VLAWMO
VADNAIS LAKE AREA WATER MANAGEMENT ORGANIZATION

West Vadnais Lake Subwatershed: Urban Stormwater Retrofit Analysis

Prepared for the Vadnais Lake Area Water Management Organization by:
Ramsey Conservation District

West Vadnais Lake Subwatershed: Urban Stormwater Retrofit Analysis

Prepared for the VLAWMO by:
Ryan Johnson, Ramsey Conservation District

VLAWMO Staff:

Stephanie McNamara
(Administrator)

Kristine Jenson
(Project Coordinator)

Brian Corcoran
(Water Resource Technician)

Vanessa Strong
(Education and Outreach Coordinator)

VLAWMO Board of Directors:

Marc Johannsen (Vadnais Heights City Council Member)
Chair of VLAWMO Board of Directors

Dan Jones (White Bear Lake City Council Member)
Vice Chair of VLAWMO Board of Directors

Bruce Ackerman (North Oaks City Council Member)
Treasurer/Secretary of VLAWMO Board of Directors

Bill Mample (White Bear Township Board Member)

Robert Uzpen (Gem Lake Mayor)

Rob Rafferty (Lino Lakes City Council Member)

Front Cover:
West Vadnais Lake Subwatershed

VLAWMO
VADNAIS LAKE AREA WATER MANAGEMENT ORGANIZATION

West Vadnais Lake Subwatershed:

Urban Stormwater Retrofit Analysis

Prepared for the Vadnais Lake Area Water Management Organization by:
Ramsey Conservation District

Abstract

This report details a subwatershed stormwater retrofit assessment recommending catchments for placement of Best Management Practice (BMP) retrofits that address the goals of the Vadnais Lake Area Water Management Organization (VLAWMO). No monitoring has been conducted in order to calibrate, verify, and/or validate the results. However, efforts were made to provide the most accurate and precise estimates for pollutant loading and reduction, along with estimated costs to reach these removal rates.

This report should be considered as one part of an overall watershed restoration plan that includes educational outreach, stream repair, riparian zone management, discharge prevention, upland native plant community restoration, and pollutant source control. The methods and analysis used attempt to provide sufficient detail to assess subwatersheds of variable scales and land uses, in order to identify optimal locations for stormwater treatment.

This report is a vital part of overall subwatershed restoration and should be considered in light of forecasting riparian and upland habitat restoration, pollutant hot-spot treatment, and educational outreach within existing or future development or watershed-restoration planning. The report includes background information, a summary of the assessment results, the methods used, catchment profile sheets of selected sites for retrofit consideration, and retrofit ranking results.

Results of this assessment are based on the development of catchment-specific conceptual stormwater treatment BMPs that either supplement existing stormwater infrastructure or provide quality and volume treatment where none currently exists. Relative comparisons were made between catchments to determine where best to initialize final retrofit design efforts. Site-specific design sets (driven by existing limitations of the landscape and the effect on design-element selection) will need to be developed to determine more refined estimates of pollutant removal amounts. This step typically occurs after identifying specific parcels for placement of BMPs.

VADNAIS LAKE AREA WATER MANAGEMENT ORGANIZATION

West Vadnais Lake Subwatershed:
Urban Stormwater Retrofit Analysis

Table of Contents

Introduction

The West Vadnais Lake Subwatershed (WVLS) is located in northern Ramsey County, MN. The WVLS consists of low density residential and a golf course on the north; medium density and multi-family throughout; commercial in the center and south west; industrial on the north east; and vast park and open space. Predevelopment, the land use consisted of mainly wet prairies, wetlands and some hardwood forest. The soils in the areas where retrofit opportunities were found consist of loamy fine sand, sandy loams, and urbanized soils. There are three major water features within the subwatershed (East & West Vadnais & Sucker Lake) and is contributed by numerous surrounding wetlands and urban runoff. Increasing levels of pollutants found in the lake and surrounding subwatershed is what prompted this study to identify BMP locations for water quality improvement.

This study identifies the most cost-effective opportunities to retrofit the stormwater conveyance system to improve water quality by reducing runoff volumes and TP levels. The methods used to complete this study were adapted from the Center for Watershed Protection. The methods include retrofit scoping, desktop analysis, a field investigation, treatment analysis/cost estimates of retrofits and an evaluation and ranking of the findings. The results of this study indentified the most cost effective retrofit location, type, and size to be installed given the contributing area within the WVLS catchments. The three catchments used for the study were delineated using terrain and storm sewer information. Catchments were broken delineated by which lake they flowed into. Catchment 1 drains into a common point before flowing under Highway 96. Catchment 2 all drains to a common point before flowing under County Road F. Figure 1 shows the individual catchments within the study area. From the three urban catchments reviewed nine retrofit locations were identified. The retrofit types proposed include bioretention consisting of filtration and infiltration where soils allowed.

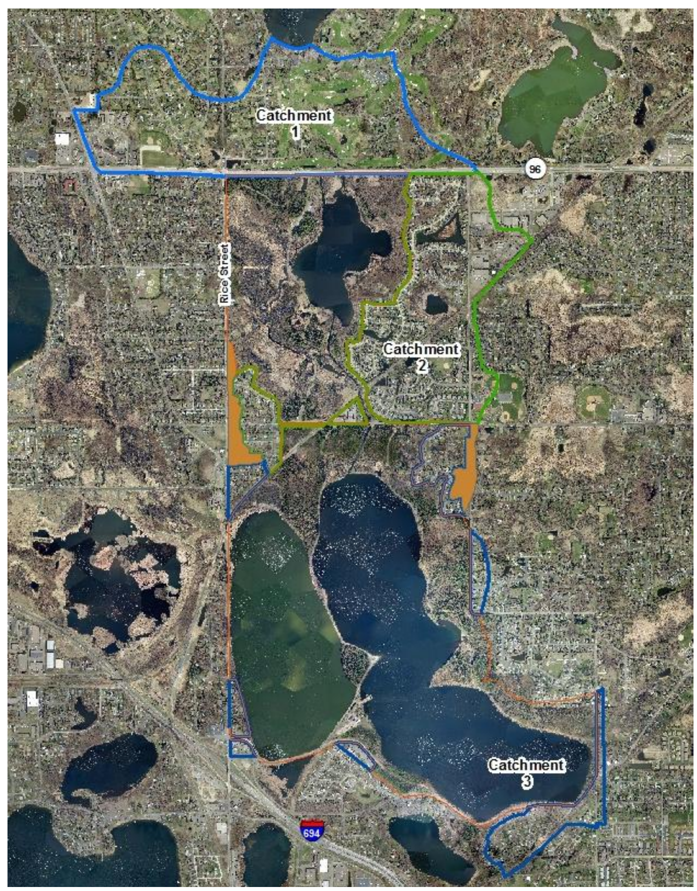


Figure 1. West Vadnais Subwatershed Catchments
(Areas with orange fill drain out of the subwatershed)

Methods

Retrofit Scoping

Each catchment was analyzed using standard land use files in WinSLAMM software to determine a base load of TP. The WinSLAMM parameters and standard land use files used can be seen in Appendix A. These base loads were calculated so that it could be determined that catchments with a greater pollutant load could be considered first when deciding which identified retrofit practices to install. During the base load modeling current water quality practices were reviewed. Municipal practices such as street sweeping or unidentified inlet sumps were not taken in to consideration during the base load modeling. A limited number of small scale treatments, such as turf swales, were discovered during the field reconnaissance. Due to the unknown effectiveness to remove pollutants and maintenance schedule of the small scale best management practices they were not taken in to consideration as treatment in the base load modeling. Larger regional treatments consist of numerous natural and man-made ponding and wetland systems. These features are assumed to have the ability to remove a percentage of TP before it enters the target waters, however, it was determined that the whole watershed be assessed and that many of the natural regional features were in need of protection as well as the lakes. With this in mind, each catchment was modeled as a whole and TP reduction through any series of regional treatment before it entered Sucker or Vadnais Lakes was not take in to consideration. However, all steps used to calculate the base load modeling were done to create an even playing field for all the catchments modeled. Although the pollutant base loads may be higher than reality, the same parameters were used in the modeling so that an overall precise comparison could be made between the catchments. More accurate and precise pollutant loads for each retrofit opportunity found within the drainage areas were calculated and discussed below in the Treatment Analysis/Cost Estimates.

Desktop Retrofit Analysis

A desktop search was conducted for each of the three catchment areas to identify potential retrofit opportunities before completing a field reconnaissance. GIS layers including topography, hydrology, soils, watershed/subwatershed boundaries, parcel info/boundaries, high-resolution aerial photography and the storm drainage infrastructure data were reviewed to determine potential retrofit placement. Several factors and key locations were considered during the desktop analyses that are conducive to retrofitting opportunities. These included areas well known for contributing increased polluted runoff (gas stations, sites with large impervious areas, storage facilities, etc.), public land (due to ease of cooperation during the installation process) and areas slated for redevelopment. Appendix C is the overall catchment and drainage area breakdown.

Retrofit Reconnaissance Investigation

After identifying potential retrofit sites through the desktop search, a field investigation was conducted to evaluate each site. 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 also revealed additional retrofit opportunities that went unnoticed during the desktop search.

VLAWMO
VADNAIS LAKE AREA WATER MANAGEMENT ORGANIZATION

Treatment Analysis/Cost Estimates

Retrofit Neighborshed Delineation

After the retrofit sites were identified each of their individual drainage areas or “neighborsheds,” consisting of runoff from surrounding streets, buildings, parking lots, and landscaped areas, etc., were delineated using drainage data gathered in the field and GIS contour data. See an example in Figure 2. This information, in conjunction with the NRCS soil survey data, was used to model the pollutant loads from each of the sites. Each of the source areas acreage was manually entered in to the WinSLAMM program under the appropriate land use type of which the site fell within. To maintain consistency all file data used in WInSLAMM, listed in Appendix A, was the same for each site modeled and street sweeping was not take into consideration in addition to the retrofit being modeled.

Retrofit Modeling & Sizing

The retrofit type and dimensions, conducive to the landscape and size of each neighborshed, was then chosen and incorporated in to the model to determine its capability to reduce TP. The retrofit types identified include: simple bioretention, moderately complex bioretention, complex bioretntion. The majority of residential bioretention BMPs modeled were all sized at 250 square feet. The soil type determined which type of bioretention cell could be installed for each location.

Figure 2. An example neighborshed and the source areas that are entered in to WinSLAMM

Retrofit Types

Bioretention: The bioretention referred to in this report, also referred to as curb cut rain gardens, takes stormwater runoff off line for treatment and utilizes the current stormwater conveyance system for overflow. Depending on the soil type at the location being constructed the bioretention basins consist of a depression utilizing native soils for infiltration or replacing current soil with an engineered soil and native vegetation plantings more conducive to infiltration. At some sites, an underdrain with connection to the existing storm sewer system may be needed if infiltration capability is limited by underlying soils or if infiltration cannot be allowed due to soil compaction or other conditions. It is important to properly design and install the engineered soils so that the bioretention basins take no less than 24 hours to drain but no more than 48 hours. The bioretention basins fell within the categories, listed below, depending on where the site was located within the landscape.

- Simple Bioretention - includes native vegetation, a curb cut and forebay, but no engineered soils or under-drains. May include a retaining wall if grade is steep.

- Moderately Complex Bioretention - includes native vegetation, engineered soils, a curb cut, forebay and underdrain, and no retaining walls.

- Complex Bioretention - is the same as the MCB, but with 1.5-2.5 ft partial perimeter walls.

A schematic of the retrofit types and example modeling parameters used within WinSLAMM of each retrofit type can be seen in Appendix B.

Retrofit Cost Estimates

Each retrofit identified was then assigned an estimated materials, design, and installation costs given its ft^2 of treatment. These cost estimates were derived from The Center of Watershed Protection manuals and recent installation costs provided by personal contacts. A unit promotion and admin costs were calculated with a total project cost and annual maintenance. A 30 year term cost/TP-removed for each retrofit was then calculated for the life-cycle of that retrofit, which was calculated from the total cost + (30 year * annual maintenance) / (30 year * TP (lb/yr)).

Results

Catchment Comparison

The three catchments and their total TP base loads are listed in the table below. It is estimated that Catchment 2 is producing the most TP load overall at 230 lbs TP per year and the most TP (lbs)/acre/year at 0.77. This information is suggested to be used in prioritizing which catchments should be considered first when efforts are put forth in installing the associated identified retrofits.

Drainage Area	Total TP (lbs)/ Year	Acres	TP (lbs)/Acre/Year
1	172	354	0.48
2	230	298	0.77
3	106	143	0.74

Catchment Profiles

The following pages provide catchment-specific information including a catchment summary and description. Each profile includes a catchment summary table showing the size of the catchment (acres) and the volume, and TP load estimates coming from the catchment. A table of individual retrofit types within the catchment and their levels of treatment is also included. This table shows the information listed below for each individual retrofit opportunity proposed. A map of retrofit locations and types is also provided in the catchment profile. More detailed retrofit locations can be seen on the large overview map and can be viewed digitally in ArcGIS with the ESRI shapefile, both provided with this report. The shapefile provides detailed retrofit locations and associated retrofit attributes.

- Catchment
- Site ID – a unique site ID number within the individual catchment
- TP – the Total Phosphorus reduced by the retrofit (lbs/year)
- TSS – the Total Suspended Solids reduced by the retrofit (lbs/year)
- Volume – the volume of water runoff reduced (cubic feet/year)
- Size – proposed size of retrofit and the size used to model (square feet)
- BMP Type – type of retrofit proposed at that site
- Materials/Labor/Design – cost estimates of materials, labor, and design
- Unit Promotion & Administrative Costs – admin costs associated with the installation of retrofits (*100 cu ft unit cost)
- Total Project Cost (**Typical Raingarden maintenance costs)
- Annual Operation & Maintenance Cost
- Term Cost – Cost/ TP removed (lbs)/30 year life cycle – retrofits are ranked from lowest to highest buy this number in each table.

This page is intentionally left blank

Catchment 1

DESCRIPTION

Existing Catchment Summary	
Acres	354
TP (lbs/yr)	172
TP(lbs)/Acre/Yr	0.48

This catchment is comprised of primarily low density land use with a large golf course. The western portion of this catchment ends at Hodgson Road, while the southern boundary is Highway 96. All the water from Catchment 1 goes through a channel and into Sucker Lake. The majority of the soils are classified as sandy loam which would allow for bioretention with engineered soils and an underdrain. Loamy sand soils were also identified within the catchment which would allow for simple to moderate bioretention, if found to not be compacted or polluted.

RETROFIT RECOMMENDATION

Multiple bioretention locations were identified in this catchment, along with one porous, and one vegetated swale option. Site 6 was identified within a ditch area that drains part of the golf course and low residential area. This site was modeled with a vegetated swale of 650 lin-ft incorporating small pooling areas/steps to reduce volume and slow the rate. This area consists of an open ditch system that enters wetland complex which connects to the Sucker Lake Channel under Highway 96. Storm sewer information for this area did not exist in great detail so before proceeding with the installation the drainage system for this area should be confirmed to determine if the installation is not currently receiving any pre-treatment. Site 7 is located adjacent to the golf course parking lot. It is proposed that 750 square feet moderately complex bioretention basin be installed to capture parking lot runoff before it drains onto the golf course. Throughout the catchment, many Bee Hive style storm sewer inlets were discovered that were set in the existing ditches. These areas were modeled by raising the inlet 1' by the addition of concrete rings. This will allow for ponding in the ditch before storm water enters the pipes.

It is suggested that retrofits proposed be considered from the top of the list down also taking in to account overall ease of installation. If all retrofit opportunities are installed 22.24 lbs of TP would be removed from the catchment resulting in a 13% decrease from the base load at an initial total project cost of $384,930.

Catchment	Site ID	TP (lb/yr)	TSS (lb/yr)	Volume (cubic-feet/yr)	Size (sq ft)	BMP Type	Materials/Labor/ Design	Unit Promotion & Admin Costs*
1	1	1.87	511	60,952	500	Simple Bioretention	$6,210.00	$565.00
1	2	1.87	511	60,952	500	Simple Bioretention	$6,210.00	$565.00
1	4	1.68	424	44,541	500	Moderately Complex Bioretention	$7,710.00	$565.00
1	5	1.27	177	12,897	500	Moderately Complex Bioretention	$7,710.00	$565.00
1	3	1.12	329	37,675	500	Complex Bioretention	$9,210.00	$565.00
1	6	6.51	1,760	141,000	4,000	Complex Bioretention	$56,210.00	$124.00
1	147	7.66	4,631	571,062	20,000	Permeable Asphalt	$280,210.00	$38.00
1	7	0.26	64	6,504	750	Moderately Complex Bioretention	$11,460.00	$420.00

Catchment 1 BMP Locations

VLAWMO
VADNAIS LAKE AREA WATER MANAGEMENT ORGANIZATION

Catchment 2

DESCRIPTION

Existing Catchment Summary	
Acres	230
TP (lbs/yr)	298
TP(lbs)/Acre/Yr	0.77

This catchment consists of medium density residential, industrial, and commercial land use mixed with open space consisting of a series of ponds, wetlands and lakes. Rice Street is the western border, McMenemy is the eastern, with Highway 96 to the North and County Road F on the south. Duplex residential housing exists within the southeastern portion of the catchment. Loamy sand soils were also identified within the catchment which would allow for simple to moderate bioretention, if found to not be compacted or polluted.

RETROFIT RECOMMENDATION

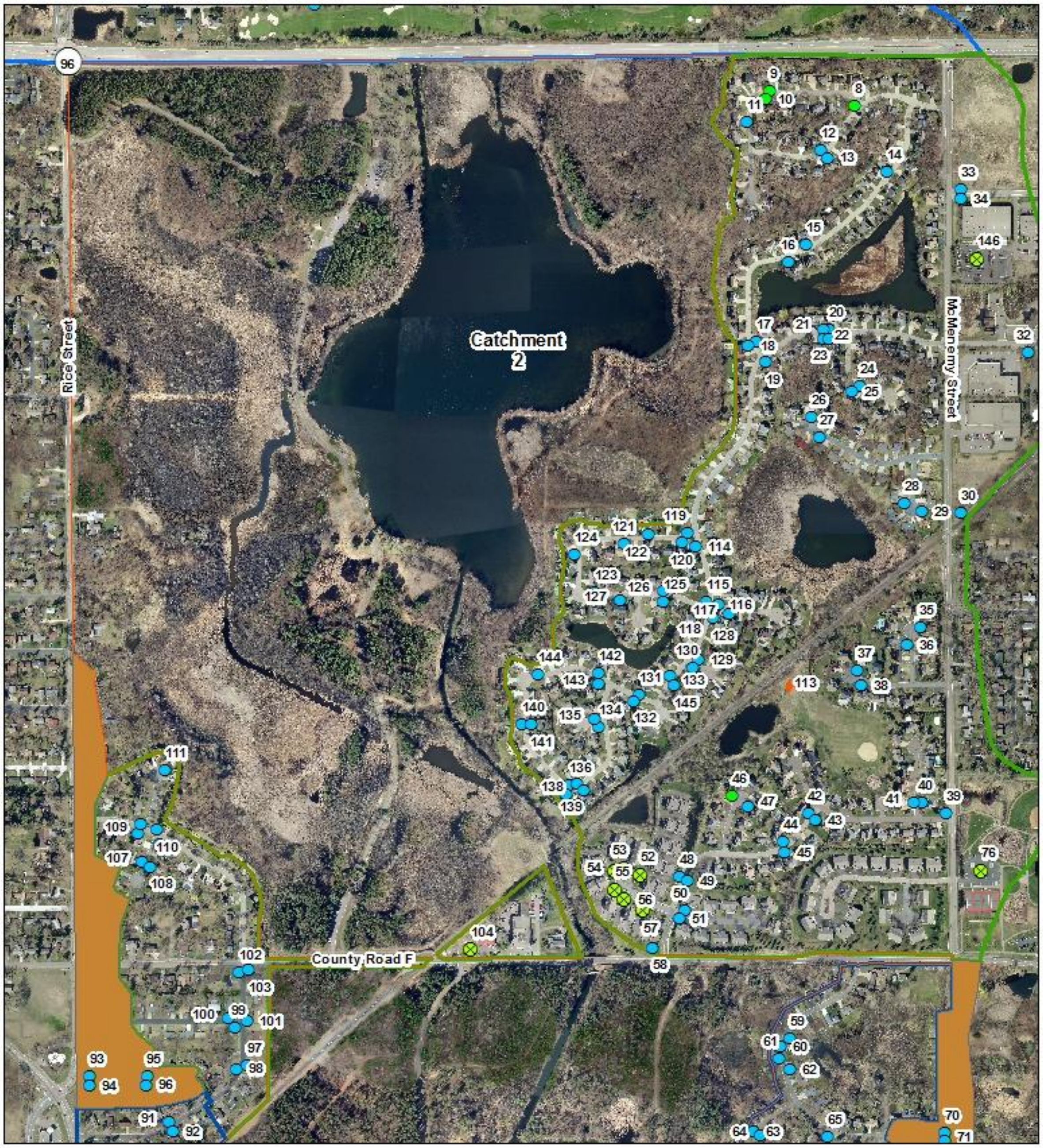
It is assumed that the runoff from this catchment is being captured and treated by the numerous wetlands and stormwater ponds present. There was little opportunity for retrofitting within this catchment since runoff from most impervious areas was being redirected for pre-treatment before entering Sucker Lake. Further water quality monitoring from wetland or stormwater pond outlets could be completed to determine if there is adequate treatment of runoff. The locations identified include moderately & complex bioretention, porous parking, and potential a new pond/wetland which would capture runoff from the surrounding areas which currently drain into the storm sewer system that discharges into existing pond/wetland complexes adjacent to Sucker Lake. Each bioretention basin installed at 250 square feet would reduce the TP going into Sucker Lake by 0.92 lbs/yr of would be removed from the catchment resulting in a 0.4% decrease from the base load at an initial total project cost of $5,000. If all BMP's were installed, an estimated 88.4 lbs of TP would be removed an annual basis which is a decrease of 38% at a cost of $560,000.

The orange areas within Catchment 2 drain out of the West Vadnais Lake Subwatershed via storm pipes. Areas were identified within these neighborsheds to help with stormwater and pollutant reductions.

Catchment	Site ID	TP (lb/yr)	TSS (lb/yr)	Volume (cubic-feet/yr)	Size (sq ft)	BMP Type	Materials/Labor/ Design	Unit Promotion & Admin Costs*	Total Project Cost**	Annual O&M	Term Cost/lb/yr (30 yr)
2	11+	0.92	267	25,158	250	Moderately Complex Bioretention	$3,960.00	$936.00	$4,896.00	$188.00	$381.74
2	8-10	0.92	267	25,158	250	Complex Bioretention	$4,710.00	$936.00	$5,646.00	$188.00	$408.91
2	146	3.04	2,675	171,414	10,000	Permeable Asphalt	$140,210.00	$64.00	$140,274.00	$7,500.00	$4,002.56

*All basins modeled using 1' of ponding and 250 sq-ft footprint. Figures shown above are **averages** across the landscape since all basins are designed equally

Catchment	Site ID	TP (lb/yr)	TSS (lb/yr)	Volume (cubic-feet/yr)	Size (sq ft)	BMP Type	Materials/Labor/ Design	Unit Promotion & Admin Costs*	Total Project Cost**	Annual O&M	Term Cost/lb/yr (30 yr)
na	na	0.10	21	2,500	400	Porous Driveway (2' depth)	$5,612.00	$565.00	$6,177.00	$188.00	$3,939.00



Catchment 2 BMP Locations

N

0 700 1,400 Feet

- Moderately Complex Bioretention
- Complex Bioretention
- Porous Materials
- Vegetated Swale
- Pond/Wetland Creation
- Engineering Practice

VLAWMO
VADNAIS LAKE AREA WATER MANAGEMENT ORGANIZATION

Catchment 3

DESCRIPTION

This catchment consists of mainly single family residential housing with a mix of institutional land use. The soils within the area where retrofit opportunities were identified consist of Urban land-Zimmerman complex and loamy fine sand which would allow for simple to moderate bioretention if found to not be compacted or polluted.

Existing Catchment Summary	
Acres	106
TP (lbs/yr)	143
TP(lbs)/Acre/Yr	0.74

RETROFIT RECOMMENDATION

Little to no treatment exists within this catchment with the exception of a wetland cell in the southeast corner of the catchment that captures water from the newer development off of Vadnais Blvd. There is a larger drainage issue on the corner of Edgerton and Vadnais Blvd that is beyond the scope of this study. For reference purposes, it is identified as a yellow triangle on the map and labeled as an Engineering Practice practice due to its multiple and complex drainage issues. This task was not modeled and no estimate was put together for the practice. A VLAWMO engineer (or outside consultant) should determine the appropriate practice to solve the local runoff and drainage issues. .

The retrofit opportunities identified within this catchment consist of moderate bioretention with the replacement of engineered soils. Moderate bioretention was identified at all the sites, and consist of 250 square feet curb cut raingardens each collecting runoff from the streets. there is an option to install a pond/wetland cell (Location 78) that could enhance the stormwater treatment if the conditions warrant. There is also 1 porous parking lot option at the school on Vadnais Blvd that could aid in volume reduction, but won't treat as much TP as the moderate bioretention basins. The bioretention basins will provide the most cost effective treatment of TP overall the other retrofit sites identified. If all retrofits are installed within this catchment it is calculated that 55.8 lbs of TP would be removed from the catchment resulting in a 53% decrease from the base load at an initial total project cost of $630,000.

Sites 52-57 are in a multi-family residential area of Catchment 2. The locations identified are porous driveways and were modeled using the Porous Control Practice shown in the Appendix.

Catchment	Site ID	TP (lb/yr)	TSS (lb/yr)	Volume (cubic-feet/yr)	Size (sq ft)	BMP Type	Materials/Labor/Design	Unit Promotion & Admin Costs*	Total Project Cost**	Annual O&M	Term Cost/lb/yr (30 yr)
3	all sites	0.92	267	25,158	250	Moderately Complex Bioretention	$3,960.00	$936.00	$4,896.00	$188.00	$381.74
3	88	0.63	378	46,579	8,000	Permeable Asphalt	$112,210.00	$75.00	$112,285.00	$6,000.00	$15,588.53

*All basins modeled using 1' of ponding and 250 sq-ft footprint. Figures shown above are **averages** across the landscape since all basins are designed equally

Catchment	Site ID	TP (lb/yr)	TSS (lb/yr)	Volume (cubic-feet/yr)	Size (sq ft)	BMP Type	Materials/Labor/Design	Unit Promotion & Admin Costs*	Total Project Cost**	Annual O&M	Term Cost/lb/yr (30 yr)
na	na	0.10	21	2,500	400	Porous Driveway (2' depth)	$5,612.00	$565.00	$6,177.00	$188.00	$3,939.00

Catchment 3 BMP Locations

VLAWMO
VADNAIS LAKE AREA WATER MANAGEMENT ORGANIZATION

Overall Retrofit Results

In the list provided below are all of the retrofit opportunities ranked from lowest to highest term cost for every catchment within the West Vadnais Lake Subwatershed. While the highest ranking projects are in Catchment 1, activities should be focused on Catchment 2. The higher density land use with storm sewers directly connecting the water resources, makes this catchment more desirable for retrofitting. Catchment 3 has lower density land use and is more disconnected from the water resource versus Catchment 2, but is higher priority than Catchment 1. All of the located BMP's will help with the removal to TP, but an added benefit is the reduction in stormwater rate and volume.

Additional Notes:
East Vadnais Lake currently receives in lake treatment by the Saint Paul Water Authority as a measure to protect the drinking water supply. VLAWMO is responsible for the external loading from the surrounding subwatershed into East Vadnais Lake. West Vadnais does not receive any treatment, and it is unlikely that any treatment can be performed. The land use around West Vadnais Lake does not allow for the addition of BMP's, and the lake is mainly surrounded by open space. It is likely that East and West Vadnais Lakes will have different water quality in comparison to each other regardless of the installation of BMP's. To improve the water quality of West Vadnais Lake, alternative in lake activities such as aeration, chemical treatment, rough fish harvest, etc. could be completed in lieu of stormwater BMP's.

Residential homeowners can look into creating a porous strip in their driveway. This was not noted in the Catchment overview and maps because there are hundreds of potential locations to implement this type of practice, and the overall Term Cost is 10 times higher due to the lower volume and TP captured.

Catchment	Site ID	TP (lb/yr)	TSS (lb/yr)	Volume (cubic-feet/yr)	Size (sq ft)	BMP Type	Materials/Labor/Design	Unit Promotion & Admin Costs*	Total Project Cost**	Annual O&M	Term Cost/lb/yr (30 yr)
1	1	1.87	511	60,952	500	Simple Bioretention	$6,210.00	$565.00	$6,775.00	$375.00	$321.30
1	2	1.87	511	60,952	500	Simple Bioretention	$6,210.00	$565.00	$6,775.00	$375.00	$321.30
2	11+	0.92	267	25,158	250	Moderately Complex Bioretention	$3,960.00	$936.00	$4,896.00	$188.00	$381.74
3	all sites	0.92	267	25,158	250	Moderately Complex Bioretention	$3,960.00	$936.00	$4,896.00	$188.00	$381.74
1	4	1.68	424	44,541	500	Moderately Complex Bioretention	$7,710.00	$565.00	$8,275.00	$375.00	$387.63
2	8-10	0.92	267	25,158	250	Complex Bioretention	$4,710.00	$936.00	$5,646.00	$188.00	$408.91
1	5	1.27	177	12,897	500	Moderately Complex Bioretention	$7,710.00	$565.00	$8,275.00	$375.00	$511.66
1	3	1.12	329	37,675	500	Complex Bioretention	$9,210.00	$565.00	$9,775.00	$375.00	$623.63
1	6	6.51	1,760	141,000	4,000	Complex Bioretention	$56,210.00	$124.00	$56,334.00	$3,000.00	$749.28
1	147	7.66	4,631	571,062	20,000	Permeable Asphalt	$280,210.00	$38.00	$280,248.00	$15,000.00	$3,177.75
1	7	0.26	64	6,504	750	Moderately Complex Bioretention	$11,460.00	$420.00	$11,880.00	$563.00	$3,736.02
2	104 &146	3.04	2,675	171,414	10,000	Permeable Asphalt	$140,210.00	$64.00	$140,274.00	$7,500.00	$4,002.56
3	88	0.63	378	46,579	8,000	Permeable Asphalt	$112,210.00	$75.00	$112,285.00	$6,000.00	$15,588.53

Catchment	Site ID	TP (lb/yr)	TSS (lb/yr)	Volume (cubic-feet/yr)	Size (sq ft)	BMP Type	Materials/Labor/Design	Unit Promotion & Admin Costs*	Total Project Cost**	Annual O&M	Term Cost/lb/yr (30 yr)
na	na	0.10	21	2,500	400	Porous Driveway (2' depth)	$5,612.00	$565.00	$6,177.00	$188.00	$3,939.00

References

Lager, J.A., W.G. Smith, and G. Tchobanoglous. *Catchbasin Technology Overview and Assessment*. U.S. EPA. Contract No. 68-03-0274. EPA-600/2-77-051. 129 pages Cincinnati, May 1977

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

Panuska, J. 1998. *Drainage System Connectedness for Urban Areas*. Memo. Wisconsin Dept of Natural Resources. Madison, WI.

Pitt, R., Voorees,J.and C.Burger. 2009. WINSLAMM v9.4: Source Loading and Management Model for Windows. http://winslamm.com/

Rawls et. al. 1998. *Use of Soil Texture, Bulk Density, and Slope of the Water Retention Curve to Predict Saturated Hydraulic Conductivity*. Transactions of the ASAE. Vol 41(4): 983-988. St. Joseph, MI.

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.

USDA. 1986. *Urban Hydrology for Small Watersheds TR-55*. Second Edition. Washington, DC.

Walker, W.W. 2007. *P8: Urban Catchment Model, V 3.4.* Developed for the USEPA, Minnesota PCA and the Wisconsin DNR.

Wenck Associates, Inc. 2007. *City of Stillwater Lake Management Plans – Lily Lake and McKusick Lake.* Prepared for City of Stillwater and Brown's Creek Watershed District. Stillwater, Minnesota.

VLAWMO
VADNAIS LAKE AREA WATER MANAGEMENT ORGANIZATION

Appendix A.

WINSLAMM modeling parameters and files used in the assessment

File Name	Date Created/ Last Modified	Created By	Description
"CPZ:" These files contain the sediment particle size distributions developed from monitored data. The files area used in the evaluation of control practices that rely upon particle settling for pollution control.			
NURP.CPZ	5/16/88	Pitt/UA	Summarizes NURP outfall particle size data
"PPD" (Pollutant Probability Distribution) files describe the pollutant concentrations found in source areas.			
WI_GEO01.ppd	11/26/02	Horwatich/USGS	USGS/DNR pollutant probability distribution file from Wisconsin monitoring data.
"PRR" (Particulate Residue Reduction) files describe the fraction of total particulates that remains in the drainage system (curbs and gutters, grass swales, and storm drainage) after rain events end due to deposition. This fraction of the total particulates does not reach the outfall, so the outfall values are reduced by the fraction indicated in the .PRR file.			
WI_DLV01.prr	7/8/01	Horwatich/USGS	USGS/DNR particulate residue reduction file for the delivery system from Wisconsin monitoring data.
"RSV" (Runoff coefficient file). These coefficients, when multiplied by rain depths, land use source areas, and a conversion factor, determine the runoff volumes needed by WinSLAMM.			
WI_SL06 Dec06.rsv	12/18/06	Horwatich/USGS	USGS/DNR runoff volumetric coefficient file from Wisconsin monitoring data. Use for all versions of WinSLAMM starting from v 9.2.0.
"STD" (Street Delivery File): These files describe the fraction of total particulates that are washed from the streets during rains, but are subsequently redeposited due to lack of energy in the flowing water.			
WI_Com Inst Indust Dec06.std	12/12/06	Horwatich/USGS	USGS/DNR street delivery file from Wisconsin monitoring data. Use for all versions of WinSLAMM starting from v 9.2.0 for Industrial, Commercial and Institutional land uses.
WI_Res and Other Urban Dec06.std	12/07/06	Horwatich/USGS	USGS/DNR street delivery file from Wisconsin monitoring data. Use for all versions of WinSLAMM starting from v 9.2.0 for Residential and Other Urban land uses.
Freeway Dec06.std	7/12/05	Pitt/UA	Street delivery file developed to account for TSS reductions due to losses in a freeway delivery system based upon early USDOT research. Renamed Freeway.std
"PSC" (Particulate Solids Concentration): Values in this file, when multiplied by source area runoff volumes and a conversion factor, calculate particulate solids loadings (lbs).			
WI_AVG01.psc	11/26/02	Horwatich/USGS	USGS/DNR particulate solids concentration file from Wisconsin monitoring data.
"RAN" (Rain Files):			
MN Minneapolis 59.RAN	NA	NA	A n event-record of rainfall for the year 1959, considered as an average year, in the form of Start Date, Start Time, End Date, End Time and Rainfall (in inches).
Settings			
Parameter	Description		
Start/End Date	Defines the modeling period in reference to the rain file data. In this case, the entire one year period was selected (i.e., 01/02/59-12/28/59).		
Winter Season Range	Set to begin on November 7th and end on March 17th.		
Drainage System	Set to "Curb and gutter, valleys, or sealed swales in fair condition.		

WINSLAMM Standard Land Use Codes

RESIDENTIAL LAND USES

- High Density Residential without Alleys (HDRNA): Urban single family housing at a density of greater than 6 units/acre. Includes house, driveway, yards, sidewalks, and streets.
- High Density Residential with Alleys (HDRWA): Same as HDRNA, except alleys exist behind the houses.
- Medium Density Residential without Alleys (MDRNA): Same as HDRNA except the density is between 2 - 6 units/acre.
- Medium Density Residential with Alleys (MDRWA): Same as HDRWA, except alleys exists behind the houses.
- Low Density Residential (LDR): Same as HDRNA except the density is 0.7 to 2 units/acre.
- Duplexes (DUP): Housing having two separate units in a single building.
- Multiple Family Residential (MFRNA): Housing for three or more families, from 1 - 3 stories in height. Units may be adjoined up-and-down, side-by-side; or front-and-rear. Includes building, yard, parking lot, and driveways. Does not include alleys.
- High Rise Residential (HRR): Same MFRNA except buildings are High Rise Apartments; multiple family units 4 or more stories in height.
- Mobile Home Park (MOBH): A mobile home or trailer park, includes all vehicle homes, the yard, driveway, and office area.
- Suburban (SUB): Same as HDRNA except the density is between 0.2 and 0.6 units/acre.

COMMERCIAL LAND USES

- Strip Commercial (SCOM): Those buildings for which the primary function involves the sale of goods or services. This category includes some institutional lands found in commercial strips, such as post offices, courthouses, and fire and police stations. This category does not include buildings used for the manufacture of goods or warehouses. This land use includes the buildings, parking lots, and streets. This land use does not include nursery, tree farms, vehicle service areas, or lumber yards.
- Shopping Centers (SHOP): Commercial areas where the related parking lot is at least 2.5 times the area of the building roof area. Parking areas usually surrounds the buildings in this land use. This land use includes the buildings, parking lot, and streets.
- Office Parks (OFPK): Land use where non-retail business takes place. The buildings are usually multi storied buildings surrounded by larger areas of lawn and other landscaping. This land use includes the buildings, lawn, and road areas. Types of establishments that may be in this category includes: insurance offices, government buildings, and company headquarters.
- Commercial Downtown (CDT): Multi-story high-density area with minimal pervious area, and with retail, residential and office uses.

INDUSTRIAL LAND USES

- Medium Industrial (MI): This category includes businesses such as lumber yards, auto salvage yards, junk yards, grain elevators, agricultural coops, oil tank farms, coal and salt storage areas, slaughter houses, and areas for bulk storage of fertilizers.

- Non-Manufacturing (LI): Those buildings that are used for the storage and/or distribution of goods waiting further processing or sale to retailers. This category mostly includes warehouses, and wholesalers where all operations are conducted indoors, but with truck loading and transfer operations conducted outside.

INSTITUTIONAL LAND USES

- Education (SCH): Includes any public or private primary, secondary, or college educational institutional grounds. Includes buildings, playgrounds, athletic fields, roads, parking lots, and lawn areas.
- Miscellaneous Institutional (INST): Churches and large areas of institutional property not part of CST and CDT.
- Hospital (HOSP): Multi-story building surrounded by parking lots and some vegetated areas.

OTHER URBAN LAND USES

- Parks (PARK): Outdoor recreational areas including municipal playgrounds, botanical gardens, arboretums, golf courses, and natural areas.
- Undeveloped (OSUD): Lands that are private or publicly owned with no structures and have a complete vegetative cover. This includes vacant lots, urban fringe areas slated for development, greenways, and forest areas.
- Cemetery (CEM): This land use file covers cemeteries, and includes road frontage along the cemetery, and paved areas and buildings within the cemetery.

FREEWAY LAND USES

- Freeways (FREE): Limited access highways and the interchange areas, including any vegetated rights-of-ways.

VLAWMO
VADNAIS LAKE AREA WATER MANAGEMENT ORGANIZATION

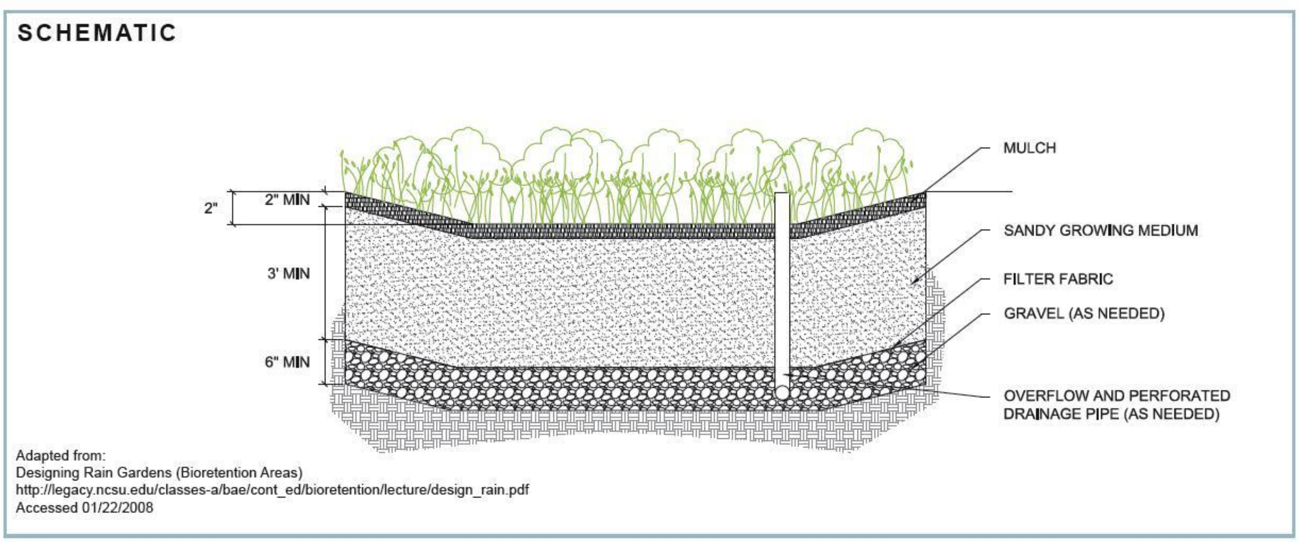
Appendix B.

Bioretention:

Curb cut raingarden, with 1.5-2ft perimeter wall, in a residential area.

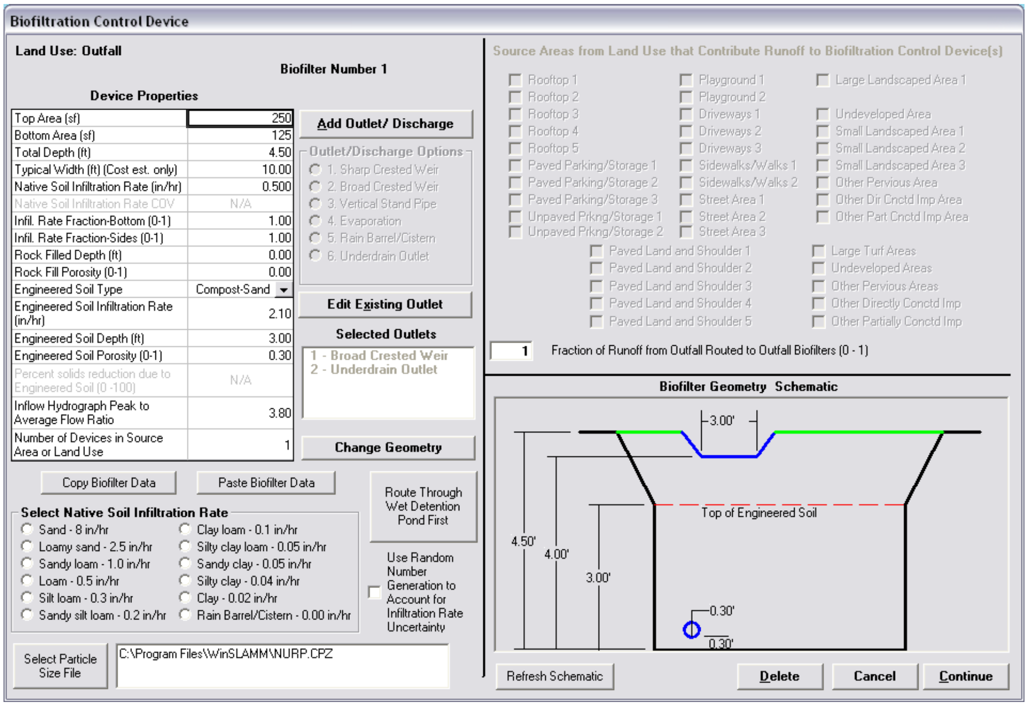
Photo Courtesy of Rusty Schmidt.

Bioretention design

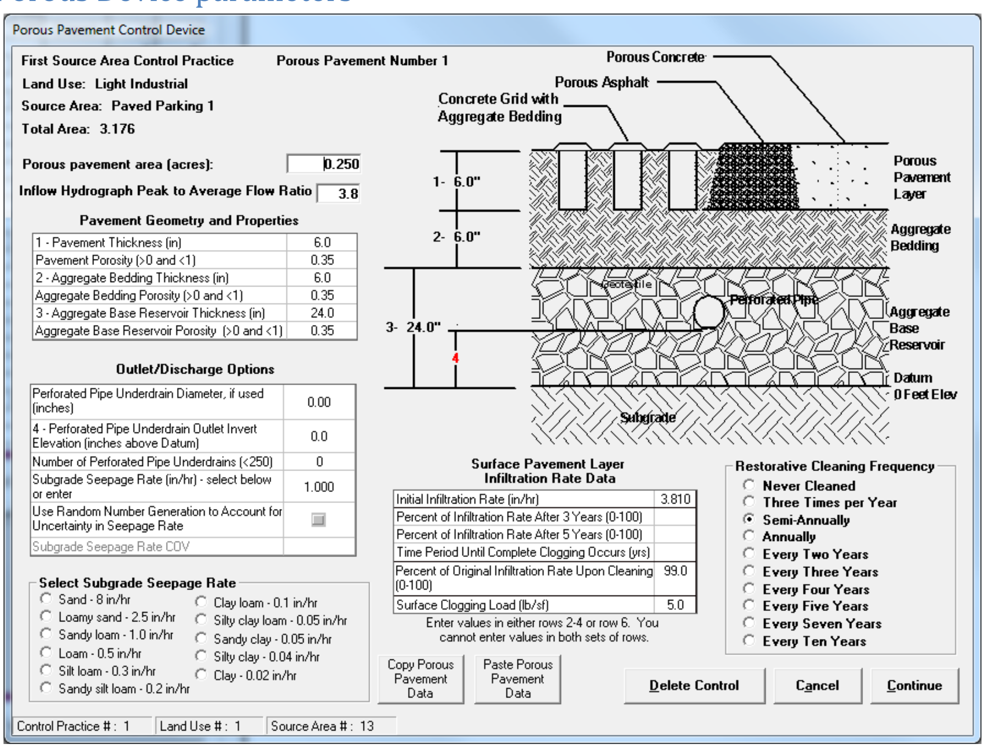


Graphic courtesy of Charles River Watershed Association, Weston, MA. www.charlesriver.org.

WinSLAMM Biofiltration Control Device parameters



WinSLAMM Porous Device parameters



Appendix C.

Cathments and Drainage Areas