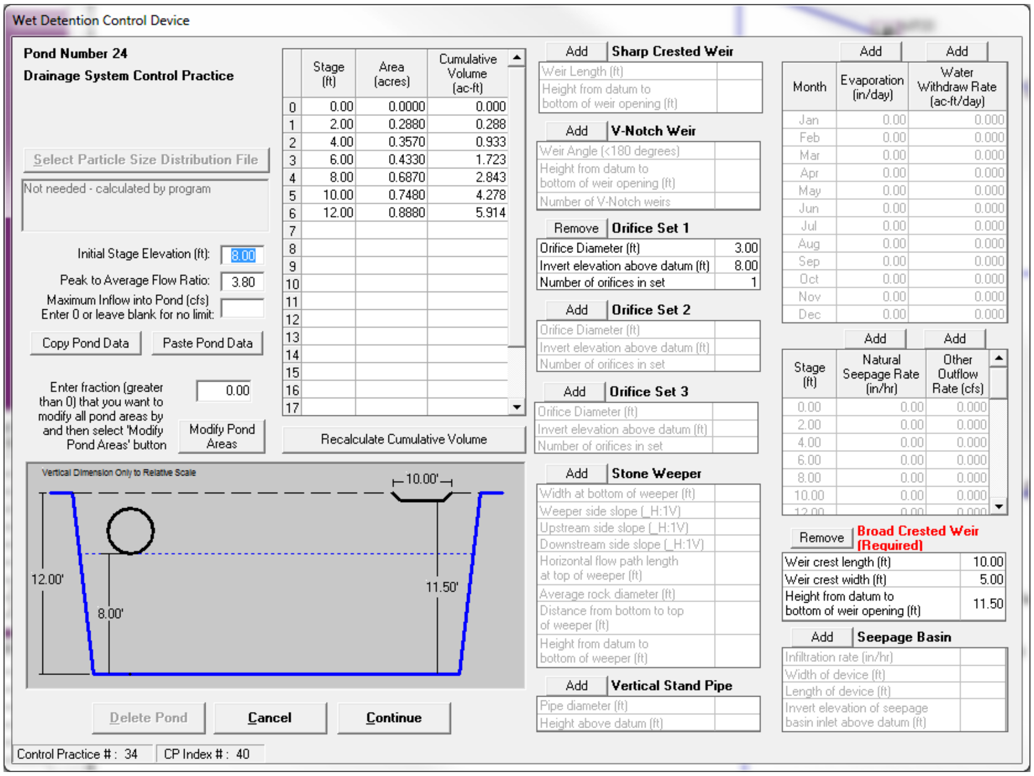

Figure 75: WinSLAMM model inputs for wet retention pond 55 (WP55) in Catchment SP-9

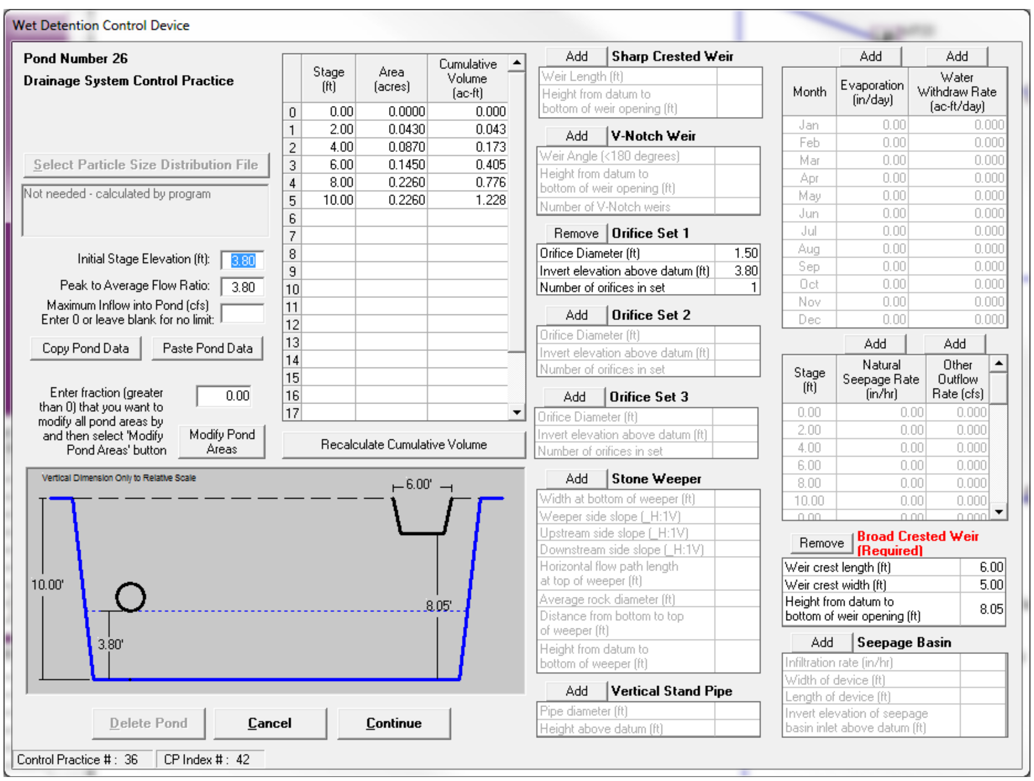

Figure 76: WinSLAMM model inputs for wet retention pond 56 (WP56) in Catchment SP-9

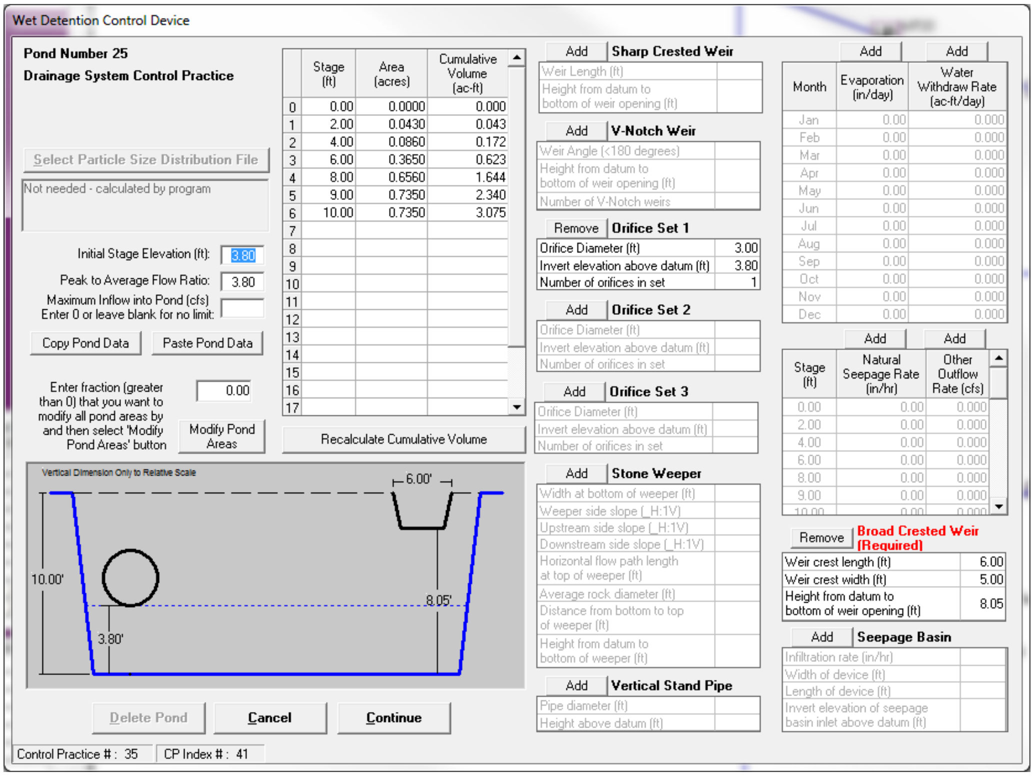

Figure 77: WinSLAMM model inputs for wet retention pond 57 (WP57) in Catchment SP-9

Proposed Conditions

BMP Modifications

Ponds were scrutinized following guidance from the Minnesota Pollution Control Agency (MPCA, 2014), 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 contributing drainage area. Ponds that did not fit this criteria where considered for modifications. Other BMPs were investigated following guidance from the Minnesota Stormwater Manual.

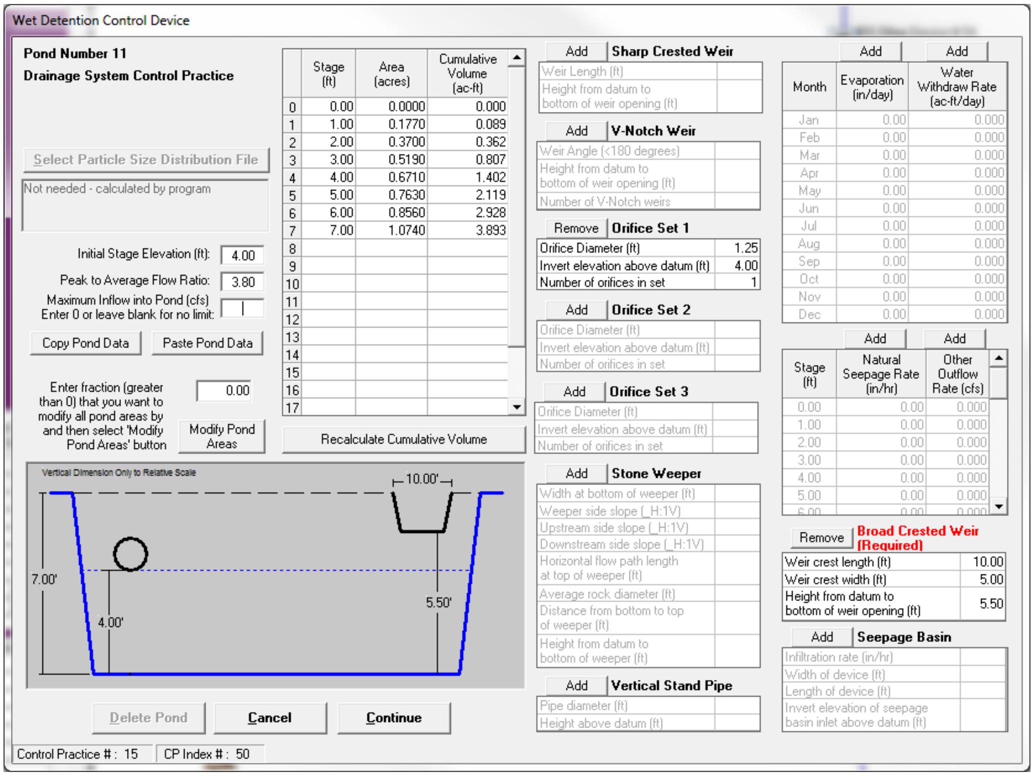

Figure 78: WinSLAMM model inputs for a BMP modification to WP8 in Catchment SP-4.

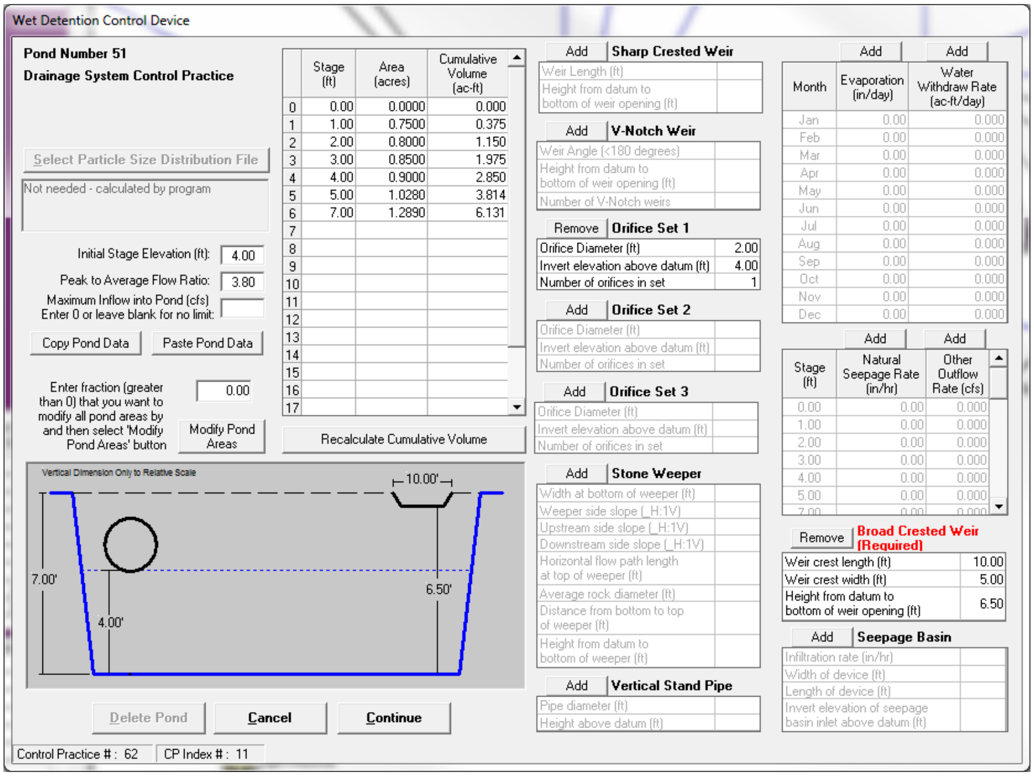

Figure 79: WinSLAMM model inputs for a BMP modification to WP48 in Catchment SP-13.

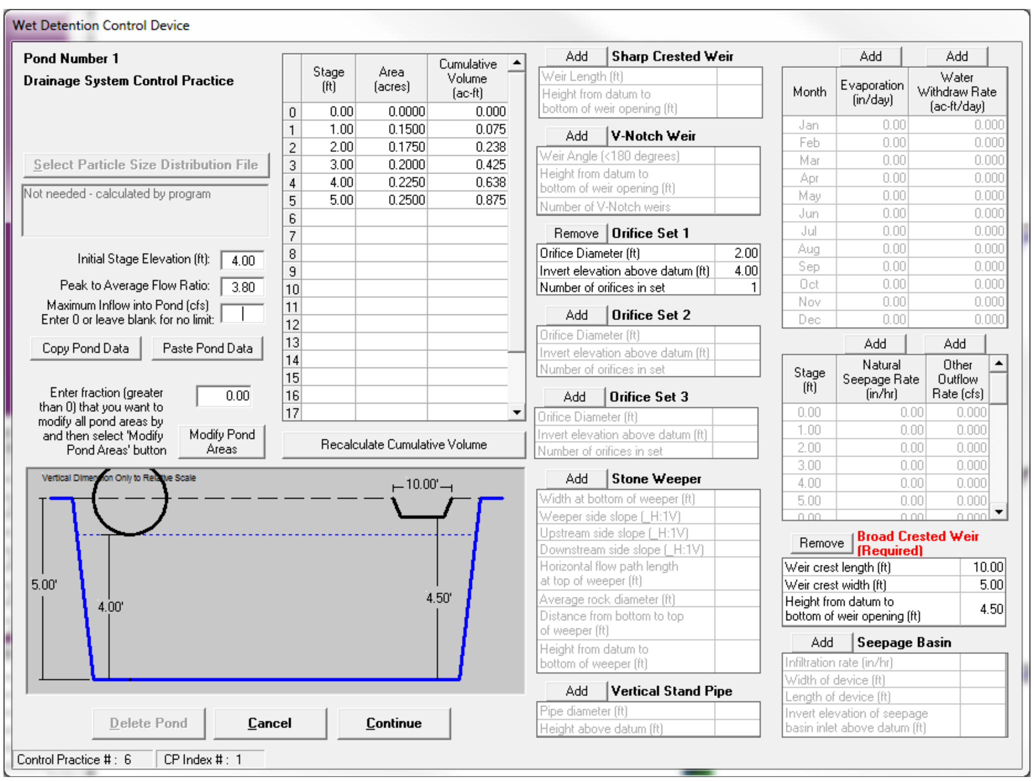

Figure 80: WinSLAMM model inputs for a BMP modification (pond expansion to 0.25 acres) to WP53 in Catchment SP-15.

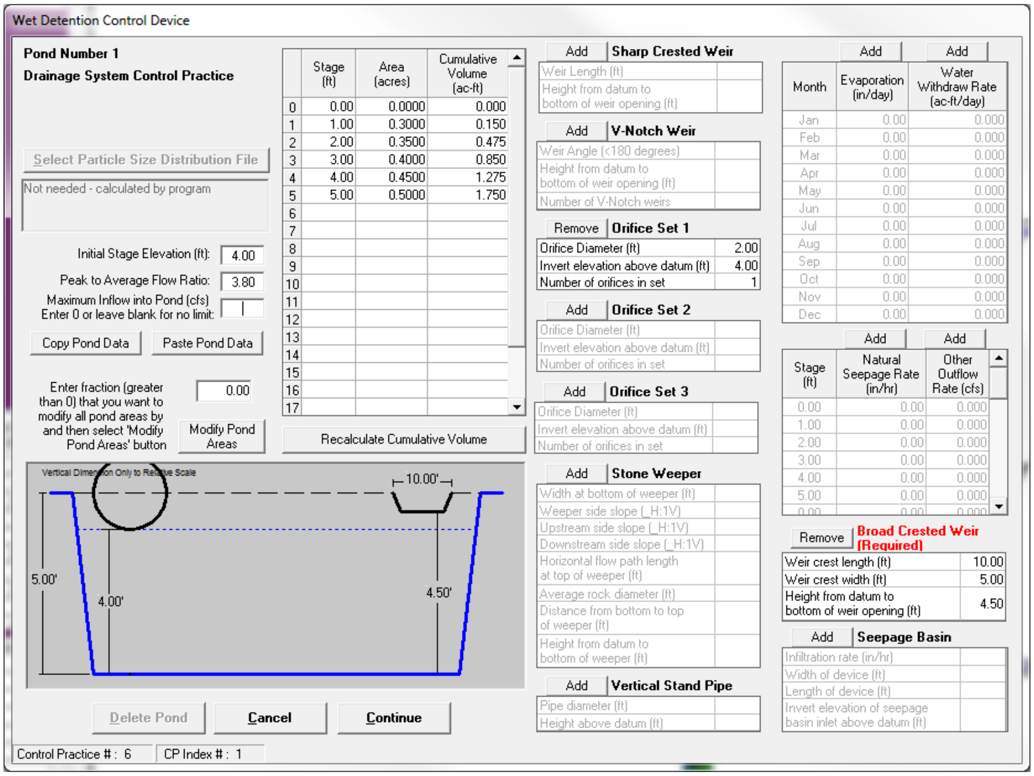

Figure 81: WinSLAMM model inputs for a BMP modification (pond expansion to 0.50 acres) to WP53 in Catchment SP-15.

Curb-Cut Rain Garden

Curb-cut rain gardens were modeled as drainage area control practices within WinSLAMM. Table 18 describes specific input parameters for rain gardens in the WinSLAMM model. Figure 82 shows the WinSLAMM biofiltration parameter input screen.

Table 18: WinSLAMM Input Parameters for Curb-Cut Rain Gardens

Parameter	Unit	Value
Top Area	sq-ft.	varies
Bottom Area	sq-ft.	Varies
Total Depth	ft.	1.5
Native Soil Infiltration Rate	in/hr	2.5
Infiltration Rate Fraction-Bottom (0-1)	-	1
Infiltration Rate Fraction-Sides (0-1)	-	1
Rock Filled Depth	ft.	N/A
Rock Fill Porosity (0-1)	-	N/A
Engineered Media Infiltration Rate	in/hr	N/A
Engineered Media Depth	ft.	N/A
Engineered Media Porosity (0-1)	-	N/A
Inflow Hydrograph Peak to Average Flow Ratio	-	3.8
Broad Crested Weir Length	ft.	3.0
Broad Crested Weir Width	ft.	0.5
Height From Datum to Bottom of Weir Opening	ft.	1.0
Underdrain Pipe Diameter	ft.	N/A
Underdrain Invert Elevation Above Datum	ft.	N/A
Number of pipes at invert elevation	-	N/A

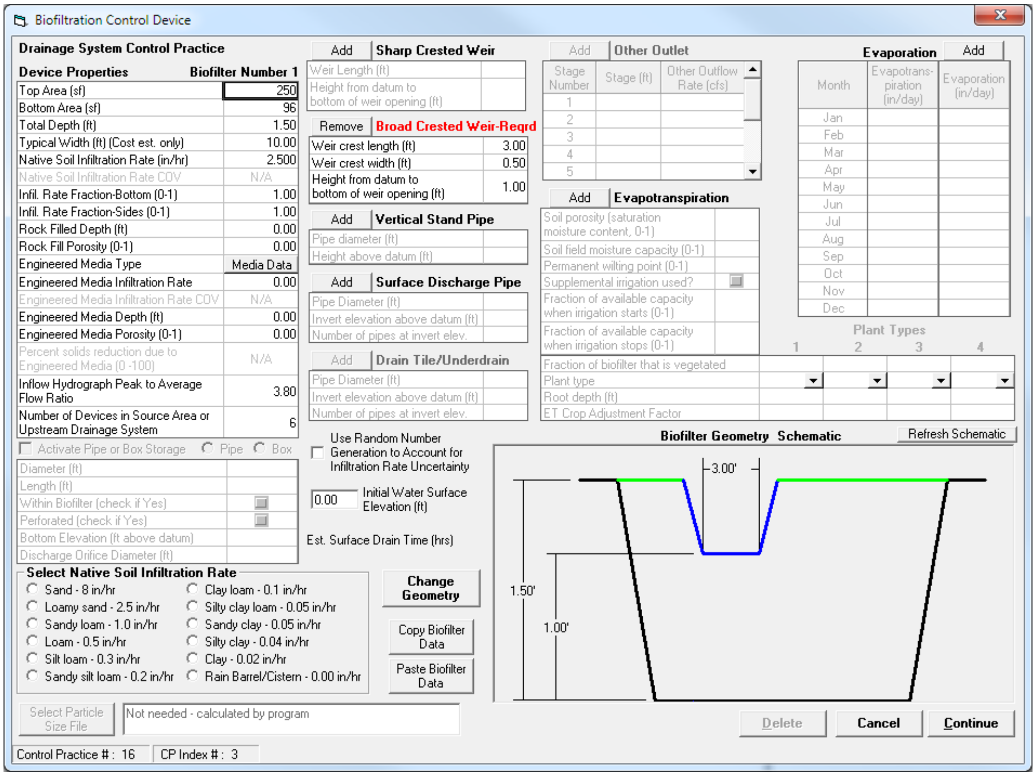

Figure 82: Bioinfiltration Control Practice Input Screen: Curb-cut Rain Garden (WinSLAMM)

Hydrodynamic Device

Table 19: 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

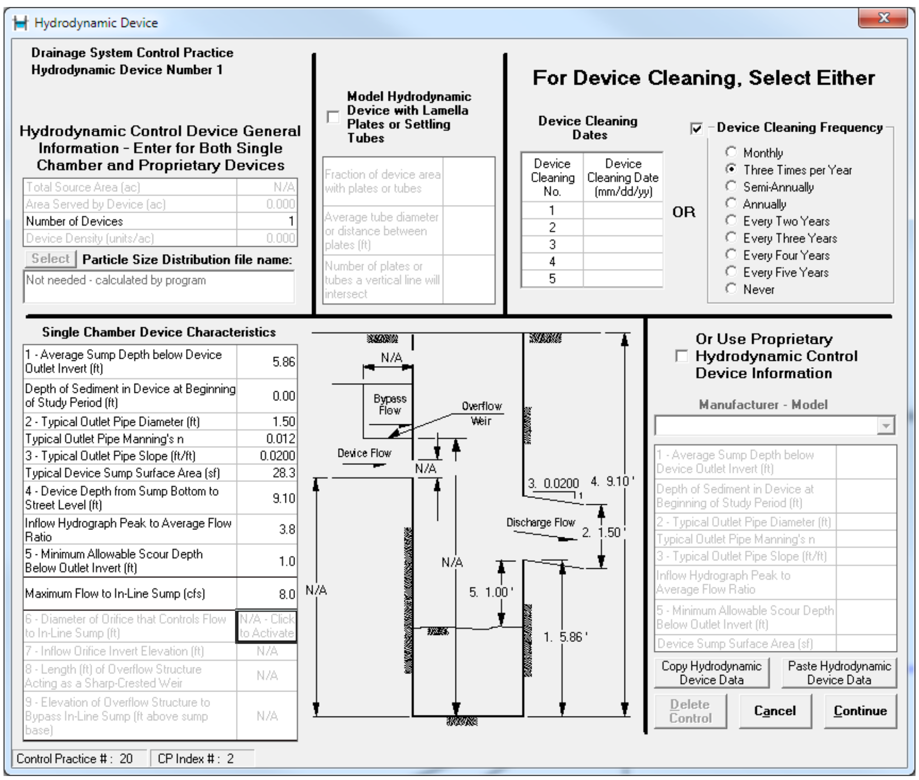

Figure 83: Hydrodynamic Device (6' diam.) WinSLAMM model inputs

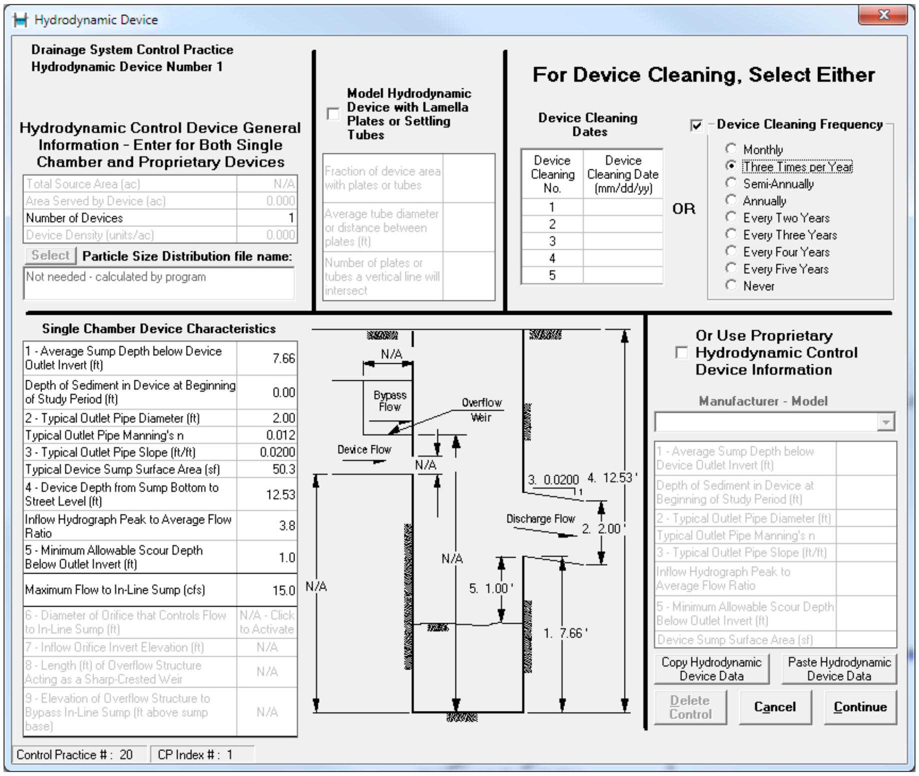

Figure 84: Hydrodynamic Device (8' diam.) WinSLAMM model inputs

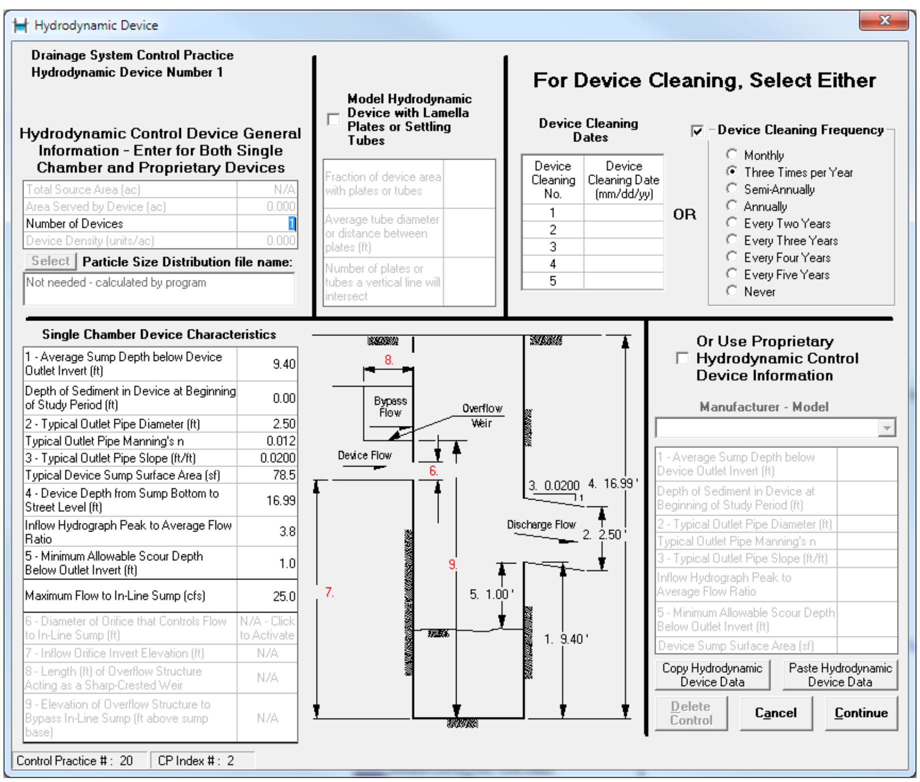

Figure 85: Hydrodynamic Device (10' diam.) WinSLAMM model inputs

Infiltration Basin

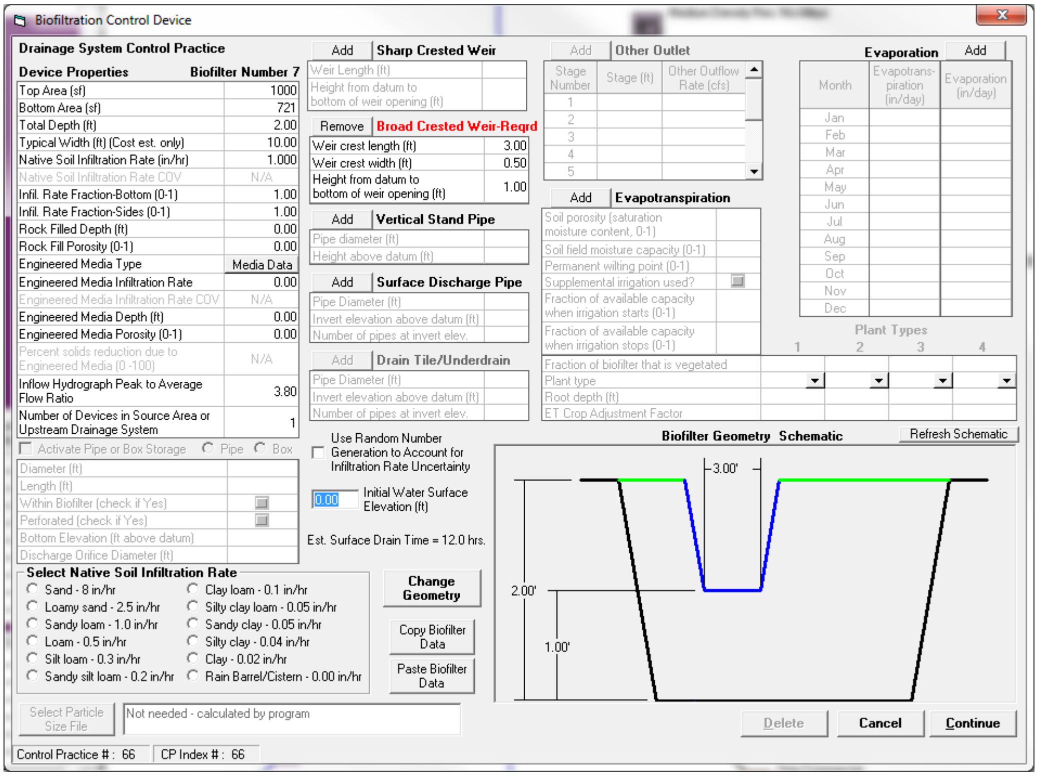

Figure 86: WinSLAMM model inputs for a 12" deep infiltration basin in subcatchment 3-4. This BMP was also proposed as a 6" deep basin.

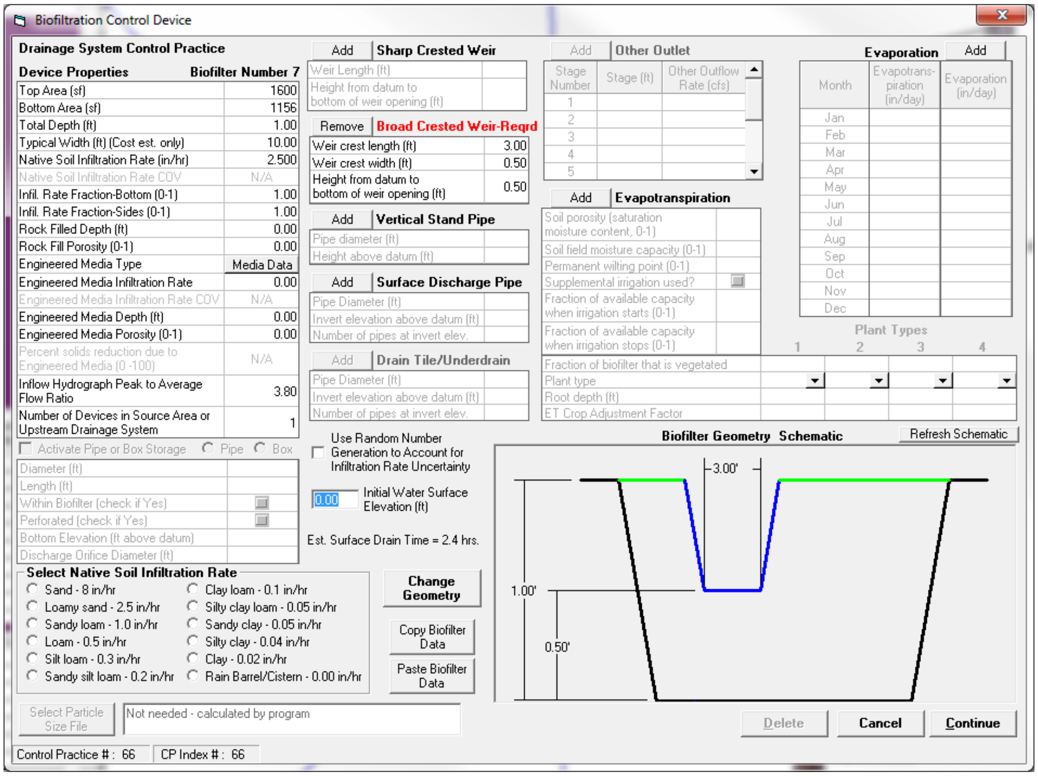

Figure 87: WinSLAMM model inputs for a 6" deep infiltration basin in subcatchment 3-11. This BMP was also proposed as a 12" deep basin.

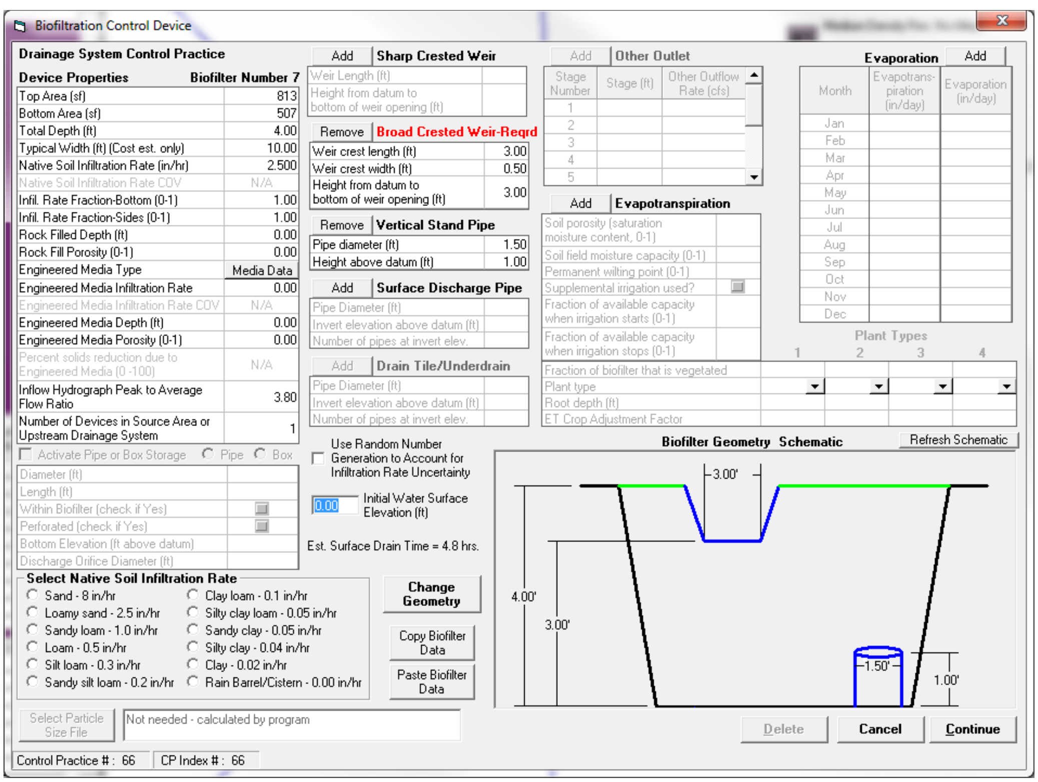

Figure 88: WinSLAMM model inputs for a 12" deep infiltration basin in subcatchment 3-19

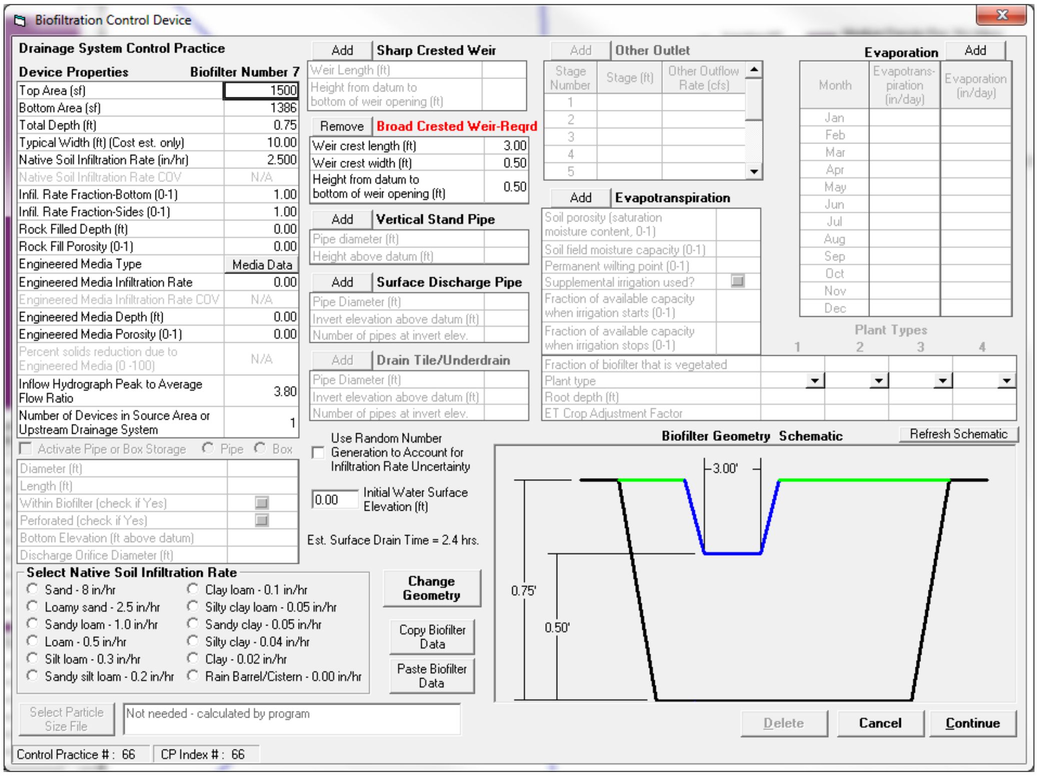

Figure 89: WinSLAMM model inputs for a 6" deep infiltration basin in subcatchment 5-4

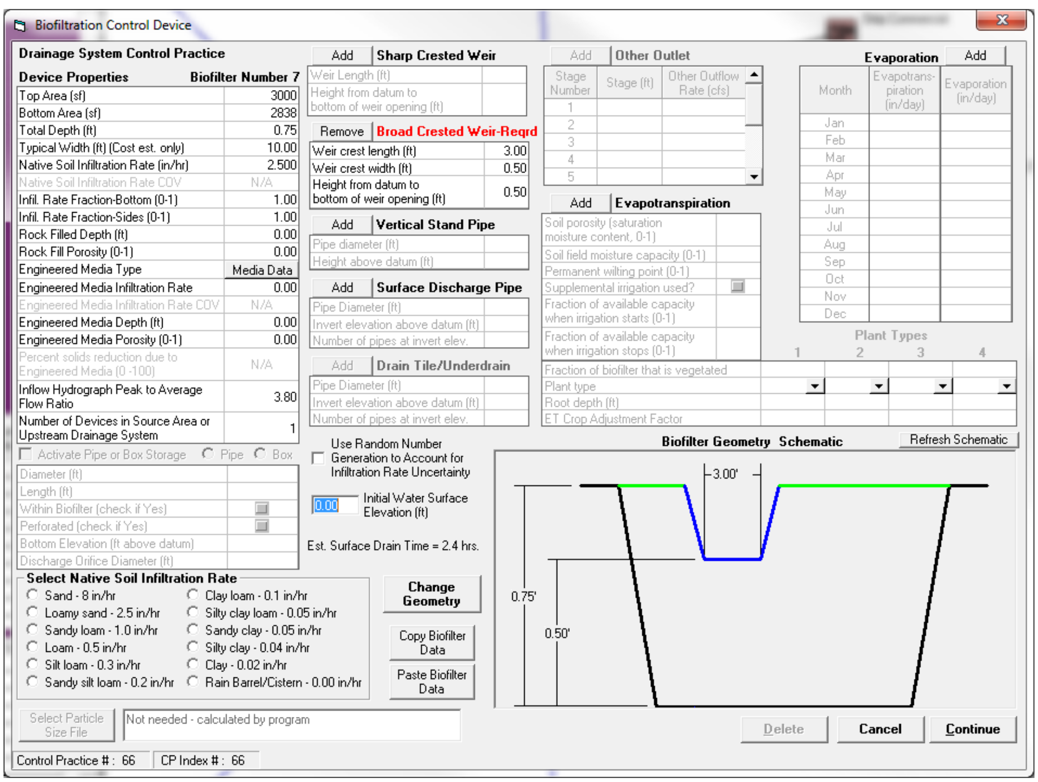

Figure 90: WinSLAMM model inputs for a 6" deep infiltration basin in subcatchment 5-9. This BMP was also proposed as a 12" deep basin.

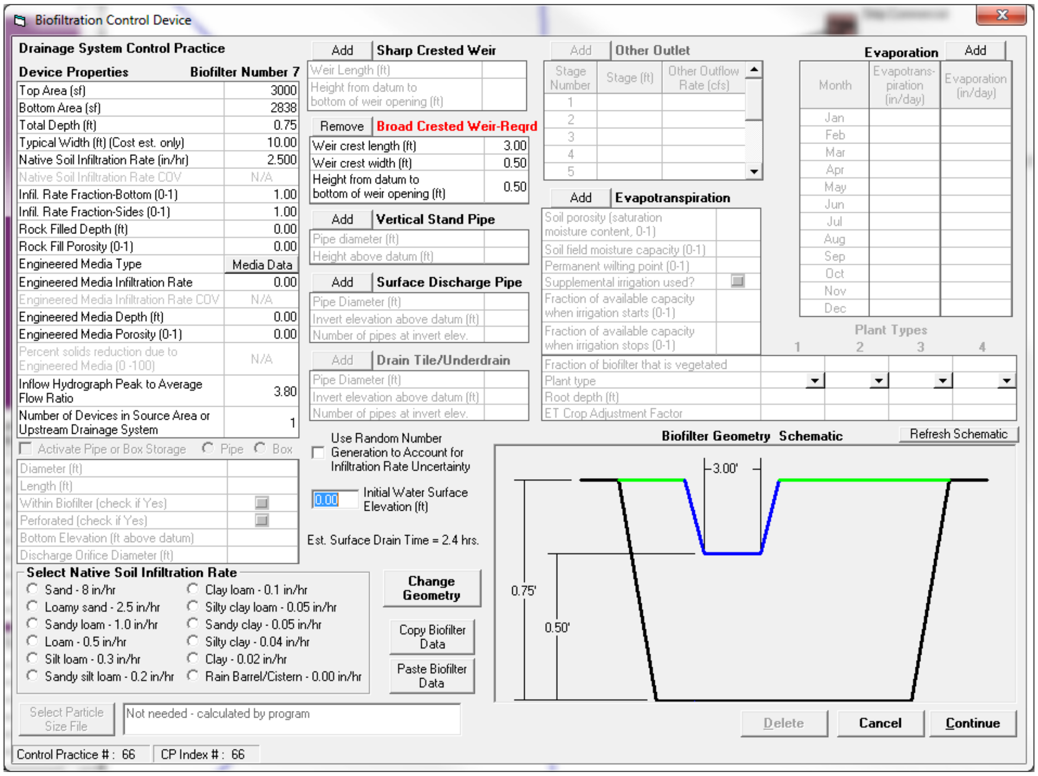

Figure 91: WinSLAMM model inputs for a 6" deep, 3,000 sq-ft. infiltration basin in subcatchment 6-16. This BMP was also proposed as a 1,660 sq-ft. basin.

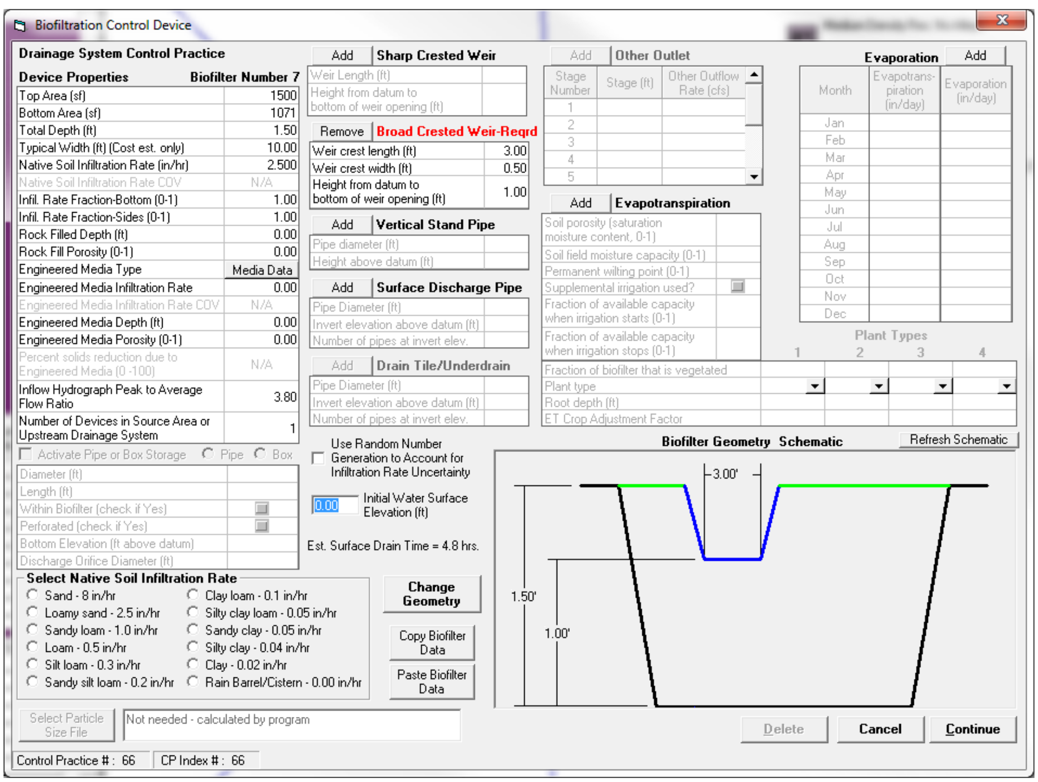

Figure 92: WinSLAMM model inputs for a 12" deep infiltration basin in subcatchment 7-1

Iron-Enhanced Sand Filter Pond Benches

Iron-Enhanced Sand Filter (IESF) benches were proposed along existing ponds requiring additional phosphorus removal. IESFs were sized based on space available and proximity to the existing storm sewer outlet.

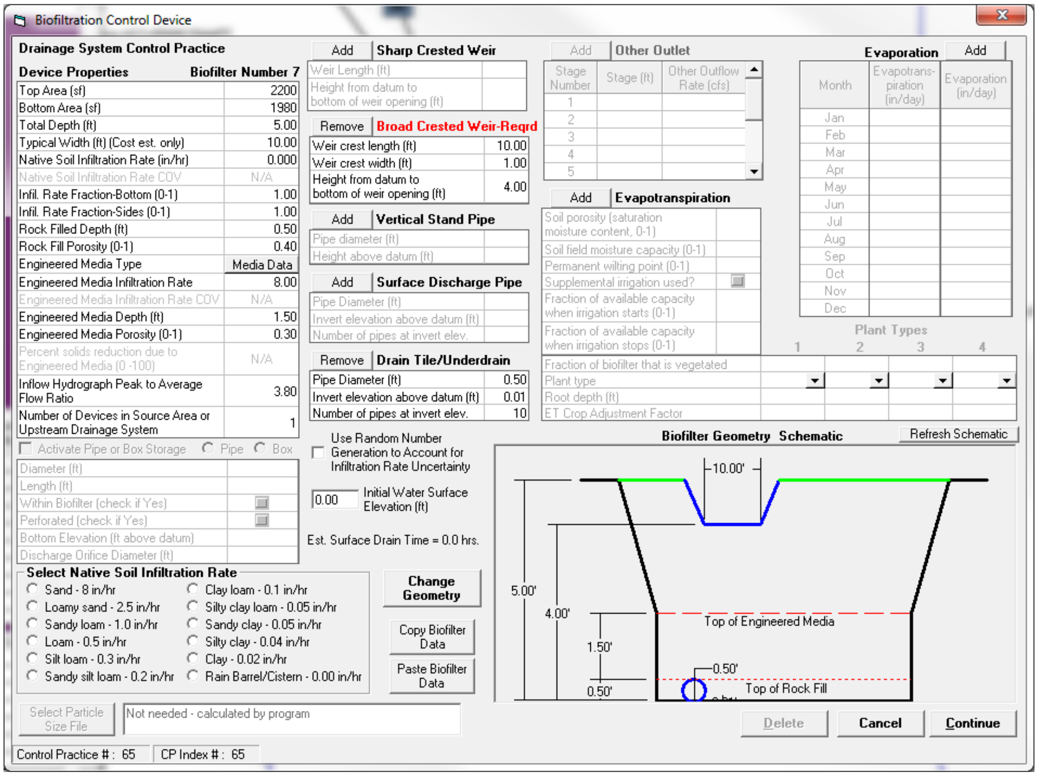

Figure 93: WinSLAMM model inputs for an IESF bench along WP16 in Catchment SP-5

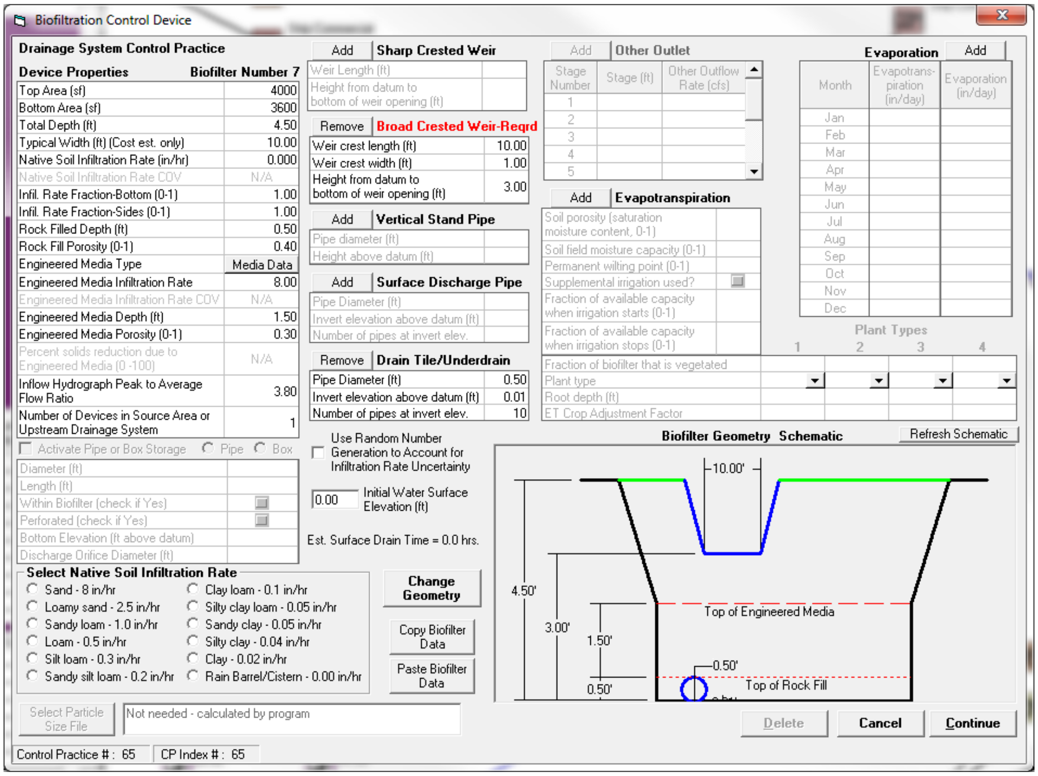

Figure 94: WinSLAMM model inputs for an IESF bench along WP30 in Catchment SP-9

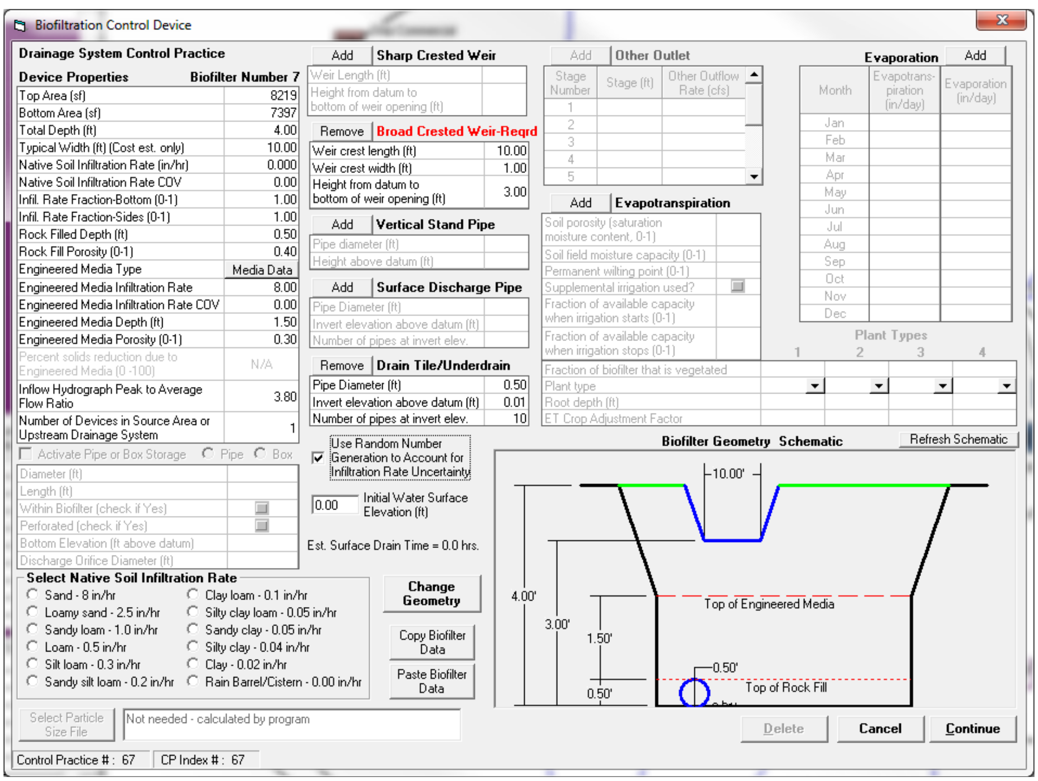

Figure 95: WinSLAMM model inputs for an IESF bench along WP41 in Catchment SP-9

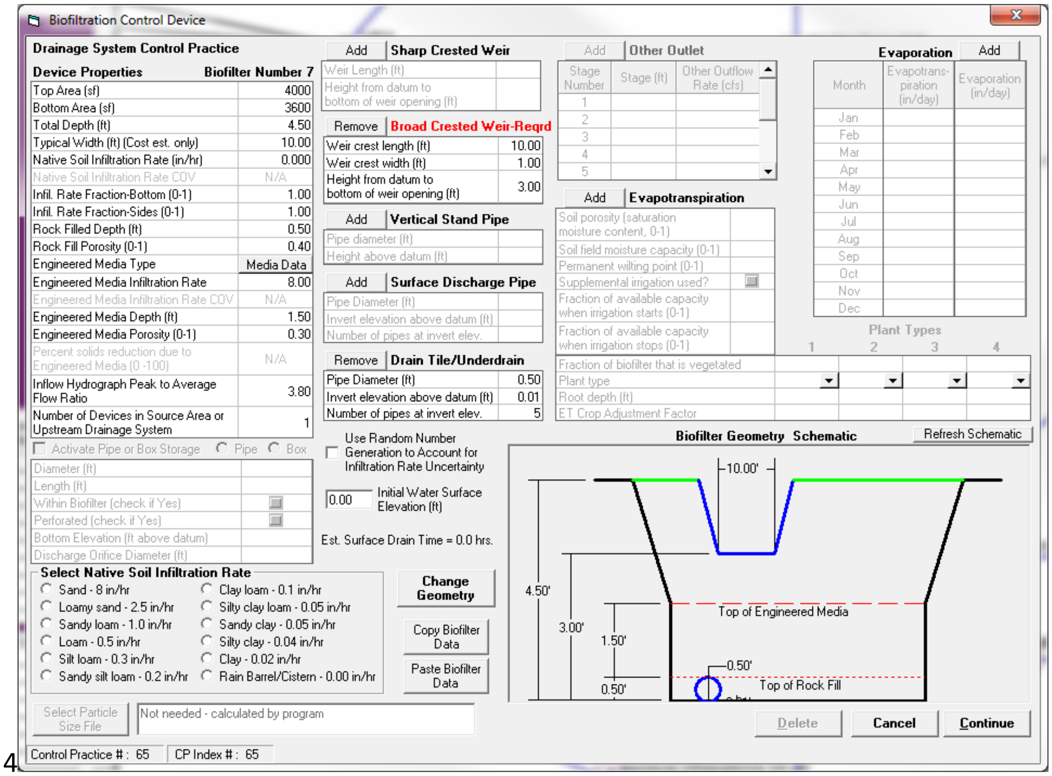

Figure 96: WinSLAMM model inputs for an IESF bench along WP20 in Catchment SP-11

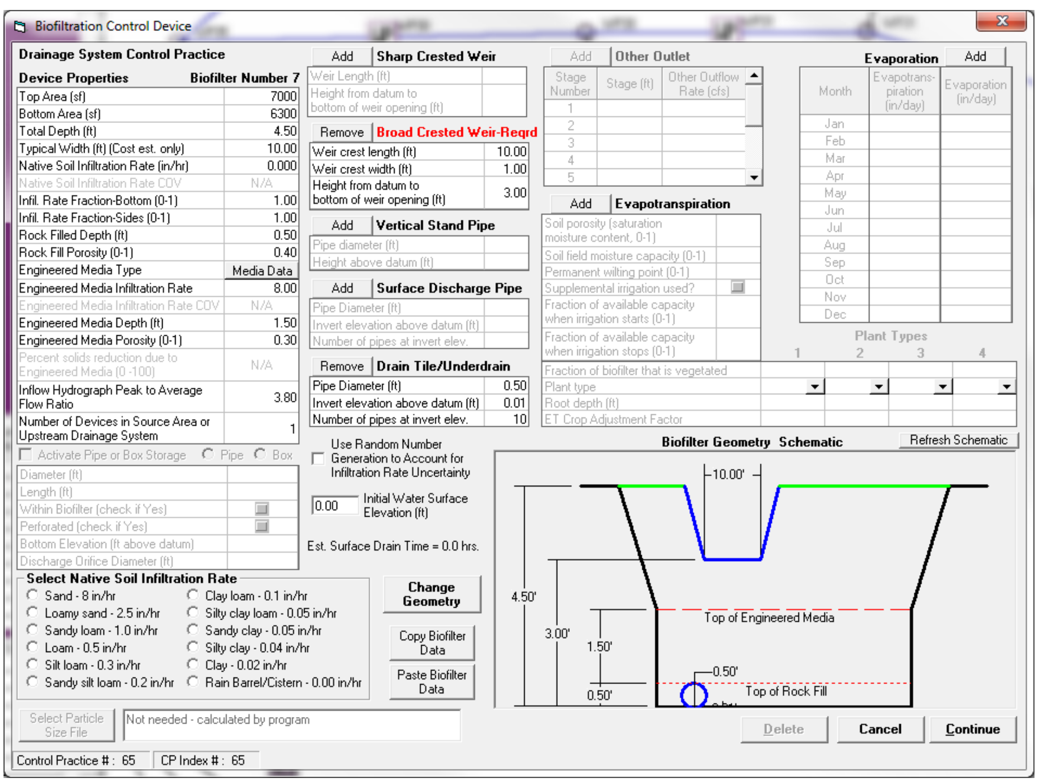

Figure 97: WinSLAMM model inputs for an IESF bench along WP22 in Catchment SP-12

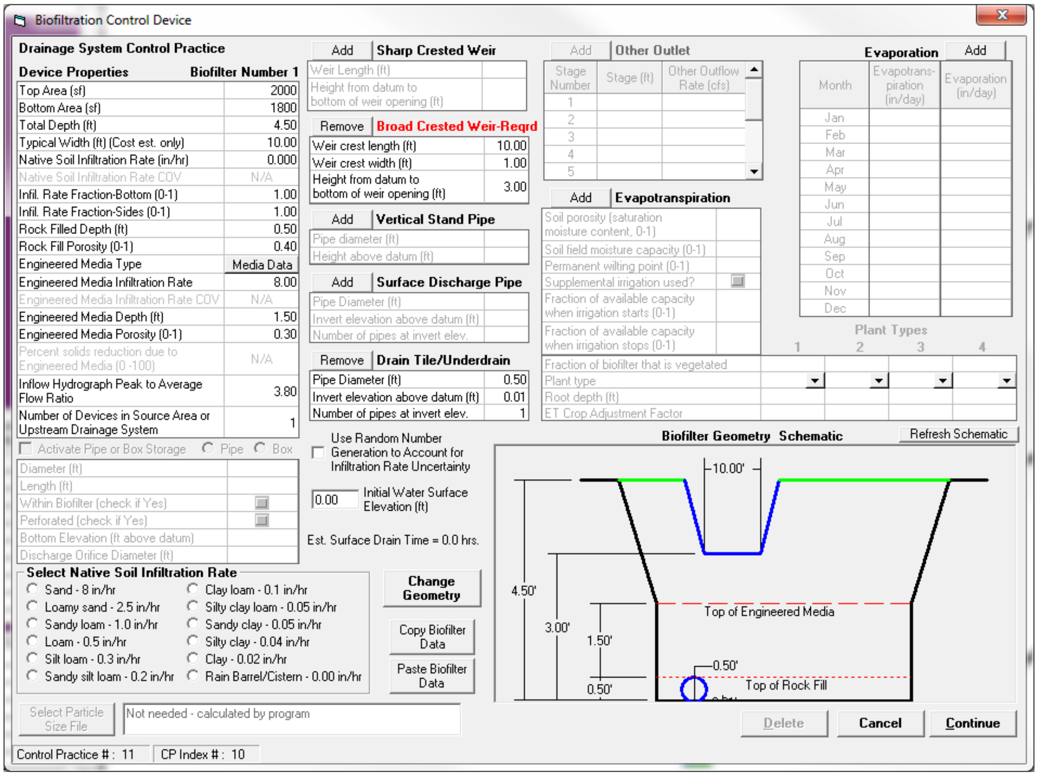

Figure 98: WinSLAMM model inputs for an IESF bench along WP42 in Catchment SP-15

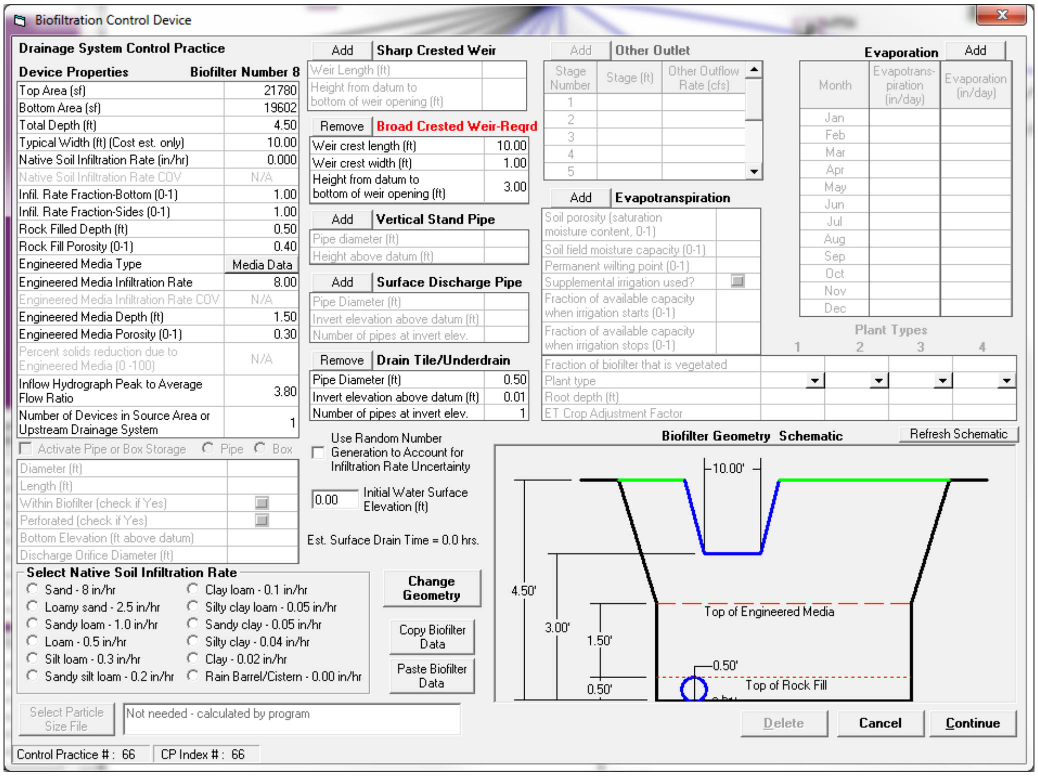

Figure 99: WinSLAMM model inputs for an on-channel IESF bench just downstream of the Springbrook Nature Center in Catchment SP-15. This device was also modeled with a 10,890 sq-ft top area and 9,800 sq-ft bottom area.

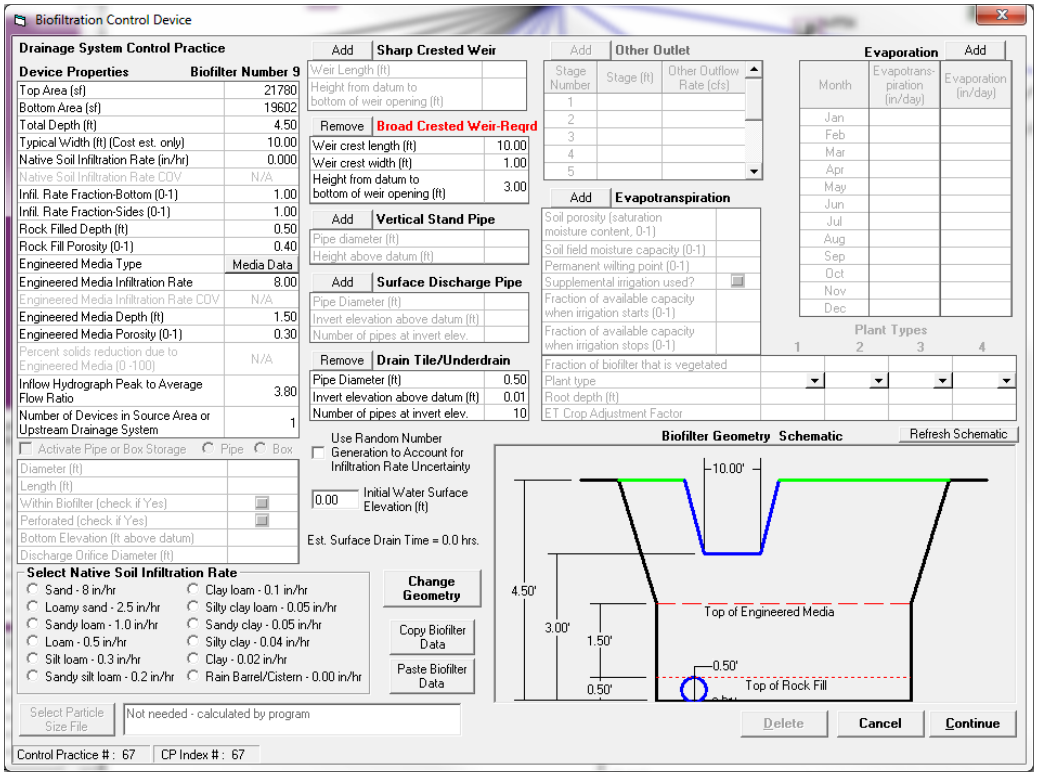

Figure 100: WinSLAMM model inputs for an IESF bench in Riverview Heights Park in Catchment SP-16. This device was also modeled with a 10,890 sq-ft top area and 9,800 sq-ft bottom area. A sedimentation basin was also modeled with this practice with both the 21,780 sq-ft and 10,890 sq-ft top areas.

Permeable Asphalt

Permeable asphalt area was determined as a 4:1 fraction of the drainage area it treats. For example, 1 acre of permeable asphalt would be proposed to treat 4 acres of drainage area. Within WinSLAMM this BMP was created as a source-control practice, as opposed to most other structural BMPs modeled in this report, which are created as drainage-control practices. Below are the input screens created in WinSLAMM.

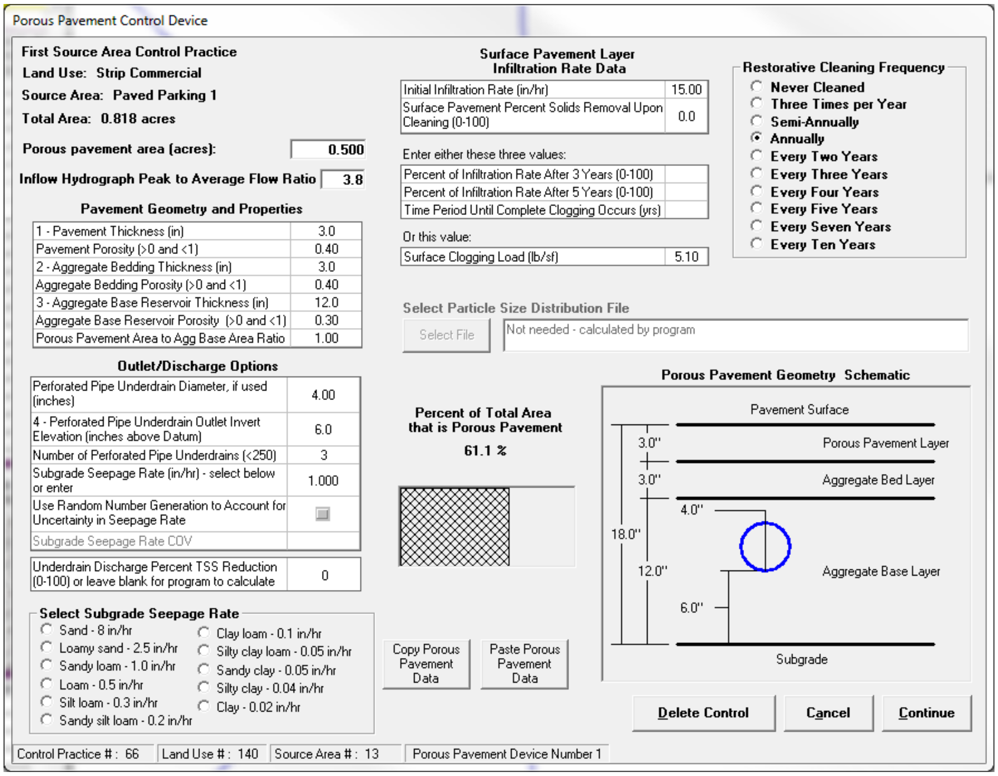

Figure 101: WinSLAMM model input screen for permeable asphalt treating strip commercial land use in Catchment SP-5

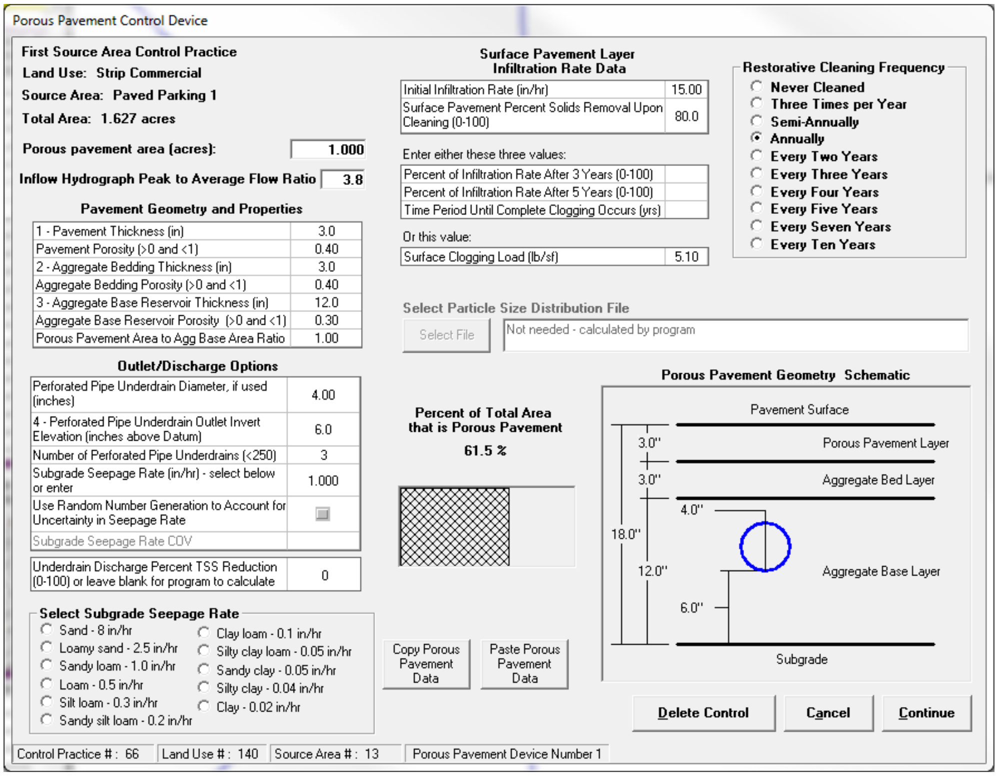

Figure 102: WinSLAMM model input screen for permeable asphalt treating strip commercial land use in Catchment SP-6

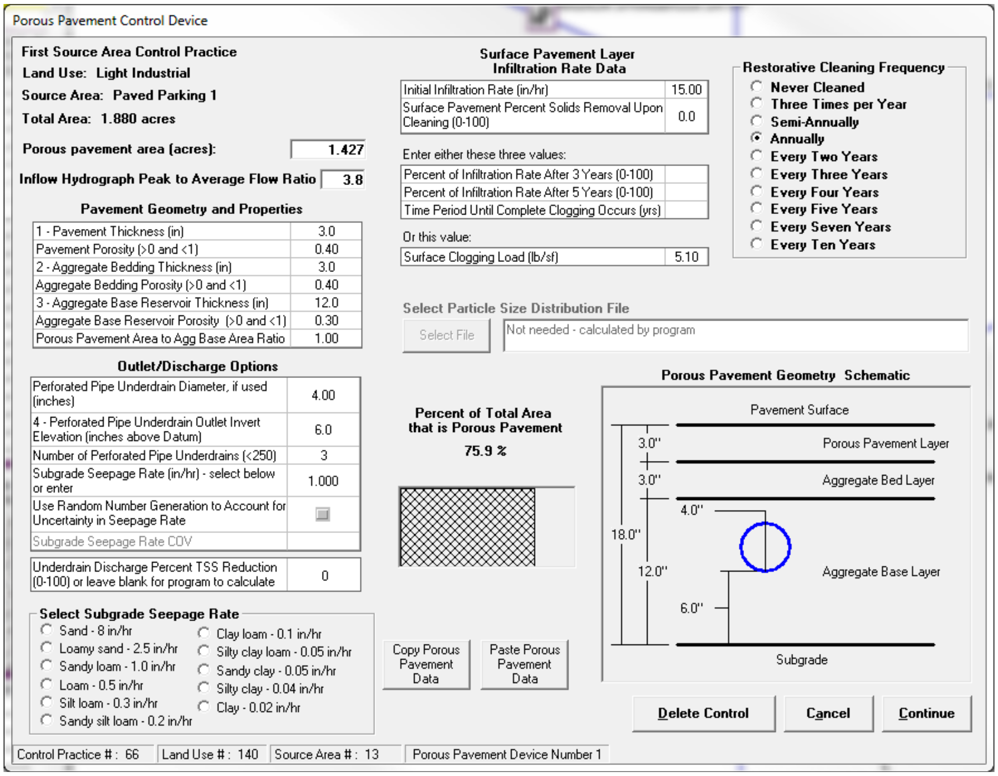

Figure 103: WinSLAMM model input screen for permeable asphalt treating light industrial land use in Catchment SP-9

Permeable Check Dam

With this BMP there are two processes that drive pollutant retention within the practice. First, the practice detains stormwater behind the dam, dropping particulate pollutants out of suspension. Secondly, any water that has been impounded by the dam can either pass through the dam (and its IESF) or be evapotranspired prior to passing through the dam. To mimic these processes within WinSLAMM two different models were created, each with the same land use, soil, and existing stormwater infrastructure conditions. Within both models a biofiltration drainage area control practice was installed.

To model the effect of detaining water behind the dam, a biofiltration control practice with the same ponding storage as the check dams was modeled. This practice did not have an underdrain and assumes very silty soils with no infiltration (0.0"/hour infiltration rate; Figure 104). Volume, TSS, and particulate phosphorus retention were determined from this model. For water passing through the filter, a similarly sized biofiltration control practice was modeled, but in this case was modeled with an underdrain (Figure 105). Dissolved phosphorus retention was determined from this model assuming that 80% of dissolved phosphorus flowing through the dam was retained (Erickson & Gulliver, 2010). Total phosphorus, or TP, reduction was the summation of particulate and dissolved phosphorus reductions between the two models.

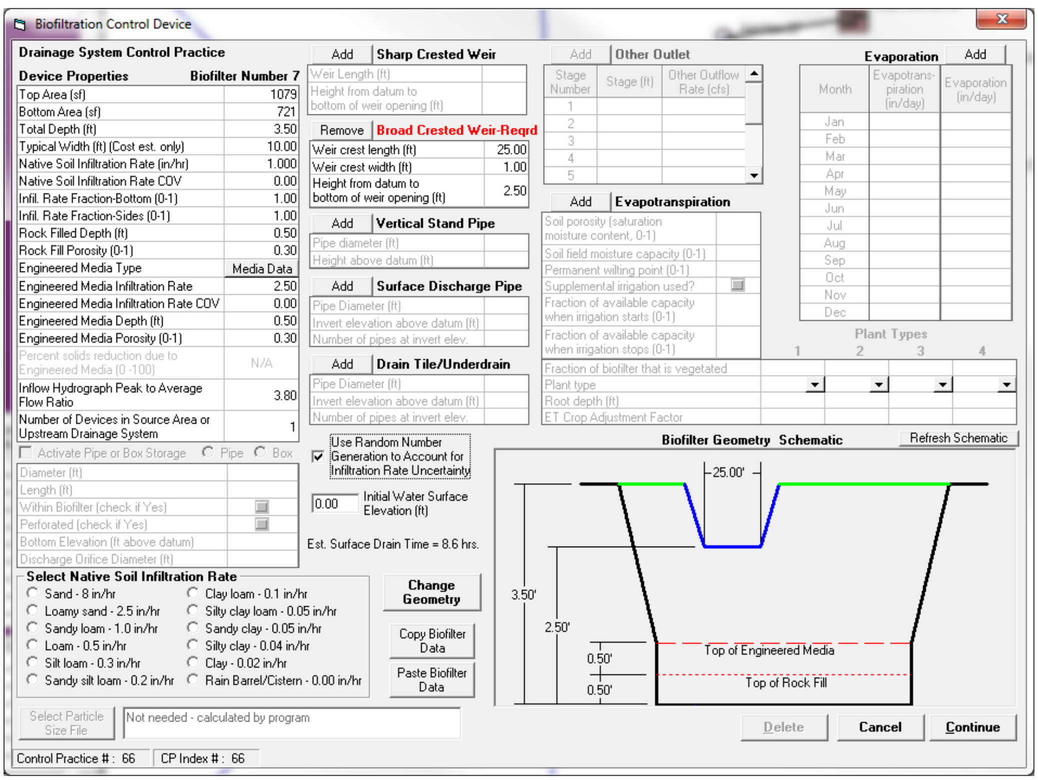

Figure 104: WinSLAMM model inputs for a permeable check dam without an underdrain in Catchment SP-5

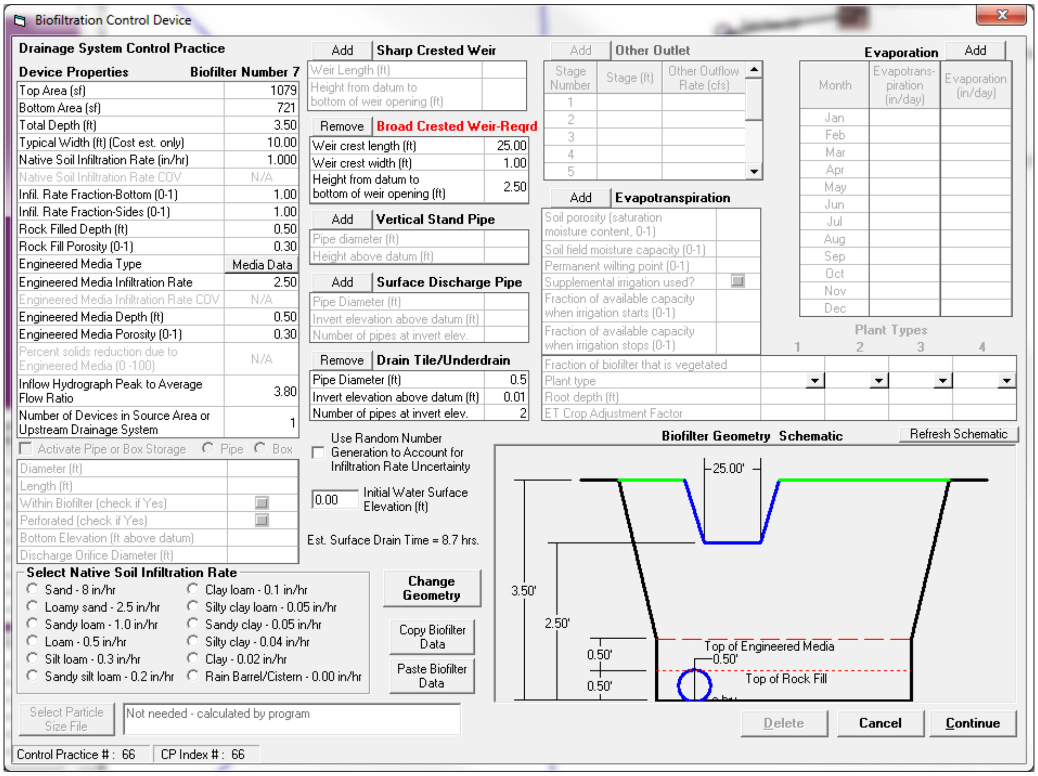

Figure 105: WinSLAMM model inputs for a permeable check dam with an underdrain in Catchment SP-5

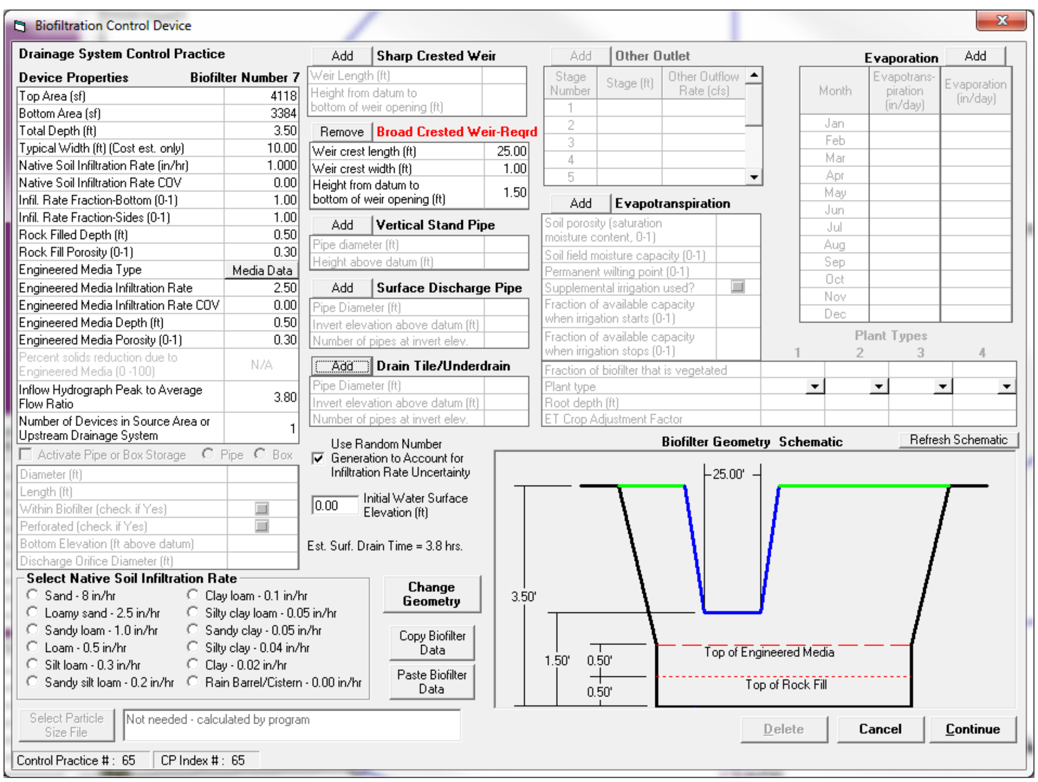

Figure 106: WinSLAMM model inputs for a permeable check dam without an underdrain in Catchment SP-11

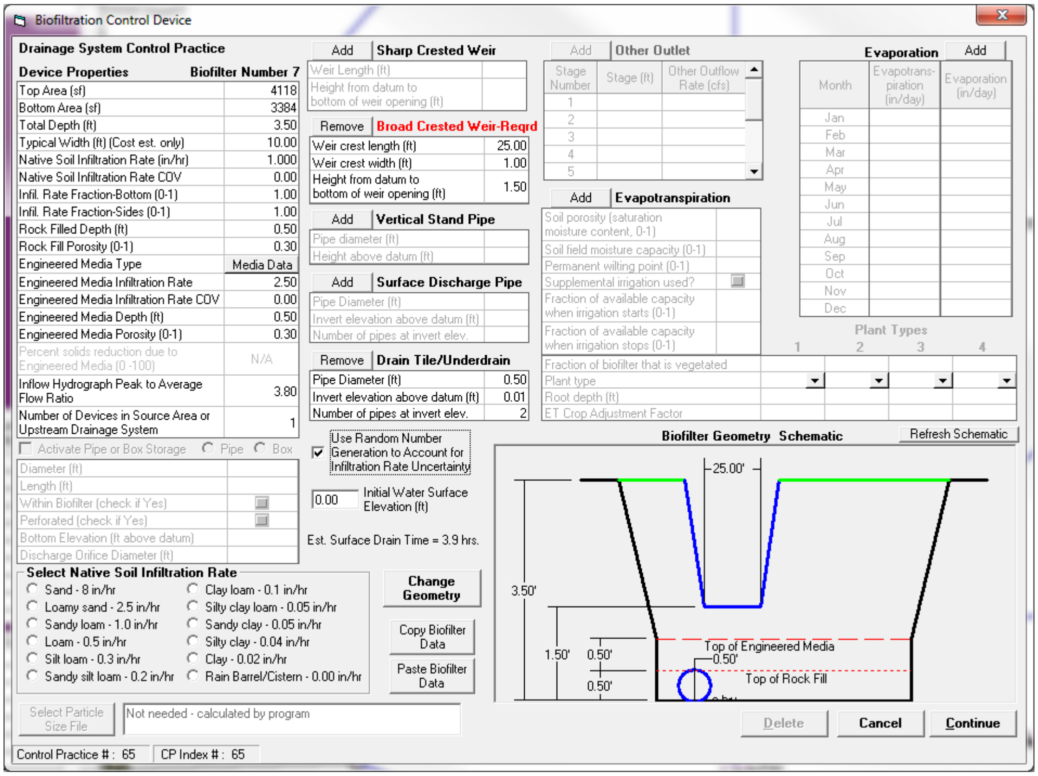

Figure 107: WinSLAMM model inputs for a permeable check dam with an underdrain in Catchment SP-11

Appendix B – Project Cost Estimates

Introduction

The ‘Cost Estimates’ section on page 22 explains the elements of cost that were considered and the assumptions that were made. 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 and underground storage.

BMP Modifications

Table 20: Cost estimate for a pond expansion on WP8 in Catchment SP-4

Activity	Units	Unit Price	Quantity	Unit Price
Design	Each	$ 5,000.00	1	$ 5,000.00
Mobilization	Each	$ 5,000.00	1	$ 5,000.00
Land Acquisition	acres	$ -	1.5	$ -
Site Prep	Each	$ 2,000.00	1	$ 2,000.00
Excavation	cu-yards	$ -	6,227	$ -
Outlet Control Structure	Each	$ 10,000.00	1	$ 10,000.00
Existing Infrastructure Retrofit	Each	$ -	1	$ -
Site Restoration/Revegetation	Each	$ 2,000.00	1	$ 2,000.00
		Total for project =		$ 24,000.00

Table 21: Cost estimate for an expansion of an infiltration basin in Catchment SP-10

Activity	Units	Unit Price	Quantity	Unit Price
Design	Each	$ 10,000.00	1	$ 10,000.00
Mobilization	Each	$ 10,000.00	1	$ 10,000.00
Land Acquisition (privately owned by purchase should not be necessary)	acres	$ -	0	$ -
Clearing, Removal of Existing Infrastructure	Each	$ 12,000.00	1	$ 12,000.00
Common Excavation & Disposal	cu-yards	$ 40.00	400	$ 16,000.00
Outlet/Inlet Control Structures	Each	$ 15,000.00	1	$ 15,000.00
Replanting	Each	$ 5,000.00	1	$ 5,000.00
Site Restoration	Each	$ 10,000.00	1	$ 10,000.00
		Total for project =		$ 78,000.00

Table 22: Cost estimate for an expansion of WP48 in Catchment SP-13 – general construction activities

Activity	Units	Unit Price	Quantity	Unit Price
Feasibility Study and Project Design	Each	$ 15,000.00	1	$ 15,000.00
Mobilization	Each	$ 10,000.00	1	$ 10,000.00
Land Acquisition - Try to enter partnership with private owner's				$ -
Site Prep	Each	$ 10,000.00	1	$ 10,000.00
Brush Removal	Each	$ 15,000.00	1	$ 15,000.00
Sediment Testing	Each	$ 10,000.00	1	$ 10,000.00
Existing Infrastructure Retrofit	Each	$ 5,000.00	1	$ 5,000.00
Outlet Control Structure	Each	$ 10,000.00	1	$ 10,000.00
Site Restoration	Each	$ 10,000.00	1	$ 10,000.00
	Project Total Before Excavation =			$ 85,000.00

Table 23: Cost estimate for an expansion of WP48 in Catchment SP-13 – range of costs for excavation based on management level, as well as total project costs.

Activity	Management Levels		
	1	2	3
Soil To Excavate (cu-yds)	3,000	3,000	3,000
Cost To Excavate ($/cu-yd)	$20	$35	$50
Cost To Excavate (Total $)	$60,000	$105,000	$160,000
Other Construction Costs ($)	$85,000	$85,000	$85,000
Total Project Cost ($)	$145,000	$190,000	$245,000

Table 24: Cost estimate for an expansion of WP53 to 0.25 acres in Catchment SP-15 – general construction activities

Activity	Units	Unit Price	Quantity	Unit Price
Feasibility Study and Project Design	Each	$ 15,000.00	1	$ 15,000.00
Mobilization	Each	$ 10,000.00	1	$ 10,000.00
Land Acquisition - Try to enter partnership with private owner's				$ -
Site Prep	Each	$ 10,000.00	1	$ 10,000.00
Brush Removal	Each	$ 15,000.00	1	$ 15,000.00
Sediment Testing	Each	$ 10,000.00	1	$ 10,000.00
Existing Infrastructure Retrofit	Each	$ 5,000.00	1	$ 5,000.00
Outlet Control Structure	Each	$ 10,000.00	1	$ 10,000.00
Site Restoration	Each	$ 10,000.00	1	$ 10,000.00
	Project Total Before Excavation =			$ 85,000.00

Table 25: Cost estimate for an expansion of WP53 to 0.25 in Catchment SP-15 – range of costs for excavation based on management level, as well as total project costs.

Activity	Management Levels		
	1	2	3
Soil To Excavate (cu-yds)	900	900	900
Cost To Excavate ($/cu-yd)	$20	$35	$50
Cost To Excavate (Total $)	$18,000	$31,500	$45,000
Other Construction Costs ($)	$85,000	$85,000	$85,000
Total Project Cost ($)	$103,000	$116,500	$130,000

Table 26: Cost estimate for an expansion of WP53 to 0.50 acres in Catchment SP-15 – general construction activities

Activity	Units	Unit Price	Quantity	Unit Price
Feasibility Study and Project Design	Each	$ 15,000.00	1	$ 15,000.00
Mobilization	Each	$ 10,000.00	1	$ 10,000.00
Land Acquisition - Try to enter partnership with private owner's				$ -
Site Prep	Each	$ 10,000.00	1	$ 10,000.00
Brush Removal	Each	$ 15,000.00	1	$ 15,000.00
Sediment Testing	Each	$ 10,000.00	1	$ 10,000.00
Existing Infrastructure Retrofit	Each	$ 5,000.00	1	$ 5,000.00
Outlet Control Structure	Each	$ 10,000.00	1	$ 10,000.00
Site Restoration	Each	$ 10,000.00	1	$ 10,000.00
	Project Total Before Excavation =			$ 85,000.00

Table 27: Cost estimate for an expansion of WP53 to 0.50 in Catchment SP-15 – range of costs for excavation based on management level, as well as total project costs.

Activity	Management Levels 1	2	3
Soil To Excavate (cu-yds)	2,500	2,500	2,500
Cost To Excavate ($/cu-yd)	$20	$35	$50
Cost To Excavate (Total $)	$50,000	$87,500	$125,000
Other Construction Costs ($)	$85,000	$85,000	$85,000
Total Project Cost ($)	$135,000	$172,500	$210,000

Iron-Enhanced Sand Filter Pond Benches

Table 28: Cost estimate for an IESF bench along WP16 in Catchment SP-5

Activity	Units	Unit Price	Quantity	Unit Price
Design/Bidding/Construction Oversight	Each	$ 40,000.00	1	$ 40,000.00
Mobilization	Each	$ 20,000.00	1	$ 20,000.00
Land Acquisition (already owned by Spring Lake Park School District)	acres	$ -	0	$ -
Clearing, Removal of Existing Infrastructure, and Pond Dewatering	Each	$ 12,000.00	1	$ 12,000.00
Common Excavation & Disposal	cu-yards	$ 40.00	326	$ 13,040.00
IESF Materials and Installation	sq-ft	$ 17.00	2,200	$ 37,400.00
Outlet/Inlet Control Structures	Each	$ 20,000.00	1	$ 20,000.00
Site Restoration	Each	$ 10,000.00	1	$ 10,000.00
		Total for project =		$ 152,440.00

Table 29: Cost estimate for an IESF bench along WP30 in Catchment SP-9

Activity	Units	Unit Price	Quantity	Unit Price
Design/Bidding/Construction Oversight	Each	$ 40,000.00	1	$ 40,000.00
Mobilization	Each	$ 15,000.00	1	$ 15,000.00
Land Acquisition (purchase property for IESF and existing pond)	acres	$ 30,000.00	1	$ 30,000.00
Clearing, Removal of Existing Infrastructure, and Pond Dewatering	Each	$ 12,000.00	1	$ 12,000.00
Common Excavation & Disposal	cu-yards	$ 40.00	593	$ 23,720.00
IESF Materials and Installation	sq-ft	$ 17.00	4,000	$ 68,000.00
Outlet/Inlet Control Structures	Each	$ 20,000.00	1	$ 20,000.00
Site Restoration	Each	$ 10,000.00	1	$ 10,000.00
		Total for project =		$ 218,720.00

Table 30: Cost estimate for an IESF bench along WP41 in Catchment SP-9

Activity	Units	Unit Price	Quantity	Unit Price
Design/Bidding/Construction Oversight	Each	$ 60,000.00	1	$ 60,000.00
Mobilization	Each	$ 20,000.00	1	$ 20,000.00
Land Acquisition	acres	$ 30,000.00	1.25	$ 37,500.00
Clearing, Removal of Existing Infrastructure, and Pond Dewatering	Each	$ 15,000.00	1	$ 15,000.00
Common Excavation & Disposal	cu-yards	$ 40.00	1,215	$ 48,600.00
IESF Materials and Installation	sq-ft	$ 17.00	8,200	$ 139,400.00
Lift Station, Pump, Electrical Housing, and Electrical Line	Each	$ 60,000.00	1	$ 60,000.00
Outlet/Inlet Control Structures	Each	$ 20,000.00	1	$ 20,000.00
Site Restoration	Each	$ 15,000.00	1	$ 15,000.00
		Total for project =		$ 415,500.00

Table 31: Cost estimate for an IESF bench along WP20 in Catchment SP-11

Activity	Units	Unit Price	Quantity	Unit Price
Design/Bidding/Construction Oversight	Each	$ 40,000.00	1	$ 40,000.00
Mobilization	Each	$ 15,000.00	1	$ 15,000.00
Land Acquisition (already owned by Anoka County)	acres	$ -	0	$ -
Clearing, Removal of Existing Infrastructure, and Pond Dewatering	Each	$ 12,000.00	1	$ 12,000.00
Common Excavation & Disposal	cu-yards	$ 40.00	593	$ 23,720.00
IESF Materials and Installation	sq-ft	$ 17.00	4,000	$ 68,000.00
Outlet/Inlet Control Structures	Each	$ 15,000.00	1	$ 15,000.00
Site Restoration	Each	$ 10,000.00	1	$ 10,000.00
		Total for project =		$ 183,720.00

Table 32: Cost estimate for an IESF bench along WP22 in Catchment SP-12

Activity	Units	Unit Price	Quantity	Unit Price
Design/Bidding/Construction Oversight	Each	$ 40,000.00	1	$ 40,000.00
Mobilization	Each	$ 20,000.00	1	$ 20,000.00
Land Acquisition (already owned by Anoka County)	acres	$ -	0	$ -
Clearing, Removal of Existing Infrastructure, and Pond Dewatering	Each	$ 12,000.00	1	$ 12,000.00
Common Excavation & Disposal	cu-yards	$ 40.00	1,037	$ 41,480.00
IESF Materials and Installation	sq-ft	$ 17.00	7,000	$ 119,000.00
Outlet/Inlet Control Structures	Each	$ 30,000.00	1	$ 30,000.00
Site Restoration	Each	$ 15,000.00	1	$ 15,000.00
		Total for project =		$ 277,480.00

Table 33: Cost estimate for an IESF bench along WP42 in Catchment SP-15

Activity	Units	Unit Price	Quantity	Unit Price
Design/Bidding/Construction Oversight	Each	$ 30,000.00	1	$ 30,000.00
Mobilization	Each	$ 15,000.00	1	$ 15,000.00
Land Acquisition (already owned by Anoka County)	acres	$ -	0	$ -
Clearing, Removal of Existing Infrastructure, and Pond Dewatering	Each	$ 12,000.00	1	$ 12,000.00
Common Excavation & Disposal	cu-yards	$ 40.00	296	$ 11,840.00
IESF Materials and Installation	sq-ft	$ 17.00	2,000	$ 34,000.00
Outlet/Inlet Control Structures	Each	$ 20,000.00	1	$ 20,000.00
Site Restoration	Each	$ 15,000.00	1	$ 15,000.00
		Total for project =		$ 137,840.00

Table 34: Cost estimate for a 0.25 acre IESF bench just downstream of the Springbrook Nature Center in Catchment SP-15. These costs are associated with project 15-G in the Catchment Profiles pages.

Activity	Units	Unit Price	Quantity	Unit Price
Design/Bidding/Construction Oversight	Each	$ 60,000.00	1	$ 60,000.00
Mobilization	Each	$ 20,000.00	1	$ 20,000.00
Land Acquisition	acres	$ 60,000.00	2	$ 90,000.00
Clearing, Removal of Existing Infrastructure, and Pond Dewatering	Each	$ 15,000.00	1	$ 15,000.00
Common Excavation & Disposal	cu-yards	$ 40.00	2,020	$ 80,800.00
IESF Materials and Installation	sq-ft	$ 17.00	10,890	$ 185,130.00
Lift Station, Pump, Electrical Housing, and Electrical Line	Each	$ 60,000.00	1	$ 60,000.00
Outlet/Inlet Control Structures	Each	$ 20,000.00	1	$ 20,000.00
Site Restoration	Each	$ 10,000.00	1	$ 10,000.00
		Total for project =		$ 540,930.00

Table 35: Cost estimate for a 0.50 acre IESF bench just downstream of the Springbrook Nature Center in Catchment SP-15. These costs are associated with project 15-G in the Catchment Profiles pages.

Activity	Units	Unit Price	Quantity	Unit Price
Design/Bidding/Construction Oversight	Each	$ 60,000.00	1	$ 60,000.00
Mobilization	Each	$ 20,000.00	1	$ 20,000.00
Land Acquisition	acres	$ 60,000.00	2	$ 90,000.00
Clearing, Removal of Existing Infrastructure, and Pond Dewatering	Each	$ 20,000.00	1	$ 20,000.00
Common Excavation & Disposal	cu-yards	$ 40.00	4,020	$ 160,800.00
IESF Materials and Installation	sq-ft	$ 17.00	21,700	$ 368,900.00
Lift Station, Pump, Electrical Housing, and Electrical Line	Each	$ 60,000.00	1	$ 60,000.00
Outlet/Inlet Control Structures	Each	$ 30,000.00	1	$ 30,000.00
Site Restoration	Each	$ 15,000.00	1	$ 15,000.00
		Total for project =		$ 824,700.00

Table 36: Cost estimate for a 0.25 acre IESF bench within/near Riverview Heights Park in Catchment SP-16. These costs are associated with project 16-E in the Catchment Profiles pages.

Activity	Units	Unit Price	Quantity	Unit Price
Design/Bidding/Construction Oversight	Each	$ 50,000.00	1	$ 50,000.00
Mobilization	Each	$ 15,000.00	1	$ 15,000.00
Land Acquisition (already owned by Fridley)	acres	$ -	0	$ -
Clearing, Removal of Existing Infrastructure, and Potential Dewatering	Each	$ 20,000.00	1	$ 20,000.00
Common Excavation & Disposal	cu-yards	$ 40.00	2,020	$ 80,800.00
IESF Materials and Installation	sq-ft	$ 17.00	10,890	$ 185,130.00
Lift Station, Pump, Electrical Housing, and Electrical Line	Each	$ 60,000.00	1	$ 60,000.00
Outlet/Inlet Control Structures	Each	$ 20,000.00	1	$ 20,000.00
Site Restoration	Each	$ 10,000.00	1	$ 10,000.00
		Total for project =		$ 440,930.00

Table 37: Cost estimate for a 0.25 acre IESF bench and sedimentation basin within/near Riverview Heights Park in Catchment SP-16. These costs are associated with project 16-E in the Catchment Profiles pages.

Activity	Units	Unit Price	Quantity	Unit Price
Design/Bidding/Construction Oversight	Each	$ 60,000.00	1	$ 60,000.00
Mobilization	Each	$ 25,000.00	1	$ 25,000.00
Land Acquisition (already owned by Fridley)	acres	$ -	0	$ -
Clearing, Removal of Existing Infrastructure, and Potential Dewatering	Each	$ 40,000.00	1	$ 40,000.00
Common Excavation & Disposal for Sed. Basin	cu-yards	$ 40.00	1,900	$ 76,000.00
Common Excavation & Disposal for IESF	cu-yards	$ 40.00	2,020	$ 80,800.00
IESF Materials and Installation	sq-ft	$ 17.00	10,890	$ 185,130.00
Lift Station, Pump, Electrical Housing, and Electrical Line	Each	$ 120,000.00	1	$ 120,000.00
Outlet/Inlet Control Structures	Each	$ 30,000.00	1	$ 30,000.00
Site Restoration (including restoring roadway)	Each	$ 30,000.00	1	$ 30,000.00
		Total for project =		$ 646,930.00

Table 38: Cost estimate for a 0.50 acre IESF bench and sedimentation basin within/near Riverview Heights Park in Catchment SP-16. These costs are associated with project 16-E in the Catchment Profiles pages.

Activity	Units	Unit Price	Quantity	Unit Price
Design/Bidding/Construction Oversight	Each	$ 70,000.00	1	$ 70,000.00
Mobilization	Each	$ 30,000.00	1	$ 30,000.00
Land Acquisition (already owned by Fridley)	acres	$ -	0	$ -
Clearing, Removal of Existing Infrastructure, and Potential Dewatering	Each	$ 50,000.00	1	$ 50,000.00
Common Excavation & Disposal for Sed. Basin	cu-yards	$ 40.00	1,900	$ 76,000.00
Common Excavation & Disposal	cu-yards	$ 40.00	4,020	$ 160,800.00
IESF Materials and Installation	sq-ft	$ 17.00	21,700	$ 368,900.00
Lift Station, Pump, Electrical Housing, and Electrical Line	Each	$ 120,000.00	1	$ 120,000.00
Outlet/Inlet Control Structures	Each	$ 30,000.00	1	$ 30,000.00
Site Restoration (including restoring roadway)	Each	$ 35,000.00	1	$ 35,000.00
		Total for project =		$ 940,700.00

Permeable Check Dam

Table 39: Cost estimate for a permeable check dam in Catchment SP-5

Activity	Units	Unit Price	Quantity	Unit Price
Design	each	$3,000.00	1	$3,000.00
Mobilization and Site Preparation	each	$3,000.00	1	$3,000.00
Land Acquisition - owned by MNDOT, would likely be maintained by city				$0.00
Engineered Soil Mix (5% iron by weight)	cu-yards	$275.00	3.1	$852.50
Rocks	cu-yards	$125.00	4.6	$575.00
Permeable Liner	per dam	$100.00	1	$100.00
Installation	per dam	$5,000.00	1	$5,000.00
			Total for Project =	$12,527.50

Table 40: Cost estimate for a permeable check dam in Catchment SP-11

Activity	Units	Unit Price	Quantity	Unit Price
Design	each	$3,000.00	1	$3,000.00
Mobilization and Site Preparation	each	$3,000.00	1	$3,000.00
Land Acquisition - owned by MNDOT, would likely be maintained by city				$0.00
Engineered Soil Mix (5% iron by weight)	cu-yards	$275.00	3.1	$852.50
Rocks	cu-yards	$125.00	4.6	$575.00
Permeable Liner	per dam	$100.00	1	$100.00
Installation	per dam	$5,000.00	1	$5,000.00
			Total for Project =	$12,527.50

Appendix C – Catchment SP-14 and SP-17 Ranking Tables

Catchments 14 and 17 are hydrologically disconnected with Springbrook. Stormwater generated in these catchments is conveyed via municipal storm sewer systems and discharged directly into the Mississippi River. Although the 143 acres within these catchments are outside the Springbrook subwatershed, this area was included during analysis as they lie within the historic Springbrook subwatershed and may not be included as part of another Stormwater Retrofit Analysis. Projects proposed in these catchments are described in detail in the *Catchment Profile*s section of this report. They are ranked in the tables below based on their cost-effectiveness for removing TP, TSS, and stormwater volume.

Table 41: Cost-effectiveness of retrofits in catchments 14 and 17 with respect to TP reduction. 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	Retrofit Location	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost (2015 Dollars)	Estimated Annual Operations & Maintenance (2015 Dollars)	Estimated cost/ lb-TP/year (30-year)[1]
1	14-A	133	Curb-Cut Rain Gardens	Multiple	SP-14	4.3-7.9	1,363-2,509	2.8-5.1	$40,600-$73,608	$900-$1,800	$524-$538
2	17-A	165	Curb-Cut Rain Gardens	Multiple	SP-17	1.5-2.4	487-792	1.1-1.8	$24,096-$40,600	$450-$900	$835-$939
3	17-B	166	Hydrodynamic Device	Subcatchment 17-1	SP-17	0.9	384	0.0	$109,752	$840	$4,998

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

Table 42: Cost-effectiveness of retrofits in catchments 14 and 17 with respect to TSS reduction. 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	Retrofit Location	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost (2015 Dollars)	Estimated Annual Operations & Maintenance (2015 Dollars)	Estimated cost/ 1,000lb-TSS/year (30-year)[1]
1	14-A	133	Curb-Cut Rain Gardens	Multiple	SP-14	4.3-7.9	1,363-2,509	2.8-5.1	$40,600-$73,608	$900-$1,800	$1,653-$1,695
2	17-A	165	Curb-Cut Rain Gardens	Multiple	SP-17	1.5-2.4	487-792	1.1-1.8	$24,096-$40,600	$450-$900	$2,573-$2,845
3	17-B	166	Hydrodynamic Device	Subcatchment 17-1	SP-17	0.9	384	0.0	$109,752	$840	$11,715

[1] [(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TSS Reduction/1,000)]

Table 4344: Cost-effectiveness of retrofits in catchments 14 and 17 with respect to volume reduction. TP and TSS 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	Retrofit Location	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost (2015 Dollars)	Estimated Annual Operations & Maintenance (2015 Dollars)	Estimated cost/ ac-ft Vol./year (30-year)
1	14-A	Page #	Curb-Cut Rain Gardens	Multiple	SP-14	4.3-7.9	1,363-2,509	2.8-5.1	$40,600-$73,608	$900-$1,800	$805-$834
2	17-A	133	Curb-Cut Rain Gardens	Multiple	SP-17	1.5-2.4	487-792	1.1-1.8	$24,096-$40,600	$450-$900	$1,139-$1,252
3	17-B	165	Hydrodynamic Device	Subcatchment 17-1	SP-17	0.9	384	0.0	$109,752	$840	N/A

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

Appendix D – Wellhead Protection Areas

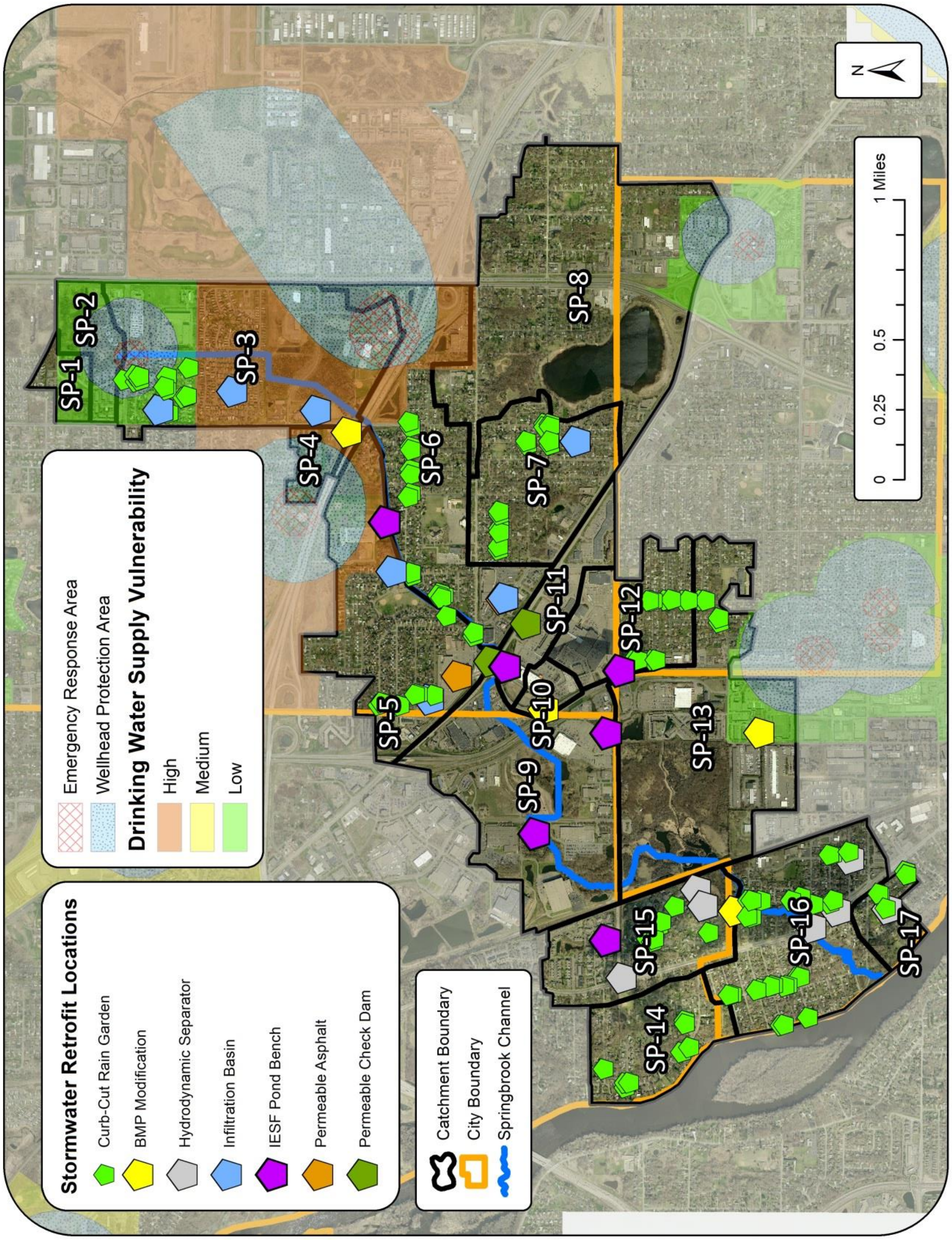

Figure 108: Subwatershed-wide map showing all proposed retrofits included in this report and potential overlap with wellhead protection areas.