Oak Glen Creek
Stormwater Retrofit Assessment

Prepared by:

ANOKA CONSERVATION DISTRICT

for the

CITY OF FRIDLEY

May 2012

Cover photo: Significant erosion along Oak Glen Creek immediately upstream of its confluence with the Mississippi River.

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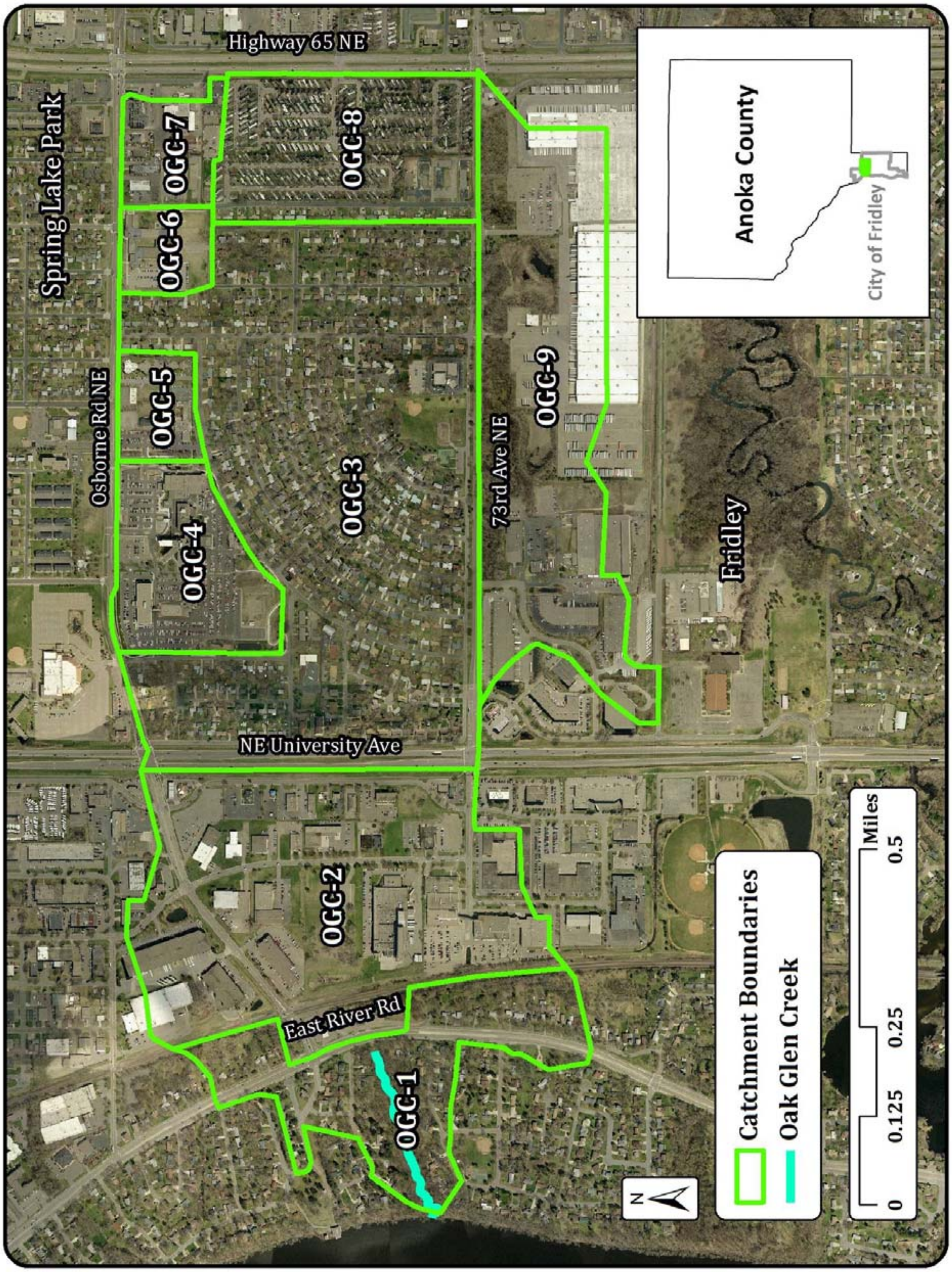


Map of stormwater catchment areas referred to in this report.

Executive Summary

This study provides recommendations for cost effectively improving treatment of stormwater from neighborhoods draining to Oak Glen Creek. Oak Glen Creek is located in the City of Fridley and ultimately drains to the Mississippi River. The watershed is 573 acres and consists of a mix of industrial, commercial, and residential land uses, all of which have significant amounts of impervious surfaces. Storm events and spring snowmelt generate excess water volume and pollutants that reach the creek via stormwater infrastructure. The fully developed nature of this watershed leaves little opportunity for large-scale stormwater treatment practices and makes it an ideal candidate for the subwatershed stormwater assessment process.

Oak Glen Creek is piped through stormwater infrastructure throughout most of the subwatershed. Only the last quarter mile stretch of creek is daylighted immediately upstream of its confluence with the Mississippi River. The small stretch of open channel may seem insignificant, yet its location in the Mississippi River Critical Corridor provides fish and wildlife habitat within an otherwise urban landscape. Significant erosion along this stretch of creek has resulted in a deteriorated corridor and bank destabilization to the point that landowner properties are threatened. In addition, the high volume of runoff that reaches the open section of creek transports excess sediments and pollutants into the creek and the Mississippi River. These issues underscore the importance of identifying upstream stormwater treatment practices that will address volume and pollutant loading.

This stormwater assessment systematically examines sources of volume and pollutants, investigates ways to improve stormwater treatment through “stormwater retrofitting,” and prioritizes opportunities by cost-effectiveness. Stormwater retrofitting refers to adding stormwater treatment to an already built-up area, where little open land exists. This process is investigative and creative. Stormwater retrofitting success is sometimes improperly judged by the number of projects installed or by comparing costs alone. Those approaches neglect to consider how much pollution is removed per dollar spent. In this stormwater assessment we estimated both costs and pollutant reductions, and used them to calculate cost effectiveness of each possible project.

We delineated the areas that drain to Oak Glen Creek through stormwater conveyances. Then, we divided those areas into nine smaller stormwater drainage areas, or “catchments.” For each catchment, we modeled stormwater volume and pollutants using the software WinSLAMM. First, we modeled base conditions, followed by existing conditions, which included existing stormwater treatment practices. Currently, the 573 acre area contributes an estimated 415 acre feet of runoff, 353 pounds of phosphorus and 147,519 pounds of total suspended solids to the creek each year. Then we modeled possible stormwater retrofits to estimate reductions in volume, total phosphorus (TP), and total suspended solids (TSS). Finally, we estimated the cost of each retrofit project, including 30-year lifespan and estimated operation and maintenance requirements. Projects were ranked by cost effectiveness with respect to total suspended solids reduction.

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

- Maintenance of, or alterations to, existing stormwater treatment practices,
- Residential curb-cut rain gardens,
- Parking lot rain gardens in commercial and industrial land uses,
- Permeable asphalt
- Impervious land cover disconnect, and
- Depavement.

If all of these practices were installed, significant pollution reduction could be accomplished. Admittedly, not all projects will be installed. Rather, they could be installed in order of cost effectiveness (pounds of pollution reduced per dollar spent).

This report provides conceptual sketches or photos of recommended stormwater retrofitting projects. The intent is to provide an understanding of the approach. If a project is selected, site-specific designs must be prepared. This typically occurs after committed partnerships are formed to install the project. Committed partnerships must include willing landowners when installed on private property.

It's noteworthy that any projects that benefit Oak Glen Creek will also benefit important downstream waterbodies. Oak Glen Creek discharges to the Mississippi River. Various reaches of the Mississippi River are impaired for *E. coli* bacteria, suspended solids, and phosphorus. For example, the Oak Glen Creek watershed is located within the "metroshed" identified in the South Metro Mississippi River TSS TMDL as a contributor to the impairment. Stormwater retrofitting in the Oak Glen Creek watershed will include practices that help alleviate these problems. In addition, this assessment was conducted immediately upstream of drinking water intakes for the Cities of Minneapolis and St. Paul, and therefore benefits their source water protection efforts.

The table on the next page summarizes potential projects. Potential projects are organized from most cost effective to least, based on cost per thousand pounds of total suspended solids removed. The benefits of each project were estimated as if that project was installed alone with no other projects upstream of it in the same catchment. Installation of projects in series will result in lower total treatment than the simple sum of treatment across the individual projects due to treatment train effects. Reported treatment levels are dependent upon optimal siting and sizing. More detail about each project can be found in the catchment profile pages of this report. Projects that were deemed unfeasible due to prohibitive size, number, or were too expensive to justify installation are not included in the table on the next page.

Catchments OGC-1 through OGC-9: Summary of preferred stormwater retrofit opportunities ranked by cost-effectiveness with respect to total suspended solids (TSS) reduction. Volume and total phosphorus (TP) reductions are also shown. For more information on each project refer to the catchment profile pages in this report.

Project Rank	Catchment ID	Retrofit Type (refer to catchment profile pages for additional detail)	Projects Identified	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Total Project Cost	Estimated Annual Operations & Maintenance (2012 Dollars)	Estimated cost/ lb-TP/year (30-year)	Estimated cost/ 1,000lb-TSS/year (30-year)
1	OGC-1	Creek Corridor Stabilization	1	6.3	633,600	0.0	$435,500	$2,217	$2,639	$26
2	OGC-2*	Existing Wet Detention Pond Excavation	1	55.8	32,631	0.0	$62,100 - $77,580	$5,406 - $7,986	$134 - $189	$229 - $324
3	OGC-6	School Parking Lot Disconnect	2	0.4	248	0.7	$950	$75	$267	$430
4	OGC-2*	Industrial Curb-cut Rain Garden Network	3	4.0	1,327	2.3	$17,700	$225	$204	$614
5	OGC-2*	Industrial Parking Lot Rain Garden	1	0.8	449	0.7	$7,020	$75	$386	$688
6	OGC-2*	Industrial Parking Lot Depavement	1	1.1	956	1.4	$17,696	$75	$604	$695
7	OGC-3	Residential Curb-cut Rain Garden Network	5 - 20	8.9 - 26.4	1,564 - 5,094	3.7 - 12.6	$28,380 - $108,480	$375 - $1,500	$148 - $194	$845 - $1,004
8	OGC-8	Industrial Parking Lot Rain Garden	1	0.8	326	0.6	$7,020	$75	$372	$948
9	OGC-1	Residential Curb-cut Rain Garden Network	3 - 9	4.8 - 10.4	856 - 2,117	2.1 - 5.3	$17,700 - $49,740	$225 - $675	$170 - $224	$952 - $1,102
10	OGC-7	Industrial Parking Lot Rain Garden	1	0.8	321	0.6	$7,020	$75	$401	$963
11	OGC-5	Office Park Parking Lot Rain Garden	1	0.9	363	0.8	$11,520	$75	$510	$1,264
12	OGC-2*	Existing Wet Detention Pond Expansion	1	38.8	22,736	0.0	$750,220	$10,593	$918	$1,566
13	OGC-5	Hospital and High-rise Residential Parking Lot Rain Garden	1	0.5-0.6	245 - 328	0.7 - 0.9	$11,520 - $20,520	$75	$918 - $1,265	$1,873 - $2,314
14	OGC-5	High-rise Residential Parking Lot Rain Garden	1	0.6	163	0.5	$7,020	$75	$515	$1,896
15	OGC-6	School Parking Lot Rain Garden	1	0.3	139	0.4	$7,020	$75	$1,030	$2,223
16	OGC-2	Industrial Parking Lot Permeable Asphalt	1	3.1	2,692	3.9	$307,370	$701	$3,531	$4,066
17	OGC-4	Hospital Parking Lot Permeable Asphalt	1	1.7	865	4.2	$329,150	$751	$6,896	$13,553

* Pollution reduction benefits and costs can not be summed with other projects in the same catchment because they are alternative options for treating the same source area.

About this Document

This Stormwater Retrofit Assessment is a watershed management tool to help prioritize stormwater retrofit projects by performance and cost effectiveness. This process helps maximize the value of each dollar spent.

Document Organization

This document is organized into three major sections, plus references and appendices. Each section is briefly described below.

Methods

The methods section outlines general procedures used when assessing the subwatershed. It overviews the processes of retrofit scoping, desktop analysis, retrofit reconnaissance investigation, cost/treatment analysis, and project ranking.

Catchment Profiles

The Oak Glen Creek subwatershed was divided into stormwater catchments for the purpose of this assessment. Each catchment was given a unique ID number. For each catchment, the following information is detailed:

Catchment Description

Within each catchment profile is a table that summarizes basic catchment information including acres, land cover, parcels, and estimated annual pollutant and volume loads. A brief description of the land cover, stormwater infrastructure, and any other important general information is also described here. Existing stormwater practices are noted, and their estimated effectiveness presented.

Retrofit Recommendations

The recommendation section describes the conceptual retrofit(s) that were scrutinized. It includes tables outlining the estimated pollutant removals by each, as well as costs. A map provides promising locations for each retrofit approach.

Retrofit Ranking

This section ranks stormwater retrofit projects across all catchments to create a prioritized project list. The list is sorted by cost per thousand pounds of total suspended solids removed for each project over 30 years. The final cost per pound treatment value includes installation and maintenance costs.

There are many possible ways to prioritize projects, and the list provided in this report is merely a starting point. Other considerations for prioritizing installation may include:

- Non-target pollutant reductions
- Timing projects to occur with other road or utility work
- Impacts to drinking water supply (see Appendix D for DWSMA and WPA map)
- Project visibility
- Availability of funding
- Total project costs
- Educational value

References

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

Appendices

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

Methods

Selection of Subwatershed

Many factors are considered when choosing which subwatershed to assess 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. Assessments supported by a Local Government Unit with sufficient capacity (staff, funding, available GIS data, etc.) to greater facilitate the assessment also rank highly. For some communities a stormwater assessment complements their MS4 stormwater permit. The focus is always on a high priority waterbody.

For this assessment, neighborhoods which drain to Oak Glen Creek were chosen for study. Oak Glen Creek is a high priority because of its value as a wildlife corridor in an otherwise urbanized landscape and its connection to the Mississippi River, which has various reaches impaired for *E. coli* bacteria, suspended solids, and phosphorus. Therefore, retrofits within the Oak Glen Creek subwatershed will also benefit the Mississippi River. The communities in the watershed, the City of Fridley, and the Anoka Conservation District are committed and equipped to improve stormwater management.

Stormwater runoff from impervious surfaces like pavement and roofs can carry a variety of pollutants. While stormwater treatment to remove these pollutants is adequate in some areas, other areas were built before modern-day stormwater treatment technologies and requirements or have undersized treatment devices.

Subwatershed Assessment Methods

The process used for this assessment is outlined below and was modified from the Center for Watershed Protection's *Urban Stormwater Retrofit Practices,* Manuals 2 and 3 (Schueler, 2005, 2007). Locally relevant design considerations were also incorporated into the process (*Minnesota Stormwater Manual*).

Step 1: Retrofit Scoping

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

In this assessment, the focus area was all areas that drain to Oak Glen Creek through stormwater conveyances. We divided this area into nine catchments using a combination of stormwater infrastructure maps, observed topography, and land cover type. In areas where topography seemed flat, catchments were delineated by observing the direction of water flow during rainfall.

The target pollutant for this study was total suspended solids, which was chosen because the Mississippi River exceeds state water quality standards for this parameter. In addition, total suspended solids contribute to water turbidity and increased transport of other pollutants, such as heavy metals. The Oak Glen Creek watershed is located within the “metroshed” identified in the South Metro Mississippi River TSS TMDL as a contributor to the impairment. Stormwater retrofitting in the Oak Glen Creek watershed will include practices that help alleviate these problems. Furthermore, other stretches of the Mississippi River are also impaired for total phosphorus. Therefore, total phosphorus reductions from the identified retrofits are presented in this assessment.

Volume of stormwater was tracked throughout this study because volume reductions will benefit the erosion and corridor destabilization issues in the daylighted section of the creek. Volume is necessary for pollutant loading calculations and potential retrofit project considerations. This assessment was also conducted immediately upstream of drinking water intakes for the Cities of Minneapolis and St. Paul, and therefore benefits their source water protection efforts.

Step 2: Desktop Retrofit Analysis

The desktop analysis involves computer-based scanning of the subwatershed for potential retrofit catchments and/or specific sites. This step also identifies areas that don’t need to be assessed because of existing stormwater infrastructure. 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, hydrology, soils, watershed/subwatershed boundaries, parcel boundaries, high-resolution aerial photography and the stormwater drainage infrastructure (with invert elevations).

Desktop retrofit analysis features to look for and potential stormwater retrofit projects.

Feature	Potential Retrofit Project
Existing Ponds	**Add storage and/or improve water quality by excavating pond bottom, modifying riser, raising embankment, and/or modifying flow routing.**
Open Space	**New regional treatment (pond, bioretention).**
Roadway Culverts	**Add wetland or extended detention water quality treatment upstream.**
Outfalls	**Split flows or add storage below outfalls if open space is available.**
Conveyance system	**Add or improve performance of existing swales, ditches and non-perennial streams.**
Large Impervious Areas	**Stormwater treatment on site or in nearby open spaces.**
Neighborhoods	**Utilize right of way, roadside ditches, curb-cut rain gardens, or filter systems before water enters storm drain network.**

Step 3: Retrofit Reconnaissance Investigation

After identifying potential retrofit sites through this desktop search, a field investigation was conducted to evaluate each site and identify additional opportunities. During the investigation, the drainage area and 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.

General list of stormwater BMPs considered for each catchment/site.

Stormwater Treatment Options for Retrofitting		
Area Treated	**Best Management Practice**	**Potential Retrofit Project**
5-500 acres	Extended Detention	**12-24 hr detention of stormwater with portions drying out between events (preferred over wet ponds). May include multiple cell design, infiltration benches, sand/peat/iron filter outlets and modified choker outlet features.**
	Wet Ponds	**Permanent pool of standing water with new water displacing pooled water from previous event.**
	Wetlands	**Depression less than 1-meter deep and designed to emulate wetland ecological functions. Residence times of several days to weeks. Best constructed off-line with low-flow bypass.**
0.1-5 acres	Bioretention	**Use of native soil, soil microbe and plant processes to treat, evapotranspirate, and/or infiltrate stormwater runoff. Facilities can either be fully infiltrating, fully filtering or a combination thereof.**
	Filtering	**Filter runoff through engineered media and pass it through an under-drain. May consist of a combination of sand, soil, compost, peat, and iron.**
	Infiltration	**A trench or sump that is rock-filled with no outlet that receives runoff. Stormwater is passed through a conveyance and pretreatment system before entering infiltration area.**
	Swales	**A series of vegetated, open channel practices that can be designed to filter and/or infiltrate runoff.**
	Other	**On-site, source-disconnect practices such as rain-leader disconnect rain gardens, rain barrels, green roofs, cisterns, stormwater planters, dry wells, or permeable pavements.**

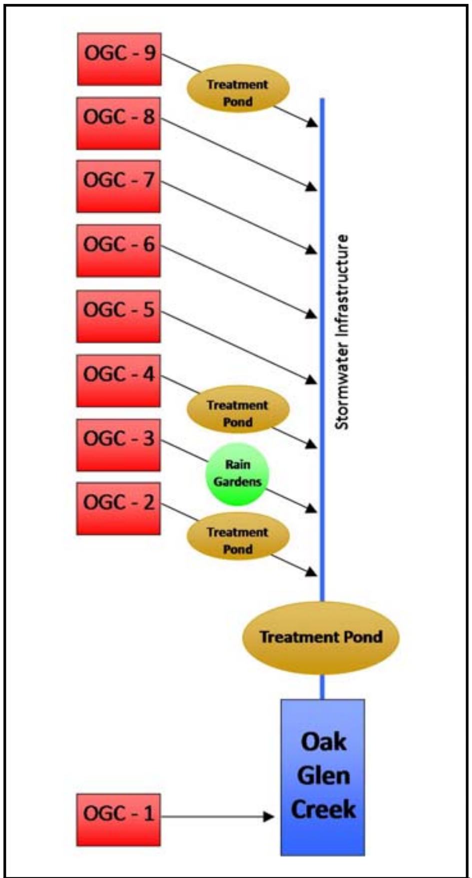
Step 4: Treatment Analysis/Cost Estimates

Sites most likely to be conducive to addressing the cities' goals and appear to have simple-to-moderate design, installation, and maintenance were chosen for a cost/benefit analysis. Estimated costs included design, installation, and maintenance annualized across a 30-year period. Estimated benefits included are pounds of phosphorus and total suspended solids removed, though projects were ranked only by cost per thousand pounds of total suspended solids removed annually.

Treatment analysis

Each proposed project's pollutant removals were estimated using the stormwater model 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 is useful for determining the effectiveness of proposed stormwater control practices. It has detailed accounting of pollutant loading from various land uses, and allows the user to build a model "landscape" that reflects the actual landscape being considered. The user is allowed to place a variety of stormwater treatment practices that treat water from various parts of this landscape. It uses rainfall and temperature data from a typical year, routing stormwater through the user's model for each storm.

The image to the right displays a simplified flow network for all catchments analyzed in this assessment. Catchment OGC-1 represents the area immediately surrounding the daylighted stretch of Oak Glen Creek, and therefore runoff from this catchment enters the creek directly. In contrast, catchments OGC-2 through OGC-9 are predominantly carried to Oak Glen Creek via existing stormwater infrastructure. The treatment pond immediately upstream of the daylighted section of Oak Glen Creek provides treatment for catchments OGC-2 through OGC-9. In addition, several other smaller best management practices (ponds and rain gardens) exist throughout the subwatershed and provide treatment at the catchment level. The effectiveness of each existing stormwater treatment practice is detailed within the catchment profiles section of this report.

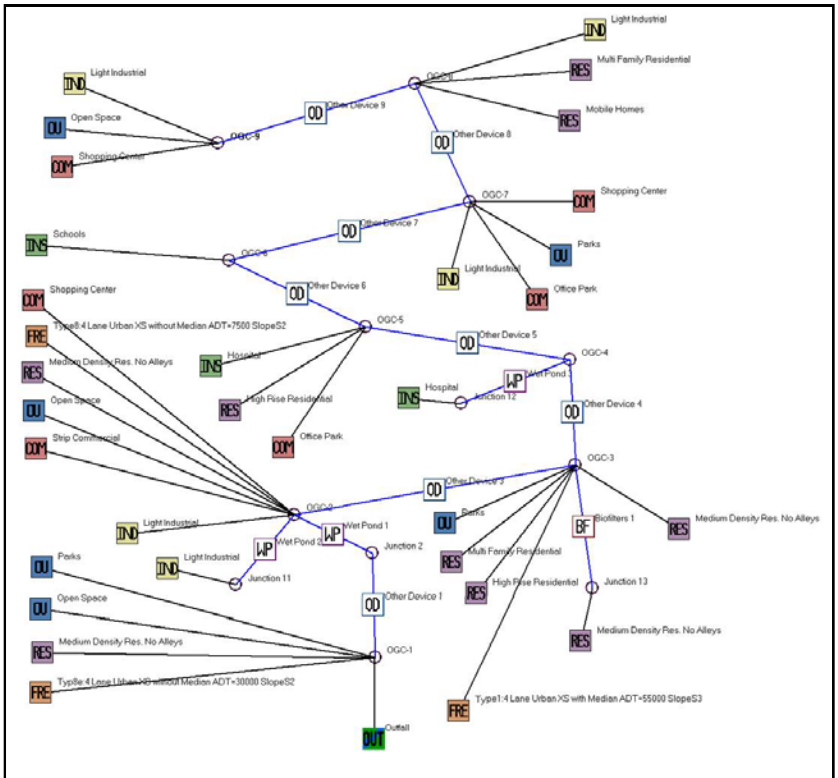


Simplified representation of existing water flow and stormwater treatment within the Oak Glen Creek subwatershed.

The newest version of WinSLAMM (version 10), which allows routing of multiple catchments and stormwater treatment practices, was used for this assessment because of the unique connectivity amongst the catchments identified in the focus area under investigation. Stormwater infrastructure routes stormwater runoff from catchments OGC-2 through OGC-9 into the treatment pond upstream of the daylighted section of Oak Glen Creek. Therefore, volume and pollutant loads to Oak Glen Creek from any of these catchments must take into consideration the treatment pond's effectiveness. The screen shot on the next page displays the WinSLAMM network used to model the existing conditions within the Oak Glen Creek subwatershed.

The initial step was to create a "base" model which estimated 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, catchments were delineated using geographic information systems (specifically, ArcMap). Each catchment was assigned a WinSLAMM standard land use file based on land cover information developed by the Metropolitan Council. A site specific land use file was created by adjusting total acreage and accounting for local soil types. This process resulted in a model that included estimates of the acreage of each type of source area (roof, road, lawn, etc.) in each catchment. For certain source areas critical to the models, estimates were verified to be accurate by calculating total acreages in ArcMap, and adjusting the model acreages if necessary.

Once the "base" model was established, an "existing conditions" model was created by incorporating existing stormwater treatment practices in each catchment. For example, street cleaning with mechanical or vacuum assisted street sweepers, rain gardens, underground sumps, stormwater treatment ponds, and others were included in the "existing conditions" model if they were present in the catchment.



WinSLAMM modeling network of the Oak Glen Creek subwatershed that represents existing conditions. Each colored square connected to a junction circle via a line represents a land cover type within a catchment (e.g. RES = residential, OU = other urban, COM = commercial, INS = institutional, IND = industrial, and FRE = freeway). All land cover types that collectively meet at a junction represent all land covers within a particular catchment. Catchments are labeled at the junction circle (e.g. OGC-2). All water from catchments OGC-2 through OGC-9 is routed through "Wet Pond 1" prior to discharge into the daylighted section of Oak Glen Creek. This pond is located within catchment OGC-2 east of the railroad tracks and south of Osborne Rd. NE.

Finally, each proposed stormwater treatment practice was added to the "existing conditions" model and pollutant reductions were generated. 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 we modeled each practice individually, and the benefits of projects may not be additive, especially if serving the same area. Reported treatment levels are dependent upon optimal site selection and sizing.

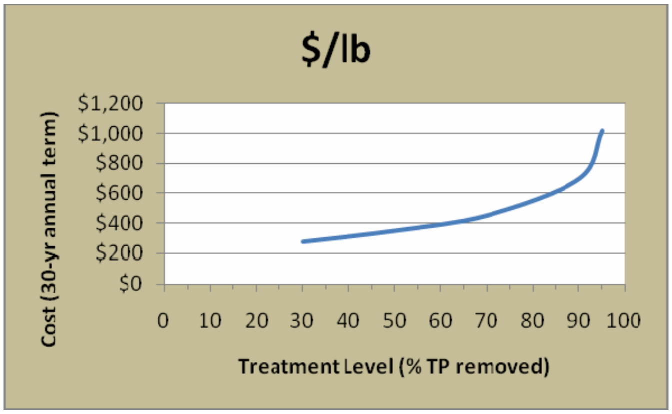
WinSLAMM stormwater computer model inputs

WinSLAMM version 10 Model Inputs	
Parameter	**File/Method**
Land use acreage	ArcMap
Rain file	Minneapolis 1959 – the year that best approximates a typical year
Winter season	Included in model; Winter dates are 11-4 to 3-13
Pollutant probability distribution file	WI_GEO01.ppdx
Runoff coefficient file	WI_SL06 Dec06.rsv
Particulate solids concentration file	WI_AVG01.pscx
Particle size distribution file	NURP.cpz
Street delivery files	WI files for each land use (.std)

Cost Estimates

Cost estimates were annualized costs that incorporated design, installation, installation oversight, and maintenance over a 30-year period, using 2012 dollars. 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 assessment, and therefore cost estimates account for only general site considerations.

The costs associated with several different pollution reduction levels were calculated. Generally, more or larger practices result in greater pollution removal. However the costs of obtaining the highest levels of treatment are often prohibitively expensive (see figure). By comparing costs of different treatment levels, the city can best choose the project sizing that meets their goals.



Step 5: Evaluation and Ranking

The cost per thousand pounds of total suspended solids treated was calculated for each potential retrofit project. Only projects that seemed realistic and feasible were considered. The recommended level was the level of treatment that would yield the greatest benefit per dollar spent while being considered feasible and not falling below a minimal amount needed to justify crew mobilization and outreach efforts. Local officials may wish to revise the recommended level based on water quality goals, finances, or public opinion.

Catchment Profiles and How to Read Them

The following pages are the "Catchment Profiles." These profiles provide the most important details of this report, including:

- Summary of existing conditions, including existing stormwater infrastructure, and estimated pollutant export to Oak Glen Creek
- Map of the catchment
- Recommended stormwater retrofits, pollutant reductions, and costs.

Following all of the catchment profiles is a summary table that ranks all projects in all catchments by cost effectiveness.

To save space and avoid being repetitive, explanations of the catchment profiles are provided below. We strongly recommend reviewing this section before moving forward in the report.

The analyses of each catchment are broken into "base, existing, and proposed" conditions. They are defined as follows:

Base conditions -	Volume and pollutant loadings from the catchment landscape without any stormwater practices.
Existing conditions -	Volume and pollutant loadings after already-existing stormwater practices are taken into account.
Proposed conditions -	Volume and pollutant loadings after proposed stormwater retrofits.

Many analyses for this assessment were performed at two geographic scales, "catchment and network." They are defined as follows:

Catchment level analyses -	See Appendix C for these analyses. Volume and pollutant loads exiting the catchment at the catchment boundary. There may be other stormwater practices existing or proposed farther downstream, but this analysis ignores them.
Network level analyses -	Volume and pollutant loads that reach Oak Glen Creek through the entire network. These will be much larger numbers than loadings from any one catchment because it is the sum of multiple catchments that discharge at the same point into the creek, and might receive treatment from the same practice. This analysis takes into account stormwater treatment ponds that are in-line with the stormwater infrastructure and upstream of Oak Glen Creek. Most notably, there is a network wet detention pond that treats all water from catchments OGC-2 through OGC-9 just before it enters the daylighted section of Oak Glen Creek. The network level analysis includes catchments OGC-1 through OGC-9.

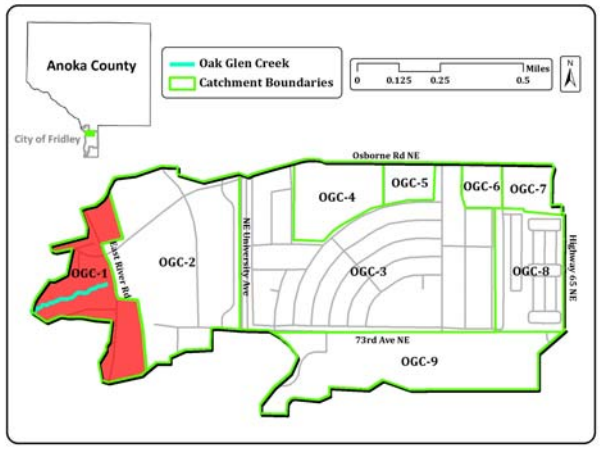
The pollutant load reduction for a proposed stormwater retrofit will often be greater at the catchment level than at the network level. This is because there is a stormwater pond that treats water from most catchments just before it enters the daylighted section of Oak Glen Creek. For example, a proposed project may capture 1,000 pounds of total suspended solids at the catchment level, but that doesn't necessarily mean 1,000 fewer pounds of total suspended solids will reach the creek because some of that was already being removed by the network wet detention pond. Benefits of a proposed project must be judged by their pollutant reductions and cost effectiveness at the network level.

The example catchment profile on the following pages explains important features within each profile.

HOW TO READ THE CATCHMENT PROFILES

EXAMPLE Catchment A

Existing Catchment Summary	
Acres	51.28
Dominant Land Cover	Residential
Parcels	237
Volume (acre-feet/yr)	18.37
TP (lb/yr)	25.00
TSS (lb/yr)	6,461.00



DESCRIPTION

Example Catchment is primarily comprised of medium-density, single-family residential land use…

EXISTING STORMWATER TREATMENT

Existing stormwater treatment practices within Example Catchment consist of street cleaning with a mechanical sweeper in the spring and fall and a network of stormwater treatment ponds…

Volume and pollutants generated from this catchment under existing conditions and excludes existing network-wide treatment practices.

Catchment ID banner.

Catchment locator map.

HOW TO READ THE CATCHMENT PROFILES

Catchment-level analysis of existing conditions.

Catchment Specific Existing Conditions

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	25.2	0.2	1%	**25.0**
	TSS (lb/yr)	7,186	725.0	10%	**6,461**
	Volume (acre-feet/yr)	18.4	0.0	0%	**18.4**
	Number of BMP's	1			
	BMP Size/Description	Street cleaning			

Volume of water and pounds of pollutants generated from the catchment without any stormwater management practices (base conditions).

Pollutants and volume removed by existing stormwater management practices.

Percent reductions by existing practices.

Pollutants and volume exiting the catchment after existing stormwater management practices.

Network-level analysis of existing conditions.

Network-Wide Existing Conditions (OGC-2 through OGC-9)

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	623.7	313.0	50%	**310.7**
	TSS (lb/yr)	216,101	124,172.0	57%	**91,929**
	Volume (acre-feet/yr)	494.5	0.0	0%	**494.5**
	Number of BMP's	All BMPs in catchments OGC-1 through OGC-9			
	BMP Size/Description	Street cleaning, rain gardens, and wet detention ponds			

Same definitions as above, except here the numbers refer to pollutants and volumes exiting catchments OGC-1 through OGC-9 in the network collectively. The existing practices include street cleaning, rain gardens, and stormwater ponds that treat water from multiple catchments, including the network wet detention pond just before Oak Glen Creek is daylighted.

HOW TO READ THE CATCHMENT PROFILES

Map shows catchment boundaries, stormwater infrastructure, and the locations of proposed stormwater retrofits.

RETROFIT RECOMMENDATIONS

Proposed stormwater retrofits. The project ID number (3 in this case) corresponds to this project's ranking study-wide. This project was the third most cost effective project at total suspended solids removal identified in this study.

<u>***Project ID #3 –*** Curb-Cut Rain Garden Network</u>
Drainage Area – 33.7 acres
Location – 5 locations throughout residential area
Property Ownership – Private
Description – The residential land cover within this catchment is best suited to residential, curb-cut rain gardens (see Appendix A for design options). Seven optimal rain garden locations were identified (see map above). Generally, ideal curb-cut rain garden locations are immediately up-gradient of a catch basin serving a large drainage area. Considering typical land owner participation rates we analyzed a scenario where 5 rain gardens were installed in catchment OGC-3. Volume and pollutant reductions resulting from the rain garden installations are highlighted in the table below.

EXAMPLE Conceptual and example images –


Before rain


During rain

HOW TO READ THE CATCHMENT PROFILES

EXAMPLE Network Wide Cost/Benefit Analysis (OGC-1 through OGC-9)

Volume or pollutant removal this project will achieve.

The project's rank (3) is shown again and three "levels" of this project are compared: 6, 9, or 12 rain gardens, for example.

Cumulative pollutant removal achieved by this project and already-existing practices.

	Cost/Benefit Analysis	Project ID					
		3 6 Rain Gardens		3 9 Rain Gardens		3 12 Rain Gardens	
		New trtmt	Net trtmt %	New trtmt	Net trtmt %	New trtmt	Net trtmt %
Treatment	TP (lb/yr)	5.4	39%	6.8	43%	7.7	46%
	TSS (lb/yr)	1,684	41%	2,127	45%	2,408	48%
	Volume (acre-feet/yr)	4.2	33%	5.4	38%	6.1	41%
	Number of BMP's	6		9		12	
	BMP Size/Description	1,500 sq ft		2,250 sq ft		3,000 sq ft	
	BMP Type	Complex Bioretention		Complex Bioretention		Complex Bioretention	
Cost	Materials/Labor/Design	$27,210		$40,710		$54,210	
	Promotion & Admin Costs	$2,450		$2,870		$3,290	
	Total Project Cost	$29,660		$43,580		$57,500	
	Annual O&M	$450		$675		$900	
	Term Cost/lb-TP/yr	$266		$313		$364	
	Term Cost/1,000lb-TSS/yr	**$855**		**$1,000**		**$1,170**	

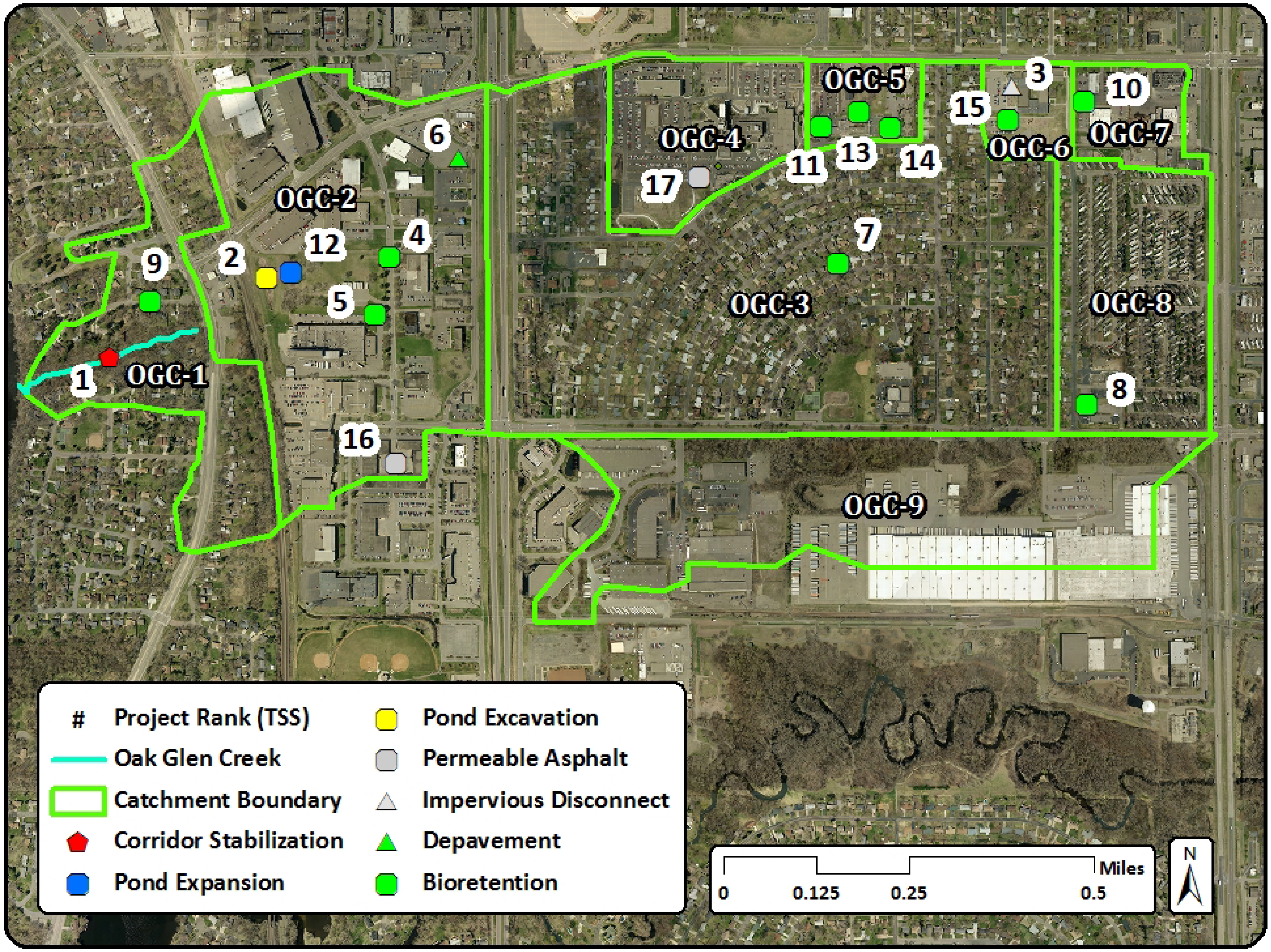
Project installation cost estimation.

Cost effectiveness at phosphorus removal. The project cost is divided by phosphorus removal in pounds (30 yrs). Includes operations and maintenance over the project life (30 years unless otherwise noted).

Cost effectiveness at suspended solids removal. The project cost is divided by suspended solids removal in pounds (30 yrs). Includes operations and maintenance over the project life (30 years unless otherwise noted).

Compare cost effectiveness of various project "levels" in these rows for TP (2nd row from bottom) or TSS (bottom row) removal. Compare cost effectiveness numbers between projects to determine the best value.

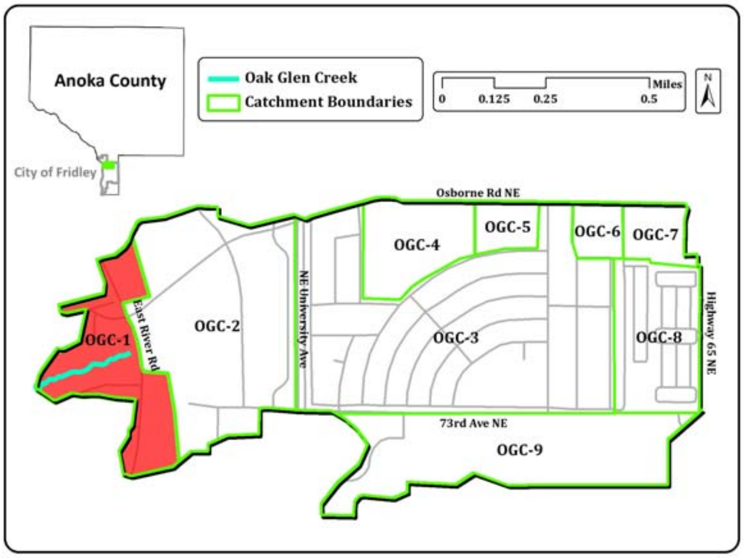
Map of stormwater catchment areas (OGC-1 through OGC-9) and potential retrofit projects referred to in this report. The numbers next to each potential project represent ranking with respect to the cost per thousand pounds of total suspended solids (TSS) removed per year. Catchment profiles on the following pages provide additional detail.



Catchment OGC-1

Existing Catchment Summary*	
Acres	51.28
Dominant Land Cover	Residential
Parcels	104
Volume (acre-feet/yr)	22.04
TP (lb/yr)	26.80
TSS (lb/yr)	8,075

*Excludes network-wide treatment practices



CATCHMENT DESCRIPTION

Catchment OGC-1 consists of the area that drains directly to the daylighted section of Oak Glen Creek. The catchment is bisected north to south by East River Rd. NE. Medium-density, single-family residential development is the primary land cover type within OGC-1. Of the 104 parcels within this catchment, 21 border the creek. Significant erosion issues exist within the Oak Glen Creek corridor and future stabilization efforts are necessary to protect property and dwellings.

EXISTING STORMWATER TREATMENT

Existing stormwater treatment within catchment OGC-1 consists of street cleaning with a regenerative air street sweeper conducted by the City of Fridley. Street cleaning is conducted a total of four times throughout the year (spring, fall, and twice throughout the summer). However, additional treatment within the residential neighborhoods is nonexistent, which results in stormwater that flows directly to Oak Glen Creek via stormwater infrastructure. In addition, the drainage areas bordering East River Road are relatively small due to the high frequency of catch basins. Existing volume and pollutant loads from catchment OGC-1 are highlighted in the tables below.

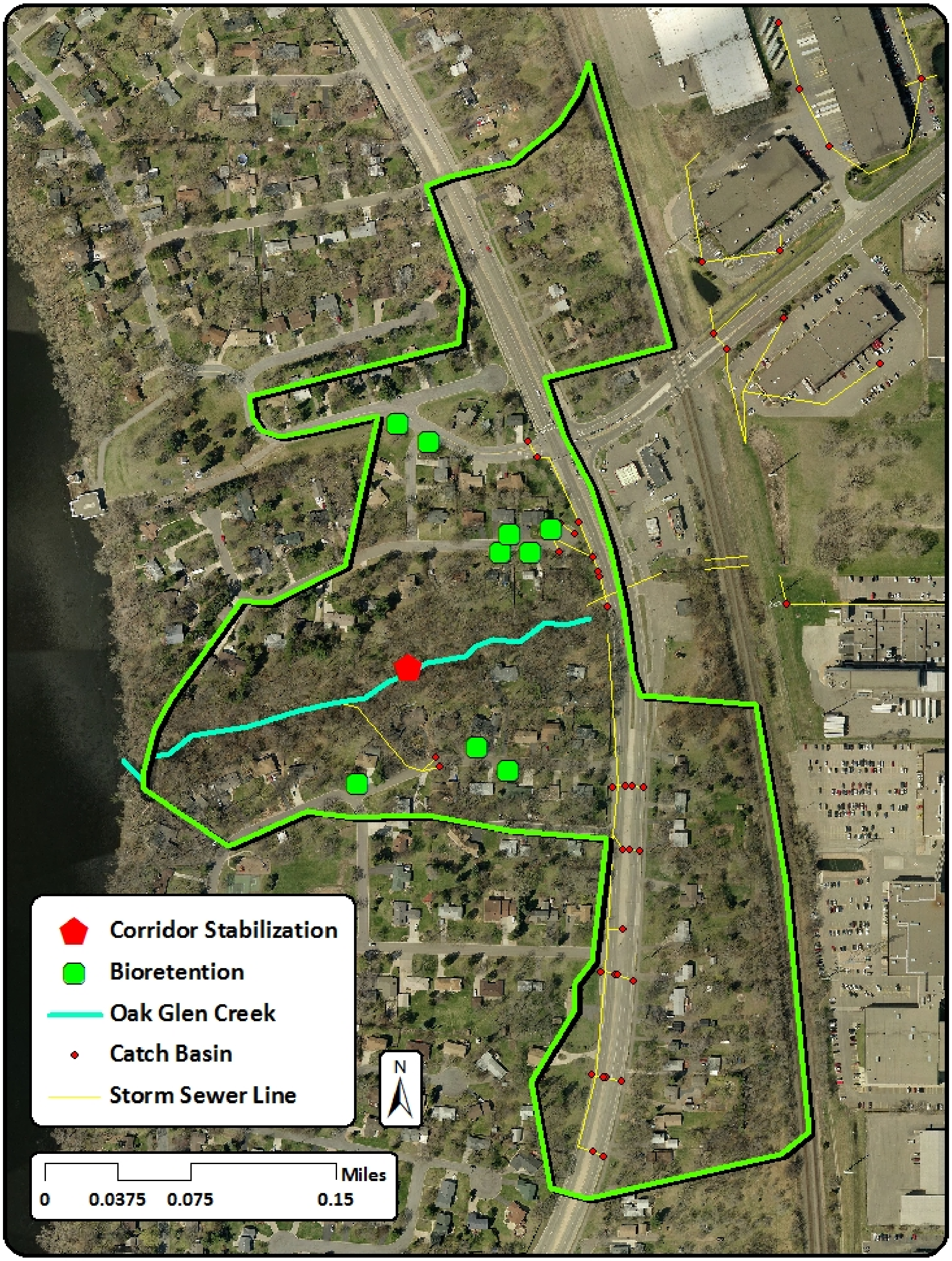
Catchment Specific Existing Conditions

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	29.0	2.2	8%	**26.8**
	TSS (lb/yr)	9,020	945.0	10%	**8,075**
	Volume (acre-feet/yr)	22.0	0.0	0%	**22.0**
	Number of BMP's	1			
	BMP Size/Description	Street Cleaning			

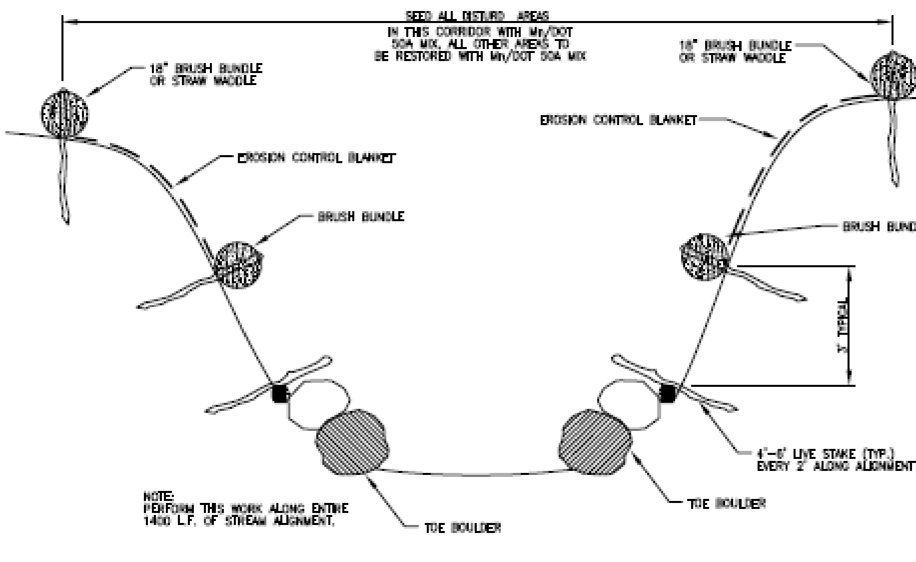
Network-Wide Existing Conditions (OGC-1 through OGC-9)

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	392.6	39.9	10%	**352.7**
	TSS (lb/yr)	169,612	22,093.0	13%	**147,519**
	Volume (acre-feet/yr)	417.6	2.8	1%	**414.8**
	Number of BMP's	All existing BMPs in catchments OGC-1 through OGC-9			
	BMP Size/Description	Street Cleaning, wet detention ponds, impervious disconnect, and rain gardens			

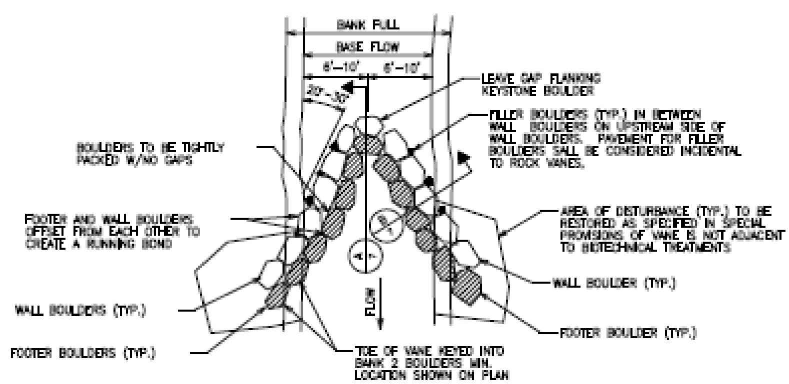
RETROFIT RECOMMENDATIONS



<u>Project ID #1 –</u> <u>Creek Corridor Stabilization</u>
Drainage Area – 573 acres
Location – Oak Glen Creek open channel west of East River Road
Property Ownership – Private
Description –
The ¼ mile section of creek corridor presently has 20-30 foot bare soil cliffs. This project will provide an 81% reduction in sediment loading, improve habitat in a critical area, and protect 20 private properties in peril. The magnitude of the problem will require aggressive corrective measures. Grade stabilization vanes will be added to reduce in-stream erosion and direct flow to the center of the creek. Boulders will be placed at the toe of the slope on each side of the creek for the entire length of the channel. Where appropriate, the banks will be graded to a suitable slope and stabilized with erosion control fabrics and vegetation. Tree thinning and removal will allow sunlight to penetrate and promote the growth of new deep-rooted vegetation.
Conceptual images -



TYPICAL CREEK SECTION
NOT TO SCALE



CROSS VANE – PLAN VIEW

Network Wide Cost/Benefit Analysis (OGC-1 through OGC-9)

	Cost/Benefit Analysis	***Project ID***					
		1 Corridor Stabilization				**Pond**	
		New trtmt	**Net %**	**New trtmt**	**Net %**	**New trtmt**	**Net %**
Treatment	**TP (lb/yr)**	6.3*	N/A**				
	TSS (lb/yr)	633,600*	N/A**				
	Volume (acre-feet/yr)	0.0*	N/A**				
	Number of BMP's	1					
	BMP Size/Description	2,640	feet				
	BMP Type	Creek Corridor Stabilization					
Cost	**Materials/Labor/Design**	$425,000					
	Promotion & Admin Costs	$10,500					
	Total Project Cost	**$435,500**					
	Annual O&M * **	$2,217					
	Term Cost/lb-TP/yr	$2,639					
	Term Cost/1,000lb-TSS/yr	**$26**					

*Reductions calculated using the Wisconsin NRCS direct volume method
**"Net %" is not applicable because volume and pollutant loading from the corridor were not included in the original WinSLAMM model. The project was included in the cost/benefit analysis to highlight the low cost of TSS removal.
***Includes estimates for annual inspections and repairs (2012 dollars)

Project ID #9 – Curb-Cut Rain Garden Network
Drainage Area – 47.3 acres
Location – 3 - 9 locations throughout medium-density residential land cover in catchment OGC-1
Property Ownership – Private
Description – The residential land cover within this catchment is best suited for residential, curb-cut rain gardens (see Appendix A for design options). Nine optimal rain garden locations were identified (see map above). Generally, ideal curb-cut rain garden locations are immediately up-gradient of a catch basin serving a large drainage area. Considering typical land owner participation rates we analyzed scenarios where 3, 6, and 9 rain gardens were installed in catchment OGC-1. Volume and pollutant reductions resulting from the rain garden installations are highlighted in the table below.
Conceptual images -


Before rain


During rain

Network Wide Cost/Benefit Analysis (OGC-1 through OGC-9)

	Cost/Benefit Analysis	Project ID					
		9 3 Rain Gardens		9 6 Rain Gardens		9 9 Rain Gardens	
		New trtmt	Net %	New trtmt	Net %	New trtmt	Net %
Treatment	TP (lb/yr)	4.8	11%	8.0	12%	10.4	13%
	TSS (lb/yr)	856	14%	1,536	14%	2,117	14%
	Volume (acre-feet/yr)	2.1	1%	3.9	2%	5.3	2%
	Number of BMP's	3		6		9	
	BMP Size/Description	750 sq ft		1,500 sq ft		2,250 sq ft	
	BMP Type	Complex Bioretention		Complex Bioretention		Complex Bioretention	
Cost	Materials/Labor/Design	$15,390		$30,570		$45,750	
	Promotion & Admin Costs	$2,310		$3,150		$3,990	
	Total Project Cost	**$17,700**		**$33,720**		**$49,740**	
	Annual O&M *	$225		$450		$675	
	Term Cost/lb-TP/yr	$170		$197		$224	
	Term Cost/1,000lb-TSS/yr	**$952**		**$1,025**		**$1,102**	

*Includes $75 per garden (2012 dollars)

Additional Retrofit Considerations

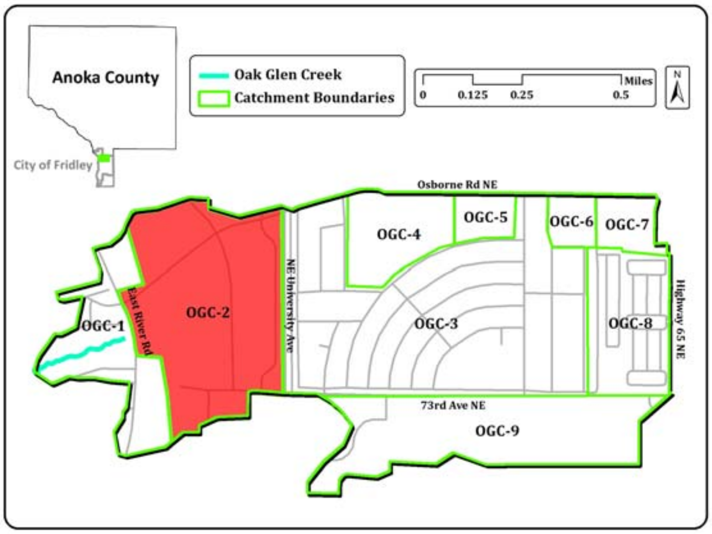
If the retrofits proposed for this catchment are inadequate due to limited landowner participation or if additional treatment is desired, below is a list of other retrofits that could be used in this catchment. However, detailed model and cost estimates were not developed because the practices would be cost prohibitive or provide minimal pollutant reduction relative to the proposed retrofits for this catchment.

- Permeable asphalt
- Tree pit filters
- Underground storage devices

Catchment OGC-2

Existing Catchment Summary*	
Acres	118.92
Dominant Land Cover	Light Industrial
Parcels	60
Volume (acre-feet/yr)	124.43
TP (lb/yr)	89.40
TSS (lb/yr)	46,035

*Excludes network-wide treatment practices



DESCRIPTION

Catchment OGC-2 is predominantly located between East River Rd. NE and University Ave. NE. Land use within OGC-2 consists primarily of light industrial with a substantial area of commercial land use and a notable area of open space surrounding the regional treatment pond.

EXISTING STORMWATER TREATMENT

Several existing stormwater treatment practices exist within catchment OGC-2. Street cleaning is conducted a total of four times throughout the year (spring, fall, and twice throughout the summer) with a regenerative air street sweeper by the City of Fridley. Two small wet detention ponds provide treatment for approximately 16 acres of light industrial land use within the northwestern corner of catchment OGC-2. Finally, a 0.29 acre wet detention pond provides regional treatment for catchments OGC-2 through OGC-9. However, the pond is drastically under-sized relative to the contributing drainage area and is only approximately six inches deep throughout the entire basin and therefore provides little benefit. Existing volume and pollutant loads from catchment OGC-2 are highlighted in the tables below.

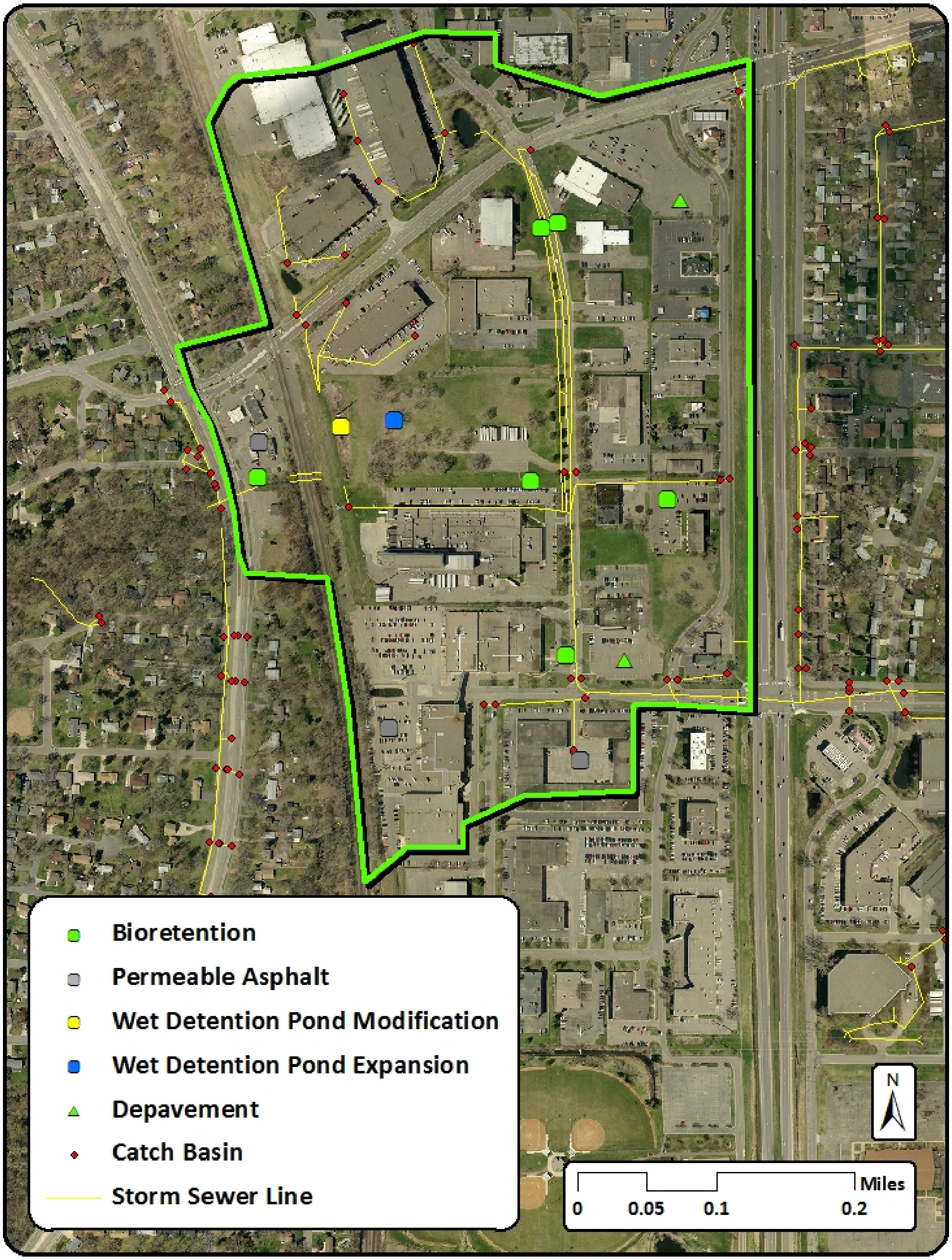
Catchment Specific Existing Conditions

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	99.0	9.6	10%	**89.4**
	TSS (lb/yr)	53,815	7,780.0	14%	**46,035**
	Volume (acre-feet/yr)	124.4	0.0	0%	**124.4**
	Number of BMP's	3			
	BMP Size/Description	Street cleaning and wet detention ponds			

Network-Wide Existing Conditions (OGC-1 through OGC-9)

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	392.6	39.9	10%	**352.7**
	TSS (lb/yr)	169,612	22,093.0	13%	**147,519**
	Volume (acre-feet/yr)	417.6	2.8	1%	**414.8**
	Number of BMP's	All existing BMPs in catchments OGC-1 through OGC-9			
	BMP Size/Description	Street Cleaning, wet detention ponds, impervious disconnect, and rain gardens			

RETROFIT RECOMMENDATIONS



<u>Project ID #2 –</u> <u>Pond Excavation</u>
Drainage Area – 520.6 acres
Location – Southeast of the intersection between Osborne Rd. NE and East River Rd.
Property Ownership – Public
Description – The existing pond is approximately six inches deep and has cattails growing throughout the basin. In addition, the inlet to the pond is substantially lower than the normal ponding elevation and has channelized to the pond outlet preventing any treatment of base or low flow conditions. The base of the pond is only 0.14 feet below the outlet weir elevation. Therefore, the total storage capacity of this pond and the potential to provide water quality benefits is extremely limited. The pond is essentially providing no treatment and very limited rate control. The proposed retrofit would result in excavation of the pond to a depth of 3.5 feet to increase storage and rate control capacity as well as provide water quality benefits. Water quality benefits achieved via the pond modification are highlighted in the table below.

Proposed Site Image -

Network Wide Cost/Benefit Analysis (OGC-1 through OGC-9)

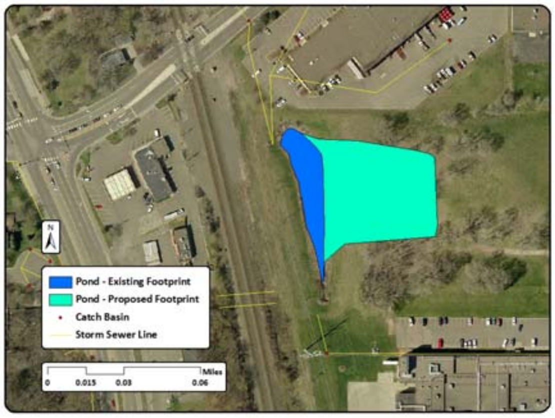
	Cost/Benefit Analysis	***Project ID***					
		2 Pond Excavation		2 Pond Excavation		2 Pond Excavation	
		New trtmt	Net %	New trtmt	Net %	New trtmt	Net %
Treatment	TP (lb/yr)	55.8	24%	55.8	24%	55.8	24%
	TSS (lb/yr)	32,631	32%	32,631	32%	32,631	32%
	Volume (acre-feet/yr)	0.0	1%	0.0	1%	0.0	1%
	Number of BMP's	1 - Level 1 material disposal, inlet/outlet structure		1 - Level 2 material disposal, inlet/outlet structure		1 - Level 3 material disposal, inlet/outlet structure	
	BMP Size/Description	645	cubic yards	645	cubic yards	645	cubic yards
	BMP Type	Wet Pond		Wet Pond		Wet Pond	
Cost	Materials/Labor/Design	$60,420		$68,160		$75,900	
	Promotion & Admin Costs	$1,680		$1,680		$1,680	
	Total Project Cost	**$62,100**		**$69,840**		**$77,580**	
	Annual O&M *	$5,406		$6,696		$7,986	
	Term Cost/lb-TP/yr	$134		$162		$189	
	Term Cost/1,000lb-TSS/yr	**$229**		**$277**		**$324**	

*Includes regenerative maintenance on a five year schedule and estimated administration (2012 dollars)

Project ID #12 – Pond Expansion
Drainage Area – 520.6 acres
Location – Southeast of the intersection between Osborne Rd. NE and East River Rd.
Property Ownership – Public/Private
Description – Expansion and excavation of the existing wet detention pond would provide additional storage and rate control as well as water quality benefits. Purchasing the parcel of land to the east of the existing pond would allow the pond's footprint to be expanded. Additional project considerations included in the total cost estimate were $15,000 for inlet and outlet modifications as well as $250,000 for purchase of the adjacent parcel (present land value). This retrofit will require extensive engineering and relocation of the pond inlet should be considered to avoid stormwater short circuiting the pond when it reaches capacity. In addition, rate control benefits may be achieved by modifying the outlet structure, but this would require an engineered hydrological analysis of potential upstream flooding issues.

A 3.5 foot deep pond was modeled. This is substantially shallower than the typical 6 to 8 foot ponds designed for stormwater treatment. Significant benefits can still be achieved with shallower ponds, but frequent maintenance is needed to avoid resuspension and scouring of settled sediment. Maintenance access can be achieved through an agreement with the company that owns the parking lot to the east of the parcel to be purchased. In addition, the proposed pond is significantly undersized for the approximately 520 acre contributing drainage area. The Minnesota Stormwater Manual recommends wet detention ponds are sized to be 1-3% of the contributing drainage area, which would require a pond area of 5-15 acres. The small area available at this site restricts this option. Pollutant removals are highlighted in the table below.

Proposed Site Image -



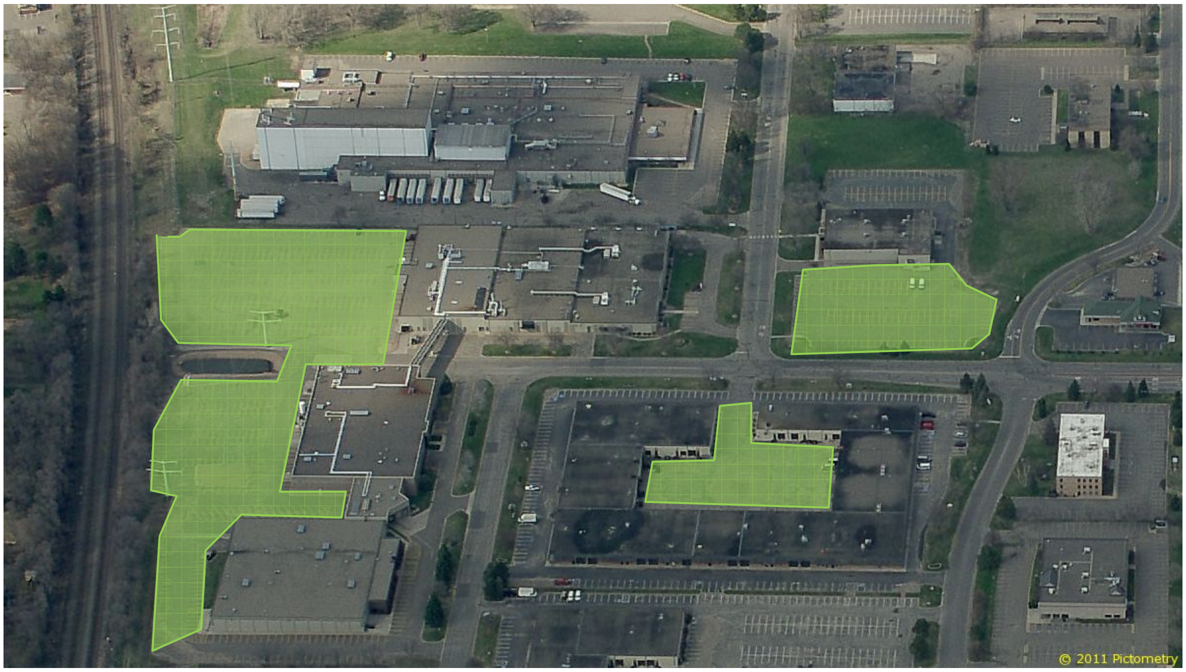
Network Wide Cost/Benefit Analysis (OGC-1 through OGC-9)

	Cost/Benefit Analysis	Project ID					
		12 Pond Expansion					
		New trtmt	Net %	New trtmt	Net %	New trtmt	Net %
Treatment	TP (lb/yr)	38.8	20%				
	TSS (lb/yr)	22,736	26%				
	Volume (acre-feet/yr)	0.0	1%				
	Number of BMP's	1					
	BMP Size/Description	25,055	cubic yards				
	BMP Type	Wet Pond					
Cost	Materials/Labor/Design	$748,540					
	Promotion & Admin Costs	$1,680					
	Total Project Cost	**$750,220**					
	Annual O&M	$10,593					
	Term Cost/lb-TP/yr	$918					
	Term Cost/1,000lb-TSS/yr	**$1,566**					

*Includes regenerative maintenance on a 10 year schedule and estimated administration (2012 dollars)

<u>Project ID #16 –</u> <u>Permeable Asphalt</u>
Drainage Area – 2.8 acres
Location – Industrial land use parking lot
Property Ownership – Private
Description – Permeable asphalt is a practice that can be used in heavily urbanized areas to treat stormwater runoff through infiltration. Parking lots can generate large volumes of runoff and high pollutant loads. At the same time, the parking space is a necessity for the business located on that property. Therefore, permeable pavement was considered as a replacement for some of the traditional pavement to reduce stormwater volumes and provide water quality treatment. Permeable pavement can treat water from an area of impervious surface approximately three times the size of the permeable pavement. Therefore, 0.7 acres of permeable asphalt would be sufficient to treat 2.8 acres of parking lot in an industrial land use. The model included maintenance, such as restorative vacuuming on an annual basis. See appendix B for more details on the design of permeable pavement. Network-wide volume and pollutant removal are shown in the table below.

Conceptual and Proposed Site Image -



The extensive areas of parking lots in the southwest corner of OGC-2 (green polygons above) offer many opportunities for permeable asphalt.

Network Wide Cost/Benefit Analysis (OGC-1 through OGC-9)

	Cost/Benefit Analysis	Project ID					
		16 Permeable Asphalt					
		New trtmt	Net %	New trtmt	Net %	New trtmt	Net %
Treatment	TP (lb/yr)	3.1	11%				
	TSS (lb/yr)	2,692	15%				
	Volume (acre-feet/yr)	3.9	2%				
	Number of BMP's	1					
	BMP Size/Description	30,492 sq ft					
	BMP Type	Permeable Asphalt					
Cost	Materials/Labor/Design	$305,690					
	Promotion & Admin Costs	$1,680					
	Total Project Cost	**$307,370**					
	Annual O&M*	$701					
	Term Cost/lb-TP/yr	$3,531					
	Term Cost/1,000lb-TSS/yr	**$4,066**					

*Includes estimates for inspections and restorative sweeping (2012 dollars)

Project ID #4 – Curb-cut Rain Garden Network
Drainage Area – 74.8 acres
Location – 3 locations throughout light industrial land use in catchment OGC-2
Property Ownership – Private
Description – Well placed curb-cut rain gardens that optimize contributing drainage areas can provide significant volume reduction and water quality benefits. Several locations within catchment OGC-2 would be well suited for curb-cut rain gardens (see catchment map). Generally, ideal curb-cut rain garden locations are immediately up-gradient of a catch basin serving a large drainage area. A scenario with three curb-cut rain gardens was modeled in catchment OGC-2. Volume and pollutant load reductions resulting from the rain garden installations are highlighted in the table below.

Network Wide Cost/Benefit Analysis (OGC-1 through OGC-9)

	Cost/Benefit Analysis	Project ID					
		4 3 Rain Gardens					
		New trtmt	Net %	New trtmt	Net %	New trtmt	Net %
Treatment	TP (lb/yr)	4.0	11%				
	TSS (lb/yr)	1,327	14%				
	Volume (acre-feet/yr)	2.3	1%				
	Number of BMP's	3					
	BMP Size/Description	750 sq ft					
	BMP Type	Complex Bioretention					
Cost	Materials/Labor/Design	$15,390					
	Promotion & Admin Costs	$2,310					
	Total Project Cost	**$17,700**					
	Annual O&M*	$225					
	Term Cost/lb-TP/yr	$204					
	Term Cost/1,000lb-TSS/yr	**$614**					

*Includes $75 per garden (2012 dollars)

Project ID #5 – Parking Lot Rain Gardens
Drainage Area – 2.5 acres
Location – Industrial land use parking lot
Property Ownership – Private
Description – In addition to curb-cut rain gardens in the road right of way, curb-cut rain gardens can be used to treat stormwater runoff from large parking lot areas. A scenario was modeled where a curb-cut rain garden treated 2.5 acres of contributing impervious surface from parking within an industrial area. Potential locations for these gardens are shown in the catchment map near the beginning of this profile. Volume and pollutant load reductions resulting from the rain garden installations are highlighted in the table below.

Network Wide Cost/Benefit Analysis (OGC-1 through OGC-9)

	Cost/Benefit Analysis	Project ID					
		5 Parking Lot Rain Garden					
		New trtmt	Net %	New trtmt	Net %	New trtmt	Net %
Treatment	TP (lb/yr)	0.8	10%				
	TSS (lb/yr)	449	13%				
	Volume (acre-feet/yr)	0.7	1%				
	Number of BMP's	1					
	BMP Size/Description	250 sq ft					
	BMP Type	Complex Bioretention					
Cost	Materials/Labor/Design	$5,270					
	Promotion & Admin Costs	$1,750					
	Total Project Cost	**$7,020**					
	Annual O&M*	$75					
	Term Cost/lb-TP/yr	$386					
	Term Cost/1,000lb-TSS/yr	**$688**					

*Includes $75 per garden (2012 dollars)

<u>Project ID #6 –</u> <u>Depavement</u>
Drainage Area – 1.0 acre
Location – Industrial land use parking lot
Property Ownership – Private
Description – Depavement of largely unused impervious surfaces is another option for reducing runoff and pollutant loading to Oak Glen Creek. A scenario was modeled that treated 1 acre of industrial parking lot. Volume and pollutant load reductions resulting from the depavement are highlighted in the table below.

Network Wide Cost/Benefit Analysis (OGC-1 through OGC-9)

	Cost/Benefit Analysis	***Project ID***					
		6 Parking Lot Depavement					
		New trtmt	**Net %**	**New trtmt**	**Net %**	**New trtmt**	**Net %**
Treatment	**TP (lb/yr)**	1.1	10%				
	TSS (lb/yr)	956	14%				
	Volume (acre-feet/yr)	1.4	1%				
	Number of BMP's	1					
	BMP Size/Description	4,356 sq ft					
	BMP Type	Depavement					
Cost	**Materials/Labor/Design**	$16,016					
	Promotion & Admin Costs	$1,680					
	Total Project Cost	**$17,696**					
	Annual O&M*	$75					
	Term Cost/lb-TP/yr	$604					
	Term Cost/1,000lb-TSS/yr	**$695**					

*Includes estimate for annual inspections (2012 dollars)

Additional Retrofit Considerations

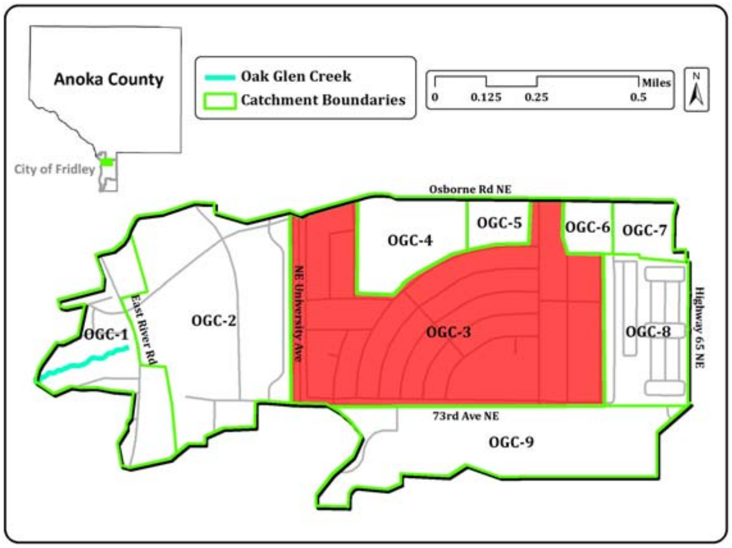
If the retrofits proposed for this catchment are inadequate due to limited landowner participation or if additional treatment is desired, below is a list of other retrofits that could be used in this catchment. However, detailed model and cost estimates were not developed because the practices would be cost prohibitive or provide minimal pollutant reduction relative to the proposed retrofits for this catchment.

- Tree pit filters
- Underground storage devices

Catchment OGC-3

Existing Catchment Summary*	
Acres	195.12
Dominant Land Cover	Residential
Parcels	566
Volume (acre-feet/yr)	85.42
TP (lb/yr)	103.60
TSS (lb/yr)	32,357

*Excludes network-wide treatment practices



DESCRIPTION

Catchment OGC-3 is positioned east of University Ave. NE, west of Albe St. NE, south of Osborne R. NE, and north of 73rd Ave. NE. Land use throughout the catchment is dominated by medium-density, single-family residential development. Madsen Park is located in the south central part of the catchment.

EXISTING STORMWATER TREATMENT

Several existing stormwater treatment practices exist within catchment OGC-3. Street cleaning with a regenerative air sweeper is conducted a total of four times throughout the year (spring, fall, and twice throughout the summer) by the City of Fridley. In addition, six residential rain gardens provide treatment of stormwater in the south central portion of OGC-3. However, the majority of the residential land use acreage is untreated. Existing volume and pollutant loads from catchment OGC-3 are highlighted in the tables below.

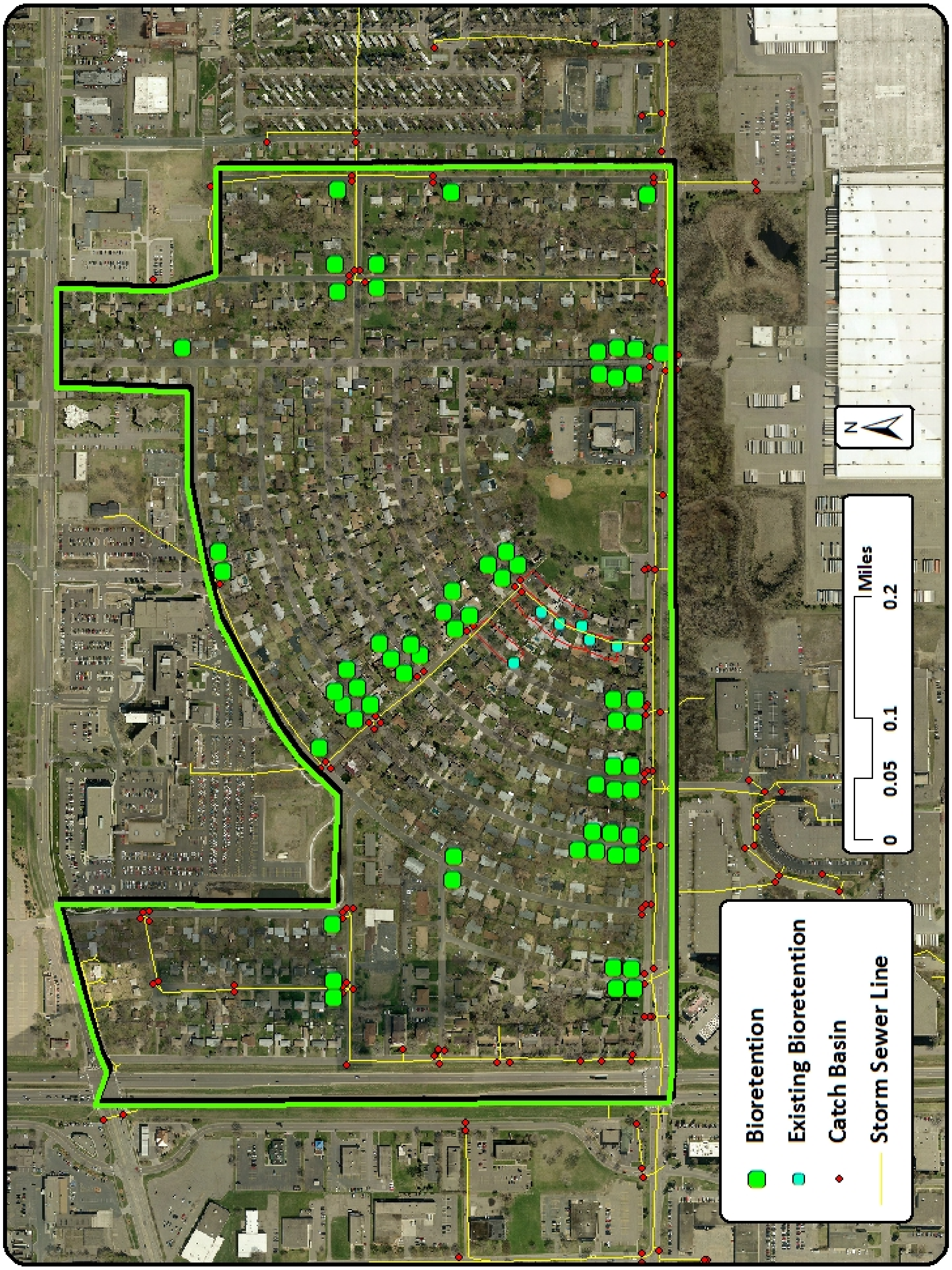
Catchment Specific Existing Conditions

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	111.9	8.3	7%	**103.6**
	TSS (lb/yr)	35,814	3,457.0	10%	**32,357**
	Volume (acre-feet/yr)	86.2	0.8	1%	**85.4**
	Number of BMP's	7			
	BMP Size/Description	Street cleaning and rain gardens			

Network-Wide Existing Conditions (OGC-1 through OGC-9)

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	392.6	39.9	10%	**352.7**
	TSS (lb/yr)	169,612	22,093.0	13%	**147,519**
	Volume (acre-feet/yr)	417.6	2.8	1%	**414.8**
	Number of BMP's	All existing BMPs in catchments OGC-1 through OGC-9			
	BMP Size/Description	Street Cleaning, wet detention ponds, impervious disconnect, and rain gardens			

RETROFIT RECOMMENDATIONS



***Project ID #7 –** Curb-Cut Rain Garden Network*
Drainage Area – 156.7 acres
Location – 5 - 20 locations throughout medium-density residential land cover in catchment OGC-3
Property Ownership – Private
Description – The residential land use within this catchment is best suited for residential, curb-cut rain gardens (see Appendix A for design options). Sixty two optimal rain garden locations were identified within catchment OGC-3 (see map above), though many more potential sites exist. Generally, ideal curb-cut rain garden locations are immediately up-gradient of a catch basin serving a large drainage area. Considering typical land owner participation rates we analyzed scenarios where 5, 10, and 20 rain gardens were installed in catchment OGC-3. Volume and pollutant load reductions resulting from the rain garden installations are highlighted in the table below
Example Images -

Before

After

Network-Wide Cost/Benefit Analysis (OGC-1 through OGC-9)

	Cost/Benefit Analysis	Project ID					
		7 5 Rain Gardens		7 10 Rain Gardens		7 20 Rain Gardens	
		New trtmt	Net %	New trtmt	Net %	New trtmt	Net %
Treatment	TP (lb/yr)	8.9	12%	15.7	14%	26.4	17%
	TSS (lb/yr)	1,564	14%	2,841	15%	5,094	16%
	Volume (acre-feet/yr)	3.7	2%	6.9	2%	12.6	4%
	Number of BMP's	5		10		20	
	BMP Size/Description	1,250 sq ft		2,500 sq ft		5,000 sq ft	
	BMP Type	Complex Bioretention		Complex Bioretention		Complex Bioretention	
Cost	Materials/Labor/Design	$25,510		$50,810		$101,410	
	Promotion & Admin Costs	$2,870		$4,270		$7,070	
	Total Project Cost	**$28,380**		**$55,080**		**$108,480**	
	Annual O&M*	$375		$750		$1,500	
	Term Cost/lb-TP/yr	$148		$165		$194	
	Term Cost/1,000lb-TSS/yr	**$845**		**$910**		**$1,004**	

*Includes $75 per garden (2012 dollars)

Additional Retrofit Considerations

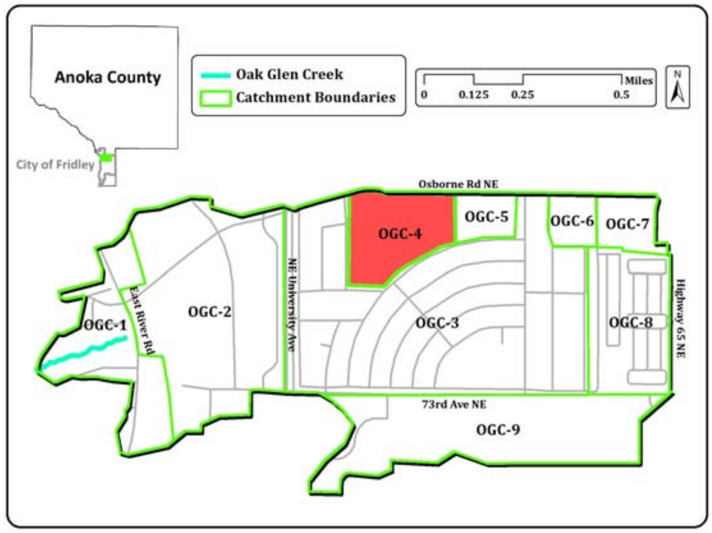
If the retrofits proposed for this catchment are inadequate due to limited landowner participation or if additional treatment is desired, below is a list of other retrofits that could be used in this catchment. However, detailed model and cost estimates were not developed because the practices would be cost prohibitive or provide minimal pollutant reduction relative to the proposed retrofits for this catchment.

- Permeable asphalt
- Tree pit filters
- Underground storage devices

Catchment OGC-4

Existing Catchment Summary*	
Acres	32.77
Dominant Land Cover	Hospital
Parcels	7
Volume (acre-feet/yr)	38.82
TP (lb/yr)	16.40
TSS (lb/yr)	5,178

*Excludes network-wide treatment practices



DESCRIPTION

Catchment OGC-4 is positioned in the north central area of the Oak Glen Creek subwatershed. Land use within this catchment is solely institutional. More specifically, Unity Hospital and associated buildings cover the entire area of catchment OGC-4.

EXISTING STORMWATER TREATMENT

Existing stormwater treatment within catchment OGC-4 consists of street cleaning with a regenerative air street sweeper conducted four times throughout the year (spring, fall, and twice throughout the summer) by the City of Fridley. In addition, a 0.29 acre wet detention pond treats stormwater runoff from the Unity Hospital campus. Existing volume and pollutant loads from catchment OGC-4 are highlighted in the tables below.

Catchment Specific Existing Conditions

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	31.1	14.7	47%	**16.4**
	TSS (lb/yr)	12,001	6,823.0	57%	**5,178**
	Volume (acre-feet/yr)	38.8	0.0	0%	**38.8**
	Number of BMP's	2			
	BMP Size/Description	Street cleaning and wet detention pond			

Network-Wide Existing Conditions (OGC-1 through OGC-9)

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	392.6	39.9	10%	**352.7**
	TSS (lb/yr)	169,612	22,093.0	13%	**147,519**
	Volume (acre-feet/yr)	417.6	2.8	1%	**414.8**
	Number of BMP's	All existing BMPs in catchments OGC-1 through OGC-9			
	BMP Size/Description	Street Cleaning, wet detention ponds, impervious disconnect, and rain gardens			

RETROFIT RECOMMENDATIONS

Project ID #17 – Permeable Asphalt
Drainage Area – 3 acres
Location – Industrial land use parking lot
Property Ownership – Private
Description – While the treatment provided by the existing wet detention pond on the Unity Hospital campus is substantial and appears to be functioning well based on model results and field observations, the southeast corner of the campus does not drain to the treatment pond. Rather, the stormwater is routed south to OGC-3.

Permeable asphalt is a practice that can be used in heavily urbanized areas to treat stormwater runoff through infiltration. Parking lots can generate large volumes of runoff and high pollutant loads. At the same time, the parking space is a necessity for the business located on that property. Therefore, permeable pavement was considered as a replacement for some of the traditional pavement to reduce stormwater volumes and provide water quality treatment. Permeable pavement can treat water from an area of impervious surface approximately three times the size of the permeable pavement. Therefore, 0.75 acres of permeable asphalt would be sufficient to treat 3 acres of parking lot in an industrial land use. The model included maintenance, such as restorative vacuuming on an annual basis. See appendix B for more details on the design of permeable pavement. Network-wide volume and pollutant removal are shown in the table below.

Conceptual and Proposed Site Image -

Parking lots in the southeast corner (green polygon above) of the Unity Hospital campus provide opportunities for permeable asphalt to treat stormwater runoff.

Network Wide Cost/Benefit Analysis (OGC-1 through OGC-9)

	Cost/Benefit Analysis	Project ID					
		17 Permeable Asphalt					
		New trtmt	Net %	New trtmt	Net %	New trtmt	Net %
Treatment	TP (lb/yr)	1.7	11%				
	TSS (lb/yr)	865	14%				
	Volume (acre-feet/yr)	4.2	2%				
	Number of BMP's	1					
	BMP Size/Description	32,670 sq ft					
	BMP Type	Permeable Asphalt					
Cost	Materials/Labor/Design	$327,470					
	Promotion & Admin Costs	$1,680					
	Total Project Cost	**$329,150**					
	Annual O&M*	$751					
	Term Cost/lb-TP/yr	$6,896					
	Term Cost/1,000lb-TSS/yr	**$13,553**					

*Includes estimates for inspections and restorative sweeping (2012 dollars)

Additional Retrofit Considerations

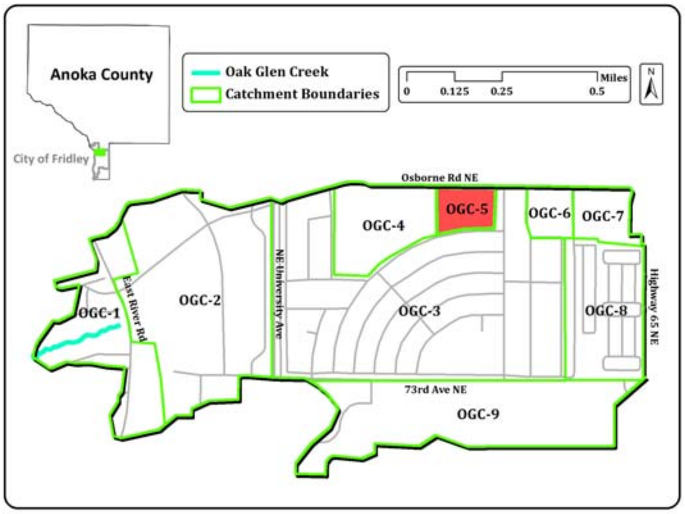
If the retrofits proposed for this catchment are inadequate due to limited landowner participation or if additional treatment is desired, below is a list of other retrofits that could be used in this catchment. However, detailed model and cost estimates were not developed because the practices would be cost prohibitive or provide minimal pollutant reduction relative to the proposed retrofits for this catchment.

- Tree pit filters
- Underground storage devices

Catchment OGC-5

Existing Catchment Summary*	
Acres	10.95
Dominant Land Cover	High Rise Residential
Parcels	14
Volume (acre-feet/yr)	9.71
TP (lb/yr)	7.60
TSS (lb/yr)	3,058

*Excludes network-wide treatment practices



DESCRIPTION

Catchment OGC-5 is located in the north-central portion of the Oak Glen Creek subwatershed, directly south of Osborne Rd. NE. Land use within the catchment is approximately evenly split among high rise residential, office park, and hospital.

EXISTING STORMWATER TREATMENT

Two stormwater treatment practices currently exist in catchment OGC-5. Street cleaning with a regenerative air street sweeper is conducted four times throughout the year (spring, fall, and twice throughout the summer) by the City of Fridley. In addition, a parking lot for Unity Hospital employees is disconnected from the stormwater infrastructure using curb cuts, which directs the runoff into a shallow turf grass depression.

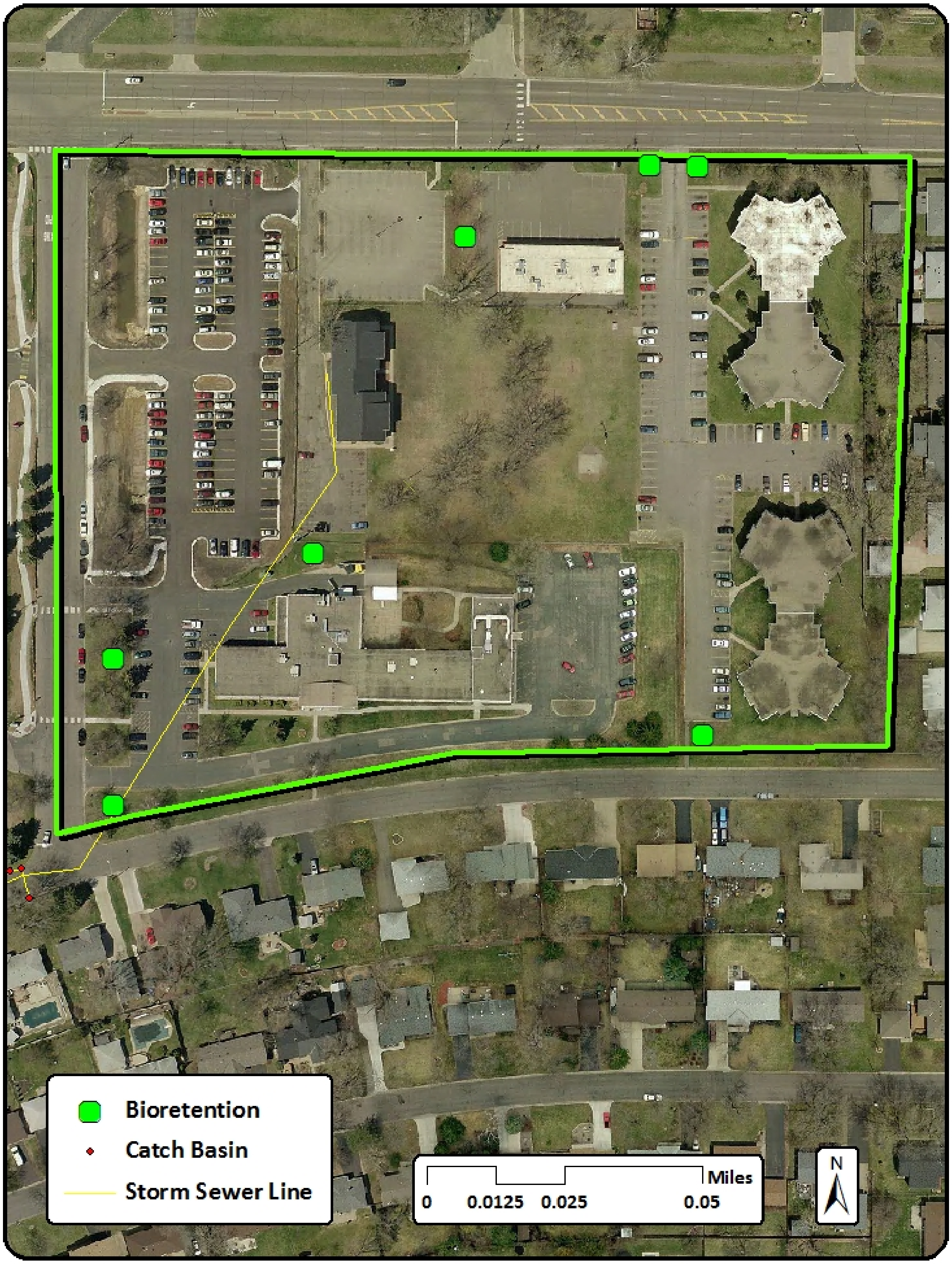
Catchment Specific Existing Conditions

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	9.5	1.9	20%	**7.6**
	TSS (lb/yr)	3,871	813.0	21%	**3,058**
	Volume (acre-feet/yr)	11.7	2.0	17%	**9.7**
	Number of BMP's	2			
	BMP Size/Description	Street cleaning and parking lot disconnect			

Network-Wide Existing Conditions (OGC-1 through OGC-9)

	Existing Conditions	**Base Loading**	**Treatment**	**Net Treatment %**	**Existing Loading**
Treatment	**TP (lb/yr)**	392.6	39.9	10%	**352.7**
	TSS (lb/yr)	169,612	22,093.0	13%	**147,519**
	Volume (acre-feet/yr)	417.6	2.8	1%	**414.8**
	Number of BMP's	All existing BMPs in catchments OGC-1 through OGC-9			
	BMP Size/Description	Street Cleaning, wet detention ponds, impervious disconnect, and rain gardens			

RETROFIT RECOMMENDATIONS



Project ID # 13 – Parking Lot Rain Gardens
Drainage Area – Variable
Location – Hospital and high-rise residential land use parking lots
Property Ownership – Private
Description – Well placed curb-cut rain gardens within catchment OGC-5 can provide treatment of a significant amount of runoff generated within the catchment. Scenarios were modeled that treated parking lots associated with the high-rise residential and institutional land uses. Two rain garden size options (500 ft^2 and 1,000 ft^2) were modeled for this scenario. Volume and pollutant load reductions resulting from the rain garden installation is highlighted in the table below.

Network Wide Cost/Benefit Analysis (OGC-1 through OGC-9)

	Cost/Benefit Analysis	Project ID					
		13 Parking Lot Rain Garden		13 Parking Lot Rain Garden			
		New trtmt	Net %	New trtmt	Net %	New trtmt	Net %
Treatment	TP (lb/yr)	0.5	10%	0.6	10%		
	TSS (lb/yr)	245	13%	328	13%		
	Volume (acre-feet/yr)	0.7	1%	0.9	1%		
	Number of BMP's	1		1			
	BMP Size/Description	500 sq ft		1,000 sq ft			
	BMP Type	Complex Bioretention		Complex Bioretention			
Cost	Materials/Labor/Design	$9,770		$18,770			
	Promotion & Admin Costs	$1,750		$1,750			
	Total Project Cost	**$11,520**		**$20,520**			
	Annual O&M*	$75		$75			
	Term Cost/lb-TP/yr	$918		$1,265			
	Term Cost/1,000lb-TSS/yr	**$1,873**		**$2,314**			

*Includes $75 per garden (2012 dollars)

Project ID #'s 11 and 14 – Parking Lot Rain Gardens
Drainage Area – Variable
Location – Office park or high-rise residential land use parking lot
Property Ownership – Private
Description – Well placed curb-cut rain gardens within catchment OGC-5 can provide treatment of a significant amount of runoff generated within the catchment. Scenarios were modeled that treated parking lots associated with institutional and high-rise residential land uses. Volume and pollutant load reductions resulting from the rain garden installations are highlighted in the table below.

Network Wide Cost/Benefit Analysis (OGC-1 through OGC-9)

	Cost/Benefit Analysis	***Project ID***					
		11 Office Park Parking Lot Rain Garden		**14 High-rise Residential Parking Lot Rain Garden**			
		New trtmt	**Net %**	**New trtmt**	**Net %**	**New trtmt**	**Net %**
Treatment	**TP (lb/yr)**	0.9	10%	0.6	10%		
	TSS (lb/yr)	363	13%	163	13%		
	Volume (acre-feet/yr)	0.8	1%	0.5	1%		
	Number of BMP's	1		1			
	BMP Size/Description	500 sq ft		250 sq ft			
	BMP Type	Complex Bioretention		Complex Bioretention			
Cost	**Materials/Labor/Design**	$9,770		$5,270			
	Promotion & Admin Costs	$1,750		$1,750			
	Total Project Cost	**$11,520**		**$7,020**			
	Annual O&M*	$75		$75			
	Term Cost/lb-TP/yr	$510		$515			
	Term Cost/1,000lb-TSS/yr	**$1,264**		**$1,896**			

*Includes $75 per garden (2012 dollars)

Additional Retrofit Considerations

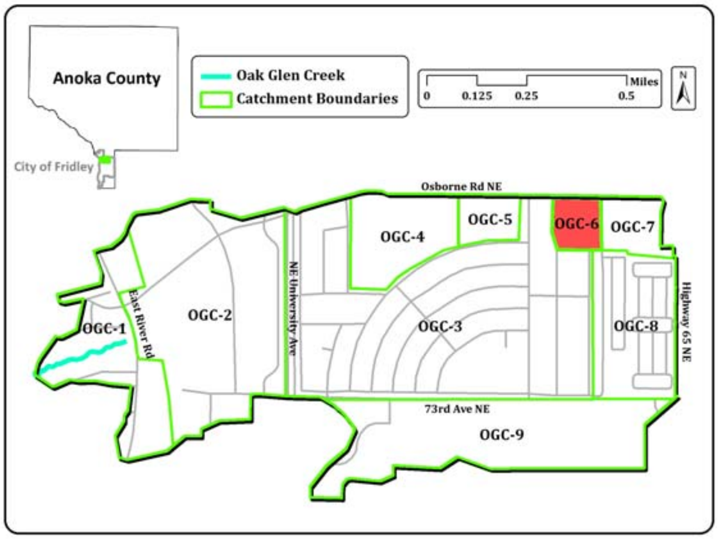
If the retrofits proposed for this catchment are inadequate due to limited landowner participation or if additional treatment is desired, below is a list of other retrofits that could be used in this catchment. However, detailed model and cost estimates were not developed because the practices would be cost prohibitive or provide minimal pollutant reduction relative to the proposed retrofits for this catchment.

- Permeable asphalt
- Tree pit filters
- Underground storage devices

Catchment OGC-6

Existing Catchment Summary*	
Acres	9.96
Dominant Land Cover	School
Parcels	6
Volume (acre-feet/yr)	8.52
TP (lb/yr)	8.40
TSS (lb/yr)	3,076

*Excludes network-wide treatment practices



DESCRIPTION

Catchment OGC-6 is positioned near the northeast corner of the Oak Glen Creek subwatershed. Land use within the catchment is solely comprised of Woodcrest Elementary School.

EXISTING STORMWATER TREATMENT

The only existing stormwater treatment practice within catchment OGC-6 is street cleaning with a regenerative air street sweeper conducted four times throughout the year (spring, fall, and twice throughout the summer) by the City of Fridley. Stormwater runoff from the school campus flows directly into the stormwater infrastructure and is carried downstream to Oak Glen Creek. The tables below highlight the existing volume and pollutant loading from catchment OGC-6.

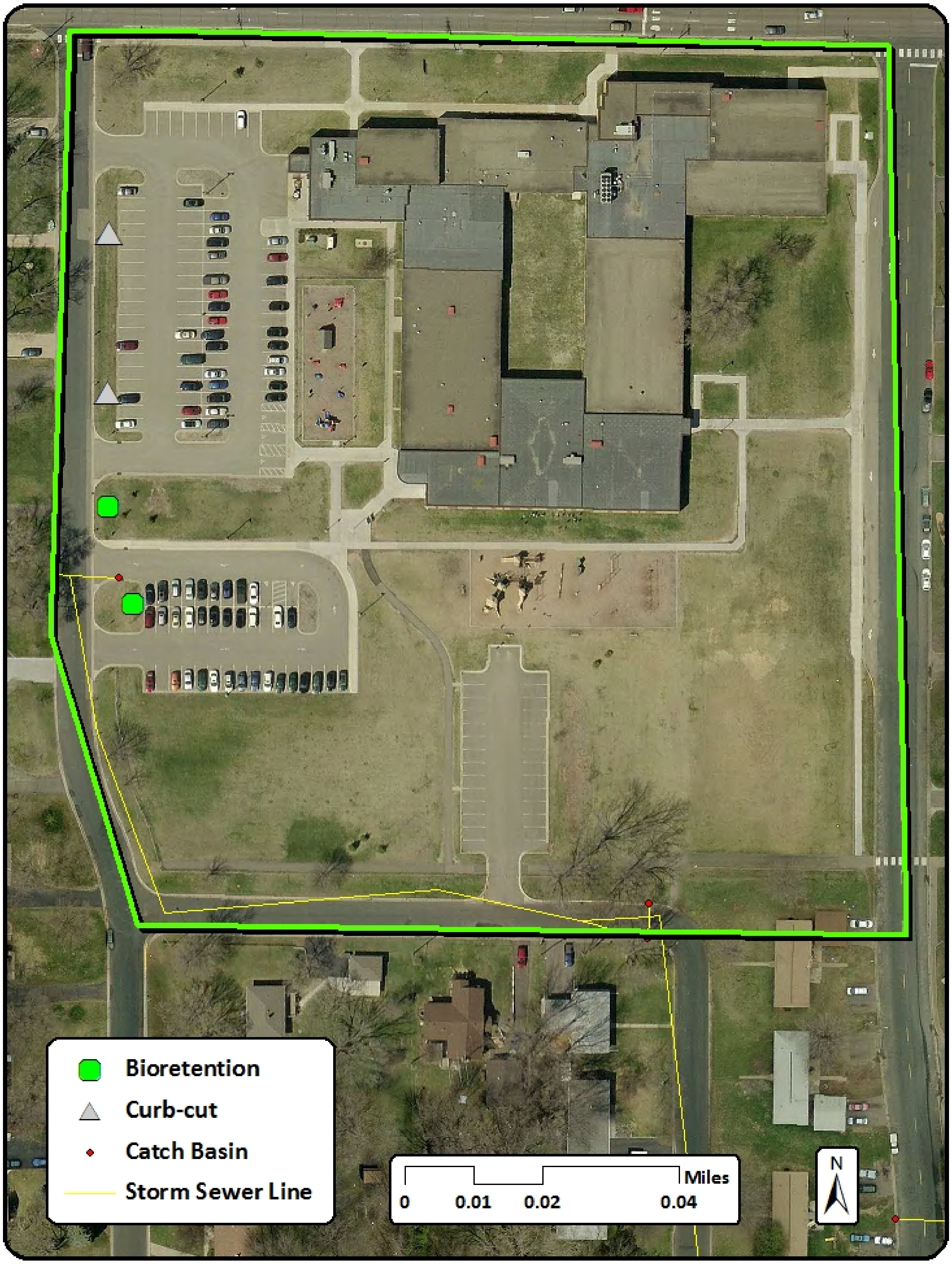
Catchment Specific Existing Conditions

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	8.7	0.3	3%	**8.4**
	TSS (lb/yr)	3,271	195.0	6%	**3,076**
	Volume (acre-feet/yr)	8.5	0.0	0%	**8.5**
	Number of BMP's	1			
	BMP Size/Description	Street cleaning			

Network-Wide Existing Conditions (OGC-1 through OGC-9)

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	392.6	39.9	10%	**352.7**
	TSS (lb/yr)	169,612	22,093.0	13%	**147,519**
	Volume (acre-feet/yr)	417.6	2.8	1%	**414.8**
	Number of BMP's	All existing BMPs in catchments OGC-1 through OGC-9			
	BMP Size/Description	Street Cleaning, wet detention ponds, impervious disconnect, and rain gardens			

RETROFIT RECOMMENDATIONS



Project ID #15 – Parking Lot Rain Gardens
Drainage Area – Variable
Location – School parking lots
Property Ownership – Private
Description – Well placed curb-cut rain gardens within catchment OGC-6 can provide substantial treatment of runoff from parking lots associated with Woodcrest Elementary School. In addition, curb-cut rain gardens installed on the school property could serve as long-term education tools. A scenario was modeled that treated parking lots associated with the school land use. Volume and pollutant load reductions resulting from the rain garden installation are highlighted in the table below.

Project ID #3 – Parking Lot Disconnect
Drainage Area – Variable
Location – School land use parking lots
Property Ownership – Private
Description – Stormwater disconnecting is the practice of routing stormwater onto permeable surfaces, such as lawn, instead of into catch basins. There are at least two promising locations for stormwater disconnects at Woodcrest Elementary School. Each would be accomplished by installing a curb-cut immediately up-gradient of an existing catch basin. The water would be directed to unused open space. Network-wide removal of volume, TSS, and TP are show in the table below.

Network Wide Cost/Benefit Analysis (OGC-1 through OGC-9)

	Cost/Benefit Analysis	Project ID					
		15 School Parking Lot Rain Garden		3 School Parking Lot Disconnect			
		New trtmt	Net %	New trtmt	Net %	New trtmt	Net %
Treatment	TP (lb/yr)	0.3	10%	0.4	10%		
	TSS (lb/yr)	139	13%	248	13%		
	Volume (acre-feet/yr)	0.4	1%	0.7	1%		
	Number of BMP's	1		2			
	BMP Size/Description	250 sq ft		20 linear feet			
	BMP Type	Complex Bioretention		Curb-Cut			
Cost	Materials/Labor/Design	$5,270		$600			
	Promotion & Admin Costs	$1,750		$350			
	Total Project Cost	$7,020		$950			
	Annual O&M*	**$75**		**$75**			
	Term Cost/lb-TP/yr	$1,030		$267			
	Term Cost/1,000lb-TSS/yr	**$2,223**		**$430**			

*Includes $75 per garden or infiltration area (2012 dollars)

Additional Retrofit Considerations

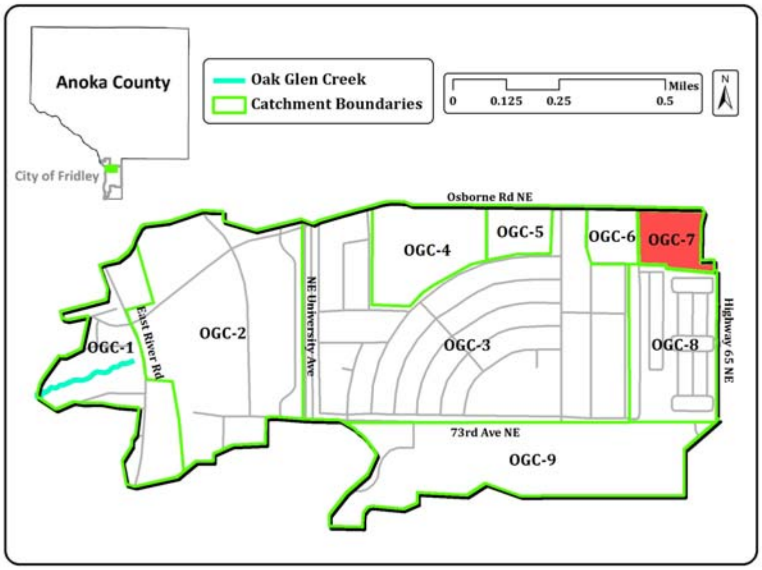
If the retrofits proposed for this catchment are inadequate due to limited landowner participation or if additional treatment is desired, below is a list of other retrofits that could be used in this catchment. However, detailed model and cost estimates were not developed because the practices would be cost prohibitive or provide minimal pollutant reduction relative to the proposed retrofits for this catchment.

- Permeable asphalt
- Tree pit filters
- Underground storage devices

Catchment OGC-7

Existing Catchment Summary*	
Acres	13.59
Dominant Land Cover	Commercial
Parcels	16
Volume (acre-feet/yr)	15.82
TP (lb/yr)	10.72
TSS (lb/yr)	5,431

*Excludes network-wide treatment practices



DESCRIPTION

Catchment OGC-7 is positioned in the northeast corner of the Oak Glen Creek subwatershed. The catchment is bordered on the east by Highway 65 NE and on the north by Osborne Rd. NE. Land use within the catchment is predominantly commercial, yet light industrial and park areas also exist.

EXISTING STORMWATER TREATMENT

The only existing stormwater treatment practice within catchment OGC-7 is street cleaning with a regenerative air street sweeper conducted four times throughout the year (spring, fall, and twice throughout the summer) by the City of Fridley. Stormwater runoff from the catchment flows directly into the stormwater infrastructure and is carried downstream to Oak Glen Creek. The tables below highlight the existing volume and pollutant loading from catchment OGC-7.

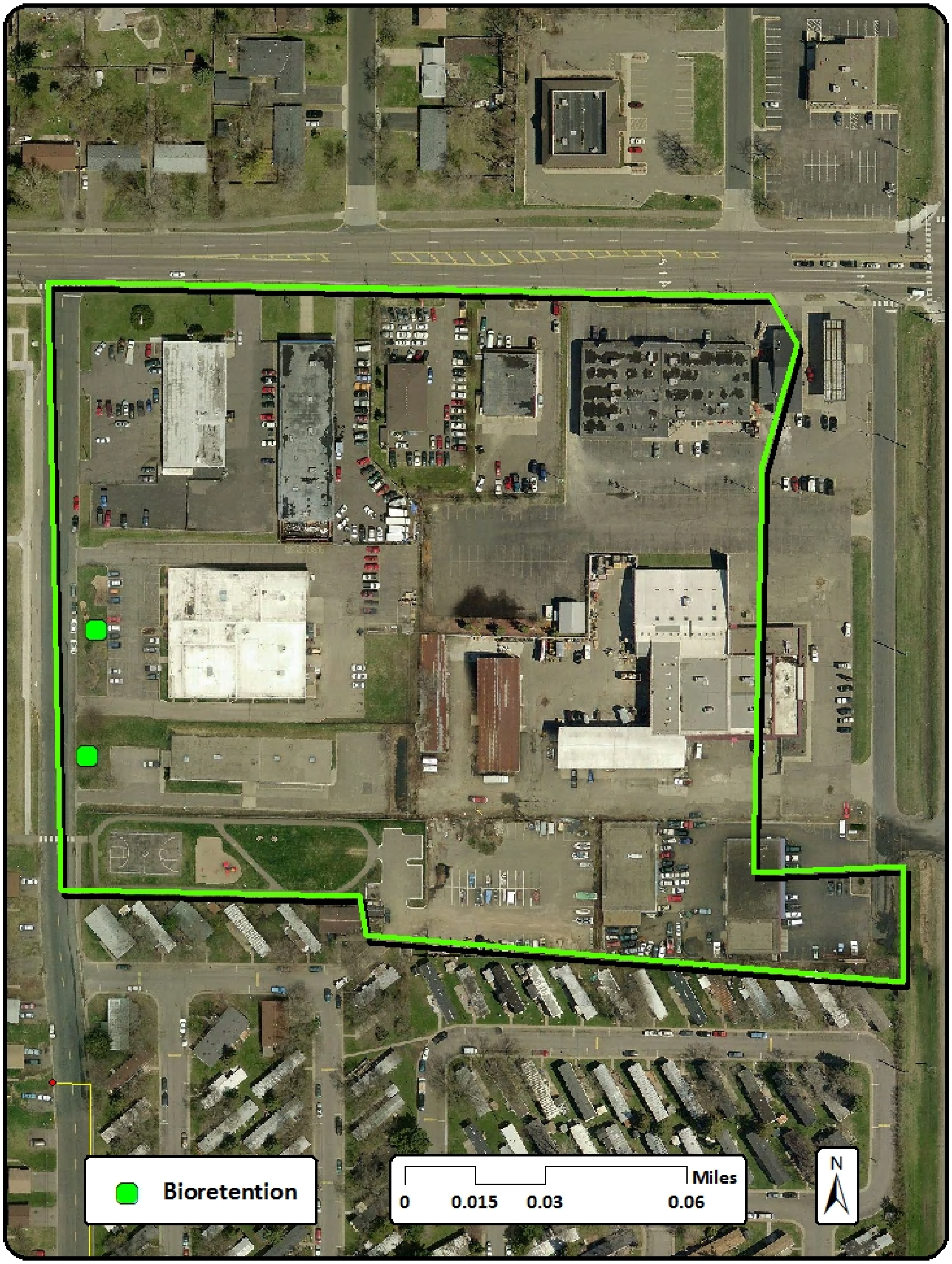
Catchment Specific Existing Conditions

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	11.0	0.3	3%	**10.7**
	TSS (lb/yr)	5,617	186.0	3%	**5,431**
	Volume (acre-feet/yr)	15.8	0.0	0%	**15.8**
	Number of BMP's	1			
	BMP Size/Description	Street cleaning			

Network-Wide Existing Conditions (OGC-1 through OGC-9)

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	392.6	39.9	10%	**352.7**
	TSS (lb/yr)	169,612	22,093.0	13%	**147,519**
	Volume (acre-feet/yr)	417.6	2.8	1%	**414.8**
	Number of BMP's	All existing BMPs in catchments OGC-1 through OGC-9			
	BMP Size/Description	Street Cleaning, wet detention ponds, impervious disconnect, and rain gardens			

RETROFIT RECOMMENDATIONS



Project ID #10 – Parking Lot Rain Garden
Drainage Area – 2.5 acres
Location – Industrial land use parking lot
Property Ownership – Private
Description – In addition to curb-cut rain gardens in the road right of way, curb-cut rain gardens can be used to treat stormwater runoff from large parking lot areas. A scenario was modeled where a curb-cut rain garden treated 2.5 acres of contributing impervious surface from parking within an industrial area. Potential locations for these gardens are shown in the map above. Volume and pollutant load reductions resulting from the rain garden installation are highlighted in the table below.

Network Wide Cost/Benefit Analysis (OGC-1 through OGC-9)

	Cost/Benefit Analysis	***Project ID***					
		10 Parking Lot Curb-cut Rain Garden					
		New trtmt	**Net %**	**New trtmt**	**Net %**	**New trtmt**	**Net %**
Treatment	**TP (lb/yr)**	0.8	10%				
	TSS (lb/yr)	321	13%				
	Volume (acre-feet/yr)	0.6	1%				
	Number of BMP's	1					
	BMP Size/Description	250 sq ft					
	BMP Type	Complex Bioretention					
Cost	**Materials/Labor/Design**	$5,270					
	Promotion & Admin Costs	$1,750					
	Total Project Cost	**$7,020**					
	Annual O&M*	$75					
	Term Cost/lb-TP/yr	$401					
	Term Cost/1,000lb-TSS/yr	**$963**					

*Includes $75 per garden (2012 dollars)

Additional Retrofit Considerations

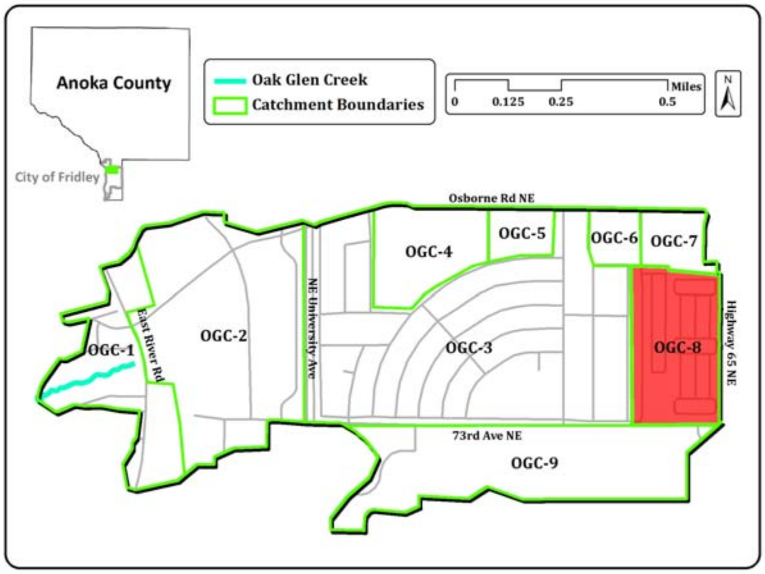
If the retrofits proposed for this catchment are inadequate due to limited landowner participation or if additional treatment is desired, below is a list of other retrofits that could be used in this catchment. However, detailed model and cost estimates were not developed because the practices would be cost prohibitive or provide minimal pollutant reduction relative to the proposed retrofits for this catchment.

- Permeable asphalt
- Tree pit filters
- Underground storage devices

Catchment OGC-8

Existing Catchment Summary*	
Acres	48.23
Dominant Land Cover	Residential
Parcels	36
Volume (acre-feet/yr)	37.99
TP (lb/yr)	31.01
TSS (lb/yr)	11,154

*Excludes network-wide treatment practices



DESCRIPTION

Catchment OGC-8 is located in the southeast portion of the Oak Glen Creek subwatershed. The catchment is bordered on the east by Highway 65 NE and on the south by 73rd Ave. NE. Land use within the catchment is primarily residential. More specifically, the Fridley Terrace Mobile Home Park comprises most of the catchment. However, smaller areas of light industrial and multi-family residential also exist.

EXISTING STORMWATER TREATMENT

The only existing stormwater treatment practice within catchment OGC-8 is street cleaning with a regenerative air street sweeper conducted four times throughout the year (spring, fall, and twice throughout the summer) by the City of Fridley. Stormwater runoff from the catchment flows directly into the stormwater infrastructure and is carried downstream to Oak Glen Creek. The tables below highlight the existing volume and pollutant loading from catchment OGC-8.

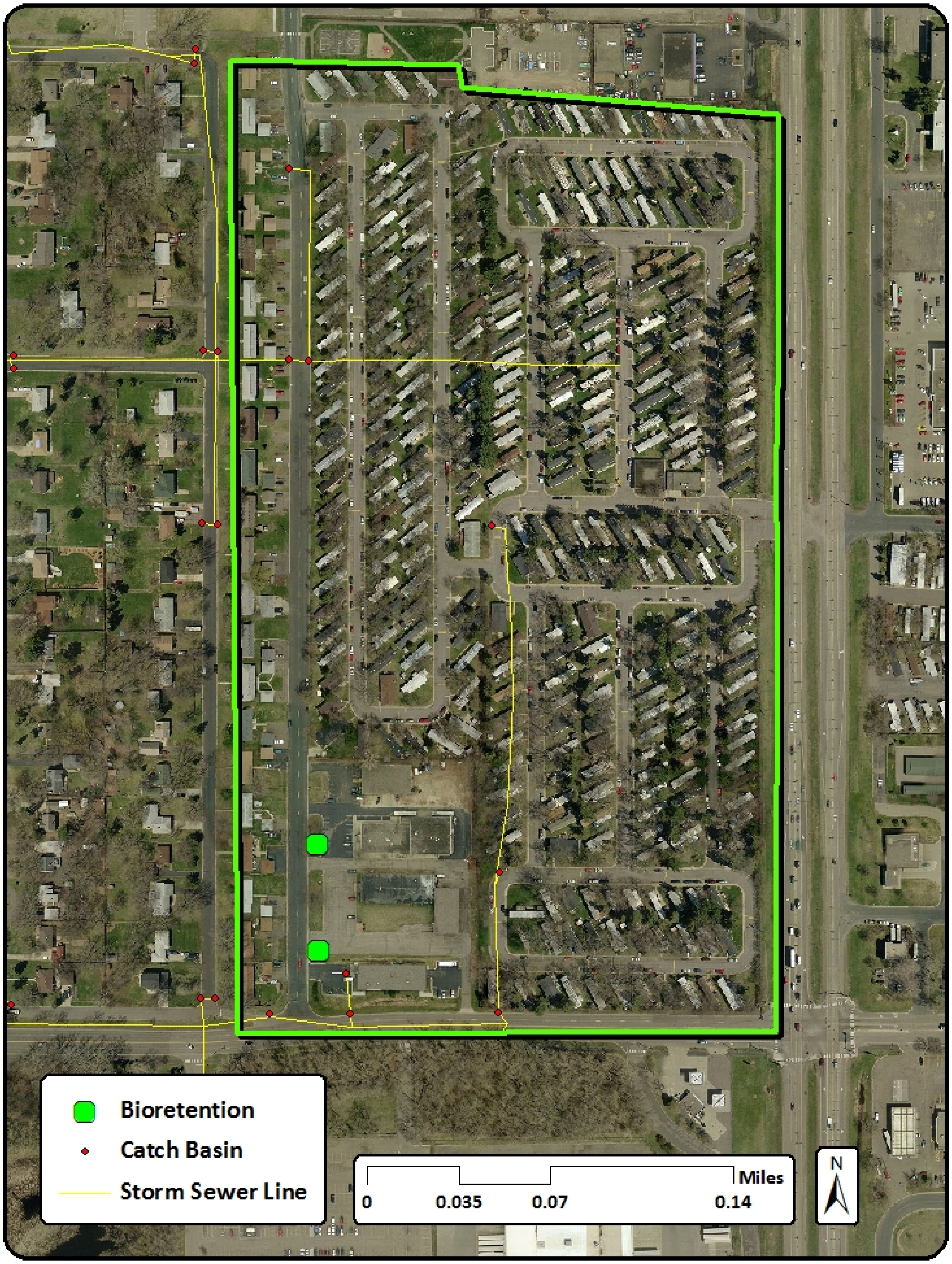
Catchment Specific Existing Conditions

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	31.5	0.5	2%	**31.0**
	TSS (lb/yr)	11,416	262.0	2%	**11,154**
	Volume (acre-feet/yr)	38.0	0.0	0%	**38.0**
	Number of BMP's	1			
	BMP Size/Description	Street cleaning			

Network-Wide Existing Conditions (OGC-1 through OGC-9)

	Existing Conditions	**Base Loading**	**Treatment**	**Net Treatment %**	**Existing Loading**
Treatment	**TP (lb/yr)**	392.6	39.9	10%	**352.7**
	TSS (lb/yr)	169,612	22,093.0	13%	**147,519**
	Volume (acre-feet/yr)	417.6	2.8	1%	**414.8**
	Number of BMP's	All existing BMPs in catchments OGC-1 through OGC-9			
	BMP Size/Description	Street Cleaning, wet detention ponds, impervious disconnect, and rain gardens			

RETROFIT RECOMMENDATIONS



Project ID #8 – Parking Lot Rain Gardens
Drainage Area – 2.5 acres
Location – Industrial land use parking lot
Property Ownership – Private
Description – In addition to curb-cut rain gardens in the road right of way, curb-cut rain gardens can be used to treat stormwater runoff from large parking lot areas. A scenario was modeled where a curb-cut rain garden treated 2.5 acres of contributing impervious surface from parking within an industrial area. Potential locations for these gardens are shown in the map above. Volume and pollutant load reductions resulting from the rain garden installation are highlighted in the table below.

Network Wide Cost/Benefit Analysis (OGC-1 through OGC-9)

	Cost/Benefit Analysis	Project ID					
		8 Curb-cut Rain Garden					
		New trtmt	Net %	New trtmt	Net %	New trtmt	Net %
Treatment	TP (lb/yr)	0.8	10%				
	TSS (lb/yr)	326	13%				
	Volume (acre-feet/yr)	0.6	1%				
	Number of BMP's	1					
	BMP Size/Description	250 sq ft					
	BMP Type	Complex Bioretention					
Cost	Materials/Labor/Design	$5,270					
	Promotion & Admin Costs	$1,750					
	Total Project Cost	**$7,020**					
	Annual O&M*	$75					
	Term Cost/lb-TP/yr	$372					
	Term Cost/1,000lb-TSS/yr	**$948**					

*Includes $75 per garden (2012 dollars)

Additional Retrofit Considerations

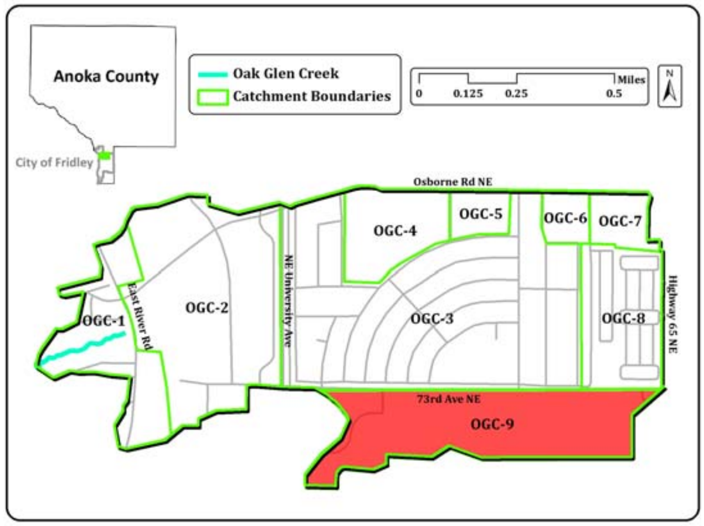
If the retrofits proposed for this catchment are inadequate due to limited landowner participation or if additional treatment is desired, below is a list of other retrofits that could be used in this catchment. However, detailed model and cost estimates were not developed because the practices would be cost prohibitive or provide minimal pollutant reduction relative to the proposed retrofits for this catchment.

- Permeable asphalt
- Tree pit filters
- Underground storage devices

Catchment OGC-9

Existing Catchment Summary*	
Acres	92.67
Dominant Land Cover	Light Industrial
Parcels	12
Volume (acre-feet/yr)	72.08
TP (lb/yr)	58.77
TSS (lb/yr)	33,155

*Excludes network-wide treatment practices



DESCRIPTION

Catchment OGC-9 is positioned along the southern border of the Oak Glen Creek subwatershed. Land use within the catchment is predominantly light industrial. A Target Distribution Center makes up the majority of this light industrial land use. The catchment also has a significant area of undeveloped open space.

EXISTING STORMWATER TREATMENT

The only existing stormwater treatment practice within catchment OGC-9 is street cleaning with a regenerative air street sweeper conducted four times throughout the year (spring, fall, and twice throughout the summer) by the City of Fridley. Stormwater runoff from the catchment flows directly into the stormwater infrastructure and is carried downstream to Oak Glen Creek. The tables below highlight the existing volume and pollutant loading from catchment OGC-9.

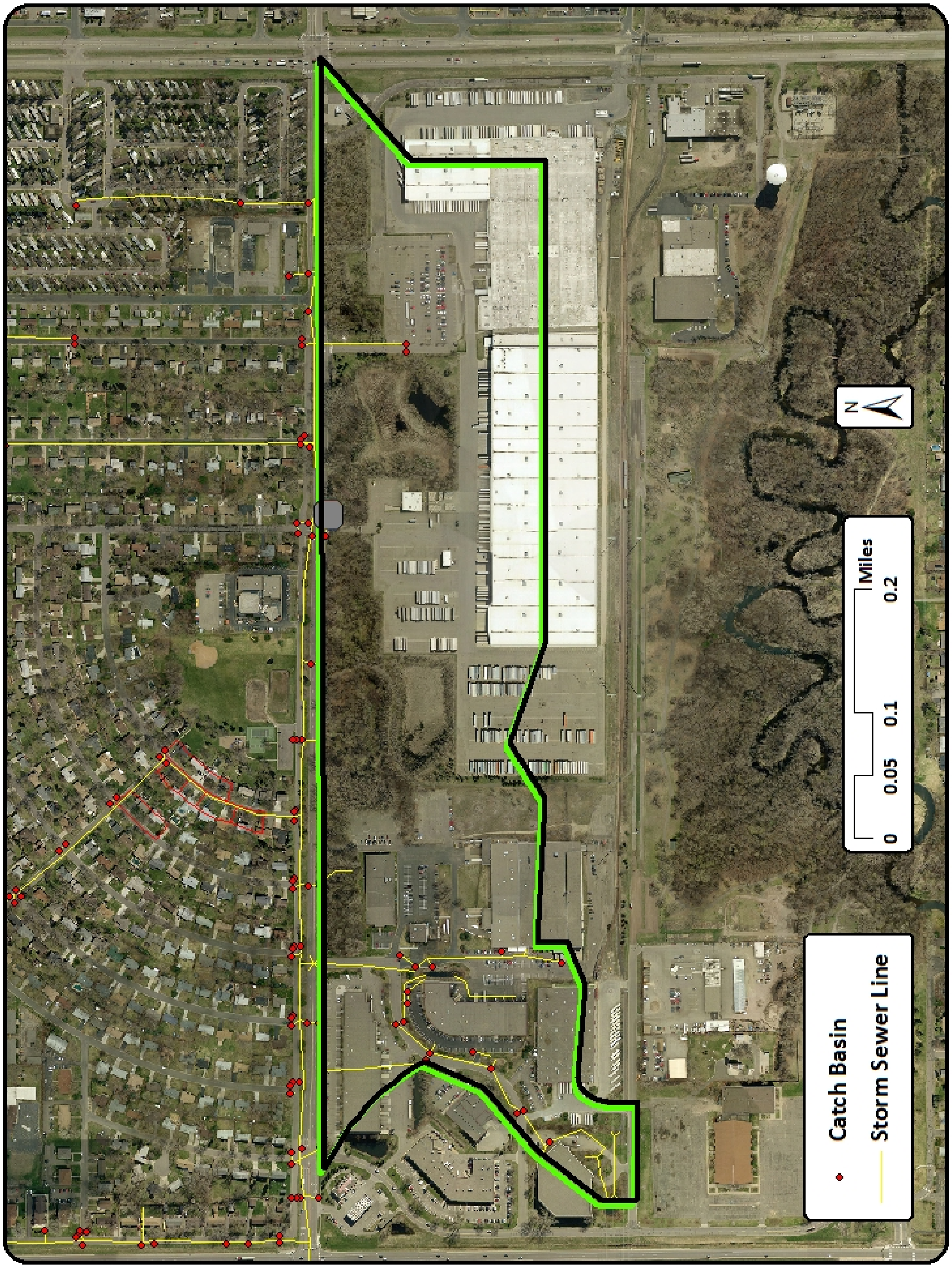
Catchment Specific Existing Conditions

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	60.9	2.1	3%	**58.8**
	TSS (lb/yr)	34,787	1,632.0	5%	**33,155**
	Volume (acre-feet/yr)	72.1	0.0	0%	**72.1**
	Number of BMP's	1			
	BMP Size/Description	Street cleaning			

Network-Wide Existing Conditions (OGC-1 through OGC-9)

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	392.6	39.9	10%	**352.7**
	TSS (lb/yr)	169,612	22,093.0	13%	**147,519**
	Volume (acre-feet/yr)	417.6	2.8	1%	**414.8**
	Number of BMP's	All existing BMPs in catchments OGC-1 through OGC-9			
	BMP Size/Description	Street Cleaning, wet detention ponds, impervious disconnect, and rain gardens			

RETROFIT RECOMMENDATIONS



The large area of open space occupied by Melody Manor Park and the inability to access the Target freight distribution yard resulted in no recommended retrofits within catchment OGC-9. Please note that upon redevelopment or expansion, new retrofit opportunities may arise.

Retrofit Ranking

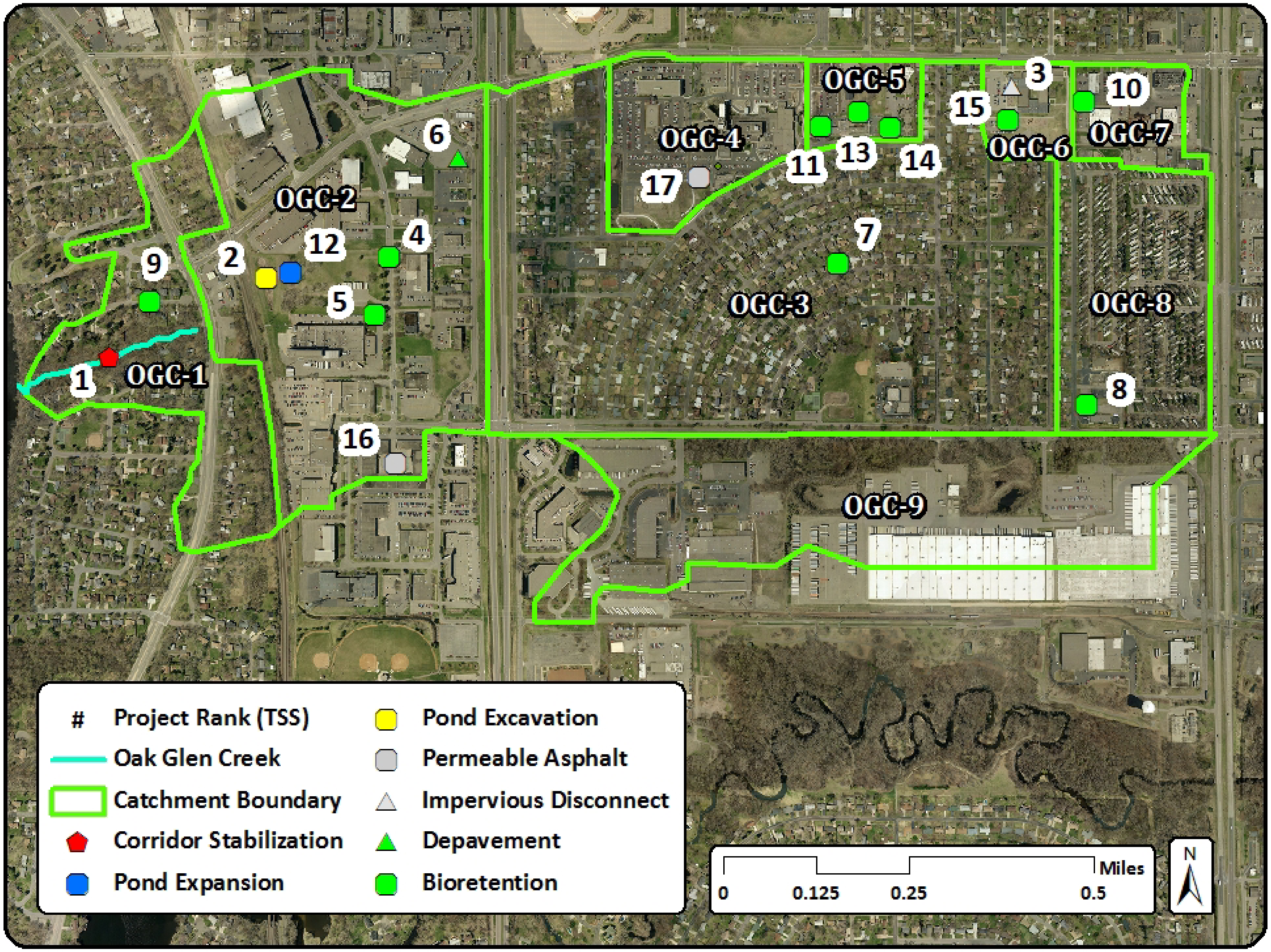
The table on the next page summarizes the assessment results. The benefits of each project were estimated as if that project were installed alone, with no other projects upstream of it in the same catchment. Reported treatment levels are dependent upon optimal siting and sizing. More detail about each project can be found in the catchment profile pages of this report. Projects that were deemed unfeasible due to prohibitive size, number, or were too expensive to justify installation are not included in the table on the next page.

Catchments OGC-1 through OGC-9: Summary of preferred stormwater retrofit opportunities ranked by cost-effectiveness with respect to total suspended solids (TSS) reduction. Volume and total phosphorus (TP) reductions are also shown. For more information on each project refer to the catchment profile pages in this report.

Project Rank	Catchment ID	Retrofit Type (refer to catchment profile pages for additional detail)	Projects Identified	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Total Project Cost	Estimated Annual Operations & Maintenance (2012 Dollars)	Estimated cost/ lb-TP/year (30-year)	Estimated cost/ 1,000lb-TSS/year (30-year)
1	OGC-1	Creek Corridor Stabilization	1	6.3	633,600	0.0	$435,500	$2,217	$2,639	$26
2	OGC-2*	Existing Wet Detention Pond Excavation	1	55.8	32,631	0.0	$62,100 - $77,580	$5,406 - $7,986	$134 - $189	$229 - $324
3	OGC-6	School Parking Lot Disconnect	2	0.4	248	0.7	$950	$75	$267	$430
4	OGC-2*	Industrial Curb-cut Rain Garden Network	3	4.0	1,327	2.3	$17,700	$225	$204	$614
5	OGC-2*	Industrial Parking Lot Rain Garden	1	0.8	449	0.7	$7,020	$75	$386	$688
6	OGC-2*	Industrial Parking Lot Depavement	1	1.1	956	1.4	$17,696	$75	$604	$695
7	OGC-3	Residential Curb-cut Rain Garden Network	5 - 20	8.9 - 26.4	1,564 - 5,094	3.7 - 12.6	$28,380 - $108,480	$375 - $1,500	$148 - $194	$845 - $1,004
8	OGC-8	Industrial Parking Lot Rain Garden	1	0.8	326	0.6	$7,020	$75	$372	$948
9	OGC-1	Residential Curb-cut Rain Garden Network	3 - 9	4.8 - 10.4	856 - 2,117	2.1 - 5.3	$17,700 - $49,740	$225 - $675	$170 - $224	$952 - $1,102
10	OGC-7	Industrial Parking Lot Rain Garden	1	0.8	321	0.6	$7,020	$75	$401	$963
11	OGC-5	Office Park Parking Lot Rain Garden	1	0.9	363	0.8	$11,520	$75	$510	$1,264
12	OGC-2*	Existing Wet Detention Pond Expansion	1	38.8	22,736	0.0	$750,220	$10,593	$918	$1,566
13	OGC-5	Hospital and High-rise Residential Parking Lot Rain Garden	1	0.5-0.6	245 - 328	0.7 - 0.9	$11,520 - $20,520	$75	$918 - $1,265	$1,873 - $2,314
14	OGC-5	High-rise Residential Parking Lot Rain Garden	1	0.6	163	0.5	$7,020	$75	$515	$1,896
15	OGC-6	School Parking Lot Rain Garden	1	0.3	139	0.4	$7,020	$75	$1,030	$2,223
16	OGC-2	Industrial Parking Lot Permeable Asphalt	1	3.1	2,692	3.9	$307,370	$701	$3,531	$4,066
17	OGC-4	Hospital Parking Lot Permeable Asphalt	1	1.7	865	4.2	$329,150	$751	$6,896	$13,553

* Pollution reduction benefits and costs can not be summed with other projects in the same catchment because they are alternative options for treating the same source area.

Map of stormwater catchment areas (OGC-1 through OGC-9) and potential retrofit projects referred to in this report. The numbers next to each potential project represent ranking with respect to the cost per thousand pounds of total suspended solids (TSS) removed per year. Catchment profiles on the following pages provide additional detail.



References

Minnesota Stormwater Steering Committee. 2005. *Minnesota Stormwater Manual.* Minnesota Pollution Control Agency. St. Paul, MN.

Schueler et. al. 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 et. al. 2007. *Urban Stormwater Retrofit Practices. Manual 3, Urban Subwatershed Restoration Manual Series. Center for Watershed Protection*. Ellicott City, MD.

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Appendix A – Rain Garden Concept Designs

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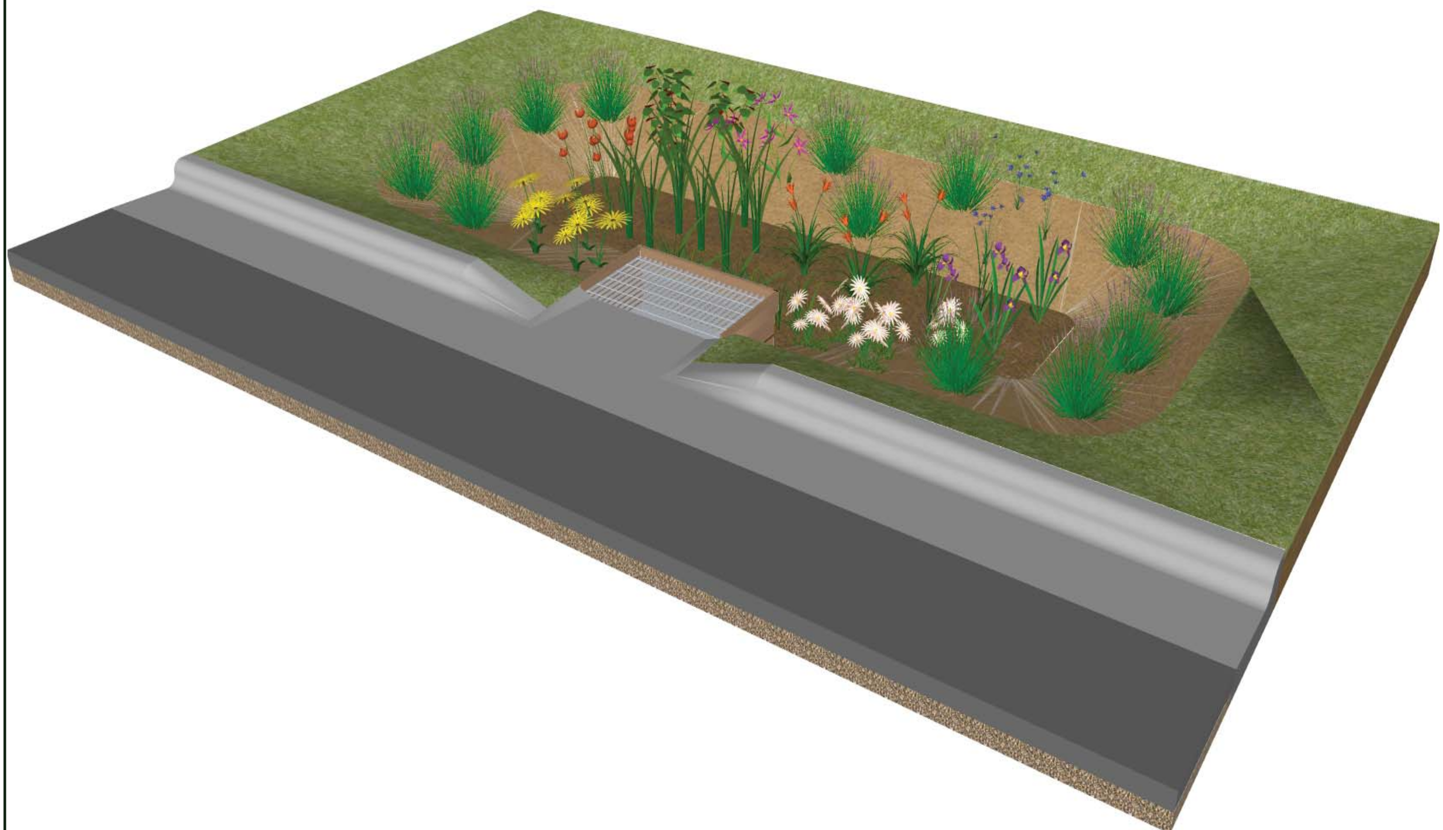
ANOKA COUNTY CURB-CUT RAINGARDENS



Drawing rainwater from the street gutter reduces runoff and pollutants to local water bodies

Prepared by the Anoka Conservation District in association with
the Metropolitan Conservation Districts

URBAN RAINWATER: SLOW IT DOWN AND SOAK IT UP

Under natural conditions the majority of rainwater falling on Anoka County would infiltrate the soil surface to be absorbed by plants or percolate more deeply into the soil to feed groundwater recharge and provide steady base-flow to streams and rivers. As land development has expanded more and more land is covered with impervious surfaces such as roads, parking lots and buildings. This conversion from native vegetation to impervious structure has greatly altered the hydrologic cycle and surface water ecology by greatly increasing runoff rates and effectively washing nutrient laden sediments and other pollutants into local surface waters. Treating and infiltrating urban rainwater as close to the point where it falls as possible is recognized as a vital and effective method for augmenting groundwater resources and reducing surface water quality impacts.

In dense residential ***sub-watersheds*** there is limited suitable public land on which to treat and infiltrate rainwater. In these situations utilizing private land and easements along roadways for treatment becomes an important tool for improving water quality. The curb and gutter system that channels rainwater quickly from your neighborhood can be disconnected with a ***curb-cut*** that directs rainwater from the street into a depressed ***raingarden***. This allows rainwater falling within the catchment area of the raingarden to return to the natural hydrologic cycle of ***infiltration*** and ***evapotranspiration***, effectively reducing downstream flooding, erosion and ***non-point source pollution***. An individual curb-cut raingarden may only mitigate for a small portion of urban runoff, however the treating the rainwater runoff close to its source is an essential strategy in hydrologic restoration and cumulatively curb-cut gardens can actualize significant benefits within an urbanized ***sub-watershed***.

The Anoka Conservation District has designed a set of curb-cut raingardens that can be applied to the physical conditions of your property and to your preference of garden shapes and plant selections. Each garden is designed to provide a water storage capacity of 100 cubic feet. Anoka Conservation

Photo by Rusty Schmidt

District has also designed a modular pretreatment box to be placed at the raingarden inlet to capture sediment and debris prior to water entering the garden. This pretreatment box is a vital component to the longevity and functionality of your raingarden.

Please utilize the key on page 4 to determine the basic design needs of your property and continue to the designated page to select your choice of plant palettes. Plant images are shown of pages 20 and 21.

curb-cut: A section of curb and gutter that has been reconstructed to convey stormwater into a filter strip, rain garden, or other stormwater management strategy.

evapotranspiration: The transfer of liquid water from the earth's surface to atmospheric water vapor as result of transpiration by plants and evaporation by solar energy and diffusion. Evapotranspiration can constitute a significant water "loss" from a watershed.

infiltration: Water moving through a permeable soil surface by the force of gravity and soil capillary action. The rate of infiltration is highly dependent on soil type. Infiltration rates within the Anoka Sand Plain are generally very high.

non-point source pollution: Rainwater runoff that has accumulated pollutant loads (nutrients, sediments, petrochemicals etc.) over a large dispersed area. As opposed to point source pollution that has a defined single source.

raingarden: A landscaped garden in a shallow depression that receives rainwater runoff from nearby impervious surfaces such as roofs, parking lots or streets. The purpose of a raingarden is to reduce peak runoff flows, increase groundwater recharge and improve water quality in our lakes, streams and wetlands. Peak flow reduction is achieved by temporarily staging runoff within the raingarden basin until it infiltrates into the soil surface or evaporates (typically within 24 hours). This process also increases the quantity and movement of soil water that may feed groundwater recharge. Infiltrated water quality is improved by reducing sediment, nutrient and other chemical pollutant loads through chemical and biological processes in the soil. Downstream water quality is improved in kind by offsetting erosive peak flows and by capturing and treating pollutants higher in the watershed.

sub-watersheds: A discreet portion of a larger watershed, typically less than 2500 acres. Sub-watersheds can be more effectively analyzed and managed for water quality with site scale treatments.

CHOOSE YOUR RAINGARDEN DESIGN

1

Property rises less than 1 foot above the top of curb height within 16 feet of the curb → Retaining not needed

Property rises greater than 1 foot above the curb height within 16 feet of the curb → Retaining wall needed

2

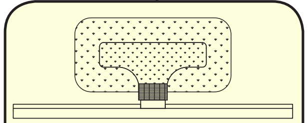
Retaining not needed:

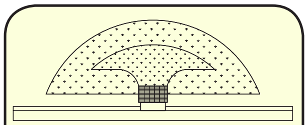
- Garden site recieves greater than 4 hours of full sun between 10 am and 4 pm → Sun garden
- Garden site recieves less than 4 hours of full sun between 10 am and 4 pm → Shade garden

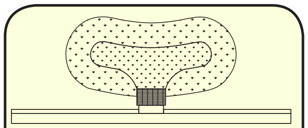
Retaining wall needed:

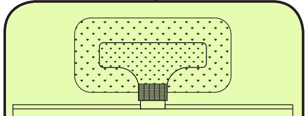
- Garden site recieves greater than 4 hours of full sun between 10 am and 4 pm → Sun garden
- Garden site recieves less than 4 hours of full sun between 10 am and 4 pm → Shade garden

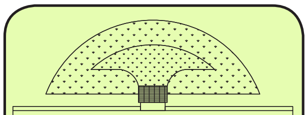
3

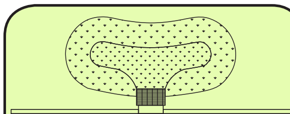

I. Rectangle
Sun, No Wall
pg. 8

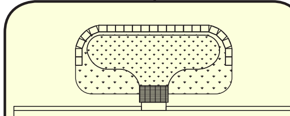

II. Arc
Sun, No Wall
pg. 9

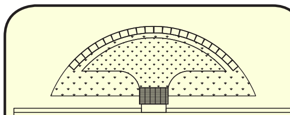

III. Curvilinear
Sun, No Wall
pg. 10

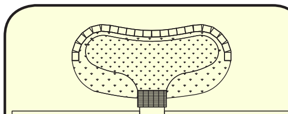

IV. Rectangle
Shade, No Wall
pg. 11

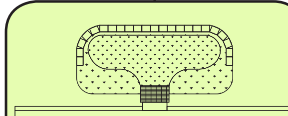

V. Arc
Shade, No Wall
pg. 12

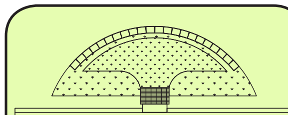

VI. Curvilinear
Shade, No Wall
pg. 13

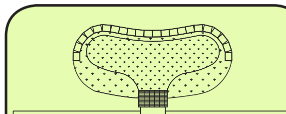

VII. Rectangle
Sun, with Wall
pg. 14


VIII. Arc
Sun, with Wall
pg. 15

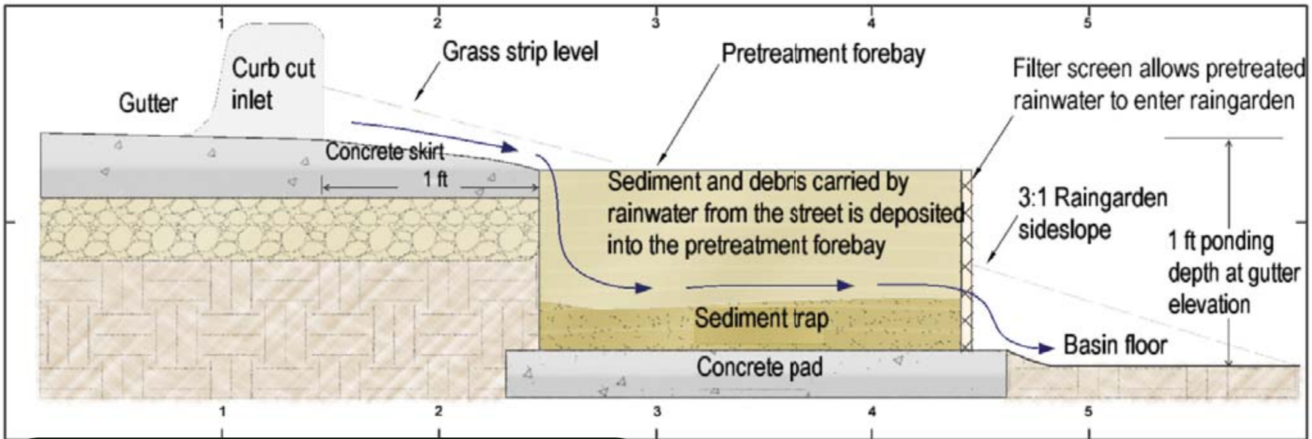

IX. Curvilinear
Sun, with Wall
pg. 16


X. Rectangle
Shade, with Wall
pg. 17

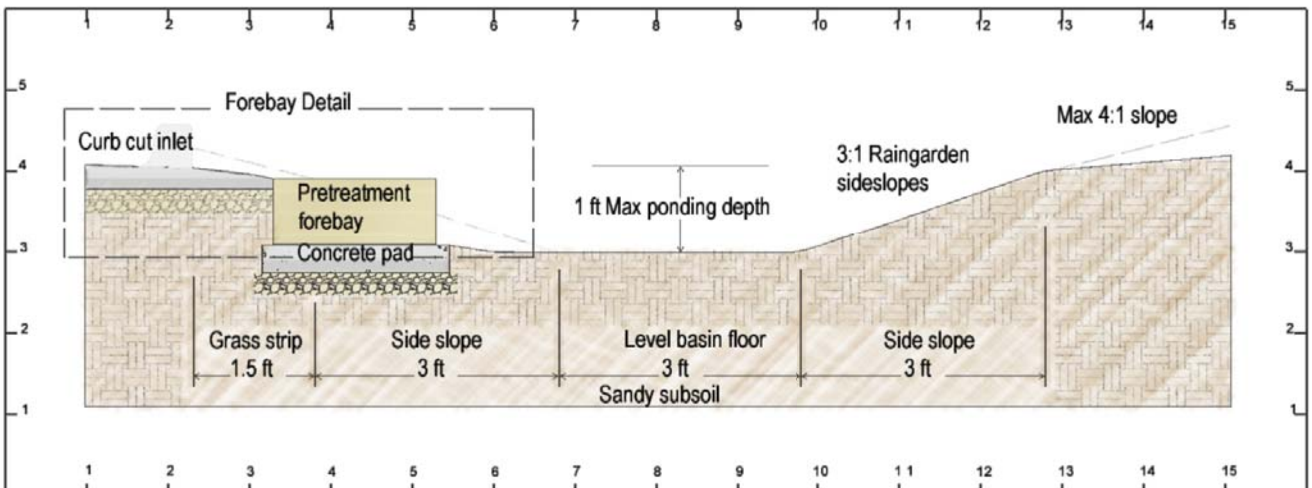

XI. Arc
Shade, with Wall
pg. 18


XII. Curvilinear
Shade, With Wall
pg. 19

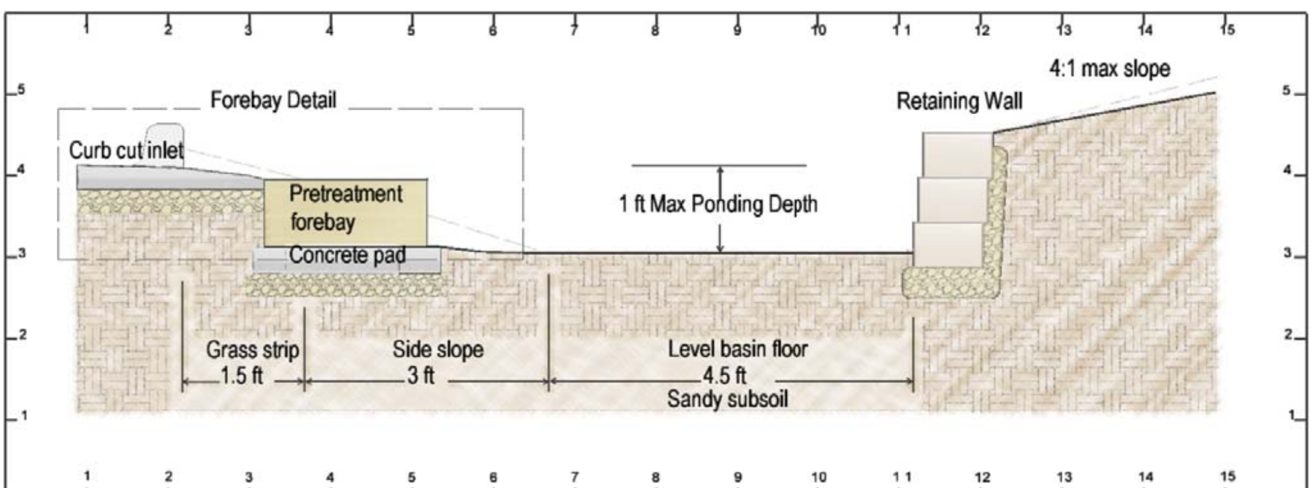
ANATOMY OF A CURB-CUT RAINGARDEN



PRETREATMENT FOREBAY

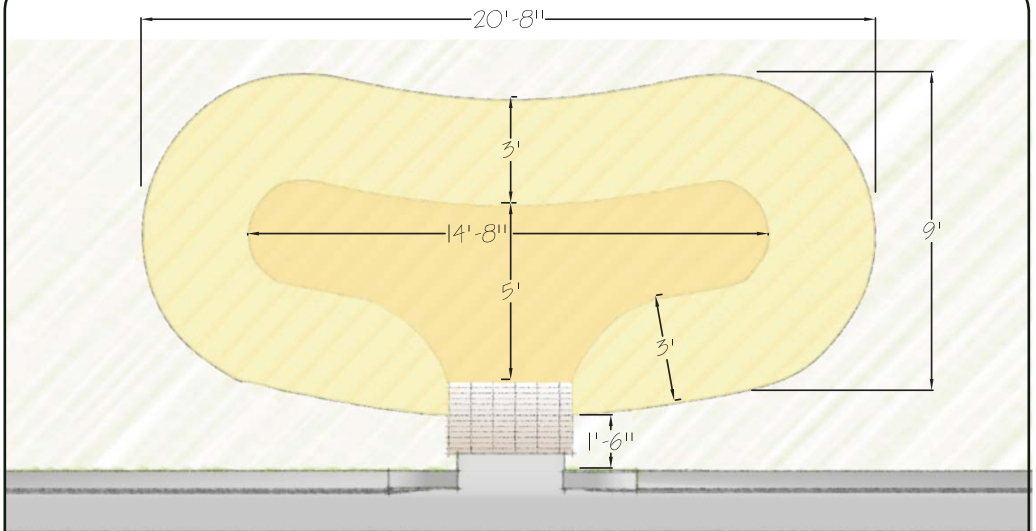


RAINGARDEN WITHOUT RETAINMENT

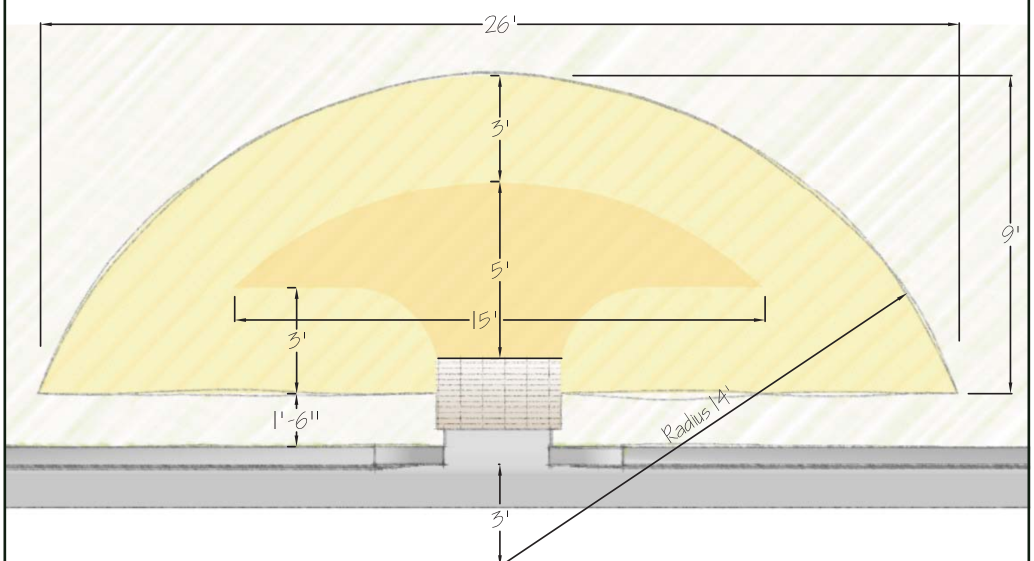


RAINGARDEN WITH RETAINING WALL

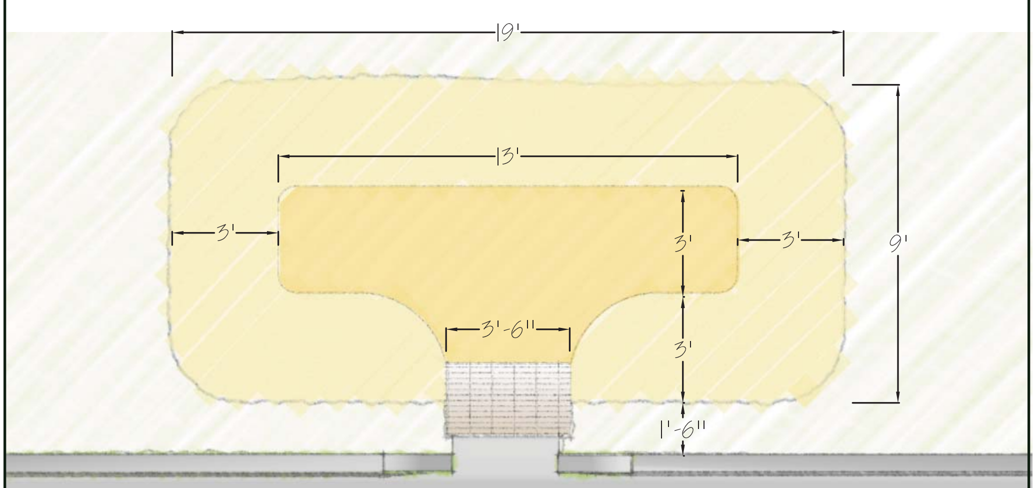
Raingarden Dimensions without a Retaining Wall



Curvilinear Garden



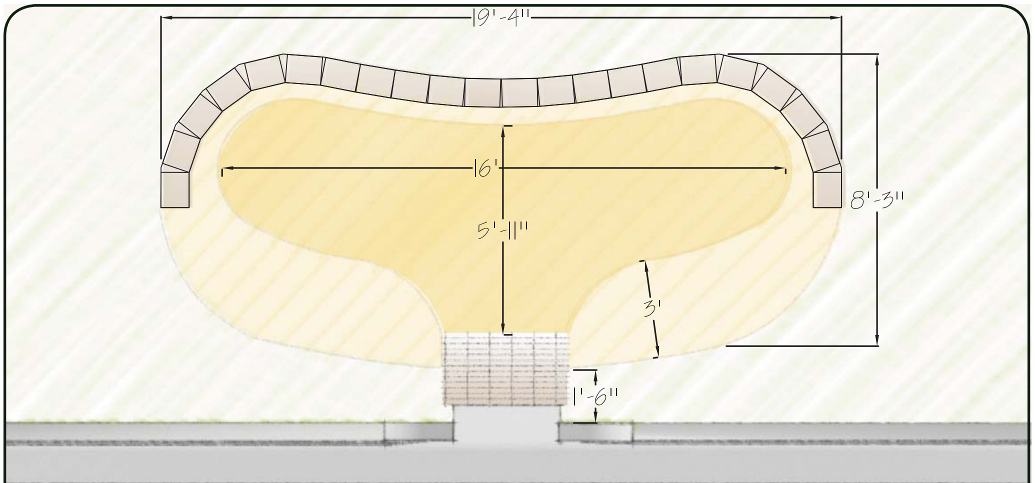
Arc Garden

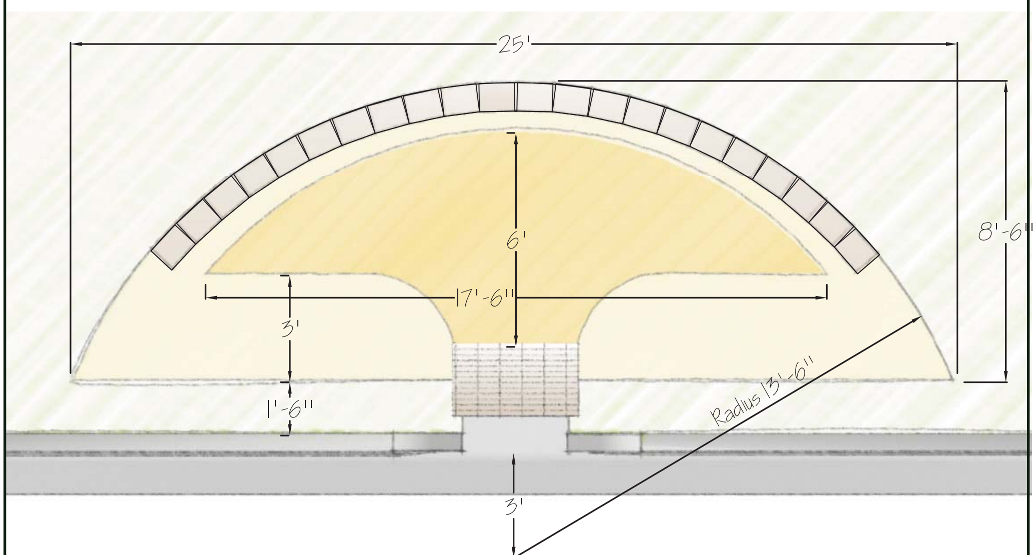


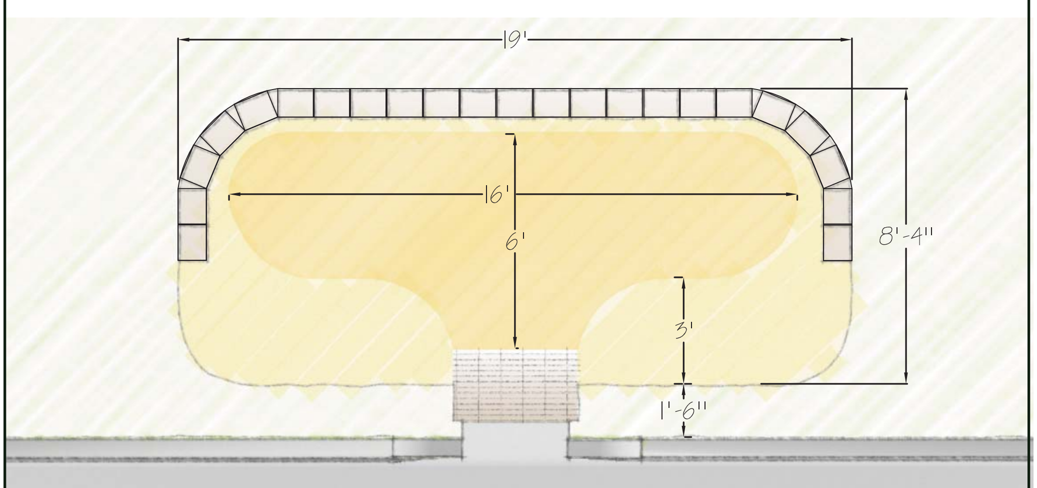
Rectangle Garden

The dimensions given are the minimum dimensions needed to achieve the storage volume required by this stormwater retrofit program. The level basin floor needs to be set 1 foot below the gutter elevation. The entire planting area should be covered with 3 inches of shredded hardwood mulch.

Raingarden Dimensions with a Retaining Wall

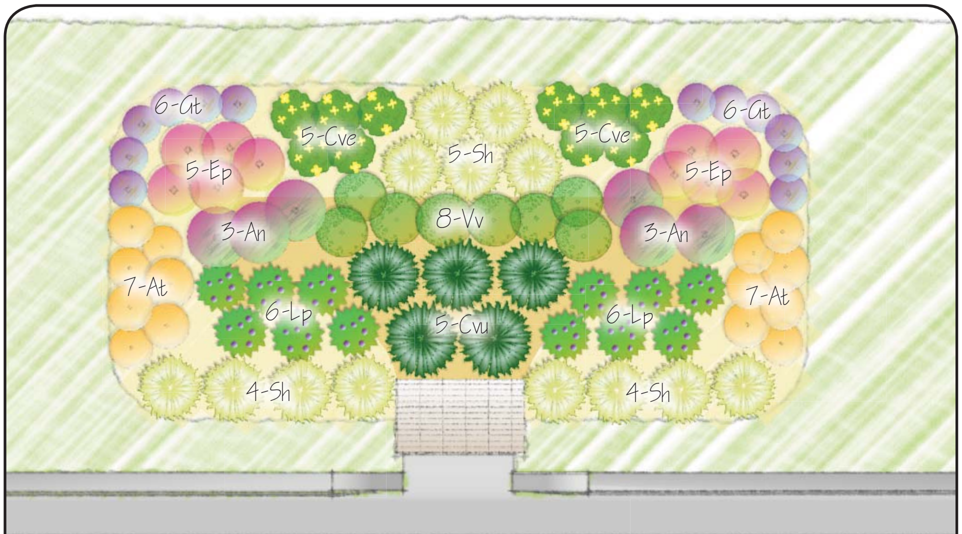




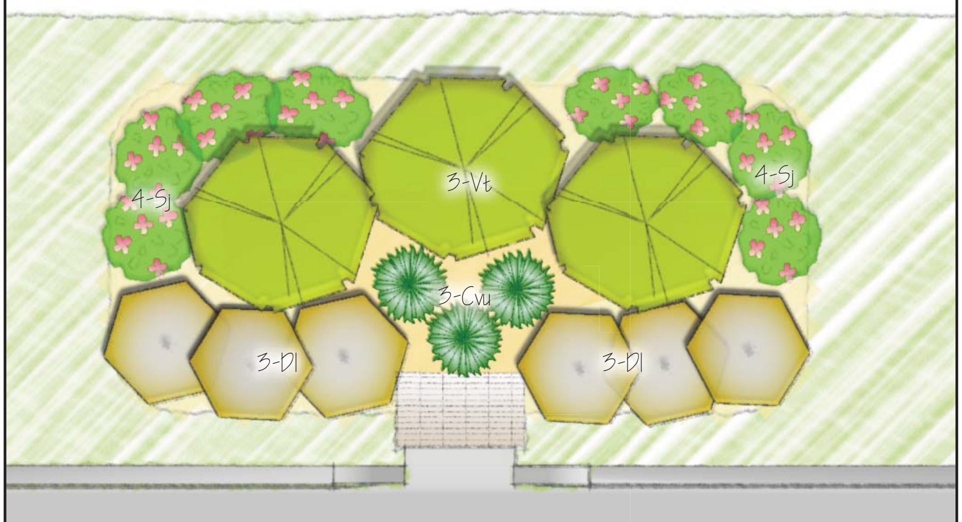


The dimensions given are the minimum dimensions needed to achieve the storage volume required by this stormwater retrofit program. The level basin floor needs to be set 1 foot below the gutter elevation. The entire planting area should be covered with 3 inches of shredded hardwood mulch.

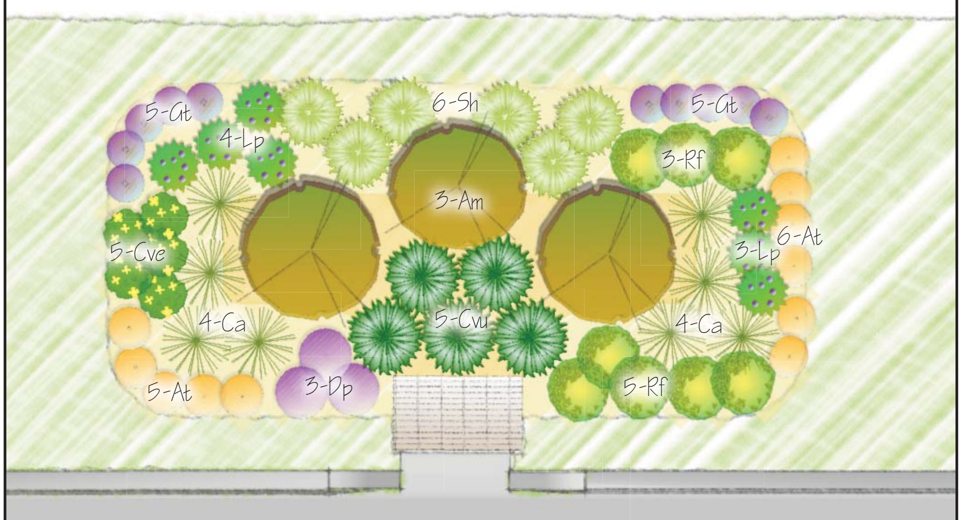
I. Rectangle Garden - Sunny Site - No Retaining Wall



Flowering Perennial Garden



Shrub Garden

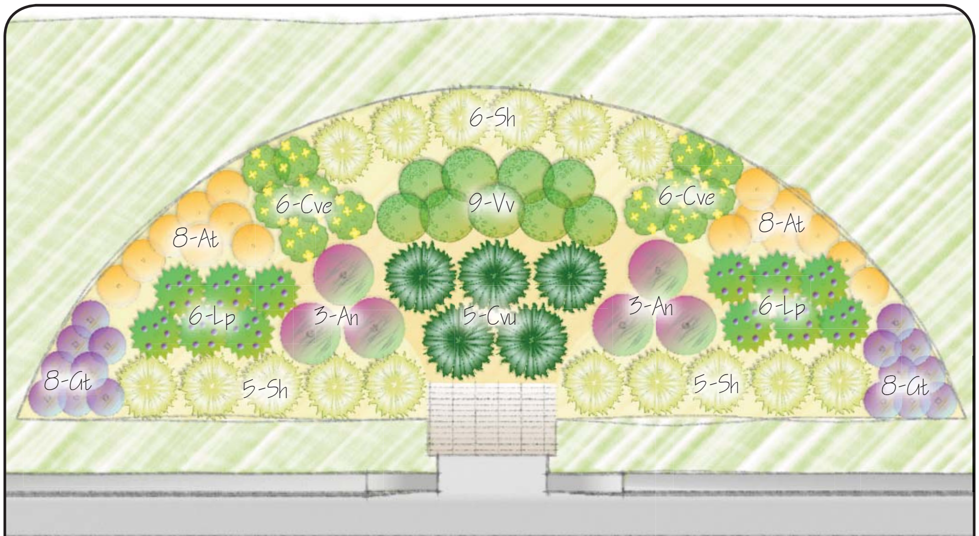


Mixed Shrub/Flower Garden

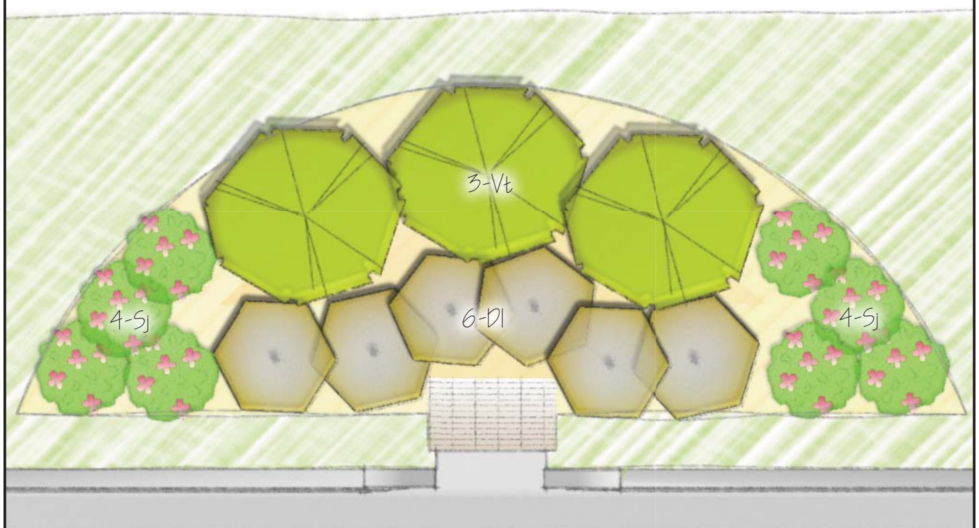
Plant Key

Am	BLACK CHOKEBERRY *Aronia melonocarpa*
At	BUTTERFLY MILKWEED *Asclepias tuberosa*
An	ASTER 'PURPLE DOME' *Aster novae-angliae 'Purple Dome'*
Ca	KARL FORESTER GRASS *Calamagrostis acutifolia*
Cvu	FOX SEDGE *Carex vulpinoidea*
Cve	COREOPSIS 'MOONBEAM' *Coreopsis verticillata 'Moonbeam'*
Dp	PURPLE PRARIE CLOVER *Dalea purpurea*
Dl	DWARF BUSH HONEYSUCKLE *Diervilla lonicera*
Ep	PURPLE CONEFLOWER *Echinacea purpurea*
Gt	PRAIRIE SMOKE *Geum trifolium*
Lp	PRAIRIE BLAZING STAR *Liatris pycnostachya*
Rf	GOLDSTRUM BLACK-EYED SUSAN *Rudbeckia fulgida*
Sj	DART'S RED SPIRAEA *Spiraea japonica*
Sh	PRAIRIE DROPSEED *Sporobolis heterolepsis*
Vv	CULVERS ROOT *Veronicastrum virginicum*
Vt	CRANBERRYBUSH VIBURNUM *Viburnum trilobum 'compactum'*

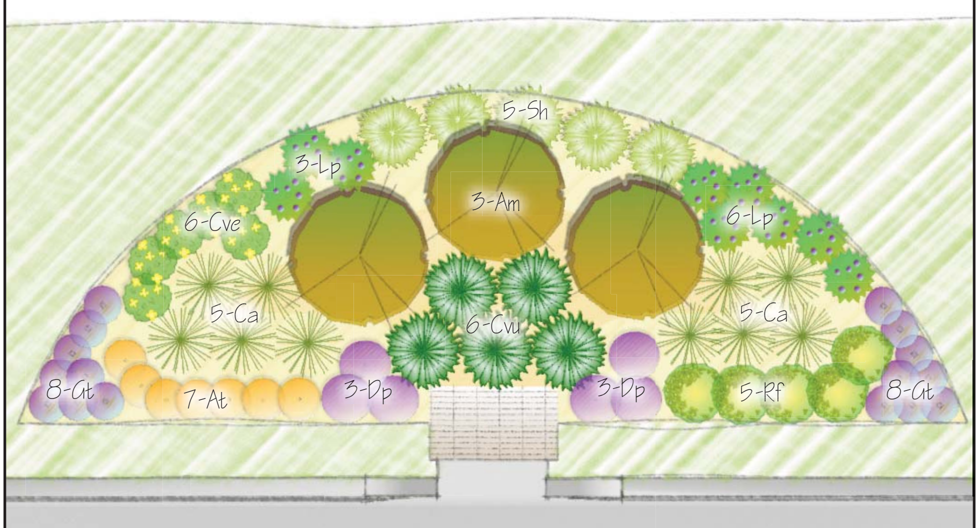
II. Arc Garden - Sunny Site - No Retaining Wall



Flowering Perennial Garden



Shrub Garden

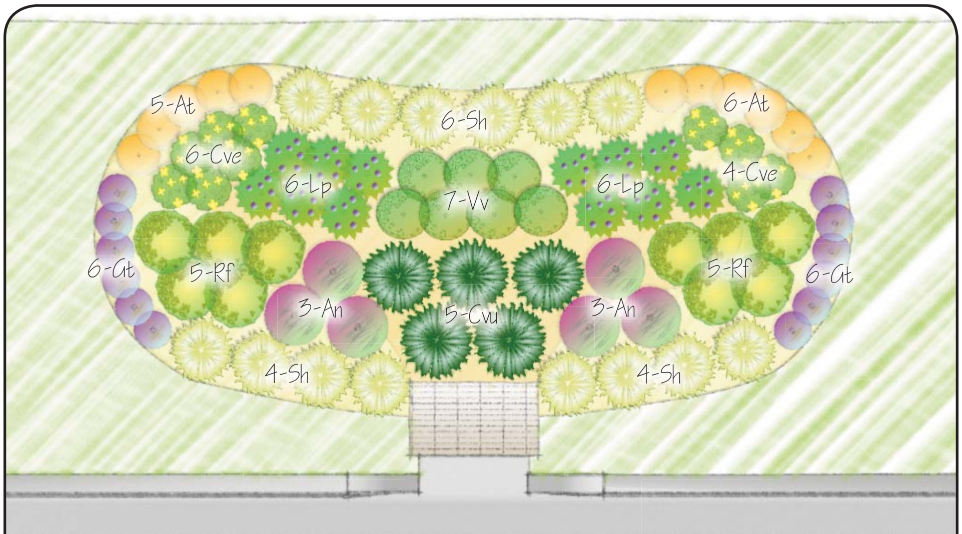


Mixed Shrub/Flower Garden

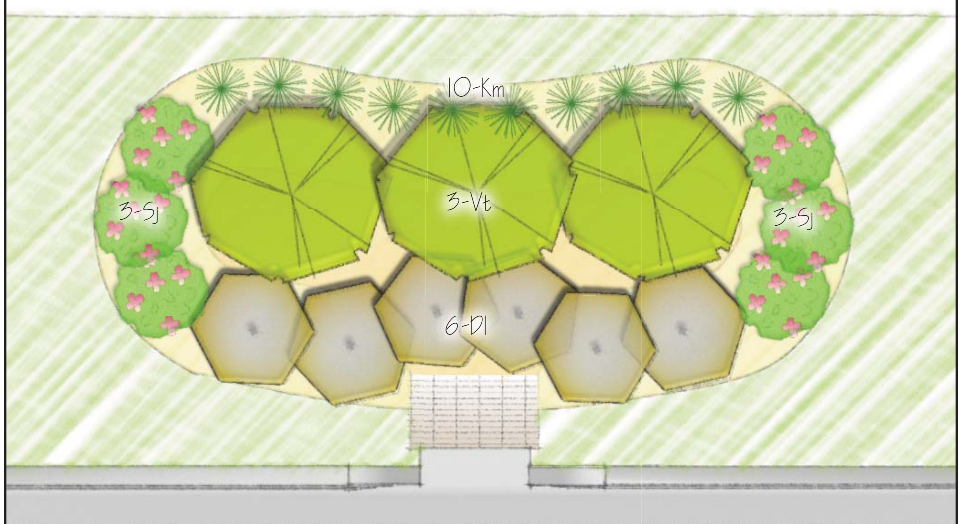
Plant Key

- Am — BLACK CHOKEBERRY, *Aronia melonocarpa*
- At — BUTTERFLY MILKWEED, *Asclepias tuberosa*
- An — ASTER 'PURPLE DOME', *Aster novae-angliae 'Purple Dome'*
- Ca — KARL FORESTER GRASS, *Calamagrostis acutifolia*
- Cvu — FOX SEDGE, *Carex vulpinoidea*
- Cve — COREOPSIS 'MOONBEAM', *Coreopsis verticillata 'Moonbeam'*
- Dp — PURPLE PRARIE CLOVER, *Dalea purpurea*
- Dl — DWARF BUSH HONEYSUCKLE, *Diervilla lonicera*
- Ep — PURPLE CONEFLOWER, *Echinacea purpurea*
- Gt — PRAIRIE SMOKE, *Geum trifolium*
- Lp — PRAIRIE BLAZING STAR, *Liatris pycnostachya*
- Rf — GOLDSTRUM BLACK-EYED SUSAN, *Rudbeckia fulgida*
- Sj — DART'S RED SPIRAEA, *Spiraea japonica*
- Sh — PRAIRIE DROPSEED, *Sporobolis heterolepsis*
- Vv — CULVERS ROOT, *Veronicastrum virginicum*
- Vt — CRANBERRYBUSH VIBURNUM, *Viburnum trilobum 'compactum'*

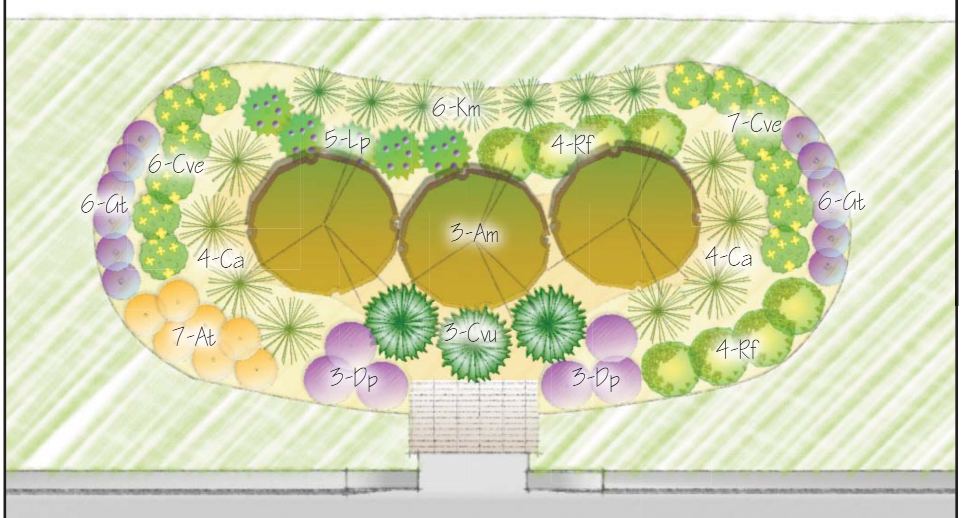
III. Curvilinear Garden - Sunny Site - No Retaining Wall



Flowering Perennial Garden



Shrub Garden

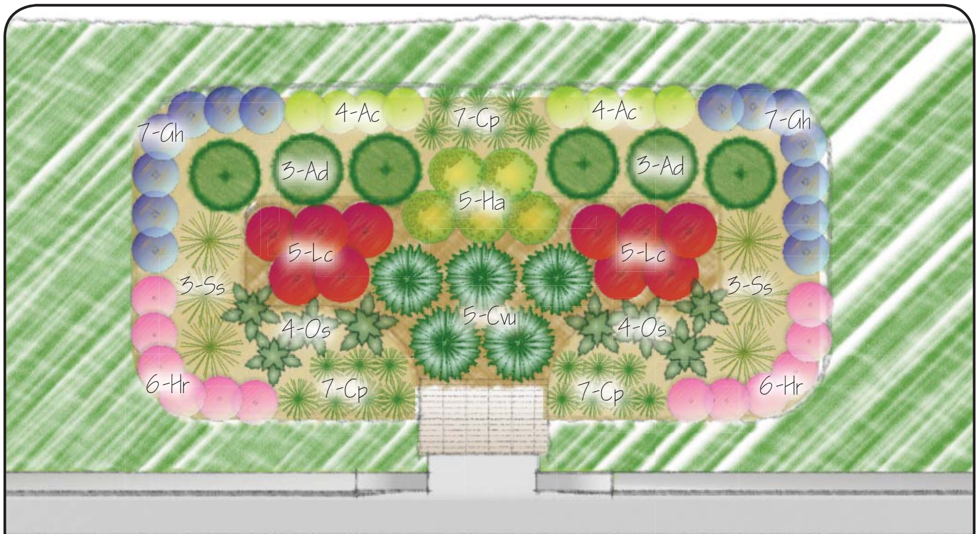


Mixed Shrub/Flower Garden

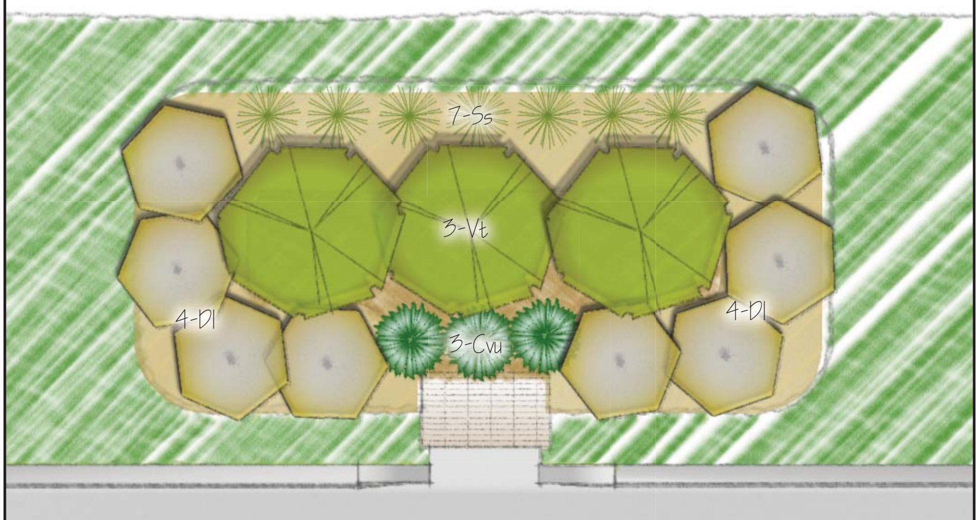
Plant Key

- **Am** — BLACK CHOKEBERRY, *Aronia melonocarpa*
- **At** — BUTTERFLY MILKWEED, *Asclepias tuberosa*
- **An** — ASTER 'PURPLE DOME', *Aster novae-angliae 'Purple Dome'*
- **Ca** — KARL FORESTER GRASS, *Calamagrostis acutifolia*
- **Cvu** — FOX SEDGE, *Carex vulpinoidea*
- **Cvu** — COREOPSIS 'MOONBEAM', *Coreopsis verticillata 'Moonbeam'*
- **Dp** — PURPLE PRARIE CLOVER, *Dalea purpurea*
- **Dl** — DWARF BUSH HONEYSUCKLE, *Diervilla lonicera*
- **Gt** — PRAIRIE SMOKE, *Geum trifolium*
- **Km** — JUNE GRASS, *Koeleria macrantha*
- **Lp** — PRAIRIE BLAZING STAR, *Liatris pycnostachya*
- **Rf** — GOLDSTRUM BLACK-EYED SUSAN, *Rudbeckia fulgida*
- **Sj** — DART'S RED SPIRAEA, *Spiraea japonica*
- **Sh** — PRAIRIE DROPSEED, *Sporobolis heterolepsis*
- **Vv** — CULVERS ROOT, *Veronicastrum virginicum*
- **Vt** — CRANBERRYBUSH VIBURNUM, *Viburnum trilobum 'compactum'*

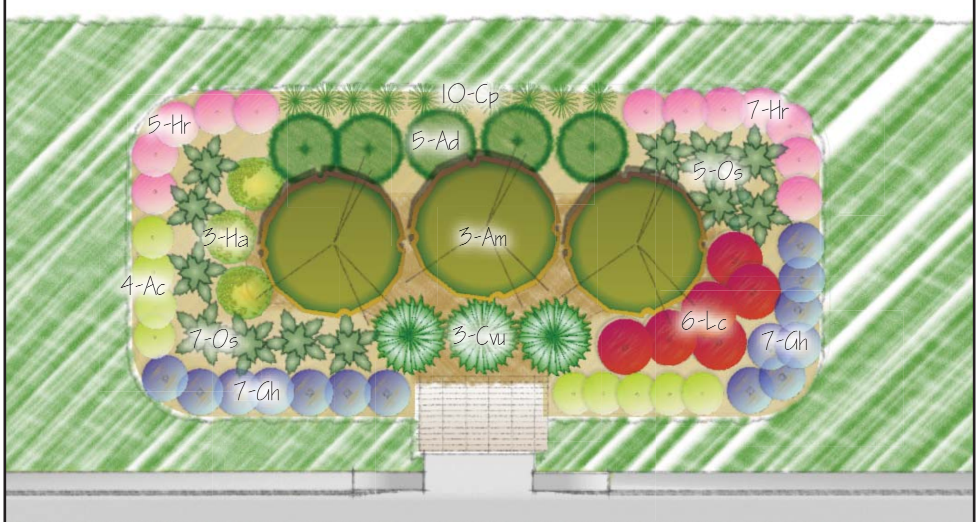
IV. Rectangle Garden - Shady Site - No Retaining Wall



Flowering Perennial Garden



Shrub Garden

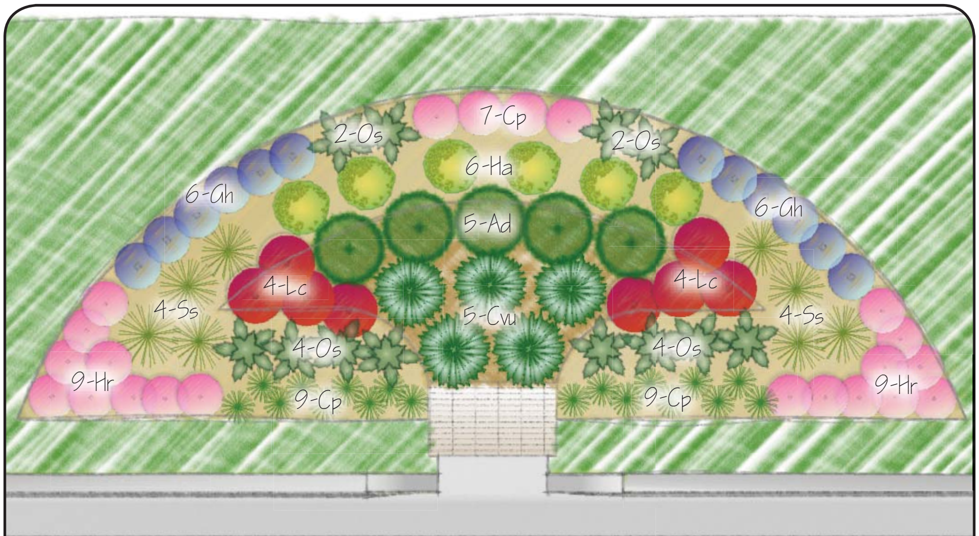


Mixed Shrub/Flower Garden

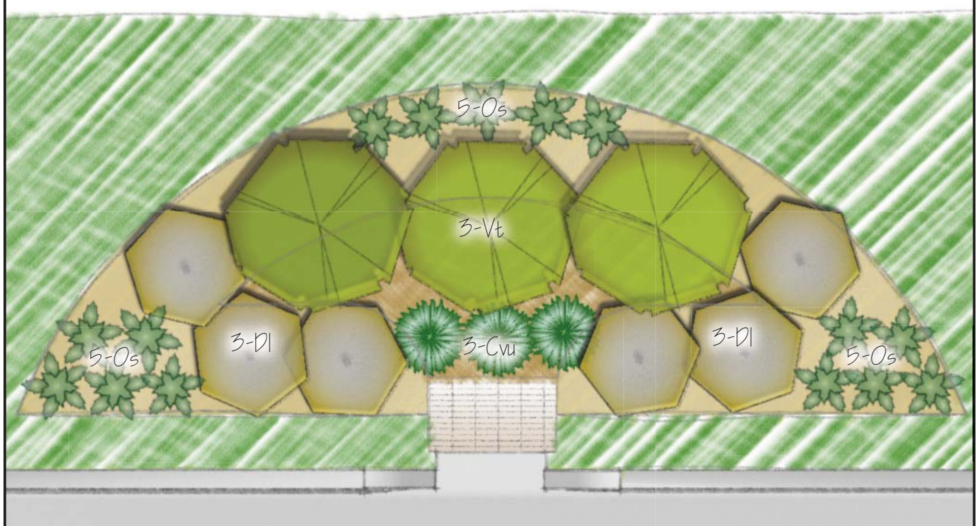
Plant Key

Am	BLACK CHOKEBERRY *Aronia melonocarpa*
Ac	CANADA ANEMONE *Anemone canadensis*
Ad	GOAT'S BEARD *Aruncus diocius*
Cp	PENNSYLVANIA SEDGE *Carex pennsylvanica*
Cvu	FOX SEDGE *Carex vulpinoidea*
Dl	DWARF BUSH HONEYSUCKLE *Diervilla lonicera*
Gh	GERANIUM 'JOHNSON BLUE' *Geranium himalayense x pratense*
Ha	SNEEZEWEED *Helenium autumnale*
Hr	ALUMROOT *Heuchera richardsonii*
Lc	CARDINAL FLOWER *Lobelia cardinalis*
Os	SENSITIVE FERN *Onoclea sensibilis*
Ss	LITTLE BLUESTEM *Schizachyrium scoparium*
Vt	CRANBERRYBUSH VIBURNUM *Viburnum trilobum 'compactum'*

V. Arc Garden - Shady Site - No Retaining Wall



Flowering Perennial Garden



Shrub Garden

Mixed Shrub/Flower Garden

Plant Key

Am	BLACK CHOKEBERRY	*Aronia melonocarpa*
Ac	CANADA ANEMONE	*Anemone canadensis*
Ad	GOAT'S BEARD	*Aruncus diocius*
Cp	PENNSYLVANIA SEDGE	*Carex pennsylvanica*
Cvu	FOX SEDGE	*Carex vulpinoidea*
Dl	DWARF BUSH HONEYSUCKLE	*Diervilla lonicera*
Ss	LITTLE BLUESTEM	*Schizachyrium scoparium*
Gh	GERANIUM 'JOHNSON BLUE'	*Geranium himalayense x pratense*
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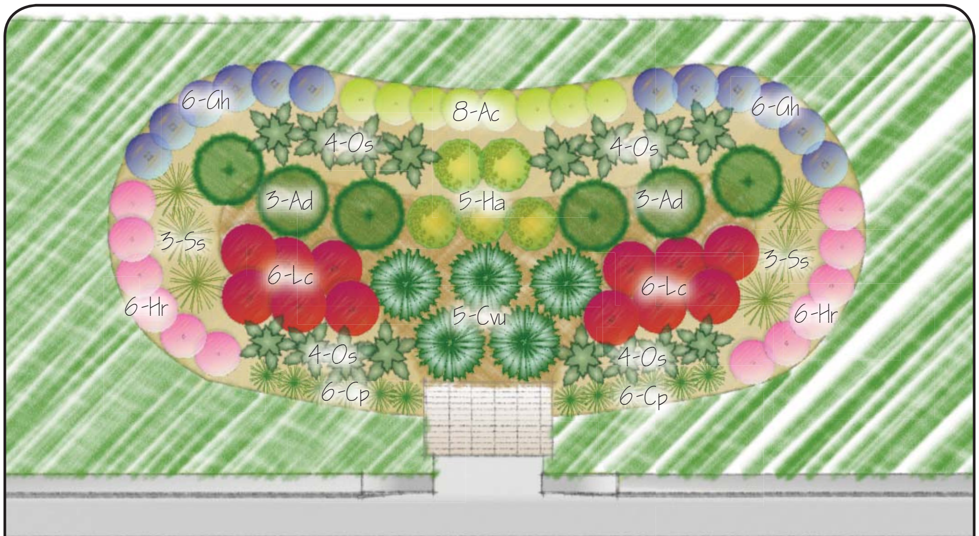
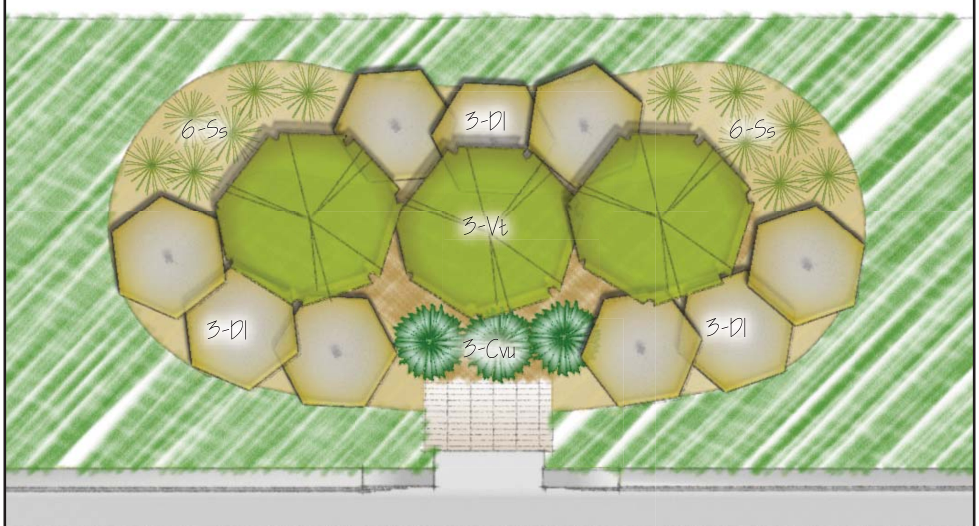
Lc	CARDINAL FLOWER	*Lobelia cardinalis*
Os	SENSITIVE FERN	*Onoclea sensibilis*
Vt	CRANBERRYBUSH VIBURNUM	*Viburnum trilobum 'compactum'*

VI. Curvilinear Garden - Shady Site - No Retaining Wall



Flowering Perennial Garden



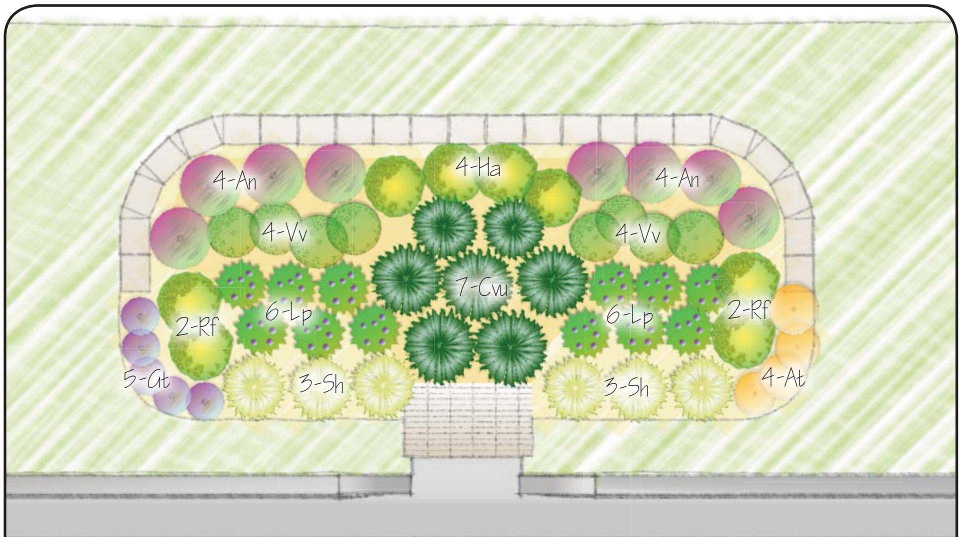
Shrub Garden

Mixed Shrub/Flower Garden

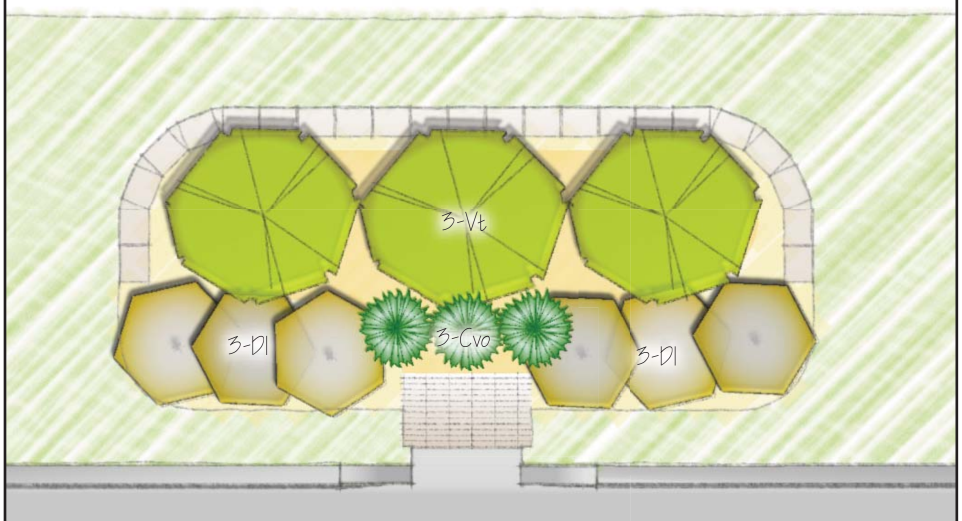
Plant Key

Am	BLACK CHOKEBERRY *Aronia melonocarpa*
Ac	CANADA ANEMONE *Anemone canadensis*
Ad	GOAT'S BEARD *Aruncus diocius*
Cp	PENNSYLVANIA SEDGE *Carex pennsylvanica*
Cvu	FOX SEDGE *Carex vulpinoidea*
Dl	DWARF BUSH HONEYSUCKLE *Diervilla lonicera*
Gh	GERANIUM 'JOHNSON BLUE' *Geranium himalayense x pratense*
Ha	SNEEZEWEED *Helenium autumnale*
Hr	ALUMROOT *Heuchera richardsonii*
Lc	CARDINAL FLOWER *Lobelia cardinalis*
Os	SENSITIVE FERN *Onoclea sensibilis*
Ss	LITTLE BLUESTEM *Schizachyrium scoparium*
Vt	CRANBERRYBUSH VIBURNUM *Viburnum trilobum 'compactum'*

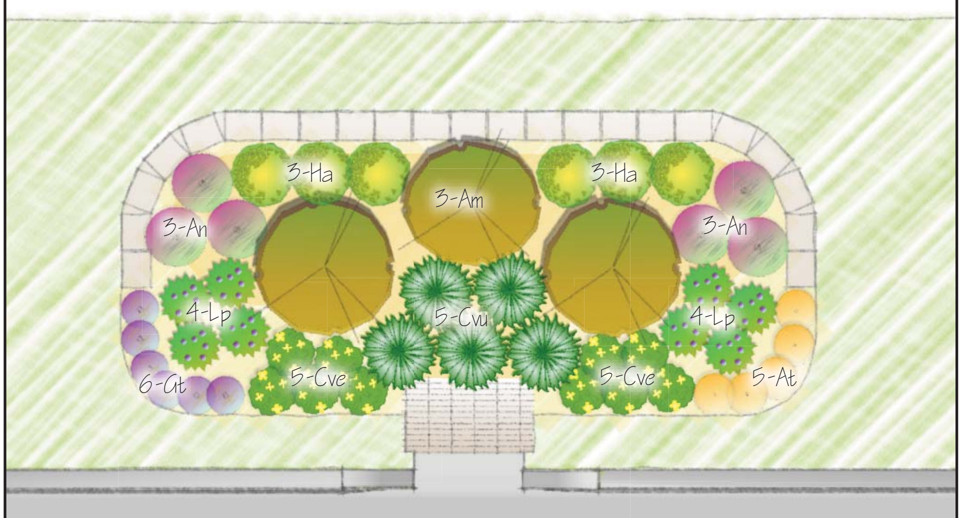
VII. Rectangle Ga rden - Sunny Site - Retaining Wall



Flowering Perennial Garden



Shrub Garden

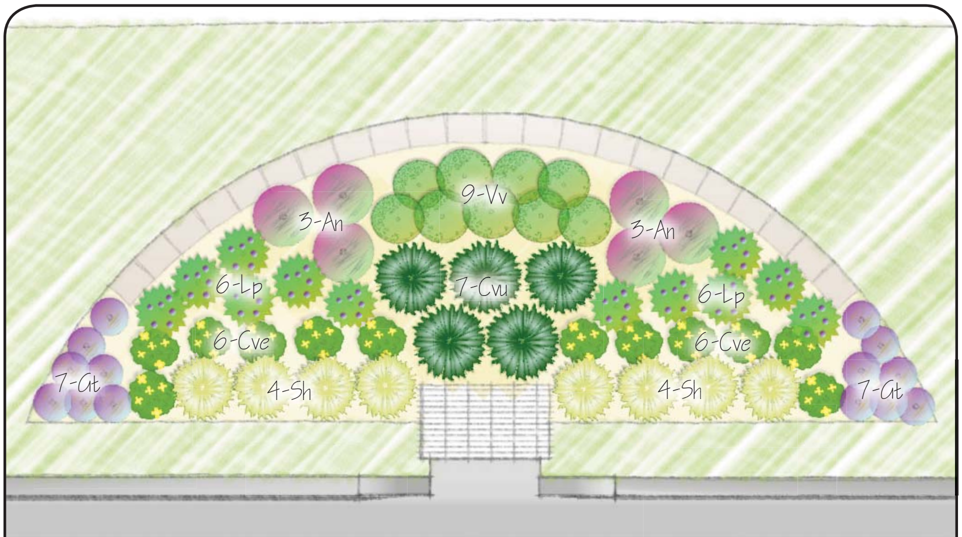


Mixed Shrub/Flower Garden

Plant Key

Am	BLACK CHOKEBERRY *Aronia melonocarpa*
At	BUTTERFLY MILKWEED *Asclepias tuberosa*
An	ASTER 'PURPLE DOME' *Aster novae-angliae 'Purple Dome'*
Cvu	FOX SEDGE *Carex vulpinoidea*
Cve	COREOPSIS 'MOONBEAM' *Coreopsis verticillata 'Moonbeam'*
Dl	DWARF BUSH HONEYSUCKLE *Diervilla lonicera*
Gt	PRAIRIE SMOKE *Geum trifolium*
Ha	SNEEZEWEED *Helenium autumnale*
Lp	PRAIRIE BLAZING STAR *Liatris pycnostachya*
Rf	GOLDSTRUM BLACK-EYED SUSAN *Rudbeckia fulgida*
Sh	PRAIRIE DROPSEED *Sporobolis heterolepsis*
Vv	CULVERS ROOT *Vronicastrum virginicum*
Vt	CRANBERRYBUSH VIBURNUM *Viburnum trilobum 'compactum'*

VIII. Arc Garden - Sunny Site - Retaining Wall



Flowering Perennial Garden

Shrub Garden

Mixed Shrub/Flower Garden

Plant Key

Am	BLACK CHOKEBERRY *Aronia melonocarpa*
At	BUTTERFLY MILKWEED *Asclepias tuberosa*
An	ASTER 'PURPLE DOME' *Aster novae-angliae 'Purple Dome'*
Ca	KARL FORESTER GRASS *Calamagrostis acutifolia*
Cvu	FOX SEDGE *Carex vulpinoidea*
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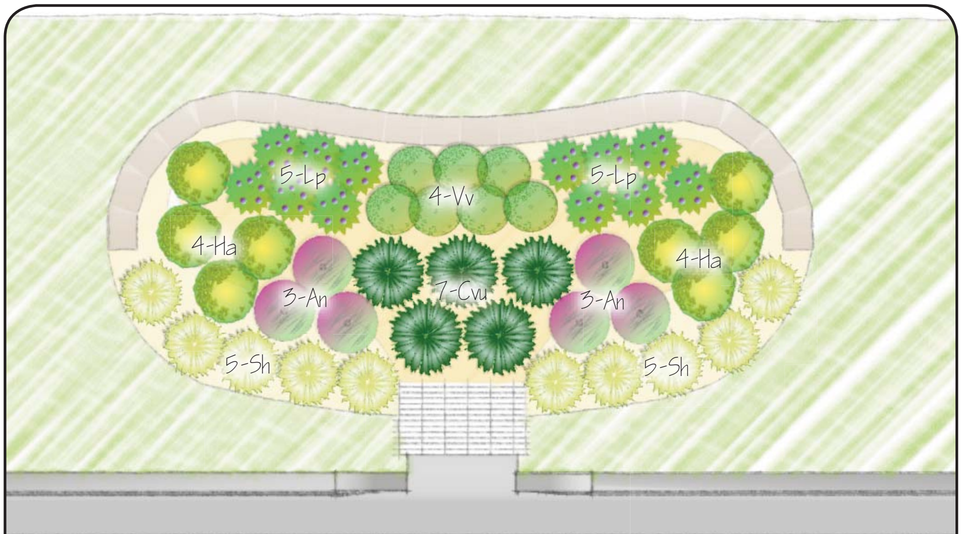
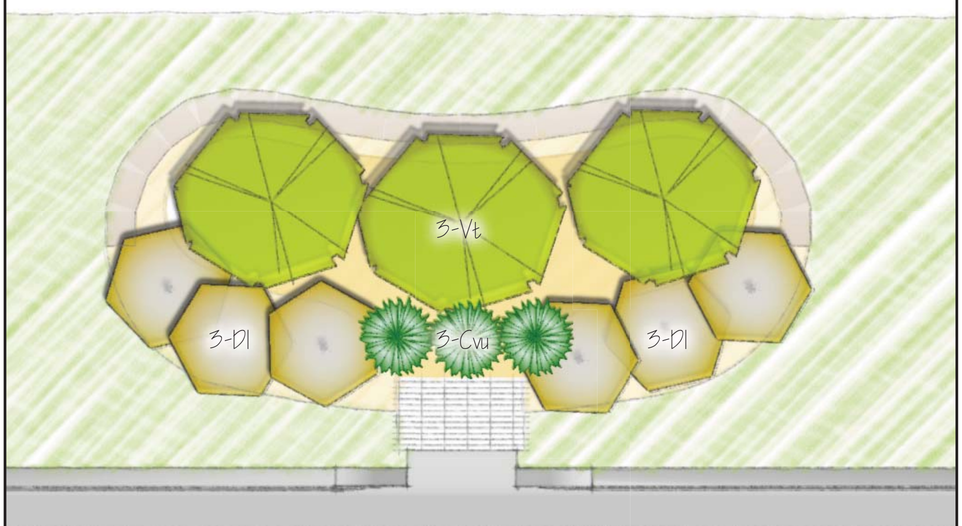
Vv	CULVERS ROOT *Veronicastrum virginicum*
Vt	CRANBERRYBUSH VIBURNUM *Viburnum trilobum 'compactum'*

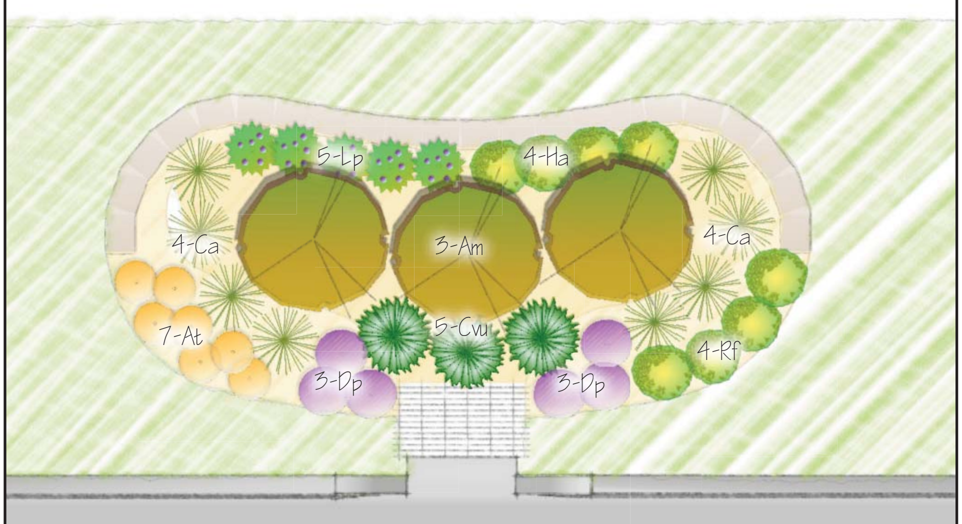
IX. Curvilinear Ga rden - Sunny Site - Retaining Wall



Flowering Perennial Garden



Shrub Garden



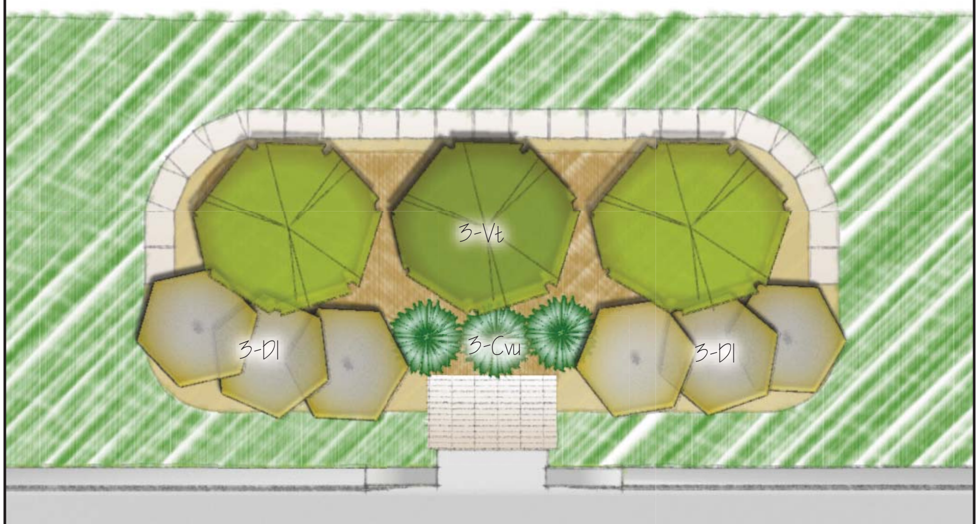
Mixed Shrub/Flower Garden

Plant Key

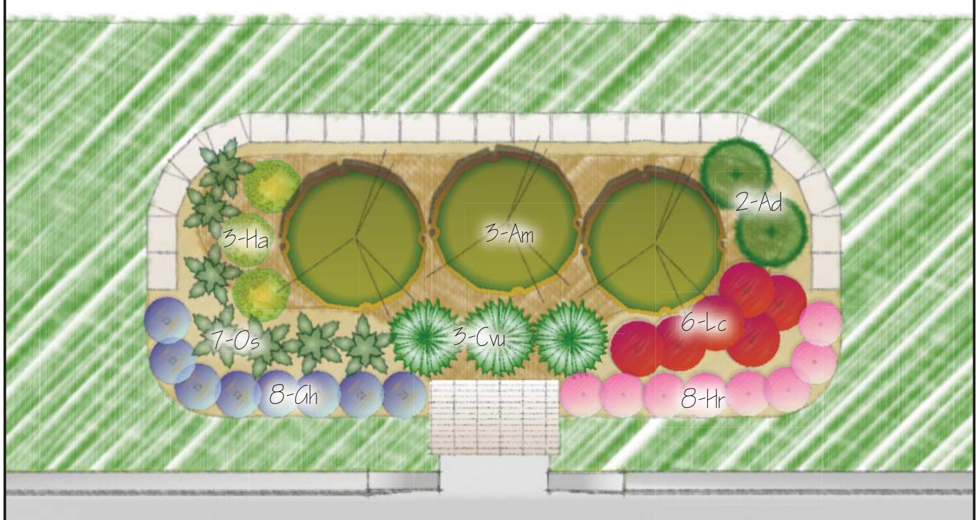
Am	BLACK CHOKEBERRY *Aronia melonocarpa*
At	BUTTERFLY MILKWEED *Asclepias tuberosa*
An	ASTER 'PURPLE DOME' *Aster novae-angliae 'Purple Dome'*
Ca	KARL FORESTER GRASS *Calamagrostis acutifolia*
Cvu	FOX SEDGE *Carex vulpinoidea*
Dl	DWARF BUSH HONEYSUCKLE *Diervilla lonicera*
Ha	SNEEZEWEED *Helenium autumnale*
Lp	PRAIRIE BLAZING STAR *Liatris pycnostachya*
Rf	GOLDSTRUM BLACK-EYED SUSAN *Rudbeckia fulgida*
Sh	PRAIRIE DROPSEED *Sporobolis heterolepsis*
Vv	CULVERS ROOT *Vronicastrum virginicum*
Vt	CRANBERRYBUSH VIBURNUM *Viburnum trilobum 'compactum'*

X. Rectangle Garden - Shady Site - Retaining Wall

Flowering Perennial Garden



Shrub Garden

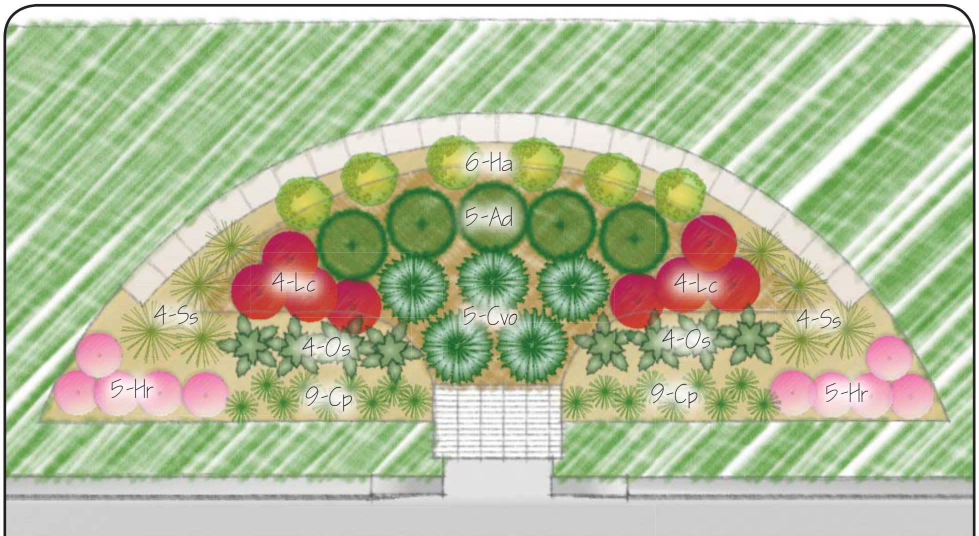


Mixed Shrub/Flower Garden

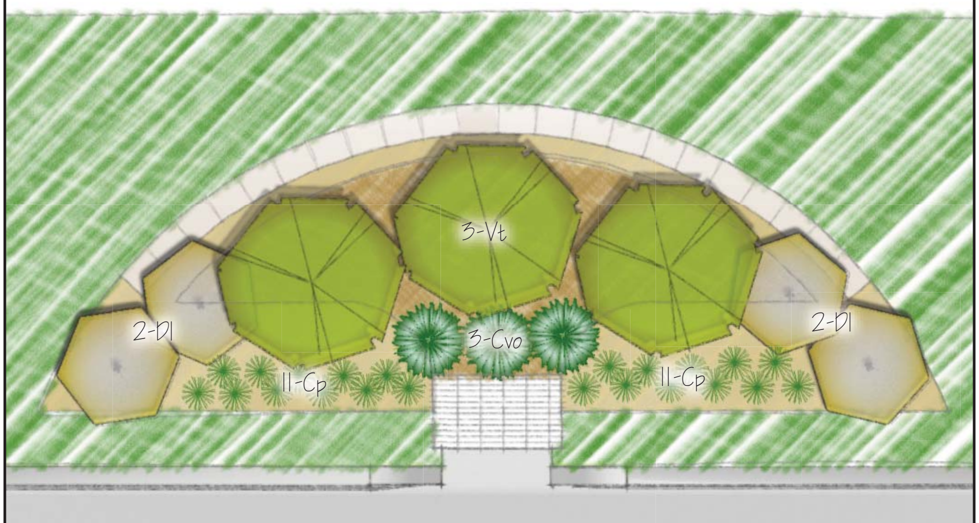
Plant Key

Am	BLACK CHOKEBERRY *Aronia melonocarpa*
Ad	GOAT'S BEARD *Aruncus diocius*
Cp	PENNSYLVANIA SEDGE *Carex pennsylvanica*
Cvu	FOX SEDGE *Carex vulpinoidea*
Dl	DWARF BUSH HONEYSUCKLE *Diervilla lonicera*
Gh	GERANIUM 'JOHNSON BLUE' *Geranium himalayense x pratense*
Ha	SNEEZEWEED *Helenium autumnale*
Hr	ALUMROOT *Heuchera richardsonii*
Lc	CARDINAL FLOWER *Lobelia cardinalis*
Os	SENSITIVE FERN *Onoclea sensibilis*
Ss	LITTLE BLUESTEM *Schizachyrium scoparium*
Vt	CRANBERRYBUSH VIBURNUM *Viburnum trilobum 'compactum'*

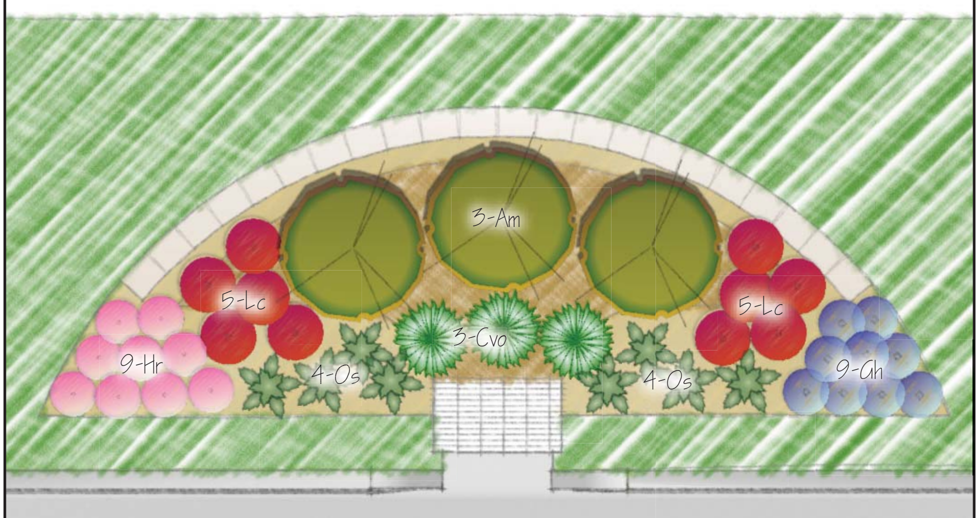
XI. Arc Garden - Shady Site - Retaining Wall



Flowering Perennial Garden



Shrub Garden



Mixed Shrub/Flower Garden

Plant Key

Am	BLACK CHOKEBERRY *Aronia melonocarpa*
Ad	GOAT'S BEARD *Aruncus diocius*
Cp	PENNSYLVANIA SEDGE *Carex pennsylvanica*
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Dl	DWARF BUSH HONEYSUCKLE *Diervilla lonicera*
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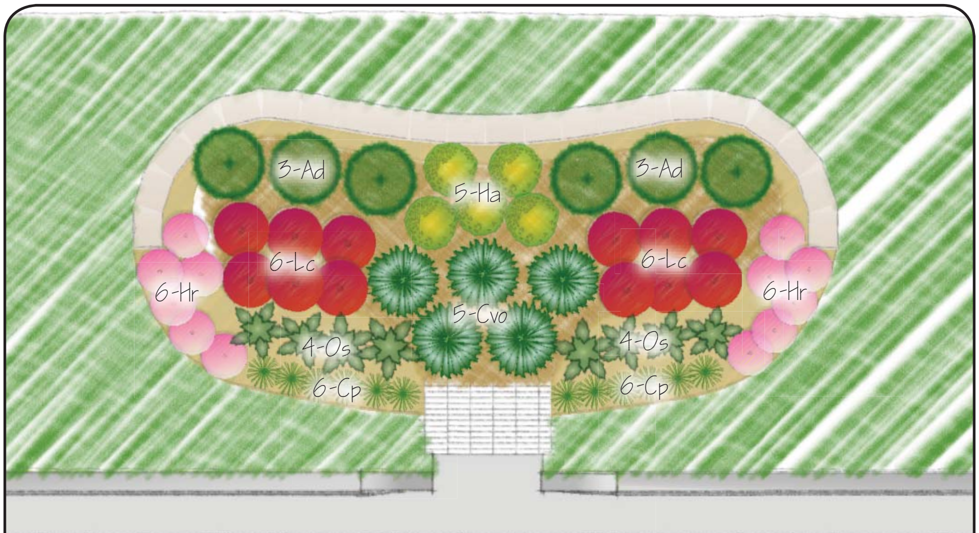
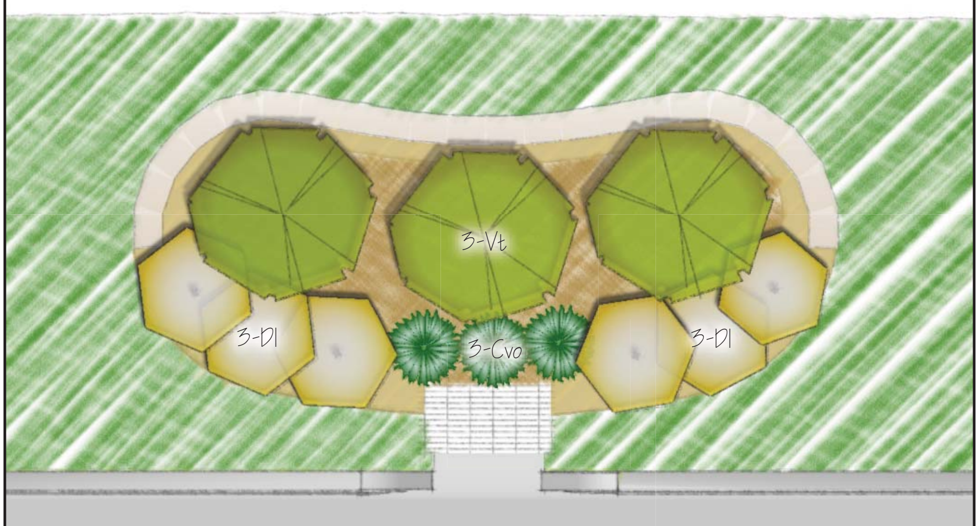
Os	SENSITIVE FERN *Onoclea sensibilis*
Ss	LITTLE BLUESTEM *Schizachyrium scoparium*
Vt	CRANBERRYBUSH VIBURNUM *Viburnum trilobum 'compactum'*

XII. Curvilinear Garden - Shady Site - Retaining Wall



Flowering Perennial Garden



Shrub Garden

Mixed Shrub/Flower Garden

Plant Key

Am	BLACK CHOKEBERRY *Aronia melonocarpa*
Ad	GOAT'S BEARD *Aruncus diocius*
Cp	PENNSYLVANIA SEDGE *Carex pennsylvanica*
Cvo	FOX SEDGE *Carex vulpinoidea*
Dl	DWARF BUSH HONEYSUCKLE *Diervilla lonicera*
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Lc	CARDINAL FLOWER *Lobelia cardinalis*
Os	SENSITIVE FERN *Onoclea sensibilis*
Vt	CRANBERRYBUSH VIBURNUM *Viburnum trilobum 'compactum'*

FLOWERING PERENNIAL
Plant pallette

CANADA ANEMONE
Anemone canadensis

GOAT'S BEARD
Aruncus diocius

BUTTERFLY MILKWEED
Asclepias tuberosa

ASTER 'PURPLE DOME'
Aster novae-angliae 'Purple Dome'

COREOPSIS 'MOONBEAM'
Coreopsis verticillata 'Moonbeam'

PURPLE PRARIE CLOVER
Dalea purpurea

PURPLE CONEFLOWER
Echinacea purpurea

GERANIUM 'JOHNSON BLUE'
Geranium himalayense x pratense

PRAIRIE SMOKE
Geum trifolium

SNEEZEWEED
Helenium autumnale

ALUMROOT
Heuchera richardsonii

PRAIRIE BLAZING STAR
Liatris pycnostachya

CARDINAL FLOWER
Lobelia cardinalis

SENSITIVE FERN
Onoclea sensibilis

GOLDSTRUM BLACK-EYED SUSAN
Rudbeckia fulgida

CULVERS ROOT
Veronicastrum virginicum

SHRUB
Plant pallette

BLACK CHOKEBERRY
Aronia melonocarpa

DWARF BUSH HONEYSUCKLE
Diervilla lonicera

DART'S RED SPIRAEA
Spiraea japonica

CRANBERRYBUSH VIBURNUM
Viburnum trilobum 'compactum'

GRASSES
Plant pallette

KARL FORESTER GRASS
Calamagrostis acutifolia

PENNSYLVANIA SEDGE
Carex pennsylvanica

FOX SEDGE
Carex vulpinoidea

JUNE GRASS
Koeleria macrantha

LITTLE BLUESTEM
Schizachyrium scoparium

PRAIRIE DROPSEED
Sporobolis heterolepsis

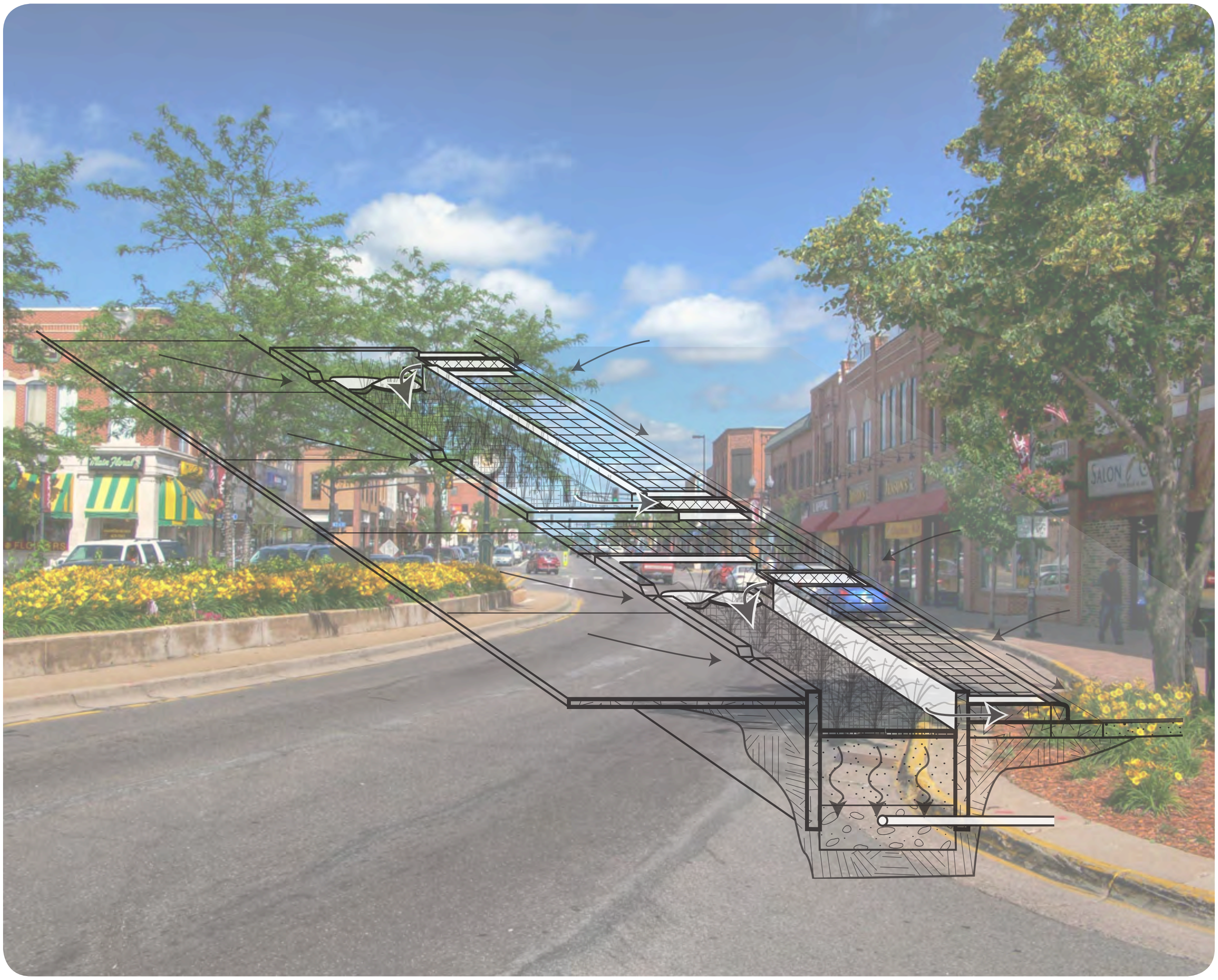
Intentionally Blank

Appendix B – Retrofit Concept Designs

- Perimeter Sand Filters
- Tree Pit Filters
- Porous Pavement
- Flow Splitters
- Hydrodynamic Separators

Intentionally Blank

Urban Stormwater Best Management Practices / Retrofit Concepts



Prepared by the Anoka Conservation District in association with
the Metropolitan Conservation Districts

Retrofit Concepts: *Perimeter Sand Filter*

Perimeter sand filters (Delaware filters) consist of two parallel trench-like chambers that are typically installed along the perimeter of a parking lot. Parking lot runoff enters the first chamber, which has a shallow permanent pool of water. The first trench captures heavy solids before the runoff spills into the second trench, which consists of a sand layer (typically 18" deep). Water infiltrates through the sand and is collected by an under-drain and delivered, ideally, to another stormwater BMP or existing stormsewer network. If both chambers fill up to capacity, excess parking lot runoff is routed to a bypass drop inlet. The sand may have iron filings added to improve dissolved phosphorus removal.

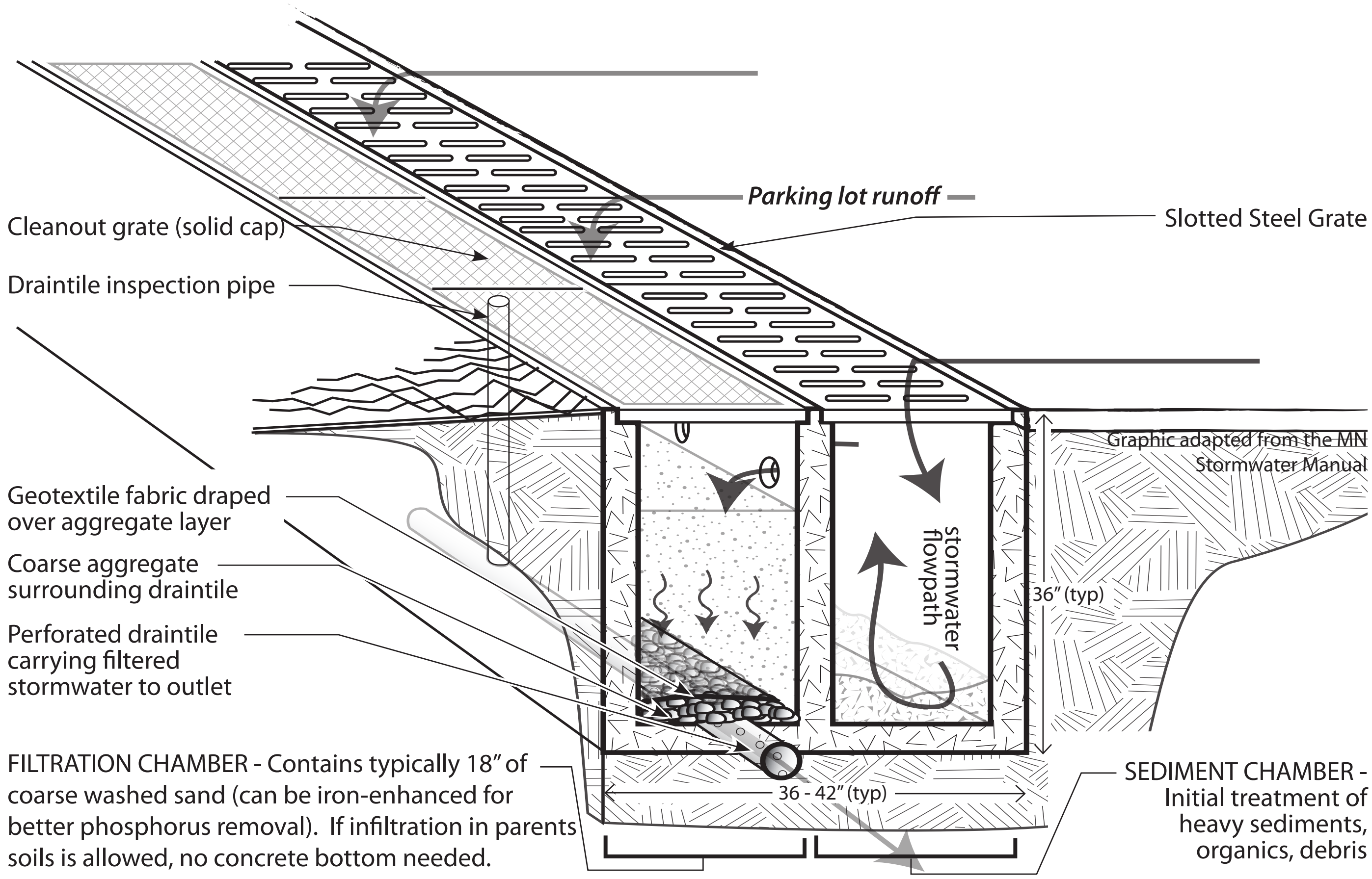

Sand filter inspection, Iowa Stormwater Partnership

BENEFITS:
- Great for adjacent to large impervious areas like parking lots
- Remove up to 90 percent of total suspended solids, 55 percent of total phosphorous, and 35 percent of total nitrogen
- Can effectively treat hot-spot runoff
- Consume small amounts of land

COST:
- Approximately $21.50 per cu ft of storage

CONCERNS:
- High maintenance burden (regular inspections for clogging, sand replacement, and removal of captured sediment)
- Not recommended for areas with high sediment content in stormwater or areas receiving significant clay/silt runoff
- Relatively costly

RECOMMENDED DRAINAGE AREA:
- Highly impervious sites up to 2 acres
- Approximately 100 linear feet treats 1 acre of impervious area



Retrofit Concepts: *Tree Pit Filter*

Stormwater tree pits consist of an underground structure and above ground plantings which collect and treat stormwater using bioretention. Although their structures differ, stormwater tree pits closely resemble traditional street trees and are perfect for urban streets where space is limited.


Tree pit filter, nyc.org

BENEFITS:
- Reduces runoff volume, flow rate and temperature
- Increases groundwater infiltration and recharge
- Improves aesthetic appeal of streets and neighborhoods
- Provides shade to nearby buildings to reduce energy costs
- Requires limited space
- Simple to install
- Available in multiple sizes
- Eliminates watering and fertilizing needed by traditional street trees

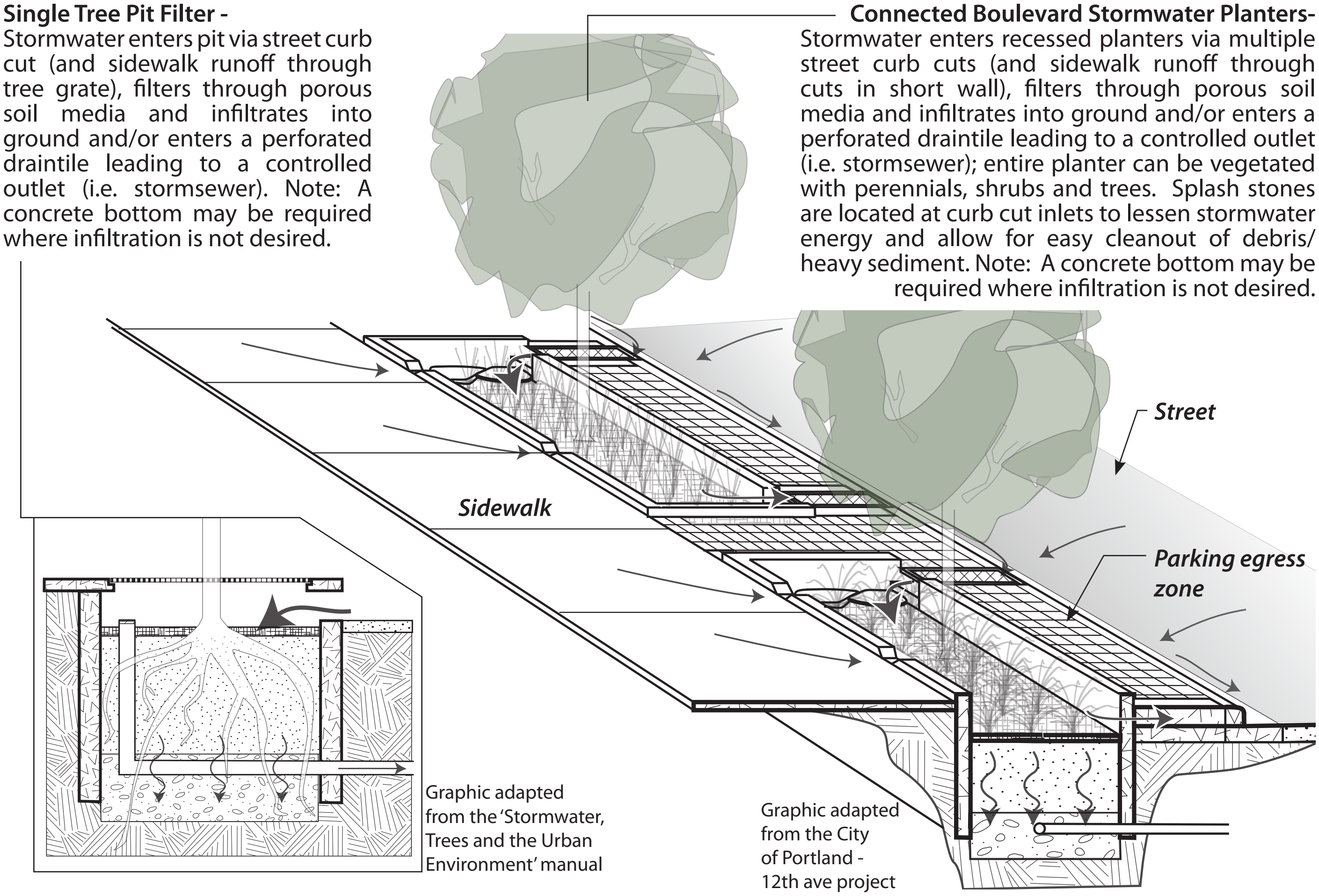
CONCERNS:
- Tree species will be limited to those that have salt tolerance and limited root aggression
- Regular inspections to prevent clogging & maintain function

RECOMMENDED DRAINAGE AREA:
- Optimum ratio at highy impervious sites is one 6' x 6' tree pit per .25 acres

COST:
- Approximately $98.75 per cu ft of storage

Single Tree Pit Filter -
Stormwater enters pit via street curb cut (and sidewalk runoff through tree grate), filters through porous soil media and infiltrates into ground and/or enters a perforated draintile leading to a controlled outlet (i.e. stormsewer). Note: A concrete bottom may be required where infiltration is not desired.

Connected Boulevard Stormwater Planters-
Stormwater enters recessed planters via multiple street curb cuts (and sidewalk runoff through cuts in short wall), filters through porous soil media and infiltrates into ground and/or enters a perforated draintile leading to a controlled outlet (i.e. stormsewer); entire planter can be vegetated with perennials, shrubs and trees. Splash stones are located at curb cut inlets to lessen stormwater energy and allow for easy cleanout of debris/heavy sediment. Note: A concrete bottom may be required where infiltration is not desired.



Graphic adapted from the 'Stormwater, Trees and the Urban Environment' manual

Graphic adapted from the City of Portland - 12th ave project

Retrofit Concepts: ***Porous Pavement***

Porous pavements come in a wide array of materials - ***concrete, asphalt, pavers, and grid*** - with void spaces that allow water to percolate through the surface and reach a subsurface layer of coarse aggregate allowing stormwater to quickly drain into the ground. Porous pavements are ideally situated in areas where soil type, seasonal water table and frost line levels allow for groundwater recharge. Porous pavements are typically used in low traffic areas and are well suited for use in parking lots, overflow areas, low traffic roads, residential driveways and pedestrian walkways. They can also be installed surrounding other stormwater management systems to provide overflow collection and infiltration.

BENEFITS:
- Reduces runoff volume, flow rate and temperature
- Increases groundwater infiltration and recharge
- Reduces the need for traditional stormwater infrastructure
- Can improve aesthetic appeal of paved areas (pavers)
- Flexible for use in areas of various shapes and sizes
- Remove up to 80 percent of total phosphorous and total nitrogen
- Reduced Ice buildup on street

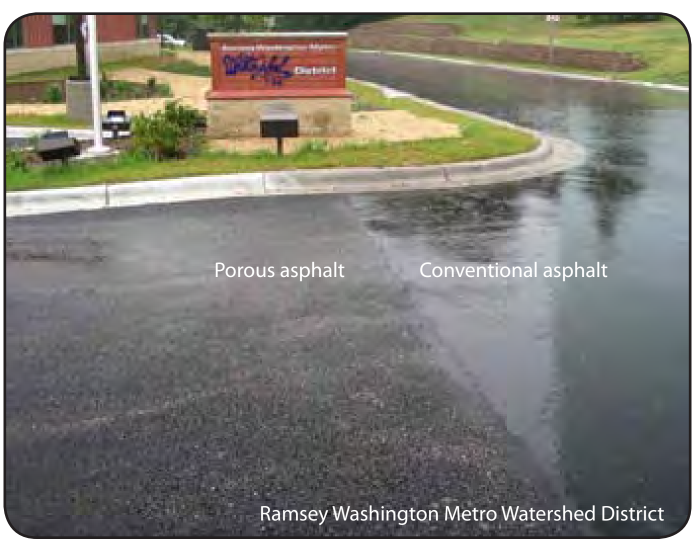
CONCERNS:
- Typically not suited for slopes greater than 5%
- Cost
- At minimum 2 vacuum sweepings per year
- Periodic replacement of fill material in joint spacing (pavers)
- Not suitable for areas generating a lot of sediment

RECOMMENDED DRAINAGE AREA:
- Typically 3:1 (drainage area to porous pavement area) or less

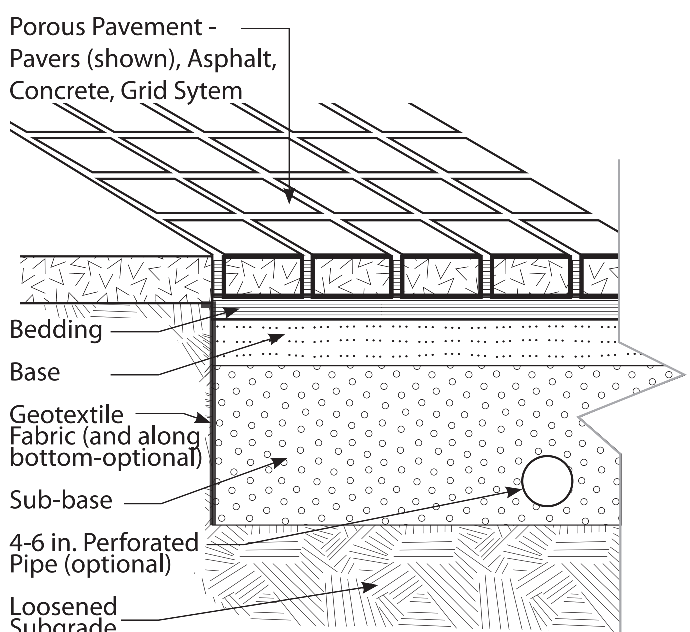
COST:
- Approximately $14 - $35 per cu ft storage depending on underlayment


Permeable pavement in parking aisle, City of Portland


Permeable pavers, Minneapolis



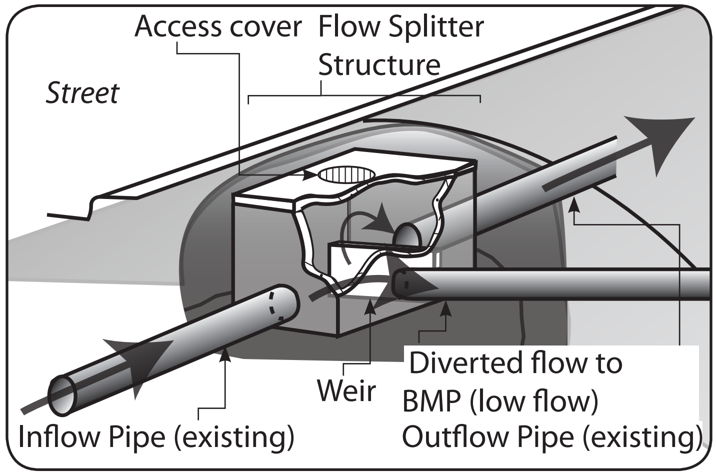
Ramsey Washington Metro Watershed District



Graphic adapted from the Charles River Watershed Association - Information Sheet

Retrofit Concepts: Flow Splitters

Flow splitters are stormsewer structures used to divert initial flows from stormsewer network out into a stormwater BMP such as constructed wetlands, detention ponds, infiltration basins, swales and various other filtration practices. During intense rain events excess stormwater travels over a weir, located in the flow splitter, and continues down pipe. Flow splitters are often designed to divert at least the 'first flush' into a BMP.



BENEFITS:

- Provides the ability to capture and treat otherwise untreated stormwater
- Allows high flows to bypass the connected stormwater BMPs thus reducing opportunities for erosion and re-suspension of sediment captured in the BMP systems
- Only periodic inspections are needed, with annual debris / sediment cleanout being sufficient

RECOMMENDED DRAINAGE AREA:

- Varies, pipe sizing can be scaled according to drainage area and capacity of Stormwater BMP that flow is diverted to

CONCERNS:

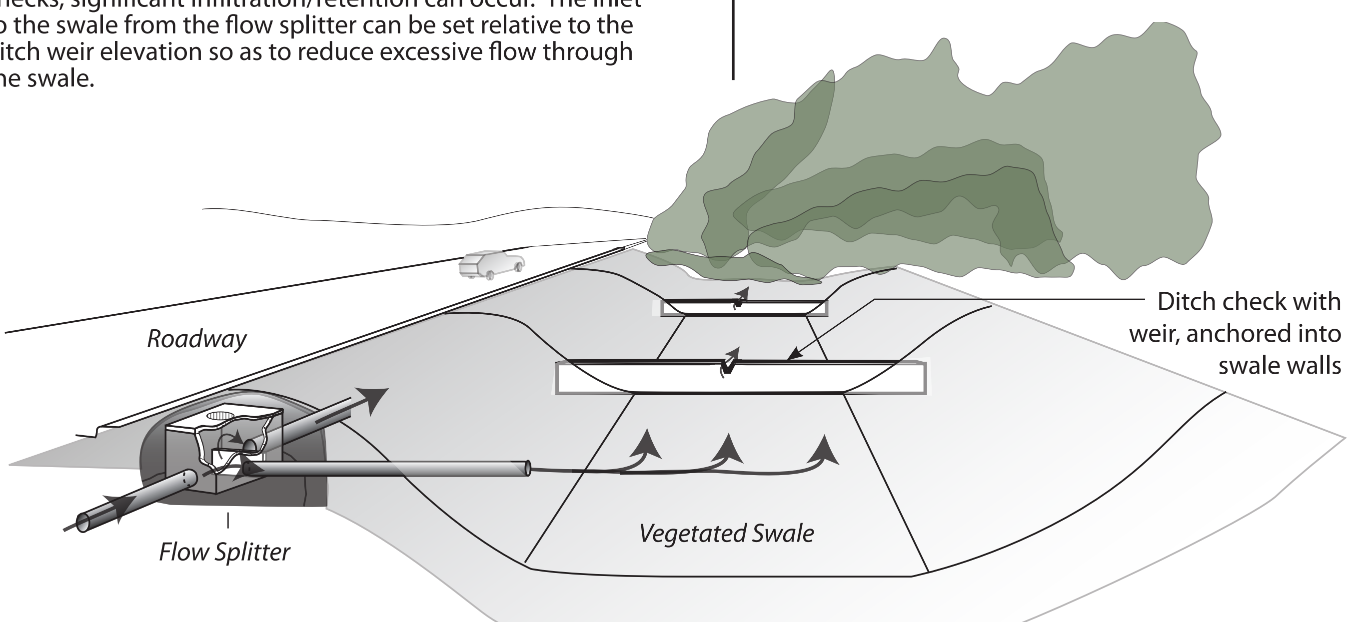
- Alone this practice does not reduce pollutants. It is a tool to divert appropriate flows into a water quality practice

COST:

- Varies, the smallest typical structure to fit a weir is 48" diameter.
- Individual component costs of a 48" diameter structure*:
  1. Base slab ~ $250,
  2. Weir ~ $200 per vertical foot,
  3. Riser (side walls) ~ $130 per vertical foot,
  4. Cover slab (with opening) ~ $300,
  5. Metal casting (top grate, option) ~ $400
  6. Diverted flow pipe ~ $2 - $10 per linear foot (depends on material and diameter)

**Based on local sourcing, 2010*

Flow Splitter to Stormwater BMP -
Flow splitters can be used to divert runoff to a suite of stormwater Best Management Practices including a vegetated swale (shown) where filtration and, with ditch checks, significant infiltration/retention can occur. The inlet to the swale from the flow splitter can be set relative to the ditch weir elevation so as to reduce excessive flow through the swale.



Retrofit Concepts: Hydrodynamic Separators

Hydrodynamic Separator devices are structural BMPs vary in size and function, but all use some form of filtration, settling, or hydrodynamic separation to remove particulate pollutants from overland or piped flow. They often replace traditional catch basins and look much the same from the surface. Below the surface is a series of baffles, chambers, and devices designed to capture pollutants. They generally remove coarse sediment, oil and grease, litter, and debris and are often employed in areas with high concentrations of pollutants in runoff (ultra urban and retrofit situations). They may serve as pre-treatment of stormwater runoff before it reaches other BMPs, such as infiltration systems. Manufacturers of the devices provide the internal design specifications and installation instructions.

BENEFITS:

- Can be used in a variety of applications including retrofitting existing stormwater systems
- Subsurface device, consumes little to no land
- Removal of sediment, oils and other floatables

CONCERNS:

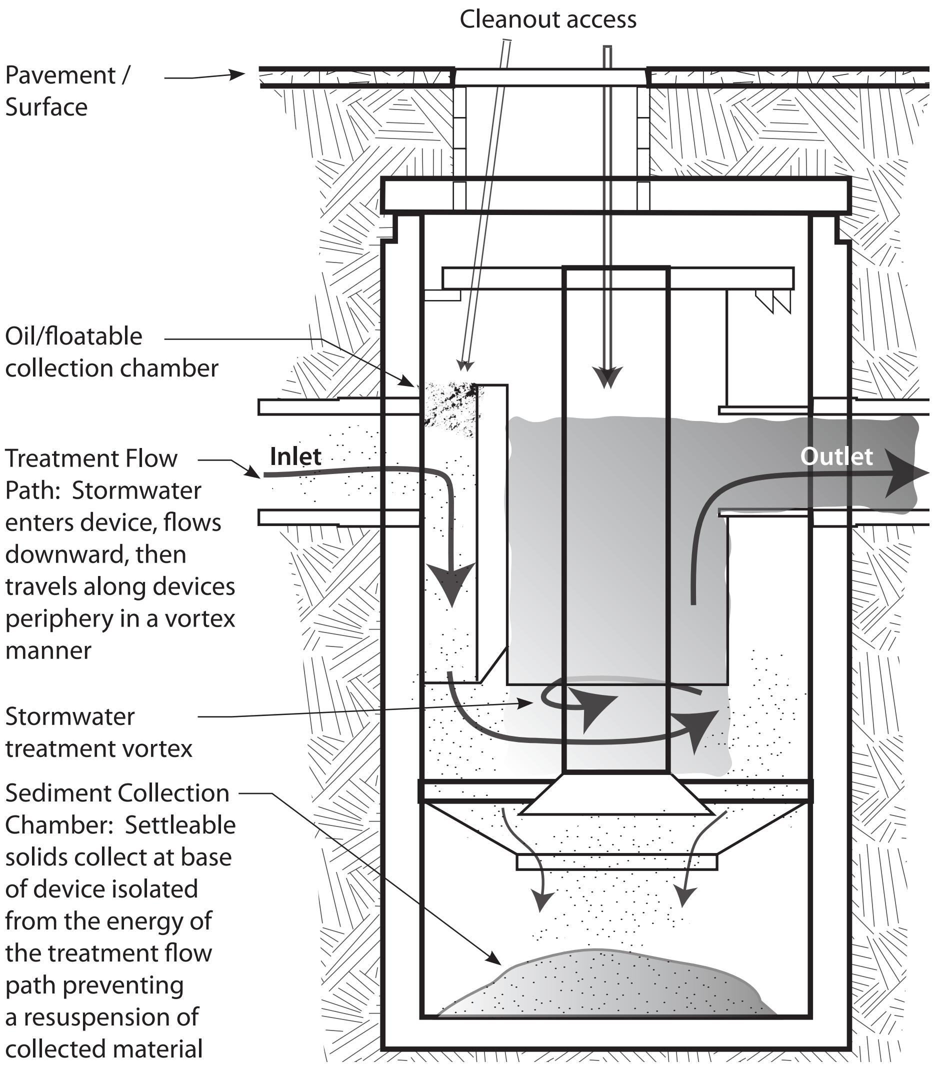
- A minimum annual vacuum removal of captured pollutants; however, required inspections every 6 months for the first year observing sedimentation and oil accumulation rates may determine more frequent visits are necessary
- High initial installation costs

RECOMMENDED DRAINAGE AREA:

- With a suite of scalable devices, drainage areas can range from a single parking lot up to 7 acres of predominently impervious surfaces (based on a standard 80% removal rate of total suspended solids on Stormceptor products**)

COST:

- Varies widely, from $2,300 to $40,000 depending on site characteristics including the amount of runoff (in cfs) required to be treated, the amount of land available, and any other treatment technologies that are presently being used. Often costs break down to approximately $9,000 per acre runoff treated*



Base design source: *Dowstream Defender***

**EPA Technology Fact Sheet*
***This mention does not constitute an endorsement of product*

Appendix C – Catchment-Specific Cost/Benefit Tables

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Appendix C: Catchment Specific Cost Benefit Analyses for Oak Glen Creek

Network level analyses were used to compare the cost effectiveness of projects throughout the Oak Glen Creek subwatershed because they represent volume and pollutant removals at the point where the water enters Oak Glen Creek. However, the tables below present the catchment specific cost/benefit analyses for proposed projects throughout the Oak Glen Creek subwatershed. The numbers in the tables represent the benefits achieved only at the catchment level, regardless of downstream treatment train effects.

OGC-1

Catchment Specific Cost/Benefit Analysis

	Cost/Benefit Analysis	Project ID					
		3 Rain Gardens		6 Rain Gardens		9 Rain Gardens	
		New trtmt	Net %	New trtmt	Net %	New trtmt	Net %
Treatment	TP (lb/yr)	4.8	24%	8.0	35%	10.4	43%
	TSS (lb/yr)	856	20%	1,536	28%	2,117	34%
	Volume (acre-feet/yr)	2.1	9%	3.9	18%	5.3	24%
	Number of BMP's	3		6		9	
	BMP Size/Description	750 sq ft		1,500 sq ft		2,250 sq ft	
	BMP Type	Complex Bioretention		Complex Bioretention		Complex Bioretention	
Cost	Materials/Labor/Design	$15,390		$30,570		$45,750	
	Promotion & Admin Costs	$2,310		$3,150		$3,990	
	Total Project Cost	$17,700		$33,720		$49,740	
	Annual O&M	$225		$450		$675	
	Term Cost/lb-TP/yr	$170		$197		$224	
	Term Cost/1,000lb-TSS/yr	**$952**		**$1,025**		**$1,102**	

OGC-2

Catchment Specific Cost/Benefit Analyses

	Cost/Benefit Analysis	**Project ID**					
		3 Rain Gardens					
		New trtmt	**Net %**	**New trtmt**	**Net %**	**New trtmt**	**Net %**
Treatment	**TP (lb/yr)**	4.0	14%				
	TSS (lb/yr)	1,329	17%				
	Volume (acre-feet/yr)	2.3	2%				
	Number of BMP's	3					
	BMP Size/Description	750 sq ft					
	BMP Type	Complex Bioretention					
Cost	**Materials/Labor/Design**	$15,390					
	Promotion & Admin Costs	$2,310					
	Total Project Cost	$17,700					
	Annual O&M	$225					
	Term Cost/lb-TP/yr	$204					
	Term Cost/1,000lb-TSS/yr	**$613**					

	Cost/Benefit Analysis	*Project ID*					
		Parking Lot Rain Garden					
		New trtmt	Net %	New trtmt	Net %	New trtmt	Net %
Treatment	TP (lb/yr)	0.9	11%				
	TSS (lb/yr)	451	15%				
	Volume (acre-feet/yr)	0.7	1%				
	Number of BMP's	1					
	BMP Size/Description	250 sq ft					
	BMP Type	Complex Bioretention					
Cost	Materials/Labor/Design	$5,270					
	Promotion & Admin Costs	$1,750					
	Total Project Cost	$7,020					
	Annual O&M	$75					
	Term Cost/lb-TP/yr	$343					
	Term Cost/1,000lb-TSS/yr	**$685**					

	Cost/Benefit Analysis	*Project ID*					
		Permeable Asphalt					
		New trtmt	Net %	New trtmt	Net %	New trtmt	Net %
Treatment	TP (lb/yr)	3.1	13%				
	TSS (lb/yr)	2,697	19%				
	Volume (acre-feet/yr)	3.9	3%				
	Number of BMP's	1					
	BMP Size/Description	30,492 sq ft					
	BMP Type	Permeable Asphalt					
Cost	Materials/Labor/Design	$305,690					
	Promotion & Admin Costs	$1,680					
	Total Project Cost	$307,370					
	Annual O&M	$701					
	Term Cost/lb-TP/yr	$3,531					
	Term Cost/1,000lb-TSS/yr	**$4,059**					

<table>
<tr><td colspan="2" rowspan="3">Cost/Benefit Analysis</td><td colspan="6">Project ID</td></tr>
<tr><td colspan="2">Parking Lot Depavement</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>New trtmt</td><td>Net %</td><td>New trtmt</td><td>Net %</td><td>New trtmt</td><td>Net %</td></tr>
<tr><td rowspan="6">Treatment</td><td>TP (lb/yr)</td><td>1.1</td><td>11%</td><td></td><td></td><td></td><td></td></tr>
<tr><td>TSS (lb/yr)</td><td>957</td><td>16%</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Volume (acre-feet/yr)</td><td>1.4</td><td>1%</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Number of BMP's</td><td colspan="2">1</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>BMP Size/Description</td><td colspan="2">4,356 sq ft</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>BMP Type</td><td colspan="2">Depavement</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td rowspan="6">Cost</td><td>Materials/Labor/Design</td><td colspan="2">$16,016</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Promotion & Admin Costs</td><td colspan="2">$1,680</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Total Project Cost</td><td colspan="2">$17,696</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Annual O&M</td><td colspan="2">$75</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Term Cost/lb-TP/yr</td><td colspan="2">$604</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Term Cost/1,000lb-TSS/yr</td><td colspan="2">$695</td><td colspan="2"></td><td colspan="2"></td></tr>
</table>

OGC-3

Catchment Specific Cost/Benefit Analysis

	Cost/Benefit Analysis	***Project ID***					
		5 Rain Gardens		**10 Rain Gardens**		**20 Rain Gardens**	
		New trtmt	**Net %**	**New trtmt**	**Net %**	**New trtmt**	**Net %**
Treatment	**TP (lb/yr)**	9.0	15%	15.8	22%	26.4	31%
	TSS (lb/yr)	1,565	14%	2,845	18%	5,100	24%
	Volume (acre-feet/yr)	3.7	5%	6.9	9%	12.6	16%
	Number of BMP's	5		10		20	
	BMP Size/Description	1,250 sq ft		2,500 sq ft		5,000 sq ft	
	BMP Type	Complex Bioretention		Complex Bioretention		Complex Bioretention	
Cost	**Materials/Labor/Design**	$25,510		$50,810		$101,410	
	Promotion & Admin Costs	$2,870		$4,270		$7,070	
	Total Project Cost	$28,380		$55,080		$108,480	
	Annual O&M	$375		$750		$1,500	
	Term Cost/lb-TP/yr	$147		$164		$194	
	Term Cost/1,000lb-TSS/yr	**$844**		**$909**		**$1,003**	

OGC-4

Catchment Specific Cost/Benefit Analyses

	Cost/Benefit Analysis	**Project ID**					
		Permeable Asphalt					
		New trtmt	**Net %**	**New trtmt**	**Net %**	**New trtmt**	**Net %**
Treatment	**TP (lb/yr)**	1.7	53%				
	TSS (lb/yr)	866	64%				
	Volume (acre-feet/yr)	4.2	11%				
	Number of BMP's	1					
	BMP Size/Description	32,670 sq ft					
	BMP Type	Permeable Asphalt					
Cost	**Materials/Labor/Design**	$327,470					
	Promotion & Admin Costs	$1,680					
	Total Project Cost	$329,150					
	Annual O&M	$751					
	Term Cost/lb-TP/yr	$6,896					
	Term Cost/1,000lb-TSS/yr	**$13,537**					

OGC-5

Catchment Specific Cost/Benefit Analyses

	Cost/Benefit Analysis	***Project ID***					
		Parking Lot Rain Garden		**Parking Lot Rain Garden**			
		New trtmt	**Net %**	**New trtmt**	**Net %**	**New trtmt**	**Net %**
Treatment	**TP (lb/yr)**	0.5	25%	0.6	26%		
	TSS (lb/yr)	244	27%	330	30%		
	Volume (acre-feet/yr)	0.7	23%	0.9	25%		
	Number of BMP's	1		1			
	BMP Size/Description	500 sq ft		1,000 sq ft			
	BMP Type	Complex Bioretention		Complex Bioretention			
Cost	**Materials/Labor/Design**	$9,770		$18,770			
	Promotion & Admin Costs	$1,750		$1,750			
	Total Project Cost	$11,520		$20,520			
	Annual O&M	$75		$75			
	Term Cost/lb-TP/yr	$918		$1,265			
	Term Cost/1,000lb-TSS/yr	**$1,881**		**$2,300**			

	Cost/Benefit Analysis	*Project ID*					
		Office Park Parking Lot Rain Garden		High-rise Residential Parking Lot Rain Garden			
		New trtmt	Net %	New trtmt	Net %	New trtmt	Net %
Treatment	TP (lb/yr)	0.9	29%	0.7	27%		
	TSS (lb/yr)	365	30%	164	25%		
	Volume (acre-feet/yr)	0.8	24%	0.5	21%		
	Number of BMP's	1		1			
	BMP Size/Description	500 sq ft		250 sq ft			
	BMP Type	Complex Bioretention		Complex Bioretention			
Cost	Materials/Labor/Design	$9,770		$5,270			
	Promotion & Admin Costs	$1,750		$1,750			
	Total Project Cost	$11,520		$7,020			
	Annual O&M	$75		$75			
	Term Cost/lb-TP/yr	$510		$441			
	Term Cost/1,000lb-TSS/yr	**$1,258**		**$1,884**			

OGC-6

Catchment Specific Cost/Benefit Analysis

	Cost/Benefit Analysis	***Project ID***					
		School Parking Lot Rain Garden		School Curb-cuts			
		New trtmt	Net %	New trtmt	Net %	New trtmt	Net %
Treatment	TP (lb/yr)	0.2	6%	0.4	8%		
	TSS (lb/yr)	137	10%	244	13%		
	Volume (acre-feet/yr)	0.4	5%	0.7	8%		
	Number of BMP's	1		2			
	BMP Size/Description	250	sq ft	20	linear feet		
	BMP Type	Complex Bioretention		Curb-Cut			
Cost	Materials/Labor/Design	$5,270		$600			
	Promotion & Admin Costs	$1,750		$350			
	Total Project Cost	$7,020		$950			
	Annual O&M	$75		$75			
	Term Cost/lb-TP/yr	$1,545		$267			
	Term Cost/1,000lb-TSS/yr	**$2,255**		**$437**			

OGC-7

Catchment Specific Cost/Benefit Analysis

	Cost/Benefit Analysis	***Project ID***					
		Parking Lot Curb-cut Rain Garden					
		New trtmt	**Net %**	**New trtmt**	**Net %**	**New trtmt**	**Net %**
Treatment	**TP (lb/yr)**	0.8	10%				
	TSS (lb/yr)	324	9%				
	Volume (acre-feet/yr)	0.6	4%				
	Number of BMP's	1					
	BMP Size/Description	250 sq ft					
	BMP Type	Complex Bioretention					
Cost	**Materials/Labor/Design**	$5,270					
	Promotion & Admin Costs	$1,750					
	Total Project Cost	$7,020					
	Annual O&M	$75					
	Term Cost/lb-TP/yr	$401					
	Term Cost/1,000lb-TSS/yr	**$954**					

OGC-8

Catchment Specific Cost/Benefit Analysis

	Cost/Benefit Analysis	*Project ID*					
		Curb-cut Rain Garden					
		New trtmt	Net %	New trtmt	Net %	New trtmt	Net %
Treatment	TP (lb/yr)	0.8	4%				
	TSS (lb/yr)	327	5%				
	Volume (acre-feet/yr)	0.6	2%				
	Number of BMP's	1					
	BMP Size/Description	250 sq ft					
	BMP Type	Complex Bioretention					
Cost	Materials/Labor/Design	$5,270					
	Promotion & Admin Costs	$1,750					
	Total Project Cost	$7,020					
	Annual O&M	$75					
	Term Cost/lb-TP/yr	$372					
	Term Cost/1,000lb-TSS/yr	**$945**					

Appendix D – Drinking Water Supply Management Area Vulnerability and Wellhead Protection Areas

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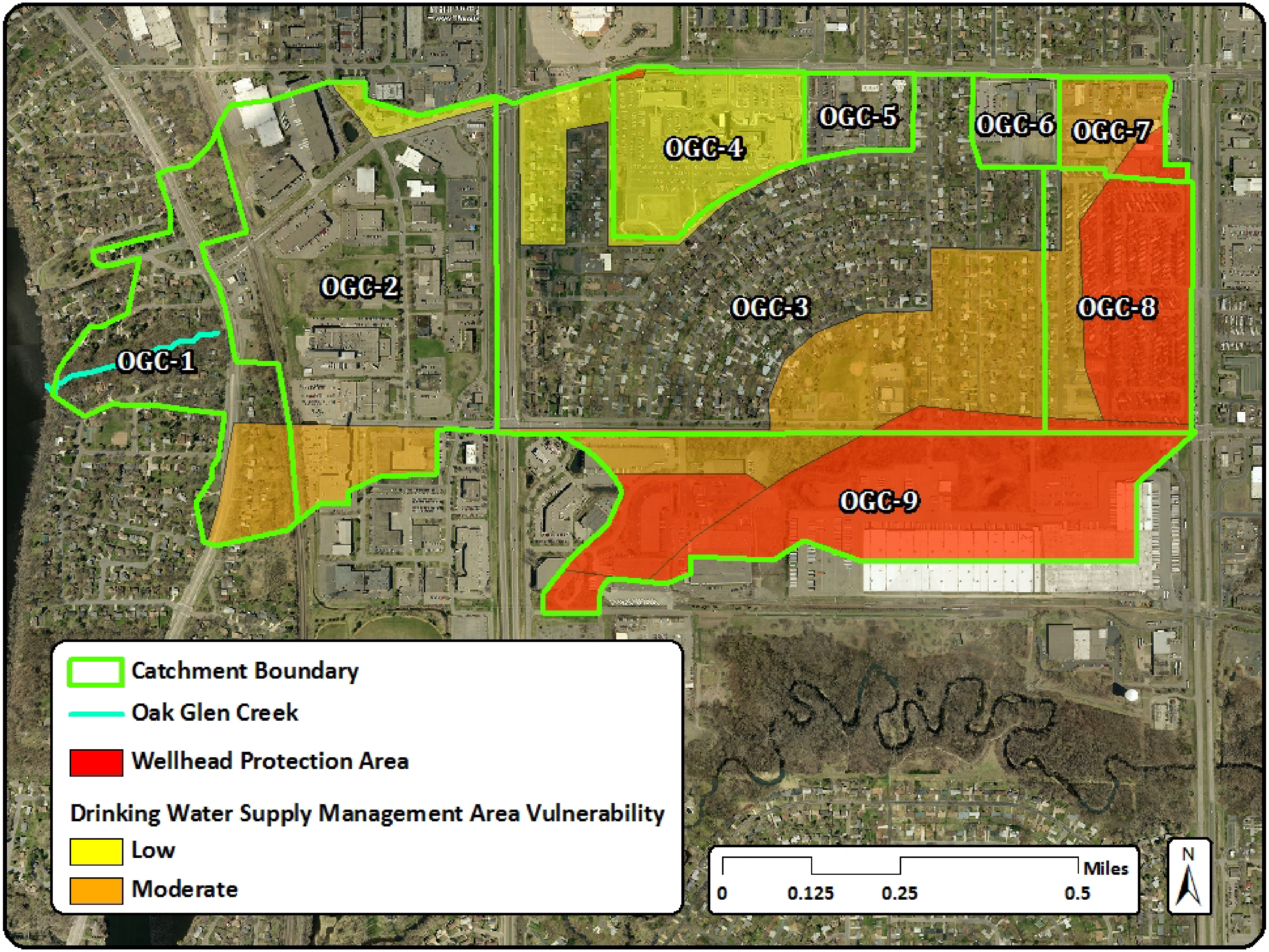
OGC-1
OGC-2
OGC-3
OGC-4
OGC-5
OGC-6
OGC-7
OGC-8
OGC-9
Catchment Boundary
Oak Glen Creek
Wellhead Protection Area
Drinking Water Supply Management Area Vulnerability
Low
Moderate
0
0.125
0.25
0.5
Miles
N

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Appendix E – Pond Retrofit Calculations

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Proposed Pond Area and Excavation Calculations

Existing Conditions (0.5 ft.)			
Elevation	Stage	Area	Vol (cumulative)
846.5	0	0.23	0
847	0.5	0.29	0.073
848	1.5	0.36	0.398
849	2.5	0.48	0.818
850	3.5	0.55	1.333
851	4.5	0.63	1.923
852	5.5	0.7	2.588
853	6.5	0.78	3.328
854	7.5	0.96	4.198
855	8.5	1.05	5.203
856	9.5	1.2	6.328

Proposed Excavation (3.5 ft. total depth)						
Elevation	Stage	Area			Excavation	
856	12.5	1.2			Acre-feet	Cubic Yards
855	11.5	1.05			0.17	274.26661
854	10.5	0.96			0.13	209.73329
853	9.5	0.78			0.1	161.3333
852	8.5	0.7		**Total**	**0.4**	**645.3332**
851	7.5	0.63				
850	6.5	0.55				
849	5.5	0.48				
848	4.5	0.36				
847	3.5	0.29				
846.5	3	0.23				
845.5	2	0.17				
844.5	1	0.13				
843.5	0	0.1				

Proposed Expansion (3.5 ft. total depth)					Excavation	
Elevation	Stage	Area			Acre-feet	Cubic yards
856	12.5	2.79			1.59	2565.1995
855	11.5	2.6			1.55	2500.6662
854	10.5	2.41			1.45	2339.3329
853	9.5	2.23			1.445	2331.2662
852	8.5	2.04			1.34	2161.8662
851	7.5	1.92			1.285	2073.1329
850	6.5	1.79			1.24	2000.5329
849	5.5	1.68			1.195	1927.9329
848	4.5	1.56			1.2	1935.9996
847	3.5	1.4			1.11	1790.7996
846.5	3	1.22			0.495	798.59984
845.5	2	1.08			1.08	1742.3996
844.5	1	0.95			0.95	1532.6664
843.5	0	0.85			0	0
				Total	**15.93**	**25700.395**

Proposed Pond Cost Estimates

Pond Excavation - Level 1 Material				
Item	**Quantity**	**Unit**	**Unit Cost**	**Extended Amount**
Mobilization	1	LS	$6,000	$6,000
Design	1	LS	$10,000	$10,000
Existing pond excavation	645	CY	$30.00	$19,350
Structure (inlet)	1	Each	$5,000	$5,000
Structure (outlet)	1	Each	$10,000	$10,000
Subtotal				$50,350
20% Contingency				$10,070
Total				**$60,420**

Pond Excavation - Level 2 Material				
Item	**Quantity**	**Unit**	**Unit Cost**	**Extended Amount**
Mobilization	1	LS	$6,000	$6,000
Design	1	LS	$10,000	$10,000
Existing pond excavation	645	CY	$40.00	$25,800
Structure (inlet)	1	Each	$5,000	$5,000
Structure (outlet)	1	Each	$10,000	$10,000
Subtotal				$56,800
20% Contingency				$11,360
Total				**$68,160**

Pond Excavation - Level 3 Material				
Item	**Quantity**	**Unit**	**Unit Cost**	**Extended Amount**
Mobilization	1	LS	$6,000	$6,000
Design	1	LS	$10,000	$10,000
Existing pond excavation	645	CY	$50.00	$32,250
Structure (inlet)	1	Each	$5,000	$5,000
Structure (outlet)	1	Each	$10,000	$10,000
Subtotal				$63,250
20% Contingency				$12,650
Total				**$75,900**

Pond Expansion				
Item	**Quantity**	**Unit**	**Unit Cost**	**Extended Amount**
Mobilization	1	LS	$6,000	$6,000
Design	1	LS	$10,000	$10,000
Pond expansion	25,055	CY	$15.00	$375,825
Structure (inlet)	1	Each	$5,000	$10,000
Site Seeding	1.4	Acre	$2,500	$3,500
1S Erosion Control Blanket	6,750	SY	$1.50	$10,125
Subtotal				$415,450
20% Contingency				$83,090
Purchase parcel				$250,000
Total				**$748,540**

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