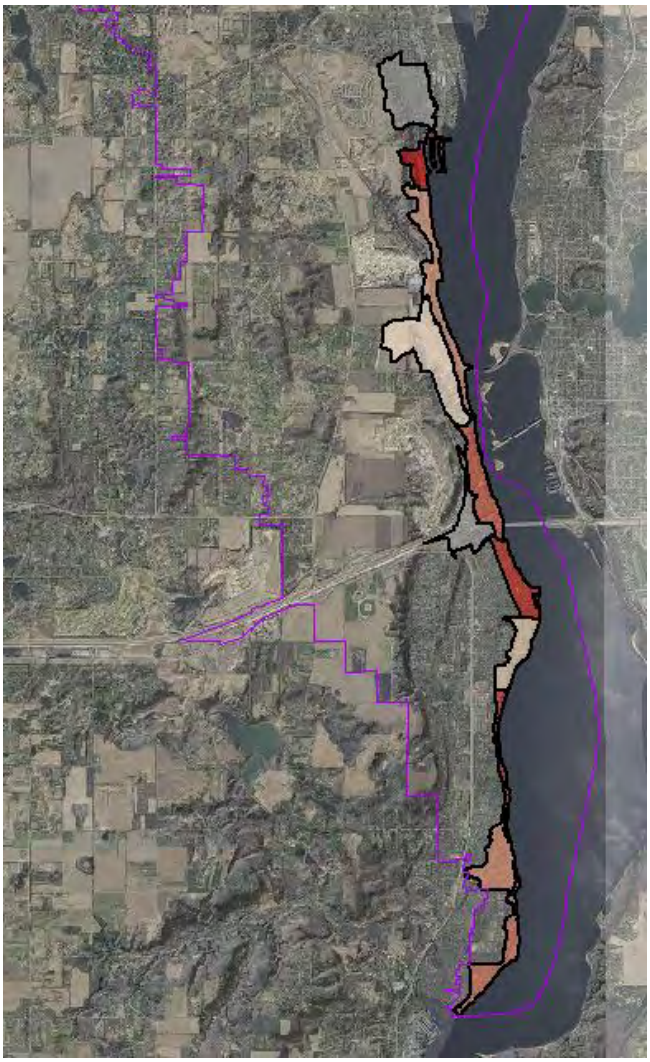
Lake St. Croix Direct Discharge (South) Stormwater Retrofit Analysis

February 20, 2018



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Contents

This report details a Subwatershed Stormwater Retrofit Analysis (SWA) resulting in recommended catchments for placement of Best Management Practice (BMP) retrofits that address the goals of the Local Governing Unit (LGU) and stakeholder partners. This document should be considered as *one part* of an overall watershed restoration plan including redevelopment and new development volume control requirements, erosion and sediment control requirements; inspection, maintenance and operation of existing stormwater quality practices; ongoing education and outreach, voluntary incentive programs and technical design assistance for private landowners.

The methods and analysis behind this document attempt to provide a sufficient level of detail to rapidly assess subwatersheds of variable scales and land-uses to identify optimal locations for stormwater treatment. The time commitment required for this methodology is appropriate for *initial analysis* applications.

The analysis's background information is discussed followed by a summary of the analysis's results; the methods used and catchment profile sheets of selected sites for retrofit consideration. Lastly, the retrofit ranking criteria and results are discussed and source references are provided.

Results of this analysis are based on the development of catchment-specific *conceptual* stormwater treatment BMPs that either supplement existing stormwater infrastructure or provide quality and volume treatment where none currently exists. Relative comparisons are then made between catchments to determine where best to initialize final retrofit design efforts and implement BMP projects. Site-specific design sets (driven by existing limitations of the landscape and its effect on design element selections) will need to be developed to determine a more refined estimate of the reported pollutant removal amounts reported in this report. This typically occurs after committed partnerships are developed for each specific target property for which BMPs are planned.

Executive Summary

The lowest 25 miles of the St Croix River Basin was designated as an Impaired Water in 2008 for excess phosphorus. For the Middle St. Croix Watershed, the 2012 Lake St. Croix Total Maximum Daily Load (TMDL) implementation plan identified that 1,521 pounds of phosphorous load reduction is needed to bring Lake St. Croix back to current State water quality standards (set from the 1992 baseline).

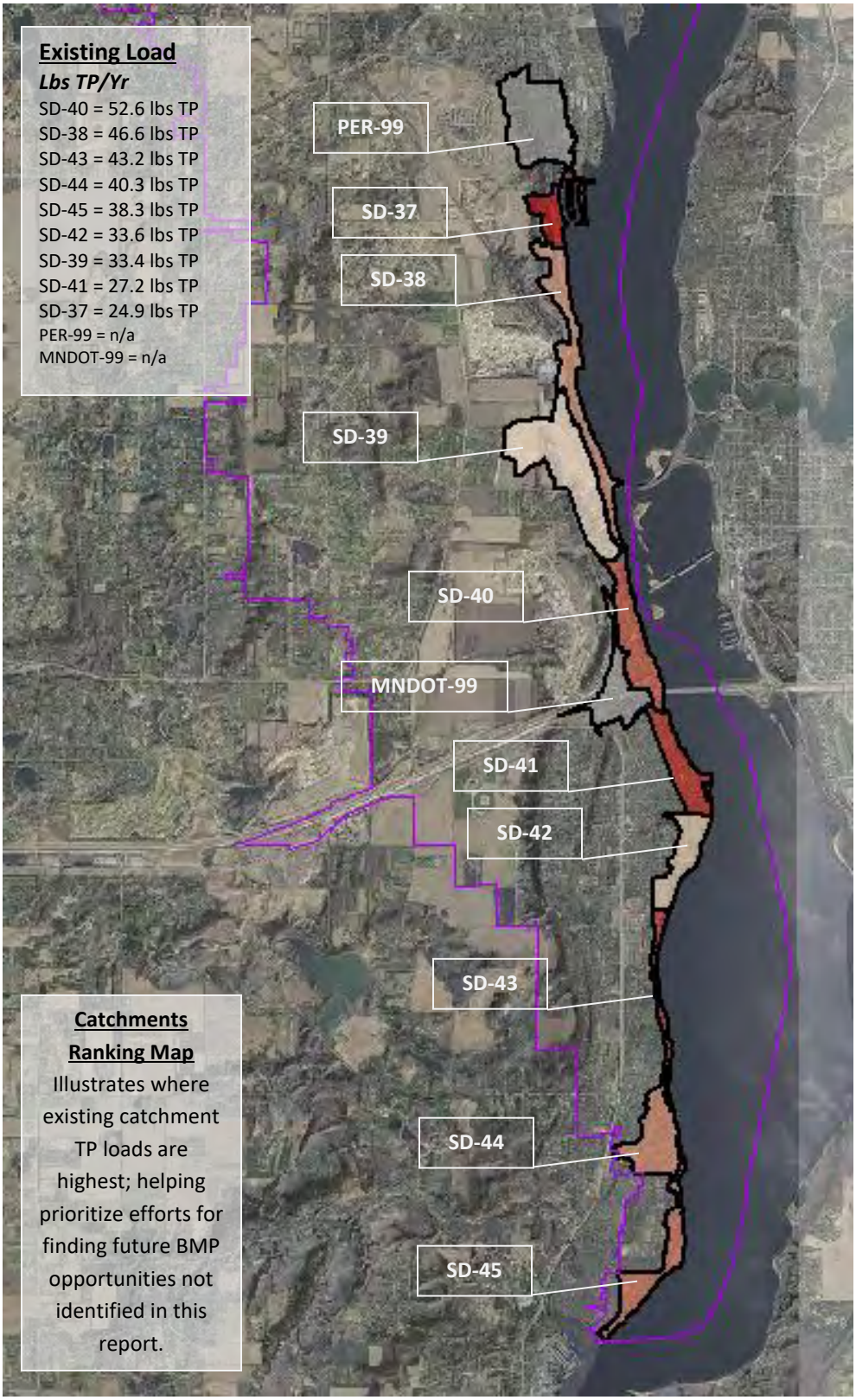
The Lake St. Croix Direct Discharge Subwatershed spans the municipalities of Stillwater, Oak Park Heights, Bayport, Lakeland, Lake St Croix Beach, and St Mary's Point (spanning the entire length of the Middle St Croix Watershed Management Organization). Two previous Subwatershed Retrofit Analyses (SWAs) were completed in 2014 and 2015 analyzing the northern half of the entire Middle St Croix Watershed that directly drains to the St Croix River. This SWA picks up where the Lake St Croix Direct (North) and Perro Creek SWAs left off, and analyzes the southern portion of the watershed that directly discharges to the St Croix River. This SWA will complete the initial prioritization process for all directly discharging catchments to the St Croix River in the entire MSCWMO.

The study area was broken into twenty-seven catchment areas and evaluated for potential pollutant sources from stormwater discharges. All catchments that received treatment from a wetland, stormwater pond, or other natural feature were excluded from this analysis since they were already receiving treatment prior to discharging into the St Croix River. Stormwater practice options were compared for each catchment, depending on specific site constraints and characteristics. Potential stormwater BMP retrofit locations were selected based on pollutant reduction potential, feasibility of installation, and maintenance.

The following table summarizes the analysis results. This analysis identified 19 practices that would reduce 110.4 pounds of total phosphorus directly discharging into Lake St. Croix from urban land uses and select ravines. These results assume water quality projects are designed and installed independent of any other infrastructure improvements. The costs of these practices can be substantially lower when designed and installed as part of a larger infrastructure improvement project such as street reconstruction or site redevelopment.

In summary, there were very few locations available for productive BMPs. After field review and modelling, it was shown that much of the land flowed to sandy depressions with high natural outlets. This eliminated many possible BMP sites. More sites were eliminated for field review because they were larger tracts of private property; where erosion issues were no longer visible from the road. There are many opportunities to reduce erosion that were not discovered. Given this, the majority of pollutant contributions to the river are likely from unstable bluffs and smaller ravines that could not be identified through this process alone. It is recommended that a comprehensive outreach strategy be implemented to target landowners who may have erosion potential on their property (identified through analysis of the Digital Elevation Model). It is this onsite review and homeowner interaction that will allow the watershed to find the near-shore opportunities and improve bluff conditions on a large scale. The end of each catchment summary can be amended after the report's completion to integrate any new opportunities.

Lake St. Croix Catchments Ranked by Existing TP Loading



Lake St. Croix Direct Proposed BMPs - Ranked by $ Cost/lb of TP/year (over 10 years)

The table below ranks each BMP against each other, regardless of catchment location. The Project Rank column is color coded to show natural breaks in the cost-benefit values, to help visualize each BMP's relative benefit. Although there is a real difference in cost-benefit between each practice, it should be noted that all of the BMPs recommended in this report would rank very highly against many traditional practices in other SWA's that use this same methodology. Many Curb-cut infiltration basins in other studies often rank in the $1,500-$3000/per lb of TP range. Every practice in this study ranks below $2,000/per lb of TP, making them all highly desirable practices to install.

Project Rank	Catchment ID	Retrofit Name	Projects Identified	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Total Project Cost	Annual Operations & Maintenance (2018 Dolla	$Cost/ lb-TP/year (10-year)	$ Cost/ ton-TSS/year (10-year)
1	SD-40	40m: Bluff Restoration	1	15.58	36,660	0.00	$45,165	$300	$309	$263
2	SD-38	38d2: Gully Load Reductions by Fixing 38c,d,e	5	10.72	16,760	2.87	$25,625	$1,150	$346	$443
3	SD-44	44g - 44h: South Riviera Treatment Train	2	2.91	883	0.69	$10,950	$263	$466	$3,075
4	SD-42	42b +42c - 4th St Redirect and Infiltration	1	6.08	1,492	1.66	$23,889	$500	$475	$3,873
5	SD-38	38d: Divert to 38C ditch + reinstall 38d basin	2	1.57	128	0.95	$7,400	$75	$519	$2,179
6	SD-40	40h: Bungalow Bioinfiltration (large)	2	2.65	761	1.12	$13,264	$75	$529	$3,683
7	SD-43	43a: Bluff Toe Stabilization	1	32.50	76,480	0.00	$180,031	$1,040	$586	$498
8	SD-40	40i: Hwy 95 Headcut Repair + Flow Disconnect	1	1.57	1,866	0.61	$8,980	$75	$622	$1,043
9	SD-38	38c: Sed Basin Repair and Ditch Repair	2	3.81	4,948	1.38	$13,800	$1,000	$625	$962
10	SD-38	38e: Simple Infiltration and Sed Cleanout on Road	1	0.74	339	0.53	$4,425	$75	$699	$3,053
11	SD-38	38a: Complex Infiltration Basin	1	7.34	1,850	1.96	$45,375	$700	$714	$5,662
12	SD-40	40j+40k: 11th St Infiltration System	1	2.34	949	0.76	$14,420	$250	$724	$3,566
13	SD-37	37a: Osprey Ave Infiltration Basin(s)	1	5.35	1,236	1.61	$37,210	$500	$789	$6,830
14	SD-44	44a - 44e: North Riviera Treatment Train	1	2.51	847	0.74	$19,127	$75	$791	$4,694
15	SD-40	40e: Rivercrest Ditch Conversion + Ravine Stabilization	1	11.23	17,197	0.74	$123,150	$150	$1,110	$1,450
16	SD-38	38b: Mod Complex Infiltration Basin	1	3.79	1,231	1.47	$35,100	$700	$1,111	$6,840
17	SD-44	44i: Turf Swale w/Improved Soils	1	0.38	168	0.19	$4,170	$75	$1,312	$5,857
18	SD-40	40g: Bungalow Bioinfiltration (small)	1	0.47	210	0.33	$5,380	$75	$1,313	$5,838
19	SD-37	37b: Mod Complex Infiltration Basin	1	0.96	289	0.45	$15,450	$40	$1,660	$10,969

About this Document

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

Document Organization

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

Methods

The Methods section outlines general procedures used when analyzing the subwatershed. It provides an overview of processes involved in retrofit scoping, desktop analysis, retrofit reconnaissance investigation, cost/treatment analysis and project ranking. It also includes general modelling and design assumptions for BMPs used in this report.

Catchment Profiles

Each catchment profile is labeled with a numerical ID for identification purposes (e.g., Catchment SD-39, Catchment SD-41). This numerical ID is referenced when comparing results across the subwatershed. Information found in each catchment profile is described below. See Appendix B for a guide to reading the catchment profiles. For each catchment, the following information is detailed:

Catchment Description

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

BMP Retrofit Recommendations

The recommendation section describes the conceptual retrofit(s) that were identified. It includes tables outlining the estimated pollutant removals by all practices proposed, as well as costs and overall cost-benefit ranking. Following this Retrofit Recommendations summary page, each practice has its own BMP Profile page which includes a map, individual cost-benefit analysis, and site specific comments on the individual proposed retrofit.

Retrofit Rankings (table included in Appendix A)

This section ranks stormwater retrofit projects across all catchments to create a prioritized project list. The list is sorted by cost-per-pound of total phosphorus removed for each project over 10 years – the typical contract obligation length for cost-share funded projects. The final cost-per-pound treatment value includes design, installation, and maintenance costs (in 2018 dollars). Cost estimates vary in precision due to exposure to real-world bids for specific practices, and will also vary when unknown site parameters are addressed during the design phase.

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

- Non-target pollutant reductions
- Timing projects to occur with other CIPs
- Project visibility
- Availability of funding
- Total project costs
- Educational value
- Additional ecological and habitat connectivity value

References

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

Appendix

This section provides supplemental information and/or data used in various portions of the assessment protocol.

Methods

Selection of Subwatershed

Before the subwatershed stormwater analysis begins, a process of identifying a high priority water body as a target takes place. Many factors are considered when choosing which subwatershed to assess for stormwater retrofits. Water quality monitoring data, non-degradation report modeling, and TMDL studies are just a few of the resources available to help determine which water bodies are a priority. Analyses supported by a Local Government Unit with sufficient capacity (staff, funding, available GIS data, etc.) to greater facilitate the analysis also rank highly.

Description of Southern Lake St. Croix Direct Discharge Subwatershed

Lake St. Croix is defined as the lower 25 miles of the 7,760 square mile St. Croix Basin between Stillwater, Minnesota and Prescott, Wisconsin. The lake was designated as impaired water in 2008 for excess phosphorus. The 2012 Lake St. Croix Total Maximum Daily Load (TMDL) Implementation identified 1,521 pounds phosphorous load reduction for the Middle St. Croix Watershed (from the 1992 baseline) to meet State water quality standards for aquatic recreation. The study spatially distributed anthropogenic runoff loads (identified in the Lake St. Croix TMDL) based on land use.

The Lake St Croix Direct Discharge (South) SWA study area (hereafter labeled 'South SWA') encompasses a total of 885 acres of directly discharging urban land use in the southern half of the Middle St Croix watershed (from southern Bayport through Lakeland, Lake St Croix Beach and St Mary's Point). Stormwater is conveyed through a network of storm sewers and open drainage ways that directly discharge to the Lake St. Croix. The remaining 6,600 acres in the South SWA study area are either treated by existing wetlands, stormponds, large BMPs, or natural depressions that offer some form of treatment prior to discharging into the St Croix River.

Monitoring for Lake St. Croix is conducted by the Metropolitan Council Environmental Services at the Hwy 36 lift-bridge at Stillwater Minnesota. Flows are calculated by adding USGS flow data for the St. Croix River at St. Croix Falls, Wisconsin and the USGS flow data for the Apple River (Wisconsin). Water quality monitoring at the Stillwater site captures most of the loading of the Lower St. Croix but does not include the Willow and Kinnickinnic Rivers, small streams, and direct runoff downstream of Stillwater. Data is published in the Lower St. Croix River Watershed Monitoring and Assessment Report, Minnesota Pollution Control Agency, February 2014.

Subwatershed Analysis Methods

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

Step 1: Retrofit Scoping

Retrofit scoping includes determining the objectives of the retrofits (volume reduction, target pollutant etc) and the level of treatment desired. It involves meeting with local stormwater managers, city staff, and watershed staff to determine the issues in the subwatershed. This step also helps to define

preferred retrofit treatment options and retrofit performance criteria. In order to create a manageable area to assess in large subwatersheds, a smaller focus area may be determined.

Lake St. Croix Direct Discharge Subwatershed Scoping

Pollutants of concern for this subwatershed were identified as total phosphorous (TP), total suspended solids (TSS), and volume. Goals of the MSCWMO, WCD, and the southern cities in the watershed were considered in the development of this analysis.

Step 2: Desktop Retrofit Analysis

Desktop retrofit analysis involves computer-based scanning of the subwatershed for potential BMP retrofit catchments and/or specific sites. This step also identifies areas that don't need to be assessed because of existing stormwater infrastructure. Accurate and current GIS data is extremely valuable in conducting the desktop retrofit analysis. Some of the most important GIS layers include: 2-foot or finer topography, hydrology, soils, watershed/subwatershed boundaries, parcel boundaries, high-resolution aerial photography, and storm drainage infrastructure (with invert elevations and flow direction). The following table highlights some important features to look for and the associated potential retrofit project.

Subwatershed Metrics and Potential Retrofit Project Site/Catchment	
Screening Metric	**Potential Retrofit Project**
Open Space	**New regional treatment (pond, infiltration basin).**
Roadway Culverts	**Add wetland or extended detention water quality treatment upstream.**
Outfalls	**Split flows or add storage below outfalls if open space is available.**
Conveyance system	**Add or improve performance of existing swales, ditches and non-perennial streams.**
Large Impervious Areas (campuses, commercial, parking)	**Stormwater treatment on-site or in nearby open spaces.**
Neighborhoods	**Utilize right of way, roadside ditches or curb-cut raingardens or filtering systems to treat stormwater before it enters storm drain network.**

Step 3: Retrofit Reconnaissance Investigation

After identifying potential retrofit sites through this desktop search, a field investigation was conducted to evaluate each site. During the investigation, the drainage area and stormwater infrastructure mapping data were verified. Site constraints were assessed to determine the most feasible retrofit options as well as to eliminate sites from consideration. The field investigation revealed additional retrofit opportunities that would have gone unnoticed during the desktop search.

The following stormwater BMPs were considered for each catchment/site:

Stormwater Treated Options for Retrofitting		
Area Treated	**Best Management Practice**	**Potential Retrofit Project**
5.1-10.0 acres	Infiltration Basin	**Large and shallow impoundment areas designed to retain and infiltrate stormwater runoff.**
0.1-5.0 Acres	Bioinfiltration	**Use of native soil, soil microbe, and plant processes to treat, evapotranspirate, and/or infiltrate stormwater runoff. Facilities can either be fully infiltrating, fully filtering or a combination thereof.**
	Biofiltration	**Filters runoff through engineered biologically active media and passes it through an under-drain. May consist of a combination of sand, soil, compost, peat, compost, or iron.**
	Tree Boxes	**A trench or sump that receives runoff. Stormwater is passed through a conveyance and pretreatment system before entering the infiltration area.**
	Gully Stabilization	**Engineered practices designed to reduce down-cutting, sloughing and eroding slopes that discharge directly to receiving waters.**
	Other	**On-site, source-disconnect practices such as rain-leader raingardens, rainleader disconnect, stormwater planters, dry wells and permeable pavements.**

Step 4: Treatment Analysis/Cost Estimates

Treatment analysis

Sites most likely address pollutant reduction goals and those that may have simple design/install/maintenance considerations are chosen for a cost/benefit analysis that relatively compares catchments/sites. Treatment concepts are developed taking into account site constraints and the subwatershed treatment objectives. Projects involving complex stormwater treatment interactions and those that may pose a risk for upstream flooding require the assistance of a professional engineer. Conceptual designs at this phase of the design process include cost and pollution reduction estimates. Reported treatment levels are dependent upon optimal site selection and sizing.

Modeling of the site is done by WinSLAMM. WinSLAMM uses event-mean concentrations based on land use for each catchment/site to estimate pollution loading of the existing conditions. The site's conceptual BMP design is then modeled to estimate varying levels of treatment by sizing and design element. This treatment model can also be used to properly size BMPs to meet restoration objectives.

General WinSLAMM Model Inputs	
Parameters	**Method for Determining Value**
Area	Natural Resource Conservation Service Custom watershed delineation tools from ESRI were used to identify catchments in ArcMap 10.5. Software generated catchment boundaries were field verified and modified when necessary.
Land Use	Using GIS, land areas discharging to Lake St. Croix were evaluated and assigned Standard Land Uses (SLU) in WinSLAMM 10.2. These SLUs describe the average characteristics of impervious and pervious surfaces in each catchment. Landuse was derived from the MNDNR Minnesota Land Cover Classification System (MLCCS). The 2006 version was used as the 2017 version was still being completed at the time of this study.
Precipitation/Temperature Data	Rainfall and temperature recordings from Minneapolis 1959 were used as a representation of an average year. Winter season was marked as November 12 to March 18 and was excluded from the model output between these dates.
Pollutant Probability Distribution	WinSLAMM uses a pollutant value file to determine the pollutant loading from a source area. The default value WI_GEO02 computed from USGS was used for this analysis.
Runoff Coefficient	The default runoff coefficient WI_SL06 was used.
Particulate Solids Concentration	The default WI_GEO01.ppd particle file developed by USGS was used.
Street Delivery Parameter File	The default street dirt delivery files were used to retain total particles that do not reach the outfall based on rain depths and street textures.
Particle Size Distribution	Average of the available outfall particle size distribution data from the National Urban Runoff Program studies.

Lake St. Croix Direct Discharge Treatment Analysis

For the South SWA treatment analysis, each catchment was first assessed for BMP applicability given specific site constraints and soil types. High bedrock, high surficial groundwater, slope, pedestrian and car traffic flow, parking needs, snow storage areas, obvious utility locations, catchbasin locations, existing landscaping, surface water runoff flow, project visibility, existing landscape maintenance, available space, and other site-specific factors dictated the selection of one or more potential BMPs for each site.

WinSLAMM was used to model catchments and potential BMPs. Soil infiltration rates were joined with each specific land use in GIS, and the results were used to model the catchment base loading. Practices were categorized based on typical functionality and design, and then modelled in WinSLAMM. The

results were tabulated in the Catchment Profile section of this document. In cases where underlying soils were classified as Urban-mixed fill, the model assumed a 0.1"/hour infiltration rate. In reality, those infiltration rates will vary, and could likely increase the pollutant reduction potential of the proposed practice. During the design phase, practices will be designed with a more precise infiltration rate (identified through field investigation and potential soil borings).

Since land-use based models do not directly measure the effects of near-stream discharge such as bluff erosion and bank loss, the BWSR Pollution Reduction Spreadsheets were used to augment the WinSLAMM pollution discharge data to simulate the effects of known ravines and near-stream erosion hotspots. The Phosphorus and Total Sediment values from these outputs were added to the BASE loading for each catchment. When a BMP treatment was recommended for those particular ravines, the pollution reduction for that practice would be factored back into the final calculations. This process is useful in determining relative cost-benefit values for practices, but it does not reflect the true percent pollution reduction for a given catchment since every single near-stream erosion hotspot cannot be accounted for in the model. This process highlights the need for more extensive outreach to bluff-top property owners along the St Croix River so more opportunities for pollution reduction can be uncovered.

Cost Estimates

Each resulting BMP was assigned estimated design, installation, and annual maintenance costs given its total area of treatment. In some cases, the practice was unique enough to require a more traditional estimate that considered unique site constraints. An annual $ Cost/lb ofTP-removed for each treatment level was calculated for the life of each BMP. Lifecycle costs include promotional, administrative, and life cycle O&M costs. The average lifecycle varies per practice, so a 10 year lifecycle was chosen for all practices to achieve an equal comparison. Cost savings occur when water quality practices are designed and installed in conjunction with larger capital improvement projects such as reconstruction or redevelopment.

Step 5: Evaluation and Ranking

The results of each BMP site were analyzed for cost/treatment to prescribe the most cost-efficient level of treatment. The BMPs were then ranked against each other to identify the best practices in the entire study area.

Lake St. Croix Direct Discharge Evaluation and Ranking

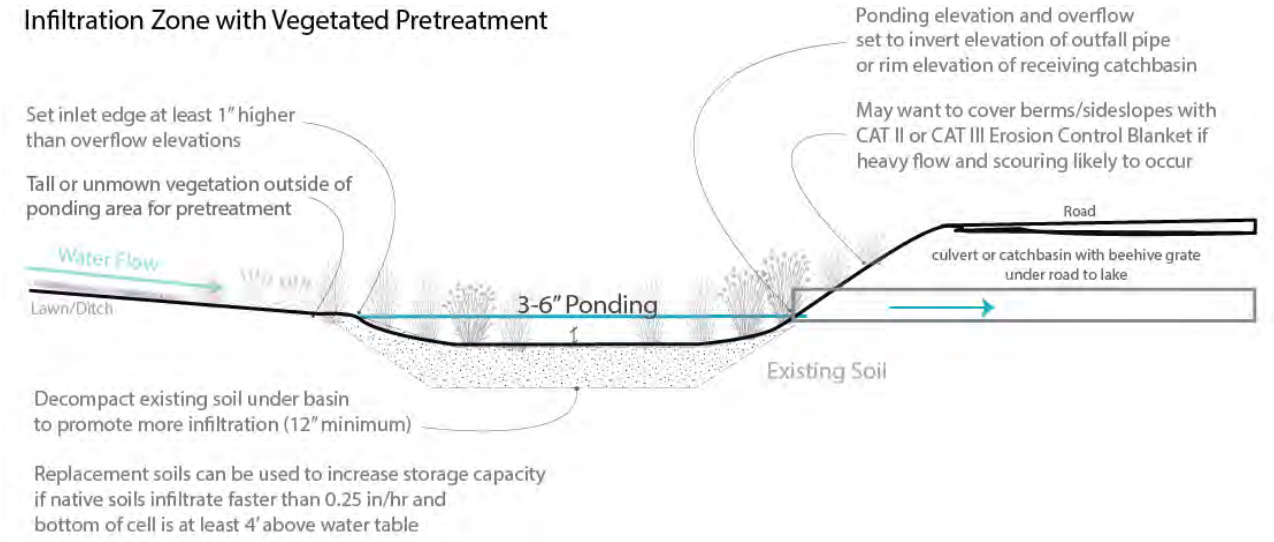
In the Lake St. Croix evaluation and ranking, each BMP was individually modelled based on its site parameters and then ranked against all other BMPs selected in the study. Typically in past SWAs, treatment goals would be identified for each catchment (instead of each BMP), by defining a maximum achievable treatment goal (such as a 30% TP treatment goal). Since bluff-face and near-stream erosion was identified as the main contributor of TP and TSS loading in the South SWA area, very few conventional BMPs were identified. Therefore, it was found to be more useful if each BMP was compared to all other BMPs (rather than ranking percent treatment achieved per catchment).

Lake St. Croix Direct Discharge Best Management Practices

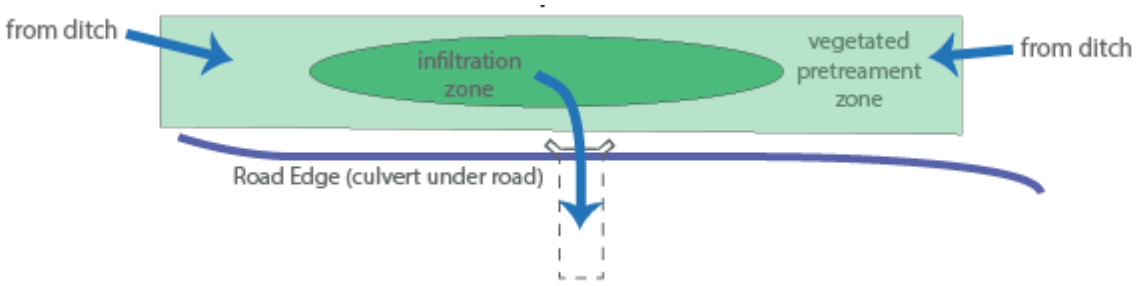
Biofiltration, Bioinfiltration, and Ponded Swales were the three retrofit BMPs identified throughout the analysis area. The typical cross-sections below describe the design assumptions used in the cost estimation process.

Bioinfiltration

BioInfiltration is a basin that infiltrates into the native soil fast enough to allow for a fully drained basin within 48 hours. There are no underdrains in a BioInfiltration Basin. All basins of either type in the analysis do not have pretreatment devices to limit gross solid accumulation and rely on additional tall vegetation upstream to capture sediment prior to entering the basin.



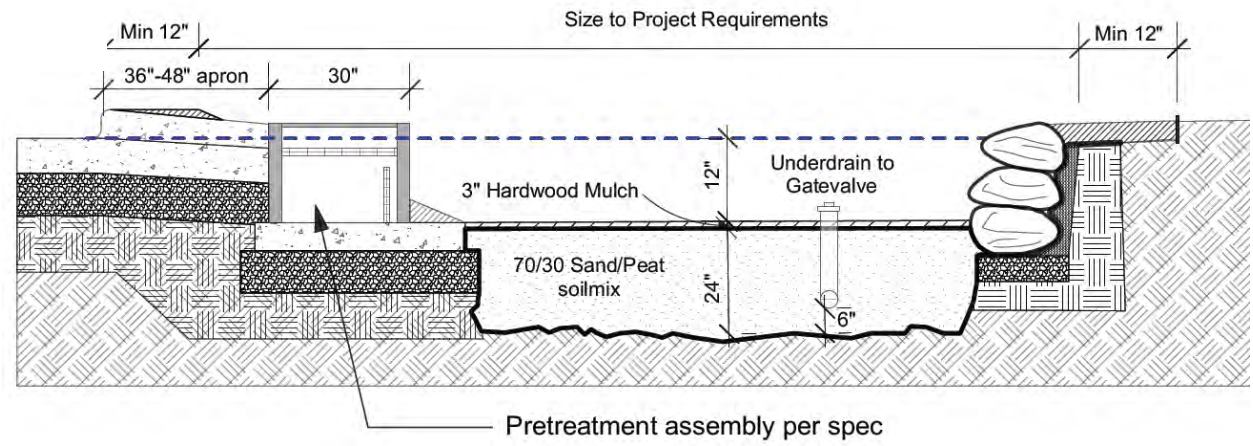
Bioinfiltration Basin – Typical Cross Section



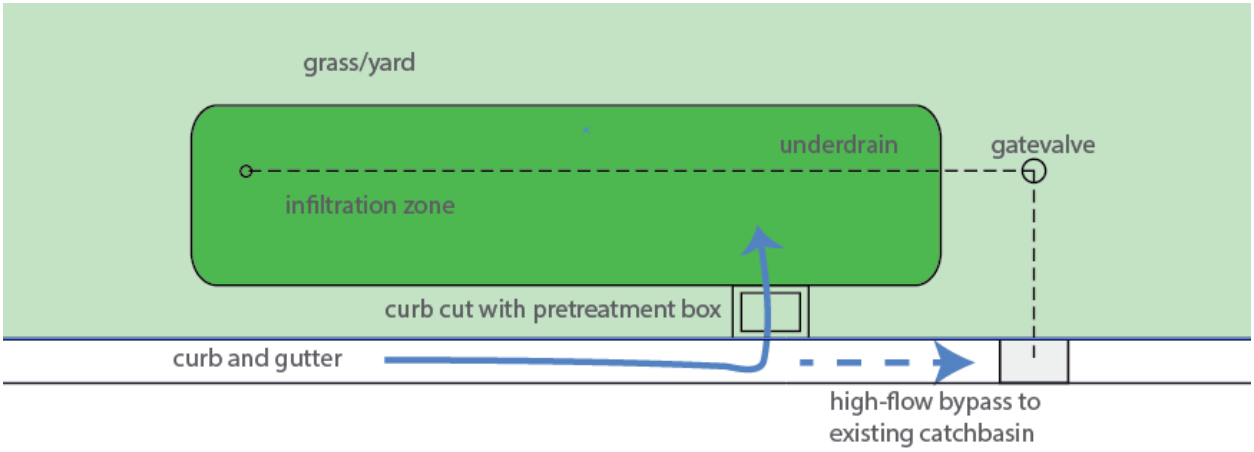
Bioinfiltration Basin – Typical Cross Section

Biofiltration

Biofiltration is bioretention basin that requires an underdrain. This is usually required when soils do not infiltrate fast enough or when there is a need for a liner beneath the cell. Cleanouts and gatevalves will typically accompany the draintile assembly. All basins of either type in the analysis do not have pretreatment devices to limit gross solid accumulation and rely on additional tall vegetation upstream to capture sediment prior to entering the basin.



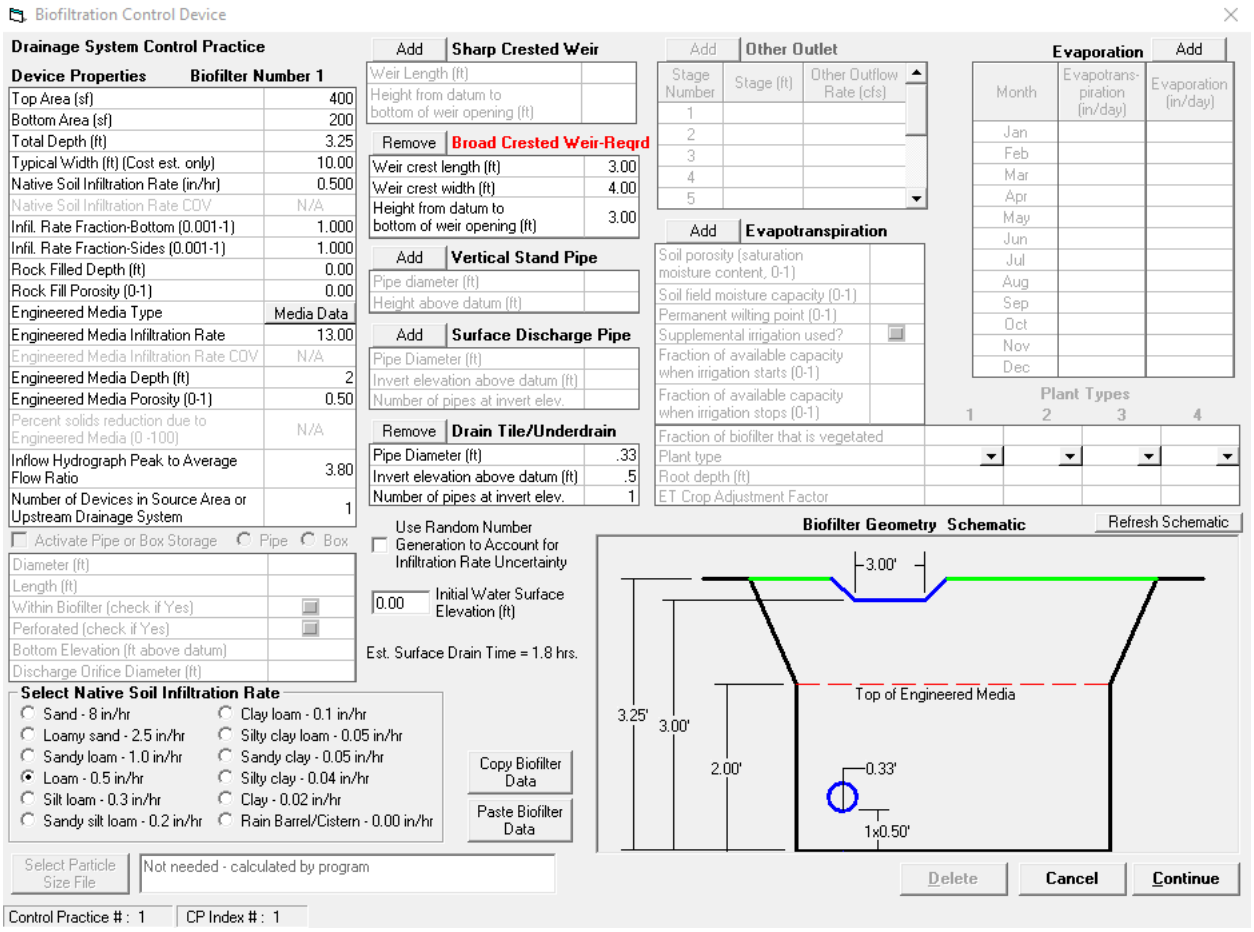
Biofiltration Curb Cut Raingarden – Typical Cross Section



Biofiltration Curb Cut Raingarden – Typical Conceptual Layout Plan

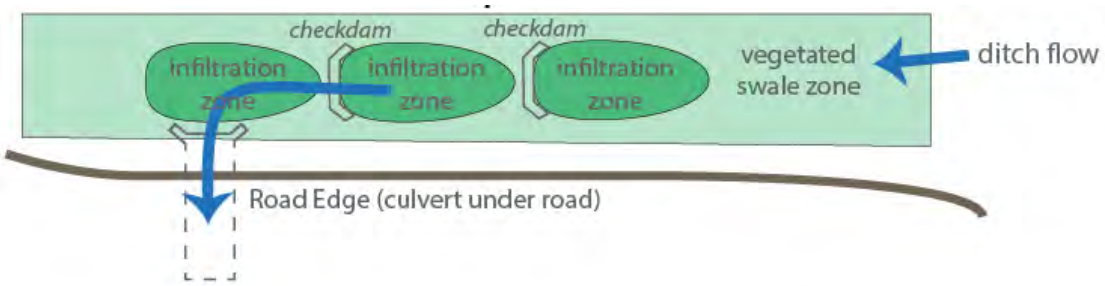
Biofiltration Modeling

The WinSLAMM model inputs curb cut raingardens are typically modelled per unique site-specific conditions; including catchment boundaries, soil conditions, and underdrain connection opportunities. Infiltration media is modelled as a 70% blend of sand with 30% peat. Sediment pretreatment devices such as the RainGuardian Bunker box are not included in the WinSLAMM model design. Refer to diagram below for typical inputs of a curb cut raingarden.

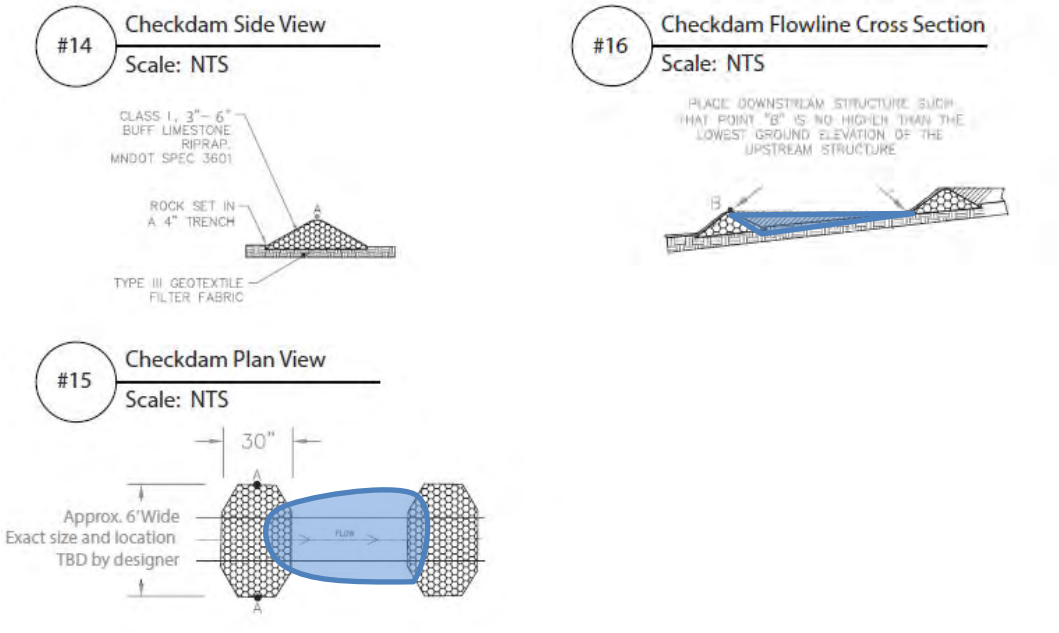


Ponded Swales

Ponded swales are essentially a flow-through (or in-line) BioInfiltration basin. Some sort of detention device will be installed at the downstream end of the swale to promote ponding at a specified depth (riprap check dam or earthen berm). The ponding area created allows for increased treatment of TP and TSS, and is a form of volume control as well. All swales with checkdams were modelled with 3-6" of ponding and would mimic the native soil infiltration rate. Swales without checkdams are also recommended, and soils were modelled with the native soil infiltration rate since the practices are based on stripping the existing sod and accumulated sediment and ripping deep into the soil until you hit the native soils again.



Ponded Swale – Typical Conceptual Layout Plan



Ponded Swale – Typical Cross Section

Ravines Stabilization

Ravine stabilization can take many forms. Stabilization usually uses some combination of check dams or grade stabilization (listed on previous pages), toe stabilization, and revegetation. Ravines are also stabilized by controlling the upstream volume contributing to the erosion. This is achieved by installing infiltration basins where possible. Sometimes water can be diverted away from, or piped down through, the ravine entirely. Ravine stabilizations are modelled with the BWSR Pollution Reduction Spreadsheets. The reductions are calculated based on the practices prescribed and vary from 100% reduction rates for diversions to as low as 25% reduction rates for headcut stabilization. These values are added to any upstream reductions for infiltration practices. See Methods discussion on previous pages to understand modelling assumptions used in this report. Below are typical Before and After images of a ravine stabilization. *(images courtesy of the Valley Branch Watershed District)*

Before

After

Before

After

CATCHMENT PROFILES AND BMP RANKINGS

Catchment Profiles

The following pages provide catchment-specific information that was analyzed for stormwater BMP retrofit treatment at various levels. Utilizing GIS each catchment is divided into several different land uses based on WinSLAMM Standard Land Use parameters.

For development of the South SWA catchment profile sections, 11 out of 30 sub-catchments were selected as first-tier areas for stormwater retrofit efforts (of which 9 were modelled extensively). The remaining 19 sub-catchments were not modelled in this analysis because they were either landlocked, were draining to existing BMPs (stormponds, wetlands, raingardens, etc), or drained to large natural depressions that essentially landlocked the area. Some minor sub-catchment boundary revisions were made to the original GIS delineation files based upon field inspection, new development, and topographical changes.

Catchment SD-37

Existing Conditions		EXISTING CONDITIONS			
		Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	24.9	0.0	0%	**24.9**
	TSS (lb/yr)	18,584	0.0	0%	**18,584**
	Volume (acre-feet/yr)	24.59	0.0	0%	**24.6**
	Number of BMP's	0			
	BMP Size/Description				
	BMP Type	No known BMPs exist			

CATCHMENT DESCRIPTION

Catchment SD-37 is 43.94 acres. It is comprised of primarily medium density, single-family residential land use and includes a few acres of multi-family residential and commercial land uses. This catchment is directly connected to the St Croix River via multiple outlets south of the marina.

EXISTING STORMWATER TREATMENT

No existing practices were modelled. There may be practices on private property (such as sump catchbasins in the marina) but they were not found or verified for this study.

SD-37: Retrofit Recommendations

RANK 13/19 - **BMP 37 a – Osprey Blvd Infiltration Basin(s)**: 1 large (or 5 small) infiltration basins on bluff in properties along Osprey Blvd.

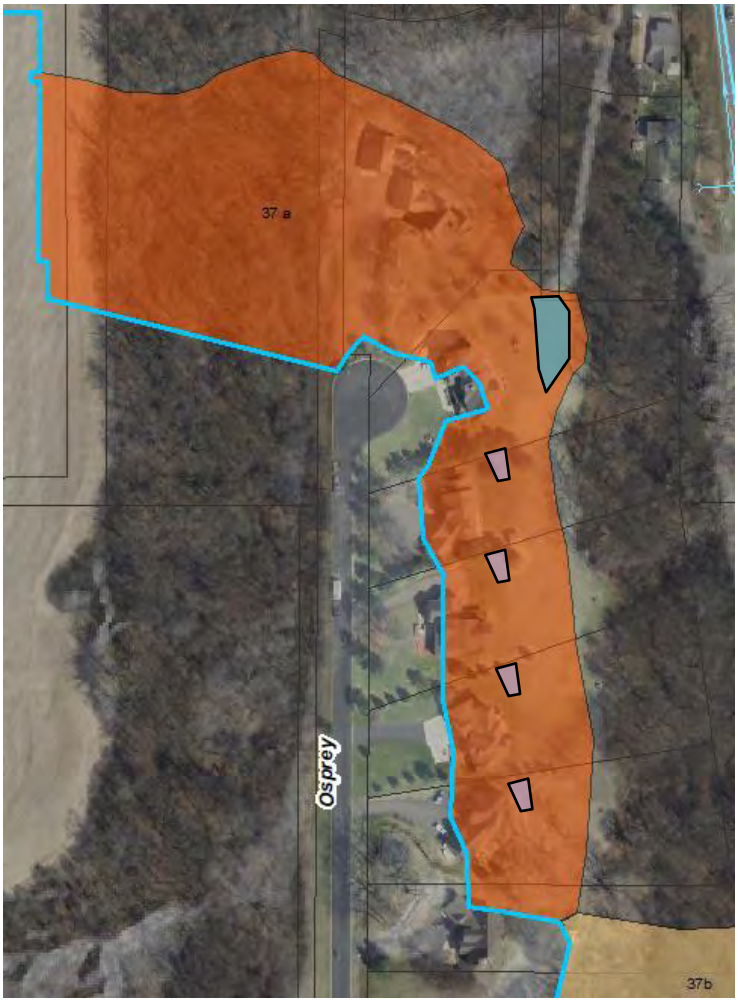
RANK 19/19 - **BMP 37 b – Infiltration Basin**: Infiltration basin capturing steep bluff and impervious lot

Cost/Removal Analysis		RETROFIT OPTIONS					
		Catchment SD-37					
		BMP 37a: Osprey Ave Infiltration Basin(s)		BMP 37b: Mod Complex Infiltration Basin		Total Reductions (all implemented)	
		New treatment	Net %	New treatment	Net %	New treatment	Net %
Treatment	TP (lb/yr)	5.4	21%	1.0	2%	6.3	25%
	TSS (lb/yr)	1236	7%	289	1%	1525.0	8%
	Volume (acre-feet/yr)	1.6	7%	0.5	2%	2.1	8%
	Number of BMP's	1		1		2	
	BMP Size/Description	1,500 sf		1,000 sf		All Practices	
	BMP Type	Simple BioInfiltration		Moderately Complex BioFiltration		Infiltration Basins	
Cost	Materials/Labor/Design	$36,210		$14,950		$51,160	
	Promotion & Admin Costs	$1,000		$500		$1,500	
	Probable Project Cost	$37,210		$15,450		$52,660	
	Annual O&M	$500		$40		$540	
	10-yr Cost/lb-TP/yr	$789		$1,660		$1,224	
	10-yr Cost/2,000lb-TSS/yr	$6,830		$10,969		$8,899	

BMP-37a: Osprey Blvd Infiltration Basin(s)

Rank 13/19

Drainage Area – 5.967 acres
Location – North end of Osprey Blvd, in backyards above bluff
Property Ownership – Private
Description – Much water flows down the wooded upper bluff, through the residential parcels, and down the lower bluff. Flows are directed both through a commercial parking lot as well as down an old access drive. The wooded slopes are very steep and have quite a bit of buckthorn and bare understory. Even though the canopy is dense and protects the slope from smaller events, it is assumed that most of the erosion occurs once flows get moving down the bluff in larger rain events. The practice recommended can take one of two forms: 1) 1 large 1500sf infiltration basin at 925 Osprey Blvd above the lower bluff outlet or 2) up to 5 small 300sf infiltration basins across the back lots along Osprey Blvd. Both options would be 6" ponding, and would take advantage of the sandy native soils for maximum infiltration. There are septic systems in the backyards, and the homes are built within 125' of the bluff top. Design considerations include avoiding the septic drain fields and to avoid hyper-saturating the bluff edge.



Primary Location = 1,500 sf basin

Secondary Location = 5x 300 sf basins

Cost/Removal Analysis		RETROFIT OPTIONS *Catchment SD-37* BMP 37a: Osprey Ave Infiltration Basin(s)	
		New treatment	Net %
Treatment	TP (lb/yr)	5.4	21%
	TSS (lb/yr)	1236	7%
	Volume (acre-feet/yr)	1.6	7%
	Number of BMP's	1	
	BMP Size/Description	1,500	sf
	BMP Type	Simple BioInfiltration	
Cost	Materials/Labor/Design	$36,210.00	
	Promotion & Admin Costs	$1,000	
	Probable Project Cost	$37,210	
	Annual O&M	$500	
	10-yr Cost/lb-TP/yr	$789	
	10-yr Cost/2,000lb-TSS/yr	$6,830	

BMP -37b: Infiltration Basin

Rank 19/19

Drainage Area – 1.93 acres
Location – Below bluff at north end of Osprey Blvd, on Hwy 95
Property Ownership – Private
Description – The practice ranks low relative to the others in this study, but is still well below the norm of $1,500-$3,000 per lb of TP of typical curb-cut raingardens. This BMP would rank very high in most other studies. This practice would take the water from the steep bare bluff that flows through the large parking lot. A channel drain would be inserted across the top of the driveway and redirect flows to an infiltration basin to the south edge of the lot. The soils are sandy and would likely require some decompaction. This basin could be fitted with an underdrain (allowing capture of larger rain events) since there is a catchbasin below the top of the hill where the basin will sit. A pretreatment device would also be necessary to contain the large sediment load flowing from the bluff.

Primary Location = 1,500 sf basin

Cost/Removal Analysis		RETROFIT OPTIONS *Catchment SD-37* BMP 37b: Mod Complex Infiltration Basin	
		New treatment	Net %
Treatment	TP (lb/yr)	1.0	2%
	TSS (lb/yr)	289	1%
	Volume (acre-feet/yr)	0.5	2%
	Number of BMP's	1	
	BMP Size/Description	1,000	sf
	BMP Type	Moderately Complex BioFiltration	
Cost	Materials/Labor/Design	$14,950.00	
	Promotion & Admin Costs	$500	
	Probable Project Cost	$15,450	
	Annual O&M	$40	
	10-yr Cost/lb-TP/yr	$1,660	
	10-yr Cost/2,000lb-TSS/yr	$10,969	

Catchment SD-38

Existing Conditions		EXISTING CONDITIONS			
		Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	46.6	0.0	0%	**46.6**
	TSS (lb/yr)	40,458	0.0	0%	**40,458**
	Volume (acre-feet/yr)	26.70	0.0	0%	**26.7**
	Number of BMP's	1			
	BMP Type	Small non-functional basin @ SE of railroad bridge (Hwy 95)			

CATCHMENT DESCRIPTION

Catchment SD-38 is 111.57 acres. It is primarily a bluff-top catchment with large tracts of open space (some degraded, most in good to great condition). The main contributors of pollutants to this area would be the impervious surface associated with the highway, erosion on the bluff faces, and the large gully contributions at the intersection of the railway and Highway 95.

EXISTING STORMWATER TREATMENT

There is one large practice below the bridge along the railway that takes water from both the highway as well as the industrial sites to the west of the highway, but the inlet has been buried by gully erosion and needs a systemic overhaul.

SD-38: Retrofit Recommendations

RANK 02/19 - BMP 38 d2 – Combined Gully Load Reductions: Factors in all recommended practices affecting gully erosion – includes BMP 38c, 38d, 38e, and adds direct gully losses to the total load.

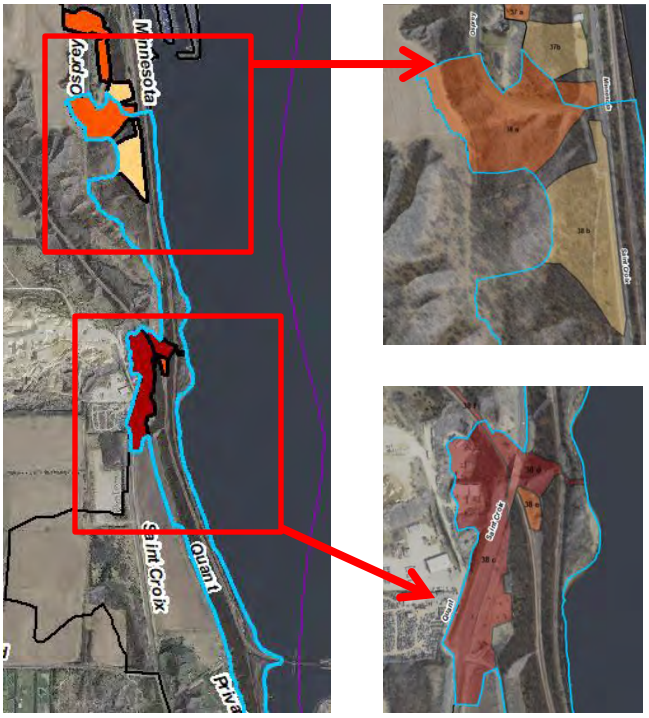
RANK 05/19 - BMP 38 d – Divert to 38c ditch+ reinstall 38d basin: After fixing 38c ditch system, divert remaining water into former sediment basin and redirect overflow away from Gully 38d.

RANK 09/19 - BMP 38 c – Infiltration Basin: repair 38c ditch system, armor headcut, and improve upon existing failed BMP

RANK 10/19 - BMP 38 e – Simple Infiltration + Sediment Cleanout: Divert flow away from Gully 38d through sediment cleanup, swale regrade, and simple infiltration basin construction

RANK 11/19 - BMP 38 a – Complex Infiltration Basin: Use new structure to divert low flows of Osprey Ave to off-line infiltration basin, high flows bypass to existing stormsewer.

RANK 16/19 - BMP 38 b – Moderately Complex Infiltration Basin: Curb Cut infiltration basin to receive water from Hwy 95 and bluff. Offline design with underdrain.



Cost/Removal Analysis		Total Reductions (all implemented)	
		New trtmt	Net %
Treatment	TP (lb/yr)	22.8	49%
	TSS (lb/yr)	20,130	50%
	Volume (acre-feet/yr)	6.8	25%
	Number of BMP's	1	
	BMP Size/Description	All Practices	
	BMP Type		
Cost	Materials/Labor/Design	$125,925	
	Promotion & Admin Costs	$5,800	
	Probable Project Cost	$131,725	
	Annual O&M	$3,700	
	10-yr Cost/lb-TP/yr	$669	
	10-yr Cost/2,000lb-TSS/yr	$3,190	

Cost/Removal Analysis		RETROFIT OPTIONS – Catchment SD-38											
		BMP 38a: Complex Infiltration Basin		BMP 38b: Mod Complex Infiltration Basin		BMP 38c: Sed Basin Repair and Ditch Repair		BMP 38d: Divert to 38C ditch + reinstall 38d basin		BMP 38e: Simple Infiltration and Sed Cleanout on Road		BMP 38d2: Gully Load Reductions by Fixing 38c,d,e	
		New trtmt	Net %	New trtmt	Net %	New trtmt	Net %	New trtmt	Net %	New trtmt	Net %	New trtmt	Net %
Treatment	TP (lb/yr)	7.3	16%	3.8	8%	3.8	8%	1.6	3%	0.7	2%	10.7	10%
	TSS (lb/yr)	1850	5%	1231	3%	4948	12%	748	2%	339	1%	16760	27%
	Volume (acre-feet/yr)	2.0	7%	1.5	5%	1.4	5%	1.0	4%	0.5	2%	2.9	11%
	Number of BMP's	1		1		1		1		1		1	
	BMP Size/Description	1,500	sf	1,500	sf	1,000	sf	2,500	sf	800	sf		sf
	BMP Type	Complex BioFiltration		Moderately Complex BioFiltration		Simple BioInfiltration		Filtration Basin (Turf)		100% Disconnect from Gully		BWSR Gully Reduction	
Cost	Materials/Labor/Design	$44,375.00		$34,100.00		$12,800.00		$6,900.00		$4,025.00		$23,725.00	
	Promotion & Admin Costs	$1,000		$1,000		$1,000		$500		$400		$1,900.00	
	Probable Project Cost	$45,375		$35,100		$13,800		$7,400		$4,425		$25,625.00	
	Annual O&M	$700		$700		$1,000		$75		$75		$1,150.00	
	10-yr Cost/lb-TP/yr	$714		$1,111		$625		$519		$699		$346	
	10-yr Cost/2,000lb-TSS/yr	$5,662		$6,840		$962		$2,179		$3,053		$443	

BMP - 38a: Complex Infiltration Basin

Rank 11/19

Drainage Area – 8.28 acres
Location – South end of Osprey Blvd, on Hwy 95 ROW
Property Ownership – Public (private if necessary)
Description – The bluff above Osprey Blvd is fairly steep, with a mix of buckthorn and bare soils in some places, and moderate native groundcover in others. The bluff flows onto Osprey and flows to any of 6 catchbasins down the steep road. There is opportunity to divert low flows from the main stormsewer, below the bluff along Hwy 95, into a 1,500sf infiltration basin. An underdrain should be able to connect to the existing stormsewer on Hwy 95. All high flows will bypass through the main stormsewer line once the basin is full. It should be verified how frequently the stormpond at the top of the catchment overflows in order to determine the appropriate high-flow bypass configuration. It appears to have ample capacity, especially above the native sandy soils.

Cost/Removal Analysis		RETROFIT OPTIONS Catchment SD-38 BMP 38a: Complex Infiltration Basin	
		New treatment	Net %
Treatment	TP (lb/yr)	7.3	16%
	TSS (lb/yr)	1850	5%
	Volume (acre-feet/yr)	2.0	7%
	Number of BMP's	1	
	BMP Size/Description	1,500	sf
	BMP Type	Complex BioFiltration	
Cost	Materials/Labor/Design	$44,375.00	
	Promotion & Admin Costs	$1,000	
	Probable Project Cost	**$45,375**	
	Annual O&M	$700	
	10-yr Cost/lb-TP/yr	**$714**	
	10-yr Cost/2,000lb-TSS/yr	**$5,662**	

Basin Location = 1,500 sf basin

Low Flow Diversion/High Flow Bypass Structure

BMP-38b: Curb Cut Infiltration Basin

Rank 16/19

Drainage Area – 5.83 acres
Location – South end of Osprey Blvd, along Hwy 95
Property Ownership – Public/Private
Description – This practice would take the water from the steep bluff that flows directly onto Highway 95. There is not much room for an adequate sized ditch for pretreatment, so a pretreatment device will have to be installed as part of the curb-cut inlet. Significant soil removal will have to occur to make this basin fit the curbline. The catchbasin depth will need to be verified by survey to determine if an underdrain connection is possible (visual inspection could not determine if adequate depth existed). The cost estimate was inflated to account for a potential fieldstone wall on the back edge of the basin. If soil can be disposed of onsite and the backslope can be regraded without a wall, then the cost and ranking should improve considerably.

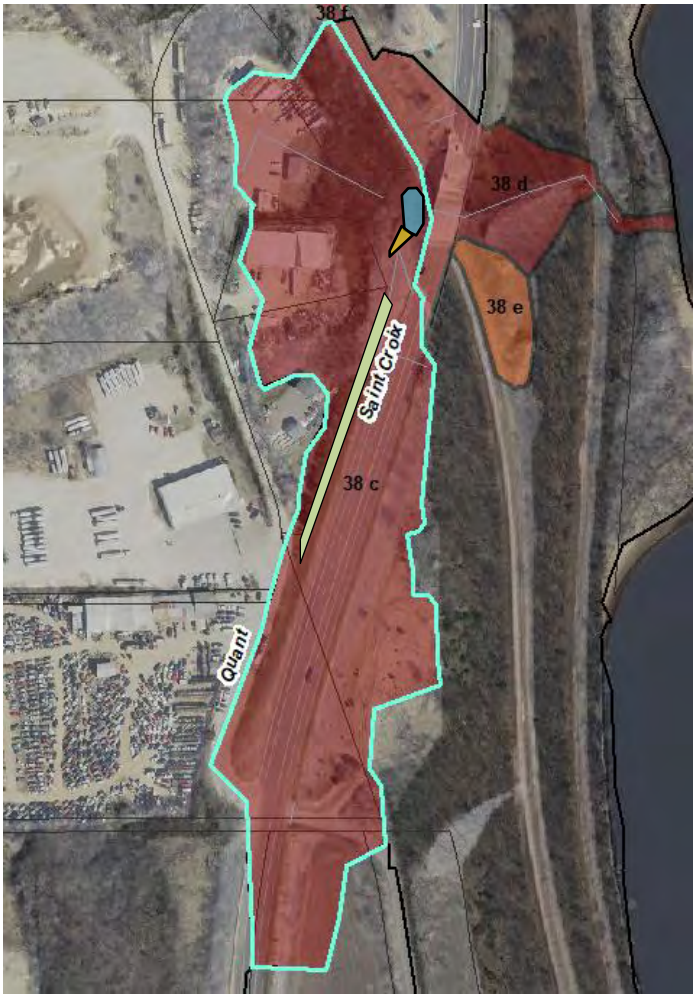
Cost/Removal Analysis		RETROFIT OPTIONS *Catchment SD-38* BMP 38b: Mod Complex Infiltration Basin	
		New treatment	Net %
Treatment	TP (lb/yr)	3.8	8%
	TSS (lb/yr)	1231	3%
	Volume (acre-feet/yr)	1.5	5%
	Number of BMP's	1	
	BMP Size/Description	1,500 sf	
	BMP Type	Moderately Complex BioFiltration	
Cost	Materials/Labor/Design	$34,100.00	
	Promotion & Admin Costs	$1,000	
	Probable Project Cost	**$35,100**	
	Annual O&M	$700	
	10-yr Cost/lb-TP/yr	**$1,111**	
	10-yr Cost/2,000lb-TSS/yr	**$6,840**	

Curb Cut Basin Location = 1,500 sf

BMP-38c: Sediment Basin and Ditch Repair

Rank 09/16

Drainage Area – 9.77 acres
Location – West side of Hwy 95, at intersection of railroad tracks and highway bridge
Property Ownership – Private/Public
Description – South of the bridge on the west side of Hwy 95, the ditch system is being bypassed and flows into a catchbasin in 38d, and flows back under the bridge causing major headcutting of the ravine and undercutting the bridge foundation. To stop the headcutting, multiple projects have to be in place. BMP 38c is the easiest of the three projects recommended in this study to fix the headcut down 38d to the river. This first calls for amending the western highway edge by excavating the first few feet of sod, and lowering the sod to a new elevation that will allow water to enter the ditch from the road again. This will prevent the bypass of flow into subcatchment 38d. Second, there is a catchbasin with a very small sediment basin that once was functioning below the bridge (intercepting flow from the industrial site above the bluff and highway 95). This basin is clogged and there is much gully erosion contributing to this site. Stabilize gully with simple riprap checkdam treatment and hydroseed. Excavate basin to 1000sf, at 1.5' ponding depth. Annual inspection and cleanout will be necessary to keep this basin functioning.



Basin Location = 1,000 sf basin

Gully Area = 90 lf

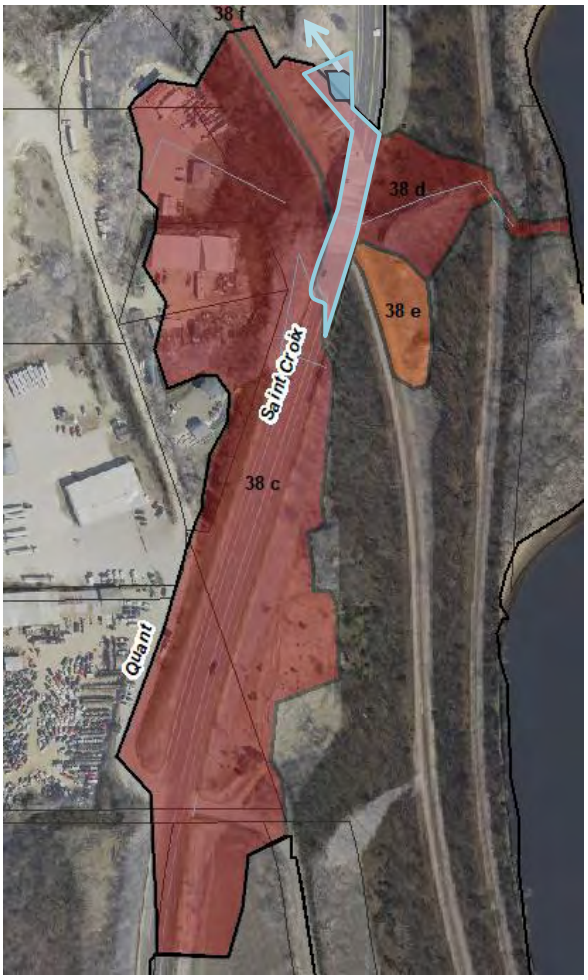
Turf Alteration Zone = 150 lf

Cost/Removal Analysis		RETROFIT OPTIONS *Catchment SD-38* BMP 38c: Sed Basin Repair and Ditch Repair	
		New treatment	Net %
Treatment	TP (lb/yr)	3.8	8%
	TSS (lb/yr)	4948	12%
	Volume (acre-feet/yr)	1.4	5%
	Number of BMP's	1	
	BMP Size/Description	1,000	sf
	BMP Type	Simple BioInfiltration	
Cost	Materials/Labor/Design	$12,800.00	
	Promotion & Admin Costs	$1,000	
	Probable Project Cost	**$13,800**	
	Annual O&M	$1,000	
	10-yr Cost/lb-TP/yr	**$625**	
	10-yr Cost/2,000lb-TSS/yr	**$962**	

BMP-38d: Infiltration Basin

Rank 05/19

Drainage Area – 0.65 acres
Location – NW Corner of Highway 95 bridge at Railroad Tracks
Property Ownership –Public
Description – There is an old basin at the NW corner of the bridge. It appears to have functioned at one point in time, then it seems that the drainage was re-routed so the it bypassed the basin and now flows directly underneath the bridge and through the eroding gully at 38d. This practice would utilize the old basin footprint, install a new inlet and outlet structure, and leave the remaining basin bottom alone. Water would flow through this basin at a maximum 1' ponding depth and overflow down into the bottom of the ravine adjacent to the SNA to the north. This new receiving area is entirely disconnected from the St Croix River.



Basin Location = 2,500 sf basin

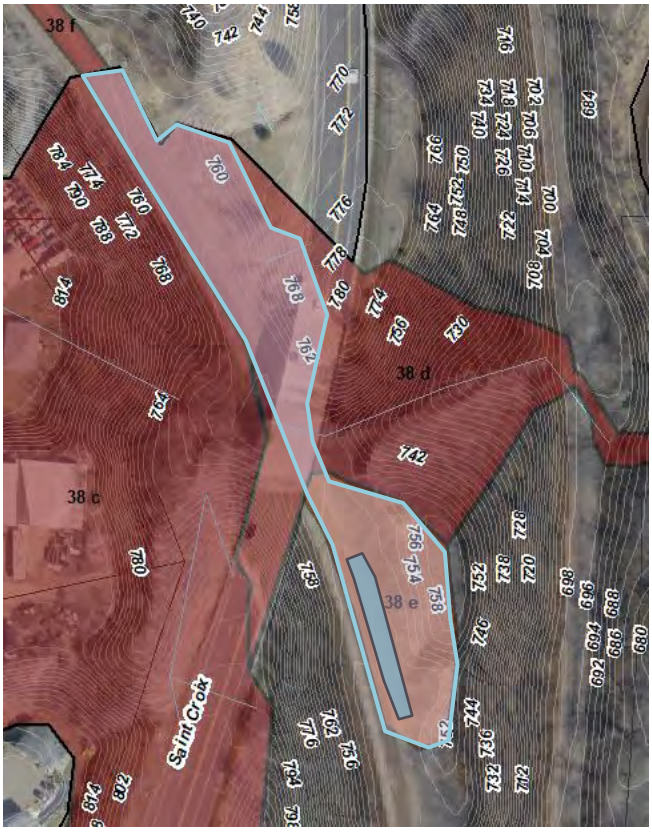
New Catchment Boundary

Cost/Removal Analysis		RETROFIT OPTIONS *Catchment SD-38* BMP 38d: Divert to 38C ditch + reinstall 38d basin	
		New treatment	Net %
Treatment	TP (lb/yr)	1.6	3%
	TSS (lb/yr)	748	2%
	Volume (acre-feet/yr)	1.0	4%
	Number of BMP's	1	
	BMP Size/Description	2,500 sf	
	BMP Type	Filtration Basin (Turf)	
Cost	Materials/Labor/Design	$6,900.00	
	Promotion & Admin Costs	$500	
	Probable Project Cost	**$7,400**	
	Annual O&M	$75	
	10-yr Cost/lb-TP/yr	**$519**	
	10-yr Cost/2,000lb-TSS/yr	**$2,179**	

BMP-38e: Infiltration Basin

Rank 10/19

Drainage Area – 1.14 acres
Location – SE Corner of intersection of Highway 95 bridge and railroad tracks
Property Ownership – Public
Description – This practice would be necessary if it is decided to disconnect as much flow from the eroding 38d gully as possible. Currently, there is about 1-2' of sediment buildup along the railroad access path. This buildup is the accumulation of erosion from 38c, and subsequently diverts runoff from the railroad grade down the 38d gully, eroding the footing of the bridge in the process. If this sediment is excavated deep enough, water can be diverted from gully head and further south along the railroad access path along a 1.5% grade (steeper if more flushing of sediment is desired). This swale will outlet into a large sandy basin that is disconnected from the 38d gully. This basin should only pond to a 6" depth and overflow should be safely directed further down the railgrade or down the bluff. This is a very inexpensive fix and should only be completed if 38c and 38d have been constructed first. The low point near the 38d gully head should be monitored annually to prevent sediment buildup and recurring bypass back into the gully again.



Basin Location = 2,500 sf basin

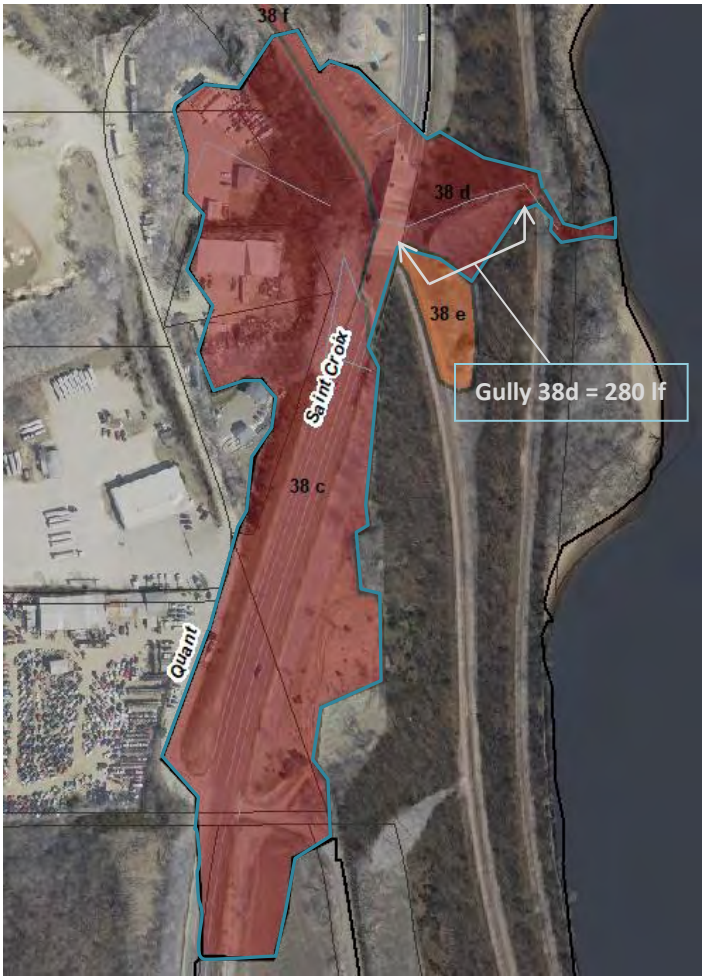
New Catchment Boundary

Cost/Removal Analysis		RETROFIT OPTIONS *Catchment SD-38* BMP 38e: Simple Infiltration and Sed Cleanout on Road	
		New treatment	Net %
Treatment	TP (lb/yr)	0.7	2%
	TSS (lb/yr)	339	1%
	Volume (acre-feet/yr)	0.5	2%
	Number of BMP's	1	
	BMP Size/Description	800	sf
	BMP Type	100% Disconnect from Gully	
Cost	Materials/Labor/Design	$4,025.00	
	Promotion & Admin Costs	$400	
	Probable Project Cost	**$4,425**	
	Annual O&M	$75	
	10-yr Cost/lb-TP/yr	**$699**	
	10-yr Cost/2,000lb-TSS/yr	**$3,053**	

BMP-38d2: Gully Load Reductions from 38c, d, e

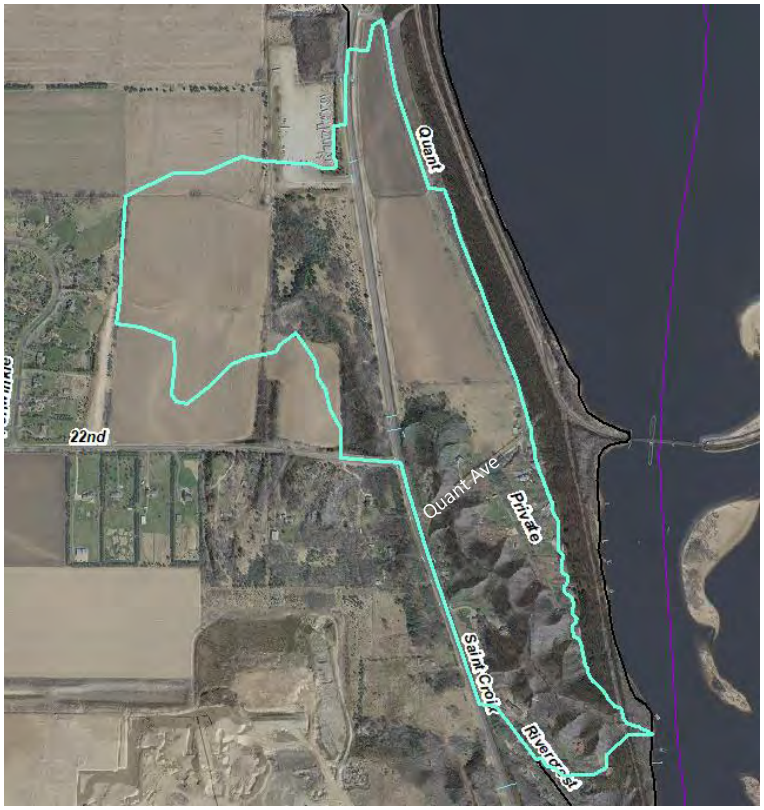
Rank 02/19

Drainage Area – 11.81 acres (38c and 38d combined)
Location – Intersection of Highway 95 and railroad tracks
Property Ownership – Public/Private
Description – BMP 38d2 is the gully erosion reduction from the combined implementation of practices 38c, 38d, and 38e. This assumes all practices recommended for this system are installed. The erosion down this gully is extensive and is the result of the combined effects of multiple failed practices. The gully pollutant load was calculated using the BWSR Pollution Reduction Spreadsheets. The individual load reductions from 38c, 38d and 38e were then added to the gully erosion numbers from the BWSR Spreadsheets (10.7 lbs/yr TP combined). The gully erosion was calculated as having begun when the bridge was created around 1965. Resulting TP and TSS reductions for fixing the gully were conservatively discounted by 50% to account for the unknown effects of catastrophic rain events that would still contribute to gully erosion.



Cost/Removal Analysis		RETROFIT OPTIONS *Catchment SD-38* BMP 38d2: Gully Load Reductions by Fixing 38c,d,e	
		New treatment	Net %
Treatment	TP (lb/yr)	10.7	10%
	TSS (lb/yr)	16760	27%
	Volume (acre-feet/yr)	2.9	11%
	Number of BMP's	1	
	BMP Size/Description		sf
	BMP Type	BWSR Sed Load Reduction	
Cost	Materials/Labor/Design	$23,725.00	
	Promotion & Admin Costs	$1,900.00	
	Probable Project Cost	$25,625.00	
	Annual O&M	$1,150.00	
	10-yr Cost/lb-TP/yr	$346	
	10-yr Cost/2,000lb-TSS/yr	$443	

Catchment SD-39



Existing Conditions		EXISTING CONDITIONS			
		Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	33.4	0.0	0%	**33.4**
	TSS (lb/yr)	13,062	0.0	0%	**13,062**
	Volume (acre-feet/yr)	18.72	0.0	0%	**18.7**
	BMP Type	no existing pratices			

CATCHMENT DESCRIPTION

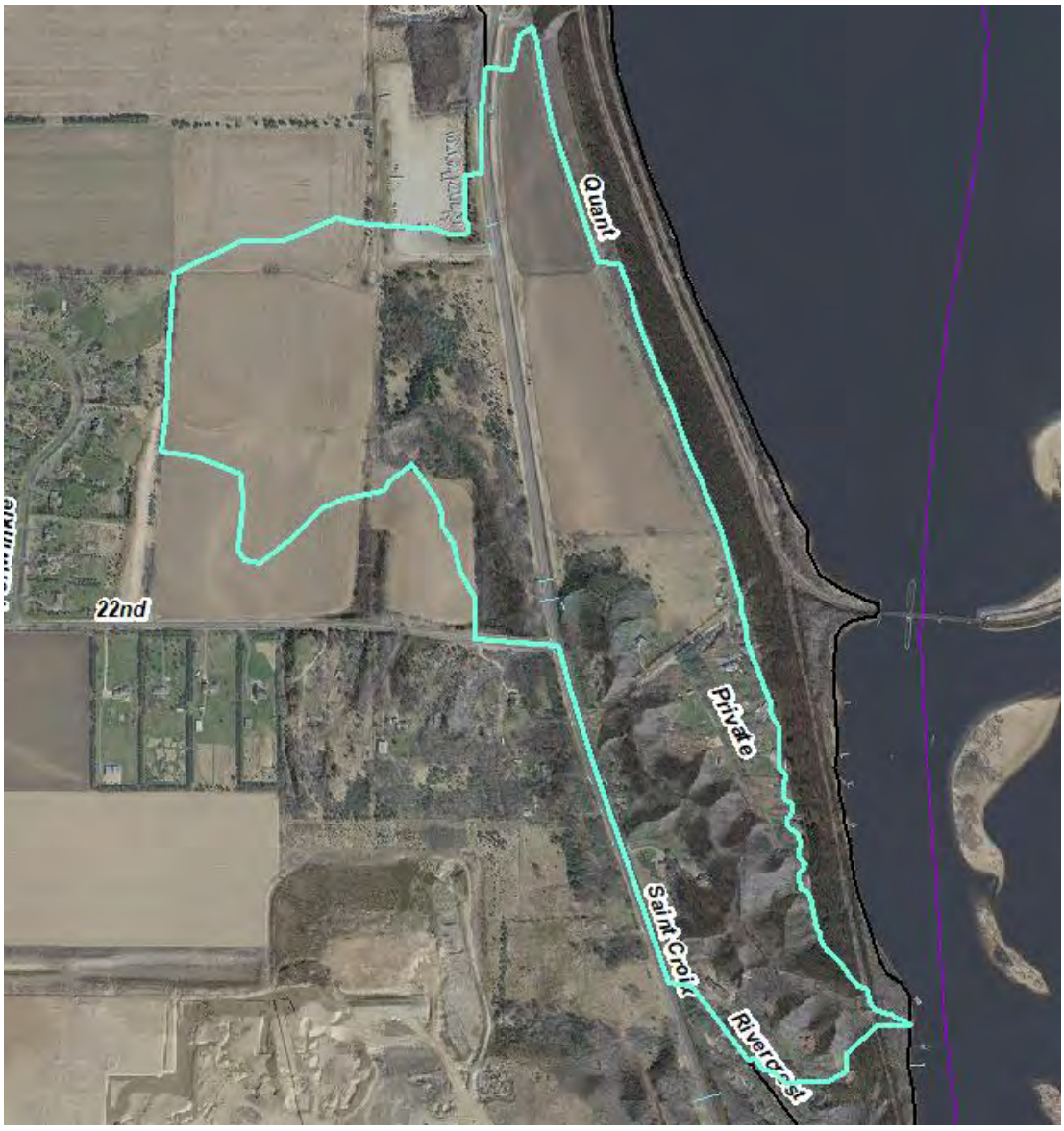
Catchment SD-39 is 164.23 acres. It is mostly agricultural land to the north and a large ravine with low density residential above the bluff in the south. The northern half drains to a large basin with a perched outlet pipe north of Quant Ave N. It would take an immensely large storm to overflow this basin, but the exact scale of this rain event is unknown. There is some heavy erosion in the central gully area (below Quant Ave), but it appears much of the erosion settles out before reaching the end of the gully. Further field verification of this gully may be warranted, but no practices were identified as of the completion of this study.

EXISTING STORMWATER TREATMENT

No existing practices were modelled. There may be practices on private property (such as sump catchbasins in the marina) but they were not found or verified for this study.

SD-39: Retrofit Recommendations

There were no BMP recommendations for Catchment SD-39.



Catchment SD-40

EXISTING CONDITIONS					
Existing Conditions		Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	56.4	3.8	7%	**52.6**
	TSS (lb/yr)	73,260	1,542	2%	**71,718**
	Volume (acre-feet/yr)	18.96	2.3	12%	**16.7**
	BMP Type	Infiltration Basins and Swales			

CATCHMENT DESCRIPTION

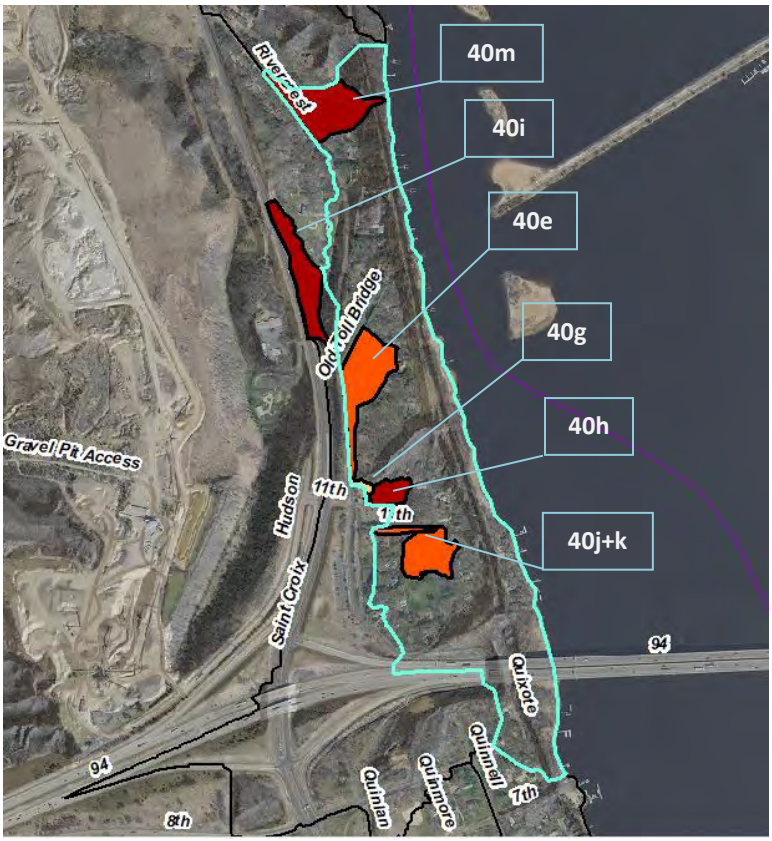
Catchment SD-40 is 81.15 acres. It is comprised of primarily Low Density Residential that drains to a few select points that usually discharge atop the bluff and flow down a ravine. These ravines offer good restoration opportunities. There are multiple residential sites that could be explored as bluff restoration opportunities as well.

EXISTING STORMWATER TREATMENT

Two known properties have BMPs installed. One is a large infiltration cell and swale on Rivercrest (above the bluff) and the other is a shoreline and raingarden below the bluff. Both were incorporated into this existing conditions model. Also included in the Base Loading model is the load reduction for BMP 40m. This is to accurately account for the load reduction of 40m in the final calculations.

SD-40: Retrofit Recommendations

RANK 01/19 - BMP 40m – Private Bluff Restoration: Eliminate bluff losses on 1 private property
RANK 06/19 - BMP 40h – Bungalow Infiltration (large): Large Infiltration cell at The Bungalow
RANK 08/19 - BMP 40i – Hwy 95 Headcut Repair + Flow Disconnect: Disconnect Highway 95 drainage
RANK 12/19 - BMP 40j + 40k – 11th St Infiltration System: Infiltration and swales above bluff on 11th St
RANK 15/19 - BMP 40e – Rivercrest Ditch Conversion + Ravine Stabilization: Convert mown ditches to infiltration swales and restore ravine with checks and toe stabilization
RANK 18/19 - BMP 40g – Bungalow Infiltration (small): Small Infiltration cell at The Bungalow



Total Reductions (all implemented)	
New trtmt	Net %
33.8	64%
57,643	80%
3.6	21%
1	
All Practices	
Ditch Conversion, Infiltration, Gully Repair	
$206,608.78	
$3,750	
$210,359	
$925	
$768	
$2,640	

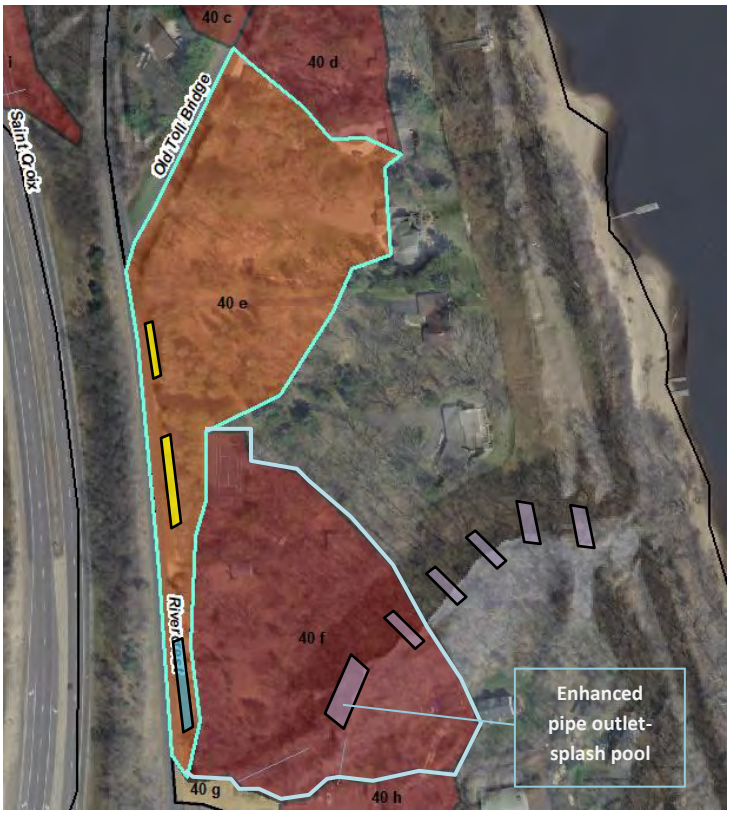
Cost/Removal Analysis		RETROFIT OPTIONS – Catchment SD-40											
		40e: Rivercrest Ditch Conversion + Ravine Stabilization		40g: Bungalow Bioinfiltration (small)		40h: Bungalow Bioinfiltration (large)		40i: Hwy 95 Headcut Repair + Flow Disconnect		40j+40k: 11th St Infiltration System		40m: Bluff Restoration	
		New treatment	Net %	New treatment	Net %	New treatment	Net %	New treatment	Net %	New treatment	Net %	New treatment	Net %
Treatment	TP (lb/yr)	11.23	21%	0.47	1%	2.65	5%	1.57	3%	2.34	4%	15.58	30%
	TSS (lb/yr)	17,197	24%	210	0%	761	1%	1,866	3%	949	1%	36,660	51%
	Volume (acre-feet/yr)	0.7	4%	0.3	2%	1.1	7%	0.6	4%	0.76	5%	0.0	0%
	Number of BMP's	1		1		1		1		1		1	
	BMP Size/Description	3,600	sf	300	sf	700	sf	1,000	sf	1,000	sf	1	each
	BMP Type	Bioinfiltration and Ravine Stabilizaiton		Filtration Basin (Turf)		Filtration Basin (Turf)		Dry Swale		Filtration Basin (Turf)		Bluff Restoration	
Cost	Materials/Labor/Design	$122,400.00		$5,130.00		$13,013.78		$7,980.00		$13,920.00		$44,165.00	
	Promotion & Admin Costs	$750		$250		$250		$1,000		$500		$1,000	
	Probable Project Cost	$123,150		$5,380		$13,264		$8,980		$14,420		$45,165	
	Annual O&M	$150		$75		$75		$75		$250		$300	
	10-yr Cost/lb-TP/yr	$1,110		$1,313		$529		$622		$724		$309	
	10-yr Cost/2,000lb-TSS/yr	$1,450		$5,838		$3,683		$1,043		$3,566		$263	

BMP-40e: Rivercrest Ditch Conversion + Ravine Stabilization

Rank 15/19

Drainage Area – 7.27 acres
Location – Rivercrest Rd N, from Old Toll Bridge Rd to The Bungalow Restaurant
Property Ownership – Public/Private
Description – There is an opportunity to dramatically reduce the volume heading to Gully 40f (near the Bungalow Restaurant) . The existing ditches along the east side of Rivercrest flow to Gully 40f; with the majority of the ditch system being mowed routinely by homeowners or maintenance crews. The swales were likely constructed when Rivercrest was reconstructed in the early 1960's. If five decades of sediment buildup could be stripped from the ditches, the native sandy soils would be exposed and would allow much more water to infiltrate in transit to the gully. Further, the ditches could be retrofit with checkdams to induce 6" max ponding depths, and the vegetation would be converted to native perennials. The final Ponded Swale would allow up to 12" of ponding with a more robust overflow to the gully. This system could be less expensive to construct (thus ranking even higher) if exposure of native soils only occurred in select areas (instead of entire ditch length).

In the gully, restoration will occur at the pipe outfall, at regular intervals, and at problem zones. At the outfall, a large riprap splash pool will be installed to dissipate flow energy. This pool can be fit with or without a large underdrain to help drainage. At regular intervals and at problem points down the gully, riprap checkdams will be installed. Some side-slope toe stabilization may have to occur at critical turns in the flow path. Flows at the pipe outfalls should be modelled to determine proper stabilization methods.



Amended Swale = 800-1600 sf each

Ravine Stabilization and Checkdams

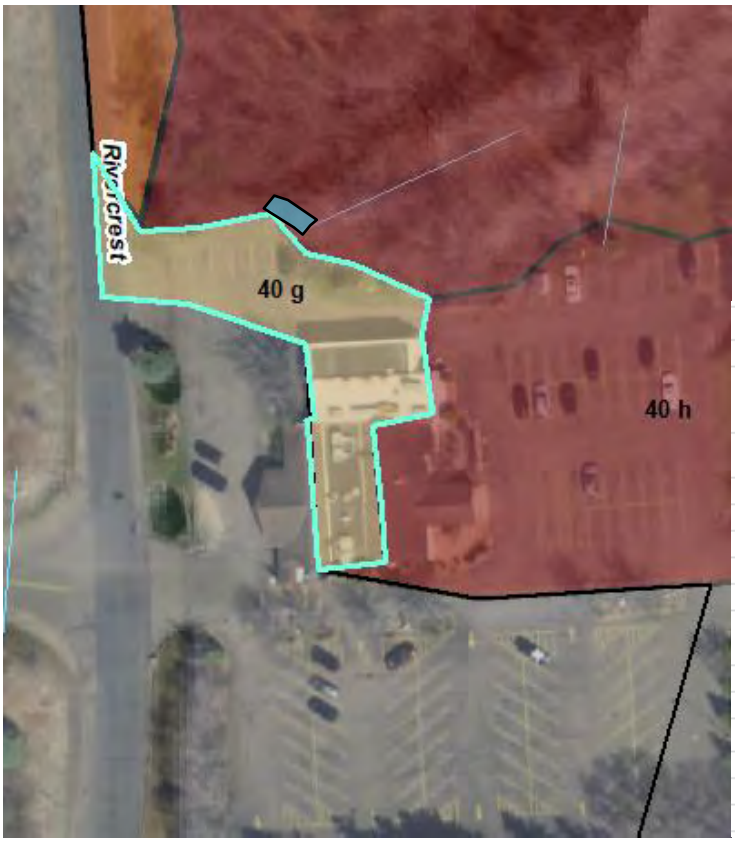
Ponded swale = 1,600 sf basin

Cost/Removal Analysis		RETROFIT OPTIONS *Catchment SD-40* 40e: Rivercrest Ditch Conversion + Ravine Stabilization	
		New treatment	Net %
Treatment	TP (lb/yr)	11.23	21%
	TSS (lb/yr)	17,197	24%
	Volume (acre-feet/yr)	0.7	4%
	Number of BMP's	1	
	BMP Size/Description	3,600	sf
	BMP Type	Bioinfiltration and Ravine Stabilizaiton	
Cost	Materials/Labor/Design	$122,400.00	
	Promotion & Admin Costs	$750	
	Probable Project Cost	$123,150	
	Annual O&M	$150	
	10-yr Cost/lb-TP/yr	$1,110	
	10-yr Cost/2,000lb-TSS/yr	$1,450	

BMP-40g: Bungalow Infiltration Basin (small)

Rank 18/19

Drainage Area – 0.25 acres
Location – NW Corner of The Bungalow parking lot
Property Ownership – Private
Description – This is a small volume control practice that would reduce runoff to Gully 40f and would also serve as treatment for snow melt (from plow storage). It would be a 300 sf turf basin, unless owners wanted perennials for cover. There would be a pretreatment device installed unless it would interfere with snow storage. Maximum ponding depth would be 9" deep. The basin could be fit with an underdrain if desired (helping turf survival), and underdrain would outlet to the gully.



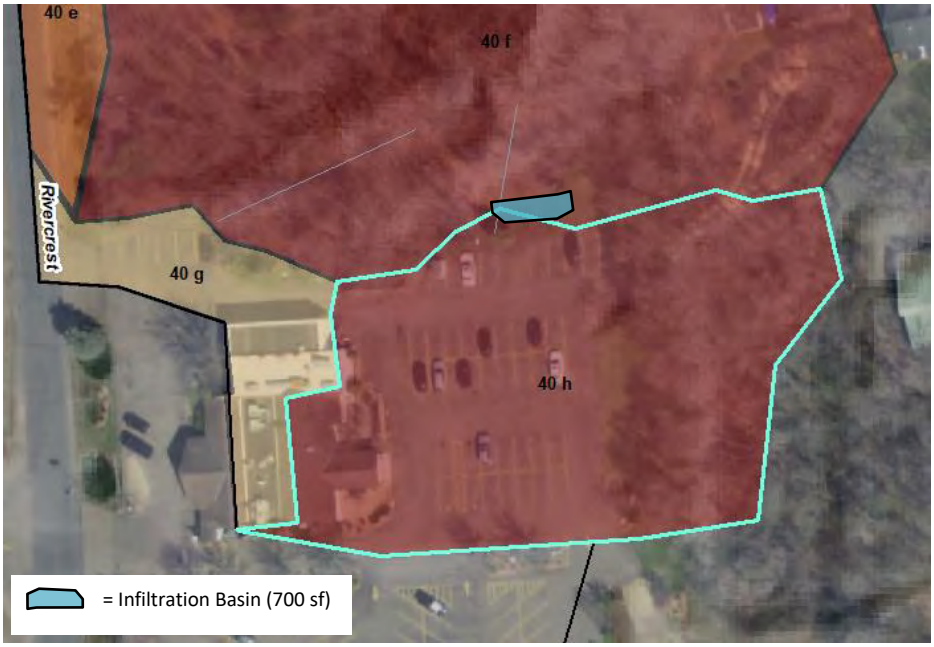
Infiltration Basin = 300 sf basin

Cost/Removal Analysis		RETROFIT OPTIONS Catchment SD-40 40g: Bungalow Bioinfiltration (small)	
		New treatment	Net %
Treatment	TP (lb/yr)	0.47	1%
	TSS (lb/yr)	210.0	0%
	Volume (acre-feet/yr)	0.3	2%
	Number of BMP's	1	
	BMP Size/Description	300	sf
	BMP Type	Filtration Basin (Turf)	
Cost	Materials/Labor/Design	$5,130.00	
	Promotion & Admin Costs	$250	
	Probable Project Cost	$5,380	
	Annual O&M	$75	
	10-yr Cost/lb-TP/yr	$1,313	
	10-yr Cost/2,000lb-TSS/yr	$5,838	

BMP-40h: Bungalow Infiltration Basin (large)

Rank 06/19

Drainage Area – 0.25 acres
Location – North edge of The Bungalow parking lot
Property Ownership – Private
Description – This is a volume control practice that would reduce parking lot runoff to Gully 40f and would also serve as treatment for snow melt (from plow storage). It would be a 700 sf turf basin, unless owners wanted perennials for cover. There would be a pretreatment device installed unless it would interfere with snow storage. Maximum ponding depth would be 9" deep. The basin could be fit with an underdrain if desired (helping turf survival), and underdrain would outlet to the gully.



Cost/Removal Analysis		RETROFIT OPTIONS *Catchment SD-40* 40h: Bungalow Bioinfiltration (large)	
		New treatment	Net %
Treatment	TP (lb/yr)	2.65	5%
	TSS (lb/yr)	761.0	1%
	Volume (acre-feet/yr)	1.1	7%
	Number of BMP's	1	
	BMP Size/Description	700	sf
	BMP Type	Filtration Basin (Turf)	
Cost	Materials/Labor/Design	$13,013.78	
	Promotion & Admin Costs	$250	
	Probable Project Cost	$13,264	
	Annual O&M	$75	
	10-yr Cost/lb-TP/yr	$529	
	10-yr Cost/2,000lb-TSS/yr	$3,683	

BMP-40i: Hwy 95 Headcut Repair + Disconnect

Rank 08/19

Drainage Area – 2.98 acres
Location – Hwy 95, NW of intersection of Old Toll Bridge Rd and Rivercrest Rd
Property Ownership – Public/Private
Description – The Highway 95 ditch outlets onto a steep wooded slope west of Rivercrest. It may have been originally intended for these flows to stay on the west side of Rivercrest, where it would outlet to a large basin between Rivercrest and Hwy 95 just 1,000 feet to the south. But over the years it appears that flows were too strong for this slope and erosion deposits have blocked the flow path. Now water is rerouted across the street to the east side of Rivercrest and flows to Gully 40f. This practice will utilize riprap to armor the eroded gully between Hwy 95 and Rivercrest (to stop further erosion and sediment buildup). This will also require the removal of sediment buildup along the west side ditch of Rivercrest to reestablish the old flow path. Some riprap may be needed to help turn water to ditch; and it may be beneficial to create a larger area for more sediment to settle at the toe of this gully slope so that the practice can endure with minimal maintenance. This practice will result in 100% flow disconnection from Gully 40f.

Gully Repair = 100 lf

Existing Flow Path = Reroute to NEW

PROPOSED FLOW PATH

Cost/Removal Analysis		RETROFIT OPTIONS Catchment SD-40 40i: Hwy 95 Headcut Repair + Flow Disconnect	
		New treatment	Net %
Treatment	TP (lb/yr)	1.57	3%
	TSS (lb/yr)	1,866	3%
	Volume (acre-feet/yr)	0.6	4%
	Number of BMP's	1	
	BMP Size/Description	1,000	sf
	BMP Type	Dry Swale	
Cost	Materials/Labor/Design	$7,980.00	
	Promotion & Admin Costs	$1,000	
	Probable Project Cost	$8,980	
	Annual O&M	$75	
	10-yr Cost/lb-TP/yr	$622	
	10-yr Cost/2,000lb-TSS/yr	$1,043	

BMP-40j + 40k: 11th St Infiltration System

Rank 12/19

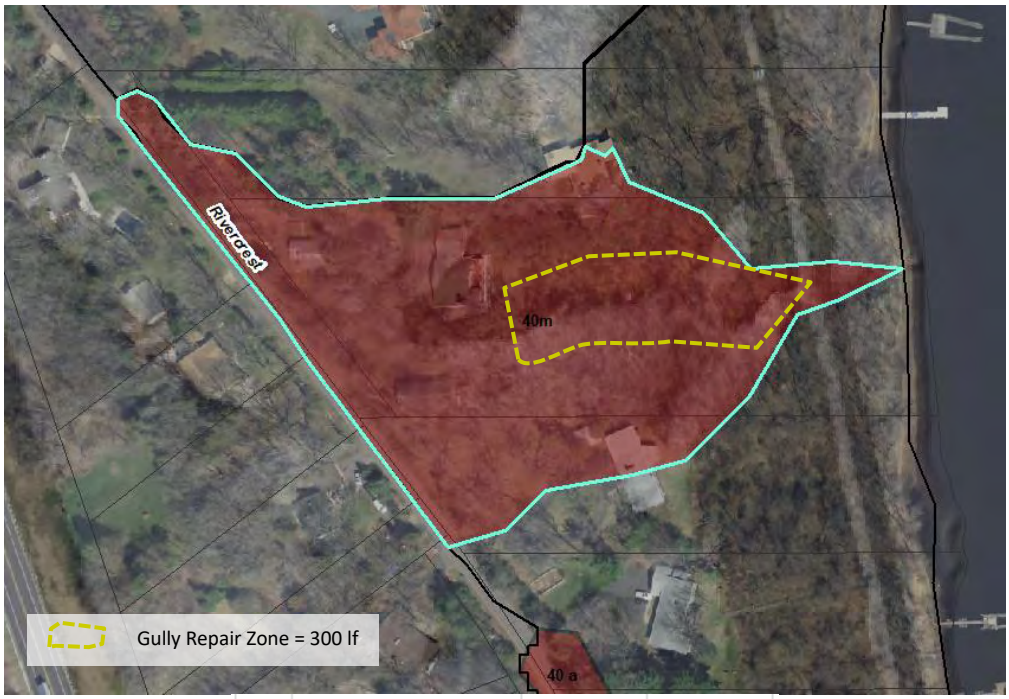
Drainage Area – 2.71 acres
Location – Intersection of 11th St N and 11th St Ct N
Property Ownership – Public/Private
Description – These practices will reduce flow to an existing gully that flows straight east from the intersection of 11th St N and 11th St Ct N. Proposed is a 1,000 sf linear infiltration basin on the SW corner of this intersection. Amending the culvert with a new structure may be necessary to achieve 12" of ponding before flows cross the road to the east. On the east side of the road is a chain of mown swales that flow to the gully head. At a minimum, collaborate with the homeowners to stop mowing the swales. As proposed, widen the narrow swale bottom to 4', rip the soils to expose the native sandy soils, and plant the swales with native perennials. Insert checkdams to promote 6" maximum ponding. It is unclear as to the extent of erosion downstream from this point; as access to the private properties were limited at the time of this study.

Cost/Removal Analysis		RETROFIT OPTIONS *Catchment SD-40* 40j+40k: 11th St Infiltration System	
		New treatment	Net %
Treatment	TP (lb/yr)	2.34	4%
	TSS (lb/yr)	949	1%
	Volume (acre-feet/yr)	0.76	5%
	Number of BMP's	1	
	BMP Size/Description	1,000	sf
	BMP Type	Filtration Basin (Turf)	
Cost	Materials/Labor/Design	$13,920.00	
	Promotion & Admin Costs	$500	
	Probable Project Cost	$14,420	
	Annual O&M	$250	
	10-yr Cost/lb-TP/yr	$724	
	10-yr Cost/2,000lb-TSS/yr	$3,566	

BMP- 40m: Private Bluff Restoration

Rank 01/19

Drainage Area – 4.01 acres
Location – South of intersection of Rivercrest and Hwy 95
Property Ownership – Private
Description – This site was discovered through a homeowner site-visit. There is a very large cut from an access path to the river that has been eroding heavily for many years. The proposed practices include installing flexible waterbars all the way down the path to divert water safely to the bottom of the slope. The existing cuts will be revegetated and some toe stabilization work will also occur at select points along the flow path to prevent further erosion. This site was modelled with only the BWSR Pollution Reduction Spreadsheets. Therefore all pollution reductions are from preventing further erosion and are not from infiltration practices.



Cost/Removal Analysis		RETROFIT OPTIONS Catchment SD-40 40m: Bluff Restoration	
		New treatment	Net %
Treatment	TP (lb/yr)	15.58	30%
	TSS (lb/yr)	36,660	51%
	Volume (acre-feet/yr)	0.0	0%
	Number of BMP's	1	
	BMP Size/Description	1	each
	BMP Type	Bluff Restoration	
Cost	Materials/Labor/Design	$44,165.00	
	Promotion & Admin Costs	$1,000	
	Probable Project Cost	$45,165	
	Annual O&M	$300	
	10-yr Cost/lb-TP/yr	$309	
	10-yr Cost/2,000lb-TSS/yr	$263	

Catchment SD-41

Existing Conditions		EXISTING CONDITIONS			
		Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	40.7	13.5	33%	**27.2**
	TSS (lb/yr)	14,254	2,183.0	15%	**12,071**
	Volume (acre-feet/yr)	18.91	4.1	22%	**14.8**
	BMP Type	12 infiltration and bluff restoration practices			

CATCHMENT DESCRIPTION

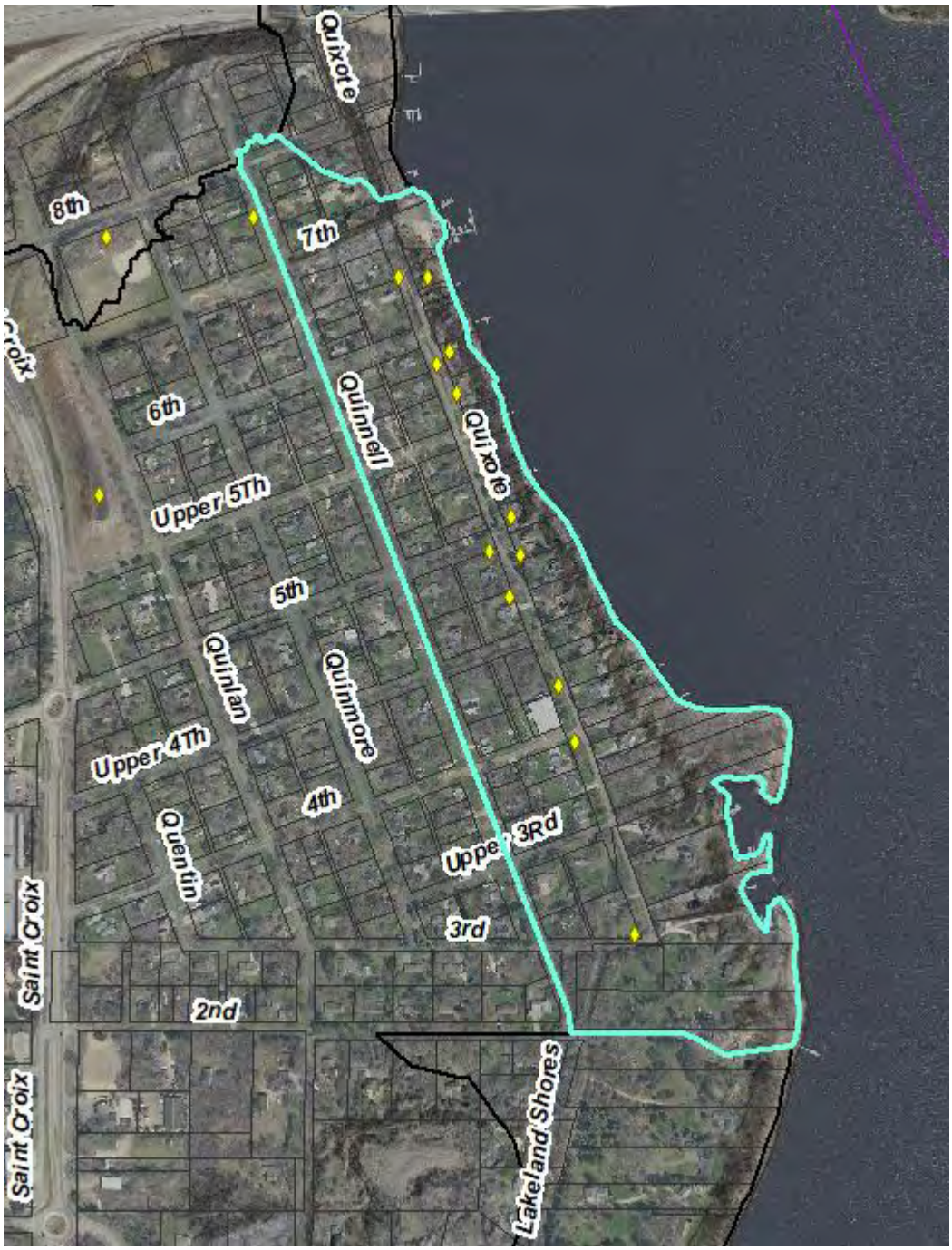
Catchment SD-41 is 61.39 acres. It is mostly Medium to Low Density Residential and is located just south of Interstate Highway 94, in the City of Lakeland. Much of the street drainage (until recently) would drain to several outfalls at the top of the bluff. These outfalls would cause considerable erosion and bluff instability.

EXISTING STORMWATER TREATMENT

This catchment has 12 major infiltration and bluff stabilization practices that were recently installed as part of a concerted effort by the City of Lakeland and the MSCWMO (marked with yellow diamonds). Most of the available land for viable practices in the right of way has already been used for these practices. Therefore, there is not much area left to recommend new practices that are worth the cost of installation. As a result, this study did not recommend any new practices for SD-41.

SD-41: RETROFIT RECOMMENDATIONS

There were no BMP recommendations for Catchment SD-41.
There may be the ability to work with homeowners individually to help reduce bluff erosion on each property. Further outreach efforts will be needed.



Catchment SD-42

Existing Conditions		EXISTING CONDITIONS			
		Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	34.3	0.8	2%	**33.6**
	TSS (lb/yr)	10,786	139	1%	**10,647**
	Volume (acre-feet/yr)	13.62	0.0	0%	**13.6**
	BMP Type	1 residential raingarden			

CATCHMENT DESCRIPTION

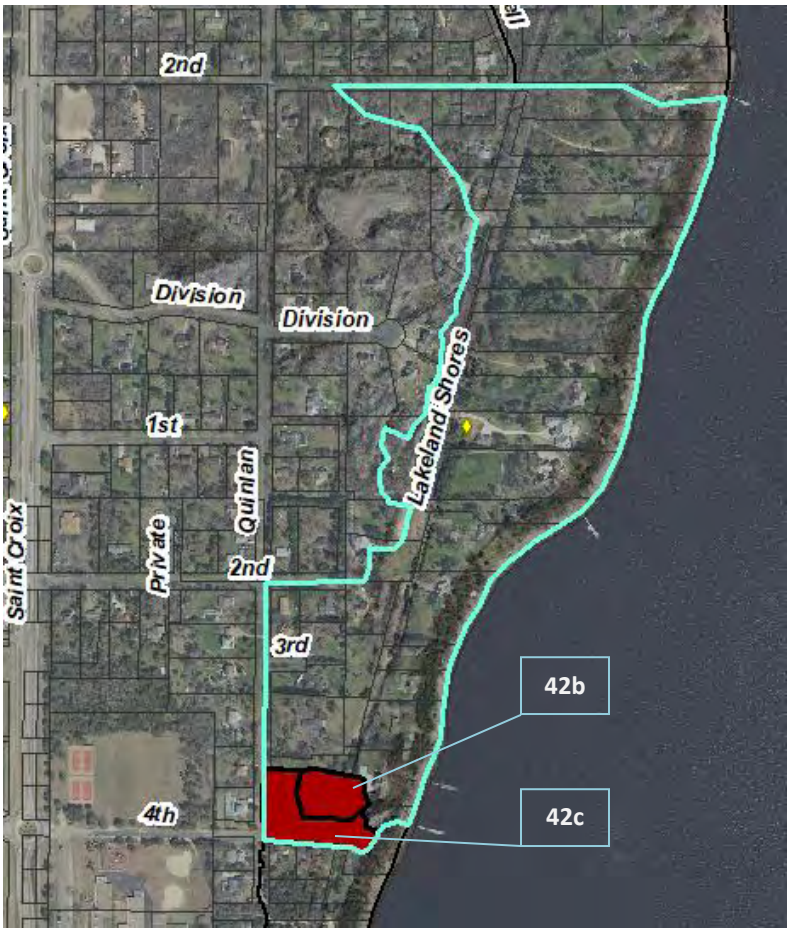
Catchment SD-42 is 58.85 acres. It is comprised mostly of Suburban Residential (0.2-0.6 units per acre). Typically 50% of the lots are mown, with the other 50% being bluff face or wooded depressions above the bluff. There is no public storm sewer infrastructure and most drainage is from the access roads, down the driveways, and to flat lawns above the bluff. The majority of opportunities lie in working with homeowners to help implement best management practices for their bluff drainage.

EXISTING STORMWATER TREATMENT

One raingarden was identified in this catchment. There are no other know existing stormwater BMPs in this catchment.

SD-42: Retrofit Recomendations

RANK 04/19 - BMP 42b+c – 4th Street Redirect and Infiltration: Divert road runoff from ravines into infiltration practices located on private property.

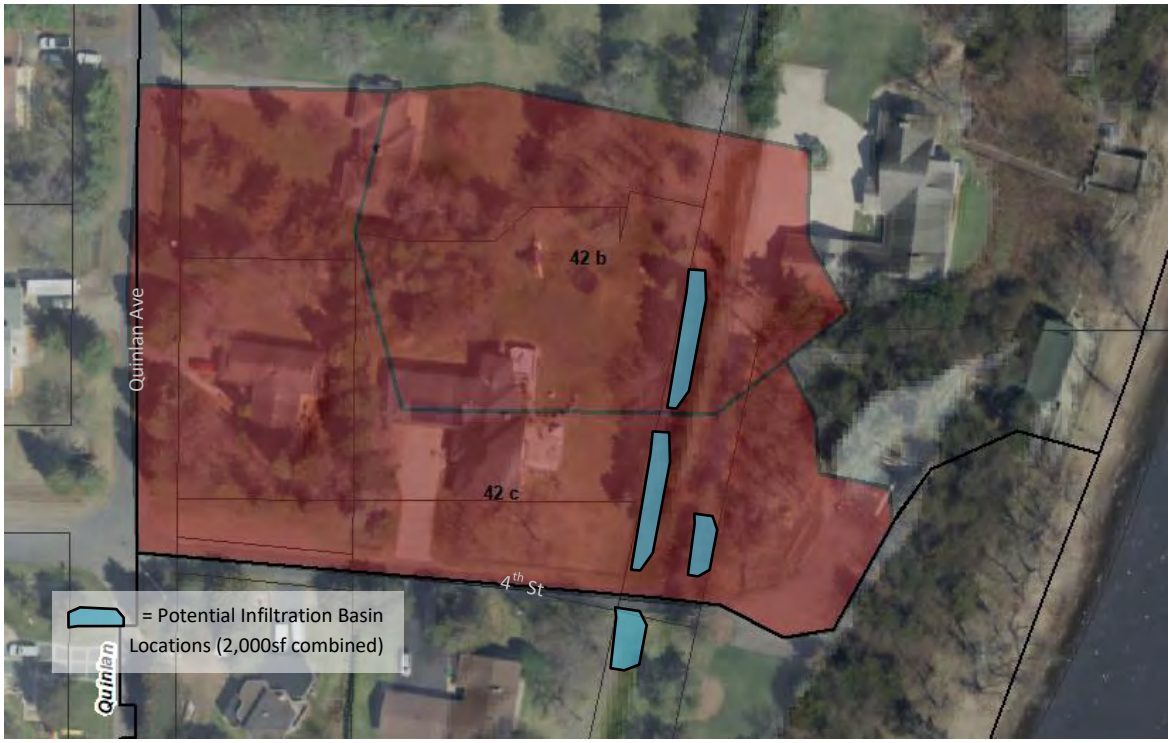


RETROFIT OPTIONS					
Catchment SD-42					
Cost/Removal Analysis		BMP 42b +42c - 4th St Redirect and Infiltration		Total Reductions (all implemented)	
		New treatment	Net %	New trtmt	Net %
Treatment	TP (lb/yr)	6.08	18%	6.08	18%
	TSS (lb/yr)	1,492	14%	1,492	14%
	Volume (acre-feet/yr)	1.7	12%	1.7	12%
	Number of BMP's	1		1	
	BMP Size/Description	2,000	sf	All Practices	
	BMP Type	Moderately Complex BioInfiltration		Infiltration and Redirection	
Cost	Materials/Labor/Design	$22,889		$22,889	
	Promotion & Admin Costs	$1,000		$1,000	
	Probable Project Cost	**$23,889**		**$23,889**	
	Annual O&M	$500		$500	
	10-yr Cost/lb-TP/yr	**$475**		**$475**	
	10-yr Cost/2,000lb-TSS/yr	**$3,873**		**$3,873**	

BMP-42b+c: 4th Street Redirect and Infiltration

Rank 04/19

Drainage Area – 2.91 acres (combined)
Location – East of Quinlan Ave N at the end of 4th St N
Property Ownership – Private/Public
Description – There are two gullies that are very close to the existing houses on the bluff. This series of practices will divert flow away from the bluff and into multiple infiltration practices as shown. Size and depth of each basin will vary depending on field verified site-constraints; but they were modelled at 6" ponding depth over 2,000 combined square feet. Basins along 4th St will receive water via channel drains installed on 4th.



Cost/Removal Analysis		RETROFIT OPTIONS Catchment SD-42 BMP 42b +42c - 4th St Redirect and Infiltration	
		New treatment	Net %
Treatment	TP (lb/yr)	6.08	18%
	TSS (lb/yr)	1,492	14%
	Volume (acre-feet/yr)	1.7	12%
	Number of BMP's	1	
	BMP Size/Description	2,000	sf
	BMP Type	Moderately Complex BioInfiltration	
Cost	Materials/Labor/Design	$22,889	
	Promotion & Admin Costs	$1,000	
	Probable Project Cost	**$23,889**	
	Annual O&M	$500	
	10-yr Cost/lb-TP/yr	**$475**	
	10-yr Cost/2,000lb-TSS/yr	**$3,873**	

Catchment SD-43

Existing Conditions		EXISTING CONDITIONS			
		Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	43.2	0.0	0%	**43.2**
	TSS (lb/yr)	80,088	0.0	0%	**80,088**
	Volume (acre-feet/yr)	4.98	0.0	0%	**5.0**
	BMP Type	2 Shoreline Stablizations			

CATCHMENT DESCRIPTION

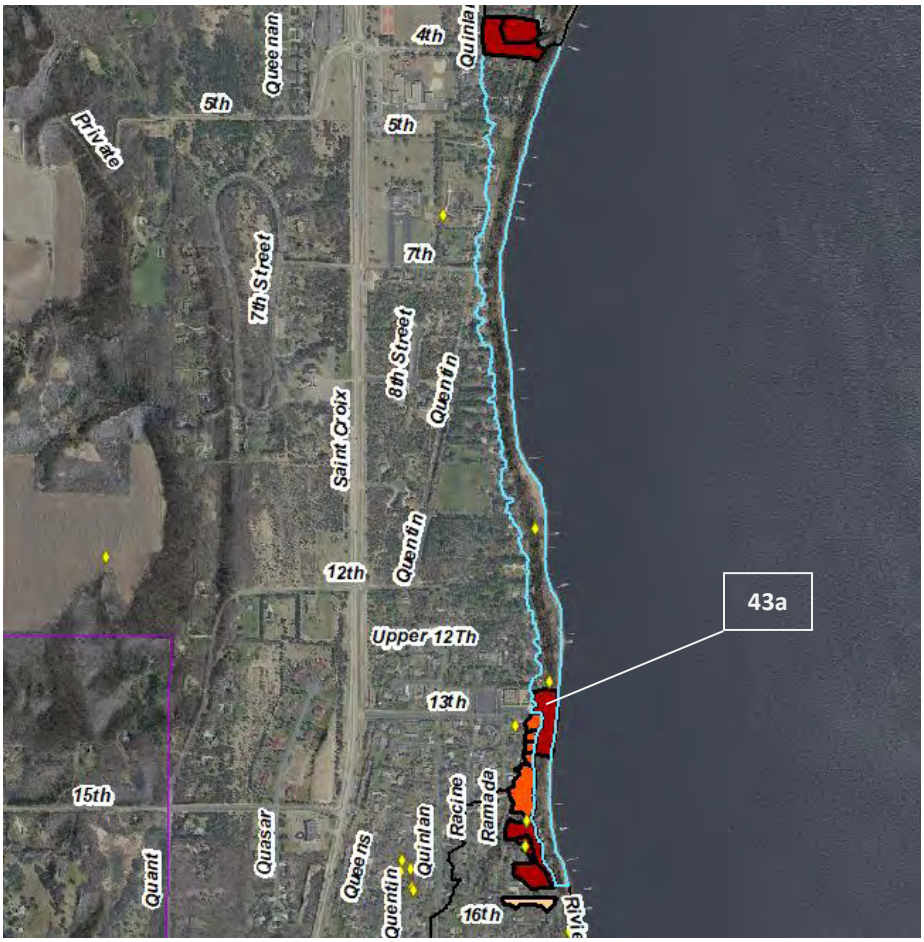
Catchment SD-43 is 32.13 acres. It spans the cities of Lakeland, Lakeland Shores, and Lake St Croix Beach. It is mostly comprised of bluff top residential lots that qualify as Low Density Residential Land Use. There are no major road drainages in this catchment, nor is there any municipal storm sewer. There is not much direct drainage in general, therefore the majority of water quality protection efforts should take the form of homeowner education and outreach for bluff management strategies.

EXISTING STORMWATER TREATMENT

There were two known existing practices in this catchment. They were both shoreline/bluff restorations. Their respective pollutant load reductions were not factored into the modelling of this catchment since WinSLAMM does not account for near stream erosion.

SD-43: Retrofit Recommendations

RANK 07/19 - BMP 43a – Bluff Toe Stabilization: Toe Stabilization of steep bluff (515 LF)

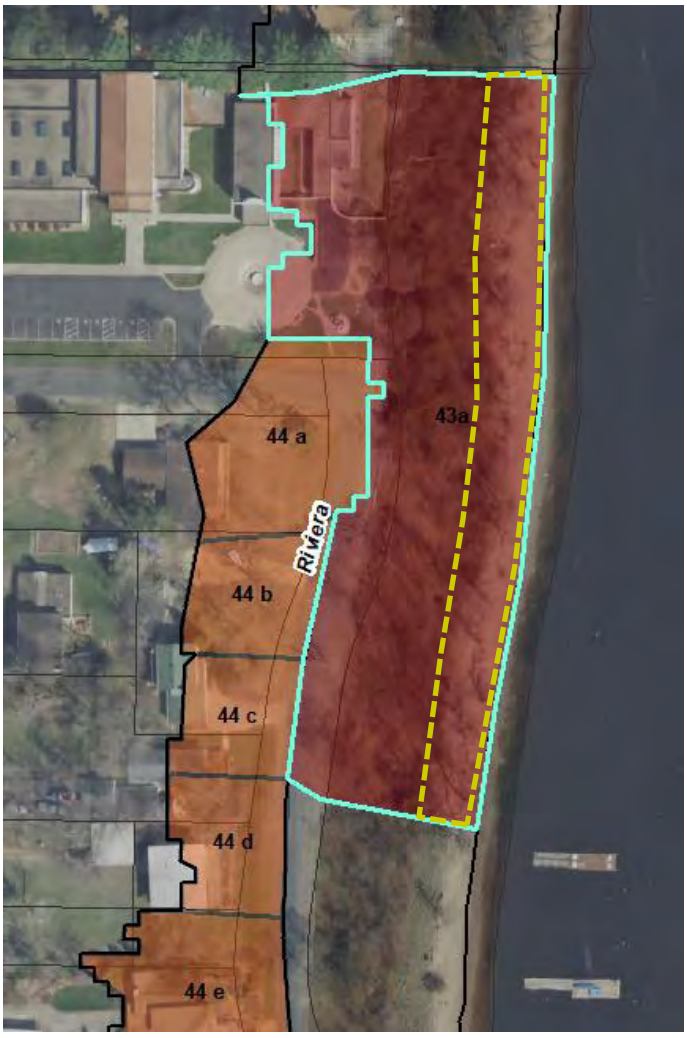


RETROFIT OPTIONS					
Catchment SD-43					
Cost/Removal Analysis		BMP 43a: Bluff Toe Stabilization		Total Reductions (all implemented)	
		New treatment	Net %	New trtmt	Net %
Treatment	TP (lb/yr)	32.5	75%	32.5	75%
	TSS (lb/yr)	76,480	95%	76,480	95%
	Volume (acre-feet/yr)	0.0	0%	0.0	0%
	Number of BMP's	1		1	
	BMP Size/Description	515	lf	All Practices	
	BMP Type	Bluff Toe and Shoreline Stabilization		Infiltration and Redirection	
Cost	Materials/Labor/Design	$177,031.25		$177,031.25	
	Promotion & Admin Costs	$3,000		$3,000	
	Probable Project Cost	**$180,031**		**$180,031**	
	Annual O&M	$1,040		$1,040	
	10-yr Cost/lb-TP/yr	**$586**		**$586**	
	10-yr Cost/2,000lb-TSS/yr	**$498**		**$498**	

BMP-43a: Bluff Toe Stabilization

Rank 07/19

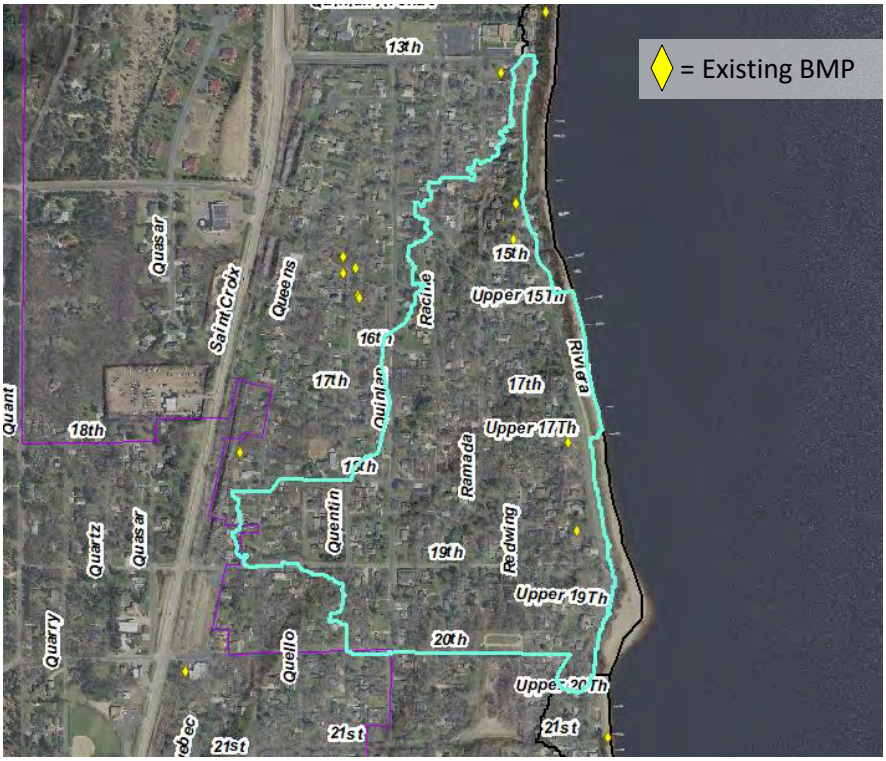
Drainage Area – 1.72 acres
Location – Intersection of 13th St S and Riviera Ave S
Property Ownership – Public
Description – This bluff is eroding at a very fast pace. Increasing frequency of near-record elevation floods along the St Croix River have pushed the stability of the bluff toe to the limit and have caused some significant losses in recent years. This project will stabilize the bluff toe with 'grouted riprap' to the 992' elevation. Some trees will have to be selectively thinned, and riprap will have to be strategically placed in order to balance their respective visual and ecological impacts.



= Toe Stabilization to 992' = 515 lf

Cost/Removal Analysis		RETROFIT OPTIONS *Catchment SD-43* BMP 43a: Bluff Toe Stabilization	
		New treatment	Net %
Treatment	TP (lb/yr)	32.5	75%
	TSS (lb/yr)	76,480	95%
	Volume (acre-feet/yr)	0.0	0%
	Number of BMP's	1	
	BMP Size/Description	515	lf
	BMP Type	Bluff Toe and Shoreline Stabilization	
Cost	Materials/Labor/Design	$177,031.25	
	Promotion & Admin Costs	$3,000	
	Probable Project Cost	**$180,031**	
	Annual O&M	$1,040	
	10-yr Cost/lb-TP/yr	**$586**	
	10-yr Cost/2,000lb-TSS/yr	**$498**	

Catchment SD-44



Existing Conditions		EXISTING CONDITIONS			
		Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	58.3	18.0	31%	**40.3**
	TSS (lb/yr)	18,681	5,669	30%	**13,012**
	Volume (acre-feet/yr)	24.36	7.8	32%	**16.5**
	BMP Type	4 residential raingardens			

CATCHMENT DESCRIPTION

Catchment SD-44 is 73.44 acres. It is comprised of primarily medium density, single-family residential land use. There is a large levee that spans the lower 2/3 of this catchment, separating the neighborhoods from the river shoreline. Most flows in this catchment make it to two discharge points at Upper 17th and Riviera and what would be 14th and Riviera. Flows in the western half of the catchment (west of Ramada, south of 15th) rarely make it to the river due to natural depressions and large grade breaks.

EXISTING STORMWATER TREATMENT

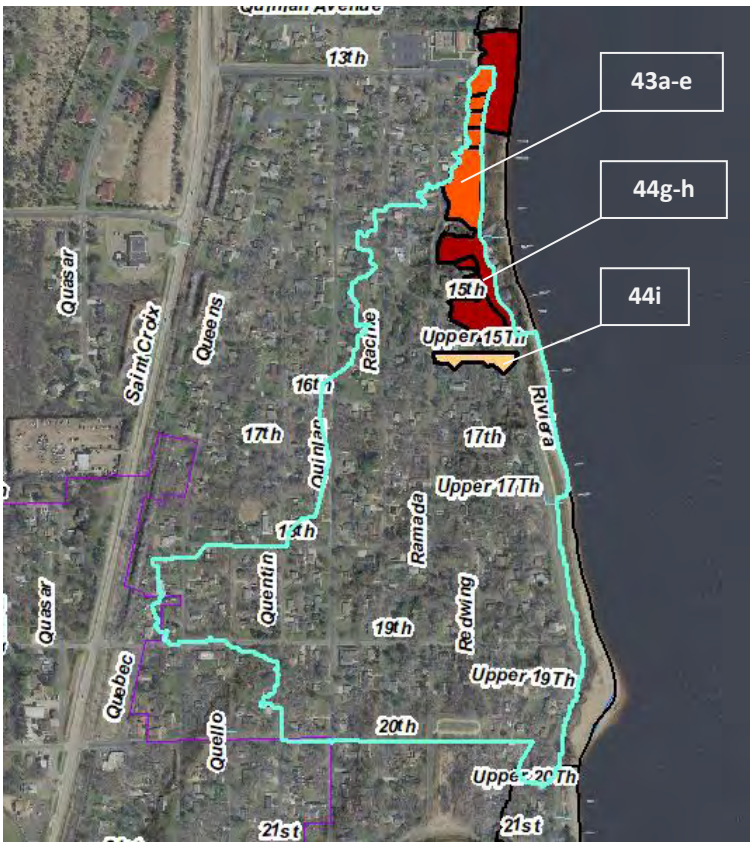
There are 4 known existing practices. All are infiltration basins on residential property. The WinSLAMM model also factored in the partial-disconnection of the western half of the catchment. This is reflected in the Existing Conditions table above, where a 31% reduction is shown. The model only discounted 50% of the flow from this catchment, where in reality it may be much larger. The exact value is unknown though, since it would require extensive field investigation to document the size and depth of natural depressions and infiltration features that contribute to this flow reduction.

SD-44: Retrofit Recommendations

RANK 03/19 - BMP 44g-44h – South Riviera Treatment Train: Multiple shallow turf swales with exposure of native sandy soils to improve infiltration.

RANK 14/19 - BMP 44a-44e – North Riviera Treatment Train: Multiple shallow turf swales with exposure of native sandy soils to improve infiltration.

RANK 17/19 - BMP 44i – Turf Swale w/Improved Soils: Linear shallow turf swale with exposure of native sandy soils to improve infiltration.

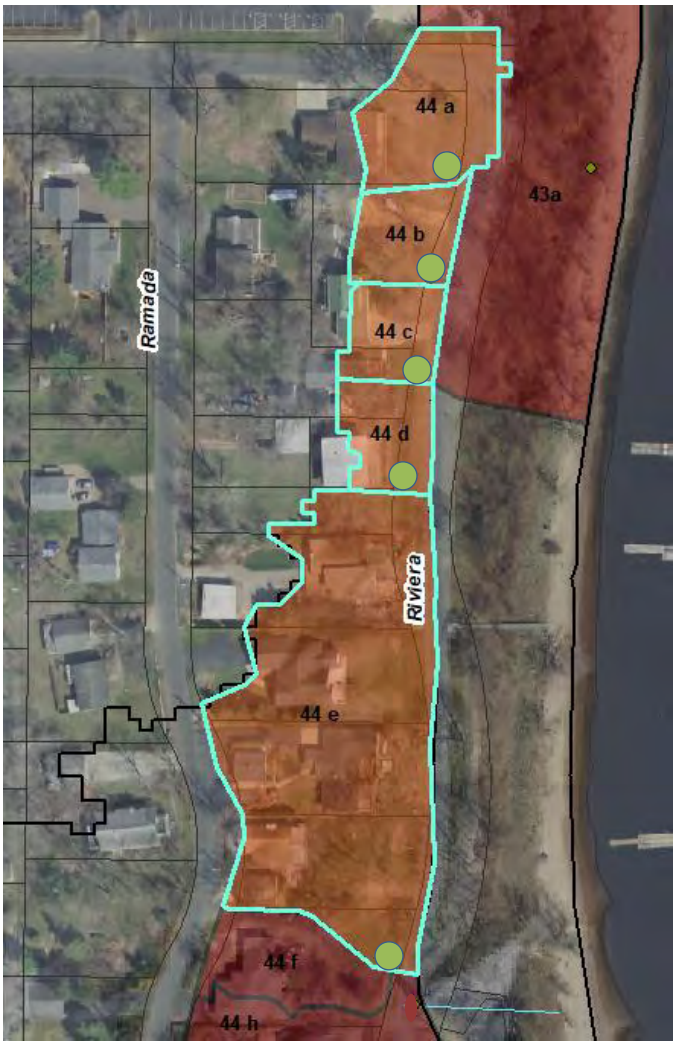


Cost/Removal Analysis		Retrofit Options — Catchment SD-44							
		BMP 44a - 44e: North Riviera Treatment Train		BMP 44g - 44h: South Riviera Treatment Train		BMP 44i: Turf Swale w/Improved Soils		Total Reductions (all implemented)	
		New trtmt	Net %	New trtmt	Net %	New trtmt	Net %	New treatment	Net %
Treatment	TP (lb/yr)	2.5	6%	2.9	7%	0.4	1%	5.8	14%
	TSS (lb/yr)	847.0	7%	883.0	7%	168.0	1%	1898.0	15%
	Volume (acre-feet/yr)	0.7	4%	0.7	4%	0.2	1%	1.6	10%
	Number of BMP's	5		2		2		1	
	BMP Size/Description	760	sf	350	sf	280	sf	All Practices	
	BMP Type	Filtration Basin (Turf)		Simple BioInfiltration		Simple BioInfiltration		BioInfiltration Basins and Swales	
Cost	Materials/Labor/Design	$18,377.13		$10,200.00		$3,420.00		$31,997	
	Promotion & Admin Costs	$750		$750		$750		$2,250	
	Probable Project Cost	$19,127		$10,950		$4,170		$34,247	
	Annual O&M	$75		$263		$75		$413	
	10-yr Cost/lb-TP/yr	$791		$466		$1,312		$856	
	10-yr Cost/2,000lb-TSS/yr	$4,694		$3,075		$5,857		$4,542	

BMP 44a-e: North Riviera Treatment Train

Rank 14/19

Drainage Area – 2.13 acres
Location – Riviera Ave S, from 13th St S to approx. 14th St outfall
Property Ownership – Private/Public
Description – This catchment has very sandy soils, but also fairly steep slopes with mown lawns. This treatment train of infiltration swales will help control discharge rates to the outfall, as well as promote infiltration for modest pollution reductions. Each point on the map below represents a 150sf turf swale, up to 12" deep, and connected to the native sandy soils (may require some deep ripping of existing compacted soils). Inlets to the swales would be by amending the sod elevation along the street edge. This would allow water to enter along the full length of the practice - as opposed to the current system of sediment buildup along the street edge, forcing all road runoff to the outfall (untreated). These systems can be designed to be offline as well, if inlets are at controlled points along a new curbline. Further, this system could rank much higher if it is determined that minimal excavation work has to be done to achieve desired infiltration rates (thus lowering the total cost).



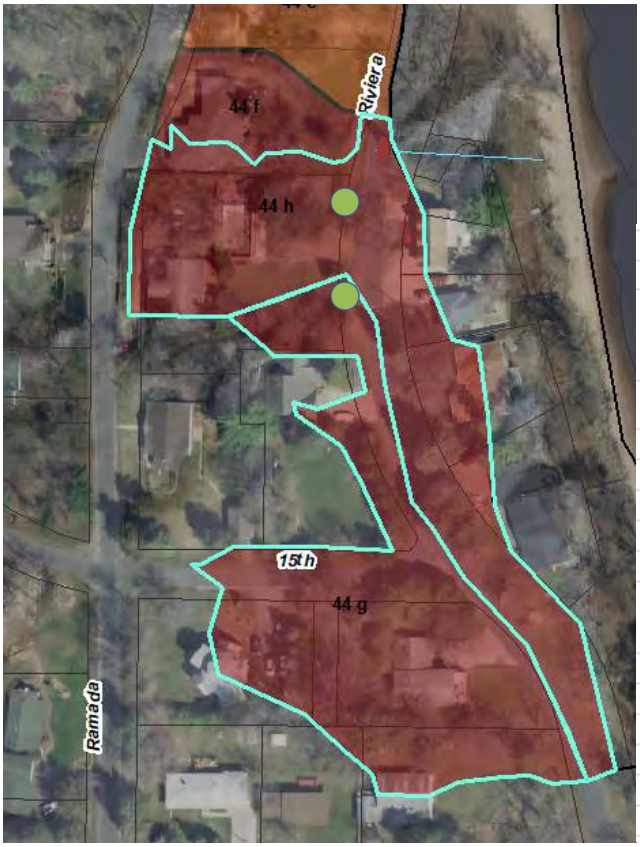
= Swale Location (approx. 150sf each)

Cost/Removal Analysis		RETROFIT OPTIONS Catchment SD-44 BMP 44a - 44e: North Riviera Treatment Train	
		New trtmt	Net %
Treatment	TP (lb/yr)	2.5	6%
	TSS (lb/yr)	847.0	7%
	Volume (acre-feet/yr)	0.7	4%
	Number of BMP's	5	
	BMP Size/Description	760	sf
	BMP Type	Filtration Basin (Turf)	
Cost	Materials/Labor/Design	$18,377.13	
	Promotion & Admin Costs	$750	
	Probable Project Cost	**$19,127**	
	Annual O&M	$75	
	10-yr Cost/lb-TP/yr	**$791**	
	10-yr Cost/2,000lb-TSS/yr	**$4,694**	

BMP 44g-h: South Riviera Treatment Train

Rank 03/19

Drainage Area – 2.32 acres
Location – Riviera Ave S, between 14th St outfall and about Upper 15th St
Property Ownership – Private/Public
Description – This catchment has very sandy soils, but also fairly steep slopes with mown lawns. This treatment train of infiltration swales will help control discharge rates to the outfall, as well as promote infiltration for modest pollution reductions. Each point on the map below represents a turf swale. BMP 44g can be designed up to 200sf, and BMP 44h only 100sf. Each basin can pond up to 12" deep. Connect swales to the native sandy soils (may require some deep ripping of existing compacted soils). Inlets to the swales would be by amending the sod elevation along the street edge. This would allow water to enter along the full length of the practice - as opposed to the current system of sediment buildup along the street edge, forcing all road runoff to the outfall (untreated). These systems can be designed to be offline as well, if inlets are at controlled points along a new curbline.



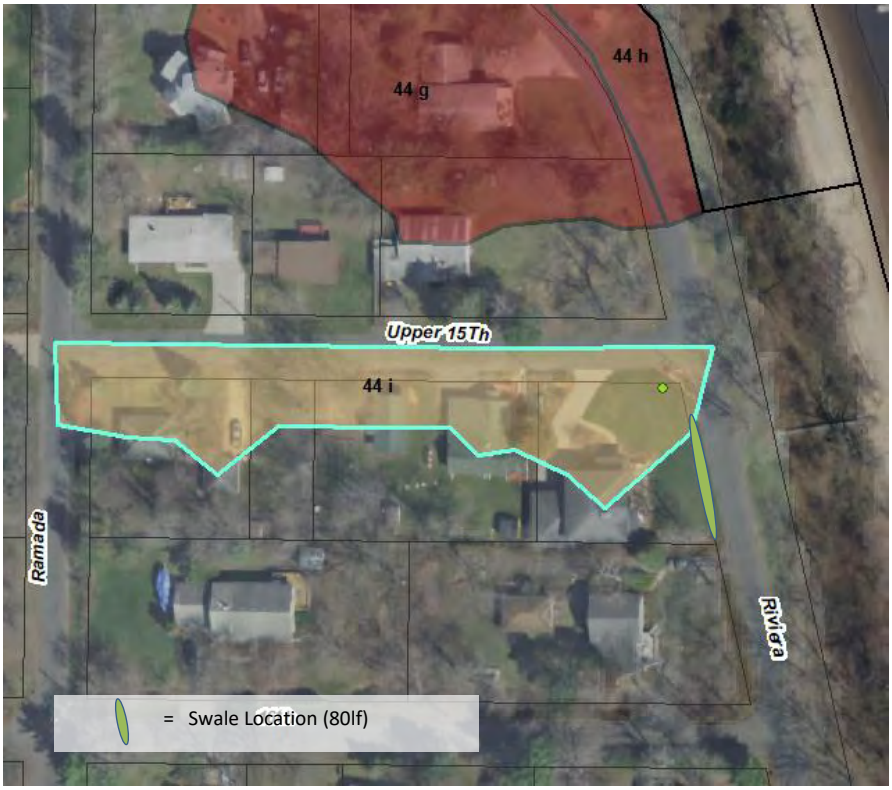
= Swale Location (300sf combined)

Cost/Removal Analysis		RETROFIT OPTIONS *Catchment SD-44* BMP 44g - 44h: South Riviera Treatment Train	
		New trtmt	Net %
Treatment	TP (lb/yr)	2.9	7%
	TSS (lb/yr)	883.0	7%
	Volume (acre-feet/yr)	0.7	4%
	Number of BMP's	2	
	BMP Size/Description	350	sf
	BMP Type	Simple BioInfiltration	
Cost	Materials/Labor/Design	$10,200.00	
	Promotion & Admin Costs	$750	
	Probable Project Cost	**$10,950**	
	Annual O&M	$263	
	10-yr Cost/lb-TP/yr	**$466**	
	10-yr Cost/2,000lb-TSS/yr	**$3,075**	

BMP 44i: Turf Swale with Improved Soils

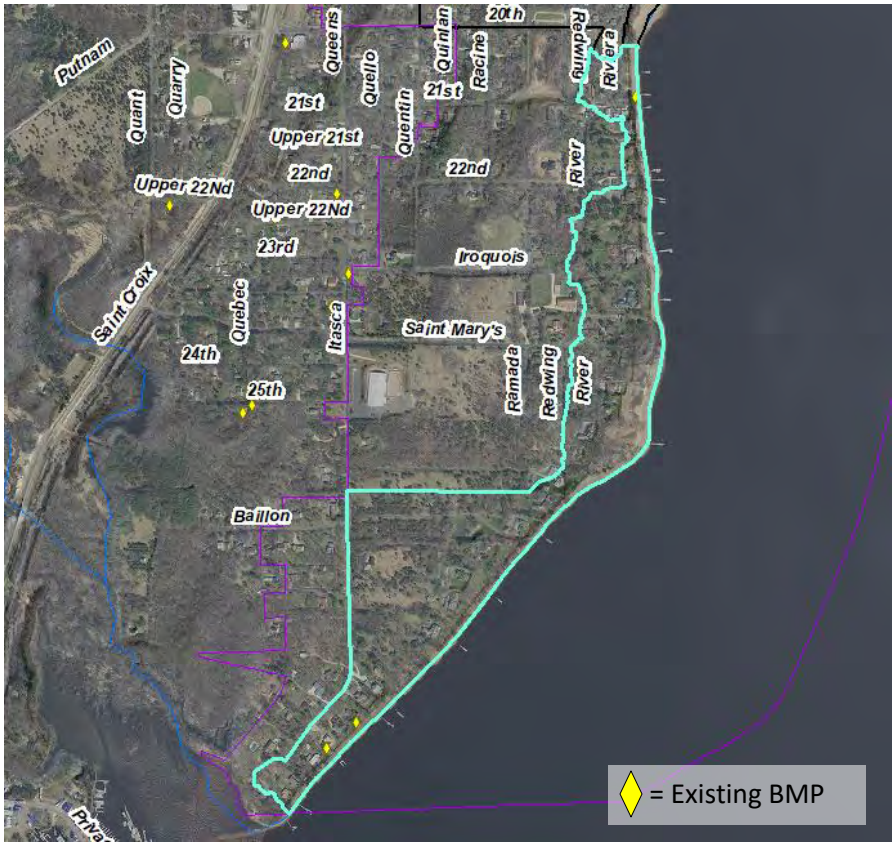
Rank 17/19

Drainage Area – 0.59 acres
Location – Riviera Ave S, at Upper 15th St
Property Ownership – Private/Public
Description – This site was one of very few opportunities that could capture more than 200lf of roadway. Although the ROW is very narrow (6'), it is still possible to install a shallow swale (8" depth) that can fit within the ROW. The slopes would be 3:1, and the practice could be up to 80lf. Underground utility conflicts are unknown. This practice could be much larger if an agreement with the property owner were reached to allow some ponding or grading outside of the ROW.



Cost/Removal Analysis		RETROFIT OPTIONS Catchment SD-44 BMP 44i: Turf Swale w/Improved Soils	
		New trtmt	Net %
Treatment	TP (lb/yr)	0.4	1%
	TSS (lb/yr)	168.0	1%
	Volume (acre-feet/yr)	0.2	1%
	Number of BMP's	2	
	BMP Size/Description	280	sf
	BMP Type	Simple BioInfiltration	
Cost	Materials/Labor/Design	$3,420.00	
	Promotion & Admin Costs	$750	
	Probable Project Cost	**$4,170**	
	Annual O&M	$75	
	10-yr Cost/lb-TP/yr	**$1,312**	
	10-yr Cost/2,000lb-TSS/yr	**$5,857**	

Catchment SD-45



Existing Conditions		EXISTING CONDITIONS			
		Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	38.6	0.4	1%	38.3
	TSS (lb/yr)	12,691	65.0	1%	12,626
	Volume (acre-feet/yr)	16.69	0.1	1%	16.6
	BMP Type	3 shoreline restorations			

CATCHMENT DESCRIPTION

Catchment SD-45 is 65.93 acres. It is comprised primarily of Low to Suburban Density land uses. It is relatively flat, with larger tracts of mown lawn and wooded edges for each larger lot. Most drainage does not make it very easily to the river given it is fairly sandy and flat and the river edges of each property are slightly bermed (at the natural floodplain elevation). The majority of opportunity for retrofit BMPs would be in shoreline restoration to protect against flood losses, and land management best practices such as reducing mowing, naturalizing the river edge, and limiting fertilization.

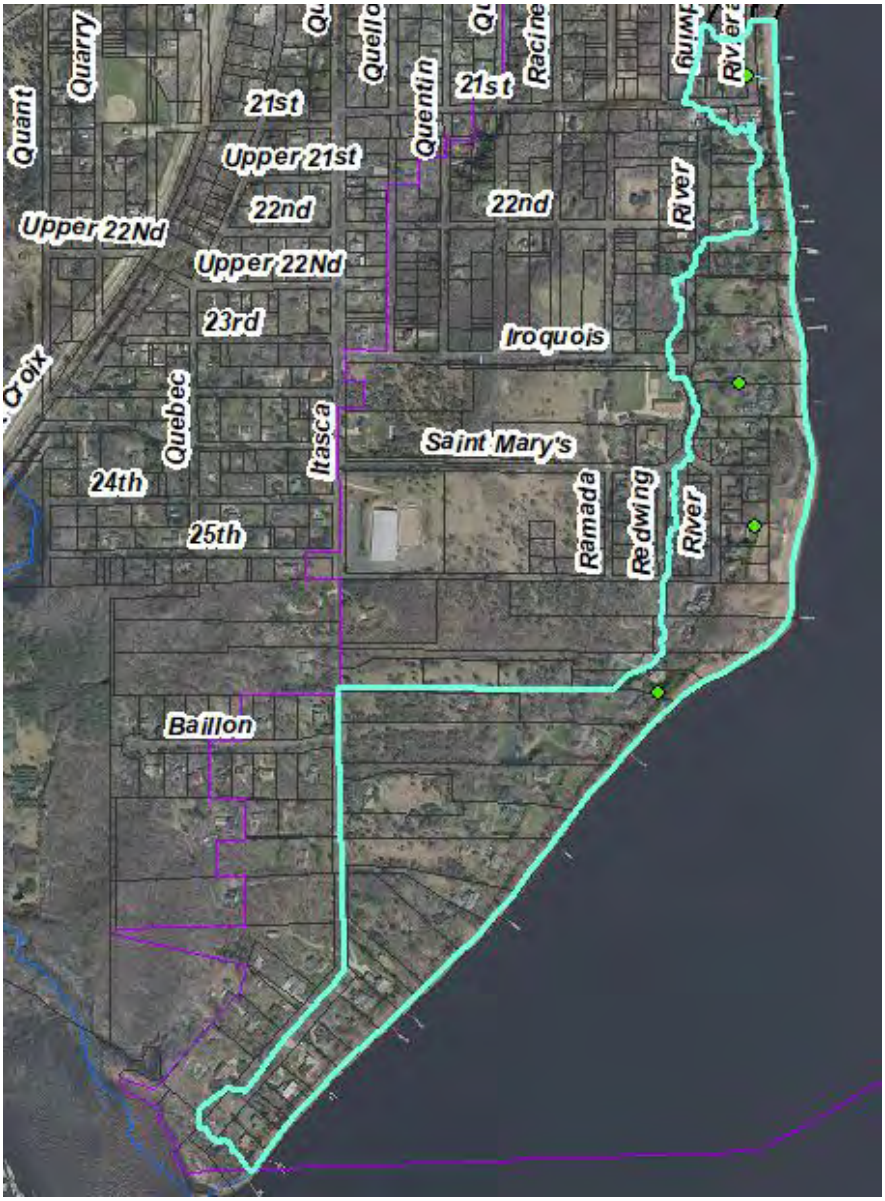
EXISTING STORMWATER TREATMENT

3 existing shorelines were modelled. All shorelines were moderately stable prior to restoration, and pollutant reductions for each were minimal as a result.

SD-45: Retrofit Recommendations

There were no BMP recommendations for Catchment SD-45. The majority of opportunity for retrofit BMPs would be in shoreline restoration to protect against flood losses, and land management best practices such as reducing mowing, naturalizing the river edge, and limiting fertilization. This would require a coordinated outreach effort to talk with homeowners on-site and look for opportunities to improve water quality in the St Croix River.

The properties at the green points were identified as having potential erosion control opportunities, based on inspection of the Digital Elevation Model and 2016 Aerials. There was no field investigation of these sites, but they could be included as priority outreach targets if such an effort was undertaken.



Catchment PER-99* *(UNRANKED)*

Existing Conditions		EXISTING CONDITIONS			
		Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	79.2	3.8	5%	**75.4**
	TSS (lb/yr)	32,288	1,510.0	5%	**30,778**
	Volume (acre-feet/yr)	53.99	0.0	0%	**53.9**
	Number of BMP's				
	BMP Size/Description				
	BMP Type	600lf of mown swales			

CATCHMENT DESCRIPTION + EXISTING STORMWATER TREATMENT

Catchment PER-99 is 120.38 acres. It is comprised primarily of Medium Density Residential (with alleys), as well as Bluff space that is categorized as either Open Space or Undeveloped (depending on observed understory condition). This catchment was UNRANKED for two reasons. 1) It was not initially included in the study area since a portion of it drained to Perro Creek. 2) The catchment received direct treatment of runoff via multiple swales, a large wooded depression, and a stormpond before discharging to the St Croix River. After gaining a better understanding of the actual vs modelled catchment boundaries, as well as seeing firsthand the actual volume of runoff discharging from this catchment, it was decided to include this catchment in the study. Even though the system does get some treatment at the end of the catchment, the state of this treatment system is inadequate to address the volume of discharge. The study recommends two practices to implement, along with others to consider after further feasibility studies are undertaken.

PER-99: Retrofit Recommendations

Rankings are relative to the rest of the study, since these practices were not included in the initial modelling efforts.

RANK 02/19 - BMP PER99b – Alley Swale Enhancement: Convert existing mown swale to unmown. Can selectively integrate native plugs where appropriate (for higher install cost).

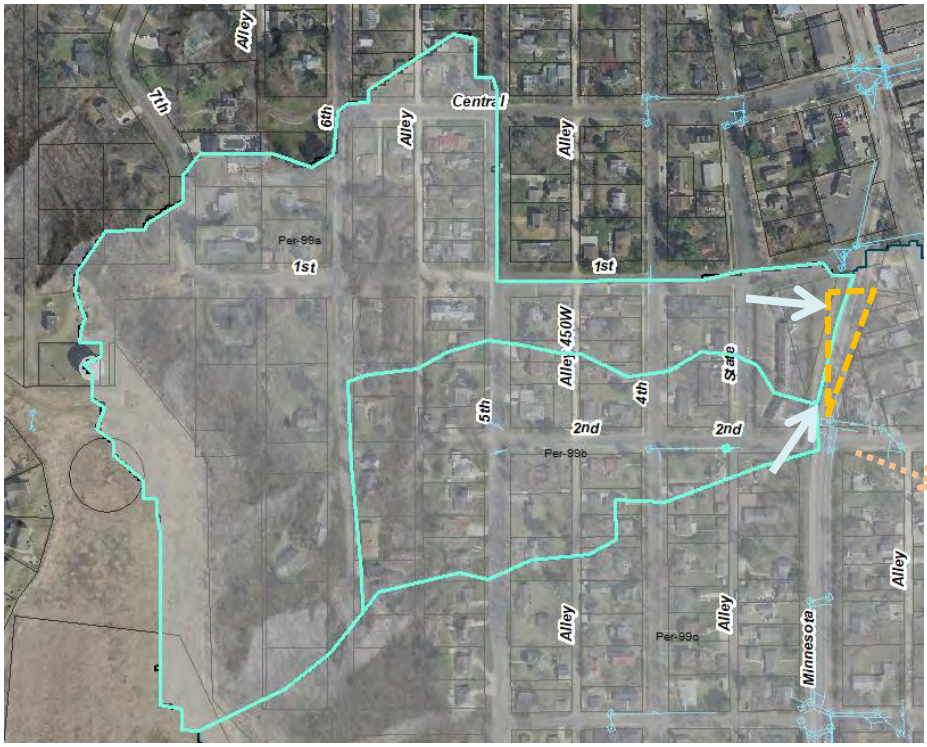
RANK 10 to 19/19 - BMP PER99a – 1st and Hwy 95 Infiltration Basin : Redirect 1st and 2nd St flows into large Infiltration basin on Main. Some utility movement required. Washington County has plans for bike path here as well.

Cost/Removal Analysis		RETROFIT OPTIONS *Catchment PER-99*					
		BMP PER-99a+b: 1st St and Hwy95 Infiltration Basin		BMP PER-99c: Alley Swale Enhancement		Total Reductions (all implemented)	
		New trtmt	Net %	New trtmt	Net %	New trtmt	Net %
Treatment	TP (lb/yr)	10.8	14%	2.5	3%	13.3	18%
	TSS (lb/yr)	4580	15%	907	3%	5487.0	18%
	Volume (acre-feet/yr)	6.9	13%	0.05	0%	7.0	13%
	Number of BMP's	1		1		2	
	BMP Size/Description	8,000 sf		2,400 sf		All Practices	
	BMP Type	Highly Complex BioFiltration		Unmown Swale Minimal Veg			
Cost	Materials/Labor/Design	$201,000		$1,190		$238,510.00	
	Promotion & Admin Costs	$6,000		$500		$7,300.00	
	Probable Project Cost	**$207,000**		**$1,690**		**$245,810.00**	
	Annual O&M	$720		$360		$2,000.00	
	10-yr Cost/lb-TP/yr	**$1,985**		**$212**		**$1,098**	
	10-yr Cost/2,000lb-TSS/yr	**$9,354**		**$1,166**		**$5,260**	

BMP PER-99a+b: 1st St and Hwy 95 Infiltration Basin

Rank 10/19 or 19/19

Drainage Area – 32.66 acres
Location – Between 1st and 2nd St on Highway 95
Property Ownership – Private/Public
Description – This site was identified as a major volume control practice. It is an infiltration basin that would occupy the Right of Way (and some private property). The basin was modelled at 8,000 sf, with 1.5' of ponding capacity and 2' of amended soils. An underdrain system would be connected to the existing stormsewer network. Replacement of 2 structures would be necessary; as well some creative grading or pipework to get flows to bypass the existing culvert under Hwy 95 and into the proposed basin. This system would preferably be an offline design. The cost of this basin is highly dependent on how many utilities have to be relocated, as well as what Washington County's plans are for the proposed bike trail that is to go through or adjacent to this site. The cost could be as low as $100,000 or as high $200,000+. This range in price is why there are two rankings for this practice. Either way, the volume and pollutant load reductions are high enough to rank this practice fairly high in any other given SWA.



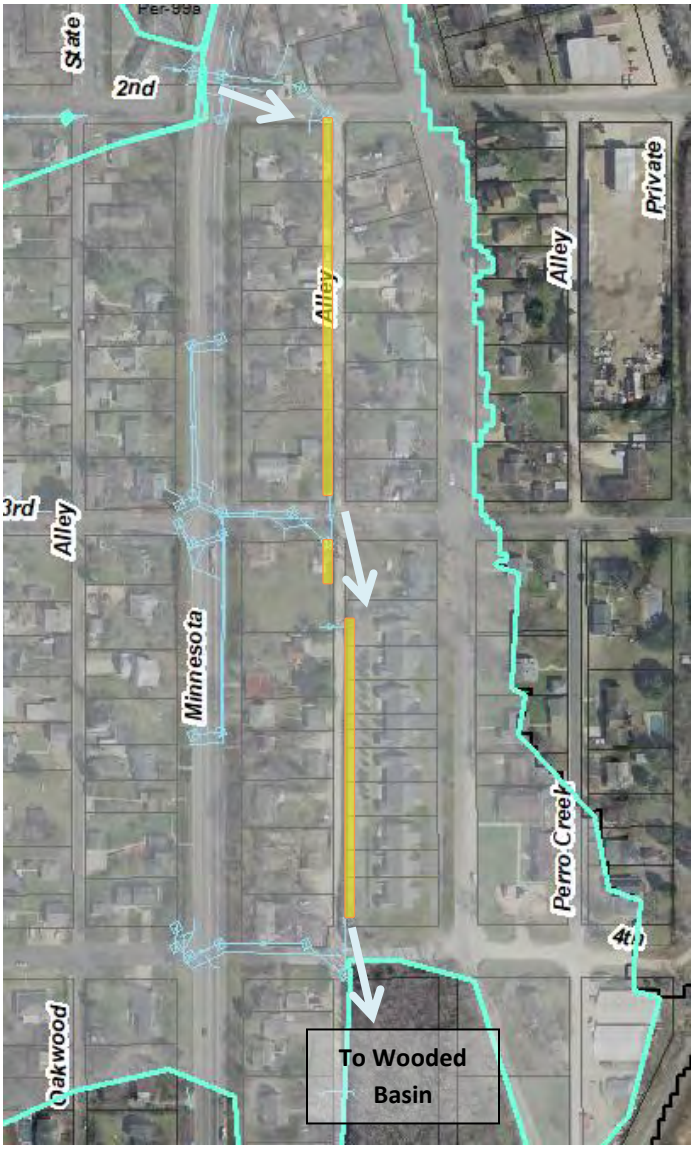
Cost/Removal Analysis		RETROFIT OPTIONS Catchment PER-99 BMP PER-99a+b: 1st St and Hwy95 Infiltration Basin	
		New trtmt	Net %
Treatment	TP (lb/yr)	10.8	14%
	TSS (lb/yr)	4580	15%
	Volume (acre-feet/yr)	6.9	13%
	Number of BMP's	1	
	BMP Size/Description	8,000	sf
	BMP Type	Highly Complex BioFiltration	

Cost		
	Materials/Labor/Design	$201,000
	Promotion & Admin Costs	$6,000
	Probable Project Cost	$207,000
	Annual O&M	$720
	10-yr Cost/lb-TP/yr	$1,985
	10-yr Cost/2,000lb-TSS/yr	$9,354

BMP 44i: Alley Swale Enhancement

Rank 02/19

Drainage Area – 96.97 acres
Location – Alley Swales from 2nd Ave to 4th Ave S, between Highway 95 and 3rd St S
Property Ownership – Private/Public
Description – The swales between these alleys are merely for conveyance of about 100 acres of runoff to the St Croix River. It is recommended that some additional treatment can be gained just by not mowing these swales. It could also be recommended to widen the swales, but additional width will not make as much of a difference as just having taller vegetation in the swales. This is an incredibly inexpensive BMP and would be a best practice for any ditch system.



Cost/Removal Analysis		RETROFIT OPTIONS *Catchment PER-99* BMP PER-99c: Alley Swale Enhancement	
		New trtmt	Net %
Treatment	TP (lb/yr)	2.5	3%
	TSS (lb/yr)	907	3%
	Volume (acre-feet/yr)	0.05	0%
	Number of BMP's	1	
	BMP Size/Description	2,400	sf
	BMP Type	Unmown Swale Minimal Veg	
Cost	Materials/Labor/Design	$1,190	
	Promotion & Admin Costs	$500	
	Probable Project Cost	$1,690	
	Annual O&M	$360	
	10-yr Cost/lb-TP/yr	$212	
	10-yr Cost/2,000lb-TSS/yr	$1,166	

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Appendices

Appendix 1 – BMP Cost Benefit Ranking Table

The table below ranks each BMP against each other, regardless of catchment location. The Project Rank column is color coded to show natural breaks in the cost-benefit values, to help visualize each BMP's relative benefit. Although there is a real difference in cost-benefit between each practice, it should be noted that all of the BMPs recommended in this report would rank very highly against many traditional practices in other SWA's that use this same methodology. Many Curb-cut infiltration basins in other studies often rank in the $1,500-$3000/per lb of TP range. Every practice in this study ranks below $2,000/per lb of TP, making them all highly desirable practices to install.

Project Rank	Catchment ID	Retrofit Name	Projects Identified	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Total Project Cost	Annual Operations & Maintenance (2018 Dolla	$Cost/ lb-TP/year (10-year)	$ Cost/ ton-TSS/year (10-year)
1	SD-40	40m: Bluff Restoration	1	15.58	36,660	0.00	$45,165	$300	$309	$263
2	SD-38	38d2: Gully Load Reductions by Fixing 38c,d,e	5	10.72	16,760	2.87	$25,625	$1,150	$346	$443
3	SD-44	44g - 44h: South Riviera Treatment Train	2	2.91	883	0.69	$10,950	$263	$466	$3,075
4	SD-42	42b +42c - 4th St Redirect and Infiltration	1	6.08	1,492	1.66	$23,889	$500	$475	$3,873
5	SD-38	38d: Divert to 38C ditch + reinstall 38d basin	2	1.57	128	0.95	$7,400	$75	$519	$2,179
6	SD-40	40h: Bungalow Bioinfiltration (large)	2	2.65	761	1.12	$13,264	$75	$529	$3,683
7	SD-43	43a: Bluff Toe Stabilization	1	32.50	76,480	0.00	$180,031	$1,040	$586	$498
8	SD-40	40i: Hwy 95 Headcut Repair + Flow Disconnect	1	1.57	1,866	0.61	$8,980	$75	$622	$1,043
9	SD-38	38c: Sed Basin Repair and Ditch Repair	2	3.81	4,948	1.38	$13,800	$1,000	$625	$962
10	SD-38	38e: Simple Infiltration and Sed Cleanout on Road	1	0.74	339	0.53	$4,425	$75	$699	$3,053
11	SD-38	38a: Complex Infiltration Basin	1	7.34	1,850	1.96	$45,375	$700	$714	$5,662
12	SD-40	40j+40k: 11th St Infiltration System	1	2.34	949	0.76	$14,420	$250	$724	$3,566
13	SD-37	37a: Osprey Ave Infiltration Basin(s)	1	5.35	1,236	1.61	$37,210	$500	$789	$6,830
14	SD-44	44a - 44e: North Riviera Treatment Train	1	2.51	847	0.74	$19,127	$75	$791	$4,694
15	SD-40	40e: Rivercrest Ditch Conversion + Ravine Stabilization	1	11.23	17,197	0.74	$123,150	$150	$1,110	$1,450
16	SD-38	38b: Mod Complex Infiltration Basin	1	3.79	1,231	1.47	$35,100	$700	$1,111	$6,840
17	SD-44	44i: Turf Swale w/Improved Soils	1	0.38	168	0.19	$4,170	$75	$1,312	$5,857
18	SD-40	40g: Bungalow Bioinfiltration (small)	1	0.47	210	0.33	$5,380	$75	$1,313	$5,838
19	SD-37	37b: Mod Complex Infiltration Basin	1	0.96	289	0.45	$15,450	$40	$1,660	$10,969