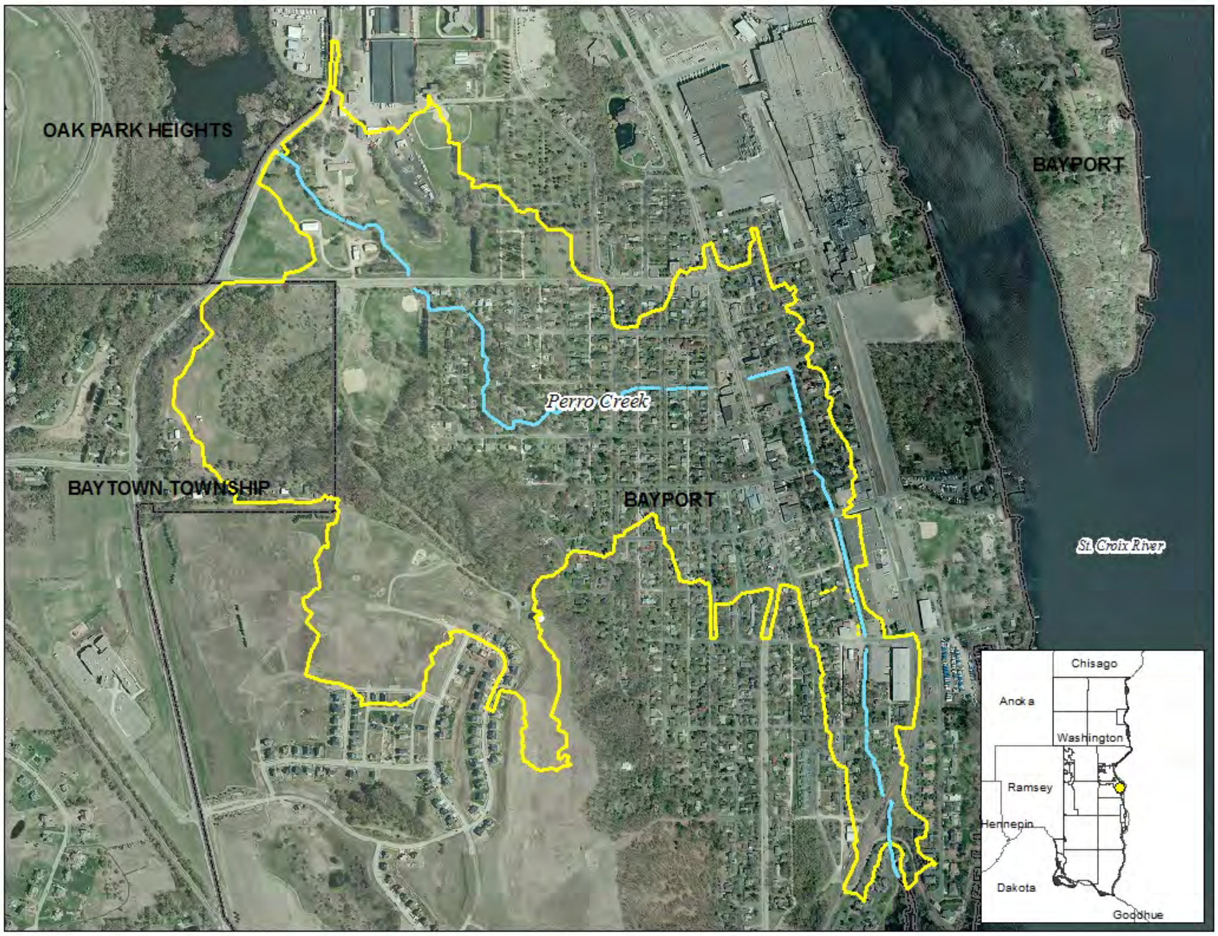
Perro Creek
Stormwater Retrofit Analysis



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for the

MIDDLE ST. CROIX WATERSHED MANAGEMENT ORGANIZATION

Contents

This report details a subwatershed stormwater retrofit analysis 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 educational outreach, stream repair, riparian zone management, discharge prevention, upland native plant community restoration, and pollutant source control. 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. This report is a vital part of overall subwatershed restoration and should be considered in light of forecasting riparian and upland habitat restoration, pollutant hot-spot treatment, agricultural and range land management, good housekeeping outreach and education, and others, within existing or future watershed restoration planning.

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 subwatershed directly discharging to the main channel of Perro Creek, and existing stormwater management practices, were analyzed for annual pollutant loading. The subwatershed was broken into eight catchment areas and evaluated for potential pollutant sources from stormwater discharges. Stormwater practice options were compared for each catchment, depending on specific site constraints and characteristics. Potential stormwater BMP retrofit locations were selected by weighing pollutant loading to the location, feasibility of installation and maintenance.

Perro Creek is a 1.8 mile urban stream that flows though Bayport, MN and discharges to the St. Croix River. Based on creek monitoring data collected upstream of the St. Croix River from 2006-2012, Perro Creek exceeds water quality standards for Total Suspended Solids (TSS), E. Coli, lead and copper. The stream also directly discharges to the St. Croix River and contributes to the Lake St. Croix impairment and TMDL for total phosphorous (TP). Utilizing bioretention based practices to reduce annual TP loading to the St. Croix River by 41.3 pounds will also result in reductions of E. Coli, lead, copper and TSS loads to the St. Croix River.

The following table summarizes the analysis results. Treatment levels (percent removal rates) for retrofit projects that resulted in a prohibitive BMP size, or number, or were too expensive to justify installation are not included. Reported treatment levels are dependent upon optimal BMP location within the catchment and total BMP area. The recommended treatment levels/amounts summarized here are based on a subjective analysis of potential BMP installations, considering estimated public participation and site constraints.

Recommended catchment rankings are based on a relative comparison of the cost per pound of phosphorus reduced over the life of the BMPs. BMP costs are estimated based on the implementation of a minimum of 1,000 square feet of BMPs initiated and constructed for the sole purpose of water quality.

A 30% reduction or 41.3 pounds of total phosphorus and a corresponding 30% (+/- 5%) reduction copper and lead could be achieved for a total cost of $511,595. These results assume water quality projects are designed and installed independent of any other infrastructure improvements. The costs of these practices are substantially lower when designed and installed as part of a larger infrastructure improvement project such as street reconstruction or commercial or institutional building redevelopment.

The process of channelization (practices to straightening and shortening the stream channel) of Perro Creek has been occurring since the establishment of the Bayport area in 1856. Channelization and removal of bank-side vegetative buffers destabilize streams and result in increased discharges of sediment and phosphorous. As part of this analysis, a rapid field analysis was conducted to identify opportunities for stream channel restoration practices to stabilize sloughing banks and restore the creeks sinuosity and native vegetated buffers. The scope of this report does not identify costs and pollutant load analysis for creek restoration projects, but potential practices are included in the catchment summary graphics.

CATCHMENT IMPLEMENTATION PRIORITY **To Achieve a 30% Reduction in TP** *($ COST/ LB of TP / YR)*				*pre BMP*	*post BMP*	*REDUCTION*
Catchment	**Term Cost/lb/yr (10 yr lifecycle)**	**Total Design and Install** *(no O&M Incl.)*	**# of BMPs**	**TP (lbs/yr)**	**TP (lbs/yr)**	**TP (lbs/yr)**
PC-4	$503	$40,420	8	15.08	10.6	4.5
PC-3	$570	$100,300	20	33.63	23.5	10.1
PC-5	$669	$227,713	30	59.54	41.7	17.9
PC-7	$782	$102,388	8	21.06	14.7	6.3
PC-6	$887	$40,775	6	8.27	5.8	2.5
	average					
TOTALS	**$682**	**$511,595**	**72**	**137.6**	**96.3**	**41.3**

TOTAL CATCHMENTS Treatment Summary (for 30% TP treatment target)			*Design and Installation Costs*			
BMP Identified	**# of BMP**	**TP Reduction (lbs)**	**Cost per SF**	**Cost Per BMP**	**Total Cost**	**Cost per lb TP Built**
Simple Bioretention w/pretreatment	47	27.26	$22.18	$4,990.00	$234,530.00	$183.05
Highly Complex Bioretention w/pretreatment	17	9.86	$45.14	$10,157.50	$172,677.50	$1,030.17
Simple Bioretention w/pretreatment	3	1.74	$22.18	$8,871.11	$26,613.33	$5,098.34
Highly Complex Bioretention w/pretreatment	3	1.74	$45.14	$18,057.78	$54,173.33	$10,378.03
Tree Pits	2	0.7	$146.53	$10,550.48	$21,100.96	$15,072.11
TOTAL *(plus $2500 Total Promo & Admin)*	**72**	41.3			**$511,595.13**	

Top-Ranked Perro Creek Catchments and TP Removal Potential

About this Document

Document Overview

The Stormwater Retrofit Analysis is a subwatershed management tool used to prioritize stormwater BMP retrofit projects based on BMP performance and cost effectiveness. This process helps maximize the value of each dollar spent.

This document is organized into four main sections that describe the general methods used, individual catchment profiles, a retrofit ranking for the subwatershed, and references used in the analysis protocol. The Appendices section provides additional information relevant to the analysis.

Under each section and subsection, project-specific information relevant to that portion of the analysis is provided with an ***Italicized Heading***.

Methods

The Methods section outlines the general procedures used when assessing the subwatershed. It details the processes of retrofit scoping, desktop analysis, retrofit field reconnaissance investigation, cost/treatment analysis, and catchment ranking. The project-specific details of each procedure are defined if different from the general standard procedures.

NOTE: the financial, technical, current landscape/stormwater system, and timeframe limits and needs are highly variable from subwatershed to subwatershed. This analysis uses some, or all, of the methods described herein.

Catchment Profiles

Each catchment profile is labeled with a numerical ID for identification purposes (e.g., Catchment PC-5, Catchment PC-7). This numerical ID is referenced when comparing results across the subwatershed. Information found in each catchment profile is described below.

Catchment Summary/Description

Within each Catchment Summary/Description section is a table that summarizes basic information including catchment size, current land cover, and estimated annual pollutant load (target pollutant(s) are specified by the LGU). A table of the principal WinSLAMM Standard Land Use model inputs and their corresponding acreage values are also reported. A brief description of the land cover, stormwater infrastructure and any other important general information is described.

Retrofit Recommendation

The Retrofit Recommendation section describes the conceptual BMP retrofit(s) selected for the catchment area and provides a description of why each specific retrofit option was chosen.

Cost/Treatment Analysis

A summary table provides for the direct comparison of the expected amount of treatment, within a catchment, that can be expected per invested dollar. In addition, the results of each catchment can be cross-referenced to optimize available capital budgets vs. load reduction goals.

Site Selection
A rendered aerial photograph highlights properties/areas suitable for BMP retrofit projects. Additional field inspections will be required to verify project feasibility, but the most ideal locations for BMP project installations are identified here.

Catchment Ranking
Catchment ranking takes into account all of the information gathered during the analysis process to create a prioritized catchment list. The list is sorted by the cost per pound of phosphorus treated within each catchment for the duration of the maintenance term (conservative estimate of BMP effective life). The final cost per pound treatment value includes installation and maintenance costs. There are many possible ways to prioritize projects within catchments, and the list provided is merely a starting point. Final catchment ranking for installation may include:

- Total amount of pollutant removal
- Non-target pollutant reductions
- BMP project visibility
- Availability of funding
- Total project costs
- Educational value

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

Appendices
The Appendices section provides supplemental information and/or data used during the analysis 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.

In areas without clearly defined studies, such as TMDL or officially listed water bodies of concern, or where little or no monitoring data exist, metrics are used to score subwatersheds against each other. In large subwatersheds (e.g., greater than 2500 acres), a similar metric scoring is used to identify areas of concern, or focus areas, for a more detailed analysis. This methodology was slightly modified from Manual 2 of the *Urban Stormwater Retrofit Practices* series.

Description of Perro Creek and the Contributing Subwatershed

Perro Creek is a 1.8 mile long urban stream that discharges to the St. Croix River. The creek is located within the city of Bayport in the northeastern suburban of the Twin Cities metropolitan area. Perro Creek conveys water from two subwatersheds that encompass a total of 660 acres of urban land use in the cities of Oak Park Heights, Stillwater and Bayport. Stormwater in the Perro Pond subwatershed is conveyed through a network of storm sewers, channels, and ponds. Perro Pond is a 53 acre DNR shallow lake that receives drainage from 340 acres of mixed urban land use primarily from the City of Oak Park Height and a small portion of Stillwater. The outlet of Perro Pond to Perro Creek is an adjustable control structure located on the southern point of Perro Pond. To alleviate flooding in Bayport, the structure is manually closed during the winter by the City of Bayport public works staff. When the southern control structure is closed, Perro Pond discharges directly to the St. Croix River through a series of storm sewers located on the north side of the pond. Stormwater in the Perro Creek direct subwatershed is conveyed to the creek through pipes and channels. The direct discharge subwatershed encompasses 323.7 acres of mixed urban land use from the City of Bayport.

Since 2006, the Washington Conservation District has collected base flow grab samples, automated flow-weighted storm composite samples and duplicate samples according to WCD Standard Operating Procedures (SOP). An automated sampler located about 1 mile upstream of the St. Croix River, continuously monitored stream flow discharge and collects event flow composite samples in the spring and summer. Data collected at this site by the WCD included total discharge, precipitation, and water quality analysis. All stream flow and chemistry data are published in the water quality monitoring reports available on the Middle St. Croix WMO website www.mscwmo.org.

Based on creek monitoring data collected upstream of the St. Croix River from 2006-2012, Perro Creek periodically exceeds water quality standards for Total Suspended Solids (TSS), E. Coli, lead, copper, and zinc. The stream also directly discharges to the St. Croix River and contributes to the Lake St. Croix impairment and TMDL for total phosphorous (TP).

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.

Perro Creek Subwatershed Scoping

Pollutants of concern for this subwatershed were identified as TP, TSS, and volume. Goals of the MSCWMO, WCD, and City of Bayport were considered.

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. An in creek analysis of Perro Creek was also conducted as part of this analysis.

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.**
	Stream Bank Restoration and Stabilization	**These bioengineered practices are designed to reduce in stream bank erosion and filter and/or infiltrate runoff.**
	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 relative pollution loading of the existing conditions. The site's conceptual BMP design is modeled to then 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 10.1. Software generated catchment boundaries were field verified and modified when necessary.
Land Use	Using GIS, land areas discharging to Perro Creek were evaluated and assigned Standard Land Uses (SLU) in WinSLAMM 10.1. These SLUs describe the average characteristics of impervious and pervious surfaces in each catchment.
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 15 to March 18.
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.

Perro Creek Treatment Analysis

For the Perro Creek Treatment analysis, each catchment (and each relevant parcel within them) was first assessed for BMP applicability given specific site constraints and soil types. Pedestrian and car traffic flow, parking needs, snow storage areas, obvious utility 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 a hypothetical BMP located at its outfall. The BMP was sized from the 10-30% treatment size and results were tabulated in the Catchment Profile section of this document.

Cost Estimates

Each resulting BMP (by percent TP-removal dictated sizing) was then assigned estimated design, installation and first-year establishment-related maintenance costs given its total cubic feet of treatment. In cases where live storage was 1 foot deep, this number roughly related to square feet of BMP coverage. An annual cost/TP-removed for each treatment level was then calculated for the life of each BMP that includes promotional, administrative and life cycle operations, and maintenance costs.

The following table provides the BMP cost estimates used to assist in cost analysis:

Average BMP Cost Estimates						
BMP	Description	Installation Materials & Labor	Annual Mainten-ance	Design Cost ($70/hr)	Installation Oversight Cost ($70/hr)	O & M Term
Rain Leader Disconnect Rain Garden	Simple residential raingarden	$7.56	$0.25/ft^2	$280/100 ft^2	$210	10
Infiltration Basin (Turf)	Amended soils with under-drains	$15.10	$2000/acre	$1120/acre	$210	10
Simple Bioinfiltration	No engineered soils or under-drains, but w/curb cuts.	$14.00	$0.75/ft^2	$1200/1000 ft^2	$210	10
Simple Bioinfiltration w/Structural Pretreatment	No engineered soils or under-drains, but w/curb cuts and structural pretreatment	$20.00	$0.75/ft^2	$1200/1000 ft^2	$210	10
Moderately Complex Biofiltration	With engineered soils, under-drains, curb cuts, no structural pretreatment but no retaining walls	$17.00	$1.50/ft^2	$2000/1000 ft^2	$290	10
Moderately Complex Biofiltration w/Structural Pretreatment	Incl. engineered soils, under-drains, curb cuts, structural pretreatment but no retaining walls	$23.00	$0.75/ft^2	$2000/1000 ft^2	$350	10
Complex Biofiltration w/Structural Pretreatment	As MCBwSP but with 1.5-2.5 ft partial perimeter walls	$27.50	$0.75/ft^2	$3750/1000ft^2	$410	10

Highly Complex Biofiltration w/Structural Pretreatment	As CBwSP but with utility or grey infrastructure modifications	$37.50	$0.75/ft^2	$7500/1000ft^2	$470	10
Curb-Cut	Cut with apron	$80.00				
Impervious Cover Conversion		$21.71	$500/acre	$1120/acre	$210	10
Stormwater Tree Pits[2]	6' x 12 ' pit with concrete vault	$140.00	$0.75/ft^2	140% above construction	$210	10
Grass/Gravel Permeable Pavement	Sand base	$18.95	$0.75/ft^2	140% above construction	$210	10
Permeable Asphalt	Granite base	$10.80	$0.75/ft^2	140% above construction	$210	10
Permeable Concrete	Granite base	$15.00	$0.75/ft^2	140% above construction	$210	10
Permeable Pavers	Granite base	$35.75	$0.75/ft^2	140% above construction	$210	10
Extended Detention		(12.98)*(CU-FT^0.75)	$1000/acre	3$2800/acre	$210	10
Wet Pond		(277.89)*(CU-FT^0.553)	$1000/acre	3$2800/acre	$210	10
Perimeter Sand Filter		$259.20				10
Structural Sand Filter	(including peat, compost or iron amendment))	$22.04	$250/25ft	$300/25ft	$210	10
Underground Sand Filter		$99.08	$0.75/ft^2	140% above construction	$210	10
Rain Barrels	Does not include pump or distribution	$25.00	$25	NA	$210	10
Cisterns	Does not include pump or distribution	$16.00	$100	NA	$210	10
Dry Swale[1]	With soil amendments	$7.13	$0.75/ft^2	$280/100 ft^2	$210	10
Water Quality Swale[1]	With soil replacement and check dams	$15.01	$0.75/ft^2	$1120/1000 ft^2	$420	10
French Drain/Dry Well		$15.00	$100	20% above construction	$210	10
Stormwater Planter (ultra urban)	Usually a stormwater disconnect BMP	$35.86	$0.75/ft^2	20% above construction	$210	10

[1] Assumed to be 15 feet in width.

[2] Assumed ultra-urban linear application.

Perro Creek Cost Analysis

For the Perro Creek cost analysis, promotion, installation and administration for each practice was estimated based on the actual costs of similar water quality retrofit projects in Washington and Dakota County from 2010-2013. Project costs assume the implementation of an average of five practices or 1000 cubic feet of treatment per project area. Cost savings occur when water quality practices are designed and installed in conjunction with larger capital improvement projects such as reconstruction or redevelopment. Annual Operation & Maintenance referred to the ft^2 estimates provided in the preceding table.

Step 5: Evaluation and Ranking

The results of each site were analyzed for cost/treatment to prescribe the most cost-efficient level of treatment.

Perro Creek Evaluation and Ranking

In the Perro Creek evaluation and ranking, the recommended level of treatment for each catchment, as reported in the Executive Summary table, was chosen by selecting the expected level of treatment considering public buy-in and above a minimal amount needed to justify crew mobilization and outreach efforts to the area. Should the cumulative expected load reduction of the recommended catchment treatment levels not meet LGU goals, a higher level of treatment (as described in the Catchment Profile tables) should be selected. The maps associated with each catchment show potential BMP locations as determined by field review. To meet treatment level goals for a catchment, a minimum percentage of potential BMPs (equaling or exceeding the “BMP Surface Area”) must be installed within that catchment.

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.

The recommended level of treatment reported in the Ranking Table is determined by weighing the cost-efficiency vs. site specific limitations about what is truly practical in terms of likelihood of being granted access to optimal BMP site locations, expected public buy-in (partnership), and crew mobilization in relation to BMP spatial grouping.

For development of the Perro Creek catchment profile section, 5 out of 9 catchments were selected as the first-tier areas for stormwater retrofit efforts. Those catchments that are land locked or have minimal impervious surface area contributing to Perro Creek were not modeled or further analyzed in this analysis (omitted from the analysis were catchments PC-1, PC-2, PC-8, and PC-9).

WinSLAMM Standard Land Use Codes		
Land Uses	Codes	Definition
Residential	HDRNA	High Density Residential without Alleys
	HDRWA	High Density Residential with Alleys
	MDRNA	Medium Density Residential without Alleys
	MDRWA	Medium Density Residential with Alleys
	LDR	Low Density Residential
	MFR	Multiple Family Residential
Commercial	STRIPCOM	Strip Commercial
	DOWNTOWN	Commercial Downtown
Industrial	MI	Medium Industrial
	LI	Non-Manufacturing
Institutional	SCH	Education Facilities
	INST	Miscellaneous Institutional
Other	PARK	Parks
	OPEN	Undeveloped
	CEM	Cemetery
Freeway	FREE	Freeways

Catchment PC-4

Term Cost Rank = #1

Base Load Summary *Catchment PC-4*	
Acres	19.4
Volume (acre-feet/yr)	9.0
TP (lb/yr)	15.1
TSS (lb/yr)	3983

WinSLAMM Input Summary *Catchment PC-4*			
Standard Land Use Code	**Acres**	**Standard Land Use Code**	**Acres**
CEM	0.98	MDRWA	11.55
FREE	0.41	MFR	0.31
LDR	0.14	OPEN	1.47
MDRNA	4.58		
TOTAL			**19.44**

DESCRIPTION

This catchment is comprised primarily of medium-density residential properties with gravel alleys. Stormwater runoff discharges into the creek though a deteriorated storm sewer system or through a combination of asphalt-lined or grass-lined ditch system that eventually converges with the storm sewer system.

RETROFIT RECOMMENDATION

A combination of bioinfiltraiton and biofiltration with coarse sediment pretreatment devices and a water quality swale are recommended for this catchment. In certain locations, elevations may require small retaining walls to achieve level depressional areas required to infiltrate or filtrate stormwater. Modeling indicates eight BMPs will achieve a 30% Total Phosphorous reduction in Catchment PC-4 of 4.5 pounds.

Modeling does not account for increased loading from gravel alleys. It is evident that gravel alleys contribute larger than modeled results for total phosphorous (TP) and total suspended solids (TSS) loading. Therefore, targeted outreach and assistance are prioritized to disconnect contributing impervious areas such as garages and rear lot parking pads from the gravel alleys.

BMP Treatment Summary *(for 30% TP treatment target of Catchment PC-4)*			*INSTALLED/DESIGNED*		
BMP Identified	**# of BMP**	**SF per BMP**	**Cost per SF**	**Cost Per BMP**	**Total Cost**
Simple Bioretention w/pretreatment	8	225	$22.18	$4,990.00	$39,920.00
TOTAL *(plus $500 Promo & Admin)*	**8**				**$40,420.00**

Catchment PC-4

Term Cost Rank = #1

	Cost/Benefit Analysis *Catchment PC-4*		*Reductions*		
	Unit	***Baseline***	**10%**	**20%**	**30%**
TREATMENT	**# BMP Projects Needed**	-	2	5	8
	Live Storage Volume (cubic feet)	-	420	839	1,272
	TP (lb/yr)	**15.08**	13.6	12.1	10.6
	TSS (lb/yr)	**3983.0**	3,513	3,043	2,573
	TSS (% reduced)	-	11.8%	23.6%	35.4%
	Volume (acre-feet/yr)	**9.0**	8.1	7.3	6.4
	Volume (% reduced)	-	9.8%	19.5%	29.3%
COST	**Design and Installation**	-	$9,980	$24,950	$39,920
	Promotion & Admin Costs	-	$500	$500	$500
	Total Project Cost	-	$10,480	$25,450	$40,420
	Annual O&M	-	$420	$839	$1,272
	Term Cost/lb/yr (30 yr)	-	**$108**	**$281**	**$503**

Catchment PC-3

Term Cost Rank = #2

Base Load Summary *Catchment PC-3*	
Acres	65.4
Volume (acre-feet/yr)	21.0
TP (lb/yr)	47.0
TSS (lb/yr)	13822

WinSLAMM Input Summary *Catchment PC-3*	
Standard Land Use Code	**Acres**
CEM	4.81
FREE	1.16
INST	0.00
LDR	0.48
MDRNA	25.45
OPEN	26.90
PARK	6.57
TOTAL	**65.37**

DESCRIPTION

This catchment is comprised primarily of medium-density residential properties without alleys. Stormwater runoff discharges into the creek though a deteriorated storm sewer system, through a combination of asphalt lined and grass-lined ditch system, and at the intersection of Perro Creek and 9th street stormwater discharges directly into the creek.

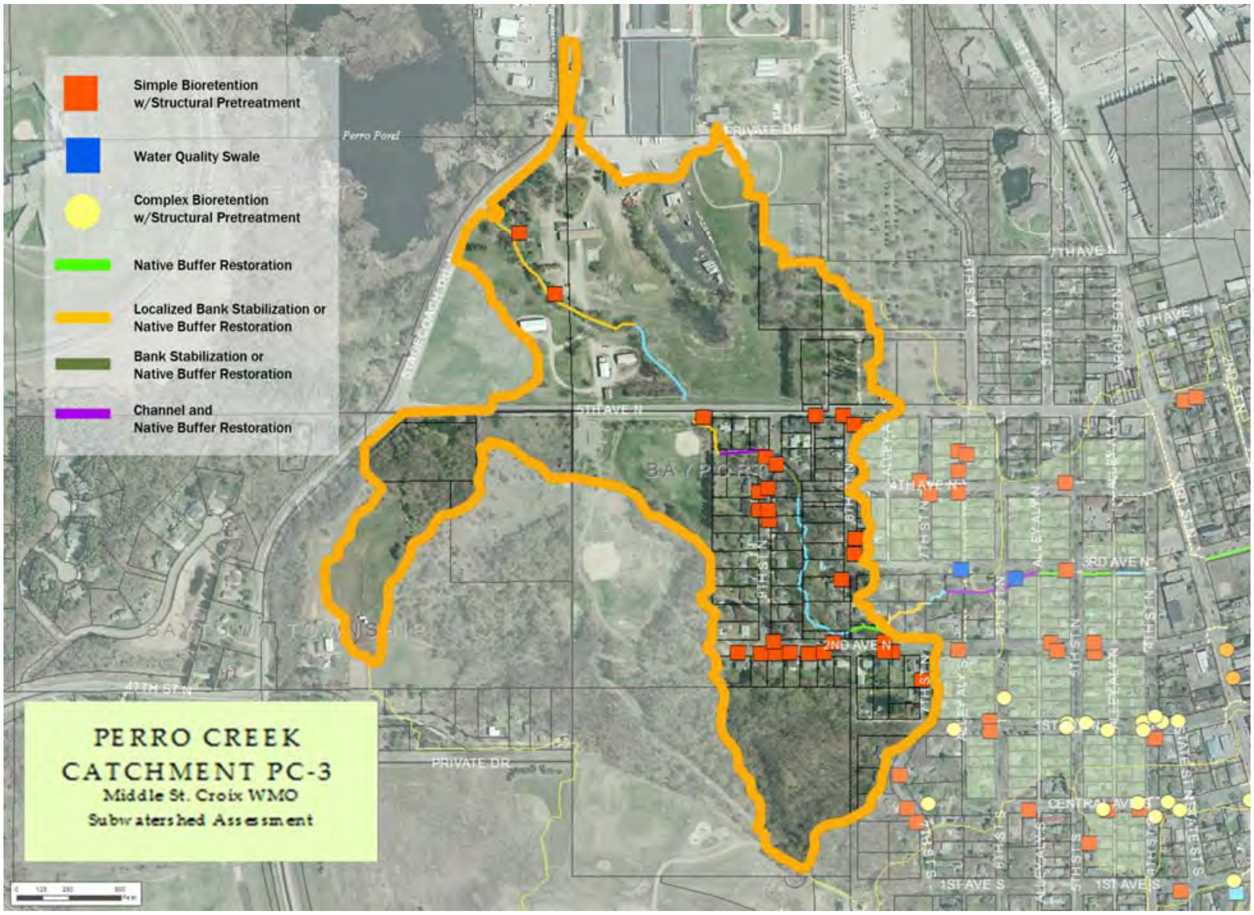
RETROFIT RECOMMENDATION

A combination of bioinfiltraiton and biofiltration with coarse sediment pretreatment devices and a water quality swale are recommended for this catchment. In certain locations, elevations may require small retaining walls to achieve level depressional areas required to infiltrate or filtrate stormwater. Modeling indicates eight BMPs will achieve a 30% Total Phosphorous reduction in Catchment PC-3 of 10.1 pounds.

BMP Treatment Summary *(for 30% TP treatment target of Catchment PC-3)*			*INSTALLED/DESIGNED*		
BMP Identified	**# of BMP**	**SF per BMP**	**Cost per SF**	**Cost Per BMP**	**Total Cost**
Simple Bioretention w/pretreatment	20	225	$22.18	$4,990.00	$99,800.00
TOTAL *(plus $500 Promo & Admin)*	**20**				**$100,300.00**

Catchment PC-3

Term Cost Rank = #2



	Cost/Benefit Analysis *Catchment PC-3*		*Reductions*		
	Unit	***Baseline***	**10%**	**20%**	**30%**
TREATMENT	**# BMP Projects Needed**	-	7	13	20
	Live Storage Volume (cubic feet)	-	1,117	2,233	3,384
	TP (lb/yr)	**33.63**	30.3	26.9	23.5
	TSS (lb/yr)	**8983.0**	7,950	6,917	5,884
	TSS (% reduced)	-	11.5%	23.0%	34.5%
	Volume (acre-feet/yr)	**21.0**	18.8	16.5	14.3
	Volume (% reduced)	-	10.7%	21.3%	32.0%
COST	**Design and Installation**	-	$34,930	$64,870	$99,800
	Promotion & Admin Costs	-	$500	$500	$500
	Total Project Cost	-	$35,430	$65,370	$100,300
	Annual O&M	-	$1,117	$2,234	$3,385
	Term Cost/lb/yr (30 yr)	-	**$154**	**$326**	**$570**

Catchment PC-5

Term Cost Rank = #3

Base Load Summary *Catchment PC-5*	
Acres	71.4
Volume (acre-feet/yr)	41.8
TP (lb/yr)	59.5
TSS (lb/yr)	17129

WinSLAMM Input Summary *Catchment PC-5*			
Standard Land Use Code	**Acres**	**Standard Land Use Code**	**Acres**
DOWNTOWN	1.30	OPEN	3.68
FREE	2.78	PARK	3.67
INST	4.56	SCH	2.34
MDRNA	19.46	STRIPCOM	2.24
MDRWA	31.40		
TOTAL			**71.43**

DESCRIPTION

This catchment contributes the largest pollutant loads to Perro Creek. It is comprised of primarily medium-density residential properties with gravel alleys. Runoff is collected and conveyed to the creek in one of three ways: though a deteriorated storm sewer system; through a combination of asphalt lined and grass-lined ditch system, and from the streets directly into the creek.

RETROFIT RECOMMENDATION

A combination of bioinfiltraiton and biofiltration with coarse sediment pretreatment devices and a water quality swale are recommended for this catchment. A 10% reduction of TP could be achieved through the use of moderate cost BMPs. Slopes, density of impervious surface and stormwater rates pose challenges for retrofitting stormwater practices to achieve 20 and 30% reductions in this catchment. High cost BMP locations require alteration of street widths and additional stormwater infrastructure. If coordinated with a larger street or stormwater infrastructure project, design and installation costs will be much lower. Through the combination of BMPs identified modeling indicates a 30% TP reduction or 17.9 pounds can be achieved in catchment PC-5.

Modeling does not account for increased loading from gravel alleys. It is evident that gravel alleys contribute larger than modeled results for total phosphorous (TP) and total suspended solids (TSS) loading. Therefore, targeted outreach and assistance are prioritized to disconnect contributing impervious areas such as garages and rear lot parking pads from the gravel alleys.

BMP Treatment Summary *(for 30% TP treatment target of Catchment PC-5)*			*INSTALLED/DESIGNED*		
BMP Identified	**# of BMP**	**SF per BMP**	**Cost per SF**	**Cost Per BMP**	**Total Cost**
Simple Bioretention w/pretreatment	15	225	$22.18	$4,990.50	$74,857.50
Highly Complex Bioretention w/pretreatment	15	225	$45.14	$10,156.50	$152,347.50
TOTAL *(plus $500 Promo & Admin)*	**30**				**$227,705.00**

Catchment PC-5

Term Cost Rank #3

	Cost/Benefit Analysis *Catchment PC-5*		*Reductions*		
	Unit	***Baseline***	**10%**	**20%**	**30%**
TREATMENT	**# BMP Projects Needed**	**-**	10	20	30
	Live Storage Volume (cubic feet)	**-**	1,682	3,363	5,095
	TP (lb/yr)	**59.54**	53.6	47.6	41.7
	TSS (lb/yr)	**17129.0**	15,334	13,539	11,744
	TSS (% reduced)	**-**	10.5%	21.0%	31.4%
	Volume (acre-feet/yr)	**41.8**	37.5	33.3	29.0
	Volume (% reduced)	**-**	10.2%	20.4%	30.5%
COST	**Design and Installation**	**-**	$49,900	$125,638	$227,213
	Promotion & Admin Costs	**-**	$500	$500	$500
	Total Project Cost	**-**	$50,400	$126,138	$227,713
	Annual O&M	**-**	$1,682	$3,363	$5,095
	Term Cost/lb/yr (10 yr)	**-**	**$125**	**$335**	**$669**

Catchment PC-7

Term Cost Rank = #4

Base Load Summary *Catchment PC-7*	
Acres	30.7
Volume (acre-feet/yr)	16.5
TP (lb/yr)	22.7
TSS (lb/yr)	7793

WinSLAMM Input Summary *Catchment PC-7*			
Standard Land Use Code	**Acres**	**Standard Land Use Code**	**Acres**
FREE	1.29	MI	1.70
LI	4.08	OPEN	4.72
MDRNA	11.41	STRIPCOM	1.02
MDRWA	6.47		
TOTAL			**30.69**

DESCRIPTION

This catchment is comprised of primarily medium-density residential properties without alleys. It also includes stormwater runoff from Hwy 95 and highly impervious light Industrial land uses. Runoff is conveyed to the creek though a deteriorated storm sewer system and at many locations directly discharged from the streets into the creek.

RETROFIT RECOMMENDATION

A combination of infiltration basins, bioinfiltraiton, biofiltration and tree pits with coarse sediment pretreatment devices are recommended for this catchment. A potential for a large infiltration basin designed to treat multiple acres of stormwater runoff was identified at the intersection of Minnesota St and 1st Ave S. Modeling indicates 8 BMPs will achieve the 30% TP reduction or 6.3 lbs. in catchment PC-7.

Modeling does not account for increased loading from gravel alleys. It is evident that gravel alleys contribute larger than modeled results for total phosphorous (TP) and total suspended solids (TSS) loading. Therefore, targeted outreach and assistance are prioritized to disconnect contributing impervious areas such as garages and rear lot parking pads from the gravel alleys.

BMP Treatment Summary *(for 30% TP treatment target of Catchment PC-7)*			*INSTALLED/DESIGNED*		
BMP Identified	**# of BMP**	**sf per BMP**	**Cost per SF**	**Cost Per BMP**	**Total Cost**
Simple Bioretention w/pretreatment	3	400	$22.18	$8,871.11	$26,613.33
Highly Complex Bioretention w/pretreatment	3	400	$45.14	$18,057.78	$54,173.33
Tree Pits *(6'x12' surface area, 4' deep cell)*	2	72	$146.53	$10,550.48	$21,100.96
TOTAL *(plus $500 Promo & Admin)*	**8**				**$102,387.63**

Catchment PC-7

Term Cost Rank #4

	Cost/Benefit Analysis *Catchment PC-7*		*Reductions*		
	Unit	***Baseline***	**10%**	**20%**	**30%**
TREATMENT	**# BMP Projects Needed**	-	3	5	8
	Live Storage Volume (cubic feet)	-	408	815	1,236
	TP (lb/yr)	**21.06**	19.0	16.8	14.7
	TSS (lb/yr)	**6555.0**	5,742	4,929	4,117
	TSS (% reduced)	-	12.4%	24.8%	37.2%
	Volume (acre-feet/yr)	**16.5**	14.7	12.9	11.2
	Volume (% reduced)	-	10.2%	20.4%	30.6%
COST	**Design and Installation**	-	$26,613	$62,729	$101,888
	Promotion & Admin Costs	-	$500	$500	$500
	Total Project Cost	-	$27,113	$63,229	$102,388
	Annual O&M	-	$426	$851	$1,290
	Term Cost/lb/yr (30 yr)	-	**$166**	**$426**	**$782**

Catchment # PC-6

Term Cost Rank = #5

Base Load Summary *Catchment PC-6*	
Acres	9.4
Volume (acre-feet/yr)	6.6
TP (lb/yr)	8.3
TSS (lb/yr)	2416

WinSLAMM Input Summary *Catchment PC-6*	
Standard Land Use Code	**Acres**
DOWNTOWN	1.01
FREE	0.72
LI	0.00
MDRNA	1.03
MDRWA	5.97
OPEN	0.23
STRIPCOM	0.44
TOTAL	**9.40**

DESCRIPTION

This catchment is comprised of primarily medium-density residential properties with gravel alleys and highly impervious land uses. Runoff is conveyed to the creek though a storm sewer system and is directly discharged from the streets into the creek at Central Avenue. The western portion of this small catchment is steeply sloped.

RETROFIT RECOMMENDATION

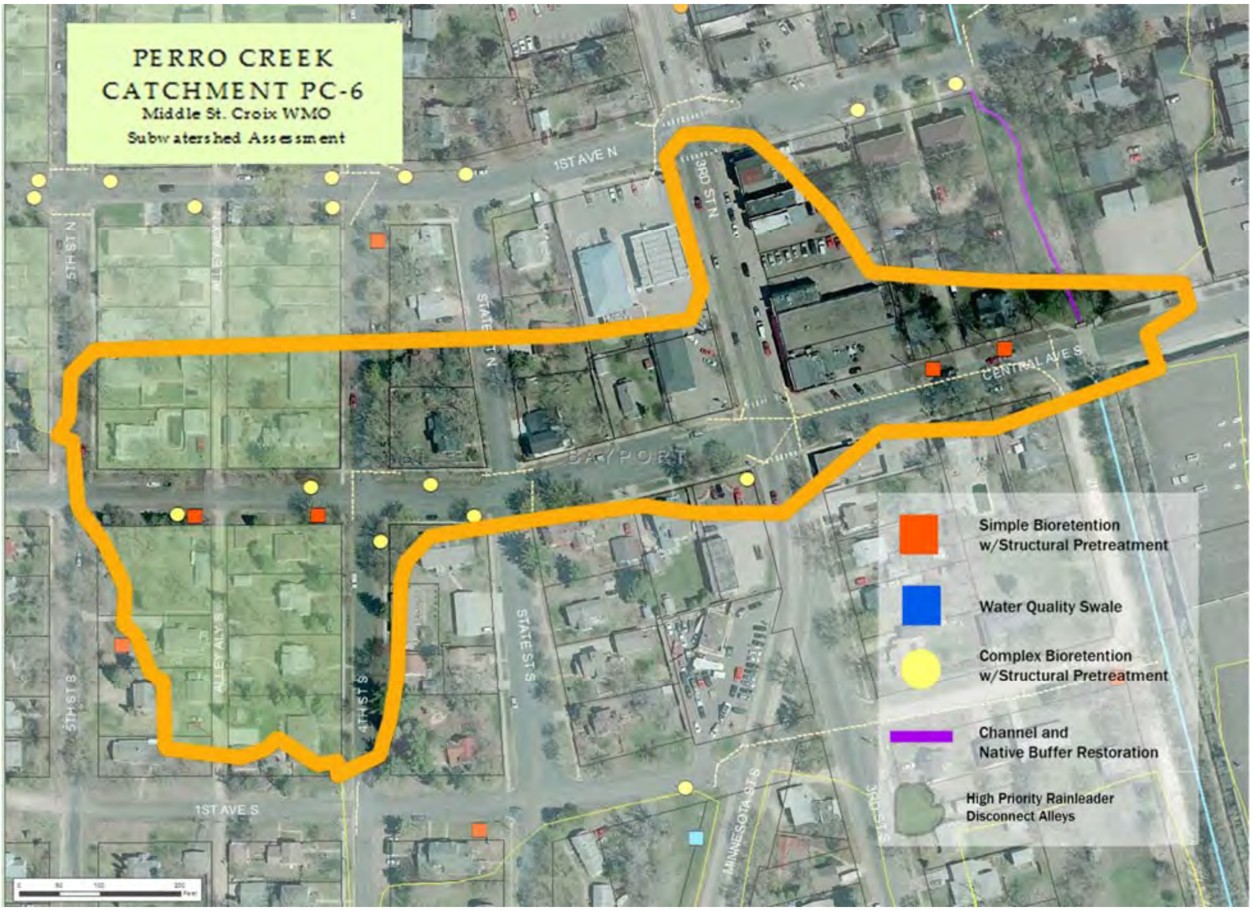
A combination of bioinfiltration and biofiltration with coarse sediment pretreatment devices are recommended for this catchment. A 20% reduction or 1.65 lbs. of TP can be achieved through the use of moderate cost BMPs. Slopes and density of impervious surface pose challenges for retrofitting stormwater practices to achieve 20% and 30% reductions in this catchment. High cost BMP locations require alteration of street widths and additional stormwater infrastructure. If coordinated with a larger street or stormwater infrastructure, practice design and installation costs will be lower. Modeling indicates 6 BMPs will achieve the 30% TP reduction or 2.47 lbs. in catchment PC-6.

Modeling does not account for increased loading from gravel alleys. It is evident that gravel alleys contribute larger than modeled results for total phosphorous (TP) and total suspended solids (TSS) loading. Therefore, targeted outreach and assistance are prioritized to disconnect contributing impervious areas such as garages and rear lot parking pads from the gravel alleys.

BMP Treatment Summary *(for 30% TP treatment target of Catchment PC-6)*			*INSTALLED/DESIGNED*		
BMP Identified	**# of BMP**	**SF per BMP**	**Cost per SF**	**Cost Per BMP**	**Total Cost**
Simple Bioretention w/pretreatment	4	225	$22.18	$4,990.00	$19,960.00
Highly Complex Bioretention w/pretreatment	2	225	$45.14	$10,157.50	$20,315.00
TOTAL *(plus $500 Promo & Admin)*	**6**				**$40,775.00**

Catchment # PC-6

Term Cost Rank = #5



	Cost/Benefit Analysis *Catchment PC-6*		*Reductions*		
	Unit	***Baseline***	**10%**	**20%**	**30%**
TREATMENT	**# BMP Projects Needed**	**-**	2	4	6
	Live Storage Volume (cubic feet)	**-**	349	698	1,058
	TP (lb/yr)	**8.27**	7.4	6.6	5.8
	TSS (lb/yr)	**2416.0**	2,155	1,894	1,633
	TSS (% reduced)	**-**	10.8%	21.6%	32.4%
	Volume (acre-feet/yr)	**6.6**	5.9	5.2	5.0
	Volume (% reduced)	**-**	8.1%	16.2%	24.3%
COST	**Design and Installation**	**-**	$9,980	$19,960	$40,275
	Promotion & Admin Costs	**-**	$500	$500	$500
	Total Project Cost	**-**	$10,480	$20,460	$40,775
	Annual O&M	**-**	$349	$698	$1,058
	Term Cost/lb/yr (10 yr)	**-**	**$188**	**$415**	**$887**

Catchment Ranking

CATCHMENT IMPLEMENTATION PRIORITY **To Achieve a 30% Reduction in TP** *($ COST/ LB of TP / YR)*				*pre BMP*	*post BMP*	*REDUCTION*
Catchment	**Term Cost/lb/yr (10 yr lifecycle)**	**Total Design and Install** *(no O&M Incl.)*	**# of BMPs**	**TP (lbs/yr)**	**TP (lbs/yr)**	**TP (lbs/yr)**
PC-4	$503	$40,420	8	15.08	10.6	4.5
PC-3	$570	$100,300	20	33.63	23.5	10.1
PC-5	$669	$227,713	30	59.54	41.7	17.9
PC-7	$782	$102,388	8	21.06	14.7	6.3
PC-6	$887	$40,775	6	8.27	5.8	2.5
	average					
TOTALS	**$682**	**$511,595**	**72**	**137.6**	**96.3**	**41.3**

TOTAL CATCHMENTS Treatment Summary (for 30% TP treatment target)			*Design and Installation Costs*			
BMP Identified	**# of BMP**	**TP Reduction (lbs)**	**Cost per SF**	**Cost Per BMP**	**Total Cost**	**Cost per lb TP Built**
Simple Bioretention w/pretreatment	47	27.26	$22.18	$4,990.00	$234,530.00	$183.05
Highly Complex Bioretention w/pretreatment	17	9.86	$45.14	$10,157.50	$172,677.50	$1,030.17
Simple Bioretention w/pretreatment	3	1.74	$22.18	$8,871.11	$26,613.33	$5,098.34
Highly Complex Bioretention w/pretreatment	3	1.74	$45.14	$18,057.78	$54,173.33	$10,378.03
Tree Pits	2	0.7	$146.53	$10,550.48	$21,100.96	$15,072.11
TOTAL *(plus $2500 Total Promo & Admin)*	**72**	41.3			**$511,595.13**	

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Appendices

Appendix 1 – Catchments not included in Ranking Table

Catchments not included in ranking table were excluded for a number of reasons, mainly involving density of impervious surface and opportunities for BMP retrofits. After BMPs are installed within the priority catchments, it is recommended that the watershed revisit the entire subwatershed to determine other catchments that, while they may be conducive to retrofitting, were not considered a high priority for this report.

Appendix 2 – Summary of Protocol

This protocol attempts to provide a sufficient level of detail to rapidly assess subwatersheds or catchments of variable scales and land uses. It provides the assessor defined project goals that aid in quickly narrowing down multiple potential sites to a point where the assessor can look critically at site-specific driven design options that affect, sometimes dramatically, BMP selection. We feel that the time commitment required for this methodology is appropriate for most initial analysis applications and has worked well thus far for the Perro Creek Analysis.

Appendix 3 – Definitions

The following terms are used throughout this document and define the basic terminology used to talk about watersheds and restoration. Many of the terms can have different meanings in different contexts, so it is imperative to define their use within this document.

Best Management Practice (BMP) – One of many different structural or non-structural methods used to treat runoff, including such diverse measures as ponding, street sweeping, bioretention, and infiltration.

Biofiltration Basin- A soil and plant based stormwater management practice that infiltrates a portion of stormwater captured, but conveys excess filtered water through an underdrain.

Bioinfiltration Basin – A soil and plant-based stormwater management practice that infiltrates all runoff captured in the basin.

Catchment – Land area within a subwatershed generally having a drainage area of 1 – 100 acres for urban areas, where all water drains to a particular point. Several catchments make up a subwatershed. The existing stormwater infrastructure helps to define a catchment; therefore it is critical to obtain accurate stormwater infrastructure mapping information (including, at a minimum, the location of inlets and pipes, flow direction, and outfall locations) before undertaking a stormwater analysis process.

Raingarden – A landscaping feature that is planted with native perennial plants and is used to manage stormwater runoff from impervious surfaces such as roofs, sidewalks, roads, and parking lots.

Retrofit – The introduction of a new or improved stormwater management element where it either never existed or did not operate effectively.

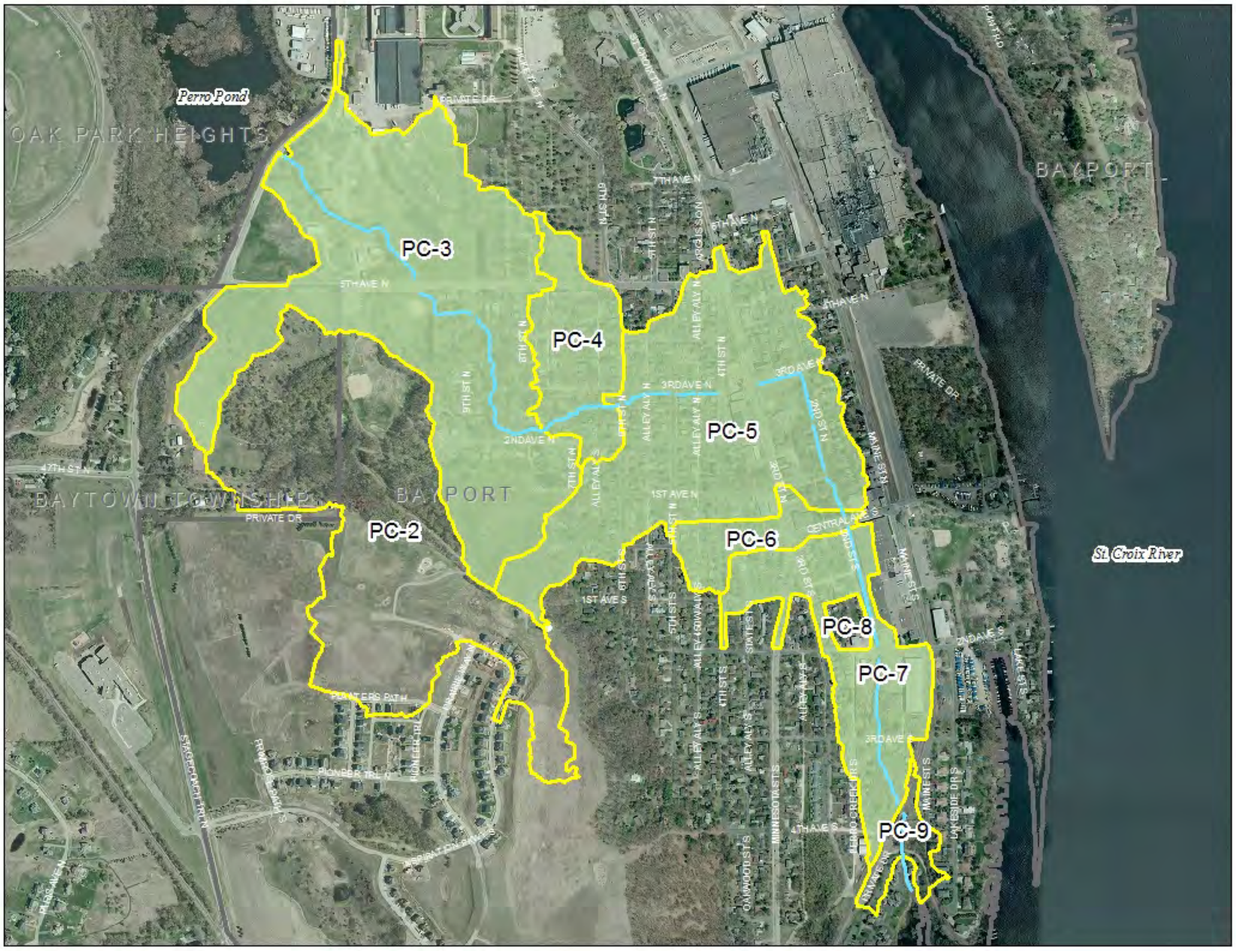
Stormwater – Water that is generated by rainfall or snowmelt that causes runoff and is often routed into drain systems for treatment or conveyance.

Subwatershed – Land area within a watershed generally having a drainage area of more than 500 acres, where all water drains to a particular point. Several subwatersheds make up a watershed. An example would be the Perro Creek subwatershed, which is within the boundaries of the Middle St. Croix Water Management Organization (the watershed). Subwatersheds are entirely based on hydrologic conditions, not political boundaries.

Urban – Any watershed or subwatershed with more than 10% total impervious cover.

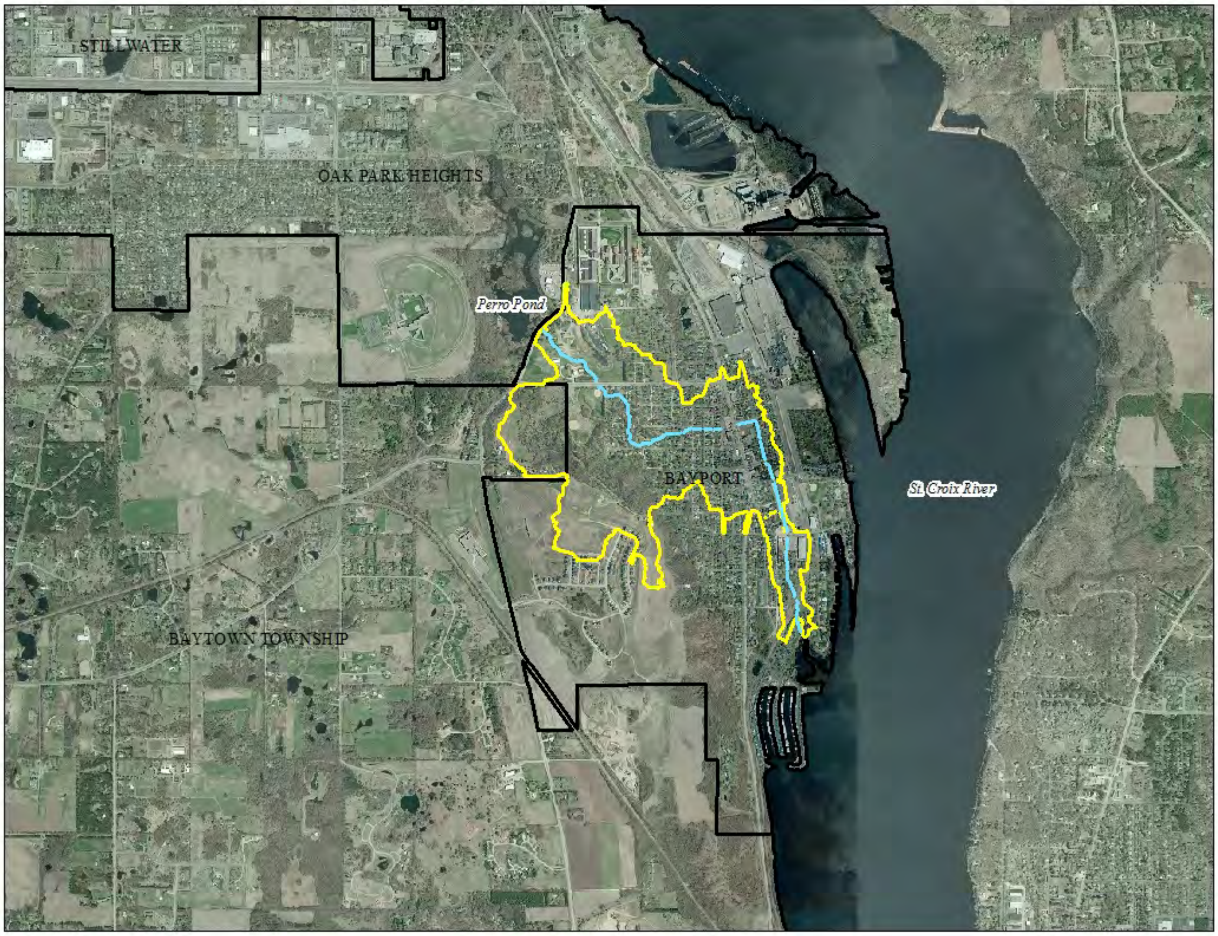
Watershed – Land area defined by topography, where all water drains to a particular point. Watershed drainage areas are large, ranging from 20 to 100 square miles or more, and are made up of several subwatersheds. There are currently 8 watersheds located either wholly or partially within Washington County, each defined along political boundaries that attempt to mimic hydrologic boundaries.

Appendix 4 – Subwatershed Maps

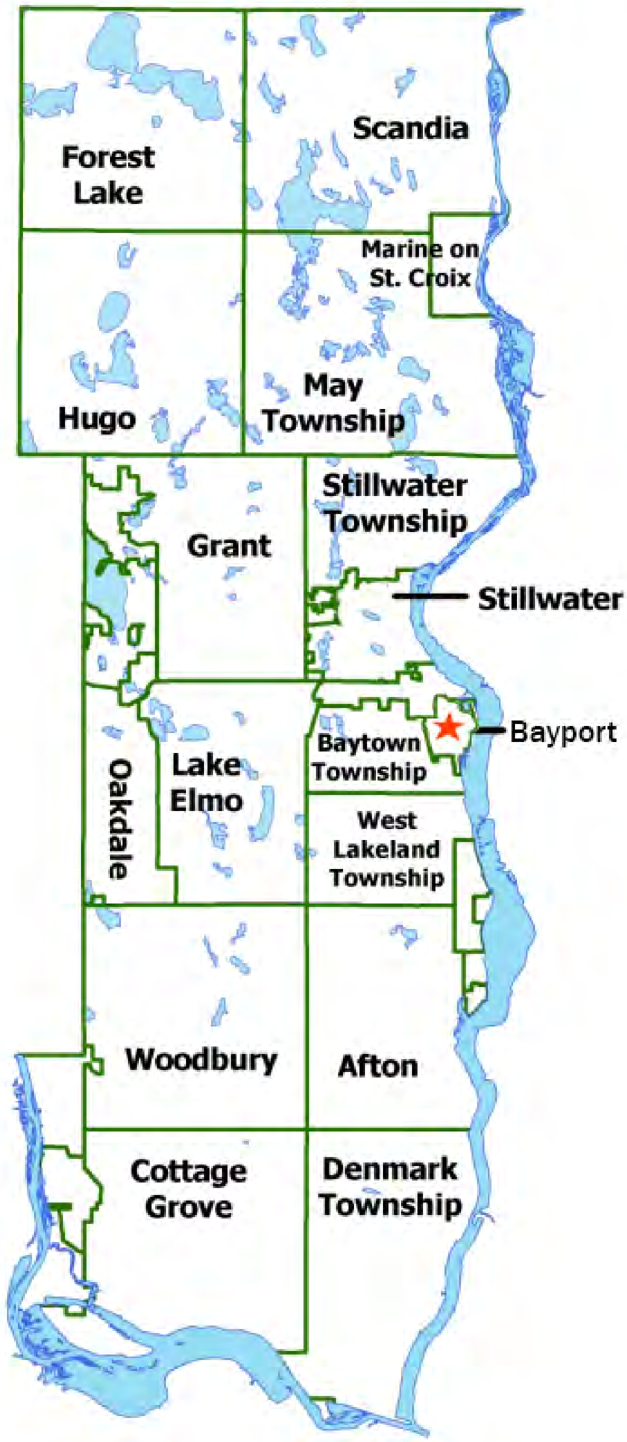


Perro Creek Subwatershed – Aerial Photo (2013)

Priority Catchments are Shaded

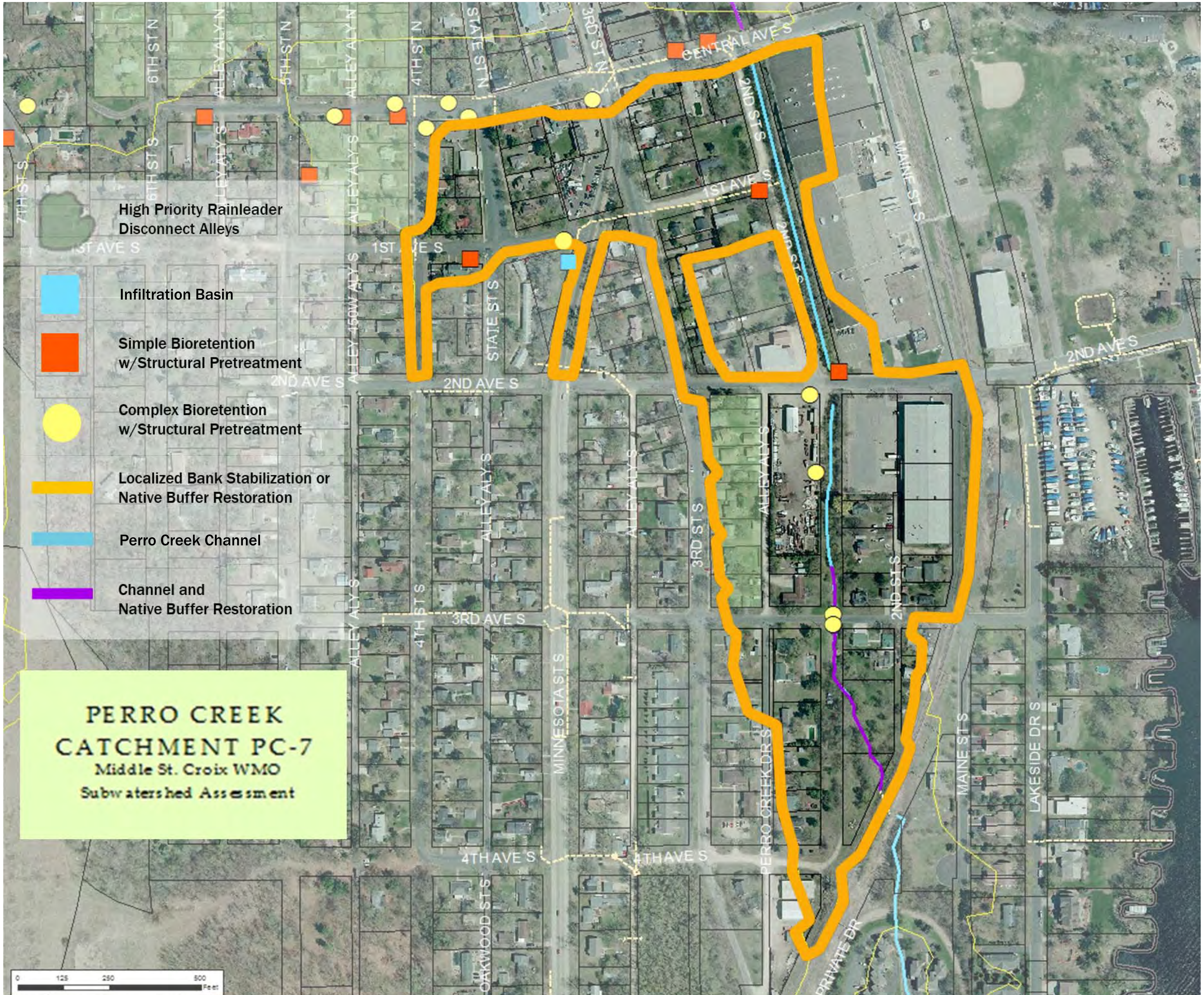


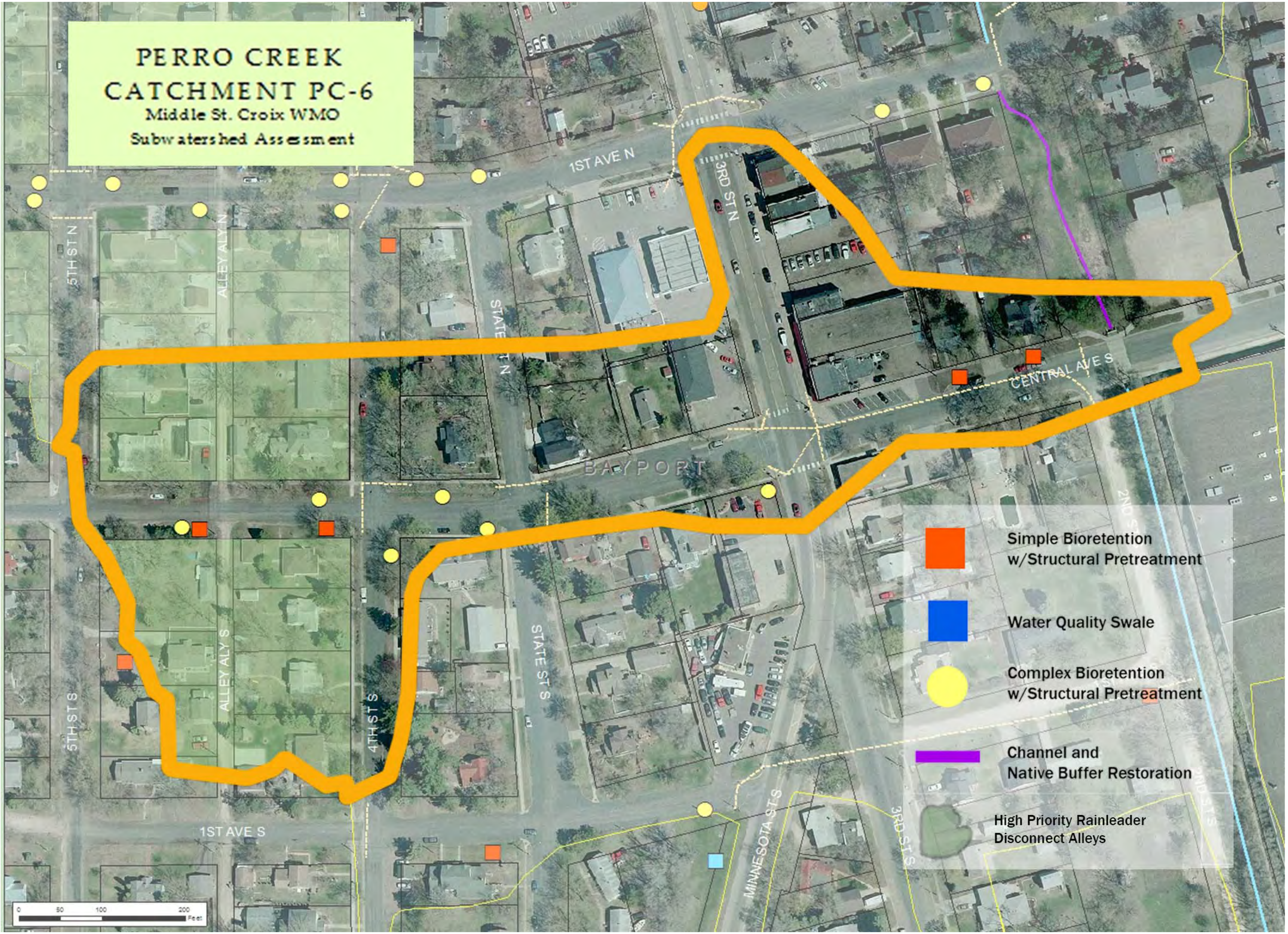
Location of the Perro Creek Subwatershed in Bayport, MN



Location of the Perro Creek Subwatershed within Washington County

Appendix 5 – Catchment Maps


High Priority Rainleader Disconnect Alleys
Infiltration Basin
Simple Bioretention w/Structural Pretreatment
Complex Bioretention w/Structural Pretreatment
Localized Bank Stabilization or Native Buffer Restoration
Perro Creek Channel
Channel and Native Buffer Restoration
PERRO CREEK
CATCHMENT PC-7
Middle St. Croix WMO
Subwatershed Assessment
CENTRAL AVE S
1ST AVE S
2ND AVE S
3RD AVE S
4TH AVE S
2ND ST S
3RD ST S
4TH ST S
STATE ST S
MINNESOTA ST S
MAINE ST S
LAKESIDE DR S
PERRO CREEK DR S
OAKWOOD ST S
PRIVATE DR
0 125 250 500 Feet


PERRO CREEK
CATCHMENT PC-6
Middle St. Croix WMO
Subwatershed Assessment
1ST AVE N
3RD ST N
5TH ST N
ALLEY ALY N
STATE ST N
CENTRAL AVE S
BAYPORT
2ND ST S
STATE ST S
ALLEY ALY S
5TH ST S
4TH ST S
1ST AVE S
MINNESOTA ST S
3RD ST S
Simple Bioretention w/Structural Pretreatment
Water Quality Swale
Complex Bioretention w/Structural Pretreatment
Channel and Native Buffer Restoration
High Priority Rainleader Disconnect Alleys


Tree Pits (or similar)
High Priority Rainleader Disconnect Alleys
Simple Bioretention w/Structural Pretreatment
Water Quality Swale
Complex Bioretention w/Structural Pretreatment
Native Buffer Restoration
Localized Bank Stabilization or Native Buffer Restoration
Bank Stabilization or Native Buffer Restoration
Channel and Native Buffer Restoration
PERRO CREEK
CATCHMENT PC-5
Middle St. Croix WMO
Subwatershed Assessment
6TH AVE N
5TH AVE N
4TH AVE N
3RD AVE N
2ND AVE N
1ST AVE N
CENTRAL AVE S
1ST AVE S
6TH ST N
5TH ST N
4TH ST N
3RD ST N
2ND ST N
7TH ST N
8TH ST N
ALLEY ALY N
ALLEY ALY S
STATE ST N
STATE ST S
MAINE ST N
MAINE ST S
PRIVATE DR
MINNESOTA ST S
2ND ST S
3RD ST S
4TH ST S
5TH ST S
6TH ST S
7TH ST S
0 125 250 500 Feet


Simple Bioretention w/Structural Pretreatment
Water Quality Swale
Complex Bioretention w/Structural Pretreatment
Native Buffer Restoration
Localized Bank Stabilization or Native Buffer Restoration
Bank Stabilization or Native Buffer Restoration
Channel and Native Buffer Restoration
PERRO CREEK
CATCHMENT PC-4
Middle St. Croix WMO
Subwatershed Assessment
6TH AVE N
5TH AVE N
4TH AVE N
3RD AVE N
2ND AVE N
6TH ST N
5TH ST N
4TH ST N
3RD ST N
7TH ST N
8TH ST N
9TH ST N
ARGUS SQ N
ALLEY ALY S
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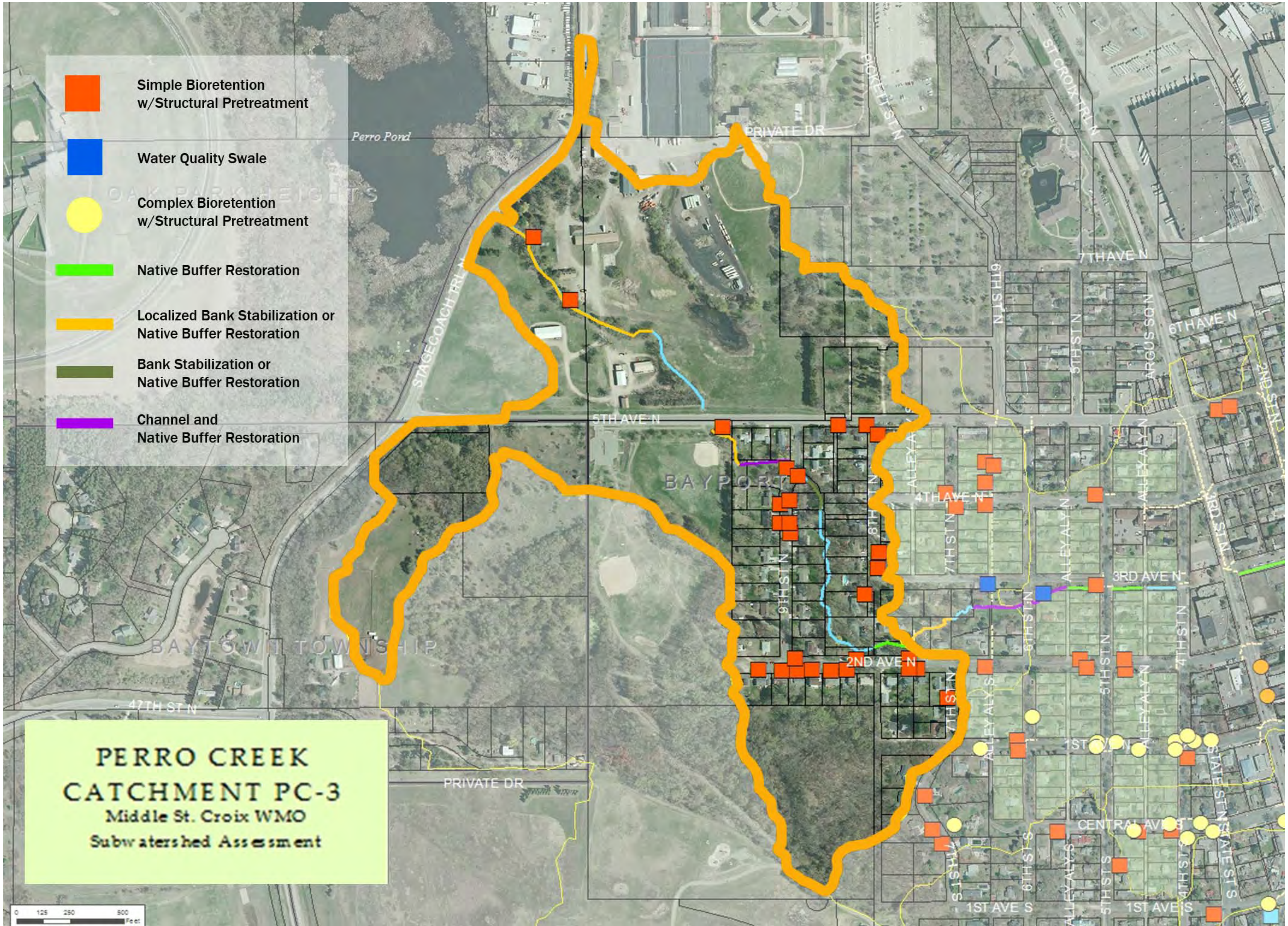
Simple Bioretention w/Structural Pretreatment
Water Quality Swale
Complex Bioretention w/Structural Pretreatment
Native Buffer Restoration
Localized Bank Stabilization or Native Buffer Restoration
Bank Stabilization or Native Buffer Restoration
Channel and Native Buffer Restoration
PERRO CREEK
CATCHMENT PC-3
Middle St. Croix WMO
Subwatershed Assessment
Perro Pond
OAK PARK HEIGHTS
BAYPORT
BAYTOWN TOWNSHIP
STAGECOACH TRL N
PRIVATE DR
PICKETT ST N
ST CROIX TRL N
7TH AVE N
6TH AVE N
5TH AVE N
4TH AVE N
3RD AVE N
2ND AVE N
1ST AVE N
CENTRAL AVE
1ST AVE S
47TH ST N
9TH ST N
8TH ST N
7TH ST N
6TH ST N
5TH ST N
4TH ST N
3RD ST N
2ND ST N
ARGUS SQ N
ALLEY ALY N
ALLEY ALY S
STATE ST N
STATE ST S
0 125 250 500 Feet