# Birch Lake

# Stormwater Retrofit Analysis

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# Executive Summary

This report details a subwatershed stormwater retrofit assessment recommending catchments for placement of Best Management Practice (BMP) retrofits that address meeting state water quality standards and the Total Maximum Daily Load completed for Birch Lake. No monitoring has been conducted in order to calibrate, verify, and/or validate the results. Efforts were made to provide accurate 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, shoreland 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.

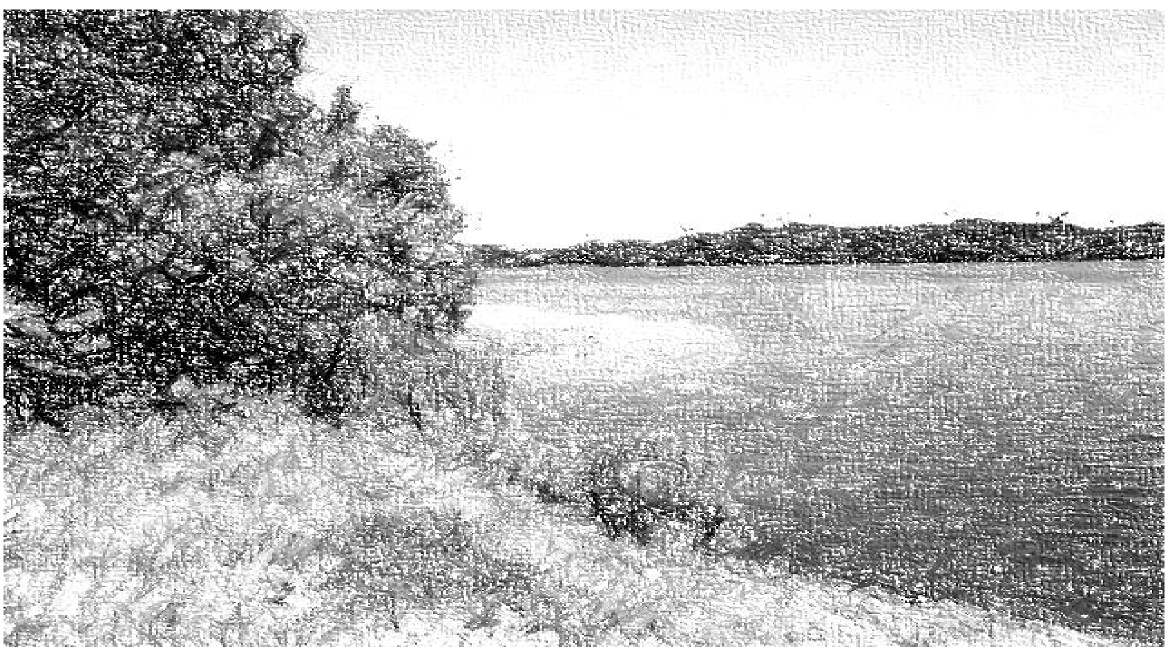
This report is a vital part of overall subwatershed restoration and should be considered when planning for riparian and upland habitat restoration, pollutant hot-spot treatment, and educational outreach with existing or future development or watershed restoration planning. The report includes background 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 where none currently exist. 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.

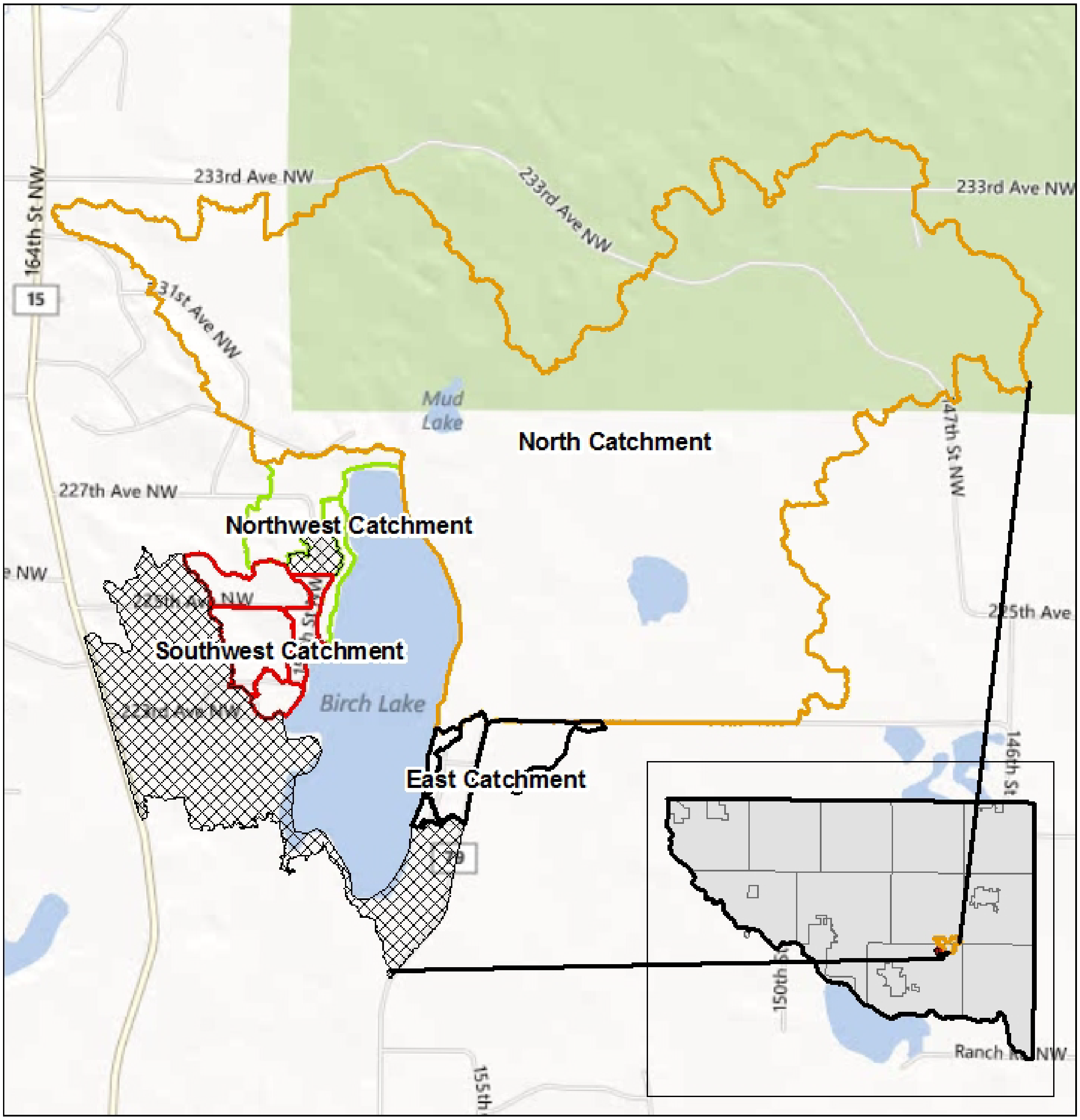
The table on page 5 summarizes potential projects. Potential projects are organized from most cost effective to least, based on cost per pound of total phosphorus removed. Installation of projects in series will result in lower total treatment than the simple sum of treatment across the individual projects due to treatment train effects. Reported treatment levels are depended upon optimal site selection and sizing. Pollutant reductions and costs listed in this report are meant to be compared relatively to one another; they are by no means actual amounts. When projects are selected, a detailed site plan and cost analysis must be completed. More detail about each project can be found in the catchment profile pages of this report.

**Catchments 1-4: Summary of preferred Stormwater retrofit opportunities ranked by cost effectiveness with respect to total phosphorus.**

| 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) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | East | Iron-Enhanced Sand Filter* | 1 | 8 | 3163 | 4.5 | $25,826 | $75 | $117 |
| 2 | North | Iron-Enhanced Sand Filter* | 1 | 103.0 | 41,390 | 52.8 | $267,415 | $7,500 | $159 |
| 3 | Northwest | Simple Bioretention | 2 to 4 | 6.0-9.2 | 2,130-3,162 | 3.0-4.4 | $6,215-11,641 | $375-750 | $97-1240 |
| 4 | East | Simple Bioretention | 2 to 4 | 4.3-6.4 | 1,775-2,625 | 2.5-3.7 | $6,215-11,641 | $375-750 | $135-178 |
| 5 | Southwest | Simple Bioretention | 5 to 10 | 4.6-7.0 | 1,839-2,773 | 2.4-3.7 | $14415-28,425 | $938-1,875 | $308-403 |
| 6 | Northwest | Lakeshore Restoration | 15 | 5.4 | 1,707 | 2.3 | $60,047 | $11,250 | $2,454 |
| 7 | East | Lakeshore Restoration | 13 | 2.8 | 1,131 | 7.4 | $60,047 | $11,250 | $4,733 |



**Map of catchments and sub-catchments (SC) referred to in this report**

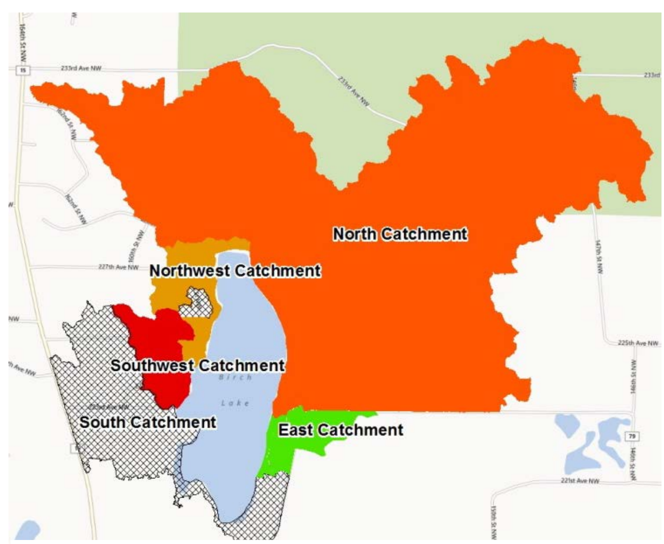


# Introduction

This study provides recommendations for cost effectively improving treatment of Stormwater from rural residential neighborhoods surrounding Birch Lake before it is discharged into the lake. Birch Lake, located in Big Lake Township MN, was determined to be non-supporting of aquatic recreation and was listed as impaired in 2006. A TMDL is scheduled for this lake as part of the MPCA's Watershed Approach for the Mississippi River (St. Cloud) Watershed. This assessment will be paired with work done to determine watershed runoff and phosphorus concentrations for the associated TMDL. Birch Lake is classified as a Recreational Development lake; these lakes generally have between 2 and 25 dwellings per mile of shoreline.

The approaches in the report are often termed "stormwater retrofitting." This 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 the costs and pollutant reductions, and used them to calculate cost effectiveness of each possible project.

The four catchments used for the study were delineated using terrain information and assistance from the Big Lake Township Roads Committee. The catchment areas shown here drain to Birch Lake, through surface flows, pipes, ditched systems or connected impervious areas. The south catchment was excluded from this report because the land is predominantly covered with herbaceous wetlands which contain minimal opportunity for retrofits. For each of the four catchments we modeled Stormwater volume and pollutants using the software WinSLAMM. First, we modeled existing conditions. 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 operations and maintenance. Projects were ranked by cost effectiveness with respect to phosphorus reduction.



Birch Lake Catchments

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

- Residential rain gardens,
- Swales,
- Iron enhanced Sand Filters,
- Lakeshore restorations

Because Stormwater catchments around Birch Lake are small, the recommended practices will work together to cumulatively reduce Stormwater into the lake. Each practice would need to be strategically placed for maximum effectiveness. A practice was considered only if an appropriate place existed and we felt it would be effective.

If all of the practices identified were installed, significant pollution reduction could be accomplished. However, funding limitations and landowner interest makes this goal unlikely. Instead, it is recommended that projects be installed in order of cost effectiveness (pounds of pollution reduced per dollar spent). Other factors, including a project's educational value/visibility, construction timing, total cost, or non-target pollutant reduction also add to project installation decisions and will need to be weighed by resource managers when selecting projects to pursue.

This report provides conceptual ideas 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 and in some cases they could require engineered plan sets. This typically occurs after committed partnerships are formed to install the project. Committed partnerships must include willing landowners when installed on private property.

Recommendations made in the 1998 Lake Assessment Report (LAR) hold true today and were stated as follows: "no untreated stormwater should be directed into the lake via stormwater conveyance systems, the amount of impervious surfaces in the developed areas should be kept to a minimum, all on site systems should be installed per code and properly maintained, and natural buffers of vegetation should be maintained between lawns and lakeshore."

It is important to note that the SWCD has a positive relationship with the Birch Lake Association and Big Lake Township which will increase success of implementation projects.

# Methods

## Retrofit Scoping

In this assessment, the focus area was the land that drains directly to Birch Lake through surface flows, pipes, ditched systems and/or connected impervious surfaces. This restricts the study area to the neighborhoods closest to the lake and encompasses the areas of highest density of development in the lake's watershed. We divided this area into four catchments using a combination of GIS mapping and field surveys, which identified Stormwater infrastructure and observed topography.

Each catchment was analyzed using standard land use files in WinSLAMM 10 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 practice to install. During the base load modeling, current water quality practices were reviewed. Two larger regional treatments consisting of a landlocked infiltration basin and a wetland system were identified. Because no water leaves the manmade infiltration basin (through surface water flows) the treatment system was not included in the model. The wetland system most defiantly does have the ability to remove a percentage TP before it enters Birch Lake; however, it was determined that the wetland system is also in need of protection and the catchment was modeled as a whole and TP reduction through the wetland was not taken into consideration. It is important to note that all steps used to calculate base load modeling were done to create an even playing field for all the catchments modeled. Although the pollutant based loads may be higher than reality the same parameters were used in the modeling so that an overall precise comparison could be made between catchments.

## Desktop Retrofit Analysis

A desktop search was conducted for each of the four catchment areas to identify potential retrofit opportunities before completing a field reconnaissance. GIS layers including 2-foot topography, hydrology, soils, watershed/subwatershed boundaries, parcel info/boundaries, aerial photography and storm drainage infrastructure data were reviewed to determine potential retrofit placement. For this assessment, Big Lake Township searched paper maps for records of Stormwater infrastructure; no permitted conveyance systems were mapped in the watershed. However, there were several conveyances identified which do not fall under the Municipal Separate Storm Sewer System permit.

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 (sites with a large percentage impervious areas), and public land due to ease of cooperation during the installation process.

## 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 conveyance (culvert) 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.

## Cost Estimates

Each retrofit identified was assigned an estimated materials, design, and installation cost 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 administration cost was 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).

## Retrofit Modeling & Sizing

The retrofit type and dimensions conducive to the landscape was then chosen and incorporated into the model to determine its capability to reduce TP. The retrofit types considered include:

- Bioretention: use of native soil, soil microbe and plant processes to treat, evapotranpirate, and/or infiltrate Stormwater runoff. Facilities can either be fully filtering or a combination thereof.
- Filtering: Filter runoff through engineered media and passing 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 con 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.

# Results

## Catchment Comparison

The four catchments and their total TP base loads are listed in the table below. It is estimated that the north catchment is producing the most TP load at 188.50 pounds of TP per year and Northwest Catchment is producing the most TP (lbs)/acre/year at 0.54. 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.

| Catchment | Total TP (lbs/year) | Acres | TP (lbs/Acre/year) |
|---|---|---|---|
| Southwest | 5.30 | 38 | 0.14 |
| **Northwest** | 21.60 | 40 | **0.54** |
| **North** | **188.50** | 955 | 0.20 |
| East | 12.90 | 33.0 | 0.39 |

## 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) the volume, and the TP load estimates coming from the catchment. A table of individual retrofit types within the catchment and their levels of treatment are also included. This table shows the information listed below for each individual retrofit opportunity proposed. A map of the retrofit locations and types is also provided in the catchment profile.

Catchment

- Site ID- a unique site location within the individual catchment
- TP-the Total Phosphorus reduced by the retrofit (lbs/yr)
- TSS-the total suspended solids reduced by the retrofit (lbs/yr)
- Volume- The volume of water runoff reduced (cubic feet/yr)
- 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 and Administrative costs- admin costs associated with the installation of retrofits (*100 cubic feet unit cost)

- Total Project Cost (**typical raingarden maintenance costs)
- Annual Operation and Maintenance cost
- Term Cost- cost/TP removed (lbs)/30 year life cycle- retrofits are ranked from lowest to highest by this number in each table.

## Southwest Catchment

| Existing Catchment Summary | |
|---|---|
| Acres | 38 |
| TP (lbs/yr) | 5.3 |
| TP(lbs)/Acre/Yr | 0.14 |

### Description

This catchment is comprised primarily of woodlands interspersed with single family residential housing. Slopes are moderately steep with sandy, well drained to excessively drained soils. For assessment purposes the catchment was further divided into four smaller sub-catchment (SC) areas based on major flow drainage patterns.

SC9.1 flows into the woodland/wetland system in SC9 on the south side of 225th avenue where it will remain until the wetland water level reaches an unknown elevation whereby it overflows into a stand pipe leading to a culvert which ultimately enters the lake at the corner of 159th and 224th avenue. It is likely that minimal water leaves this wetland and no BMPs were identified for this area at this time, though it is likely that there are locations for bioretention practices which would protect the wetland filtering capacity and this area should be considered for retrofits after the other opportunities have been exhausted.

SC3 and SC 3.1 flow into Birch Lake via connected impervious surfaces (roads, small curbs and rooftops) and direct surface flow. Stormwater/snowmelt from the crest of the hill on 224th avenue builds as it moves towards the lake gaining water until it is directed into the lake by a culvert and small curb on the east side of the road.

### Recommendations:

**SC3 & SC3.1:** It is recommended to slow or intercept the accumulation of water moving down 224th avenue by redirecting water into a series of infiltration basins (most likely rain gardens) on privately owned properties. Five optimal rain garden locations, sized to a minimum of 250 square feet each, were identified (see map below), thus we analyzed a scenario where all five rain gardens were installed in SC3 and SC3.1. There may also be an opportunity to divert some of the flow into the township easement into the wetland system or a swale off of 224th. There are likely additional opportunities for infiltration basin placement within this catchment; thus, a scenario with 10 raingardens was also developed. Volume and pollutant reductions resulting from the rain garden installations are highlighted in the table below.

### Alternate Recommendations:

**SC 9.0 & 9.1:** No Best Management Practices (BMPs) were identified for this area at this time, though it is likely that there are locations for bioretention practices which would protect the wetland filtering capacity and this area should be considered for retrofits after the other opportunities have been exhausted. Additionally, if necessary and feasible, the height of the wetland outlet could be increased; though conversations with township officials indicate that the level of the wetland is set such that the residential properties within the area are not impacted by water levels.

Volume and pollutant reductions resulting from practices described are highlighted in the table and locations shown in the map below.

| | | EXISTING | RETROFIT OPTIONS | | | |
|---|---|---|---|---|---|---|
| | | | Project ID | | | |
| | | Existing Loading | SC3.0 & SC3.1 | | SC3.0 & SC3.1 | |
| | | | New trtmt | Net % | New trtmt | Net % |
| Treatment | TP (lb/yr) | **14.8** | 4.6 | 31% | 7.0 | 47% |
| | TSS (lb/yr) | **5,320** | 1,839 | 35% | 2,773 | 52% |
| | Volume (acre-feet/yr) | **7.6** | 2.4 | 32% | 3.7 | 49% |
| | Number of BMP's | 0 | 5 | | 10 | |
| | BMP Size/Description | | 1,250 | square feet | 2,500 | square feet |
| | BMP Type | | Simple Bioretention | | Simple Bioretention | |
| Cost | Materials/Labor/Design | | $14,125 | | $28,250 | |
| | Promotion & Admin Costs | | $290 | | $175 | |
| | Total Project Cost | | $14,415 | | $28,425 | |
| | Annual O&M | | $938 | | $1,875 | |
| | Term Cost/1,000lb-TSS/yr | | $771 | | $1,018 | |
| | Term Cost/lb-TP/yr | | **$308** | | $403 | |

## Northeast Catchment

| Existing Catchment Summary | |
|---|---|
| Acres | 40 |
| TP (lbs/yr) | 21.60 |
| TP(lbs)/Acre/Yr | 0.54 |

### Description

This catchment is comprised primarily of woodlands interspersed with single family residential housing. Steep slopes on lakeshore have been identified as critical areas for retrofitting practices via the Mississippi River (St. Cloud) Watershed Restoration and Protection Project priority planning process. The majority of the soils in this catchment are sandy and well drained. For the assessment purposes the catchment was further divided into three smaller sub-catchment (SC) areas based on major flow drainage patterns.

SC2.0 captures flow from approximately 27 acres of moderately steep slopes which flow into the lake on the northwest. With the exception of properties adjacent to the lake, the majority of runoff from this catchment infiltrates into the sands rather than entering the lake.

SC 4.0 is composed of shoreland residential properties with steep slopes which surface flow directly into the lake.

SC 5 captures stormwater from the crest of the hill on 159$^{th}$ Ave. and routes it to a catch basin which flows into a small wet area along the shore as well as along the road and down to the township owned public access on the west side of the lake. A portion of 159$^{th}$ Ave. (shown as closed system) flows into a land locked infiltration basin on the west side of the road.

### Recommendations:

**SC4:** This SC was identified as the primary candidate for stormwater reduction practices due to steep slopes and level of impervious surfaces (residential development) adjacent to the lake. Locations for infiltration were not directly identified because the residential properties between the road and lake are difficult to view without accessing each property. Nonetheless, local knowledge would indicate that there are opportunities for infiltration practices on the lake side of many of the properties as well as near the public access. We analyzed a scenario with both 500 square feet of infiltration practices and another with 1,000 square feet in SC4.

**SC2 & SC 5:** Shoreline restoration along the lake shore properties should also be considered. Shoreline is critical for fisheries, water quality and overall ecology. While pollutant reductions from lakeshore restorations are not great, the approach still deserves serious consideration as these projects do provide multiple, valuable benefits including: protection against erosion, filter yard runoff before it enters the lake, and provides fish and wildlife habitat. We analyzed a scenario with lakeshore restoration covering 1,500 linear feet of shoreline along all parcels within the Northeast catchment. Each lakeshore restoration was assumed to be 15 feet wide and to cover a minimum of 75 % of each lakeshore property.

### Alternate Recommendations:

**SC 5:** Permeable asphalt could be considered for the parking lot and boat access point in SC5, particularly if the access was to be reconstructed; although initial investigation appears cost prohibitive.

A more preferable option would be to redirect runoff from the area into an infiltration basin or grassed swale.

| | | EXISTING CONDITION | RETROFIT OPTIONS | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | *Project ID* | | | | | | | |
| | ***Existing Conditions*** | Existing Loading | SC4 & SC2 | | SC4 | | SC4, SC2, SC5 (lake side of properties and public access) | | SC5 (Public Access) | |
| | | | New trtmt | Net % | New trtmt | Net % | New trtmt | Net % | New trtmt | Net % |
| *Treatment* | TP (lb/yr) | **21.6** | 5.4 | 25% | 6.0 | 28% | 9.2 | 43% | 0.02 | 0.09% |
| | TSS (lb/yr) | **6,827** | 1,707 | 16% | 2,130 | 20% | 3,162 | 29% | 3.00 | 0.04% |
| | Volume (acre-feet/yr) | **9.3** | 2.3 | 25% | 3.0 | 32% | 4.4 | 47% | 0.00 | 0.00% |
| | Number of BMP's | 0 | 15 | | 2 | | 4 | | 4 | |
| | BMP Size/Description | N/A | 1,500 | square feet | 500 | square feet | 1,000 | Square feet | 8,712 | Square feet |
| | BMP Type | | Lakeshore Restoration | | Simple Bioretention | | Simple Bioretention | | Permeable Asphalt | |
| *Cost* | Materials/Labor/Design | | $6,000 | | $5,650 | | $11,300 | | $87,120 | |
| | Promotion & Admin | | $254 | | $565 | | $341 | | $70 | |
| | Total Project Cost | | $6,254 | | $6,215 | | $11,641 | | $87,190 | |
| | Annual O&M | | $1,125 | | $375 | | $750 | | $6,534 | |
| | Term Cost/1,000lb- | | $781 | | $273 | | $360 | | $3,146,781 | |
| | Term Cost/lb-TP/yr | | **$247** | | $97 | | **$124** | | $472,017 | |

## North Catchment

| Existing Catchment Summary | |
|---|---|
| Acres | 955 |
| TP (lbs/yr) | 188.5 |
| TP(lbs)/Acre/Yr | 0.20 |

### Description

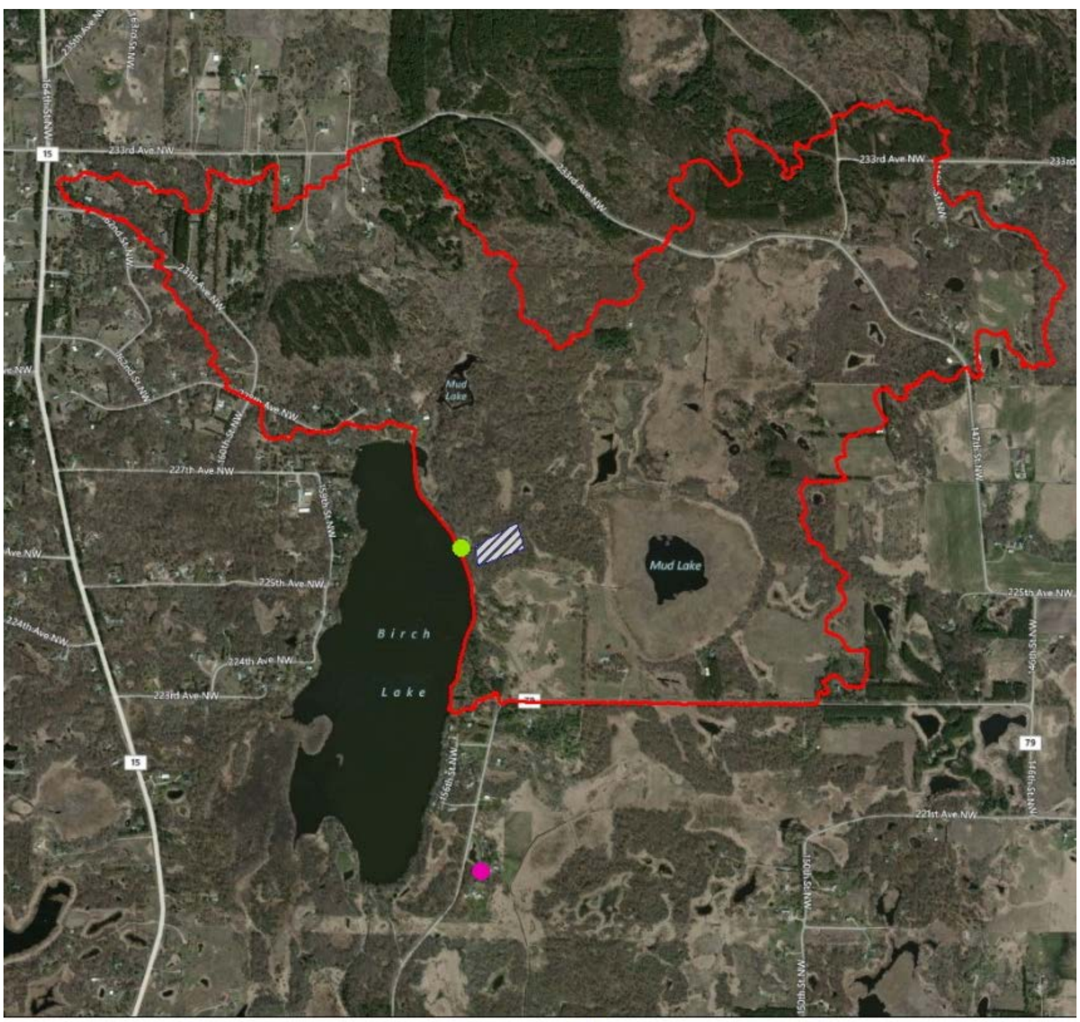
This catchment makes up the majority of the watershed draining to Birch Lake and is comprised primarily of a partially drained/ditched wetland system as well as woodland areas. Slopes are relatively flat and soils range from well drained sands to poorly drained Seelyeville muck. While the wetlands are currently minimally impacted, historical records indicate that the area was once used for agricultural production. As such, there is possibility that the wetlands may be saturated with phosphorus and acting as a source rather than utilizing the nutrient. No monitoring data exists to prove/disprove this theory.

### Recommendations:

**SC 6.0**: It is recommended to gather water quality samples at the outlet of this watershed; samples should be analyzed for: Total suspended solids, total phosphorus, and orthophosphorus (or dissolved phosphorus) as well as flow. Samples should be gathered when the water is flowing. If orthophosphorus is elevated, a phosphorus removal strategy such as a Sand Enhanced Iron Filter (i.e. permeable weir, permeable check dam, or sand filter bed) should be considered. This practice will need to be designed by an engineer, cost, sizing and pollutant reductions included in the tables are not spot-on and need to be based on more variables than were included here. For more Information on these filter types, visit:
http://stormwater.safl.umn.edu/sites/stormwater.safl.umn.edu/files/080310erickson.pdf

Volume and pollutant reductions resulting from practices described are highlighted in the table and locations shown in the map below.

| | | EXISTING | RETROFIT OPTIONS | |
|---|---|---|---|---|
| | *Existing Conditions* | Existing Loading | Project ID | |
| | | | North Catchment | |
| | | | New trtmt | Net % |
| Treatment | TP (lb/yr) | **188.5** | 103.0 | 55% |
| | TSS (lb/yr) | **76,429** | 41,390 | 54% |
| | Volume (acre-feet/yr) | **112.5** | 52.8 | 47% |
| | Number of BMP's | N/A | 1 | |
| | BMP Size/Description | N/A | 10,000 | square feet |
| | BMP Type | | Structural Sand Filter | |
| Cost | Materials/Labor/Design | | $215,000 | |
| | Promotion & Admin Costs | | $52,415 | |
| | Total Project Cost | | $267,415 | |
| | Annual O&M | | $7,500 | |
| | Term Cost/1,000lb-TSS/yr | | $397 | |
| | Term Cost/lb-TP/yr | | **$159** | |




Inlet/Recommended Monitoring Location
Iron Enhanced Sand Filter

## East Catchment

| Existing Catchment Summary | |
|---|---|
| Acres | 33.0 |
| TP (lbs/yr) | 12.90 |
| TP(lbs)/Acre/Yr | 0.40 |

### Description

This catchment is comprised primarily of woodlands interspersed with single family residential housing. The majority of the soils in this catchment, with the exception of the wetland areas, are sandy and well drained. The bulk of the housing is located near the lake where the terrain is very flat. For the assessment purposes the catchment was further divided into three smaller sub-catchment (SC) areas based on major flow drainage patterns.

SC 8.0 captures flow from approximately 18 acres of wetland/woodlands through a ditched system and directs the flow under County Road 79 where it is routed underground only to daylight on the east side of 156$^{th}$ street where it flows into the lake along a township owned easement. In addition to water from the wetland area, stormwater from lawns and the street in SC 8.1 move into the ditch. It is likely, some of the runoff from this catchment would infiltrate into the sands rather than entering the ditch.

SC 1.0 is composed of shoreland residential properties ranging from 50 to 75 linear feet of shoreline each.

### Recommendations:

**SC 8.1:** Two ideal locations for bioretention practices were located in SC8.1. We analyzed a scenario with both 500 square feet of infiltration practices and another with 1,000 square feet in SC8.1 assuming that there are additional ideal locations for bioretention.

**SC 1.0:** Ideal locations for infiltration in SC 1.0 likely exist though they were not directly identified because the residential properties between the road and lake would be difficult to view without accessing each property. Nonetheless, local knowledge would indicate that there are opportunities for infiltration practices on the lake side of many of the properties. It is recommended to work with the lakeshore residents in SC1.0 in identifying locations to reduce runoff.

**SC 1.0**: Most defiantly there are opportunities for lakeshore restoration along each shoreline property; thus analyzed a scenario with lakeshore restoration covering 1000 linear feet of shoreline along all parcels within the SC1.0. Each lakeshore restoration was assumed to be a minimum of 15 feet wide and to cover a minimum of 75 % of each lakeshore property. Shoreline is critical for fisheries, water quality and overall ecology. While pollutant reductions from lakeshore restorations are not great, the approach still deserves serious consideration as these projects do provide multiple, valuable benefits including: protection against erosion, filter yard runoff before it enters the lake, and provides fish and wildlife habitat.

### Alternate Recommendations:

**SC 8.1:** It is recommended to gather water quality samples at the culvert on the west side of County Road 79 and at the easement ditch prior to its entrance into the lake on the west side of 156$^{th}$ street; samples should be analyzed for: Total suspended solids, total phosphorus, and orthophosphorus (or

dissolved phosphorus) as well as flow if possible. Samples should be gathered when the water is flowing. If orthophosphorus is elevated, a phosphorus removal strategy such as a Sand Enhanced Iron Filter (i.e. permeable weir, permeable check dam, or sand filter bed) should be considered. This practice would need to be designed by an engineer, cost, sizing and pollutant reductions included in the tables are not spot-on and need to be based on more variables than could be included here. For more Information on these filter types, visit:
http://stormwater.safl.umn.edu/sites/stormwater.safl.umn.edu/files/080310erickson.pdf

Volume and pollutant reductions resulting from practices described are highlighted in the table and locations shown in the map below.

| | | EXISTING CONDITION | RETROFIT OPTIONS | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Existing Conditions* | Existing Loading | *Project ID* | | | | | | | |
| | | | SC1.0 | | SC 8.0/8.1 | | SC8.1 | | SC 1.0 | |
| | | | New trtmt | Net % | New trtmt | Net % | New trtmt | Net % | New trtmt | Net % |
| *Treatment* | TP (lb/yr) | **12.9** | 2.8 | 22% | 8.0 | 62% | 4.3 | 33% | 6.4 | 50% |
| | TSS (lb/yr) | **4,962** | 1,131 | 23% | 3,163 | 64% | 1,775 | 36% | 2,625 | 53% |
| | Volume (acre-feet/yr) | **7.4** | 1.8 | 25% | 4.5 | 61% | 2.5 | 34% | 3.7 | 50% |
| | Number of BMP's | N/A | 13 | | | | 2 | | 4 | |
| | BMP Size/Description | N/A | 15,000 | square feet | 100 | square feet | 500 | Square Feet | 1,000 | Square Feet |
| | BMP Type | | Lakeshore Restoration | | Perimeter Sand Filter | | Simple Bioretention | | Simple Bioretention | |
| *Cost* | Materials/Labor/Design | | $60,000 | | $24,000 | | $5,650 | | $11,300 | |
| | Promotion & Admin Costs | | $47 | | $1,826 | | $565 | | $341 | |
| | Total Project Cost | | $60,047 | | $25,826 | | $6,215 | | $11,541 | |
| | Annual O&M | | $11,250 | | $75 | | $375 | | $750 | |
| | Term Cost/1,000lb-TSS/yr | | $11,717 | | $296 | | $328 | | $432 | |
| | Term Cost/lb-TP/yr | | $4,733 | | **$117** | | **$135** | | **$178** | |

## Overall Retrofit Results

In the list provided below are all of the retrofit opportunities ranked from lowest to highest total cost for every catchment within the Birch Lake subwatershed. From the four catchments studied within the watershed , 48 individual retrofit locations were identified. Projects that were deemed unfeasible due to prohibitive size, number, or were too expensive to justify installation are not included in the table below.

*The first two recommendations require some preliminary monitoring to determine the feasibility of each project. Thus, the initial recommendation is to gather data as described in the Catchment recommendations while simultaneously working with residents to install bioretention practices. Examples of each practice type can be viewed in Appendix B. Installation of several projects simultaneously results in the lowest cost per pound of total phosphorus removed. Finally, shoreline is critical for fisheries, water quality and overall ecology. While pollutant reductions from lakeshore restorations are not great, the approach still deserves serious consideration as these projects do provide multiple, valuable benefits.

**Summary of preferred Stormwater retrofit opportunities ranked by cost-effectiveness with respect to total phosphorus reduction.**

| 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) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | East | Iron-Enhanced Sand Filter* | 1 | 8 | 3163 | 4.5 | $25,826 | $75 | $117 |
| 2 | North | Iron-Enhanced Sand Filter* | 1 | 103.0 | 41,390 | 52.8 | $267,415 | $7,500 | $159 |
| 3 | Northwest | Simple Bioretention | 2 to 4 | 6.0-9.2 | 2,130-3,162 | 3.0-4.4 | $6,215-11,641 | $375-750 | $97-1240 |
| 4 | East | Simple Bioretention | 2 to 4 | 4.3-6.4 | 1,775-2,625 | 2.5-3.7 | $6,215-11,641 | $375-750 | $135-178 |
| 5 | Southwest | Simple Bioretention | 5 to 10 | 4.6-7.0 | 1,839-2,773 | 2.4-3.7 | $14415-28,425 | $938-1,875 | $308-403 |
| 6 | Northwest | Lakeshore Restoration | 15 | 5.4 | 1,707 | 2.3 | $60,047 | $11,250 | $2,454 |
| 7 | East | Lakeshore Restoration | 13 | 2.8 | 1,131 | 7.4 | $60,047 | $11,250 | $4,733 |

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## *Appendix A.*

| General WinSLAMM Model Inputs | |
|---|---|
| **Parameter** | File/Method |
| **Land use acreage** | ArcMap |
| **Precipitation/Temperature Data** | Minneapolis 1959-the rainfall year that best approximates a typical year. |
| **Winter Season** | Included in model. Winter dates are 11-4 to 3-13 |
| **Pollutant probability distribution** | WI_GE001.ppd |
| **Runoff coefficient file** | WI_SL06 Dec06.rsv |
| **Particulate solids concentration file** | WI_AVG01.psc |
| **Particle residue delivery file** | WI_DLV01.prr |
| **Street delivery files** | WI files for each land use |

### 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 (DUPLEX): Housing having two separate units in a single building.

Multiple Family Residential (MFR): 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 (SUBR): Same as HDRNA except the density is between 0.2 and 0.6 units/acre.

**OTHER URBAN LAND USES**

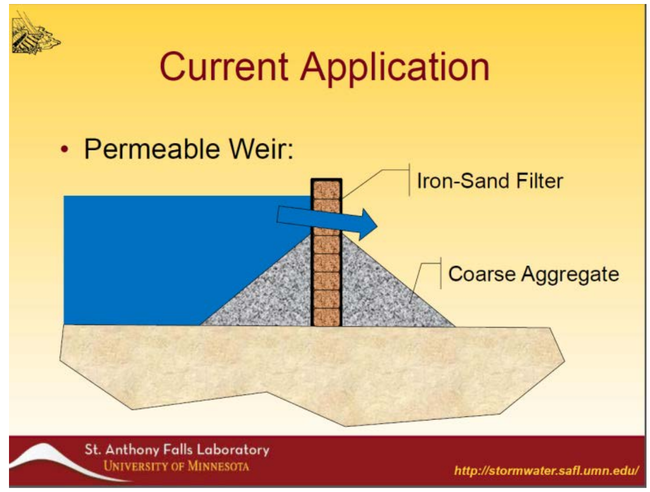
Parks (PARK): Outdoor recreational areas including municipal playgrounds, botanical gardens, arboretums, golf courses, and natural areas.

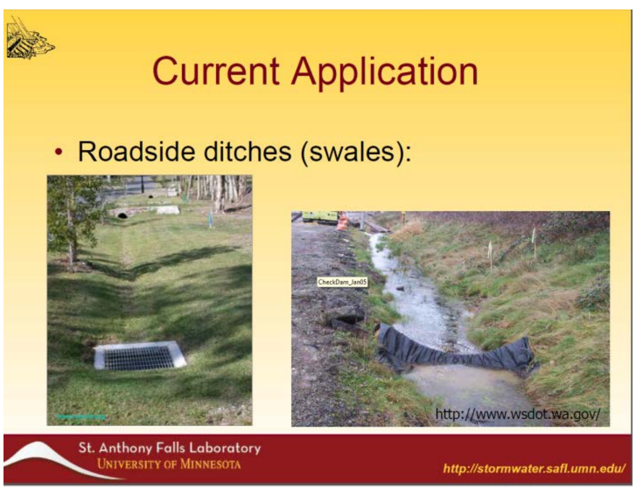
Undeveloped (OPEN): Lands that are private or publicly owned with no structures and have a complete vegetative cover. This includes vacant lots, urban fringe areas slated for development, greenways, and forest areas.

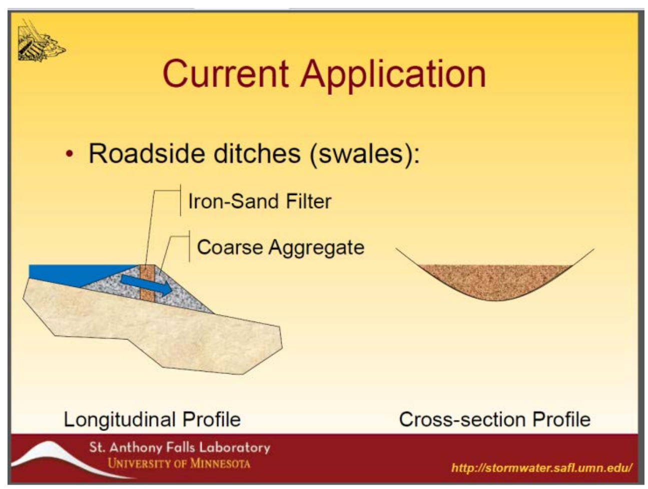
Cemetery (CEM): This land use file covers cemeteries, and includes road frontage along the cemetery, and paved areas and buildings within the cemetery.

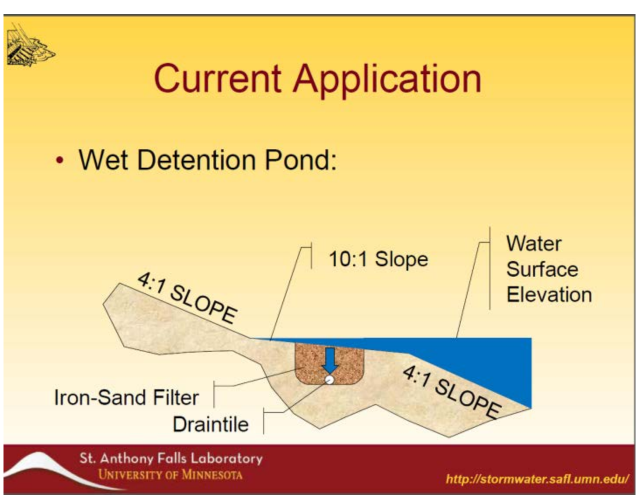
## *Appendix B.*

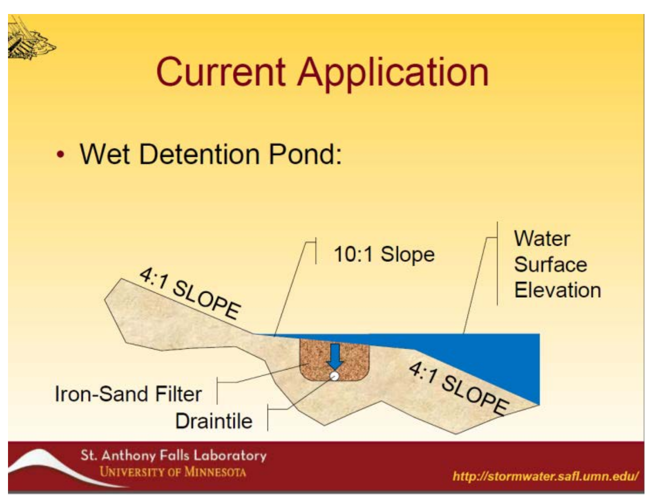
1) Iron enhanced sand filter concepts

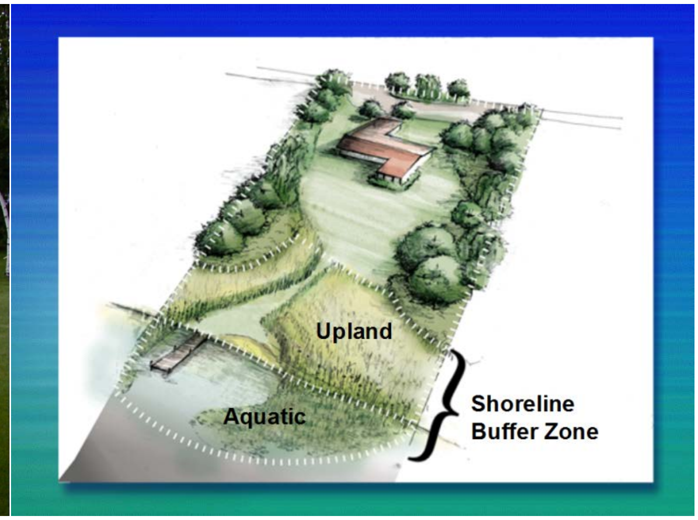



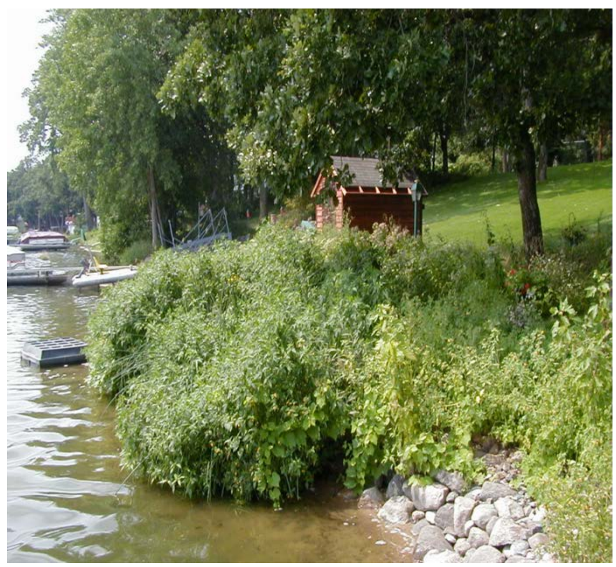
## 2) Bioretention Concepts

City of
St. Cloud Rain Garden Retrofits


3) Shoreline Restoration




Pictured above: Orono Lake Shoreline Buffer Courtesy of Roxanne Esperenza/MNDNR



Pictured above: Briggs Lake Chain Shoreline Buffer (Before and After)

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