Little Elk Lake Sub-Watershed Assessment

December 2021



Prepared by:

Sherburne Soil & Water Conservation District

In partnership with

Baldwin Township, MN



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Executive Summary

At 362 acres and with 4.94 miles of shoreline, Little Elk Lake (DNR ID 710055) is one of the largest developed recreation lake in Sherburne County, MN. Though it is large, the lake is almost entirely within the littoral (vegetated) zone with an average depth of 7 ft and a maximum depth of 15 ft. The lake is moderately to well developed with both year-long and seasonal homes lining the south, east and west shores of the lake. Several homes line the lake's northern end along with by a large wetland complex which ushers in Battle Brook, a relatively small stream that originates in the southeast corner of Benton County and runs through Mille Lacs County before entering Sherburne County. Little Elk Lake is mostly enclosed within Baldwin Township in Sherburne County.

Little Elk Lake has been known to exhibit abundant plant growth and mid / late summer algae blooms which can reduce the water clarity of the lake. In 2011, following two years of water quality monitoring through the Minnesota Pollution Control Agency's Intensive Watershed Monitoring program, the lake was found to not be meeting water quality standards and was listed on the State of Minnesota's impaired waterbodies list for excessive nutrient content. The Little Elk Lake Improvement Association works diligently to encourage conservation along the shores of the lake and within its watershed. Additionally, Baldwin Township has overseen numerous projects to protect the lake including working with the Sherburne SWCD in past years to complete several stormwater control projects within adjacent residential neighborhoods. In 2022, the lake will be focus of a Total Maximum Daily Load (TMDL) study in which a nutrient budget will be calculated for external and internal sources of phosphorus to the lake. This study will quantify both the phosphorus sources and the reductions needed to meet water quality standards.

In late 2020, staff from Sherburne SWCD met with the Baldwin Township board regarding completion of a Sub-Watershed Assessment (SWA) which would identify priority rural and urban areas in the lake's watershed as well as determine appropriate conservation practices for these areas. With that, the project was set to begin in spring 2021.

A SWA is intended to identify potential projects within a target area to improve the water quality of a defined receiving waterbody. These potential projects are often practices that are needed to be retrofit into existing developed landscapes. In this study, instead of aiming for a certain number of projects or achieving a certain cost budget, the focus is to identify feasible practices in specific locations then examine their cost efficiency compared to pollutant reduction. In this report, both the costs to install the practice and the estimated pollutant reduction are compared to determine the cost effectiveness (amount of pollutant removed per dollar spent).

The Little Elk Lake watershed was delineated using a combination of Department of Natural Resources spatial information along with on-the-ground examinations of culvert locations and elevations. The 22,578 acre watershed was further delineated into more manageable sized 36 sub-watersheds. Seventeen of these sub-watersheds were deemed "urban" based upon dwelling density and the remaining nineteen sub-watersheds described here as "rural". In urban sub-watersheds, stormwater runoff pollutant estimates were estimated using the environmental modeling program WinSLAMM, the Source Loading and Management Model for Windows. The model first was run using baseline conditions, which included existing stormwater or other Best Management Practices (BMPs). To minimize costs with the study, the model was not calibrated so can only be used as an estimation tool to provide relative information. Specific model inputs are detailed in Appendix A. For the rural sub-watersheds, the Chisago

County SWCD's protocol, "Rural Sub-watershed Analysis Protocol" was used to examine land characteristics and ultimately determine priority rural sub-watersheds to focus attention.

Following the initial computer modeling seven urban and seven rural sub-watersheds were determined priority areas for further analysis due to their high pollutant or water volume annual load, high load per acre, proximity to the receiving waterbody, and overall condition of the sub-watershed. Baldwin Township Supervisors and Sherburne SWCD staff visited the urban sub-watersheds located around the lake and, using aerial maps and on-the-ground observations, identified potential BMP locations. Sherburne SWCD conducted separate visits to rural watershed areas, one visit to examine Sherburne County focused priority sites and one visit with Mille Lacs SWCD staff to examine conditions within Mille Lacs County focus sub-watersheds. In total, 55 potential projects were identified (Figure 1).

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

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

Based upon the study results modeling, implementing all potential BMP practices within the 14 priority sub-watersheds would result in an estimated reduction of 319 lbs of phosphorus and 13,948 lbs of sediment. However, it is recognized that installing all these recommendations is not feasible due to funding availability, site-specific detailed conditions, and participation of willing landowners. Instead, it is recommended that projects be pursued in order of cost effectiveness according to Table 1 to achieve the greatest pollution reduction for the smallest amount of cost. Installation of projects in series will result in lower total treatment than the simple sum of treatment achieved by the individual projects due to treatment train effects. Reported treatment levels are depending upon optimal site selection and sizing. More detail about each project can be found in the catchment profile page of this report.

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

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50 R004 LEL_R004_01 Wascob - 7.1 6.0 \$13,088 \$1,849 \$2,178 51 R006 LEL_R006_02 Wascob - 8.3 7.0 \$16,000 \$1,932 \$2,273 52 R005 LEL_R005_01 Wascob - 5.5 4.7 \$13,088 \$2,388 \$2,809 53 R013 LEL_R013_02 Pasture / Manure Mgmt - 2.0 2.5 \$7,500 \$3,676 \$3,000 54 R013 LEL_R013_04 Pasture / Manure Mgmt - 1.7 2.0 \$7,500 \$4,545 \$3,750	49	R011		Pasture / Manure Mgmt	-	2.7	4.0	\$7,500	\$2,799	\$1,875
52 R005 LEL_R005_01 Wascob - 5.5 4.7 \$13,088 \$2,388 \$2,809 53 R013 LEL_R013_02 Pasture / Manure Mgmt - 2.0 2.5 \$7,500 \$3,676 \$3,000 54 R013 LEL_R013_04 Pasture / Manure Mgmt - 1.7 2.0 \$7,500 \$4,545 \$3,750	50	R004	LEL_R004_01	Wascob	-	7.1	6.0		\$1,849	\$2,178
52 R005 LEL_R005_01 Wascob - 5.5 4.7 \$13,088 \$2,388 \$2,809 53 R013 LEL_R013_02 Pasture / Manure Mgmt - 2.0 2.5 \$7,500 \$3,676 \$3,000 54 R013 LEL_R013_04 Pasture / Manure Mgmt - 1.7 2.0 \$7,500 \$4,545 \$3,750	51	R006	LEL_R006_02	Wascob	-	8.3	7.0	\$16,000	\$1,932	\$2,273
54 R013 LEL_R013_04 Pasture / Manure Mgmt - 1.7 2.0 \$7,500 \$4,545 \$3,750	52	R005	LEL_R005_01	Wascob	-	5.5	4.7			\$2 <i>,</i> 809
54 R013 LEL_R013_04 Pasture / Manure Mgmt - 1.7 2.0 \$7,500 \$4,545 \$3,750	53	R013	LEL_R013_02	Pasture / Manure Mgmt	-		2.5	\$7,500	\$3,676	\$3,000
55 R006 LEL_R006_01 Wascob - 3.9 3.6 \$19,044 \$4,858 \$5,246	54	R013			-	1.7	2.0		\$4,545	\$3,750
	55	R006	LEL_R006_01	Wascob	-	3.9	3.6	\$19,044	\$4,858	\$5,246

Table 1. Ranked BMP summary from an assessment of Little Elk Lake sub-watersheds.Table sortedby 30-year cost / lb. removal of total phosphorus.

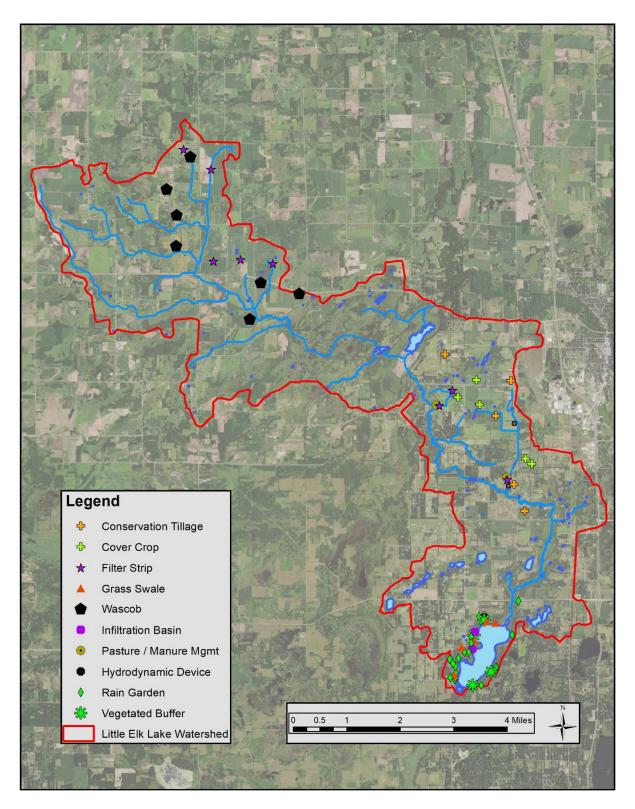


Figure 1. Map of BMP options identified and modeled within the Little Elk Lake SWA.

Introduction

Many factors are considered when choosing which sub-watersheds to analyze for BMP 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. Sub-watershed analyses supported by a Local Government Unit with sufficient capacity (staff, funding, available GIS data, etc.) to greater facilitate the process also rank highly. For some communities a sub-watershed analysis complements their Municipal Separate Storm Sewer System (MS4) stormwater permit. The focus is always on a high priority waterbody.

Little Elk Lake is one of the largest waterbodies in Sherburne County, Minnesota at approximately 362 acres in size. The lake is relatively shallow with an average depth of 7 feet and maximum of 15 feet. The watershed that drains to the lake consists of 22,578 acres of and includes the headwaters in Benton County (2,791 acres), a portion of Mille Lacs County (10,079 acres) and ends in Sherburne County (12,948 acres). The stream draining this watershed is called Battle Brook. Battle Brook continues at the lake's southern outlet and travels further downstream to the St. Francis River.

Little Elk Lake was included on the State of Minnesota's 2011 impaired waterbodies list for holding excessive nutrient content which feeds abundant plant growth as well as mid and late summer algae blooms. Recently collected data from 2019 and 2020 suggests the lake's nutrient content, algae abundance, and water clarity continues to exceed state water quality standards. However, long-term Secchi disk clarity monitoring conducted by Little Elk Lake Improvement Association volunteers indicates that there have been subtle improvements in the lake's clarity (LELIA annual meeting presentation, 2021).

Battle Brook is a small tributary stream that is currently listed by the State of Minnesota as being impaired for excessive e.coli bacteria as well as a poor fish and insect community. During 2019-2020 Intensive Watershed Monitoring, the collected data suggests that the phosphorus being transported via Battle Brook is on the higher side (two year mean of 75 ug/L, range of 39-122 ug/L) but still falling underneath the Central Stream standard threshold of 100 ug/L at this time.

At the time of this writing, internal sources of phosphorus to Little Elk Lake have not been quantified or studied. However, in 2022 the lake will be focus of a Total Maximum Daily Load (TMDL) study in which a nutrient budget will be calculated for external and internal sources of phosphorus to the lake. This study will quantify both the phosphorus sources and the reductions needed to meet water quality standards.

Completing this assessment allows for a formal process to be completed in identifying the best areas to complete conservation work within. It also provided an opportunity to discuss conservation with area stakeholders and managers. Finally, as this report identifies the best locations for conservation work and the most cost-effective practices to install in these locations, this analysis will be helpful for future pursuit of funding to help bring these practices to fruition.

About This Document

This Sub-Watershed Assessment is a watershed management tool to help prioritize urban and rural conservation projects by performance and cost effectiveness. This process helps maximize the value of each dollar spent.

Urban Catchments:

Urban sub-watersheds (catchments) are defined as being adjacent to and directly draining to the lake. These areas are largely built-out residential. Modeling of existing conditions and pollutant reductions for each project was completed with the environmental model WinSLAMM.

Urban catchments are noted on the maps in this report with a lake identifier code, the letter "U", followed by the sub-watershed name. Individual BMP projects are further noted after the sub-watershed code with a number value. An example is provided below:

LEL_U001_01

LEL = Little Elk Lake U001 = Urban sub-watershed 001 01 = Project #01 in this sub-watershed

Rural Catchments:

Rural sub-watersheds (catchments) are defined as areas not adjacent to Little Elk Lake, but within the lake's drainage area and contributing drainage to the lake's primary inlet stream, Battle Brook. The Chisago SWCD protocol "Rural Sub-watershed Analysis Protocol Part 1-Targeting" was used to highlight the areas with the highest potential for contributing sediment and nutrients to the Lake.

Rural catchments are noted on the maps in this report with a lake identifier code, the letter "R", followed by the sub-watershed name. Individual BMP projects are further noted after the sub-watershed code with a number value. An example is provided below:

LEL_R001_01 LEL = Little Elk Lake R001 = Rural sub-watershed 001 01 = Project #01 in this sub-watershed

Analytical Process and Elements

This sub-watershed analysis is a management tool that can help to identify and prioritize potential BMP retrofit projects by performance and cost-effectiveness. This tool helps to maximize the value of each dollar spent. The process used for this analysis is outlined in the following pages and was modified from the Center for Watershed Protection's Urban Stormwater Retrofit Practices, Manuals 2 and 3 (Schueler & Kitchell, 2005 and Schueler et al. 2007) as well as a protocol developed by Chisago SWCD (Rural Sub-watershed Analysis Protocol, 2015). Locally relevant design considerations were also incorporated into the process (Technical Documents, Minnesota Stormwater Manual, 2014).

Scoping includes determining the objectives of the retrofits (volume reduction, target pollutant, etc.) and the level of treatment desired. It involves meeting with local land decision-makers and other partners to determine the issues in the watershed. This step also helps to define preferred retrofit treatment options and retrofit performance criteria. To create a manageable area to analyze in large sub-watersheds, a focus area may be determined.

In this analysis, the focus areas first consisted of the 36 sub-watersheds draining towards Little Elk Lake. Following additional research into these areas, the list was paired back to 14 sub-watersheds that were determined to have higher modeled pollutant loads as well as capacity for improvement. These watersheds include primarily urban lakeshore residence areas, suburban parcels, and rural agricultural or pasture and animal lots. Existing stormwater infrastructure maps, topography data, and direct observations of flow following rain events were used to determine drainage boundaries for the sub-watersheds included in this analysis.

The targeted pollutants for this study were TP and TSS, though volume was also estimated and reported as it is necessary for pollutant loading calculations and potential retrofit project considerations. Table 2 describes the target pollutants and their role in water quality degradation. Projects that effectively reduce loading of multiple target pollutants can provide greater immediate and long-term benefits.

It should be noted that although chloride is an emerging stormwater pollutant of concern, particularly in urban areas, this report does little to address it. Chloride dissolves readily in stormwater and is unable to be "treated" using traditional stormwater practices. To reduce chloride from reaching Little Elk Lake, resources are best spent investigating ways to utilize "Smart Salting" technology and techniques which result in less road salt on area roads and less chemical fertilizer on farming fields. Residential water softeners are an additional source of chloride to groundwater, so education and outreach on how to use these machines as efficiently as possible is encouraged.

Total Phosphorus (TP)	Phosphorus is a nutrient essential to plant growth and is commonly the factor that limits the growth of plants in surface water bodies. TP is a combination of particulate phosphorus (PP), which is bound to sediment and organic debris, and dissolved phosphorus (DP), which is in solution and readily available for plant growth (active).
Total Suspended Solids (TSS)	Very small mineral and organic particles that can be dispersed into the water column due to turbulent mixing. TSS loading can create turbid and cloudy water conditions and carry with it TP. As such, reductions in TSS will also result in TP reductions.
Volume	Higher runoff volumes and velocities can carry greater amounts of TSS and TP to receiving water bodies. It can also exacerbate soil erosion, thereby increasing TSS and TP loading. As such, reductions in volume may reduce TSS loading and, by extension, TP loading.

Table 2: Target Pollutants

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

Field investigation is conducted after potential retrofits are identified in the desktop analysis to evaluate each site and identify additional opportunities. During the investigation, the drainage area and surface stormwater infrastructure mapping data were verified. Site constraints were assessed to determine the

most feasible retrofit options as well as eliminate sites from consideration. The field investigation may have also revealed additional retrofit opportunities that could have gone unnoticed during the desktop search. Finally, where needed a small-scale culvert inventory may be completed to verify drainage pathways and sub-watershed boundaries.

Modeling involves assessing multiple scenarios to estimate pollutant loading and potential reductions by proposed retrofits. WinSLAMM (version 10.4.0), which allows routing of multiple catchments and stormwater treatment practices, was used for the urban analysis. WinSLAMM estimates volume and pollutant loading based on acreage, land use, and soils information. Therefore, the volume and pollutant estimates in this report are not waste load allocations, nor does this report serve as a TMDL for the study area. The WinSLAMM model was not calibrated and was only used as an estimation tool to provide relative ranking across potential projects. Soils throughout the study area were predominantly sandy based on the information available in the Sherburne County soil survey.

The initial step was to create a "base" model which estimates pollutant loading from each catchment in its present-day state without taking into consideration any existing stormwater treatment. To accurately model the land uses in each catchment, a full watershed delineation was completed using the watershed ArcGIS Spatial Analysis tools and modified manually as necessary using stormwater infrastructure data. The drainage areas were then consolidated into catchments using ArcGIS Spatial Analysis. Land use data were used to calculate acreages of each land use type within each catchment. Soil types throughout the sub-watershed were modeled in this analysis based on the information available in the NRCS Web Soil Survey. Entering the acreage of each type of source area (roof, road, lawn, etc.) in each catchment. After "base" models were completed, an "existing" conditions model was run using any current stormwater treatment such as street cleaning, stormwater treatment ponds, etc.

For the rural analysis, the Revised Universal Soil Loss Equation 2 (RUSLE2) software was used to determine pollutant reductions from prospective BMPs. "Base" conditions were determined first, all fields were assumed to utilize a corn / soybean rotation (RUSLE setting Corn FC Disk Fld Cult-Soybeans FC Disk Fld Cult) and contouring was assumed at a middle value for the absolute row grade. Field export estimates were input to the Board of Water and Soil Resources' (BWSR) Pollution Reduction Estimator spreadsheet to determine the level of phosphorus and sediment reduction on a given BMP practice. MinnFarm (Schmidt and Wilson, 2008) was used for animal feedlot modeling. Table 3 displays the most common BMPs selected for Priority Zone catchments and the modeling procedures that were utilized for each one. Note that nutrient management is currently believed to be utilized by all agricultural operators in the watershed so this was not an option included in the study.

Parameter / BMP	Model
Wascob	BWSR Spreadsheet - Gully
Grassed Waterway	BWSR Spreadsheet - Gully
Filter Strip	BWSR Spreadsheet - Filter Strip; RUSLE2
Gully Stabilization	BWSR Spreadsheet - Gully
Permanent Vegetation	BWSR Spreadsheet - Sheet and Rill; RUSLE2
Cover Crops	BWSR Spreadsheet - Sheet and Rill; RUSLE2
Conservation Tillage	BWSR Spreadsheet - Sheet and Rill; RUSLE2
Pasture / Manure Mgmt	MinnFarm; RUSLE2

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

Cost estimating is essential for the comparison and ranking of projects, development of work plans, and pursuit of grants and other funds. Costs throughout this report were estimated using a multitude of sources, including The Center for Watershed Protection's Urban SubWatershed Restoration Manuals (Schueler & Kitchell, 2005 and Schueler et al. 2007), recent project installation quotes, and cost estimates provided to the Sherburne SWCD by personal contacts. Cost estimates were annualized costs that incorporated the elements listed below over a 10 (rural projects) and 30 (urban projects) year period.

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

Design includes site surveying, engineering, and construction oversight.

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

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

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

In cases where promotion to landowners is important, such as rain gardens, those costs were included as well. In cases where multiple, similar projects are proposed in the same locality, promotion and administration costs were estimated using a non-linear relationship that accounted for savings with scale. Design assistance from an engineer is assumed for practices in-line with the stormwater conveyance system, involving complex stormwater treatment interactions, or posing a risk for upstream flooding. No

site-specific construction investigations were done as part of this stormwater retrofit analysis, and therefore cost estimates account for only general site considerations. Detailed feasibility analyses may be necessary for some projects. Generalized cost estimates are provided in Appendix B.

Project ranking is essential to identify which projects could be pursued to achieve water quality goals. The intent of this analysis is to provide the information necessary to enable local natural resource managers to successfully secure funding for the most cost-effective projects to achieve water quality goals. This analysis ranks potential projects by cost-effectiveness to facilitate project selection. There are many possible ways to prioritize projects, and the list provided in this report is merely a starting point. Local resource management professionals will be responsible to select projects to pursue. Several considerations in addition to project cost-effectiveness for prioritizing installation are included.

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

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

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

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

Additional Conservation Considerations

The intent of this study was to examine the existing conditions and mitigation potential for surface water flow ("stormwater") related pollution, with a specific receiving waterbody (Little Elk Lake) in mind. Other conservation-minded activities were noted during this study which were out of the original scope but are included below for the reader's general information.

<u>Shoreline erosion</u>: Erosion along shoreline can unfortunately be common as waves, wind, and ice batter the shorelines, vegetation management changes, and developmental pressure increases. As a shoreline erodes, it can deposit sediment and nutrients into a lake which may lead to algae proliferation and habitat alteration. It also can be frustrating to a landowner to see their property "washing away". Of course, shoreline erosion occurs in various degrees and so the remedy for a degrading shoreline changes with the extent of the issue present. The best proven methods for shoreline erosion control are 1) increasing native vegetation on the toe, slope, and upland areas of the shoreline, 2) combatting serious erosion situations with bioengineered products or rock rip rap (in extreme cases or steep slopes), 3) altering the grade of the slope or 4) a combination of all techniques. Each shoreline is different and so a unique approach may need to be considered depending on the slope, soils, cause of disturbance, position on the lake, etc. Sherburne SWCD provides technical assistance to landowners through our shoreline management program – for more information visit: https://www.sherburneswcd.org/water-management.html.

<u>Hobby farm and animal waste</u>: Sherburne County hosts numerous small animal operations, sometimes called small farms or hobby farms. Consisting of small operations with chickens, goats, sheep, alpacas, horses or cows these farms offer rich recreational experiences for families. Resource concerns related to animal waste may or may not occur on these farms related to the quality of soils, vegetation management, waste management and proximity to surface or ground water. As Battle Brook is currently listed by the Minnesota Pollution Control Agency as holding excessive e.coli bacteria, improvements on animal feedlots may help to reduce bacteria content in the stream and connected waterways.

Sherburne SWCD has staff with expertise in small farm operations and animal waste management and can offer free technical assistance through a Small Farms Program for county residents. Visit the SWCD's website for more information on soil health, pasture management, nutrient management and more: https://www.sherburneswcd.org/rural-resource-management.html.

Study Area

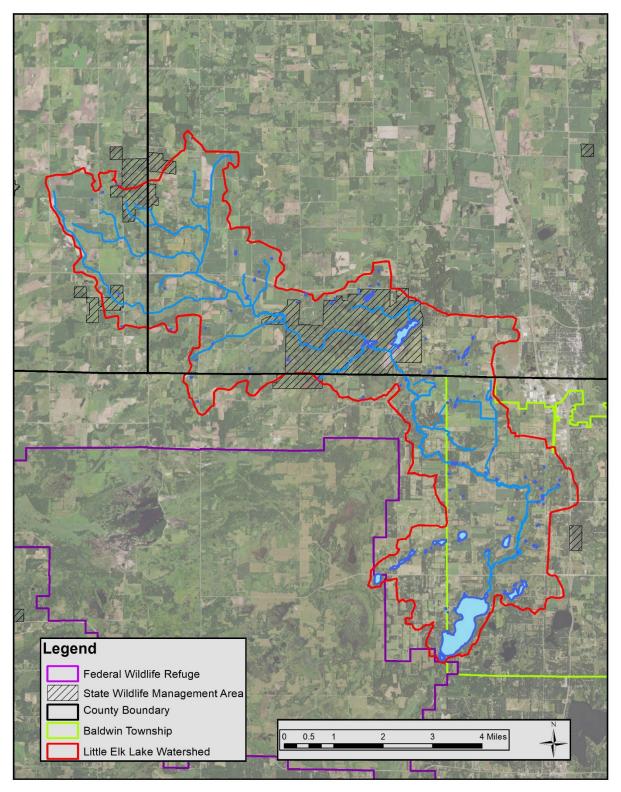


Figure 2: Little Elk Lake watershed.

Geographic Setting

Little Elk Lake lies mostly within Baldwin Township and a portion of Blue Hill Township, Sherburne County, Minnesota (Figure 2). Its watershed spans 22,578 acres, nearly 13,000 of which (50%) lies in Sherburne County. Roughly 39% of the watershed falls within Mille Lacs County and the remaining small portion can be found in Benton County. The area has been historically noted for agricultural as well as several large portions of public land including several Wildlife Management Areas and the nearby Sherburne National Wildlife Refuge. However, this watershed has seen development pressure as suburbs span outwards from both Princeton and Zimmerman.

Soils

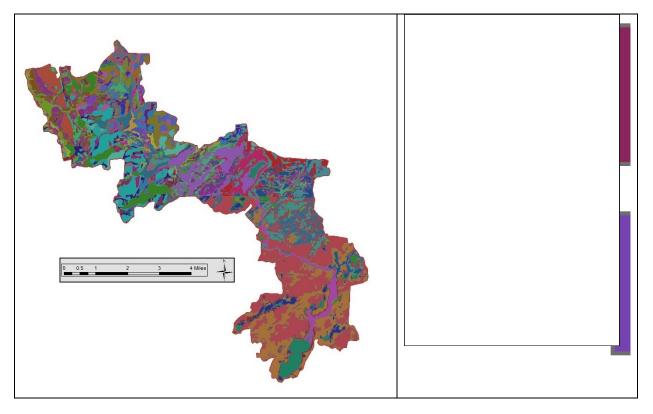


Figure 3: Little Elk Lake watershed area soils.

Most of Sherburne County lies within the Anoka Sand Plains, a broad area that years ago was lake bottom (Figure 3). Sand dunes, kettle lakes and tunnel valleys are prominent features in the region and are associated with glacial activity. These sandy soils are excessively drained, making for high infiltration rates and relatively low organic matter. While bedrock in the western portion of the county underlie the topsoil at depths of 0-100 feet, the eastern areas of the county where Little Elk Lake is located hold sedimentary rocks under topsoil with bedrock being found 50-300 feet below the soil. These soils make for high movement conditions, so infiltration-based practices are most suitable. However, sandy soils need to be carefully managed due to the potential for leaching of pollutants with groundwater.

Watershed Delineation and Priority Setting

In determining the applicable study area for this exercise, a number of resources were utilized including previous available watershed delineations, aerial photography, LIDAR information, observations of surface flow in relation to culvert locations, etc. These resources were compiled into a GIS databased and used to create the map depicted on Figure 2, which represents the watershed, or contributing catch-basin for Little Elk Lake. Following this exercise several questionable existed which required further examination. SWCD staff completed a culvert inventory of key areas of the watershed and examined flow characteristics in several ditches to assist delineating the full watershed as well as sub-watersheds as described in the text that follows.

These resources were used within a GIS database to delineate 36 sub-watershed catchments within the Little Elk Lake watershed. 17 of these watersheds were deemed "urban", while the remaining 19 sub-watersheds placed in a "rural" category. Following sub-watershed delineation, the stormwater modeling program WinSLAMM was used to estimate current stormwater pollutant contributions from each of the urban sub-watersheds. The current pollution load from each sub-watershed was estimated and ranked in terms of most phosphorus and solids produced per acre basis. The result was the determination of seven priority basins which, due to their unique conditions, were estimated to have higher pollutant loads per area and thus should be approached first for pollution reduction (Figure 4). Local knowledge of conditions and the opportunity to retrofit during upcoming construction played a role in priority area selection as well.

For rural sub-watersheds, the Chisago County SWCD's protocol, "Rural Sub-watershed Analysis Protocol" was followed to determine priority focus zones. This GIS-based protocol utilizes soil, slope, precipitation, land management, hydrology, and other information sources to identify areas most likely to contribute phosphorus and sediment to a receiving waterbody. Land areas are thus identified in terms of their potential for phosphorus and sediment delivery. In Figure 5, areas in orange / red coloring are assumed to have a higher pollutant delivery than areas shaded in green or light yellow. Figure 6 depicts the resulting rural sub-watershed focus areas because of the rural assessment protocol.

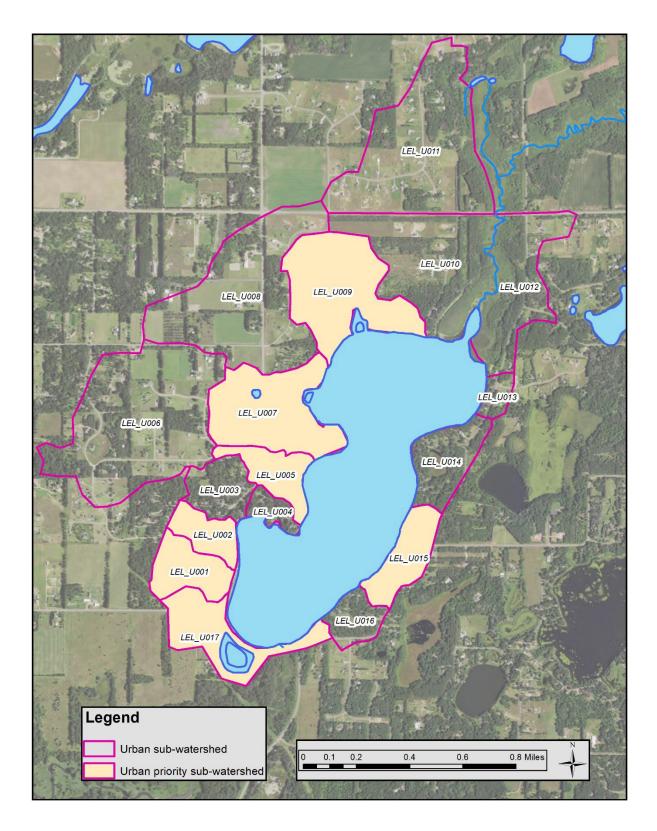


Figure 4: Little Elk Lake urban priority and non-priority sub-watersheds.

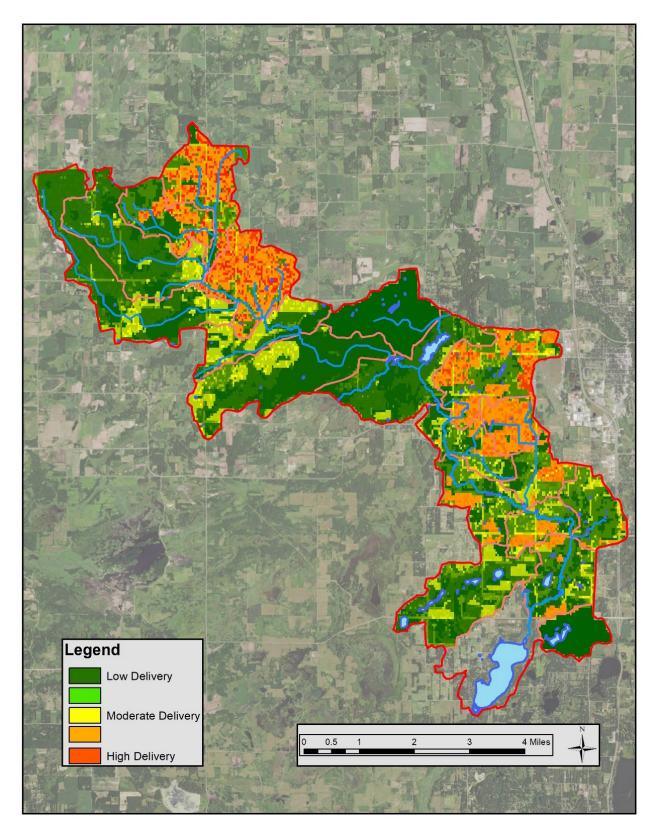


Figure 5: Little Elk Lake rural land analysis results.

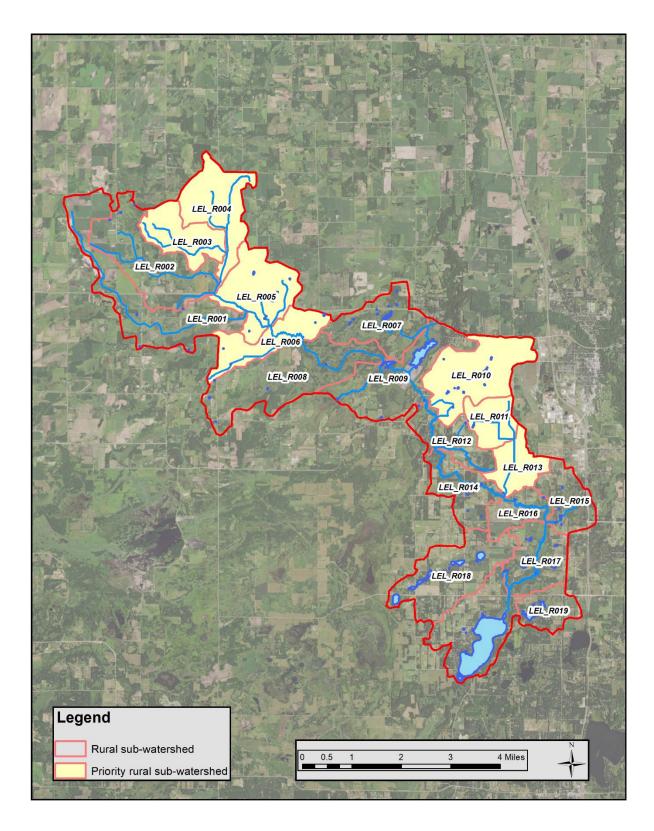


Figure 6: Little Elk Lake rural priority and non-priority sub-watersheds.

BMP Identification Process Note

As previously noted, potential BMPs were identified through several resources including aerial map reviews, on the ground observations and conversations with Baldwin Township Supervisors and Mille Lacs SWCD staff. Several conversations were had with private landowners in the watershed. This section of the report is included to review some of the discoveries and challenges involved with this process.

<u>Urban / lakeshore sub-watersheds</u>: The western and northern side of Little Elk Lake includes numerous relatively small parcels. Smaller practices such as rain gardens require a certain footprint, but must also meet setback requirements from wells, structures, groundwater table, etc. In this environment obstacles such as trees, tree roots, mailboxes, pavement, and other items can present a challenge as well. Finally, as you near the lakeshore area the distance from the surface to groundwater table decreases. The Minnesota Stormwater Manual requires a minimum a three-foot separation between the bottom of an infiltration practice and the groundwater, and in some cases a potential infiltration BMP had to be removed from consideration due to this requirement. When possible, alternatives such as vegetative swales were considered.

<u>Rural sub-watersheds</u>: As the watershed extends to the north, lot sizes increase. Suburban home parcels from 1-5 acres in size dot the landscape north of Little Elk Lake, and on the west side of the City of Princeton. Gradually, lot sizes increase to accommodate agriculture and animal pastures.

The larger lot sizes here offer opportunities for BMP placement. However, the hydrology of the landscape and the land use often dictate if BMPs are feasible and which types would work best. Some of the glacial outwash areas in the watershed have very little relief, so a single "edge-of-field" BMP would do little to capture and treat water runoff. Numerous areas would require field-scale BMPs such as cover crop or conservation tillage to be effective.

Sub-Watershed Profiles

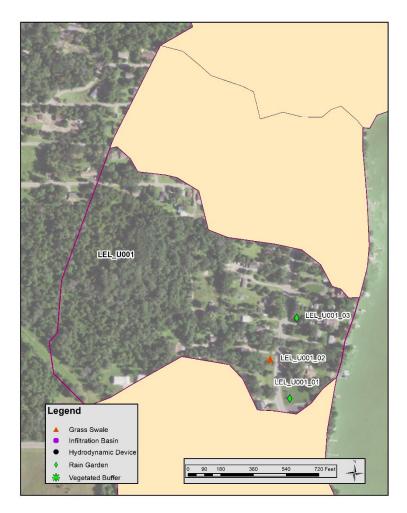
The pages that follow outline each of the priority urban and rural sub-watersheds. The urban subwatersheds are presented first, followed by the rural sub-watersheds. For each, the following information is provided:

- Baseline pollution modeling (urban only)
- The potential BMPs that could be incorporated in the landscape
- The estimated pollution reductions from these BMPs
- The estimated cost of these BMPs
- The pollution reduction relative to cost (\$ per lb of reduction)

Priority Sub-watershed U001

Sub-watershed Characteristics					
Acres	33.7				
Dominant Land Cover Med Dense Urba					

This sub-watershed lies on the southwest side of Little Elk Lake and is steeply sloped. BMPs were selected near the higher density lakeside regions of the sub-watershed.



Existing Conditions		Base Loading	Treatment	Net Treatment %	Existing Loading			
	Number of BMPs	1						
ent	BMP Types	Street Cleaning						
reatment	TP (lb/yr)	18.8	1.7	9%	17.1			
Tre	TSS (lb/yr)	8,504	730.0	9%	7,774			
	Volume (acre-feet/yr)	13.5	0.0	0%	13.5			

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

Table 4: Sub-watershed U001 potential BMP projects.Pollutant estimates based upon standardWinSLAMM and RUSLE2 parameters.Costs based upon conservative estimates from The Center forWatershed Protection's Urban Subwatershed Restoration Manuals and local project experience.

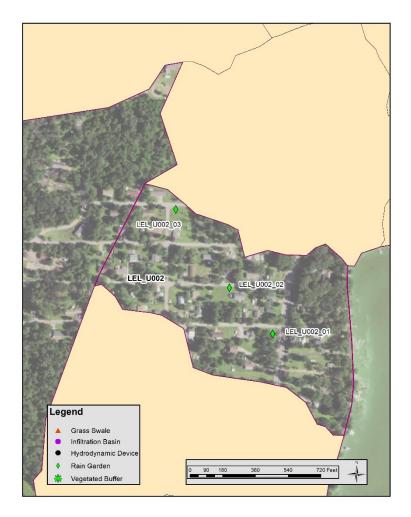
	LEL_U001_01				LEL_U001_02				
	Curb-Cut Rain Garden				Vegetated Swale				
Cost/Removal Analysis New % Treatment Reduction				Cost/Removal Analysis New Treatment Re					
	Number of BMPs	1			Number of BMPs	1			
'nt	Total Size of BMPs	250) sq-ft	ut	Total Size of BMPs	5	0 In-ft		
Treatment	TP (lb/yr)	0.61	3.6%	Treatment	TP (lb/yr)	0.86	5.0%		
Tre	TSS (lb/yr)	273	3.5%	Tre	TSS (lb/yr)	383	4.9%		
	Volume (acre-feet/yr)	0.18	1.3%		Volume (acre-feet/yr)	0.34	2.5%		
	Administration & Promotion Costs*	\$1,8	00		Administration & Promotion Costs*	\$1,800			
st	Design & Construction Costs**	\$9,300 🙀 Design & 0		Design & Construction Costs**	\$3,220				
Cost	Total Estimated Project Cost	\$11,1	.00	Cost	Total Estimated Project Cost	\$5,0	20		
	Annual O&M***	\$8	5		Annual O&M***	\$8	0		
۲.	30-yr Average Cost/lb-TP	\$74	6	2	30-yr Average Cost/lb-TP	\$28	8		
Efficiency	30-yr Average Cost/1,000lb-TSS	\$1,6	67	Efficiency	30-yr Average Cost/1,000lb-TSS	\$64	6		
Eff	30-yr Average Cost/ac-ft Vol.	\$2,5	20	Effi	30-yr Average Cost/ac-ft Vol.	\$738			
*Indi	rect Cost: (30 hours at \$60/hour base cost)	•		*Inc	irect Cost: (30 hours at \$60/hour)				
**Dir	rect Cost: (\$30/sqft materials & labor) + 30 hours/	'BMP at \$60/hour d	esign)	**D	rect Cost: (\$50/sqft materials & labor) + 12 hou	s/BMP at \$60/hour	design)		
***Pe	er BMP: (\$150/year at years 10 and 20) + (\$75/yea	r routine maintena	nce)	***F	er BMP: (\$150/year at year 10) + (\$75/year for r	outine maintenance)			

	LEL_U001_03						
	Curb-Cut Rain Garden						
	Cost/Removal Analysis New % Treatment Reduction						
	Number of BMPs	1					
ent	Total Size of BMPs	250	sq-ft				
Ireatment	TP (lb/yr)	1.12	6.6%				
Tre	TSS (lb/yr)	509	6.5%				
	Volume (acre-feet/yr)	0.58	4.3%				
	Administration & Promotion Costs*	\$1,800					
st	Design & Construction Costs**	\$9,30	0				
Cost	Total Estimated Project Cost	\$11,10	00				
	Annual O&M***	\$85					
ر. ک	30-yr Average Cost/lb-TP	\$406	;				
Efficiency	30-yr Average Cost/1,000lb-TSS	\$894					
30-yr Average Cost/ac-ft Vol. \$789							
*Indi	irect Cost: (30 hours at \$60/hour base cost)						
**Dii	rect Cost: (\$30/sqft materials & labor) + 30 hours/	BMP at \$60/hour de	sign)				
***P	er BMP: (\$150/year at years 10 and 20) + (\$75/yea	r routine maintenan	ce)				

Priority Sub-watershed U002

Sub-watershed Characteristics						
Acres	23.3					
Dominant Land Cover	Med Dense Urban					

This sub-watershed lies along the western edge of Little Elk Lake and includes rolling topography and housing in medium density.



Existing Conditions		Base Loading	Treatment	Net Treatment %	Existing Loading			
	Number of BMPs	1						
ent	BMP Types	Street Cleaning						
atm	TP (lb/yr)	13.0	1.2	9%	11.8			
Tre	TSS (lb/yr)	5,880	505.0	9%	5,375			
	Volume (acre-feet/yr)	9.3	0.0	0%	9.3			

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

Table 5: Sub-watershed U002 potential BMP projects.Pollutant estimates based upon standardWinSLAMM and RUSLE2 parameters.Costs based upon conservative estimates from The Center forWatershed Protection's Urban Subwatershed Restoration Manuals and local project experience.

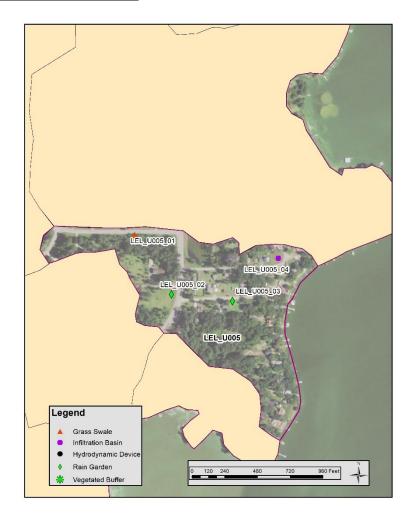
	LEL_U002_01				LEL_U002_02				
	Curb-Cut Rain Garden				Curb-Cut Rain Garden				
Cost/Removal Analysis New % Treatment Reduction				Cost/Removal Analysis New Treatment Red					
	Number of BMPs	1			Number of BMPs	1			
'nt	Total Size of BMPs	750) sq-ft	nt	Total Size of BMPs	25	D sq-ft		
Treatment	TP (lb/yr)	2.71	23.0%	Treatment	TP (lb/yr)	0.89	7.5%		
Tre	TSS (lb/yr)	1,244	23.1%	Tre	TSS (lb/yr)	401	7.5%		
	Volume (acre-feet/yr)	1.91	20.5%		Volume (acre-feet/yr)	0.48	5.2%		
	Administration & Promotion Costs*	\$1,8	00		Administration & Promotion Costs*	\$1,8	00		
st	Design & Construction Costs**	\$24,3	00	tz Design & Construction Costs**		\$9,300			
Cost	Total Estimated Project Cost	\$26,1	.00	Cost	Total Estimated Project Cost	\$11,1	L00		
	Annual O&M***	\$85	5		Annual O&M***	\$8	5		
y.	30-yr Average Cost/lb-TP	\$35	2	2	30-yr Average Cost/lb-TP	\$51	1		
Efficiency	30-yr Average Cost/1,000lb-TSS	\$76	8	Efficiency	30-yr Average Cost/1,000lb-TSS	\$1,135 \$944			
Eff	30-yr Average Cost/ac-ft Vol.	\$49	9	Eff	30-yr Average Cost/ac-ft Vol.				
*Indi	rect Cost: (30 hours at \$60/hour base cost)			*Ind	lirect Cost: (30 hours at \$60/hour base cost)				
**Dir	ect Cost: (\$30/sqft materials & labor) + 30 hours/	BMP at \$60/hour de	esign)	**D	rect Cost: (\$30/sqft materials & labor) + 30 hou	rs/BMP at \$60/hour d	esign)		
***Pe	er BMP: (\$150/year at years 10 and 20) + (\$75/yea	r routine maintenai	nce)	***	er BMP: (\$150/year at years 10 and 20) + (\$75/y	vear routine maintena	nce)		

Number of BMPs 1 Total Size of BMPs 250 sq-ft TP (lb/yr) 0.58 4.9% TSS (lb/yr) 257 4.8% Volume (acre-feet/yr) 0.24 2.6% Administration & Promotion Costs* \$9,300 Design & Construction Costs** \$9,300 Total Estimated Project Cost \$11,100 Annual O&M*** \$85 30-yr Average Cost/1,000lb-TSS \$1,770 30-yr Average Cost/ac-ft Vol. \$1,879	Cost/Removal Analysis Treatment Reduction Treatment Reduction Mumber of BMPs 1 Total Size of BMPs 250 TP (lb/yr) 0.58 TSS (lb/yr) 257 Volume (acre-feet/yr) 0.24 Z6% Administration & Promotion Costs* \$9,300 Total Estimated Project Cost Annual O&M*** 30-yr Average Cost/1,000lb-TSS \$1,770	Curb-Cut Rain Garden						
Total Size of BMPs 250 sq-ft TP (lb/yr) 0.58 4.9% TS (lb/yr) 257 4.8% Volume (acre-feet/yr) 0.24 2.6% Administration & Promotion Costs* \$9,300 Design & Construction Costs** \$9,300 Total Estimated Project Cost \$11,100 Annual O&M*** \$85 30-yr Average Cost/lb-TP \$784 30-yr Average Cost/l,000lb-TSS \$1,770 30-yr Average Cost/ac-ft Vol. \$1,879	Total Size of BMPs 250 sq-ft TP (lb/yr) 0.58 4.9% TS (lb/yr) 257 4.8% Volume (acre-feet/yr) 0.24 2.6% Administration & Promotion Costs* \$1,800 Design & Construction Costs** \$9,300 Total Estimated Project Cost \$11,100 Annual O&M*** \$85 30-yr Average Cost/lb-TP \$7.84 30-yr Average Cost/l,000lb-TSS \$1,770 30-yr Average Cost/ac-ft Vol. \$1,879	Cost/Removal Analysis						
TP (lb/yr) 0.58 4.9% TSS (lb/yr) 257 4.8% Volume (acre-feet/yr) 0.24 2.6% Administration & Promotion Costs* \$1,800 Design & Construction Costs* \$9,300 Total Estimated Project Cost \$11,100 Annual O&M*** \$85 30-yr Average Cost/lb-TP \$784 30-yr Average Cost/lb-TS \$1,770 30-yr Average Cost/ac-ft Vol. \$1,879	TP (lb/yr) 0.58 4.9% TSS (lb/yr) 257 4.8% Volume (acre-feet/yr) 0.24 2.6% Administration & Promotion Costs* \$1,800 Design & Construction Costs** \$9,300 Total Estimated Project Cost \$11,100 Annual O&M*** \$85 30-yr Average Cost/lb-TP \$784 30-yr Average Cost/l,000lb-TSS \$1,770 30-yr Average Cost/ac-ft Vol. \$1,879		Number of BMPs	1				
IOS (ID) (II) IDS (ID) (II) Volume (acre-feet/yr) 0.24 2.6% Administration & Promotion Costs* \$1,800 Design & Construction Costs* \$9,300 Total Estimated Project Cost \$11,100 Annual O&M*** \$85 30-yr Average Cost/lb-TP \$784 30-yr Average Cost/l,000lb-TSS \$1,770 30-yr Average Cost/ac-ft Vol. \$1,879	Volume (acre-feet/yr) 0.24 2.6% Administration & Promotion Costs* \$1,800 Design & Construction Costs* \$9,300 Total Estimated Project Cost \$11,100 Annual O&M*** \$85 30-yr Average Cost/lb-TP \$784 30-yr Average Cost/l,000lb-TSS \$11,770 30-yr Average Cost/ac-ft Vol. \$1,879	ent	Total Size of BMPs	250	sq-ft			
IOD (ID) (ID) IDD (ID) (ID) Volume (acre-feet/yr) 0.24 2.6% Administration & Promotion Costs* \$1,800 Design & Construction Costs* \$9,300 Total Estimated Project Cost \$11,100 Annual O&M*** \$85 30-yr Average Cost/lb-TP \$784 30-yr Average Cost/l,000lb-TSS \$1,770 30-yr Average Cost/sc-ft Vol. \$1,879	ISO (D/)1/1 ISO (D/)1/1 Volume (acre-feet/yr) 0.24 2.6% Administration & Promotion Costs* \$1,800 Design & Construction Costs* \$9,300 Total Estimated Project Cost \$11,100 Annual O&M*** \$85 30-yr Average Cost/lb-TP \$784 30-yr Average Cost/l,000lb-TSS \$1,770 30-yr Average Cost/ac-ft Vol. \$1,879 *Indirect Cost: (30 hours at \$60/hour base cost)	ق TP (lb/yr) 0.58 4.9%						
Administration & Promotion Costs* \$1,800 Design & Construction Costs** \$9,300 Total Estimated Project Cost \$11,100 Annual O&M*** \$85 30-yr Average Cost/lb-TP \$784 30-yr Average Cost/lb-TSS \$1,770 30-yr Average Cost/ac-ft Vol. \$1,879	Administration & Promotion Costs* \$1,800 Design & Construction Costs** \$9,300 Total Estimated Project Cost \$11,100 Annual O&M*** \$85 30-yr Average Cost/lb-TP \$784 30-yr Average Cost/l,000lb-TSS \$1,770 30-yr Average Cost/ac-ft Vol. \$1,879	ž TSS (lb/yr) 257 4.8%						
Design & Construction Costs**\$9,300Total Estimated Project Cost\$11,100Annual O&M***\$8530-yr Average Cost/lb-TP\$78430-yr Average Cost/l,000lb-TSS\$1,77030-yr Average Cost/ac-ft Vol.\$1,879	Design & Construction Costs** \$9,300 Total Estimated Project Cost \$11,100 Annual O&M*** \$85 30-yr Average Cost/lb-TP \$784 30-yr Average Cost/l,000lb-TSS \$1,770 30-yr Average Cost/ac-ft Vol. \$1,879	Volume (acre-feet/yr) 0.24 2.6%						
Total Estimated Project Cost \$11,100 Annual O&M*** \$85 30-yr Average Cost/lb-TP \$784 30-yr Average Cost/lb-TP \$1,770 30-yr Average Cost/l,000lb-TSS \$1,770 30-yr Average Cost/ac-ft Vol. \$1,879	Total Estimated Project Cost \$11,100 Annual O&M*** \$85 30-yr Average Cost/lb-TP \$784 30-yr Average Cost/l,000lb-TSS \$1,770 30-yr Average Cost/ac-ft Vol. \$1,879		Administration & Promotion Costs*	\$1,80	0			
Initial Estimated Project Cost \$11,100 Annual O&M*** \$85 30-yr Average Cost/lb-TP \$784 30-yr Average Cost/1,000lb-TSS \$1,770 30-yr Average Cost/ac-ft Vol. \$1,879	Initiated Project Cost \$11,100 Annual O&M*** \$85 30-yr Average Cost/lb-TP \$784 30-yr Average Cost/1,000lb-TSS \$1,770 30-yr Average Cost/ac-ft Vol. \$1,879	The Design & Construction Costs** \$9,300						
30-yr Average Cost/lb-TP \$784 30-yr Average Cost/1,000lb-TSS \$1,770 30-yr Average Cost/ac-ft Vol. \$1,879	30-yr Average Cost/lb-TP \$784 30-yr Average Cost/1,000lb-TSS \$1,770 30-yr Average Cost/ac-ft Vol. \$1,879	S	Total Estimated Project Cost	\$11,10	00			
30-yr Average Cost/1,000lb-TSS \$1,770 30-yr Average Cost/ac-ft Vol. \$1,879	Signal 30-yr Average Cost/1,000lb-TSS \$1,770 30-yr Average Cost/ac-ft Vol. \$1,879 *Indirect Cost: (30 hours at \$60/hour base cost)		Annual O&M***	\$85				
30-yr Average Cost/ac-it vol. \$1,879	*Indirect Cost: (30 hours at \$60/hour base cost)	रे 30-yr Average Cost/lb-TP \$784						
30-yr Average Cost/ac-it vol. \$1,879	*Indirect Cost: (30 hours at \$60/hour base cost)	30-yr Average Cost/1,000lb-TSS \$1,770						
*Indirect Cost: (20 hours at \$60/hour base cost)		ቖ 30-yr Average Cost/ac-ft Vol. \$1,879						
muneci cost. (so nours at soumour base cost)	**Direct Cost: (\$30/sqft materials & labor) + 30 hours/BMP at \$60/hour design)							

Sub-watershed U005

Sub-watershed Characteristics				
Acres	29.8			
Dominant Land Cover	Med Dense Urban			

Along the west side of Little Elk Lake, sub-watershed U005 includes numerous residential small lots as well as a public access owned by Baldwin Township.



	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading					
	Number of BMPs	2								
ent	BMP Types	Street Cleaning, Wetland Pond								
eatment	TP (lb/yr)	18.9	2.6	14%	16.3					
Tre	TSS (lb/yr)	8,652	1136.0	13%	7,516					
	Volume (acre-feet/yr)	14.5	0.2	1%	14.3					

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

Table 6: Sub-watershed U005 potential BMP projects.Pollutant estimates based upon standardWinSLAMM and RUSLE2 parameters.Costs based upon conservative estimates from The Center forWatershed Protection's Urban Subwatershed Restoration Manuals and local project experience.

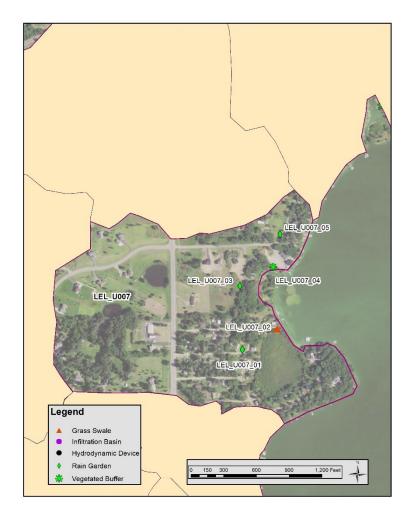
	LEL_U005_01				LEL_U005_02				
	Vegetated S	wale			Curb-Cut Rain Garden				
	Cost/Removal Analysis	New Treatment	% Reduction		Cost/Removal Analysis	New Treatment	% Reduction		
	Number of BMPs	1			Number of BMPs	1	Î		
ent	Total Size of BMPs	50) In-ft	-	Total Size of BMPs	750) sq-ft		
Treatment	TP (lb/yr)	0.62	3.8%		TP (lb/yr)	2.18	13.4%		
Tre	TSS (lb/yr)	283	3.8%	100	TSS (lb/yr)	1,002	13.3%		
	Volume (acre-feet/yr)	0.51	3.5%		Volume (acre-feet/yr)	1.70	11.9%		
	Administration & Promotion Costs*	\$1,8	00		Administration & Promotion Costs*	\$1,8	00		
Cost	Design & Construction Costs**	\$3,2	20	(oct	Design & Construction Costs**	\$24,3	800		
S	Total Estimated Project Cost	\$5,0	20	Š	Total Estimated Project Cost	\$26,100			
	Annual O&M***	\$80)		Annual O&M***	\$8	5		
5	30-yr Average Cost/lb-TP	\$39	9		30-yr Average Cost/lb-TP	\$43	8		
Efficiency	30-yr Average Cost/1,000lb-TSS	\$87	4	Efficioners	30-yr Average Cost/1,000lb-TSS	\$95	3		
Eff	^密 30-yr Average Cost/ac-ft Vol. \$487			544	30-yr Average Cost/ac-ft Vol.	\$56	1		
*Ind	*Indirect Cost: (30 hours at \$60/hour) *Indirect Cost: (30 hours at \$60/hour base cost)								
**Di	rect Cost: (\$50/sqft materials & labor) + 12 hours/	BMP at \$60/hour d	lesign)	**	Direct Cost: (\$30/sqft materials & labor) + 30 hour	s/BMP at \$60/hour d	esign)		
***P	er BMP: (\$150/year at year 10) + (\$75/year for rou	tine maintenance)		**	Per BMP: (\$150/year at years 10 and 20) + (\$75/y	ear routine maintena	nce)		

	LEL_U005_03				LEL_U005_04			
	Curb-Cut Rain	Garder	1 I		Infiltration Basin			
	Cost/Removal Analysis	New Treatment	% Reduction			Cost/Removal Analysis	New Treatment	% Reduction
	Number of BMPs	1				Number of BMPs	1	
ant	Total Size of BMPs	750) sq-ft		ent	Total Size of BMPs	1,000	sq-ft
Treatment	TP (lb/yr)	2.11	13.0%		Treatment	TP (lb/yr)	3.45	21.2%
Tree	TSS (lb/yr) 986 13.1%			Tre	TSS (lb/yr)	843	11.2%	
	Volume (acre-feet/yr)	1.87	13.0%			Volume (acre-feet/yr)	2.16	15.1%
	Administration & Promotion Costs*	\$1,80	00			Administration & Promotion Costs*	\$1,80	00
म्ह	Design & Construction Costs**	\$24,3	00		st	Design & Construction Costs**	\$31,8	00
Cost	Total Estimated Project Cost	\$26,1	.00		Cost	Total Estimated Project Cost	\$33,6	00
	Annual O&M***	\$85	5			Annual O&M***	\$85	5
5	30-yr Average Cost/lb-TP	\$45	3			30-yr Average Cost/lb-TP	\$34	9
30-yr Average Cost/10-1P 5455 30-yr Average Cost/1,000lb-TSS \$969			Efficien	30-yr Average Cost/1,000lb-TSS	\$1,42	29		
Effi	30-yr Average Cost/ac-ft Vol. \$512				÷	30-yr Average Cost/ac-ft Vol.	\$55	8
*Ind	*Indirect Cost: (30 hours at \$60/hour base cost)			*	*Indirect Cost: (30 hours at \$60/hour base cost)			
**Di	**Direct Cost: (\$30/sqft materials & labor) + 30 hours/BMP at \$60/hour design)			*	**Direct Cost: (\$30/sqft materials & labor) + 30 hours/BMP at \$60/hour design)			
***P	er BMP: (\$150/year at years 10 and 20) + (\$75/yea	r routine maintenai	nce)	*:	**Pe	r BMP: (\$150/year at years 10 and 20) + (\$75/yea	ir routine maintenar	ice)

Sub-watershed U007

Sub-watershed Characteristics				
Acres	84.0			
Dominant Land Cover	Med Dense Urban			

Sub-watershed U007 includes a number of residential parcels and a single business. A single stormwater pond currently exists and is maintained by the County.



	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading					
	Number of BMPs	2								
ent	BMP Types		Street Cleaning, Wetland Pond							
eatment	TP (lb/yr)	49.1	2.4	5%	46.7					
Tre	TSS (lb/yr)	22,329	2362.0	11%	19,967					
	Volume (acre-feet/yr)	36.2	0.1	0%	36.1					

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

Table 7: Sub-watershed U007 potential BMP projects.Pollutant estimates based upon standardWinSLAMM and RUSLE2 parameters.Costs based upon conservative estimates from The Center forWatershed Protection's Urban Subwatershed Restoration Manuals and local project experience.

	LEL_U007_01				LEL_U007_02				
	Curb-Cut Rain	Garder	l		Vegetated Swale				
	Cost/Removal Analysis	New Treatment	% Reduction		Cost/Removal Analysis	New Treatment	% Reduction		
	Number of BMPs	1			Number of BMPs	1			
nt	Total Size of BMPs	750) sq-ft	a t	Total Size of BMPs	50) In-ft		
Treatment	TP (lb/yr)	4.01	8.6%	Treatment	TP (lb/yr)	1.45	3.1%		
Tre	TSS (lb/yr)	404	2.0%	Tro	TSS (lb/yr)	365	1.8%		
	Volume (acre-feet/yr)	0.37	1.0%		Volume (acre-feet/yr)	0.37	1.0%		
	Administration & Promotion Costs*	\$1,8	00		Administration & Promotion Costs*	\$1,8	00		
st	Design & Construction Costs**	\$24,3	00	÷	Design & Construction Costs**	\$3,2	20		
Cost	Total Estimated Project Cost	\$26,1	.00	Coct	Total Estimated Project Cost	\$5,0	20		
	Annual O&M***	\$8	5		Annual O&M***	\$80	C		
~	30-yr Average Cost/lb-TP	\$23	8	2	30-yr Average Cost/lb-TP	\$17	1		
Efficiency	30-yr Average Cost/1,000lb-TSS \$2,364		64	Efficiency	30-yr Average Cost/1,000lb-TSS	\$67	8		
Effi	30-yr Average Cost/ac-ft Vol. \$2,600			Eff	30-yr Average Cost/ac-ft Vol.	\$67	3		
*Ind	*Indirect Cost: (30 hours at \$60/hour base cost) *Indirect Cost: (30 hours at \$60/hour)								
**Di	rect Cost: (\$30/sqft materials & labor) + 30 hours/	BMP at \$60/hour d	esign)	**[Direct Cost: (\$50/sqft materials & labor) + 12 hour	s/BMP at \$60/hour c	lesign)		
***P	er BMP: (\$150/year at years 10 and 20) + (\$75/yea	r routine maintena	nce)	***	Per BMP: (\$150/year at year 10) + (\$75/year for r	outine maintenance)			

	LEL_U007_03				LEL_U007_04			
	Curb-Cut Rain	Garden	1		Shoreline Buffer Strip			
	Cost/Removal Analysis	New Treatment	% Reduction		Cost/Removal Analysis	New Treatment	% Reduction	
	Number of BMPs	1			Number of BMPs	1		
ant	Total Size of BMPs	250	sq-ft	1	Total Size of BMPs	2,00	0 sqft	
Treatment	TP (lb/yr)	3.71	7.9%		TP (lb/yr)	2.62	5.6%	
Tre	TSS (lb/yr)	338	1.7%	Teo	TSS (lb/yr)	400	2.0%	
	Volume (acre-feet/yr)	0.41	1.1%		Volume (acre-feet/yr)	n/a	n/a	
	Administration & Promotion Costs*	\$1,80	00		Administration & Promotion Costs*	\$1,8	00	
st	Design & Construction Costs**	\$9,30	00	4	Design & Construction Costs**	\$3,9	50	
Cost	Total Estimated Project Cost	\$11,1	00	Cact	Total Estimated Project Cost	\$5,7	50	
	Annual O&M***	\$85	,		Annual O&M***	\$1	0	
2	30-yr Average Cost/lb-TP	\$123	3	5	30-yr Average Cost/lb-TP	\$7	7	
Efficiency	Solution State Sta			Efficion	30-yr Average Cost/1,000lb-TSS	\$50)4	
Effi	30-yr Average Cost/ac-ft Vol. \$1,101			560	30-yr Average Cost/ac-ft Vol.	n/:	a	
*Indirect Cost: (30 hours at \$60/hour base cost) *Indirect Cost: (3			direct Cost: (30 hours at \$60/hour)					
**Di	**Direct Cost: (\$30/sqft materials & labor) + 30 hours/BMP at \$60/hour design) **Direct Cost: (\$1.10/sqft for materials and labor + \$1,750 design and oversight)				ersight)			
***P	er BMP: (\$150/year at years 10 and 20) + (\$75/yea	r routine maintenan	ice)	**	Per BMP: (\$10/year)			

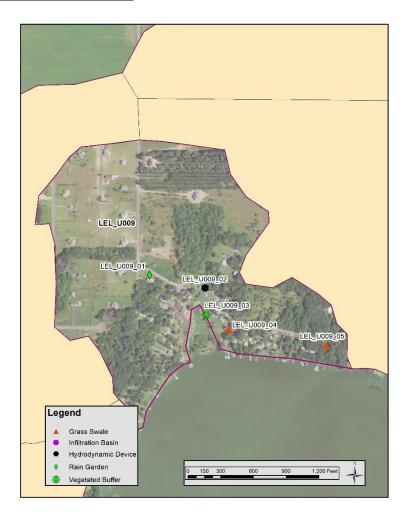
LEL_U007_05							
Curb-Cut Rain Garden							
Cost/Removal Analysis New % Treatment Reduction							
	Number of BMPs	1					
ent	Total Size of BMPs	250	sq-ft				
Treatment	TP (lb/yr)	5.06	10.8%				
Tre	TSS (lb/yr)	884	4.4%				
	Volume (acre-feet/yr)	0.85	2.4%				
	Administration & Promotion Costs*	\$1,800					
st	Design & Construction Costs**	\$9,300					
Cost	Total Estimated Project Cost	\$11,10	00				
	Annual O&M***	\$85					
S	30-yr Average Cost/lb-TP	\$90	90				
Efficiency	30-yr Average Cost/1,000lb-TSS	\$515					
Eff	30-yr Average Cost/ac-ft Vol.	\$536					

**Direct Cost: (\$30/sqft materials & labor) + 30 hours/BMP at \$60/hour design)
***Per BMP: (\$150/year at years 10 and 20) + (\$75/year routine maintenance)

Sub-watershed U009

Sub-watershed Characteristics				
Acres	94.1			
Dominant Land Cover	Med Dense Urban			

This sub-watershed lies on the north end of Little Elk Lake. The shoreline area is quite densely populated with numerous structures, balancing out the sparse areas to the north.



	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading				
	Number of BMPs	1							
ent	BMP Types	Street Cleaning							
Ireatment	TP (lb/yr)	52.4	5.8	11%	46.6				
Tre	TSS (lb/yr)	23,747	2515.0	11%	21,232				
	Volume (acre-feet/yr)	37.7	0.0	0%	37.7				

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

Table 8: Sub-watershed U009 potential BMP projects.Pollutant estimates based upon standardWinSLAMM and RUSLE2 parameters.Costs based upon conservative estimates from The Center forWatershed Protection's Urban Subwatershed Restoration Manuals and local project experience.

LEL_U009_01					LEL_U009_02						
	Curb-Cut Rain Garden					Curb-Cut Rain Garden					
Cost/Removal Analysis New % Treatment Reductio		% Reduction		Cost/Removal Analysis		New Treatment	% Reduction				
	Number of BMPs	1				Number of BMPs	1				
ent	Total Size of BMPs	250) sq-ft		ent .	Total Size of BMPs	250) sq-ft			
Treatment	TP (lb/yr)	0.51	1.1%		Treatment	TP (lb/yr)	0.73	1.6%			
Tre	TSS (lb/yr)	234	1.1%		Tre.	TSS (lb/yr)	336	1.6%			
	Volume (acre-feet/yr)	0.39	1.0%			Volume (acre-feet/yr)	0.57	1.5%			
	Administration & Promotion Costs*	\$1,800			1	Administration & Promotion Costs*	\$1,8	00			
st	Design & Construction Costs**	\$9,3	\$9,300		ا ير	Design & Construction Costs**	\$9,3	00			
Cost	Total Estimated Project Cost	\$11,1	.00		Cost	Total Estimated Project Cost	\$11,100				
	Annual O&M***	\$8	5		7	Annual O&M***	\$85	5			
5	30-yr Average Cost/lb-TP	\$89	2		2	30-yr Average Cost/lb-TP	\$62	3			
Efficiency	30-yr Average Cost/1,000lb-TSS	\$1,944			30-yr Average Cost/1,000lb-TSS		\$1,3	54			
ΕĤ	30-yr Average Cost/ac-ft Vol.	\$1,1	66		<u>ت</u>	30-yr Average Cost/ac-ft Vol.	\$79	3			
*Ind	irect Cost: (30 hours at \$60/hour base cost)			*1	ndir	ect Cost: (30 hours at \$60/hour base cost)					
**Di	rect Cost: (\$30/sqft materials & labor) + 30 hours/	BMP at \$60/hour d	esign)	**	*Dire	ect Cost: (\$30/sqft materials & labor) + 30 hours/	BMP at \$60/hour d	esign)			
***P	er BMP: (\$150/year at years 10 and 20) + (\$75/yea	r routine maintena	nce)	**	**Per	r BMP: (\$150/year at years 10 and 20) + (\$75/yea	ir routine maintena	nce)			

LEL_U009_03					LEL_U009_04				
Vegetated Swale					Vegetated Swale				
Cost/Removal Analysis New % Treatment Reduction			Cost/Removal Analysis	New Treatment	% Reduction				
	Number of BMPs	1			Number of BMPs	1			
ent	Total Size of BMPs	50) In-ft		Total Size of BMPs	5	0 In-ft		
Treatment	TP (lb/yr)	0.83	1.8%		Total Size of BMPs TP (lb/yr) TSS (lb/yr)	0.53	1.1%		
Tre	TSS (lb/yr)	1,127	5.3%	ŝ	ັ້ TSS (lb/yr)	237	1.1%		
	Volume (acre-feet/yr)	0.48	1.3%		Volume (acre-feet/yr)	0.37	1.0%		
	Administration & Promotion Costs*	\$1,800			Administration & Promotion Costs*	\$1,8	00		
st	Design & Construction Costs**	\$3,22	\$3,220 \$5,020 \$80		Design & Construction Costs**	\$3,2	20		
Cost	Total Estimated Project Cost	\$5,0			^S Total Estimated Project Cost	\$5,0	20		
	Annual O&M***	\$80			Annual O&M***	\$8	0		
S	30-yr Average Cost/lb-TP	\$29	8		हे 30-yr Average Cost/lb-TP	\$46	57		
Efficiency	30-yr Average Cost/1,000lb-TSS	\$219			30-yr Average Cost/1,000lb-TSS	\$1,0	44		
Eff	30-yr Average Cost/ac-ft Vol.	\$51	3	20	部 30-yr Average Cost/ac-ft Vol.	\$67	'3		
*Indi	rect Cost: (30 hours at \$60/hour)			*1	ndirect Cost: (30 hours at \$60/hour)				
**Di	rect Cost: (\$50/sqft materials & labor) + 12 hours/	BMP at \$60/hour d	esign)	**	Direct Cost: (\$50/sqft materials & labor) + 12 hour	s/BMP at \$60/hour	design)		
***P	er BMP: (\$150/year at year 10) + (\$75/year for rou	tine maintenance)		**	*Per BMP: (\$150/year at year 10) + (\$75/year for r	outine maintenance)			

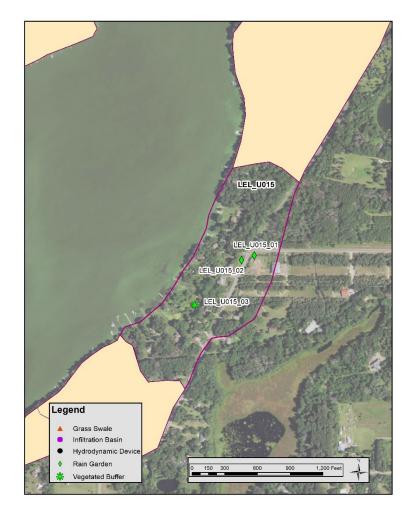
LEL_U009_05								
	Vegetated S	wale						
	Cost/Removal Analysis	New Treatment	% Reduction					
	Number of BMPs	1						
ut	Total Size of BMPs	50 ln-ft						
Treatment	TP (lb/yr)	0.45	1.0%					
Tre	TSS (lb/yr)	204	1.0%					
	Volume (acre-feet/yr)	0.32	0.9%					
	Administration & Promotion Costs*	\$1,80	0					
st	Design & Construction Costs**	\$3,220						
Cost	Total Estimated Project Cost	\$5,02	20					
	Annual O&M***	\$80						
5	30-yr Average Cost/lb-TP	\$550)					
Efficiency	30-yr Average Cost/1,000lb-TSS	\$1,21	.2					
Eff	30-yr Average Cost/ac-ft Vol.	\$770						

**Direct Cost: (\$50/sqft materials & labor) + 12 hours/BMP at \$60/hour design)
***Per BMP: (\$150/year at year 10) + (\$75/year for routine maintenance)

Sub-watershed U015

Sub-watershed Characteristics						
Acres	34.4					
Dominant Land Cover	Med Dense Urban					

Sub-watershed U015 lies along the eastern side of Little Elk Lake and includes medium density residential lots and rolling terrain.



Existing Conditions		Base Loading	Treatment	Net Treatment %	Existing Loading							
	Number of BMPs	1										
ent	BMP Types	Street Cleaning										
eatme	TP (lb/yr)	19.2	2.1	11%	17.0							
Tre	TSS (lb/yr)	8,681	919.0	11%	7,762							
	Volume (acre-feet/yr)	13.8	0.0	0%	13.8							

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

Table 9: Sub-watershed U015 potential BMP projects.Pollutant estimates based upon standardWinSLAMM and RUSLE2 parameters.Costs based upon conservative estimates from The Center forWatershed Protection's Urban Subwatershed Restoration Manuals and local project experience.

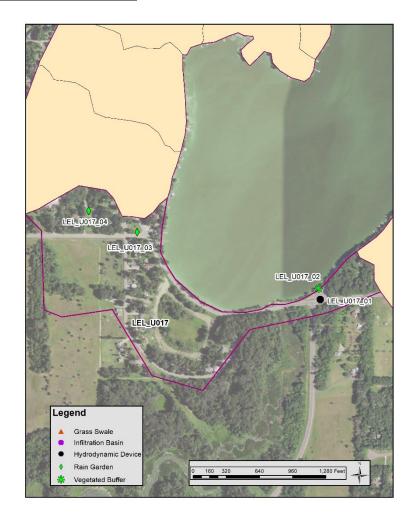
LEL_U015_01					LEL_U015_02						
	Curb-Cut Rain Garden					Curb-Cut Rain Garden					
Cost/Removal Analysis New % Treatment Reduction			Cost/Removal Analysis		New Treatment	% Reduction					
	Number of BMPs	1				Number of BMPs	1				
nt	Total Size of BMPs	250	D sq-ft		'nt	Total Size of BMPs	250) sq-ft			
Treatment	TP (lb/yr)	0.70	4.1%		Treatment	TP (lb/yr)	0.62	3.6%			
Tre	TSS (lb/yr)	320	4.1%		Tre	TSS (lb/yr)	284	3.7%			
	Volume (acre-feet/yr)	0.55	4.0%			Volume (acre-feet/yr)	0.48	3.5%			
	Administration & Promotion Costs*	\$1,800 \$9,300 \$11,100				Administration & Promotion Costs*	\$1,8	00			
Cost	Design & Construction Costs**				Cost	Design & Construction Costs**	\$9,3	00			
ප	Total Estimated Project Cost				ප	Total Estimated Project Cost	\$11,1	.00			
	Annual O&M***	\$8	5			Annual O&M***	\$8	5			
ر. در	30-yr Average Cost/lb-TP	\$65	0		5	30-yr Average Cost/lb-TP	\$73	4			
Efficiency	30-yr Average Cost/1,000lb-TSS	\$1,4	22	:	Efficiency	30-yr Average Cost/1,000lb-TSS	\$1,6	02			
Eff	30-yr Average Cost/ac-ft Vol.	\$82	8	1	EĤ	30-yr Average Cost/ac-ft Vol.	\$94	2			
*Indi	irect Cost: (30 hours at \$60/hour base cost)			*1	ndir	ect Cost: (30 hours at \$60/hour base cost)					
**Di	rect Cost: (\$30/sqft materials & labor) + 30 hours/	BMP at \$60/hour d	esign)	**	*Dire	ect Cost: (\$30/sqft materials & labor) + 30 hours/	'BMP at \$60/hour d	esign)			
***P	er BMP: (\$150/year at years 10 and 20) + (\$75/yea	r routine maintena	nce)	**	**Pe	r BMP: (\$150/year at years 10 and 20) + (\$75/yea	ir routine maintena	nce)			

Shoreline Buffer Strip							
	Cost/Removal Analysis	New Treatment	% Reduction				
	Number of BMPs	1					
ent	Total Size of BMPs	4,500	sqft				
Ireatment	TP (lb/yr)	0.97	5.7%				
Tre	TSS (lb/yr)	106	1.4%				
	Volume (acre-feet/yr)	n/a	n/a				
	Administration & Promotion Costs*	\$1,80	0				
Cost	Design & Construction Costs**	\$6,700					
ප	Total Estimated Project Cost	\$8,500					
	Annual O&M***	\$10					
ç	30-yr Average Cost/lb-TP	\$303	;				
Efficiency	30-yr Average Cost/1,000lb-TSS	\$2,77	0				
Eff	30-yr Average Cost/ac-ft Vol.	n/a					

Sub-watershed U017

Sub-watershed Characteristics						
Acres	54.3					
Dominant Land Cover	Med Dense Urban					

Sub-watershed U017 is at the south end of the lake. Some residential areas exist, but it also includes a good portion of a county road and a DNR public lake access.



	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading							
	Number of BMPs	1										
ent	BMP Types	Street Cleaning										
Ireatment	TP (lb/yr)	30.2	3.3	11%	26.9							
Tre	TSS (lb/yr)	13,703	1451.0	11%	12,252							
	Volume (acre-feet/yr)	21.8	0.0	0%	21.8							

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

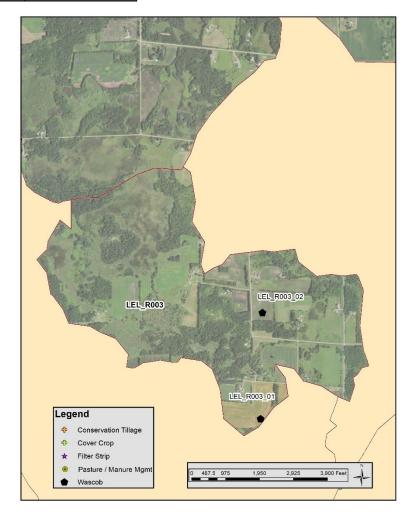
Table 10: Sub-watershed U017 potential BMP projects.Pollutant estimates based upon standardWinSLAMM and RUSLE2 parameters.Costs based upon conservative estimates from The Center forWatershed Protection's Urban Subwatershed Restoration Manuals and local project experience.

LEL_U017_01					LEL_U017_02				
	6' Hydrodynamic Device				Shoreline Buffer Strip				
Cost/Removal Analysis		New Treatment	% Reduction	n Cost/Removal Analysis		New Treatment	% Reductior		
	Number of BMPs	nber of BMPs 1			Number of BMPs	1			
ent	Total Size of BMPs		5 ft dia	nt	Total Size of BMPs	1,800) sqft		
eatment	TP (lb/yr)	3.01	11.2%	Treatment	TP (lb/yr)	1.30	4.8%		
Tre	TSS (lb/yr)	746	6.1%	Tre	TSS (lb/yr)	309	2.5%		
	Volume (acre-feet/yr)	0.19	0.9%		Volume (acre-feet/yr)	n/a	n/a		
	Administration & Promotion Costs*	\$2,400 \$27,000			Administration & Promotion Costs*	\$1,8	00		
	Design & Construction Costs**			Cost	Design & Construction Costs**	\$3,7	30		
Cost	Total Estimated Project Cost	\$29,4	\$29,400		Total Estimated Project Cost	\$5,5	30		
	Annual O&M***	\$36	0		Annual O&M***	\$10	0		
2	30-yr Average Cost/lb-TP	\$44	5	cy	30-yr Average Cost/lb-TP	\$14	9		
Efficiency	30-yr Average Cost/1,000lb-TSS	\$1,7	96	Efficiency	30-yr Average Cost/1,000lb-TSS	\$62	9		
ΕĤ	30-yr Average Cost/ac-ft Vol.	n/a	a	Ef	30-yr Average Cost/ac-ft Vol.	n/a	a		
*Indi	irect Cost: (24 hours at \$100/hr)	•		*Inc	irect Cost: (30 hours at \$60/hour)				
**Di	rect Cost: (\$18,000 HD materials) + (\$9,000 labor 8	& construction)		**Di	rect Cost: (\$1.10/sqft for materials and labor + \$	1,750 design and ove	ersight)		
***P	er BMP: (2 cleanings/year)*(3 hrs/cleaning)*\$60/I	nr)		***F	er BMP: (\$10/year)				

	LEL_U017_03				LEL_U017_04				
	Curb-Cut Rain Garden					Curb-Cut Rain Garden			
Cost/Removal Analysis New % Treatment Reduction				Cost/Removal Analysis	New Treatment	% Reduction			
	Number of BMPs	1				Number of BMPs	1		
sut	Total Size of BMPs	750) sq-ft		ent	Total Size of BMPs	250	sq-ft	
Treatment	TP (lb/yr)	1.92	7.1%		Treatment	TP (lb/yr)	0.65	2.4%	
Tree	TSS (lb/yr)	881	7.2%			TSS (lb/yr)	301	2.5%	
	Volume (acre-feet/yr)	1.50	6.9%			Volume (acre-feet/yr)	0.51	2.4%	
	Administration & Promotion Costs*	\$1,800 \$24,300				Administration & Promotion Costs*	\$1,80	00	
st	Design & Construction Costs**				Cost	Design & Construction Costs**	\$9,30	00	
Cost	Total Estimated Project Cost	\$26,1	.00		8	Total Estimated Project Cost	\$11,1	00	
	Annual O&M***	\$85				Annual O&M***	\$85	5	
2	30-yr Average Cost/lb-TP	\$49	7		cγ	30-yr Average Cost/lb-TP	\$70	0	
Efficiency	30-yr Average Cost/1,000lb-TSS	\$1,084			30-yr Average Cost/1,000lb-TSS		\$1,5:	12	
E#	30-yr Average Cost/ac-ft Vol.	\$63	7		Eff	30-yr Average Cost/ac-ft Vol.	\$88	7	
*Ind	irect Cost: (30 hours at \$60/hour base cost)				*Ind	rect Cost: (30 hours at \$60/hour base cost)			
**Di	rect Cost: (\$30/sqft materials & labor) + 30 hours/	BMP at \$60/hour d	esign)		**Di	rect Cost: (\$30/sqft materials & labor) + 30 hours/	'BMP at \$60/hour de	esign)	
***P	er BMP: (\$150/year at years 10 and 20) + (\$75/yea	r routine maintena	nce)		***P	er BMP: (\$150/year at years 10 and 20) + (\$75/yea	ir routine maintenar	nce)	

Sub-watershed Characteristics					
Acres	857.0				
Dominant Land Cover	Agriculture				

Sub-watershed R003 sits near the headwaters of Battle Brook, in Mille Lacs County. A number of agricultural fields dot the landscape and the rolling terrain is well suited for WASCOBs.



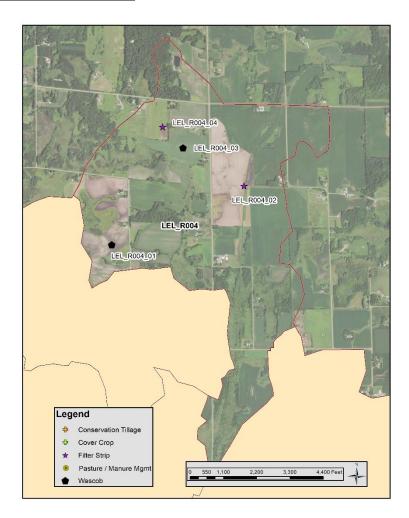
Treatment Calculations and Cost Analysis

Table 11: Sub-watershed R003 potential BMP projects.Pollutant estimates based upon standardRUSLE2 and BWSR pollution calculator estimates.Costs based upon conservative estimates from currentliterature research and local project experience.

	LEL_R003_01			LEL_R003_02		
	Wascob			Wascob		
	Cost/Removal Analysis	New Treatment			Cost/Removal Analysis	New Treatment
	Number of BMPs	1	1 I		Number of BMPs	1
eatment	BMP catchment area	19 acres	1	nent	BMP catchment area	7.9 acres
reati	TP (lb/yr)	8.7	i	Treatment	TP (lb/yr)	5.4
1	TSS (lb/yr)	10.2	1	F	TSS (lb/yr)	6.4
	Administration & Promotion Costs*	\$1,125	1 [Administration & Promotion Costs*	\$844
ধ	Design & Construction Costs**	\$11,863	1	st	Design & Construction Costs**	\$8,860
Cost	Total Estimated Project Cost	\$13,088	1	Cost	Total Estimated Project Cost	\$9,804
	Annual O&M***	\$100	i		Annual O&M***	\$100
	Average Cost/lb-TP	\$1,513	1 [Average Cost/Ib-TP	\$1,806
	Average Cost/1,000lb-TSS	\$1,286	1		Average Cost/1,000lb-TSS	\$1,534
*Ind	*Indirect Cost: (15 hours at \$75/hr)			*Indirect Cost: (11 hours at \$75/hr)		
**Di	**Direct Cost: (Estimated labor and construction costs)			**Direct Cost: (Estimated labor and construction costs)		
***P	er BMP: (\$100 / yr)			***Pe	er BMP: (\$100 / yr)	

Sub-watershed Characteristics				
Acres	1188.0			
Dominant Land Cover	Agriculture			

R004 sits next to R003 at the headwaters of Battle Brook in Mille Lacs County. The sub-watershed largely consists of agriculture land, primarily producing corn and soybeans.



Treatment Calculations and Cost Analysis

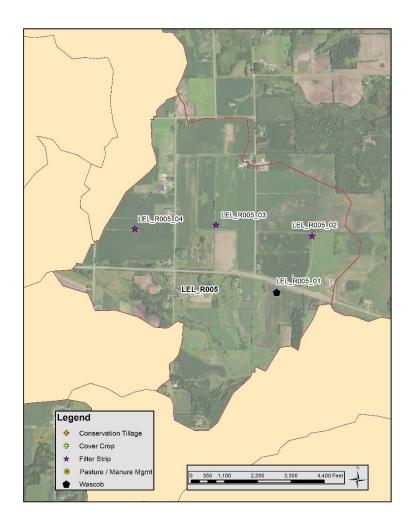
Table 13: Sub-watershed R004 potential BMP projects.Pollutant estimates based upon standardRUSLE2 and BWSR pollution calculator estimates.Costs based upon conservative estimates from currentliterature research and local project experience.

	LEL_R004_01			LEL_R004_02		
	Wascob			Filter Strip		
	Cost/Removal Analysis	New Treatment		Cost/Removal Analysis	New Treatment	
	Number of BMPs	1		Number of BMPs	1	
Treatment	BMP catchment area	15.4 acres		BMP catchment area	190.0 acres	
reati	TP (lb/yr)	8.7		TP (lb/yr)	17.8	
7	TSS (lb/yr)	10.2		F TSS (lb/yr)	12.4	
	Administration & Promotion Costs*	\$1,125		Administration & Promotion Costs*	\$1,120	
st	Design & Construction Costs**	\$11,863		sign & Construction Costs**	\$5,560	
Cost	Total Estimated Project Cost	\$13,088		Total Estimated Project Cost	\$6,780	
	Annual O&M***	\$100		Annual O&M***	\$100	
	Average Cost/lb-TP	\$2,178		Average Cost/lb-TP	\$384	
	Average Cost/1,000lb-TSS	\$1,849		Average Cost/1,000lb-TSS	\$552	
*Ind	irect Cost: (15 hours at \$75/hr)		*	Indirect Cost: (16 hours at \$70/hr)		
**Di	rect Cost: (Estimated labor and construction costs)		*	**Direct Cost: (Estimated labor and construction costs)		
***P	er BMP: (\$100 / yr)		*	**Per BMP: (\$100 / yr)		

	LEL_R004_03			LEL_R004_04		
	Wascob			Filter Strip		
	Cost/Removal Analysis	New Treatment			Cost/Removal Analysis	New Treatment
	Number of BMPs	1	i I I		Number of BMPs	1
nent	BMP catchment area	22.3 acres	i	reatment	BMP catchment area	25.9 acres
Treatment	TP (lb/yr)	8.4	i	reati	TP (lb/yr)	7.6
1	TSS (lb/yr)	9.9	1	7	TSS (lb/yr)	4.6
	Administration & Promotion Costs*	\$1,125] [Administration & Promotion Costs*	\$1,120
st	Design & Construction Costs**	\$11,863		Cost	Design & Construction Costs**	\$5,560
Cost	Total Estimated Project Cost	\$13,088	1	S	Total Estimated Project Cost	\$6,780
	Annual O&M***	\$100	Í		Annual O&M***	\$100
	Average Cost/lb-TP	\$1,786	1 F		Average Cost/Ib-TP	\$301
	Average Cost/1,000lb-TSS	\$1,518	i		Average Cost/1,000lb-TSS	\$398
*Ind	irect Cost: (15 hours at \$75/hr)		,	*Indi	rect Cost: (16 hours at \$70/hr)	
**Di	rect Cost: (Estimated labor and construction costs)		,	**Dir	ect Cost: (Estimated labor and construction costs	
***P	er BMP: (\$100 / yr)			***Per BMP: (\$100 / yr)		

Sub-watershed Characteristics					
Acres	1268.0				
Dominant Land Cover	Agriculture				

Sub-watershed R005 is largely dominated by agriculture. The area includes many small ditches which could integrate the use of filter strips for water quality protection.



Treatment Calculations and Cost Analysis

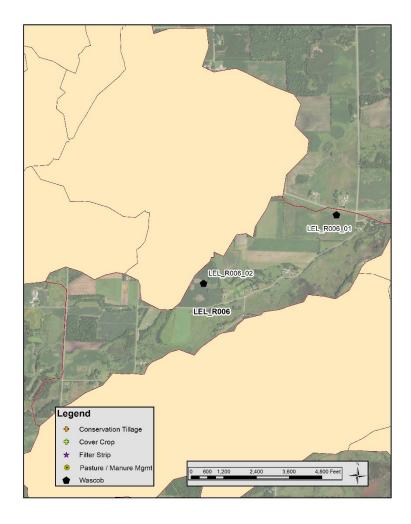
Table 13: Sub-watershed R005 potential BMP projects.Pollutant estimates based upon standardRUSLE2 and BWSR pollution calculator estimates.Costs based upon conservative estimates from currentliterature research and local project experience.

	LEL_R005_01			LEL_R005_02		
	Wascob			Filter Strip		
	Cost/Removal Analysis	New Treatment			Cost/Removal Analysis	New Treatment
	Number of BMPs	1	ilt		Number of BMPs	1
atment	BMP catchment area	17.3 acres		Treatment	BMP catchment area	265.3 acres
reati	TP (lb/yr)	4.7		reati	TP (lb/yr)	14.8
1	TSS (lb/yr)	5.5			TSS (lb/yr)	8.9
	Administration & Promotion Costs*	\$1,125			Administration & Promotion Costs*	\$1,120
st	Design & Construction Costs**	\$11,863		st	Design & Construction Costs**	\$5,560
Cost	Total Estimated Project Cost	\$13,088		Cost	Total Estimated Project Cost	\$6,780
	Annual O&M***	\$100			Annual O&M***	\$100
	Average Cost/lb-TP	\$2,809			Average Cost/lb-TP	\$463
	Average Cost/1,000lb-TSS	\$2,388			Average Cost/1,000lb-TSS	\$766
*Ind	irect Cost: (15 hours at \$75/hr)			*Indir	rect Cost: (16 hours at \$70/hr)	
**Di	rect Cost: (Estimated labor and construction costs)		*	**Direct Cost: (Estimated labor and construction costs)		
***P	er BMP: (\$100 / yr)		*	***Pe	r BMP: (\$100 / yr)	

LEL_R005_03			LEL_R005_04			
	Filter Strip			Filter Strip		
	Cost/Removal Analysis New Treatment			Cost/Removal Analysis	New Treatment	
	Number of BMPs	1		Number of BMPs	1	
nent	BMP catchment area	291.6 acres		BMP catchment area TP (lb/yr)	70.9 acres	
Treatment	TP (lb/yr)	24.3		हु TP (lb/yr)	20.7	
1	TSS (lb/yr)	18.1		TSS (lb/yr)	15.7	
	Administration & Promotion Costs*	\$1,120		Administration & Promotion Costs*	\$1,120	
st	Design & Construction Costs**	\$5,560		Design & Construction Costs**	\$5,560	
Cost	Total Estimated Project Cost	\$6,780		^S Total Estimated Project Cost	\$6,780	
	Annual O&M***	\$100		Annual O&M***	\$100	
	Average Cost/lb-TP	\$590		Average Cost/Ib-TP	\$301	
	Average Cost/1,000lb-TSS	\$790		Average Cost/1,000lb-TSS	\$398	
*Ind	irect Cost: (16 hours at \$70/hr)		*	ndirect Cost: (16 hours at \$70/hr)		
**Di	rect Cost: (Estimated labor and construction costs)		*	Direct Cost: (Estimated labor and construction cost	5)	
***P	er BMP: (\$100 / yr)		*	**Per BMP: (\$100 / yr)		

Sub-watershed Characteristics					
Acres	883.0				
Dominant Land Cover	Agriculture				

R006 is a strip of agricultural land that sits near the Mille Lacs / Sherburne County line. Several WASCOB opportunities were identified in this SWA.



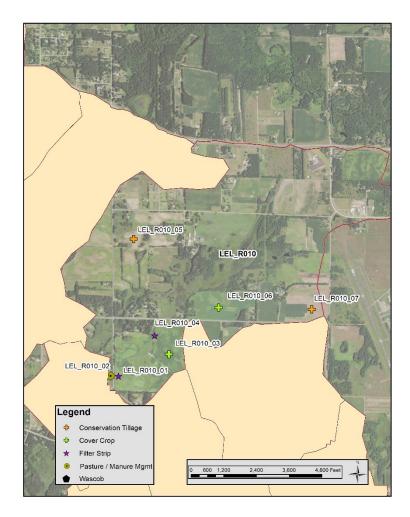
Treatment Calculations and Cost Analysis

Table 14: Sub-watershed R006 potential BMP projects.Pollutant estimates based upon standardRUSLE2 and BWSR pollution calculator estimates.Costs based upon conservative estimates from currentliterature research and local project experience.

	LEL_R006_01			LEL_R006_02		
	Wascob			Wascob		
	Cost/Removal Analysis New Treatment		$\left \right $	Cost/Removal Analysis	New Treatment	
	Number of BMPs	1	1 1	Number of BMPs	1	
nent	BMP catchment area	37.0 acres		BMP catchment area	26.9 acres	
Treatment	TP (lb/yr)	3.6	1	BMP catchment area	7.0	
7	TSS (lb/yr)	3.9		F TSS (lb/yr)	8.3	
	Administration & Promotion Costs*	\$1,125	1 [Administration & Promotion Costs*	\$1,125	
st	Design & Construction Costs**	\$17,719		₩ Design & Construction Costs**	\$17,719	
Cost	Total Estimated Project Cost	\$19,044	1	Total Estimated Project Cost	\$19,044	
	Annual O&M***	\$200	i	Annual O&M***	\$200	
	Average Cost/lb-TP	\$5,246	1 [Average Cost/Ib-TP	\$2,273	
	Average Cost/1,000lb-TSS	\$4,858	1 L	Average Cost/1,000lb-TSS	\$1,932	
*Ind	*Indirect Cost: (15 hours at \$75/hr)		*	Indirect Cost: (15 hours at \$75/hr)		
**Di	rect Cost: (Estimated labor and construction costs)		*	**Direct Cost: (Estimated labor and construction costs)		
***P	er BMP: (\$100 / yr)		*	***Рег ВМР: (\$100 / уг)		

Sub-watershed Characteristics					
Acres	1502.0				
Dominant Land Cover	Agriculture				

This sub-watershed holds both agricultural and animal operations and is located entirely within Sherburne County, just outside of the City of Princeton.



Treatment Calculations and Cost Analysis

Table 15: Sub-watershed R010 potential BMP projects.Pollutant estimates based upon standardRUSLE2, MinnFarm and BWSR pollution calculator estimates.Costs based upon conservative estimatesfrom current literature research and local project experience.

	LEL_R010_01			LEL_R010_02		
	Filter Strip			Pasture / Manure Mgmt		
	Cost/Removal Analysis	New Treatment		Cost/Removal Analysis	New Treatment	
	Number of BMPs	1		Number of BMPs	1	
eatment	BMP catchment area	33.1 acres	Treatment	BMP catchment area	10.0 acres	
reat	TP (lb/yr)	4.2	reat	TP (lb/yr)	10.0	
7	TSS (lb/yr)	2.3	1	TSS (lb/yr)	12.4	
	Administration & Promotion Costs*	\$1,120		Administration & Promotion Costs*	\$1,200	
Cost	Design & Construction Costs**	\$5,560	*	Design & Construction Costs**	\$6,200	
S	Total Estimated Project Cost	\$6,780	Cost	Total Estimated Project Cost	\$7,500	
	Annual O&M***	\$100		Annual O&M***	\$100	
	Average Cost/Ib-TP	\$104		Average Cost/Ib-TP	\$750	
	Average Cost/1,000lb-TSS	\$191		Average Cost/1,000lb-TSS	\$603	
*Indi	rect Cost: (16 hours at \$70/hr)		*In	direct Cost: (16 hours at \$75/hr)		
**Dii	rect Cost: (Estimated labor and construction costs)		**[**Direct Cost: (Estimated labor and construction costs)		
***P	er BMP: (\$100 / yr)		***	Per BMP: (\$100 / yr)		

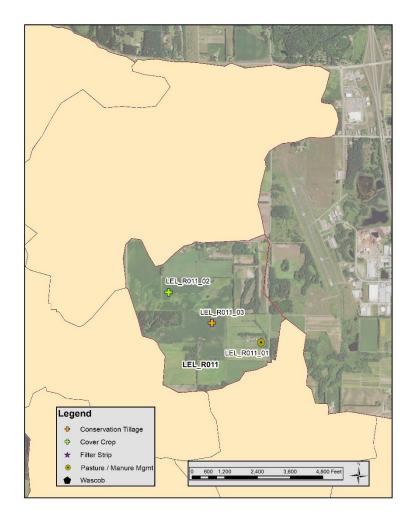
	LEL_R010_03			LEL_R010_04		
	Cover Crop			Filter Strip		
	Cost/Removal Analysis	New Treatment		Cost/Removal Analysis	New Treatment	
	Number of BMPs			Number of BMPs	1	
nent	BMP catchment area	129.3 acres		BMP catchment area	30.1 acres	
Treatment	TP (lb/yr)	17.5		BMP catchment area TP (lb/yr)	6.4	
ц	TSS (lb/yr)	12.3		F TSS (lb/yr)	3.9	
	Administration & Promotion Costs*	\$640		Administration & Promotion Costs*	\$1,120	
st	Design & Construction Costs**	\$12,260		ਸ਼ Design & Construction Costs**	\$5,560	
Cost	Total Estimated Project Cost	\$12,900		Total Estimated Project Cost	\$6,780	
	Annual O&M	-		Annual O&M***	\$100	
	Average Cost/lb-TP	\$737		Average Cost/Ib-TP	\$126	
	Average Cost/1,000lb-TSS	\$1,050		Average Cost/1,000lb-TSS	\$204	
*Ind	irect Cost: (\$5 / acre)		*Indirect Cost: (16 hours at \$70/hr)			
**Di	rect Cost: (\$95 / acre)		*	*Direct Cost: (Estimated labor and construction costs)	
			*	**Per BMP: (\$100 / yr)		

	LEL_R010_05 Cover Crop			LEL_R010_06 Conservation Tillage		
	Cost/Removal Analysis	New Treatment		Cost/Removal Analysis	New Treatment	
	Number of BMPs	1		Number of BMPs	1	
nent	BMP catchment area	45.9 acres	reatment	BMP catchment area	73.2 acres	
eati	TP (lb/yr)	4.9	reat	TP (lb/yr)	19.0	
=	TSS (lb/yr)	3.2	-	TSS (lb/yr)	11.2	
	Administration & Promotion Costs*	\$230		Administration & Promotion Costs*	\$366	
st	Design & Construction Costs**	\$4,361	Cost	Design & Construction Costs**	\$8,418	
Cost	Total Estimated Project Cost	\$4,590	S	Total Estimated Project Cost	\$8,784	
	Annual O&M	-	1	Annual O&M	-	
	Average Cost/lb-TP	\$939	1	Average Cost/lb-TP	\$462	
	Average Cost/1,000lb-TSS	\$1,421		Average Cost/1,000lb-TSS	\$787	
Indi	rect Cost: (\$5 / acre)		*In	direct Cost: (\$5 / acre)		
*Diı	rect Cost: (\$95 / acre)		**D	irect Cost: (\$115 / acre)		

	Conservation	Tillage		
	Cost/Removal Analysis	New Treatment		
	Number of BMPs	1		
Ireatment	BMP catchment area	40.1 acres		
reat	TP (lb/yr)	7.6		
	TSS (lb/yr)	4.8		
	Administration & Promotion Costs*	\$201		
st	Design & Construction Costs**	\$4,612		
	Total Estimated Project Cost	\$4,812		
	Annual O&M	-		
	Average Cost/lb-TP	\$637		
	Average Cost/1,000lb-TSS	\$1,007		
ndi	irect Cost: (\$5 / acre)			

Sub-watershed (Characteristics
Acres	560.0
Dominant Land Cover	Agriculture

Sub-watershed R011 sits outside of the City of Princeton, as the region transitions from suburbs to agriculture. Several fields and one hobby farm are located in this sub-watershed.



Treatment Calculations and Cost Analysis

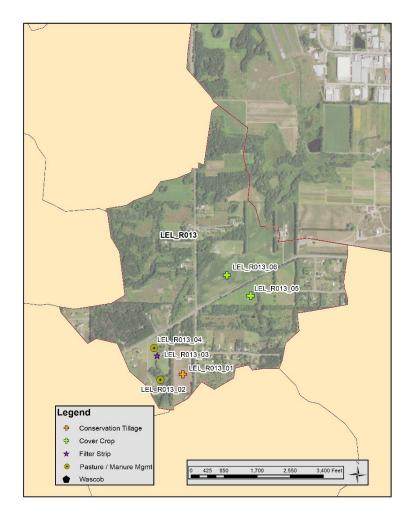
Table 16: Sub-watershed R011 potential BMP projects.Pollutant estimates based upon standardRUSLE2, MinnFarm and BWSR pollution calculator estimates.Costs based upon conservative estimatesfrom current literature research and local project experience.

	LEL_R011_01			LEL_R011_02		
	Pasture / Manure Mgmt			Cover Crop		
	Cost/Removal Analysis New Treatment			Cost/Removal Analysis	New Treatment	
	Number of BMPs	1		Number of BMPs	1	
eatment	BMP catchment area	16.5 acres		BMP catchment area TP (lb/yr)	189.1 acres	
reati	TP (lb/yr)	4.0		TP (lb/yr)	20.6	
7	TSS (lb/yr)	2.7		TSS (lb/yr)	13.7	
	Administration & Promotion Costs*	\$1,200		Administration & Promotion Costs*	\$946	
st	Design & Construction Costs**	\$6,200	Cost	Design & Construction Costs**	\$17,965	
Cost	Total Estimated Project Cost	\$7,500	ŝ	³ Total Estimated Project Cost	\$18,900	
	Annual O&M***	\$100		Annual O&M	-	
	Average Cost/lb-TP	\$1,875		Average Cost/lb-TP	\$917	
	Average Cost/1,000lb-TSS	\$2,799		Average Cost/1,000lb-TSS	\$1,378	
*Ind	irect Cost: (16 hours at \$75/hr)		*Indirect Cost: (\$5 / acre)			
**Di	rect Cost: (Estimated labor and construction costs)		**	Direct Cost: (\$95 / acre)		
***P	er BMP: (\$100 / yr)					

TSS (lb/yr) 16.2 Administration & Promotion Costs* \$499 Design & Construction Costs** \$11,477 Total Estimated Project Cost \$11,976 Annual O&M - Average Cost/lb-TP \$443		Conservation	Tillage		
BMP catchment area 99.8 acres TP (lb/yr) 27.0 TSS (lb/yr) 16.2 Administration & Promotion Costs* \$499 Design & Construction Costs** \$11,477 Total Estimated Project Cost \$11,976 Annual O&M - Average Cost/lb-TP \$443		Cost/Removal Analysis	New Treatment		
TSS (lb/yr) 16.2 Administration & Promotion Costs* \$499 Design & Construction Costs** \$11,477 Total Estimated Project Cost \$11,976 Annual O&M - Average Cost/lb-TP \$443		Number of BMPs	1		
TSS (lb/yr) 16.2 Administration & Promotion Costs* \$499 Design & Construction Costs** \$11,477 Total Estimated Project Cost \$11,976 Annual O&M - Average Cost/lb-TP \$443	Freatment	BMP catchment area	99.8 acres		
TSS (lb/yr) 16.2 Administration & Promotion Costs* \$499 Design & Construction Costs** \$11,477 Total Estimated Project Cost \$11,976 Annual O&M - Average Cost/lb-TP \$443	reati	TP (lb/yr)	27.0		
Design & Construction Costs** \$11,477 Total Estimated Project Cost \$11,976 Annual O&M - Average Cost/lb-TP \$443	-	TSS (lb/yr)	16.2		
Total Estimated Project Cost \$11,976 Annual O&M - Average Cost/lb-TP \$443		Administration & Promotion Costs*	\$499		
Annual O&M - Average Cost/lb-TP \$443	st	Design & Construction Costs**	\$11,477		
Average Cost/lb-TP \$443	Cost	Total Estimated Project Cost	\$11,976		
		Annual O&M	-		
		Average Cost/lb-TP	\$443		
Average Cost/1,000lb-TSS \$739		Average Cost/1,000lb-TSS	\$739		

Sub-watershed Characteristics				
Acres	613.0			
Dominant Land Cover	Agriculture			

Sub-watershed R013 includes agricultural land and two animal operations along a County ditch. BMPs installed here would prevent nutrients and bacteria from entering Battle Brook.



Treatment Calculations and Cost Analysis

Table 17: Sub-watershed R013 potential BMP projects.Pollutant estimates based upon standardRUSLE2, MinnFarm and BWSR pollution calculator estimates.Costs based upon conservative estimatesfrom current literature research and local project experience.

	LEL_R013_01			LEL_R013_02			
	Conservation Tillage			Pasture / Manure Mgmt			
	Cost/Removal Analysis	New Treatment		Cost/Removal Analysis	New Treatment		
	Number of BMPs	1		Number of BMPs	1		
eatment	BMP catchment area	10.2 acres		BMP catchment area TP (lb/yr)	7.4 acres		
reati	TP (lb/yr)	2.4		TP (lb/yr)	2.5		
1	TSS (lb/yr)	1.4	•	TSS (lb/yr)	2.0		
	Administration & Promotion Costs*	\$51		Administration & Promotion Costs*	\$1,200		
Cost	Design & Construction Costs**	\$1,173	Cost	Besign & Construction Costs**	\$6,200		
8	Total Estimated Project Cost	\$1,224		^S Total Estimated Project Cost	\$7,500		
	Annual O&M	-		Annual O&M***	\$100		
	Average Cost/lb-TP	\$506		Average Cost/lb-TP	\$3,000		
	Average Cost/1,000lb-TSS	\$893		Average Cost/1,000lb-TSS	\$3,676		
*Ind	irect Cost: (\$5 / acre)		*1	*Indirect Cost: (16 hours at \$75/hr)			
**Di	rect Cost: (\$115 / acre)		**	Direct Cost: (Estimated labor and construction costs			
			**	*Per BMP: (\$100 / yr)			

	LEL_R013_03			LEL_R013_04		
	Filter Strip			Pasture / Manure Mgmt		
	Cost/Removal Analysis New Treatment			Cost/Removal Analysis	New Treatment	
	Number of BMPs 1			Number of BMPs	1	
ment	BMP catchment area	8.9 acres		BMP catchment area	7.3 acres	
Treatment	TP (lb/yr)	7.3		BMP catchment area TP (lb/yr)	2.0	
1	F TSS (lb/yr) 6.1			TSS (lb/yr)	1.7	
	Administration & Promotion Costs* \$1,120			Administration & Promotion Costs*	\$1,200	
ъ	Design & Construction Costs**	\$5,560	tt -	Besign & Construction Costs**	\$6,200	
Cost	Total Estimated Project Cost	\$6,780		Total Estimated Project Cost	\$7,500	
	Annual O&M***	\$100		Annual O&M***	\$100	
	Average Cost/lb-TP	\$824		Average Cost/lb-TP	\$3,750	
	Average Cost/1,000lb-TSS	\$994		Average Cost/1,000lb-TSS	\$4,545	
*Ind	irect Cost: (16 hours at \$70/hr)		*Indirect Cost: (16 hours at \$75/hr)			
**Di	rect Cost: (Estimated labor and construction costs)		*	*Direct Cost: (Estimated labor and construction costs	;)	
***P	er BMP: (\$100 / yr)		*	**Per BMP: (\$100 / yr)		

	<i>LEL_R013_05</i> Cover Crop			LEL_R013_06		
				Cover Crop		
	Cost/Removal Analysis	New Treatment	$\left \right $	Cost/Removal Analysis	New Treatment	
	Number of BMPs	1		Number of BMPs	1	
ment	BMP catchment area	24.9 acres	Treatment	BMP catchment area	48.1 acres	
reatm	TP (lb/yr)	2.2	eatr	TP (lb/yr)	7.8	
H	TSS (lb/yr)	1.4	1	TSS (lb/yr)	5.2	
	Administration & Promotion Costs*	\$125		Administration & Promotion Costs*	\$241	
÷	Design & Construction Costs**	\$2,366	٦ L	Design & Construction Costs**	\$4,570	
Cost	Total Estimated Project Cost	\$2,490	Cost	Total Estimated Project Cost	\$4,810	
	Annual O&M	-	1	Annual O&M	-	
	Average Cost/lb-TP	\$1,132	1 🗖	Average Cost/lb-TP	\$616	
	Average Cost/1,000lb-TSS	\$1,779	111	Average Cost/1,000lb-TSS	\$934	
ʻInd	irect Cost: (\$5 / acre)		*In	direct Cost: (\$5 / acre)		
*Di	rect Cost: (\$95 / acre)		**0	Pirect Cost: (\$95 / acre)		

Literature Cited

Chisago SWCD. 2015. Rural Subwatershed Analysis Protocol. North Branch, Chisago County, MN

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Appendix A: Modeling Methods

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

WinSLAMM

Pollutant and volume reductions were estimated using the stormwater model Source Load and Management Model for Windows (WinSLAMM). WinSLAMM uses an abundance of stormwater data from the Upper-Midwest and elsewhere to quantify runoff volumes and pollutant loads from urban areas. It has detailed accounting of pollutant loading from various land uses and allows the user to build a model "landscape". WinSLAMM uses rainfall and temperature data from a typical year (1959 data from Minneapolis for this analysis), routing stormwater through the user's model for each storm. WinSLAMM version 10.4.0 was used for this analysis to estimate volume and pollutant loading and reductions. Additional inputs for WinSLAMM are provided in Table 18.

General WinSLAMM Model Inputs				
Parameter	File or Method			
Land use acreage	ArcMap with 2015 Land Use			
Precipitation / Temperature	Minneapolis 1959 (user preference, best approximates a typical year)			
Winter Season	Included in model, 11-12 to 3-18			
Pollutant probability distribution	WI_GE001.ppd			
Runoff coefficient file	WI_SL06 Dec06.rsv			
Particulate solids concentration file	WI_AVG01.psc			
Particle residue delivery file	WI_DLV01.prr			
Street delivery files	WI files for each land use			
Street sweeping	2x annually			

Table 18:	General WinSLAMM	Model Input	s (i.e.	Current File Data).
		model input	U .U.U.	ourrent i no butuj.

BMP model designs

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

and llog	- Low Donaity D	esidential	Total Area: 0.552 acres	1 7 (0) (0)
	e: Low Density R Trea: Streets 1	esidential	l otal Area: 0.552 acres	Type of Street Cleaner
				Mechanical Broom Cleaner
First Sou	rce Area Control I	Practice		C Vacuum Assisted Cleaner
Line Number	t C Street Clean Street Cleaning Date	aning Dates OR Street Cleaning Frequency	 Street Cleaning Frequency 7 Passes per Week 5 Passes per Week 4 Passes per Week 3 Passes per Week 	Street Cleaner Productivity 1. Coefficients based on street texture, parking density and parking controls 2. Other (specify equation
2			C 2 Passes per Week	coefficients)
3 4 5 6		<u>र</u> र र	One Pass per Week One Pass Every Two Weeks One Pass Every Four Weeks One Pass Every Eight Weeks	Equation coefficient M (slope, M<1) 0.44 Equation coefficient B (intercept, B>1) 245
7		-	C One Pass Every Twelve Weeks	
8 9 10		× ×	C Two Passes per Year (Spring and Fall) C One Pass Each Spring	Parking Densities C 1. None © 2. Light
Final clea		ng date (MM/DD/YY): [ribution file name:	Press 'F1' for Help	C 3. Medium C 4. Extensive (short term) C 5. Extensive (long term) Are Parking Controls Imposed? C Yes ← No
Сору	Cleaning Data	Paste Cleaning Data	Delete Control Car	ncel Edits <u>Cl</u> ear <u>C</u> ontinu

Figure 7: Street Sweeping. Street sweeping model inputs for the Little Elk Lake study.

Drainage System Control Practice	1	Add Sharp Crested Weir	Add	Other Outlet		Evaporation	Add
Device Properties Biofilter Number 1		Weir Length (ft)	Stage	Stage (it) Other Outflow		Evapotrans-	Evaporation
Top Area (sf)	8000	Height from datum to	Number	Rate (cfs)	Month	piration	[in/day]
Bottom Area (sf)	5000	bottom of weir opening (ft)	1			(in/day)	(100000)
Total Depth (ft)	4.00	Remove Broad Crested Weir	2		Jan		
Typical Width (ft) (Cost est. only)	40.00	Weir crest length (ft) 3.00	3		Feb		
Native Soil Infiltration Rate (in/hr)	1.000	Weir crest width (ft) 1.00	4		Mar		
Native Soil Infiltration Rate COV	N/A	Height from datum to	5	•	Apr		
Infil. Rate Fraction-Bottom (0-1)	0.75	bottom of weir opening (ft) 3.50	Add	Evapotranspiration	May		
Infil. Rate Fraction-Sides (0-1)	0.60	Add Vertical Stand Pipe		ty (saturation	Jun		
Rock Filled Depth (ft)	0.00			ontent, 0-1)	Jul		
Rock Fill Porosity (0-1)	0.00	Pipe diameter (ft)		ioisture capacity (0-1)	Aug		
Engineered Media Type	Media Data	Height above datum (ft)		t wilting point (0-1)	Sep		
Engineered Media Infiltration Rate	0.00	Remove Surface Discharge Pipe		ntal irrigation used?	Oct		
Engineered Media Infiltration Rate COV	N/A	Pipe Diameter (ft) 1.00		available capacity	Nov		
Engineered Media Depth (ft)	0.00	Invert elevation above datum (ft) 2.00	and the second sectors in	ation starts (0-1)	Dec		
Engineered Media Porosity (0-1)	0.00	Number of pipes at invert elev. 1	Fraction of	available capacity	PI	ant Types	
Percent solids reduction due to Engineered Media (0 -100)	N/A	Add Drain Tile/Underdrain		ation stops (0-1)	1 2	3	4
Inflow Hydrograph Peak to Average		Pipe Diameter (ft)	Plant type		*	*	•
Flow Ratio	3.80	Invert elevation above datum (ft)	Root dept	n (ft)			1991 - 1992 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 -
umber of Devices in Source Area or 1		Number of pipes at invert elev.	ET Crop A	djustment Factor Biofilter Geometry	Schematic	Refre:	sh Schematio
🗖 Activate Pipe or Box Storage 🛛 🤇	Pipe C Box	Generation to Account for		bioliker decilierty	oonomaato		
Diameter (ft)		Infiltration Rate Uncertainty		-3.00' -			
Length (ft)		Initial Water Surface					
Within Biofilter (check if Yes)		0.00 Initial Water Surrace Elevation (ft)					1
Perforated (check if Yes)		Elevelor (n)		1.00			
Bottom Elevation (It above datum)		Est. Surface Drain Time = 24.0 hrs.		1		1	
Discharge Orifice Diameter (ft)						1	
Select Native Soil Infiltration Ra	ate					1	
C Sand - 8 in/hr C Cla	v Ioam - 0.1 in/h	Change 4.0	n'				
C Loamy sand - 2.5 in/hr C Silt	y clay loam - 0.0	acomery	3.50'			1	
	ndy clay - 0.05 in			1		1	
	v clav - 0.04 in/l			2.00'		1	
	v - 0.02 in/hr			1 2.00		1	
C Silt Ioam - 0.3 in/hr C Cla		-0.00 in /hr Paste Biofilter		1		1	
	in Barrel/Cistern	Data		1		1	

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

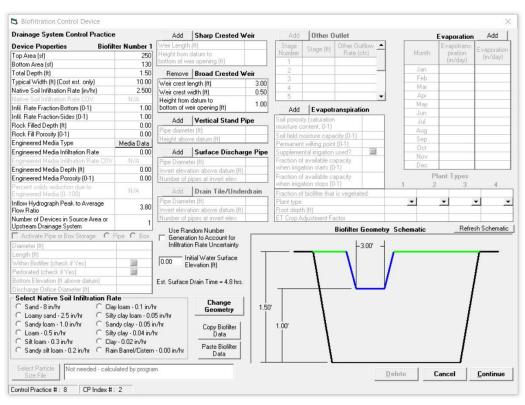


Figure 9: 250 sqft Rain Garden. Standard size used in most modeling applications.

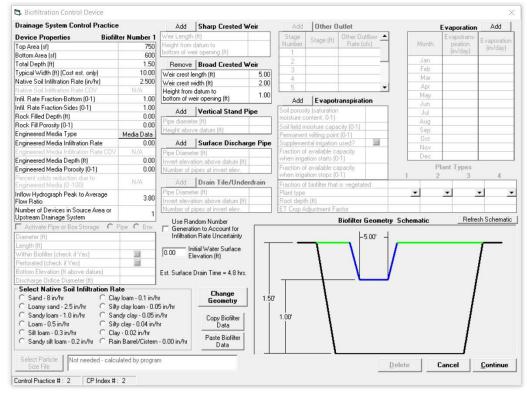


Figure 10: 750 sqft Rain Garden. Standard size used in several modeling scenarios.

and Use: Commerci ource Area: Streets	Total Area: Filter Strip No		
econd Source Area	Control Practice		
D	evice Properties		
Total Area in Sour	ce Area (ac)	0.540	
Area Fraction Serv) 0.15		
Total Filter Strip W	'idth (ft)	20	
Flow Length (ft)		90	
Dynamic Infiltration	n Rate (in/hr)	0.500	
Typical Longitudin		0,020	
Typical Grass Heig	and the state in the second	6.0	
Grass Retardance		C 💌	
Use Stochastic Ar Infiltration Rate Ur	nalysis to account for Incertainty		
Native Soil Infiltrati	ion Rate COV		
Surface Clogging I	Load (lbs/sf)	3.50	
This ratio must be g	reater than 0.05 to acti		
This ratio must be g			
2		vate the filter strip Vie Flow Retard	
2	Filter Strip Width	vate the filter strip Vie Flow Retard	
s	Fitter Strip Width Elect Particle Size File ated by program Dynamic Infiltration Clay loam in/hr C Silty clay k /hr C Sandy clay C Silty clay - nr C Clay - 0.01	Vate the filter strip Flow Length Retard Tab • 0.05 in/hr • 0.025 in/hr v - 0.025 in/hr 0.02 in/hr	
Silver Sold State Sold State State State State Sold State Sold State Sold State Sold State	Fitter Strip Width elect Particle Size File ated by program Dynamic Infiltration Clay loam in/hr Silty clay loa C Silty clay - r Clay - 0.01 in/hr	Vate the filter strip Flow Length Retard Tab • 0.05 in/hr • 0.025 in/hr v - 0.025 in/hr 0.02 in/hr	

Figure 11: Filter strip. Some properties are standard, others customized given site-specific conditions.

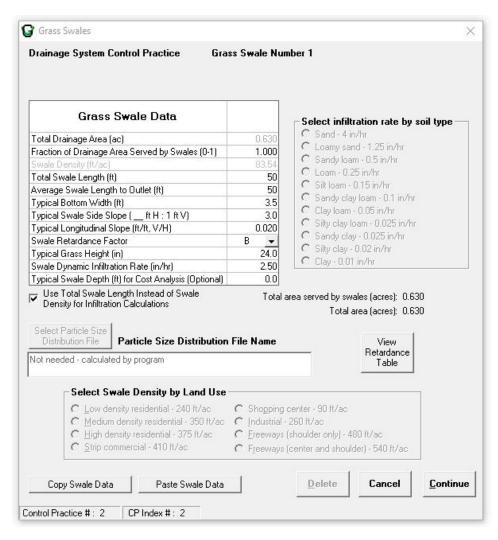


Figure 12: Vegetated Swale. Pictured is an example of a 50 ft swale.

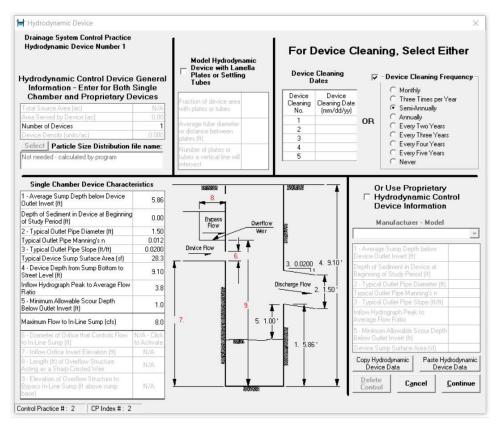


Figure 13: 4 ft Hydrodynamic Device.

Rural Modeling Procedures

Existing condition and BMP reduction conditions were estimated for rural areas using a combination of the RUSLE2 modeling program as well as the BWSR Pollution Reduction Calculator, per protocols outlined in the Chisago County SWCD's protocol, "Rural Sub-watershed Analysis Protocol". MinnFarm (Schmidt and Wilson, 2008) was utilized for animal pasture settings to estimate phosphorus conditions and, although not included in this report, e.coli outputs. RUSLE2 general inputs are provided in Table 19.

Table 19: General RUSLE Model Inputs	Table 19:	RUSLE Model Inp	outs.
--------------------------------------	-----------	-----------------	-------

Parameter	File or Method
Location	USA\Minnesota\Sherburne County OR Mille Lacs County
Soil	Location dependent
Slope	Location dependent
Avg Steepness, %	Location dependent
Base mgmt, conventional	managements\CMZ 04\b.Multi-year Rotation Templates\Corn-Soybeans\CB mulch till\Corn FC Disk Cult - Soybeans FC Disk Fld Cult
Base mgmt, No-till	managements\CMZ 04\b.Multi-year Rotation Templates\Corn-Soybeans\CB NT\corn grain;NT Soybeans, nr NT single disk openers z4
Base mgmt, Cover crop	managements\CMZ 04\b.Multi-year Rotation Templates\Cover Crops rotations\corn grain SC, disk afer w annual clover cover crop soybeans z4
Base mgmt, Filter strip	managements\CMZ 04\b.Multi-year Rotation Templates\Corn-Soybeans\CB mulch till\Corn FC Disk Cult - Soybeans FC Disk Fld Cult

Appendix B: BMP Cost Estimates

The following section includes estimates of BMPs evaluated in this report. Cost estimates were derived from a number of sources including The Center for Watershed Protection's Urban Sub-watershed Restoration Manuals, current literature research and local project experience.

Urban BMP Cost Profiles

250 sqft Rain Garden		Assume	
Administration & Promotion Costs	\$1,800		lirect Cost (30 hours at \$60/hour base cost)
Design & Construction Costs	\$9,300		ect Cost (\$30/sqft for materials and labor) + 30 hours/BMP at \$60/hour for design)
Total Estimated Project Cost	\$11,100		r BMP (\$150/year for rehabilitation at years 10 and 20) + (\$75/year for routine maintenance)
Annual O & M	\$85		
500 sqft Rain Garden		Assume	
Administration & Promotion Costs	\$1,800		lirect Cost (30 hours at \$60/hour base cost)
Design & Construction Costs	\$16,800		ect Cost (\$30/sqft for materials and labor) + 30 hours/BMP at \$60/hour for design)
Total Estimated Project Cost	\$18,600	Annual O&M Per	r BMP (\$150/year for rehabilitation at years 10 and 20) + (\$75/year for routine maintenance)
Annual O & M	\$85		
750 sqft Rain Garden		Assume	
Administration & Promotion Costs	\$1,800	Admin Ind	lirect Cost (30 hours at \$60/hour base cost)
Design & Construction Costs	\$24,300		ect Cost (\$30/sqft for materials and labor) + 30 hours/BMP at \$60/hour for design)
Total Estimated Project Cost	\$26,100		r BMP (\$150/year for rehabilitation at years 10 and 20) + (\$75/year for routine maintenance)
Annual O & M	\$85		
Vegetated Swale	¢1.000	Assume	
Administration & Promotion Costs	\$1,800		lirect Cost (30 hours at \$60/hour)
Design & Construction Costs	\$3,220		rect Cost (\$50/Inft for materials and labor) + 12 hours/BMP at \$60/hour for design)
Total Estimated Project Cost	\$5,020	Annual O&M Per	r BMP (\$150/year for rehabilitation at year 10) + (\$75/year for routine maintenance)
Annual O & M	\$80		
Shoreline Buffer Strip		Assume	
Administration & Promotion Costs	\$1,800	Admin Ind	lirect Cost (30 hours at \$60/hour)
Design & Construction Costs	\$3,220	Design/Const Dir	ect Cost (\$1.10/sqft materials and labor + \$1750 design and oversight)
Total Estimated Project Cost	\$5,020	Annual O&M Per	r BMP (\$150/year for rehabilitation at year 10) + (\$75/year for routine maintenance)
Annual O & M	\$80		
4' dia Hydrodynamic Device		Assume	
Administration & Promotion Costs	\$1,752		lirect Cost (24 hours at \$60/hour)
Design & Construction Costs	\$18,000		ect Cost (\$9,000 for materials) + (\$9,000 for labor and installation costs)
Total Estimated Project Cost	\$19,752		r BMP (2 cleanings/year)*(3 hours/cleaning)*(\$60/hour)
Annual O & M	\$420	Annual Oxivi Per	i bivir (z cleanings) year) (s nouis) cleaning) (sooynoui)
	9 7 20		
6' dia Hydrodynamic Device		Assume	
Administration & Promotion Costs	\$2,400		lirect Cost (24 hours at \$100/hour)
Design & Construction Costs	\$27,000		ect Cost (\$18,000 for materials) + (\$9,000 for labor and installation costs)
Total Estimated Project Cost	\$28,752	Annual O&M Per	r BMP (2 cleanings/year)*(3 hours/cleaning)*(\$60/hour)
Annual O & M	\$420		
8' dia Hydrodynamic Device		Assume	
Administration & Promotion Costs	\$2,400		lirect Cost (24 hours at \$100/hour)
Design & Construction Costs	\$54,000		ect Cost (\$36,000 for materials) + (\$18,000 for labor and installation costs)
Total Estimated Project Cost	\$55,752		r BMP (2 cleanings/year)*(3 hours/cleaning)*(\$60/hour)
Annual O & M	\$420		(· · · · · · · · · · · · · · · · · · ·
		-	
10' dia Hydrodynamic Device	40 · 00	Assume	
Administration & Promotion Costs	\$2,400		lirect Cost (24 hours at \$100/hour)
Design & Construction Costs	\$108,000		rect Cost (\$72,000 for materials) + (\$36,000 for labor and installation costs)
Total Estimated Project Cost	\$109,752	Annual O&M Per	r BMP (2 cleanings/year)*(3 hours/cleaning)*(\$60/hour)
Annual O & M	\$420		

Rural BMP Cost Profiles

Grassed Waterway		Assume	
Administration & Promotion Costs	\$1,752		Indirect Cost (24 hours at \$60/hour)
Design & Construction Costs	\$2,210		Direct Cost (\$500 initial, \$1,150 design, \$560 install oversight)
Total Estimated Project Cost	\$3,962	Designy const	
Annual O & M	\$100		
	<i>100</i>		
Wascob (0-10 acres drainage)		Assume	
Administration & Promotion Costs	\$844	Admin	11 hours at \$75/hr
Design & Construction Costs	\$8,860	Design/Const	Estimated labor and construction costs
Total Estimated Project Cost	\$9,804	0 & M	\$100 / year
Annual O & M	\$100		
		• · · · · ·	
Wascob (10-20 acres drainage)	¢1.125	Assume	15 haven at 675 /hz
Administration & Promotion Costs Design & Construction Costs	\$1,125		15 hours at \$75/hr Estimated labor and construction costs
5	\$11,863	0,	
Total Estimated Project Cost	\$13,088 \$100	0 & M	\$100 / year
Annual O & M	\$100		
Wascob (20-40 acres drainage)		Assume	
Administration & Promotion Costs	\$1,125	Admin	15 hours at \$75/hr
Design & Construction Costs	\$17,719		Estimated labor and construction costs
Total Estimated Project Cost	\$19,044	0 & M	\$100 / year
Annual O & M	\$200		
Filter Strip		Assume	
Administration & Promotion Costs	\$1,120	Admin	16 hours at \$70/hr
Design & Construction Costs	\$5,560	Design/Const	Estimated labor and construction costs
Total Estimated Project Cost	\$6,780	0 & M	\$100 / year
Annual O & M	\$100		
Cover Crops (per acre)	4-	Assume	
Administration & Promotion Costs	\$5		\$5 per acre
Design & Construction Costs	\$95	Design/Const	
Total Estimated Project Cost	\$100	0 & M	\$100 / year
Annual O & M			
Conservation Tillage (per acre)		Assume	
Administration & Promotion Costs	\$5		\$5 per acre
Design & Construction Costs	\$115		\$115 per acre
Total Estimated Project Cost	\$120	0 & M	\$100 / year
Annual O & M	+		, ,
Pasture / Manure Mgmt		Assume	
Administration & Promotion Costs	\$1,200	Admin	16 hours at \$75/hr
Authinistration & Fromotion Costs	φ <u></u> 1)200		
Design & Construction Costs	\$6,200		Estimated labor and construction costs
			Estimated labor and construction costs \$100 / year