Big Lake & Lake Mitchell
Stormwater Subwatershed Assessment

Big Lake Shoreline (Photo: Sherburne SWCD)

Prepared by:

Sherburne Soil & Water Conservation District

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Executive Summary

Big Lake and Lake Mitchell are two of the most popular recreational lakes in Sherburne County. Their clear waters and sandy shorelines draw lake residents and visitors alike for fishing, swimming, recreational boating, and summer relaxation. The City of Big Lake operates Lakeside Park along the southwestern side of Big Lake which features two boat launches, a sandy beach, picnic facilities, volleyball courts, and much green space. Lakeside Park is commonly bustling with activity during the summer months and particularly on hot summer days. Lake Mitchell has a public boat launch on the lake's southeast side.

Both Big Lake and Lake Mitchell are currently reaching their water quality conditional use goals; the lakes boast relatively clear summer water conditions with minimal nutrient and algal content. Water quality monitoring conducted by the Big Lake Community Lakes Association (BLCLA) over a period of 20+ years has shown no detectable water chemistry trends, but each lake's clarity is slowly improving and both remain within a Mesotrophic state. However, monitoring of chloride has shown a steady increase in lake concentrations over the past 20 years, from 20 ug/L to 40 ug/L. The BLCLA and City of Big Lake have formed a collaborative partnership to take a proactive approach to preserving the condition of their lake. Their activities have included addressing concerns with aquatic invasive species prevention and management, lake ecology education, wildlife and recreational opportunities, and pollution mitigation. The City of Big Lake also oversees a Municipal Separate Storm Sewer System (MS4) permit through the State of Minnesota.

In summer 2018, the Sherburne Soil and Water Conservation District proposed to the City of Big Lake and their engineer Bolton-Menk to complete a stormwater study through a protocol known locally as a Sub-Watershed Assessment. This analysis is primarily intended to identify potential projects within the watershed to improve water quality and stormwater pollution mitigation. Stormwater retrofits refer to best management practices (BMPs) that are added to an already developed landscape where little open space exists. The process is investigative and creative. Stormwater retrofits can be improperly judged by the total number of projects installed or by comparing costs alone. Those approaches neglect to consider how much pollution is removed per dollar spent. In this analysis, both costs and pollutant reductions were estimated and used to calculate cost-effectiveness for each potential retrofit identified.

The Big and Mitchell Lakes watershed was divided into over 30 sub-catchment areas using Geographic Information System programs, land elevation data, stormwater infrastructure data. The modeling program WinSLAMM was used to estimate current export of water volume, total phosphorus (TP) and total suspended solids (TSS) from each sub-catchment area with baseline conditions and then including existing stormwater BMPs. The model was not calibrated, so can only be used as an estimation tool to provide relative information on existing conditions and changes due to potential BMP retrofits. Specific model inputs are detailed in Appendix A.

Following the initial modeling of all sub-catchments, 12 of these sub-catchments were determined priority areas due to their high pollutant or water volume annual load and opportunity for retrofit projects (such as being located in an area scheduled for road construction). Staff from the City of Big Lake Public Works Department, Bolton-Menk and Sherburne SWCD examined these priority areas using aerial maps and by on-the-ground reconnaissance surveys to look for BMP retrofit potential. A variety of stormwater retrofit approaches were identified and were included into the WinSLAMM model to determine pollution mitigation potential. In total, 61 potential projects were identified.

Costs associated with project design, administrative duties, construction, and operation and maintenance were estimated based upon the best available information. Cost data were assumed over a 30-year lifespan and compared against the model benefits (pollutant reduction) to rank projects according to a cost-benefit variable (cost-effectiveness). Although the highest ranked projects in this analysis should be considered for potential retrofit projects, it is acknowledged that other variables must be considered before implementation. Considerations for funding limitations, landowner interest, educational opportunity / visibility, site-specific feasibility and construction timing or other factors must be weighed by the City of Big Lake and the Sherburne SWCD prior to determining which retrofit projects to pursue.

Table 1 and Table 2 displays the findings of this study, including the applicable potential stormwater retrofit options within the priority areas along with the BMP types, their pollutant reduction potential, overall cost and cost effectiveness. Table 1 lists each potential project in order of cost-effectiveness with respect to phosphorus, the pollutant of highest concern for Big Lake and Lake Mitchell. Table 2 displays the BMP list sorted with respect to total suspended solids, another pollutant of concern. The most cost effective options are listed first, while lesser cost-effective options fall lower on the list.

Based upon WinSLAMM modeling, the 350 acre study area including 30 sub-catchments contributes an estimated 179 acre-feet of runoff, 129 pounds of phosphorus, and 67,521 pounds of solids annually. Implementing all potential BMP practices within the 12 priority sub-catchments would result in an estimated reduction of 12.50 lbs of phosphorus and 5,797 lbs of sediment, or nearly 10% of the annual load for these two pollutants. However, it is recognized that installing even half of these recommendations is not feasible due to funding availability, site-specific detailed conditions, and participation of willing landowners. Instead, it is recommended that projects be pursued in order of cost effectiveness according to Tables 1 and 2 in order to achieve the greatest pollution reduction for the smallest amount of cost. Installation of projects in series will result in lower total treatment than the simple sum of treatment achieved by the individual projects due to treatment train effects. Reported treatment levels are depending upon optimal site selection and sizing. More detail about each project can be found in the catchment profile page of this report.

Finally, it should be noted that the cost estimates and pollution reduction estimates in this report are fine-tuned to be as accurate as possible but are likely on the conservative side. Site specific conditions, final BMP designs, fluctuations in material costs and bids from contractors will vary with any installed work. Users of this report should recognize that final numbers may vary from reported estimates here, but a scalable approach can be used when determining priority projects to pursue. In other words, in the priority ranking tables below the project costs and pollution reduction estimates may all be higher or lower, however the end costs should impact each project similarly so the higher ranking projects should still rank high given a different cost or pollutant reductions structure. Thus, this report should be considered a guidance tool for informed decision making on potential stormwater retrofit projects.

Table 1. Ranked BMP summary from an assessment of Big and Mitchell Lake stormwater. List includes BMP size options within 12 of 31 sub catchment areas which would address urban stormwater runoff. Table sorted by 30-year cost / lb. removal of total phosphorus. Note: VS = Vegetated Swale, RG = Rain Garden, HD = Hydrodynamic Device.

Project Rank	Sub catchment	Project ID	BMP Type	Volume Reduction (cu-ft/yr)	TP Reduction (lbs/yr)	TSS Reduction (lbs/yr)	Project Cost	Estimated 30-yr O&M	30-yr Cost / 1,000 lb TSS	30-yr Cost / lb TP
1	12	VS 12-2	30 ft VS	6,745	0.35	155	$6,026	$225	$581	$1,296
2	12	VS 12-1	30 ft VS	5,226	0.30	134	$6,026	$225	$672	$1,499
3	11	RG 11-2	250 sqft RG	8,953	0.48	217	$15,844	$85	$1,093	$2,434
4	4	VS 4-1	50 ft VS	7,236	0.20	95	$7,026	$225	$1,154	$2,465
5	4	RG 4-4	750 sqft RG	15,862	0.44	201	$28,844	$100	$1,214	$2,628
6	17	HD 17-1	6' dia HD	162	0.49	355	$55,752	$420	$1,940	$2,700
7	11	RG 11-1	250 sqft RG	7,301	0.43	194	$15,844	$85	$1,217	$2,722
8	12	RG 12-1	250 sqft RG	9,289	0.41	184	$15,844	$85	$1,294	$2,870
9	26	RG 26-2	250 sqft RG	13,738	0.39	179	$15,844	$85	$1,351	$2,950
10	22	RG 22-3	250 sqft RG	13,821	0.38	178	$15,844	$85	$1,390	$2,967
11	22	RG 22-6	250 sqft RG	13,821	0.38	178	$15,844	$85	$1,390	$2,967
12	4	RG 4-3	250 sqft RG	10,983	0.31	143	$15,844	$85	$1,720	$3,693
13	15	RG 15-6	250 sqft RG	10,774	0.31	143	$15,844	$85	$1,704	$3,693
14	15	RG 15-3	250 sqft RG	9,795	0.28	130	$15,844	$85	$1,873	$4,063
15	15	RG 15-4	250 sqft RG	8,681	0.25	114	$15,844	$85	$2,130	$4,633
16	4	RG 4-2	250 sqft RG	8,681	0.24	112	$15,844	$85	$2,201	$4,715
17	22	RG 22-1	250 sqft RG	8,812	0.24	112	$15,844	$85	$2,201	$4,715
18	11	HD 11-3	4' dia HD	0	0.31	132	$28,752	$420	$2,138	$4,988
19	11	HD 11-1	4' dia HD	0	0.30	130	$28,752	$420	$2,166	$5,065
20	26	RG 26-3	250 sqft RG	8,131	0.23	104	$15,844	$85	$2,286	$5,078
21	15	RG 15-5	250 sqft RG	7,445	0.21	98	$15,844	$85	$2,491	$5,389
22	22	RG 22-5	250 sqft RG	7,725	0.21	98	$15,844	$85	$2,515	$5,389
23	26	RG 26-1	250 sqft RG	7,577	0.22	97	$15,844	$85	$2,456	$5,445
24	22	RG 22-7	250 sqft RG	7,877	0.20	93	$15,844	$85	$2,641	$5,679
25	12	HD 12-1	4' dia HD	0	0.27	115	$28,752	$420	$2,439	$5,725
26	15	RG 15-1	250 sqft RG	7,018	0.20	92	$15,844	$85	$2,641	$5,741
27	14	RG 14-3	250 sqft RG	6,751	0.20	91	$15,844	$85	$2,681	$5,804
28	19	HD 19-1	6' dia HD	133	0.17	113	$55,752	$420	$3,943	$5,827
29	22	RG 22-2	250 sqft RG	7,020	0.19	89	$15,844	$85	$2,780	$5,934
30	22	RG 22-4	250 sqft RG	7,020	0.19	89	$15,844	$85	$2,780	$5,934

Table 2. Ranked BMP summary from an assessment of Big and Mitchell Lake stormwater, continued. List includes BMP size options within 12 of 31 sub catchment areas which would address urban stormwater runoff. Table sorted by 30-year cost / lb. removal of total phosphorus. Note: VS = Vegetated Swale, RG = Rain Garden, HD = Hydrodynamic Device.

Project Rank	Sub catchment	Project ID	BMP Type	Volume Reduction (cu-ft/yr)	TP Reduction (lbs/yr)	TSS Reduction (lbs/yr)	Project Cost	Estimated 30-yr O&M	30-yr Cost / 1,000 lb TSS	30-yr Cost / lb TP
31	4	RG 4-5	250 sqft RG	6,875	0.19	88	$15,844	$85	$2,809	$6,002
32	25	RG 25-1	250 sqft RG	6,632	0.19	87	$15,844	$85	$2,765	$6,070
33	22	RG 22-8	250 sqft RG	6,504	0.18	80	$15,844	$85	$2,934	$6,602
34	26	RG 26-4	250 sqft RG	6,291	0.18	80	$15,844	$85	$2,950	$6,602
35	14	RG 14-2	250 sqft RG	5,854	0.16	76	$15,844	$85	$3,220	$6,949
36	12	HD 12-2	6' dia HD	509	0.31	131	$28,752	$420	$3,082	$7,316
37	14	RG 14-4	250 sqft RG	5,113	0.14	66	$15,844	$85	$3,719	$8,002
38	25	RG 25-3	250 sqft RG	4,636	0.13	60	$15,844	$85	$4,001	$8,802
39	14	RG 14-1	250 sqft RG	4,340	0.12	56	$15,844	$85	$4,401	$9,431
40	11	HD 11-2	6' dia HD	133	0.25	101	$55,752	$420	$3,865	$9,489
41	15	RG 15-2	250 sqft RG	4,177	0.12	54	$15,844	$85	$4,514	$9,780
42	4	RG 4-1	250 sqft RG	4,176	0.11	53	$15,844	$85	$4,715	$9,965
43	13	RG 13-1	250 sqft RG	3,841	0.11	49	$15,844	$85	$4,715	$10,778
44	25	RG 25-2	250 sqft RG	3,395	0.10	43	$15,844	$85	$5,501	$12,282
45	21	HD 21-1	8' dia HD	0	0.28	128	$55,752	$420	$6,637	$14,519
46	4	RG 4-6	250 sqft RG	2,795	0.07	35	$15,844	$85	$7,235	$15,090
47	21	HD 21-2	8' dia HD	322	0.18	114	$55,752	$420	$10,324	$16,302
48	13	HD 13-1	4' dia HD	0	0.09	32	$28,752	$420	$7,746	$20,575
49	15	HD 15-1	6' dia HD	54	0.08	35	$28,752	$420	$11,410	$27,383
50	15	HD 15-2	6' dia HD	54	0.09	35	$28,752	$420	$11,275	$27,383
51	14	HD 14-1	6' dia HD	48	0.08	31	$28,752	$420	$12,447	$30,916
52	26	HD 26-1	4' dia HD	88	0.05	19	$28,752	$420	$12,662	$34,653
53	26	HD 26-2	6' dia HD	125	0.07	27	$28,752	$420	$13,499	$35,496
54	4	HD 4-2	6' dia HD	166	0.06	26	$28,752	$420	$15,973	$36,862
55	4	HD 4-1	8' dia HD	340	0.10	43	$109,752	$420	$17,869	$43,219
56	22	HD 22-1	6' dia HD	236	0.05	14	$28,752	$420	$19,168	$68,457
57	22	HD 22-3	6' dia HD	233	0.05	14	$28,752	$420	$19,168	$68,457
58	22	HD 22-4	6' dia HD	210	0.04	14	$28,752	$420	$23,960	$68,457
59	25	HD 25-1	6' dia HD	187	0.03	14	$28,752	$420	$28,188	$68,457
60	25	HD 25-2	6' dia HD	197	0.03	14	$28,752	$420	$28,188	$68,457
61	22	HD 22-2	6' dia HD	244	0.05	13	$28,752	$420	$19,168	$73,723

Introduction

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

Big Lake and Lake Mitchell are 253 and 169 acres, respectfully, and lie entirely within the boundaries of the City of Big Lake, Sherburne County, Minnesota. The lakes are relatively deep for this region (48 feet and 33 ft maximum depth) and are recharged by a 350 acre watershed that consists of both terrain-derived delivery as well as a stormwater system overseen by the City of Big Lake Public Works Department. There are no stream inlets feeding the lakes, though there is a hydraulic connection with Blacks Lake through a culvert that enters Lake Mitchell. The lakes are said to have a few springs feeding the waters as well. An outlet exists on Lake Mitchell which drains to Beaudry Lake to the east which eventually discharges into the Elk River.

Currently, both lakes are currently meeting State of Minnesota water quality goals. The Big Lake Community Lakes Association collects water quality data on a regular basis from the lakes, and these data indicate Mesotrophic conditions and water clarity that is improving at a rate of approximately 1.0 ft per decade in the lakes. The BLCLA and City of Big Lake partner often on projects to protect the lake from pollution, encourage safe recreational boating practices, and prevent aquatic invasive species introduction. Big and Mitchell Lakes are high priority waterbodies, as detailed within the Sherburne County Local Water Management Plan, due to their recreational prominence and existing high quality condition. Protection of the lakes are critical in order to maintain their current state.

The urban development surrounding these lakes has resulted in the need for a complex stormwater drainage network. Increases in impervious surface result in the need to convey water quickly off of streets and sidewalks, and this discharge leads directly to Big and Mitchell Lakes in most cases. Stormwater runoff can carry a variety of pollutants with it. While stormwater treatment to remove these pollutants is adequate in some areas, other areas were built prior to modern-day stormwater treatment technologies and requirements. BMP retrofitting may increase water holding capacity and pollutant mitigation.

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

In this analysis, the focus areas were the contributing drainage areas to storm sewer outfalls that discharge directly into Big and Mitchell Lakes. More specifically, outfalls with limited existing treatment were selected. Included are areas of residential, commercial and minimal industrial land uses. Existing stormwater infrastructure maps and topography data were used to determine drainage boundaries for the sub-catchments included in this analysis. Stormwater infrastructure plans were provided by Bolton-Menk which aided in catchment delineation, existing treatment conditions and retrofit scoping.

The targeted pollutants for this study were TP and TSS, though volume was also estimated and reported as it is necessary for pollutant loading calculations and potential retrofit project considerations. Table 3 describes the target pollutants and their role in water quality degradation. Projects that effectively reduce loading of multiple target pollutants can provide greater immediate and long-term benefits.

It should be noted that although chloride is an emerging stormwater pollutant of concern, particularly in urban areas, this report does little to address it. Chloride dissolves readily in stormwater and is unable to be "treated" using traditional stormwater practices. In order to reduce chloride from reaching Big and Mitchell Lakes, resources are best spent investigating ways to place less road salt on area roads and encourage residents to utilize water softeners as efficiently as possible.

Table 3: Target Pollutants

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 and TP to receiving water bodies. It can also exacerbate soil erosion, thereby increasing TSS and TP loading. As such, reductions in volume may reduce TSS loading and, by extension, TP loading.

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

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

Modeling involves assessing multiple scenarios to estimate pollutant loading and potential reductions by proposed retrofits. WinSLAMM (version 10.2.0), which allows routing of multiple catchments and stormwater treatment practices, was used for this analysis. This is important for estimating treatment train effects associated with multiple BMPs in series. Furthermore, it allows for estimation of volume and pollutant loading at the outfall point to the waterbody, which is the primary point of interest in this type of study.

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

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, a full watershed delineation was completed using the watershed ArcGIS Spatial Analysis tools and modified manually as necessary using stormwater infrastructure data. The drainage areas were then consolidated into catchments using ArcGIS Spatial Analysis. Land use data were used to calculate acreages of each land use type within each catchment. Soil types throughout the subwatershed were modeled as sand in this analysis based on the information available in the Sherburne County soil survey. Entering the acreages, land use, and soil data into WinSLAMM ultimately resulted in a model that included estimates of the acreage of each type of source area (roof, road, lawn, etc.) in each catchment.

Once the "base" model was established, an "existing conditions" model was created by incorporating notable existing stormwater treatment practices in the catchment for which data were available from the City of Big Lake. For example, street cleaning with mechanical or vacuum street sweepers, stormwater treatment ponds, hydrodynamic devices, and others were included in the "existing conditions" model if information was available.

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

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 2016 dollars. Costs throughout this report were estimated using a multitude of sources. Costs were derived from The Center for Watershed Protection's Urban Subwatershed Restoration Manuals (Schueler & Kitchell, 2005 and Schueler et al. 2007) and recent installation costs and cost estimates provided to the Sherburne SWCD by personal contacts. Cost estimates were annualized costs that incorporated the elements listed below over a 30-year period.

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

Design includes site surveying, engineering, and construction oversight.

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

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

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

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

Project ranking is essential to identify which projects could be pursued to achieve water quality goals. 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.

If all identified practices were installed (Figure 3), significant pollution reduction could be accomplished. However, funding limitations and landowner interest will likely be limiting factors for implementation. The tables on the following pages rank all modeled projects by cost-effectiveness.

Projects were ranked in terms of the 30 year cost per pound of total phosphorus removed (Tables 1 and 2), but could be ranked with respect to the cost per 1,000 pound of total suspended solids removed as well.

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

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

BMP Descriptions

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

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

- Bioretention
- Curb-cut Rain Garden
- Boulevard Bioswale
- Infiltration Basin
- Hydrodynamic Device
- Permeable Pavement
- Iron-Enhanced Sand Filter Pond Bench
- Modification to an Existing Pond
- New Stormwater Pond

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 dissolved phosphorus.

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 redirects it into shallow roadside basins. These curb-cut rain gardens can provide treatment for impervious surface runoff from one to many properties and can be located anywhere sufficient space is available. Because curb-cut rain gardens capture water that is already part of the stormwater drainage system, they are more likely to provide higher benefits. Generally, curb-cut rain gardens were proposed in areas without sufficient existing stormwater treatment and located immediately 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 1).

Figure 1: Sherburne County curb-cut rain garden

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 gardens at years 10 and 20. Annual maintenance was assumed to be completed by the landowner of the property at which the rain garden could be installed.

Vegetated Swale

Figure 2: Vegetated swale. Photo by MN Pollution Control Agency (MN Stormwater Manual).

One option for retrofitting a stormwater BMP within an existing boulevard or along a roadside is a vegetated swale. Swales typically range from 5-50' in length, house a rich native plant community, and can be installed along a roadside or even between an existing sidewalk and roadway curb (Figure 2). Unlike rain gardens, these practices are typically much shallower (1-3" in depth) and may have a curb-cut inlet and outlet. Although many rain gardens have outlets in the form of underdrains or risers, the swale outlet allows for a nearly continuous flow of stormwater through the practice. Although infiltration does occur, the primary form of treatment is the settling of pollutants as stormwater flows through the dense plant community.

This practice was modeled to estimate the pollutant reduction capacity for TSS, TP, and stormwater volume in medium density residential drainage areas ranging from 0.25 to 4 acres. A 20' long (parallel to roadway), 4' wide (perpendicular to roadway), and 3" deep bioswale was modeled with an infiltration rate of 2.5"/hour. No underdrain was modeled with this practice as they are designed to be flow-through systems with limited ponding (≤ 3"). Additional model inputs are noted in Appendix A.

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 allows 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 2016 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.

It should be noted that no suitable locations were identified for infiltrations within the 12 priority areas in the study. Should future opportunities arise, these retrofits could be modeled for estimated pollutant reductions.

Hydrodynamic Devices

In heavily urbanized settings 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 of the possible solutions is the hydrodynamic device (Figure 3). 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.

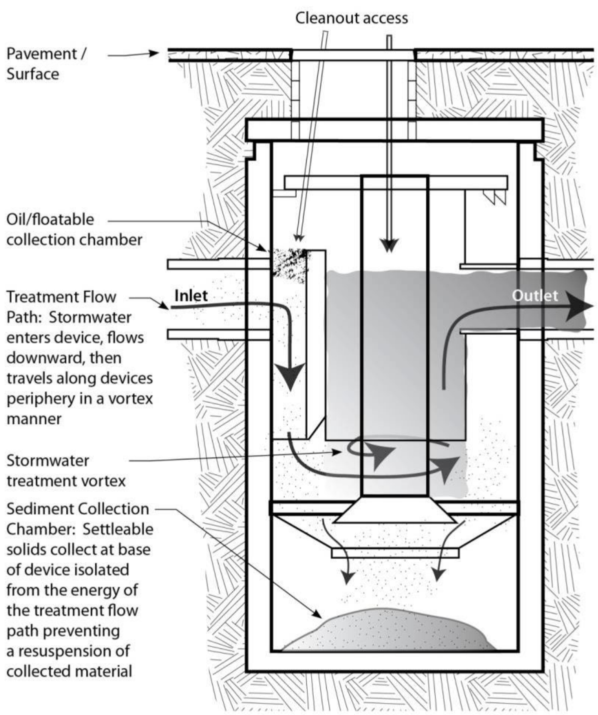


Figure 3: Hydrodynamic device schematic.

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 similar reports d. Devices were proposed along particular storm sewer lines and often just upstream of intersections with another, larger line. Model results assume the device is receiving input from all nearby catch basins noted.

In order to calculate the 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.

Modification to an Existing Pond

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

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

Listed below are 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 range widely, but were estimated to be $20/cu.-yd, $35/cu.-yd, and $50/cu.yd for levels 1, 2, and 3, respectively.

It should be noted that no pond modifications were identified during the course of this study. Detailed inventories of stormwater pond performance (intake / outfall water quality, pond depth, flow rates, etc.) could be collected to better assess current performance and if a need exists for modification.

New Stormwater Pond

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

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

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

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

In order to calculate cost-benefit, the cost of each project had to be estimated. All new stormwater ponds were assumed to involve excavation and disposal of soil, installation of inlet and outlet control structures and emergency overflow, land acquisition, erosion control, and vegetation management.

Additionally, project engineering, promotion, administration, construction oversight, and long-term maintenance (including annual inspections and removal of accumulated sediment/debris from the pretreatment area) had to be considered in order to capture the true cost of the effort. Complete pond dredging is not included in the long-term maintenance cost because project life is estimated to be 30 years. Load reduction estimates for these projects are noted in the Catchment Profiles section.

It should be noted that no new pond structure locations were identified during the course of this study.

Study Area

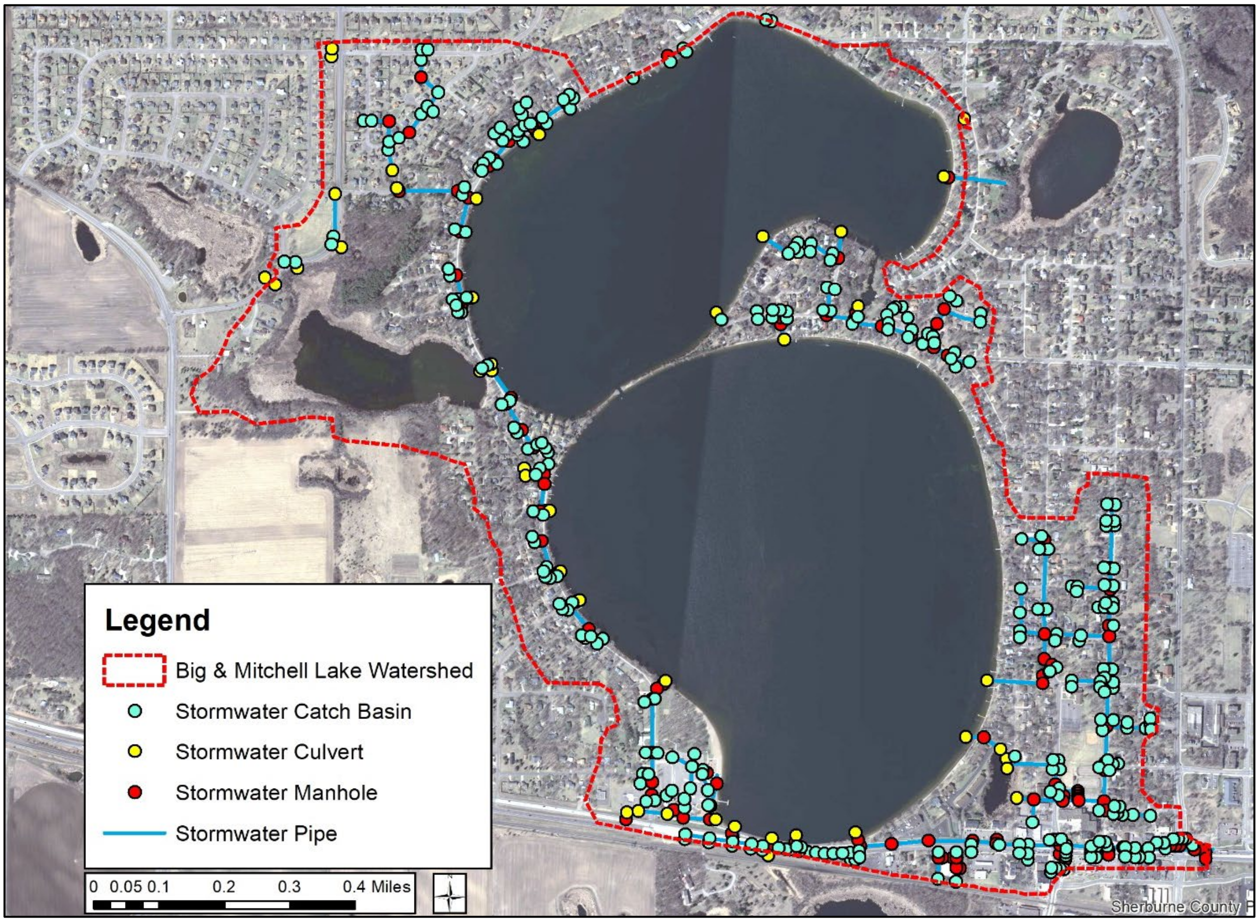


Figure 4: Big and Mitchell Lake stormwater catchment and sub catchment areas.

In determining the applicable study area for this exercise, a number of resources were utilized including previous available watershed delineations, stormwater routing information provided by the City of Big Lake Public Works Department and Bolton & Menk, aerial photography and LIDAR information. These resources were compiled into a GIS databased and used to create the map depicted on Figure 4, which represents the watershed, or contributing stormwater catch-basin for Mitchell and Big Lakes. This area is approximately 350 acres in size. GIS software (ESRI ArcMap Spatial Analyst) was utilized to break apart the 350 acre watershed into manageable sized sub-catchment regions (Figure 5). Originally 31 basins were identified, but one was removed after field investigations confirmed it did not drain to the lakes.

The stormwater modeling program WinSLAMM was used to estimate current stormwater pollutant contributions from each of the sub-catchments. Existing stormwater treatment structures were obtained from the City of Big Lake and Bolton-Menk to more accurately estimate real conditions on the landscape into the model. The current pollution load from each sub-catchment was estimated and ranked in terms of most phosphorus and solids produced per acre basis. The result was the determination of 12 priority basins which , due to their unique conditions, were estimated to have higher pollutant loads per area and should be approached first for pollution reduction (Figure 5). Local knowledge of conditions and the opportunity to retrofit during upcoming construction played a role in priority area selection as well.

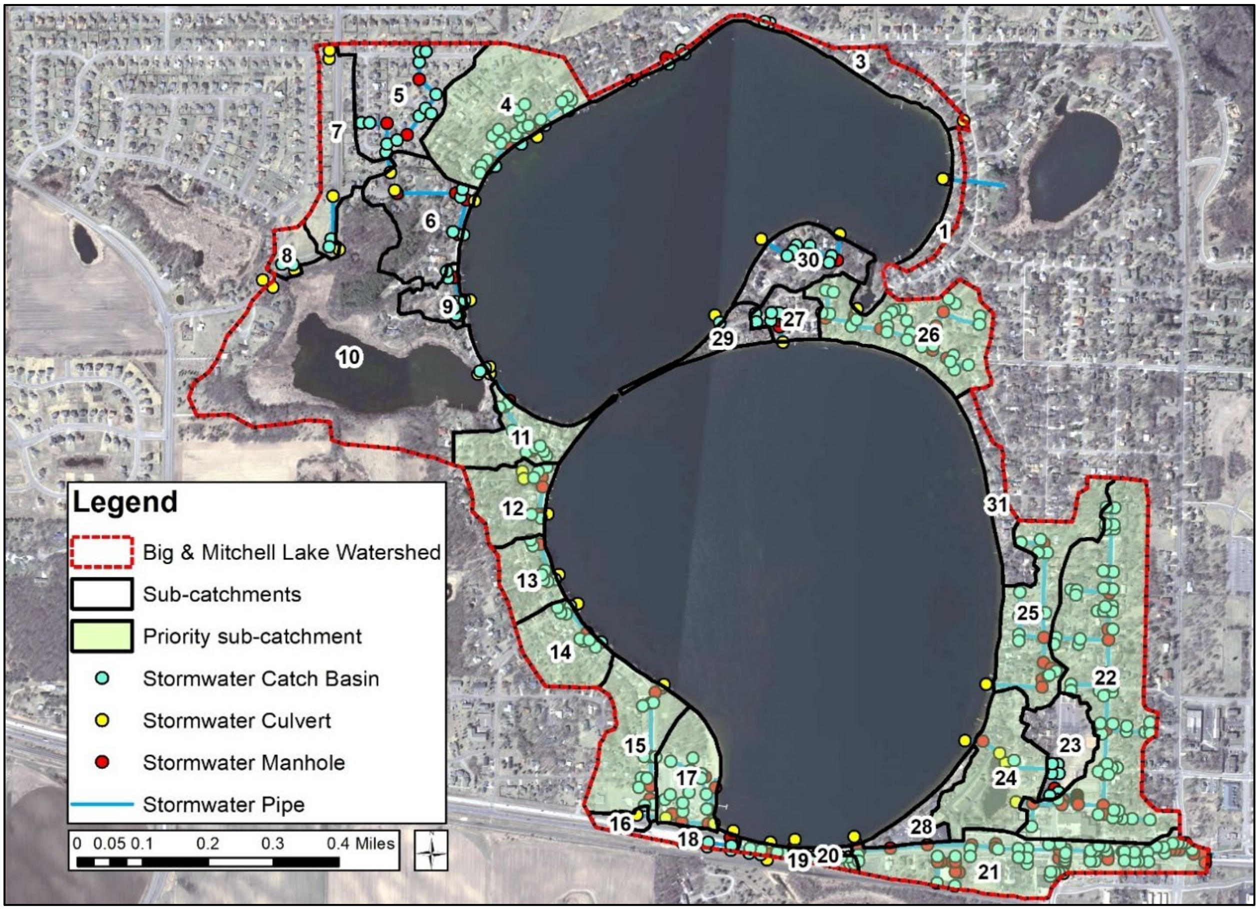


Figure 5: Big and Mitchell Lake stormwater catchment and sub catchment areas.

The stormwater modeling program WinSLAMM was used to estimate current stormwater pollutant contributions from each of the sub-catchments. Existing stormwater treatment structures were obtained from the City of Big Lake and Bolton-Menk to more accurately estimate real conditions on the landscape into the model. The current pollution load from each sub-catchment was estimated and ranked in terms of most phosphorus and solids produced per acre basis. The result was the determination of 12 priority basins which, due to their unique conditions, were estimated to have higher pollutant loads per area and should be approached first for pollution reduction (Figure 5).

A breakdown of each sub-catchment based upon its initial (pre-treatment) conditions along with its current conditions (with existing treatment structures) is provided in Table 4. The stormwater model currently estimates that stormwater treatment efforts by the City of Big Lake (stormwater ponds, street cleaning, catch basins and other stormwater practices) are reducing stormwater volume by 6.2%, solids by 22.5%, and phosphorus by 24%.

Table 4: Big and Mitchell Lake stormwater catchment and sub catchment area details. Note that upon further review, sub-catchment 2 was removed as it was determined it was a non-contributing basin to the lakes.

Sub-Catchment	Area (Acres)	Initial Runoff Volume (cuft)	Initial Solids (lbs)	Initial Phosphorus (lbs)	Current Runoff Volume (cuft)	Current Total Solids (lbs)	Current Total Phosphorus (lbs)
1	3.3	53,905	287	0.70	53,905	287	0.70
3	7.9	6,217	116	0.51	6,217	116	0.51
4	20.2	352,292	5,088	11.20	352,291	4,294	9.31
5	16.0	280,121	4,045	8.92	36,540	380	0.86
6	13.8	233,521	2,132	4.74	233,521	1,961	4.31
7	11.2	260,872	1,902	4.11	260,868	1,830	3.94
8	2.8	50,881	575	1.24	50,880	539	1.16
9	3.4	56,269	813	1.79	56,271	653	1.41
10	64.4	1,755,000	2,532	6.36	1,755,000	2,345	5.91
11	8.4	146,090	2,110	4.65	146,090	1,948	4.26
12	8.3	176,599	2,367	5.23	175,995	2,253	4.95
13	5.9	103,626	1,497	3.30	101,791	1,270	2.77
14	8.6	149,410	2,158	4.76	147,280	1,834	3.99
15	13.7	238,531	3,445	7.60	236,106	2,965	6.46
16	1.5	33,263	1,370	1.99	18,392	502	0.73
17	9.3	265,307	2,840	3.98	263,942	2,725	3.97
18	2.7	156,478	1,730	1.03	156,478	1,511	0.78
19	2.0	110,855	1,125	1.50	110,854	1,103	1.47
20	0.7	31,432	571	1.14	30,883	436	0.94
21	21.8	1,097,000	11,795	15.87	1,096,000	10,689	14.03
22	42.3	950,831	13,211	26.14	937,353	11,084	21.49
23	7.4	218,701	2,600	5.02	218,701	2,549	4.90
24	14.1	501,066	3,066	6.56	469,231	2,670	5.67
25	16.5	288,684	4,169	9.20	178,290	2,371	5.26
26	18.1	316,993	4,578	10.10	310,393	3,794	8.24
27	4.2	73,394	1,060	2.34	71,358	882	1.92
28	3.9	106,851	1,095	1.53	51,387	492	0.78
29	3.6	27,971	270	0.66	27,971	260	0.63
30	9.0	158,147	2,284	5.04	156,267	1,955	4.26
31	6.1	121,836	1,923	4.37	121,836	1,824	4.15
Totals	**351.2**	**8,322,143**	**82,753**	**161.56**	**7,832,091**	**67,521**	**129.74**

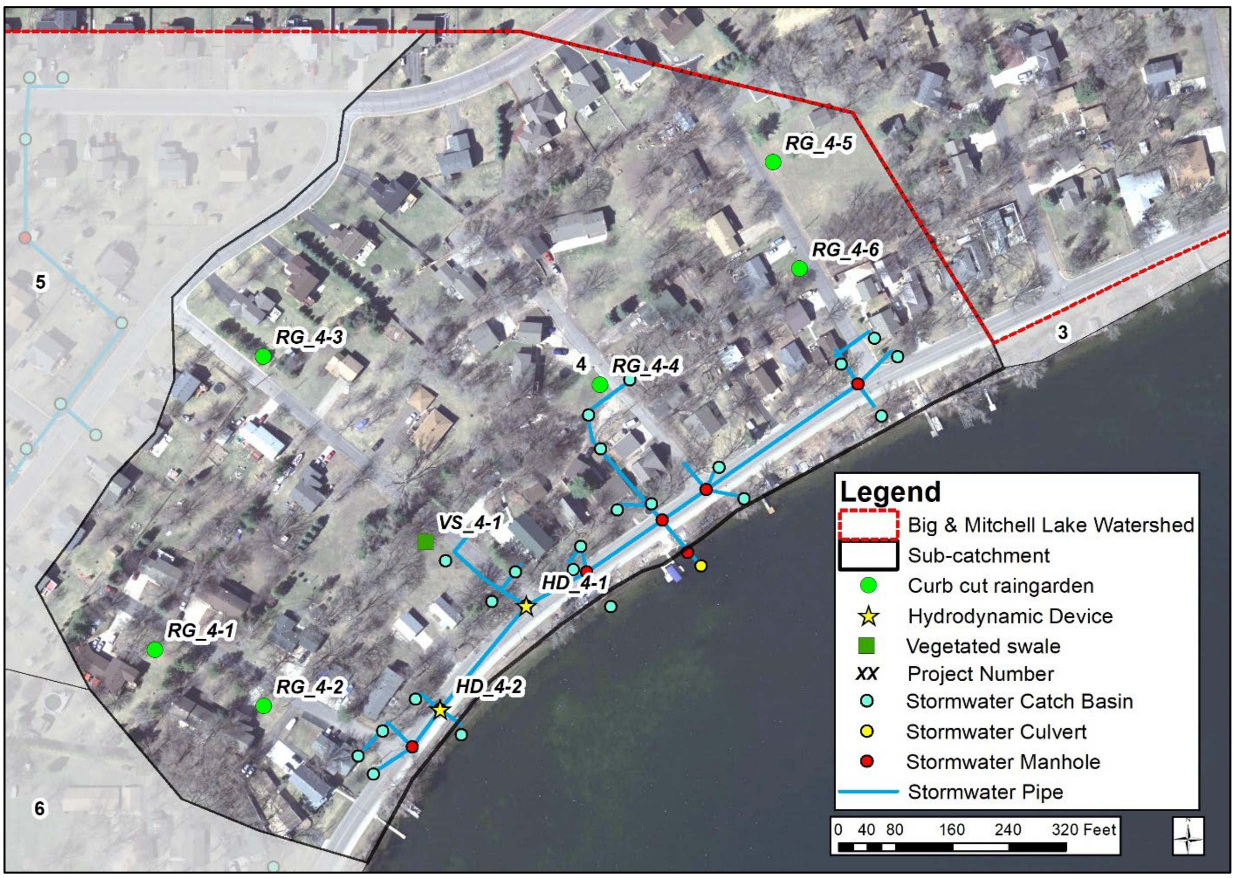
Priority Sub-catchment Profiles

The remaining portion of this document will present each of the 12 priority sub-catchments to the reader. The sub-catchment profile will describe the characteristics of the area including the dominant land use, hydrology, existing treatments, and potential stormwater retrofit practices that were identified as part of this study.

Priority Sub-Catchment 4

Sub-catchment 4 Current	
Acres	20.16
Dominant Land Cover	Medium Density Urban
Existing BMPs	St Sweep, Catch Basins
Volume (cu-ft/yr)	352,291
TP (lb/yr)	9.31
TSS (lb/yr)	4294

This sub-catchment lies on the northwest side of Lake Mitchell and is the 4th largest of the 30 sub-catchments identified in this study. Moderate slopes are found on this landscape, which may be classified as a medium density urban environment. Traffic consists of primarily residents with some additional cars traveling along the lake on Lakeshore Drive.



Treatment Calculations and Cost Analysis

As outlined in the tables below, several potential projects were identified for this sub-catchment, including rain garden installations, vegetated swales and hydrodynamic devices. The tables that follow outline the project type, pollution parameters following installation of the project, the cost of the project and the cost per pound of pollutant reduction. Modeling results are independent of each other; that is, the reductions and costs are associated with each single project and do not reflect savings or additional pollutant reduction that would occur with multiple BMP installations.

Table 5: Sub-catchment 4 potential stormwater retrofit projects. Pollutant estimates based upon standard WinSLAMM parameters, costs based upon conservative estimates from The Center for Watershed Protection's Urban Subwatershed Restoration Manuals and local project experience.

RG 4-1				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	0.24		
	Volume (ac-ft/yr)	348,115	4,176	1.2
	TP (lb/yr)	9.20	0.11	1.2
	TSS (lb/yr)	4241	53	1.2
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$4,715		
	30-yr Avg Cost /1,000lb-TSS	$9,965		

RG 4-2				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	0.55		
	Volume (cu-ft/yr)	343,610	8,681	2.5
	TP (lb/yr)	9.07	0.24	2.6
	TSS (lb/yr)	4182	112	2.6
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$2,201		
	30-yr Avg Cost /1,000lb-TSS	$4,715		

RG 4-3				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	0.75		
	Volume (cu-ft/yr)	341,308	10,983	3.1
	TP (lb/yr)	9.00	0.31	3.3
	TSS (lb/yr)	4151	143	3.3
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$1,720		
	30-yr Avg Cost /1,000lb-TSS	$3,693		

RG 4-4				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	750 sqft Rain Garden		
	Catchment (ac)	0.91		
	Volume (cu-ft/yr)	336,429	15,862	4.5
	TP (lb/yr)	8.88	0.44	4.7
	TSS (lb/yr)	4093	201	4.7
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$1,214		
	30-yr Avg Cost /1,000lb-TSS	$2,628		

RG 4-5				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	0.42		
	Volume (cu-ft/yr)	345,416	6,875	2.0
	TP (lb/yr)	9.12	0.19	2.0
	TSS (lb/yr)	4206	88	2.0
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$2,809		
	30-yr Avg Cost /1,000lb-TSS	$6,002		

RG 4-6				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	0.16		
	Volume (cu-ft/yr)	349,496	2,795	0.8
	TP (lb/yr)	9.24	0.07	0.8
	TSS (lb/yr)	4259	35	0.8
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$7,235		
	30-yr Avg Cost /1,000lb-TSS	$15,090		

Table 5 continued: Sub-catchment 4 potential stormwater retrofit projects. Pollutant estimates based upon standard WinSLAMM parameters, costs based upon conservative estimates from The Center for Watershed Protection's Urban Subwatershed Restoration Manuals and local project experience.

VS 4-1				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	50 ft Vegetated Swale		
	Catchment (ac)	0.63		
	Volume (cu-ft/yr)	345,055	7,236	2.1
	TP (lb/yr)	9.11	0.20	2.2
	TSS (lb/yr)	4199	95	2.2
Cost & Efficiency	Administration & Promotion	$3,650		
	Design & Construction	$3,376		
	Total Estimated Cost	$7,026		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$1,154		
	30-yr Avg Cost /1,000lb-TSS	$2,465		

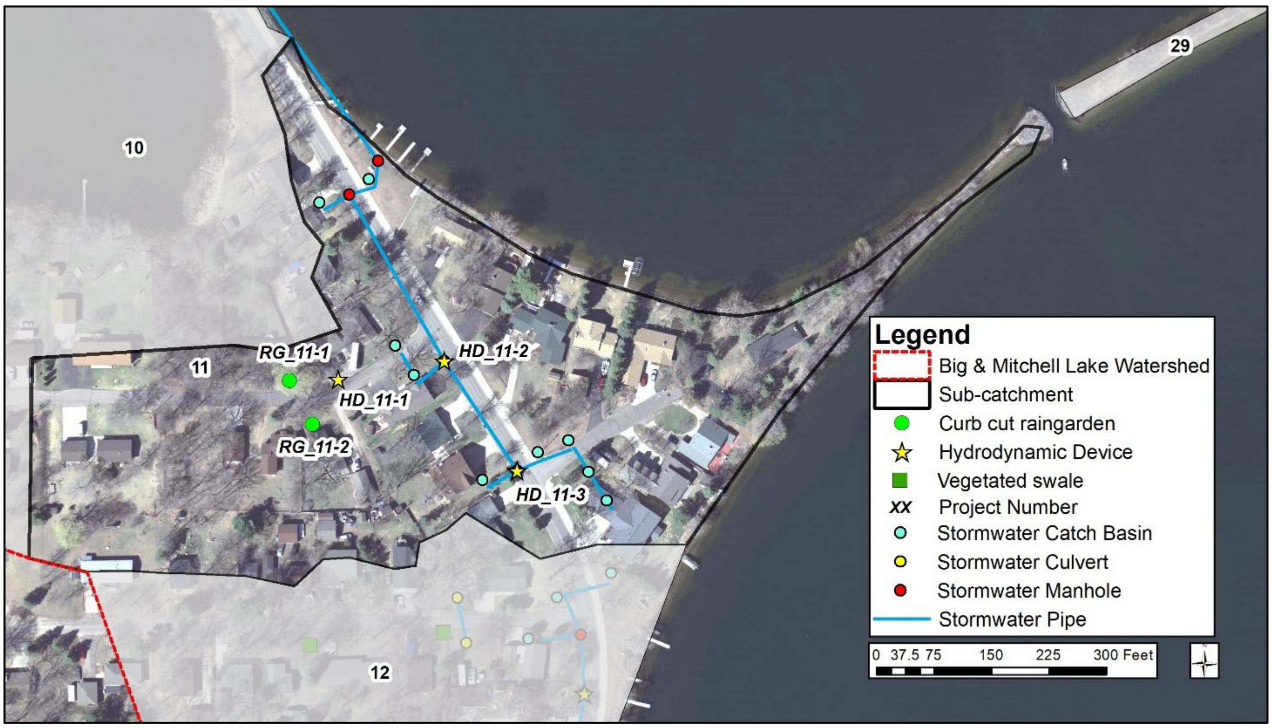
HD 4-1				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	8' dia Hydrodynamic Device		
	Catchment (ac)	7.06		
	Volume (cu-ft/yr)	352,291	0	0.0
	TP (lb/yr)	9.21	0.10	1.1
	TSS (lb/yr)	4251	43	1.0
Cost & Efficiency	Administration & Promotion	$1,752		
	Design & Construction	$54,000		
	Total Estimated Cost	$55,752		
	Annual O&M	$420		
	30-yr Avg Cost / lb-TP	$17,869		
	30-yr Avg Cost /1,000lb-TSS	$43,219		

HD 4-2				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	6' dia Hydrodynamic Device		
	Catchment (ac)	3.12		
	Volume (cu-ft/yr)	352,291	0	0.0
	TP (lb/yr)	9.25	0.06	0.6
	TSS (lb/yr)	4268	26	0.6
Cost & Efficiency	Administration & Promotion	$1,752		
	Design & Construction	$27,000		
	Total Estimated Cost	$28,752		
	Annual O&M	$420		
	30-yr Avg Cost / lb-TP	$15,973		
	30-yr Avg Cost /1,000lb-TSS	$36,862		

Priority Sub-Catchment 11

Sub-catchment 11 Current	
Acres	8.36
Dominant Land Cover	Medium Density Urban
Existing BMPs	St Sweep, Catch Basins
Volume (cu-ft/yr)	146,090
TP (lb/yr)	4.26
TSS (lb/yr)	1948

This sub-catchment includes the western peninsula that lies between Big Lake and Lake Mitchell. The area has a flat slope which directs stormwater to a centrally located pipe system outletting to Lake Mitchell. Traffic consists of primarily residents with some additional cars traveling along the lake on Lakeshore Drive. Road construction is slated for 2020 in this area.



Treatment Calculations and Cost Analysis

As outlined in the tables below, several potential projects were identified for this sub-catchment, including rain garden installations and hydrodynamic devices. The tables that follow outline the project type, pollution parameters following installation of the project, the cost of the project and the cost per pound of pollutant reduction. Modeling results are independent of each other; that is, the reductions and costs are associated with each single project and do not reflect savings or additional pollutant reduction that would occur with multiple BMP installations.

Table 6: Sub-catchment 11 potential stormwater retrofit projects. Pollutant estimates based upon standard WinSLAMM parameters, costs based upon conservative estimates from The Center for Watershed Protection's Urban Subwatershed Restoration Manuals and local project experience.

RG 11-1				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	0.45		
	Volume (cu-ft/yr)	138,789	7,301	5.0
	TP (lb/yr)	3.83	0.43	10.2
	TSS (lb/yr)	1754	194	10.0
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$1,217		
	30-yr Avg Cost /1,000lb-TSS	$2,722		

RG 11-2				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	0.57		
	Volume (cu-ft/yr)	137,137	8,953	6.1
	TP (lb/yr)	3.78	0.48	11.3
	TSS (lb/yr)	1731	217	11.1
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$1,093		
	30-yr Avg Cost /1,000lb-TSS	$2,434		

HD 11-1				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	4' dia Hydrodynamic Device		
	Catchment (ac)	1.11		
	Volume (cu-ft/yr)	146,090	0	0.0
	TP (lb/yr)	3.96	0.30	7.1
	TSS (lb/yr)	1818	130	6.7
Cost & Efficiency	Administration & Promotion	$1,752		
	Design & Construction	$18,000		
	Total Estimated Cost	$19,752		
	Annual O&M	$420		
	30-yr Avg Cost / lb-TP	$2,166		
	30-yr Avg Cost /1,000lb-TSS	$5,065		

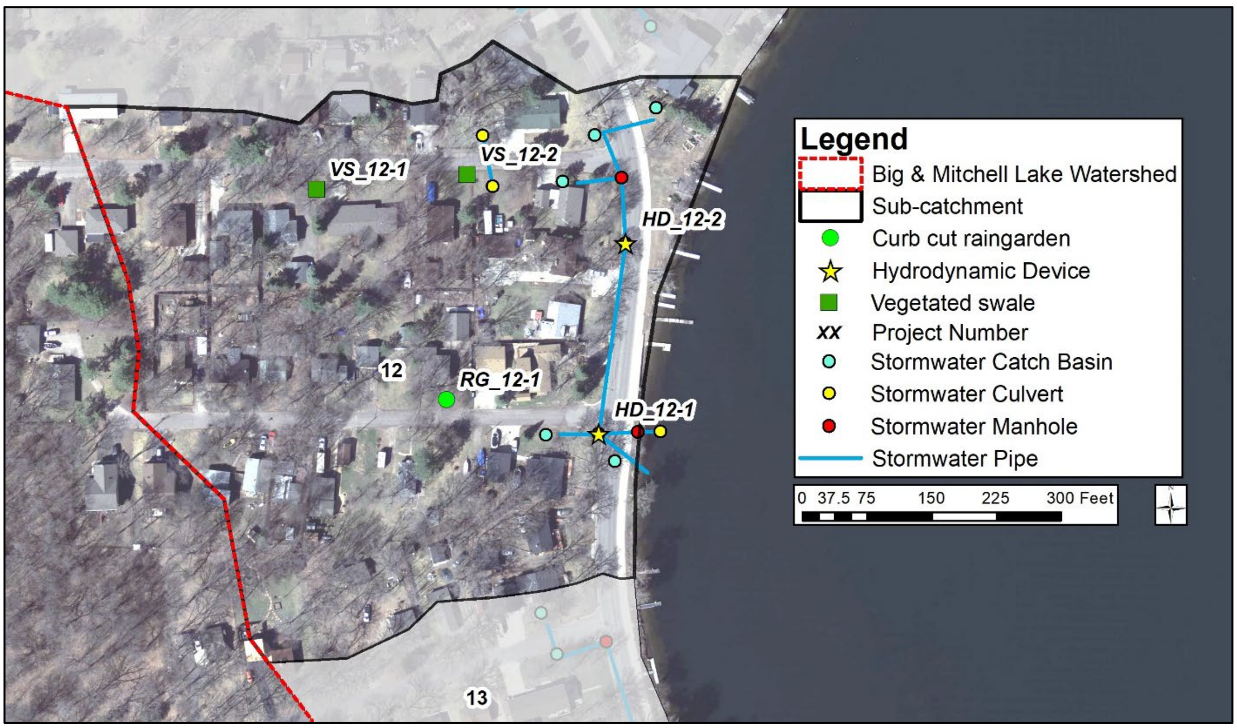
HD 11-2				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	6' dia Hydrodynamic Device		
	Catchment (ac)	3.28		
	Volume (cu-ft/yr)	146,090	0	0.0
	TP (lb/yr)	4.01	0.25	5.8
	TSS (lb/yr)	1847	101	5.2
Cost & Efficiency	Administration & Promotion	$1,752		
	Design & Construction	$27,000		
	Total Estimated Cost	$28,752		
	Annual O&M	$420		
	30-yr Avg Cost / lb-TP	$3,865		
	30-yr Avg Cost /1,000lb-TSS	$9,489		

HD 11-3				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	4' dia Hydrodynamic Device		
	Catchment (ac)	1.22		
	Volume (cu-ft/yr)	146,090	0	0.0
	TP (lb/yr)	3.95	0.31	7.2
	TSS (lb/yr)	1816	132	6.8
Cost & Efficiency	Administration & Promotion	$1,752		
	Design & Construction	$18,000		
	Total Estimated Cost	$19,752		
	Annual O&M	$420		
	30-yr Avg Cost / lb-TP	$2,138		
	30-yr Avg Cost /1,000lb-TSS	$4,988		

Sub-Catchment 12

Sub-catchment 12 Current	
Acres	8.32
Dominant Land Cover	Medium Density Urban
Existing BMPs	St Sweep, Catch Basins
Volume (cu-ft/yr)	175,995
TP (lb/yr)	4.95
TSS (lb/yr)	2253

This sub-catchment lies along the western side of Big Lake. The area has a low grade slope which directs stormwater to a pipe system on the eastern side. Traffic consists of primarily residents with some additional cars traveling along the lake on Lakeshore Drive. Road construction is slated for 2020 in this area.



Treatment Calculations and Cost Analysis

As outlined in the tables below, several potential projects were identified for this sub-catchment, including rain garden installations, vegetated swales and hydrodynamic devices. The tables that follow outline the project type, pollution parameters following installation of the project, the cost of the project and the cost per pound of pollutant reduction. Modeling results are independent of each other; that is, the reductions and costs are associated with each single project and do not reflect savings or additional pollutant reduction that would occur with multiple BMP installations.

Table 7: Sub-catchment 12 potential stormwater retrofit projects. Pollutant estimates based upon standard WinSLAMM parameters, costs based upon conservative estimates from The Center for Watershed Protection's Urban Subwatershed Restoration Manuals and local project experience.

RG 12-1				
Cost/Removal Analysis		New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	0.46		
	Volume (cu-ft/yr)	166,706	9,289	5.3
	TP (lb/yr)	4.54	0.41	8.2
	TSS (lb/yr)	2069	184	8.2
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$1,294		
	30-yr Avg Cost /1,000lb-TSS	$2,870		

VS 12-1				
Cost/Removal Analysis		New Treatment	Reduction	% Reduction
Treatment	BMP	30 ft VS		
	Catchment (ac)	0.36		
	Volume (cu-ft/yr)	170,769	5,226	3.0
	TP (lb/yr)	4.65	0.30	6.0
	TSS (lb/yr)	2119	134	5.9
Cost & Efficiency	Administration & Promotion	$3,650		
	Design & Construction	$2,376		
	Total Estimated Cost	$6,026		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$672		
	30-yr Avg Cost /1,000lb-TSS	$1,499		

VS 12-2				
Cost/Removal Analysis		New Treatment	Reduction	% Reduction
Treatment	BMP	30 ft VS		
	Catchment (ac)	0.6		
	Volume (cu-ft/yr)	169,250	6,745	3.8
	TP (lb/yr)	4.60	0.35	7.0
	TSS (lb/yr)	2098	155	6.9
Cost & Efficiency	Administration & Promotion	$3,650		
	Design & Construction	$2,376		
	Total Estimated Cost	$6,026		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$581		
	30-yr Avg Cost /1,000lb-TSS	$1,296		

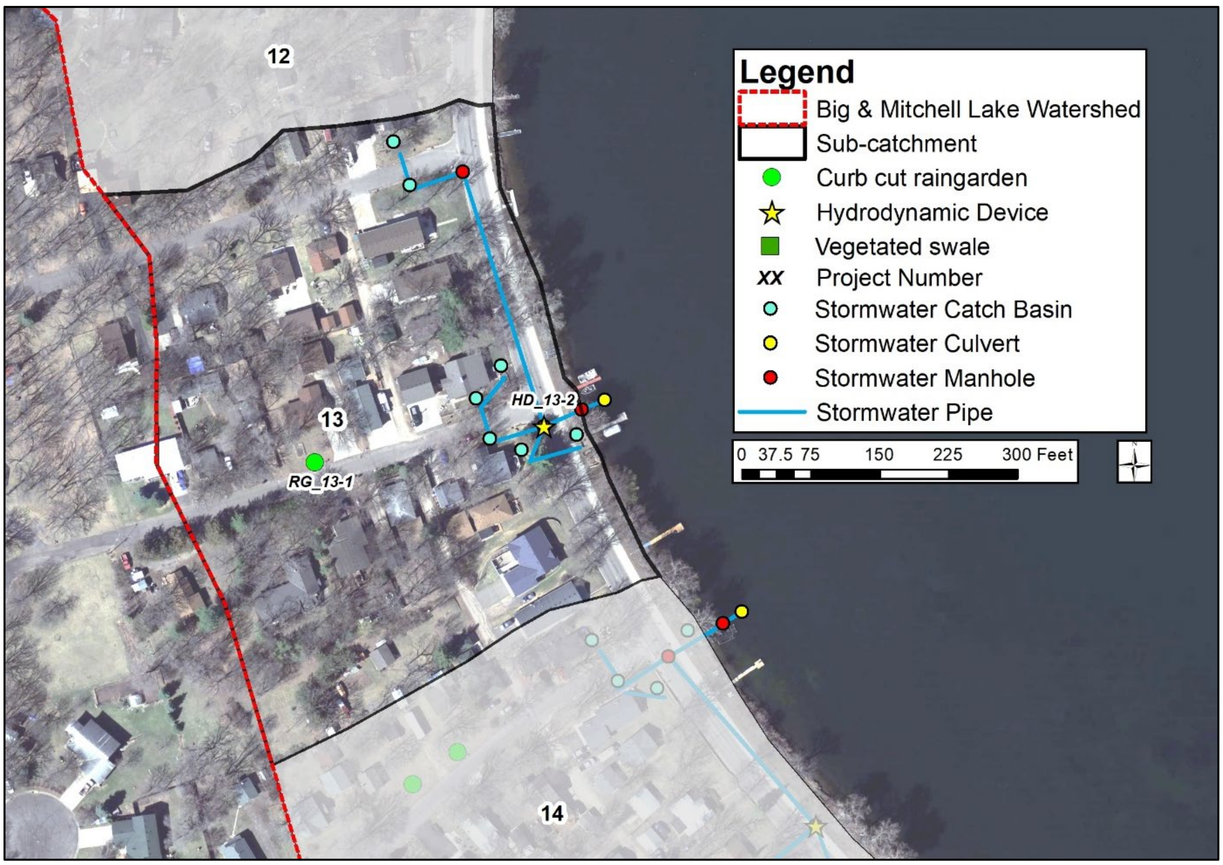
HD 12-1				
Cost/Removal Analysis		New Treatment	Reduction	% Reduction
Treatment	BMP	4' dia Hydrodynamic Device		
	Catchment (ac)	1.22		
	Volume (cu-ft/yr)	175,489	506	0.3
	TP (lb/yr)	4.68	0.27	5.5
	TSS (lb/yr)	2138	115	5.1
Cost & Efficiency	Administration & Promotion	$1,752		
	Design & Construction	$18,000		
	Total Estimated Cost	$19,752		
	Annual O&M	$420		
	30-yr Avg Cost / lb-TP	$2,439		
	30-yr Avg Cost /1,000lb-TSS	$5,725		

HD 12-2				
Cost/Removal Analysis		New Treatment	Reduction	% Reduction
Treatment	BMP	6' dia Hydrodynamic Device		
	Catchment (ac)	2.18		
	Volume (cu-ft/yr)	175,486	509	0.3
	TP (lb/yr)	4.64	0.31	6.3
	TSS (lb/yr)	2122	131	5.8
Cost & Efficiency	Administration & Promotion	$1,752		
	Design & Construction	$27,000		
	Total Estimated Cost	$28,752		
	Annual O&M	$420		
	30-yr Avg Cost / lb-TP	$3,082		
	30-yr Avg Cost /1,000lb-TSS	$7,316		

Sub-Catchment 13

Sub-catchment 13 Current	
Acres	5.93
Dominant Land Cover	Medium Density Urban
Existing BMPs	St Sweep, Catch Basins
Volume (cu-ft/yr)	101,791
TP (lb/yr)	2.77
TSS (lb/yr)	1270

This sub-catchment lies along the western side of Big Lake. The area has a low grade slope which directs stormwater to a pipe system on the eastern side. Traffic consists of primarily residents with some additional cars traveling along the lake on Lakeshore Drive. Road construction is slated for 2020 in this area.



Treatment Calculations and Cost Analysis

Building density is high in this area and as a result only two potential projects were identified for this sub-catchment, including a rain garden installation and a hydrodynamic devices. The tables that follow outline the project type, pollution parameters following installation of the project, the cost of the project and the cost per pound of pollutant reduction. Modeling results are independent of each other; that is, the reductions and costs are associated with each single project and do not reflect savings or additional pollutant reduction that would occur with multiple BMP installations.

Table 8: Sub-catchment 13 potential stormwater retrofit projects. Pollutant estimates based upon standard WinSLAMM parameters, costs based upon conservative estimates from The Center for Watershed Protection's Urban Subwatershed Restoration Manuals and local project experience.

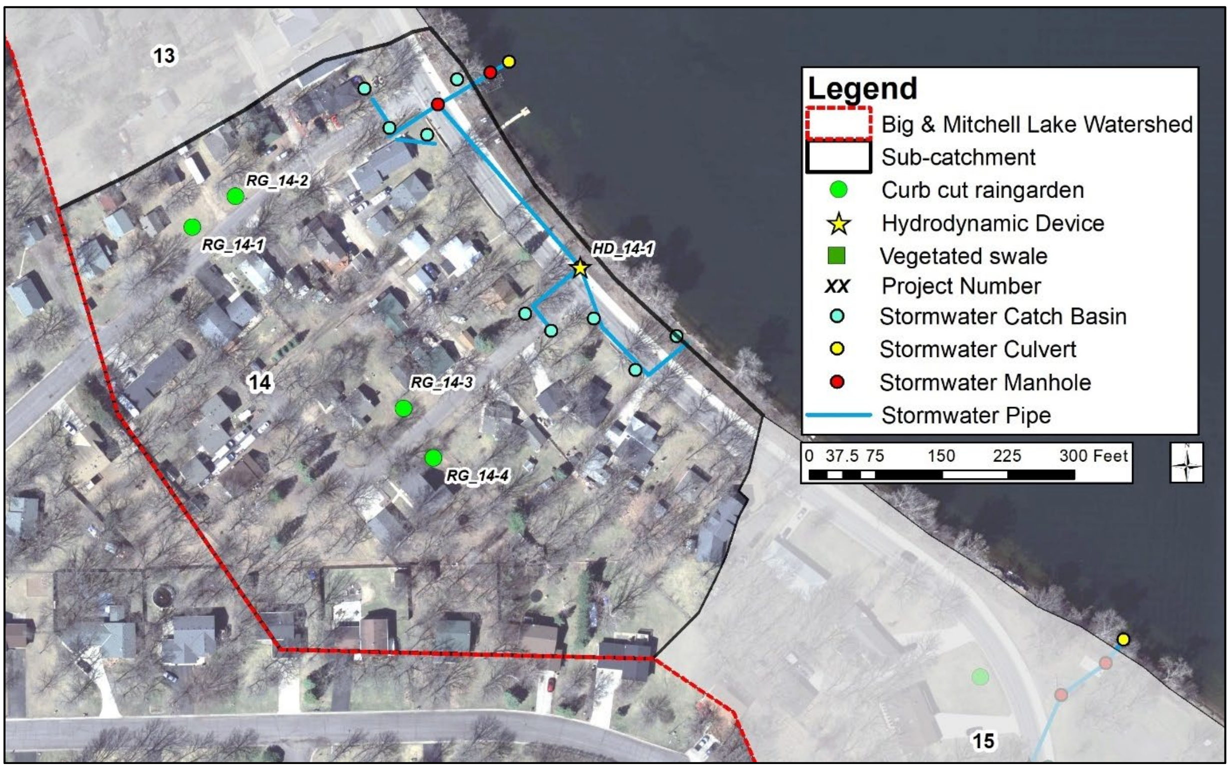
	RG 13-1			
	Cost/Removal Analysis	**New Treatment**	**Reduction**	**% Reduction**
Treatment	**BMP**	250 sqft Rain Garden		
	Catchment (ac)	0.22		
	Volume (cu-ft/yr)	97,950	3,841	3.8
	TP (lb/yr)	2.66	0.11	4.0
	TSS (lb/yr)	1221	49	3.9
Cost & Efficiency	**Administration & Promotion**	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$4,715		
	30-yr Avg Cost /1,000lb-TSS	$10,778		

	HD 13-1			
	Cost/Removal Analysis	**New Treatment**	**Reduction**	**% Reduction**
Treatment	**BMP**	4' dia Hydrodynamic Device		
	Catchment (ac)	1.86		
	Volume (cu-ft/yr)	101,749	42	0.0
	TP (lb/yr)	2.69	0.09	3.1
	TSS (lb/yr)	1238	32	2.5
Cost & Efficiency	**Administration & Promotion**	$1,752		
	Design & Construction	$18,000		
	Total Estimated Cost	$19,752		
	Annual O&M	$420		
	30-yr Avg Cost / lb-TP	$7,746		
	30-yr Avg Cost /1,000lb-TSS	$20,575		

Sub-Catchment 14

Sub-catchment 14 Current	
Acres	8.55
Dominant Land Cover	Medium Density Urban
Existing BMPs	St Sweep, Catch Basins
Volume (cu-ft/yr)	147,280
TP (lb/yr)	3.99
TSS (lb/yr)	1834

This sub-catchment lies on the west/southwest side of Big Lake. The area has a low grade slope which directs stormwater to a pipe system on the eastern side. Traffic consists of primarily residents with some additional cars traveling along the lake on Lakeshore Drive. Road construction is slated for 2020 in this area.



Treatment Calculations and Cost Analysis

As outlined in the tables below, several potential projects were identified for this sub-catchment, including rain garden installations and hydrodynamic devices. The tables that follow outline the project type, pollution parameters following installation of the project, the cost of the project and the cost per pound of pollutant reduction. Modeling results are independent of each other; that is, the reductions and costs are associated with each single project and do not reflect savings or additional pollutant reduction that would occur with multiple BMP installations.

Table 9: Sub-catchment 14 potential stormwater retrofit projects. Pollutant estimates based upon standard WinSLAMM parameters, costs based upon conservative estimates from The Center for Watershed Protection's Urban Subwatershed Restoration Manuals and local project experience.

RG 14-1				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	0.25		
	Volume (cu-ft/yr)	142,940	4,340	2.9
	TP (lb/yr)	3.87	0.12	3.0
	TSS (lb/yr)	1778	56	3.1
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$4,401		
	30-yr Avg Cost /1,000lb-TSS	$9,431		

RG 14-2				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	0.35		
	Volume (cu-ft/yr)	141,426	5,854	4.0
	TP (lb/yr)	3.83	0.16	4.1
	TSS (lb/yr)	1758	76	4.1
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$3,220		
	30-yr Avg Cost /1,000lb-TSS	$6,949		

RG 14-3				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	0.43		
	Volume (cu-ft/yr)	140,529	6,751	4.6
	TP (lb/yr)	3.79	0.20	4.9
	TSS (lb/yr)	1743	91	5.0
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$2,681		
	30-yr Avg Cost /1,000lb-TSS	$5,804		

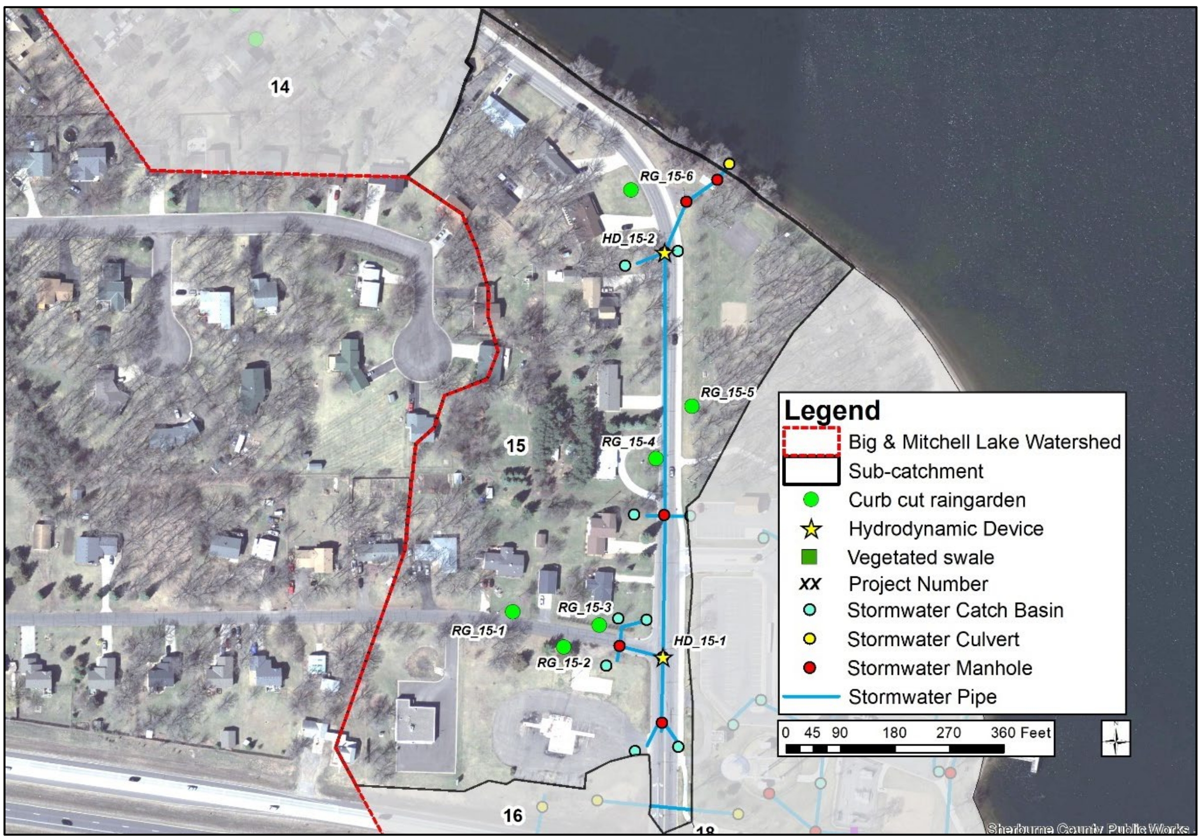
RG 14-4				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	0.3		
	Volume (cu-ft/yr)	142,167	5,113	3.5
	TP (lb/yr)	3.85	0.14	3.6
	TSS (lb/yr)	1768	66	3.6
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$3,719		
	30-yr Avg Cost /1,000lb-TSS	$8,002		

HD 14-1				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	6' dia Hydrodynamic Device		
	Catchment (ac)	1.99		
	Volume (cu-ft/yr)	147,232	48	0.0
	TP (lb/yr)	3.91	0.08	1.9
	TSS (lb/yr)	1803	31	1.7
Cost & Efficiency	Administration & Promotion	$1,752		
	Design & Construction	$27,000		
	Total Estimated Cost	$28,752		
	Annual O&M	$420		
	30-yr Avg Cost / lb-TP	$12,447		
	30-yr Avg Cost /1,000lb-TSS	$30,916		

Sub-Catchment 15

Sub-catchment 15 Current	
Acres	13.65
Dominant Land Cover	Medium Density Urban
Existing BMPs	St Sweep, Catch Basins
Volume (cu-ft/yr)	236,106
TP (lb/yr)	6.46
TSS (lb/yr)	2965

This sub-catchment lies on the southwest side of Big Lake and is the 9th largest of the 30 sub-catchments identified in this study. Low slopes are found on this landscape, which consists of mostly residential but some commercial areas adjacent to US-10. Traffic consists of primarily residents with some additional cars traveling along the lake on Lakeshore Drive.



Treatment Calculations and Cost Analysis

As outlined in the tables below, several potential projects were identified for this sub-catchment, including rain garden installations, vegetated swales and hydrodynamic devices. The tables that follow outline the project type, pollution parameters following installation of the project, the cost of the project and the cost per pound of pollutant reduction. Modeling results are independent of each other; that is, the reductions and costs are associated with each single project and do not reflect savings or additional pollutant reduction that would occur with multiple BMP installations.

Table 10: Sub-catchment 15 potential stormwater retrofit projects. Pollutant estimates based upon standard WinSLAMM parameters, costs based upon conservative estimates from The Center for Watershed Protection's Urban Subwatershed Restoration Manuals and local project experience.

RG 15-1

	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	0.43		
	Volume (cu-ft/yr)	229,088	7,018	3.0
	TP (lb/yr)	6.26	0.20	3.1
	TSS (lb/yr)	2873	92	3.1
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$2,641		
	30-yr Avg Cost /1,000lb-TSS	$5,741		

RG 15-2

	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	0.24		
	Volume (cu-ft/yr)	231,929	4,177	1.8
	TP (lb/yr)	6.34	0.12	1.8
	TSS (lb/yr)	2911	54	1.8
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$4,514		
	30-yr Avg Cost /1,000lb-TSS	$9,780		

RG 15-3

	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	0.64		
	Volume (cu-ft/yr)	226,311	9,795	4.1
	TP (lb/yr)	6.18	0.28	4.4
	TSS (lb/yr)	2835	130	4.4
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$1,873		
	30-yr Avg Cost /1,000lb-TSS	$4,063		

RG 15-4

	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	0.55		
	Volume (cu-ft/yr)	227,425	8,681	3.7
	TP (lb/yr)	6.21	0.25	3.8
	TSS (lb/yr)	2851	114	3.8
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$2,130		
	30-yr Avg Cost /1,000lb-TSS	$4,633		

RG 15-5

	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	0.46		
	Volume (cu-ft/yr)	228,661	7,445	3.2
	TP (lb/yr)	6.25	0.21	3.3
	TSS (lb/yr)	2867	98	3.3
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$2,491		
	30-yr Avg Cost /1,000lb-TSS	$5,389		

RG 15-6

	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	0.73		
	Volume (cu-ft/yr)	225,332	10,774	4.6
	TP (lb/yr)	6.15	0.31	4.8
	TSS (lb/yr)	2822	143	4.8
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$1,704		
	30-yr Avg Cost /1,000lb-TSS	$3,693		

Table 10 continued: Sub-catchment 15 potential stormwater retrofit projects. Pollutant estimates based upon standard WinSLAMM parameters, costs based upon conservative estimates from The Center for Watershed Protection's Urban Subwatershed Restoration Manuals and local project experience.

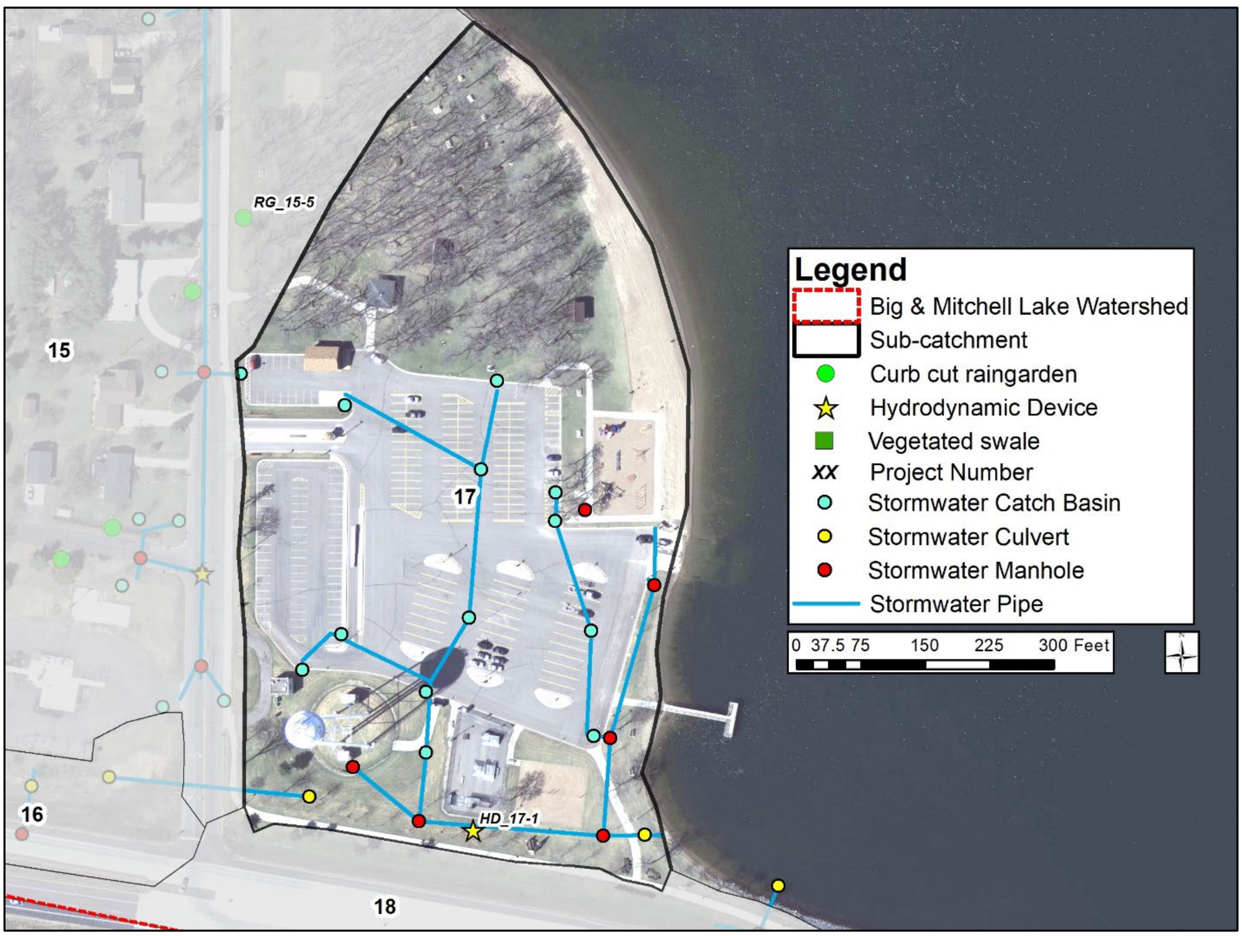
HD 15-1				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	6' dia Hydrodynamic Device		
	Catchment (ac)	1.8		
	Volume (cu-ft/yr)	236,052	54	0.0
	TP (lb/yr)	6.38	0.08	1.3
	TSS (lb/yr)	2930	35	1.2
Cost & Efficiency	Administration & Promotion	$1,752		
	Design & Construction	$27,000		
	Total Estimated Cost	$28,752		
	Annual O&M	$420		
	30-yr Avg Cost / lb-TP	$11,410		
	30-yr Avg Cost /1,000lb-TSS	$27,383		

HD 15-2				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	6' dia Hydrodynamic Device		
	Catchment (ac)	1.86		
	Volume (cu-ft/yr)	236,052	54	0.0
	TP (lb/yr)	6.37	0.09	1.3
	TSS (lb/yr)	2930	35	1.2
Cost & Efficiency	Administration & Promotion	$1,752		
	Design & Construction	$27,000		
	Total Estimated Cost	$28,752		
	Annual O&M	$420		
	30-yr Avg Cost / lb-TP	$11,275		
	30-yr Avg Cost /1,000lb-TSS	$27,383		

Sub-Catchment 17

Sub-catchment 17 Current	
Acres	9.31
Dominant Land Cover	Parking lot, turf
Existing BMPs	St Sweep, Catch Basins, Infiltration pipe
Volume (cu-ft/yr)	264,052
TP (lb/yr)	3.97
TSS (lb/yr)	2781

This sub-catchment lies on the southwest side of Big Lake and includes Lakeside Park, a popular park that includes a boat launch, beach, skateboard park, picnic and restroom facilities. The park has a low grade slope but much impervious surface and is located in close proximity to the lake. The area sees abundant traffic between the beach and boat launch users along with special event traffic.



Treatment Calculations and Cost Analysis

As outlined in the table below, a single project was identified for this sub-catchment. This was due to challenges with retrofitting a busy area, and also considering that some of the parking lot has existing stormwater control structures in place. Table 17 outlines the project type, pollution parameters following installation of the project, the cost of the project and the cost per pound of pollutant reduction.

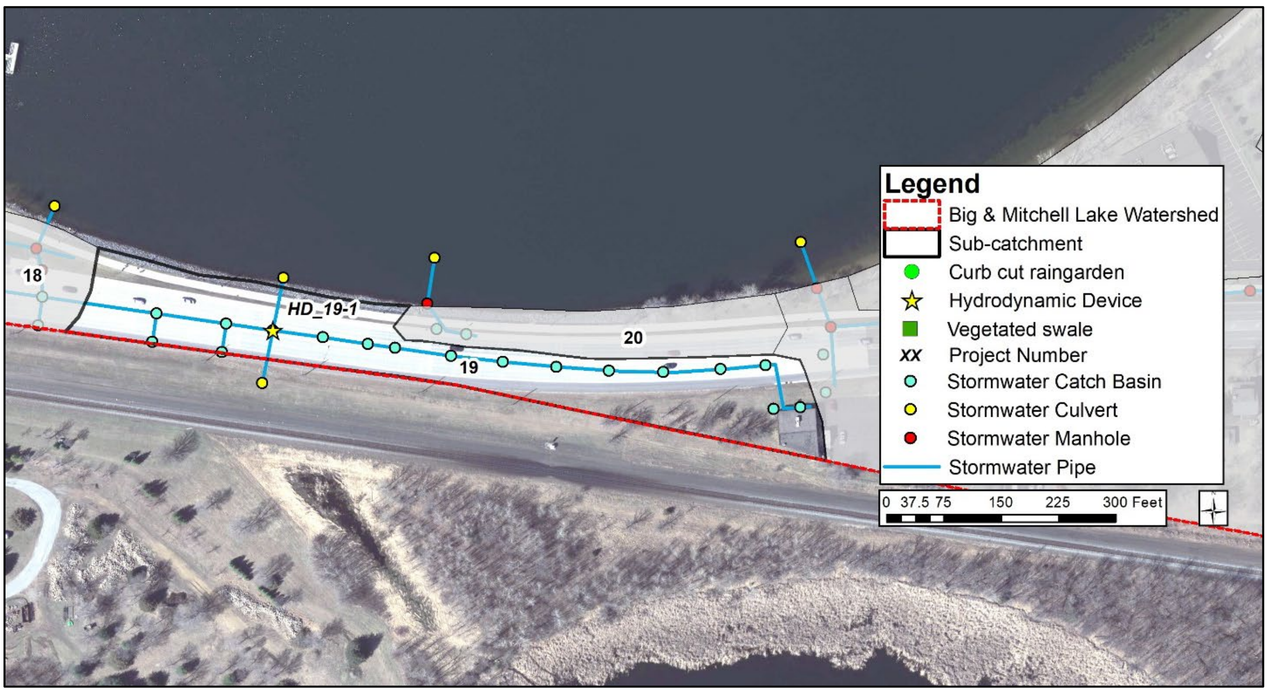
Table 11: Sub-catchment 17 potential stormwater retrofit projects. Pollutant estimates based upon standard WinSLAMM parameters, costs based upon conservative estimates from The Center for Watershed Protection's Urban Subwatershed Restoration Manuals and local project experience.

HD 17-1				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	6' dia Hydrodynamic Device		
	Catchment (ac)	4.14		
	Volume (cu-ft/yr)	257,775	6,277	2.4
	TP (lb/yr)	3.47	0.49	12.5
	TSS (lb/yr)	2426	355	12.8
Cost & Efficiency	Administration & Promotion	$1,752		
	Design & Construction	$27,000		
	Total Estimated Cost	$28,752		
	Annual O&M	$420		
	30-yr Avg Cost / lb-TP	$1,940		
	30-yr Avg Cost /1,000lb-TSS	$2,700		

Sub-Catchment 19

Sub-catchment 19 Current	
Acres	1.98
Dominant Land Cover	Highway
Existing BMPs	St Sweep, Catch Basins
Volume (cu-ft/yr)	110,854
TP (lb/yr)	1.47
TSS (lb/yr)	1103

This sub-catchment lies on the south side of Big Lake and is one of the smallest basins in the study, but holds the most impervious surface. A large amount of traffic flows through this site, which drains directly to Big Lake. The site is challenging to address stormwater issues on due to the limited available space.



Treatment Calculations and Cost Analysis

As outlined in the tables below, a single option was identified – installation of a hydrodynamic devices at the confluence of several stormwater pipes. The table that follows outlines the project type, pollution parameters following installation of the project, the cost of the project and the cost per pound of pollutant reduction.

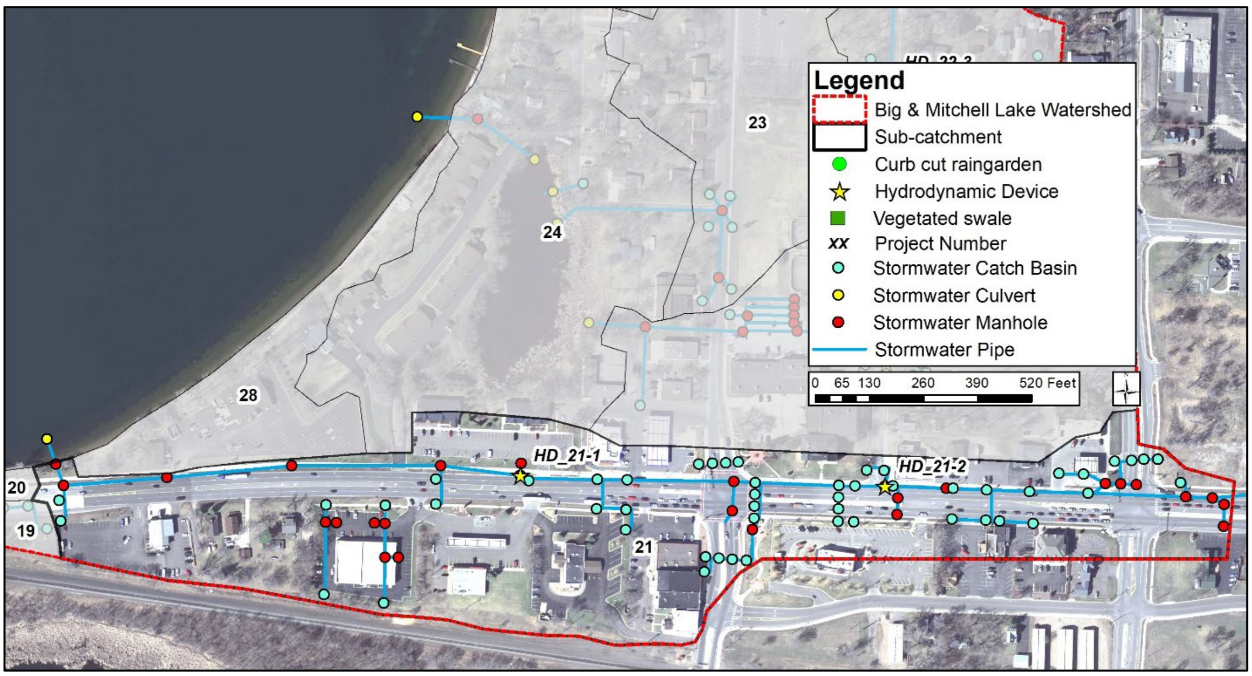
Table 12: Sub-catchment 19 potential stormwater retrofit projects. Pollutant estimates based upon standard WinSLAMM parameters, costs based upon conservative estimates from The Center for Watershed Protection's Urban Subwatershed Restoration Manuals and local project experience.

HD 19-1				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	6' dia Hydrodynamic Device		
	Catchment (ac)	1.71		
	Volume (cu-ft/yr)	110,854	0	0.0
	TP (lb/yr)	1.30	0.17	11.4
	TSS (lb/yr)	990	113	10.2
Cost & Efficiency	Administration & Promotion	$1,752		
	Design & Construction	$18,000		
	Total Estimated Cost	$19,752		
	Annual O&M	$420		
	30-yr Avg Cost / lb-TP	$3,943		
	30-yr Avg Cost /1,000lb-TSS	$5,827		

Sub-Catchment 21

Sub-catchment 21 Current	
Acres	21.81
Dominant Land Cover	Highway, Commercial
Existing BMPs	St Sweep, Catch Basins
Volume (cu-ft/yr)	1,096,000
TP (lb/yr)	14.03
TSS (lb/yr)	10689

This sub-catchment lies on the southeast side of Big Lake and is the 3rd largest of the 30 sub-catchments identified in this study. Low slopes are found on this landscape, which consists of commercial urban areas and US-10 – much impervious surface. This area likely has the highest traffic movement of all areas in the study.



Treatment Calculations and Cost Analysis

The area has much impervious surface and numerous buildings, so retrofitting stormwater practices around these items would be challenging. Opportunities to store or infiltrate stormwater underground, or route to other areas, would be the only options. Table 13 outlines two hydrodynamic device options for the sub-catchment. Modeling results are independent of each other; that is, the reductions and costs are associated with each single project and do not reflect savings or additional pollutant reduction that would occur with multiple BMP installations.

Table 13: Sub-catchment 21 potential stormwater retrofit projects. Pollutant estimates based upon standard WinSLAMM parameters, costs based upon conservative estimates from The Center for Watershed Protection's Urban Subwatershed Restoration Manuals and local project experience.

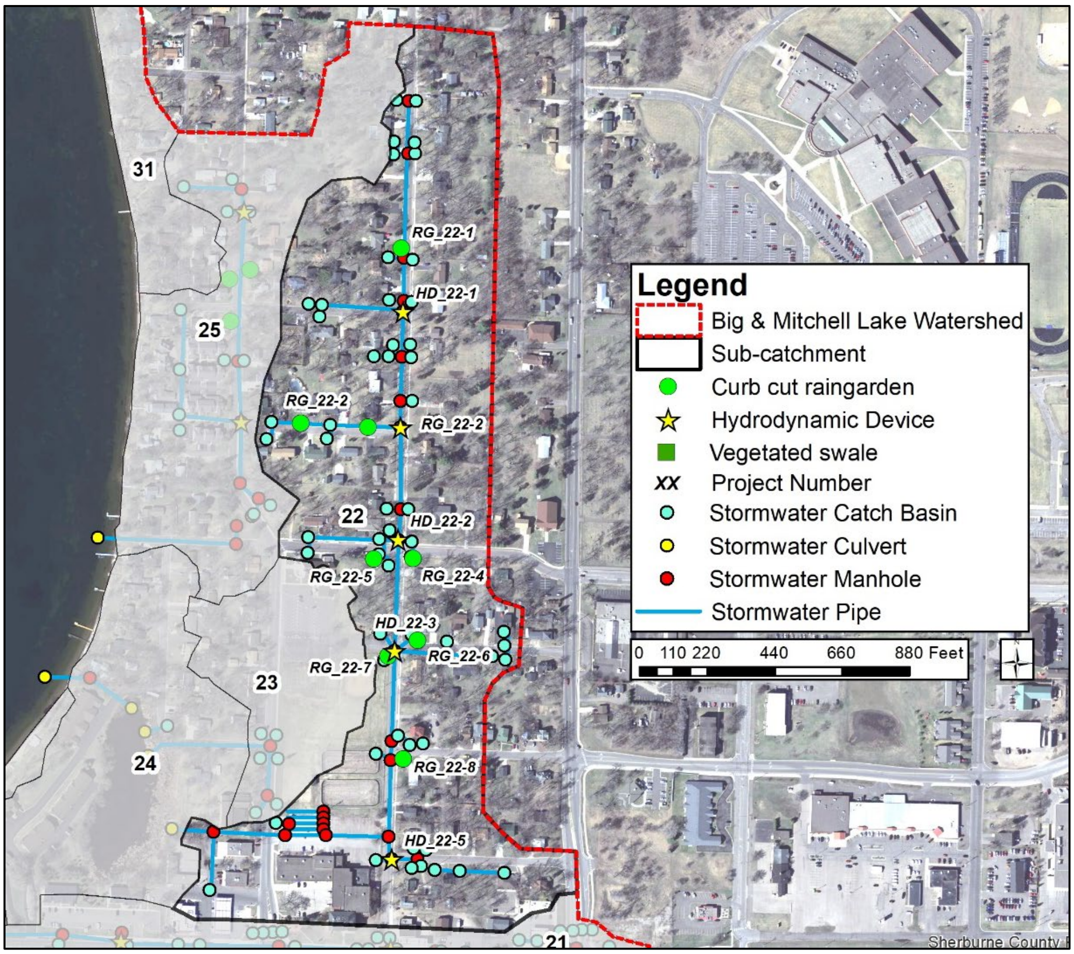
	HD 21-1			
	Cost/Removal Analysis	**New Treatment**	**Reduction**	**% Reduction**
Treatment	**BMP**	8' dia Hydrodynamic Device		
	Catchment (ac)	5.56		
	Volume (cu-ft/yr)	1,096,000	0	0.0
	TP (lb/yr)	13.75	0.28	2.0
	TSS (lb/yr)	10561	128	1.2
Cost & Efficiency	**Administration & Promotion**	$1,752		
	Design & Construction	$54,000		
	Total Estimated Cost	$55,752		
	Annual O&M	$420		
	30-yr Avg Cost / lb-TP	$6,637		
	30-yr Avg Cost /1,000lb-TSS	$14,519		

	HD 21-2			
	Cost/Removal Analysis	**New Treatment**	**Reduction**	**% Reduction**
Treatment	**BMP**	8' dia Hydrodynamic Device		
	Catchment (ac)	4.94		
	Volume (cu-ft/yr)	1,096,000	0	0.0
	TP (lb/yr)	13.85	0.18	1.3
	TSS (lb/yr)	10575	114	1.1
Cost & Efficiency	**Administration & Promotion**	$1,752		
	Design & Construction	$54,000		
	Total Estimated Cost	$55,752		
	Annual O&M	$420		
	30-yr Avg Cost / lb-TP	$10,324		
	30-yr Avg Cost /1,000lb-TSS	$16,302		

Sub-Catchment 22

Sub-catchment 22 Current	
Acres	42.28
Dominant Land Cover	Medium Density Urban
Existing BMPs	St Sweep, Catch Basins, Hydrodynamic Network
Volume (cu-ft/yr)	937,353
TP (lb/yr)	20.56
TSS (lb/yr)	10678

This sub-catchment lies on the east side of Big Lake and represents the largest sub-catchment of this stormwater retrofit study. The area consists of low grade slopes and residential lots, though some commercial lots exist in the southern reach. A large stormwater treatment network exists in the Big Lake City Hall parking lot..



Treatment Calculations and Cost Analysis

As outlined in the tables below, several potential projects were identified for this sub-catchment, including rain garden installations and hydrodynamic devices. The tables that follow outline the project type, pollution parameters following installation of the project, the cost of the project and the cost per pound of pollutant reduction. Modeling results are independent of each other; that is, the reductions and costs are associated with each single project and do not reflect savings or additional pollutant reduction that would occur with multiple BMP installations.

Table 14: Sub-catchment 22 potential stormwater retrofit projects. Pollutant estimates based upon standard WinSLAMM parameters, costs based upon conservative estimates from The Center for Watershed Protection's Urban Subwatershed Restoration Manuals and local project experience.

RG 22-1				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	0.56		
	Volume (cu-ft/yr)	928,541	8,812	0.9
	TP (lb/yr)	20.32	0.24	1.2
	TSS (lb/yr)	10566	112	1.0
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$2,201		
	30-yr Avg Cost /1,000lb-TSS	$4,715		

RG 22-2				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	0.43		
	Volume (cu-ft/yr)	930,333	7,020	0.7
	TP (lb/yr)	20.37	0.19	0.9
	TSS (lb/yr)	10589	89	0.8
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$2,780		
	30-yr Avg Cost /1,000lb-TSS	$5,934		

RG 22-3				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	1.09		
	Volume (cu-ft/yr)	923,532	13,821	1.5
	TP (lb/yr)	20.18	0.38	1.8
	TSS (lb/yr)	10500	178	1.7
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$1,390		
	30-yr Avg Cost /1,000lb-TSS	$2,967		

RG 22-4				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	0.43		
	Volume (cu-ft/yr)	930,333	7,020	0.7
	TP (lb/yr)	20.37	0.19	0.9
	TSS (lb/yr)	10589	89	0.8
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$2,780		
	30-yr Avg Cost /1,000lb-TSS	$5,934		

RG 22-5				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	0.48		
	Volume (cu-ft/yr)	929,628	7,725	0.8
	TP (lb/yr)	20.35	0.21	1.0
	TSS (lb/yr)	10580	98	0.9
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$2,515		
	30-yr Avg Cost /1,000lb-TSS	$5,389		

RG 22-6				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	1.09		
	Volume (cu-ft/yr)	923,532	13,821	1.5
	TP (lb/yr)	20.18	0.38	1.8
	TSS (lb/yr)	10500	178	1.7
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$1,390		
	30-yr Avg Cost /1,000lb-TSS	$2,967		

Table 14 continued: Sub-catchment 22 potential stormwater retrofit projects. Pollutant estimates based upon standard WinSLAMM parameters, costs based upon conservative estimates from The Center for Watershed Protection's Urban Subwatershed Restoration Manuals and local project experience.

RG 22-7				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	0.45		
	Volume (cu-ft/yr)	929,476	7,877	0.8
	TP (lb/yr)	20.36	0.20	1.0
	TSS (lb/yr)	10585	93	0.9
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$2,641		
	30-yr Avg Cost /1,000lb-TSS	$5,679		

RG 22-8				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	0.41		
	Volume (cu-ft/yr)	930,849	6,504	0.7
	TP (lb/yr)	20.38	0.18	0.9
	TSS (lb/yr)	10598	80	0.7
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$2,934		
	30-yr Avg Cost /1,000lb-TSS	$6,602		

HD 22-1				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	6' dia Hydrodynamic Device		
	Catchment (ac)	3.29		
	Volume (cu-ft/yr)	937,117	236	0.0
	TP (lb/yr)	20.51	0.05	0.2
	TSS (lb/yr)	10664	14	0.1
Cost & Efficiency	Administration & Promotion	$1,752		
	Design & Construction	$27,000		
	Total Estimated Cost	$28,752		
	Annual O&M	$420		
	30-yr Avg Cost / lb-TP	$19,168		
	30-yr Avg Cost /1,000lb-TSS	$68,457		

HD 22-2				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	6' dia Hydrodynamic Device		
	Catchment (ac)	3.71		
	Volume (cu-ft/yr)	937,109	244	0.0
	TP (lb/yr)	20.51	0.05	0.2
	TSS (lb/yr)	10665	13	0.1
Cost & Efficiency	Administration & Promotion	$1,752		
	Design & Construction	$27,000		
	Total Estimated Cost	$28,752		
	Annual O&M	$420		
	30-yr Avg Cost / lb-TP	$19,168		
	30-yr Avg Cost /1,000lb-TSS	$73,723		

HD 22-3				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	6' dia Hydrodynamic Device		
	Catchment (ac)	3.24		
	Volume (cu-ft/yr)	937,120	233	0.0
	TP (lb/yr)	20.51	0.05	0.2
	TSS (lb/yr)	10664	14	0.1
Cost & Efficiency	Administration & Promotion	$1,752		
	Design & Construction	$27,000		
	Total Estimated Cost	$28,752		
	Annual O&M	$420		
	30-yr Avg Cost / lb-TP	$19,168		
	30-yr Avg Cost /1,000lb-TSS	$68,457		

HD 22-4				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	6' dia Hydrodynamic Device		
	Catchment (ac)	2.23		
	Volume (cu-ft/yr)	937,143	210	0.0
	TP (lb/yr)	20.52	0.04	0.2
	TSS (lb/yr)	10664	14	0.1
Cost & Efficiency	Administration & Promotion	$1,752		
	Design & Construction	$27,000		
	Total Estimated Cost	$28,752		
	Annual O&M	$420		
	30-yr Avg Cost / lb-TP	$23,960		
	30-yr Avg Cost /1,000lb-TSS	$68,457		

Sub-Catchment 25

Sub-catchment 25 Current	
Acres	16.52
Dominant Land Cover	Medium Density Urban
Existing BMPs	Biofilter, Catchbasins
Volume (cu-ft/yr)	175,226
TP (lb/yr)	4.58
TSS (lb/yr)	2090

This sub-catchment lies on the east side of Big Lake and consists of residential lots as well as shoreline lots. Low slopes are found on this landscape, which consists of mostly residential but some commercial areas adjacent to US-10. Traffic consists of primarily residents with some additional cars traveling along the lake on Lakeshore Drive.

Treatment Calculations and Cost Analysis

As outlined in the tables below, several potential projects were identified for this sub-catchment, including rain garden installations, vegetated swales and hydrodynamic devices. The tables that follow outline the project type, pollution parameters following installation of the project, the cost of the project and the cost per pound of pollutant reduction. Modeling results are independent of each other; that is, the reductions and costs are associated with each single project and do not reflect savings or additional pollutant reduction that would occur with multiple BMP installations.

Table 15: Sub-catchment 25 potential stormwater retrofit projects. Pollutant estimates based upon standard WinSLAMM parameters, costs based upon conservative estimates from The Center for Watershed Protection's Urban Subwatershed Restoration Manuals and local project experience.

RG 25-1				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	0.56		
	Volume (cu-ft/yr)	168,594	6,632	3.8
	TP (lb/yr)	4.39	0.19	4.2
	TSS (lb/yr)	2003	87	4.2
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$2,765		
	30-yr Avg Cost /1,000lb-TSS	$6,070		

RG 25-2				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	0.25		
	Volume (cu-ft/yr)	171,831	3,395	1.9
	TP (lb/yr)	4.49	0.10	2.1
	TSS (lb/yr)	2047	43	2.1
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$5,501		
	30-yr Avg Cost /1,000lb-TSS	$12,282		

RG 25-3				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	0.36		
	Volume (cu-ft/yr)	170,590	4,636	2.6
	TP (lb/yr)	4.45	0.13	2.9
	TSS (lb/yr)	2030	60	2.9
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$4,001		
	30-yr Avg Cost /1,000lb-TSS	$8,802		

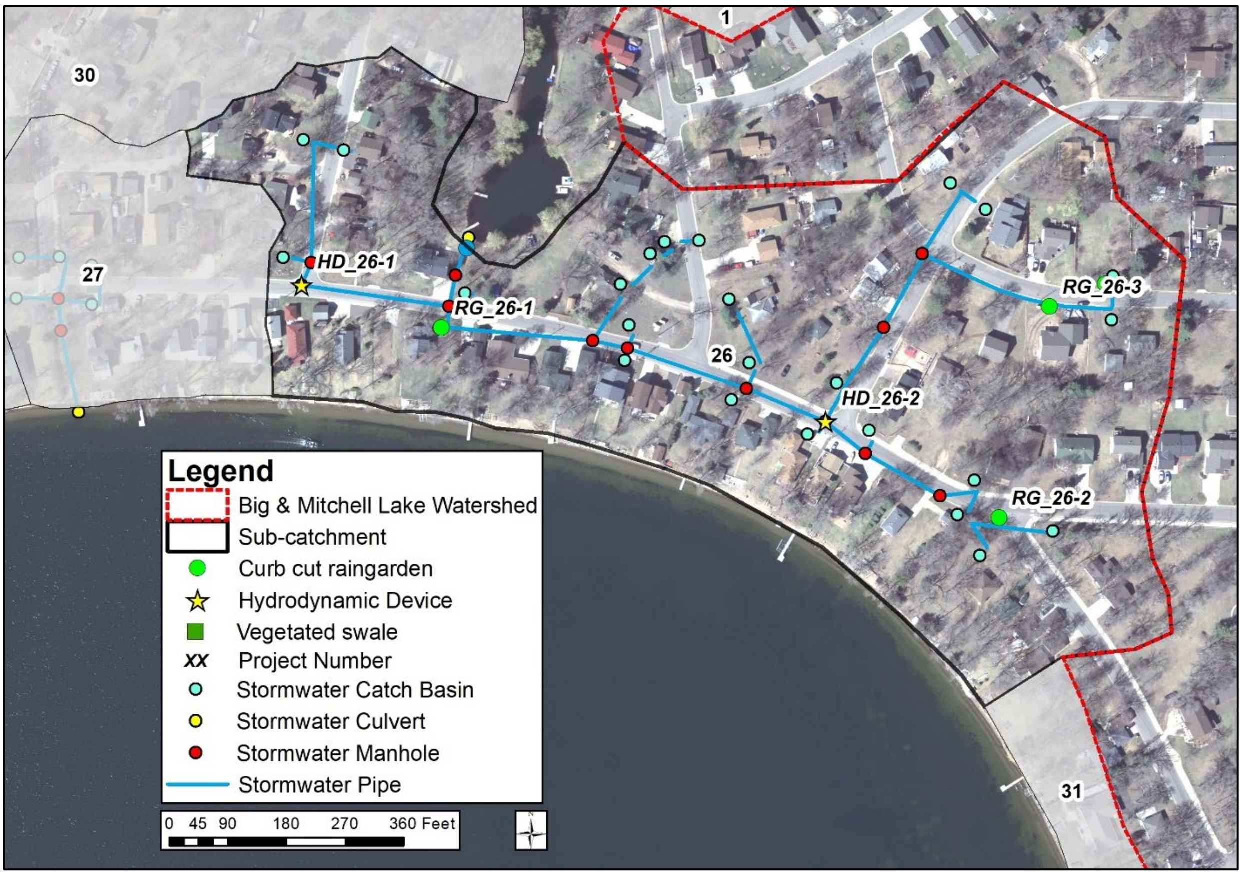
HD 25-1				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	6' dia Hydrodynamic Device		
	Catchment (ac)	2.56		
	Volume (cu-ft/yr)	175,039	187	0.1
	TP (lb/yr)	4.55	0.03	0.7
	TSS (lb/yr)	2076	14	0.7
Cost & Efficiency	Administration & Promotion	$1,752		
	Design & Construction	$27,000		
	Total Estimated Cost	$28,752		
	Annual O&M	$420		
	30-yr Avg Cost / lb-TP	$28,188		
	30-yr Avg Cost /1,000lb-TSS	$68,457		

HD 25-2				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	6' dia Hydrodynamic Device		
	Catchment (ac)	2.68		
	Volume (cu-ft/yr)	175,029	197	0.1
	TP (lb/yr)	4.55	0.03	0.7
	TSS (lb/yr)	2076	14	0.7
Cost & Efficiency	Administration & Promotion	$1,752		
	Design & Construction	$27,000		
	Total Estimated Cost	$28,752		
	Annual O&M	$420		
	30-yr Avg Cost / lb-TP	$28,188		
	30-yr Avg Cost /1,000lb-TSS	$68,457		

Sub-Catchment 26

Sub-catchment 26 Current	
Acres	18.14
Dominant Land Cover	Medium Density Urban
Existing BMPs	St Sweep, Catch Basin
Volume (cu-ft/yr)	310,393
TP (lb/yr)	8.24
TSS (lb/yr)	3794

This sub-catchment lies on the northeast side of Big Lake, along the base of an eastern peninsula that separates Big from Mitchell lake.. The area consists of low to moderate grade slopes and residential lots, with some riparian lots as well. The stormwater network drains to Lake Mitchell through an outlet that enters a small bay on the lake's south-southeastern side..



Treatment Calculations and Cost Analysis

As outlined in the tables below, several potential projects were identified for this sub-catchment, including rain garden installations and hydrodynamic devices. The tables that follow outline the project type, pollution parameters following installation of the project, the cost of the project and the cost per pound of pollutant reduction. Modeling results are independent of each other; that is, the reductions and costs are associated with each single project and do not reflect savings or additional pollutant reduction that would occur with multiple BMP installations.

Table 16: Sub-catchment 26 potential stormwater retrofit projects. Pollutant estimates based upon standard WinSLAMM parameters, costs based upon conservative estimates from The Center for Watershed Protection's Urban Subwatershed Restoration Manuals and local project experience.

RG 26-1				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	Number of BMPs	250 sqft Rain Garden		
	BMP	0.47		
	Volume (cu-ft/yr)	302,816	7,577	2.4
	TP (lb/yr)	8.03	0.22	2.6
	TSS (lb/yr)	3697	97	2.6
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$2,456		
	30-yr Avg Cost /1,000lb-TSS	$5,445		

RG 26-2				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	1.08		
	Volume (cu-ft/yr)	296,655	13,738	4.4
	TP (lb/yr)	7.85	0.39	4.7
	TSS (lb/yr)	3615	179	4.7
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$1,351		
	30-yr Avg Cost /1,000lb-TSS	$2,950		

RG 26-3				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	0.51		
	Volume (cu-ft/yr)	302,262	8,131	2.6
	TP (lb/yr)	8.01	0.23	2.8
	TSS (lb/yr)	3690	104	2.7
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$2,286		
	30-yr Avg Cost /1,000lb-TSS	$5,078		

RG 26-4				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	250 sqft Rain Garden		
	Catchment (ac)	0.38		
	Volume (cu-ft/yr)	304,102	6,291	2.0
	TP (lb/yr)	8.06	0.18	2.2
	TSS (lb/yr)	3714	80	2.1
Cost & Efficiency	Administration & Promotion	$8,468		
	Design & Construction	$7,376		
	Total Estimated Cost	$15,844		
	Annual O&M	$225		
	30-yr Avg Cost / lb-TP	$2,950		
	30-yr Avg Cost /1,000lb-TSS	$6,602		

HD 26-1				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	4' dia Hydrodynamic Device		
	Catchment (ac)	0.77		
	Volume (cu-ft/yr)	310,305	88	0.0
	TP (lb/yr)	8.19	0.05	0.6
	TSS (lb/yr)	3775	19	0.5
Cost & Efficiency	Administration & Promotion	$1,752		
	Design & Construction	$18,000		
	Total Estimated Cost	$19,752		
	Annual O&M	$420		
	30-yr Avg Cost / lb-TP	$12,662		
	30-yr Avg Cost /1,000lb-TSS	$34,653		

HD 26-2				
	Cost/Removal Analysis	New Treatment	Reduction	% Reduction
Treatment	BMP	6' dia Hydrodynamic Device		
	Catchment (ac)	2.74		
	Volume (cu-ft/yr)	310,268	125	0.0
	TP (lb/yr)	8.17	0.07	0.9
	TSS (lb/yr)	3767	27	0.7
Cost & Efficiency	Administration & Promotion	$1,752		
	Design & Construction	$27,000		
	Total Estimated Cost	$28,752		
	Annual O&M	$420		
	30-yr Avg Cost / lb-TP	$13,499		
	30-yr Avg Cost /1,000lb-TSS	$35,496		

Literature Cited

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

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

Appendix A: Modeling Methods.

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

WinSLAMM

Pollutant and volume reductions were estimated using the stormwater model Source Load and Management Model for Windows (WinSLAMM). WinSLAMM uses an abundance of stormwater data from the Upper-Midwest and elsewhere to quantify runoff volumes and pollutant loads from urban areas. It has detailed accounting of pollutant loading from various land uses and allows the user to build a model "landscape". WinSLAMM uses rainfall and temperature data from a typical year (1959 data from Minneapolis for this analysis), routing stormwater through the user's model for each storm. WinSLAMM version 10.2.0 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).

General WinSLAMM Model Inputs	
Parameter	***File or Method***
Land use acreage	ArcMap with 2015 Land Use
Precipitation / Temperature	Minneapolis 1959 (user preference, best approximates a typical year)
Winter Season	Included in model, 11-12 to 3-18
Pollutant probability distribution	WI_GE001.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
Street sweeping	2x annually

BMP model designs

The diagrams that follow represent the standard parameters defined for various BMPs used in the modeling process, including existing conditions as well as proposed BMPs.

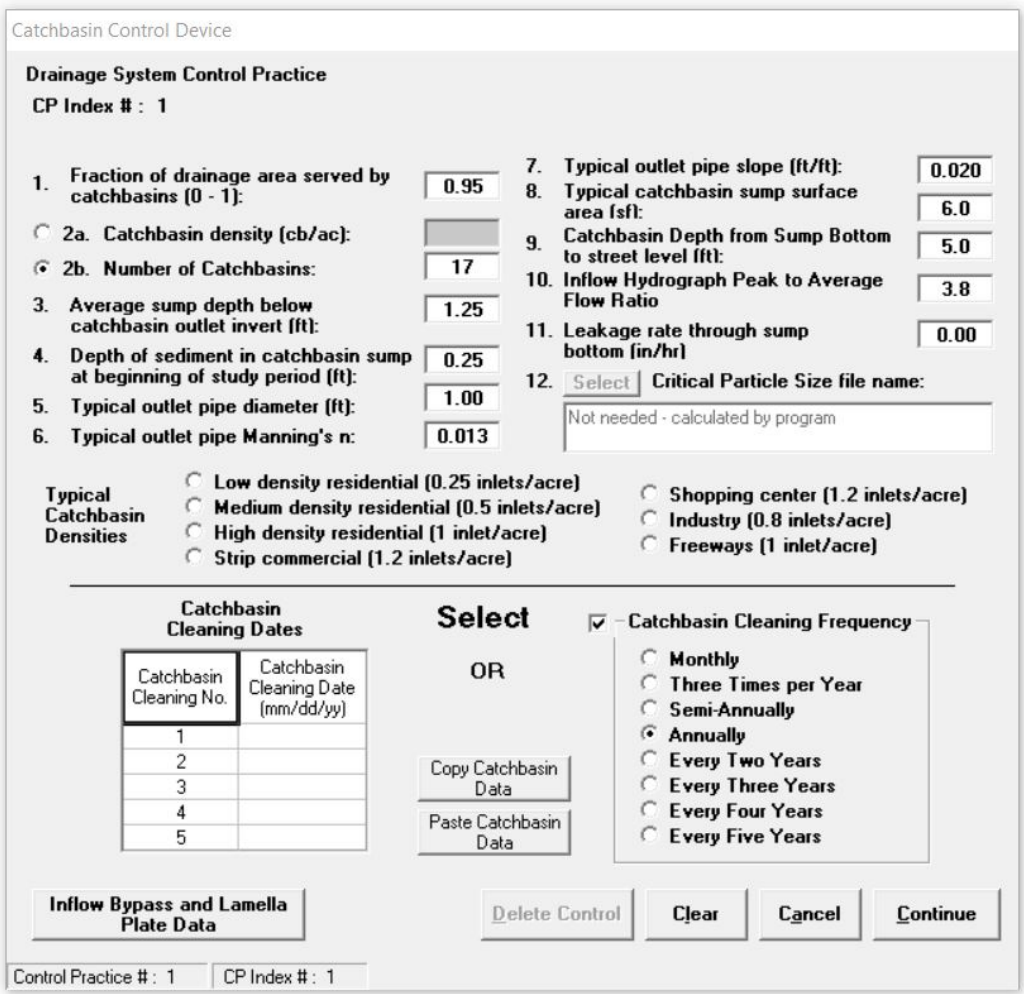


Figure 6: Catch Basin Device. Some model inputs are standard, some are site specific (e.g. Option 1 and 2 in the example above).

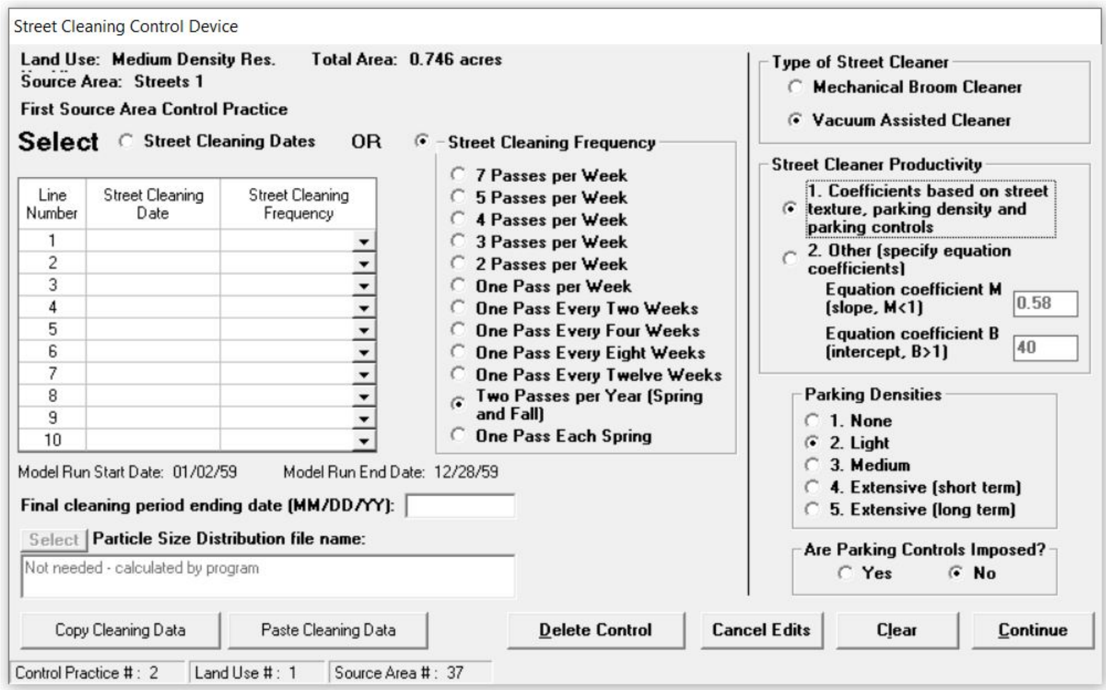


Figure 7: Street Sweeping. Some model inputs are standard, some are site specific (e.g. Parking Density in the example above).

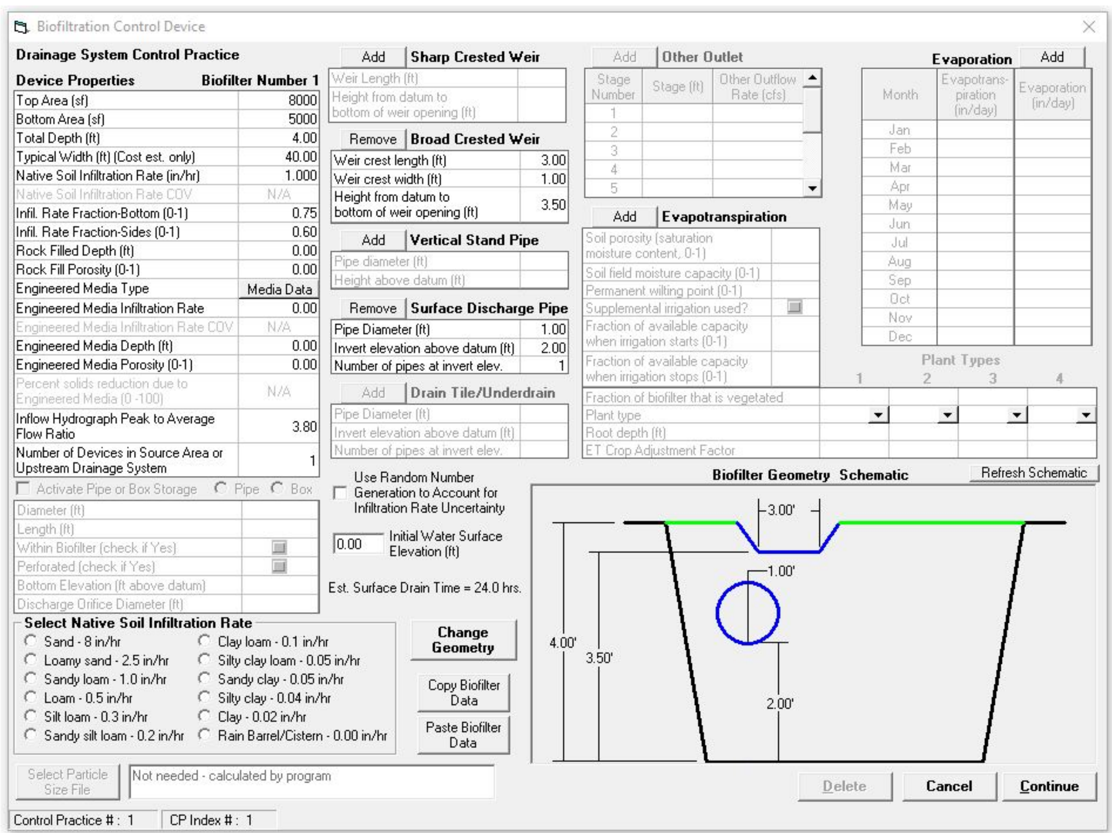


Figure 8: Biofiltration Control Device. Model inputs will vary depending on site specific conditions.

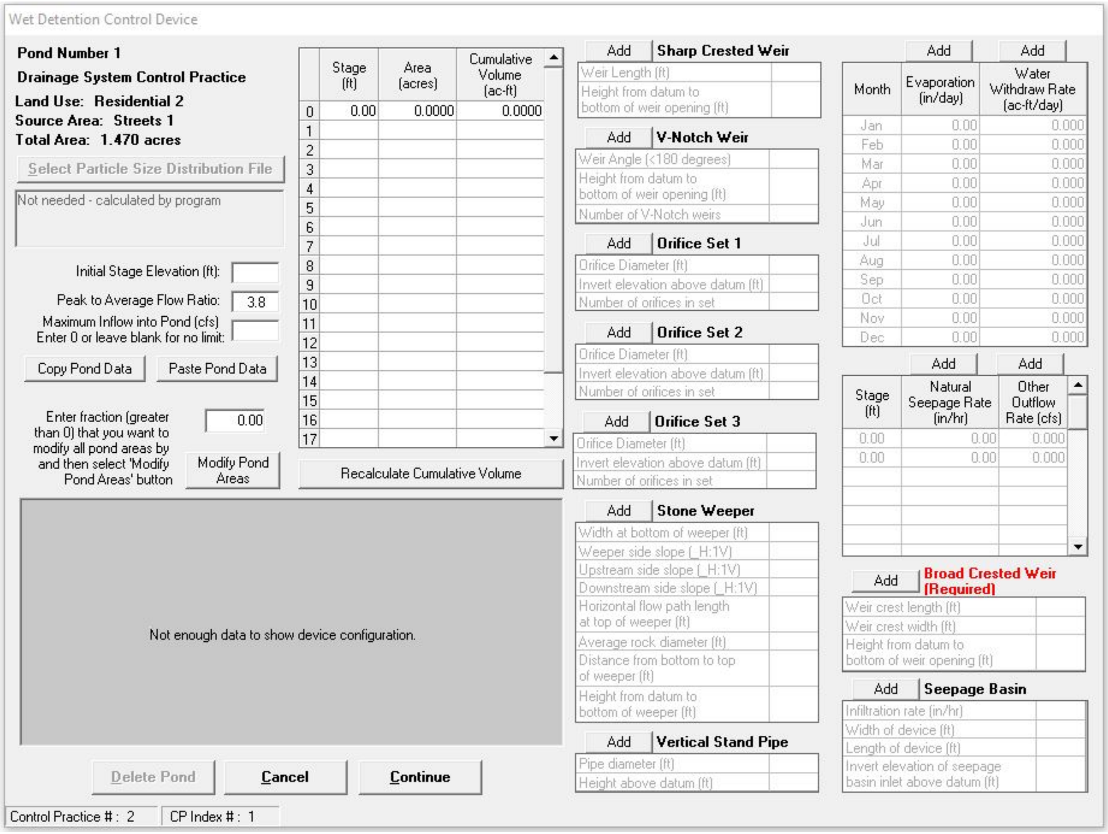


Figure 9: Wet Detention Control Device. Model inputs will vary depending on site specific conditions.

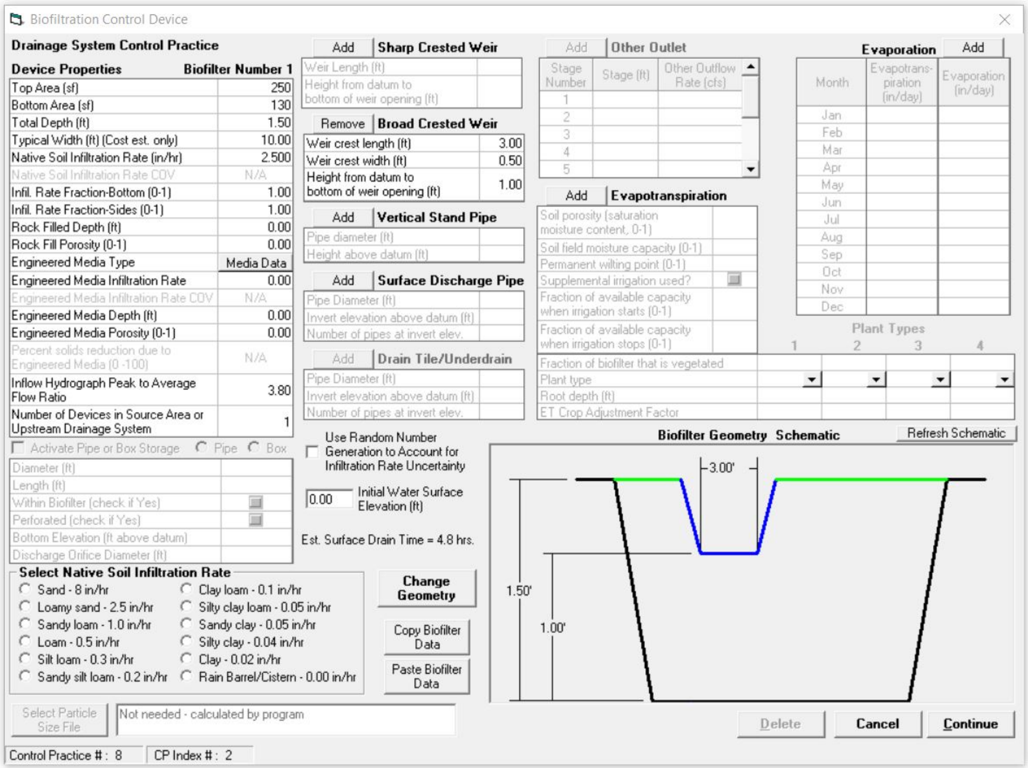


Figure 10: 250 sqft Rain Garden. Standard size used in most modeling applications.

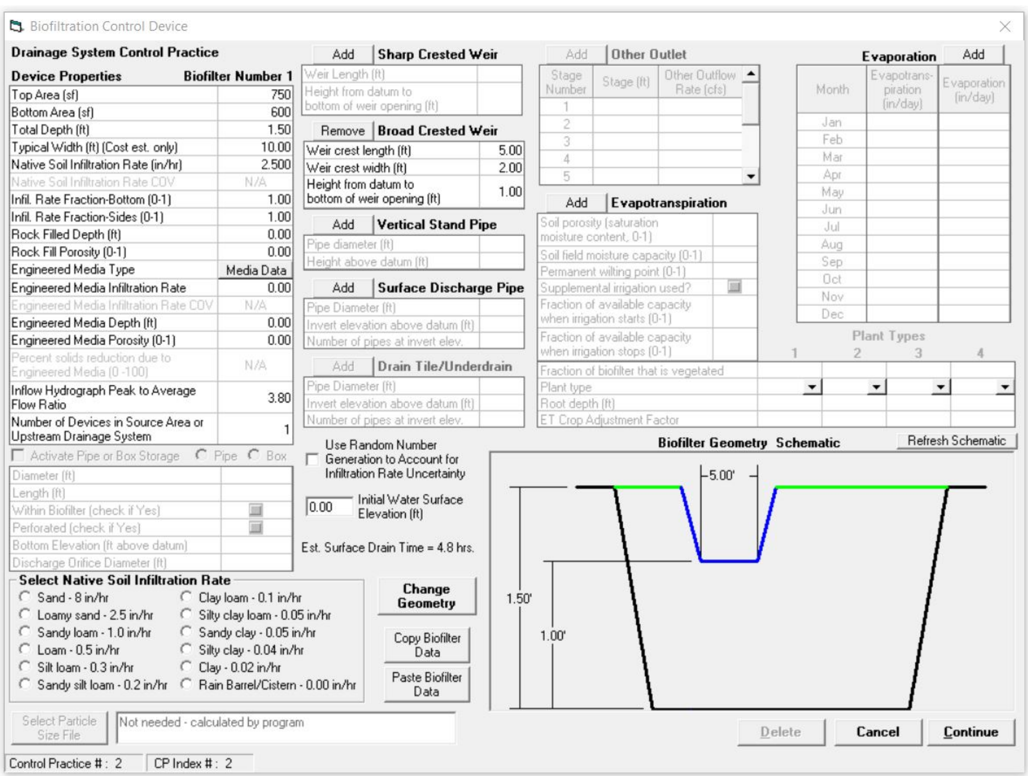


Figure 11: 750 sqft Rain Garden. Standard size used in several modeling scenarios.

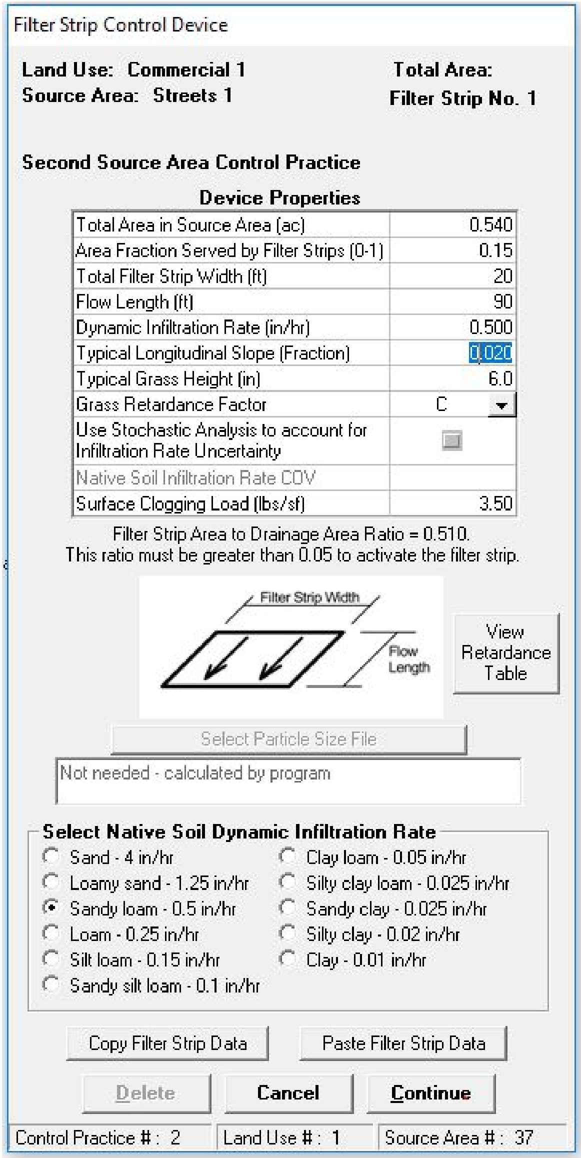


Figure 12: Filter strip. Some properties are standard, others customized given site-specific conditions.

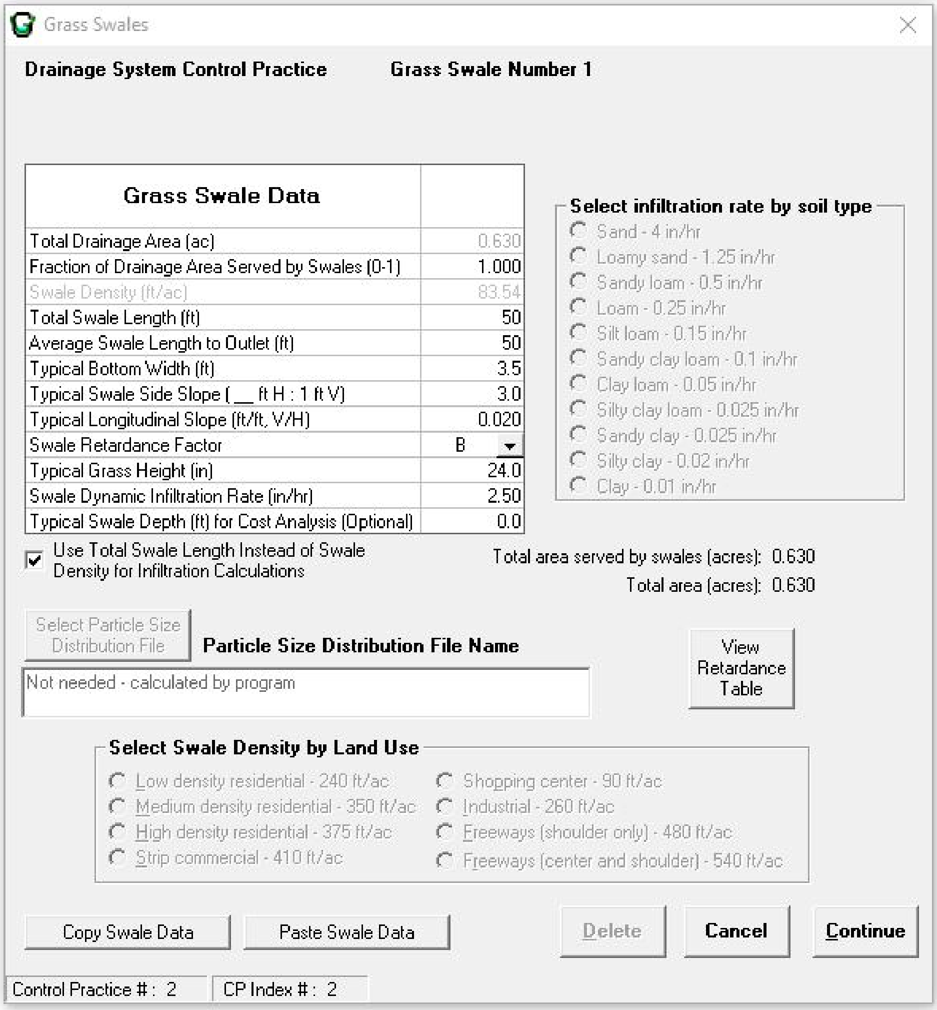


Figure 13: Vegetated Swale. Pictured is an example of a 50 ft swale.

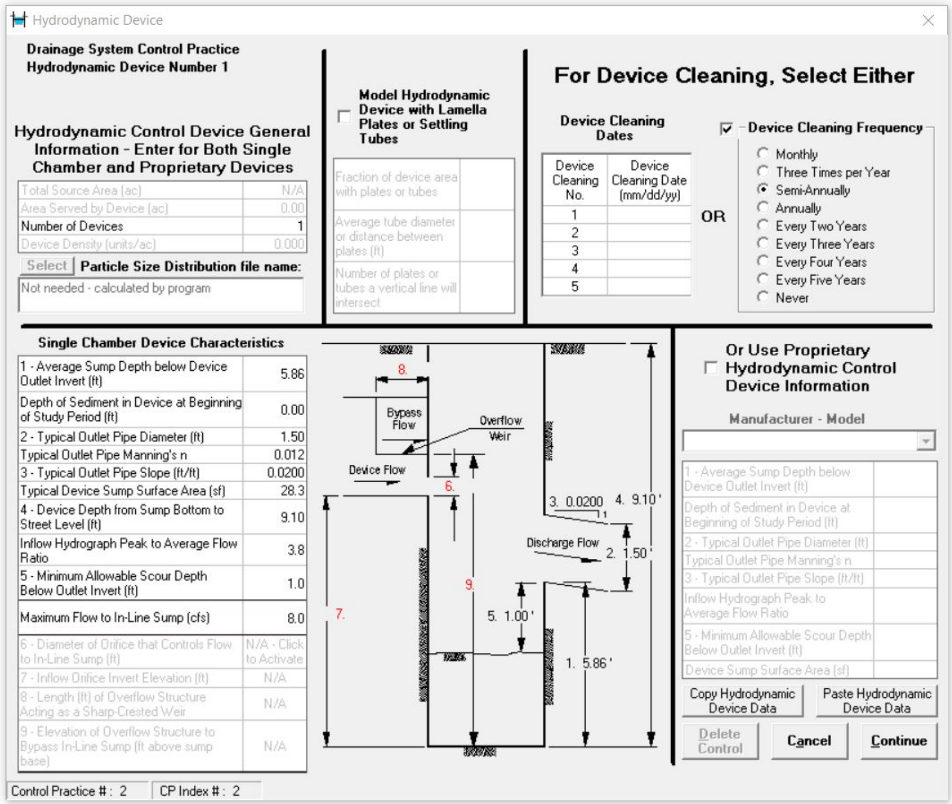


Figure 14: 4 ft Hydrodynamic Device.

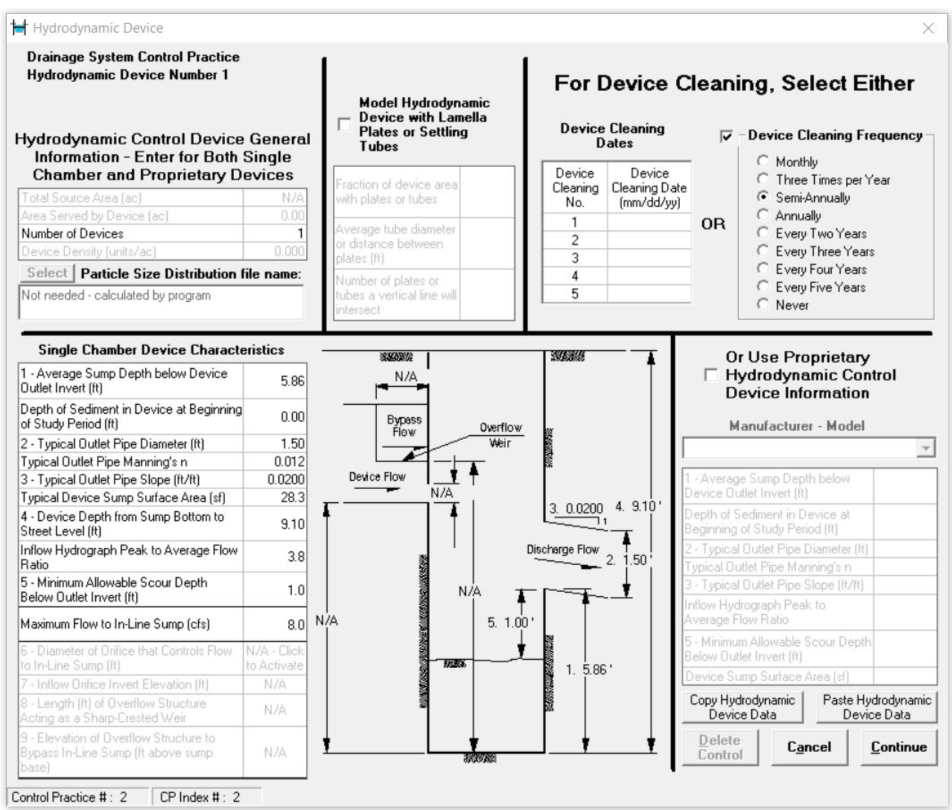


Figure 15: 6 ft Hydrodynamic Device.

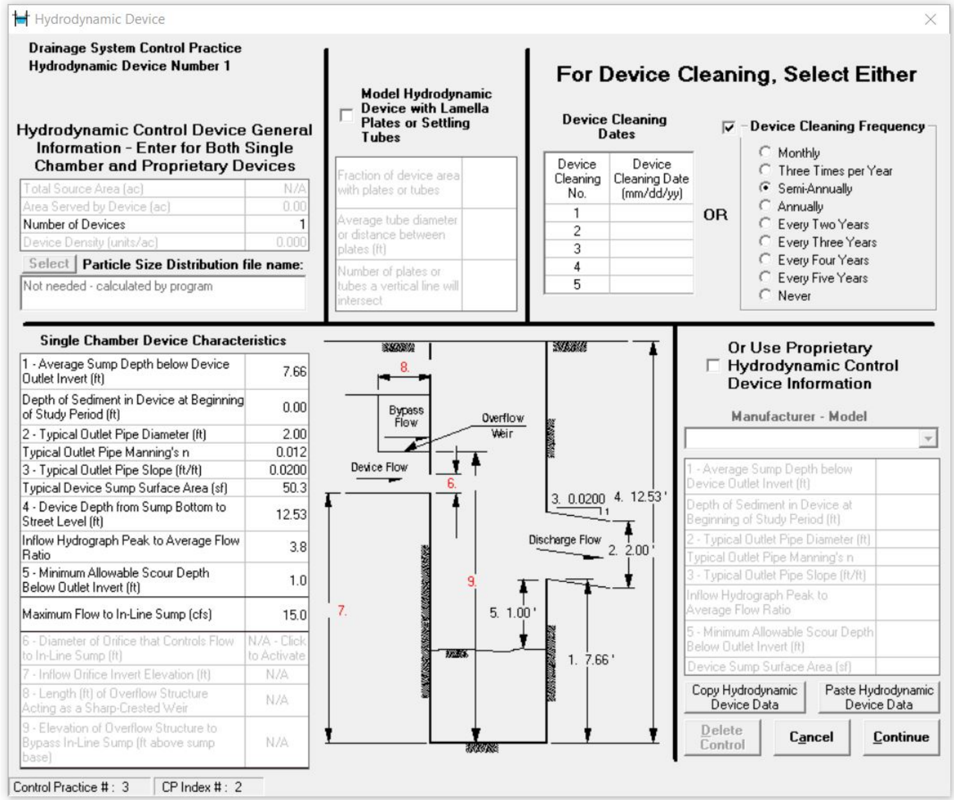


Figure 16: 8 ft Hydrodynamic Device.