Urban Subwatershed Analysis Protocol

Metro Conservation District's Urban Subwatershed Analysis (SWA) Program

The Subwatershed Analysis (SWA) Program is a collaborating effort between the Metro Conservation Districts (MCD), a joint powers governmental entity consisting of eleven Soil and Water Conservation Districts in Minnesota's Twin Cities metropolitan area. The SWA Program is implemented by Conservation Districts working with local cities and watershed districts to complete subwatershed retrofit analysis studies for subwatersheds of priority or impaired surface waters. The goal of these studies is to identify the most cost-effective opportunities to retrofit the stormwater conveyance system to improve water quality, reduce storm runoff volumes, and manage stormwater rates of discharge within priority subwatersheds. In this presentation we will explain the process used to meet this goal which includes identifying subwatersheds for analysis, finding locations for retrofit projects, modeling potential retrofit projects for pollution reduction estimates, and developing a cost estimate for each potential retrofit project. The final product is a ranked list of cost effective retrofit projects that provide the greatest pollutant reduction per dollar spent over the life of the project. The MCD has used the ranked lists from studies to acquire significant grant funding for the installation of retrofit projects.

Subwatershed Selection

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. Assessments supported by a Local Government Unit with sufficient capacity (staff, funding, available GIS data, etc.) to greater facilitate the assessment also rank highly. For some communities a stormwater assessment complements their MS4 stormwater permit. The focus is always on a high priority waterbody. To receive CWF dollars, reasoning as to how the subwatershed was selected must be documented.

Subwatershed Analysis Methods

The process used for this assessment 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 incorporated into the process (Minnesota Stormwater Manual).

The urban subwatershed analysis process for this project includes five steps:

1. **Project Scoping** – Determine project objectives, meet with local experts, define preferred treatment options and criteria, and refine subwatershed focus area.
2. **Desktop Analysis** – Computer-based evaluation of catchments within the subwatershed.
3. **Field Investigation** – Evaluate focus areas and specific sites identified during Desktop Analysis.
4. **Treatment/Cost Analysis** – Estimate potential benefits of projects, prepare cost estimates, and rank projects in terms of cost/benefit.
5. **Reporting** – Summarize methods and findings. Use a report table to list projects with the best cost benefit. A report template is available.

Step 1: Project 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 management organization members 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 defined. Include at least one meeting with partners/stakeholders into your SWA workplan.

Step 2: Desktop Analysis

Desktop analysis involves computer-based evaluation of the subwatersheds in the target project area. The overall goal of the desktop analysis is to flag sites within the project area that may be suitable for the installation of water quality BMPs. GIS data is used to visually look for clues in the landscape that may suggest appropriateness for certain forms of stormwater BMP's (see following table).

Desktop retrofit analysis features to look for and potential stormwater retrofit projects.

Feature	Potential Retrofit Project
Existing Ponds	**Add storage and/or improve water quality by excavating pond bottom, modifying riser, raising embankment, adding an Iron-enhanced Sand Filter (IESF), stormwater reuse, and/or modifying flow routing**
Open Space (public or private)	**New regional treatment (pond, bioretention).**
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; stormwater reuse**
Neighborhoods	**Utilize right of way, roadside ditches, curb-cut rain gardens, or filter systems before water enters storm drain network.**

The desktop portion of the analysis must also involve at least one of the following approaches before proceeding to step 3 – Field Investigation:

Approach	Typical Reasons for Selection
1. **Model subwatershed existing conditions (using P8 or WinSLAMM) and select highest ranking catchments for further investigation – based on potential loading/contribution**	• *Base models already exist for subwatershed (provided by other partners)* • *Highly complex subwatershed (number of landuse types, existing stormwater infrastructure)* • *Available budget* • *User preference*
2. **Prioritize catchments based on proximity and estimated delivery to receiving water body (i.e. directly connected, landlocked catchments, etc.)**	• *Medium to large subwatersheds* • *Land morphology/stormwater infrastructure characterized by Isolated catchment areas* • *Available budget* • *User preference*
3. **Select all catchments within selected subwatershed for further analysis**	• *Monolithic landuse types* • *Small to medium subwatersheds* • *Available budget* • *User preference*

Desktop Preparations for Field Work

After desktop analysis is completed, field maps must be prepared for field work. Field maps should include base data layers such as air photos, topographic contour lines, catchment lines, parcel lines (differentiate between public and private ownership), public right-of-way, political divisions, stormsewer infrastructure and land use. Have at least two pages per catchment – having all the data needed for field navigation and analysis and another page with basic (parcel lines, stormsewer infrastructure, roads, etc.) to write down field codes/notes. Experienced BMP designers should scan the GIS data looking for clues in the landscape that may suggest certain BMP practice locations. Potential BMPs should be noted on the maps for field verification. If potential projects are identified within Right Of Way, utility maps can help further vet potential project locations.

Depending on the size of the subwatershed area and available budget; fieldwork should be focused on prioritized catchments. Prioritize field work by identifying catchments that need the most field verification, that have the most potential for retrofitting, that are direct drainage to priority waterbody, etc.

Step 3: Field Investigation

After identifying potential retrofit sites through the desktop search, a field investigation is conducted to evaluate each site to test assumptions and identify site-limiting factors on BMP design. Site constraints are assessed to determine the most feasible BMP retrofit options as well as eliminate sites from consideration. During the investigation, the drainage area and stormwater infrastructure mapping data are verified. The field investigation may also reveal additional retrofit opportunities that could have gone unnoticed during the desktop search.

Public right-of-way and public land within priority catchments are used as a starting point for visual assessment. Potential BMP locations that were identified during the Desktop Analysis step but could not be seen from public areas were visited by contacting individual landowners and scheduling formal site visits.

Field Work Procedures

Materials Needed: Base maps with required data, field codes, colored pens, camera, GPS (optional), 100' tape, 25' tape, catchbasin grate lifter, flashlight, credentials and business cards, marked vehicle

Minimum Data for Field Maps: Air photos, topographic contour lines, catchment lines, parcel lines (differentiate between public and private ownership), public right-of-way, political divisions, stormsewer infrastructure, land use soils information (can be on a subwatershed overview page), areas of interest for field checks.

Field Map Size: 11" x 17" field maps work best for use in the field.

Procedure:

1. Create hardcopy base maps. Base maps are needed for all land area within each priority catchment. Map scale should be no greater than 1 inch = 300 feet for proper interpretation of site features (smaller scale may be used). Each printed map should display the following: aerial photo, parcels, contours, and roads – this map is to be used for taking field notes. An overall large-scale location map is needed, showing the area covered by each base map.

2. Identify all potential viewing areas for each base map (typically public roadways and public property).

3. Take legible field notes (using a dark-colored pen); record site characteristics, potential BMP locations, stormwater infrastructure locations, pour points, and any other pertinent information. Record critical locations using GPS (approximate locations by sketching on base maps).

4. Scan field notes and create a digital file for all field-checked areas.

5. Maintain a list of probable high-priority project areas not observable from public roadways or public property for individual follow-up site visits. Create a standardized packet of information for landowners that includes a description of the project, a map of the site, information about potential BMPs and cost-share grants available, and other pertinent information. Conduct follow-up site visits with landowners.

6. For all potential BMP locations, evaluate cost-benefit potential. Using simple evaluation methods, staff will determine the expected P reduction due to BMP installations.

Step 4: Treatment/Cost Analysis

Catchment benefits must be based on a comparison of pre- and post-BMP installation modeling estimates (choose P8 or WinSLAMM)

Rank catchments using cost/benefit analysis (cost table provided; can be modified to use local cost data)

Sites most likely to be conducive to addressing the cities' and watershed district's goals and appear to have simple-to-moderate design, installation, and maintenance were chosen for a cost/benefit analysis. Estimated costs included design, installation, and maintenance annualized across a 30-year period. Estimated benefits can be pounds of phosphorus removed, total suspended solids removed, volume removed, or another pollutant of concern though projects were ranked only by cost per pound of phosphorus removed annually. Note, some studies report pollutant loading only during the growing season. Make sure you are modeling according to treatment goals and parameters set by previous studies/models if available.

Treatment analysis

Each proposed project's pollutant removal estimates must be estimated using a water quality stormwater model like P8 or WinSLAMM. Both are useful for determining the effectiveness of proposed stormwater control practices. WinSLAMM uses an abundance of stormwater data from the upper Midwest and elsewhere to quantify runoff volumes and pollutant loads from urban areas. It has detailed accounting of pollutant loading from various land uses, and allows the user to build a model "landscape" that reflects the actual landscape being considered. The user is allowed to place a variety of stormwater treatment practices that treat water from various parts of this landscape. It uses rainfall and temperature data from a typical year, routing stormwater through the user's model for each storm.

A *base model* is constructed to estimate pollutant loading from each catchment in its present-day state considering existing stormwater treatment. To accurately model runoff volumes and pollutant loading and washoff, the subwatershed is divided into smaller subwatersheds, *catchments*, that are defined by topographical data and stormsewers (the combination of the two data sets defines what is sometimes referred to as a *Pipeshed*). Several land uses are then delineated within each catchment using geographic information systems (ArcGIS), and each is assigned WinSLAMM standard land use definition.

BMPs most likely to be conducive to addressing the project goals and appear to have reasonable design, installation, and maintenance should be chosen for a cost/benefit analysis. Estimated costs must include design, installation, and maintenance annualized across a 30-year period.

WinSLAMM Procedure

WinSLAMM defines 26 such *Land Uses* made up of multiple *Source Area* types (roof tops, driveways, open space, sidewalks, etc.) in various levels of connectedness to the storm sewer. Source area contribution to each land use is expressed as a percentage of the total area and the adjustment of said land use file automatically adjust these values in terms of acres. Each land use is also paired with a pervious area soil type to account for initial abstraction loss to infiltration in the landscape. These parings combined with the 26 land uses allow for up to 78 potential land use/pervious are soil type definitions for every delineated land use in a catchment. A finished, customized land use file is created for each catchment by adjusting total acreage of each of these and combining them within one model.

Once the *base model* is established any existing stormwater treatment can be defined and inserted. For example, street cleaning with mechanical or vacuum street sweepers, rain gardens, underground sumps, stormwater treatment ponds, and others are included in an *existing conditions* model if they were present in the catchment.

Finally, for each catchment, proposed stormwater treatment practices are added to the *existing conditions model* and pollutant reductions were generated. A generalized, concept design for each practice is used at this level of analysis. Whenever possible, site-specific parameters are included. Design parameters are modified to optimize efficacy and to provide various treatment level options. Reported treatment levels are dependent upon optimal site selection and sizing (see *Catchment Profiles and How to Read Them*, for further information).

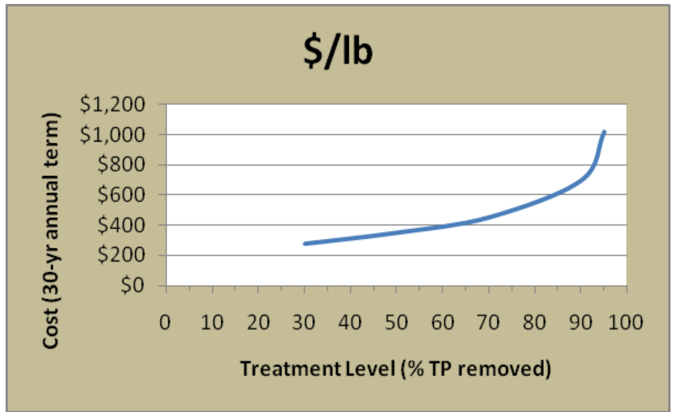
WinSLAMM stormwater computer model inputs

General WinSLAMM Model Inputs	
Parameter	**File/Method**
Land use	**MetCouncil data or City Zoning data conversion, or Manual definition: WinSLAMM Standard Land Use definitions**
Precipitation/Temperature Data	**Minneapolis 1959 – the rainfall year that best approximates a typical year.**
Winter season	**Included in model. Winter dates are 11-4 to 3-13.**
Pollutant probability distribution	**WI_GEO02.ppd**
Runoff coefficient file	**WI_SL06 Dec06.rsv**
Particulate solids concentration file	**WI_AVG01.psc**
Particle residue delivery file	**WI_DLV01.prr**
Street delivery files	**WI files for each land use.**

Cost Estimates

Cost estimates were annualized costs that incorporated design, installation, installation oversight, and maintenance over a 30-year period. In cases where promotion to landowners is important, such as rain gardens, those costs were included as well. In cases where multiple, similar projects are proposed in the same locality, promotion and administration costs were estimated using a non-linear relationship that accounted for savings with scale. Design assistance from an engineer is assumed for practices in-line with the stormwater conveyance system, involving complex stormwater treatment interactions, or posing a risk for upstream flooding. It should be understood that no site-specific construction investigations were done as part of this stormwater assessment, and therefore cost estimates account for only general site considerations.

The costs associated with several different pollution reduction levels were calculated. Generally, more or larger practices result in greater pollution removal. However the costs of obtaining the highest levels of treatment are often prohibitively expensive (see figure). By comparing costs of different treatment levels, the cities and watershed organization can best choose the project sizing that meets their goals.



Evaluation and Ranking

The cost per pound of phosphorus treated was calculated for each potential retrofit project. Only projects that seemed realistic and feasible were considered. The recommended level was the level of treatment that would yield the greatest benefit per dollar spent while being considered feasible and not falling below a minimal amount needed to justify crew mobilization and outreach efforts. Local officials may wish to revise the recommended level based on water quality goals, finances, or public opinion.

Subwatershed Analysis – Final Report

The SWA Final Report is a physical document that is assembled to act as a stand-alone report including all pertinent information to conduct the analysis and install prioritized BMPs. The report must have a structure containing the following information:

1. **Executive summary -** include cost/benefit ranking table (ranking catchments, not individual BMPs); must use standardized format (see appendix)
2. **Required maps-** subwatershed and all catchments (one overview map); individual catchments (one map for each priority catchment – can be within individual catchment descriptions section); catchment connectivity (one map or diagram showing flow routing between all catchments and receiving water)
3. **Catchment descriptions**- profile for each priority catchment must include pertinent catchment characteristics (such as model inputs), written description of existing conditions, catchment overview map showing potential BMP locations, and description of potential BMPs
4. **Local cost table** - using standardized format (local cost modifications allowed)
5. **Appendix -** model descriptions, protocol/methodology, definitions, and references

Document Sections	Key Elements
Executive Summary	• Project narrative • Include cost/benefit ranking table (ranking catchments, not individual BMPs); must use standardized format (see appendix)
Catchment Profiles (see appendix for example)	• Overview map showing subwatershed and all

	catchments • Profile for each priority catchment must include pertinent catchment characteristic: 1. model inputs 2. written description of existing conditions 3. catchment overview map showing potential BMP locations and description of potential BMPs
Retrofit Ranking	Prioritized project list across all contributing catchments
References	Identify source information used to produce SWA
Appendix	SWA methods overview -

The final report includes all pertinent supporting information required to conduct the analysis and install prioritized BMPs. All five steps included in this methodology should be described in detail.

Appendix A

Contents:

1. Example Scoping Document
2. WinSLAMM 10 and P8 Screenshots
3. Example Field Book Layout
4. Example Field Investigation Codes
5. Modeling Parameters for and Cost Estimates for BMPs
6. Catchment Profiles - Walkthrough
7. Urban SWA Ranking Table
8. Glossary of Terms

1. *Example Scoping Document*

Subwatershed Assessment Stakeholder Meeting 1

Sample Subwatershed – EWD

I. Partners	
3.10.2011	1:00 - 3:00
Meeting called by	Washington Conservation District (WCD)
Type of meeting	Planning and Scoping
Facilitator	Pete Young (WCD)
Note taker	Jay Riggs (WCD)
Other Attendees	Amy Carolan (Example Watershed District), Andy Schilling (WCD), City of Stillwater

II. Needs and Capabilities Assessment	
1 hour	

Discussion

Establish LGU interest level and regulatory drivers that will shape watershed goals and evaluate existing local retrofit capa city and needs.

Conclusions

1. Regulatory drivers
2. Data availability (GIS layers, monitoring info, reports, plans, etc.)
3. EWD, community capabilities: BMP Program, maintenance of stormwater infrastructure
4. Government and non-government partnerships
5. Residents' knowledge of water quality issues; common concerns (algae, water clarity, etc.)
6. Key community contacts: media, politicians, local groups/associations, local outreach opportunities
7. Funding resources (for assessment, outreach, and future projects)
8. Listed species of concern in subwatershed

Action Items	Person Responsible	Deadline
ITEM 1	WCD	ASAP
ITEM 2	WCD	ASAP
ITEM 3	EWD	DATE
ITEM 4	EWD	DATE
ITEM 5	CITY	DATE
ITEM 6	WCD	DATE

III. Existing Data Analysis	
20 minutes	

Discussion

Define key problems and impairments in the watershed; target retrofit efforts to assist in shaping goals and objectives through analysis of historical data; identify quantity, quality and resolution of existing data and additional resources required.

Data Needed or Revision	Task	Partner	Deadline
DATA NEEDED 1	OBTAIN	CITY	ASAP
DATA NEEDED 2	OBTAIN	EWD	ASAP
DATA NEEDED 3	OBTAIN	EWD	ASAP

Pollutant/WQ Problem of Concern	Partner
1. TP	EWD
2. Volume	CITY, EWD
3. TSS	CITY, EWD
4. Non-native/invasive vegetation	CITY, EWD
5. POLLUTANT 5	EWD

Action Items	Person Responsible	Deadline
Talk to City/Watershed to obtain shapefiles	WCD STAFF 1	ASAP
ACTION ITEM 2	MCD STAFF 1	ASAP
ACTION ITEM 3	WCD STAFF 2	ASAP

2: WinSLAMM and P8 Screenshots:

WinSLAMM 10 Routing View:

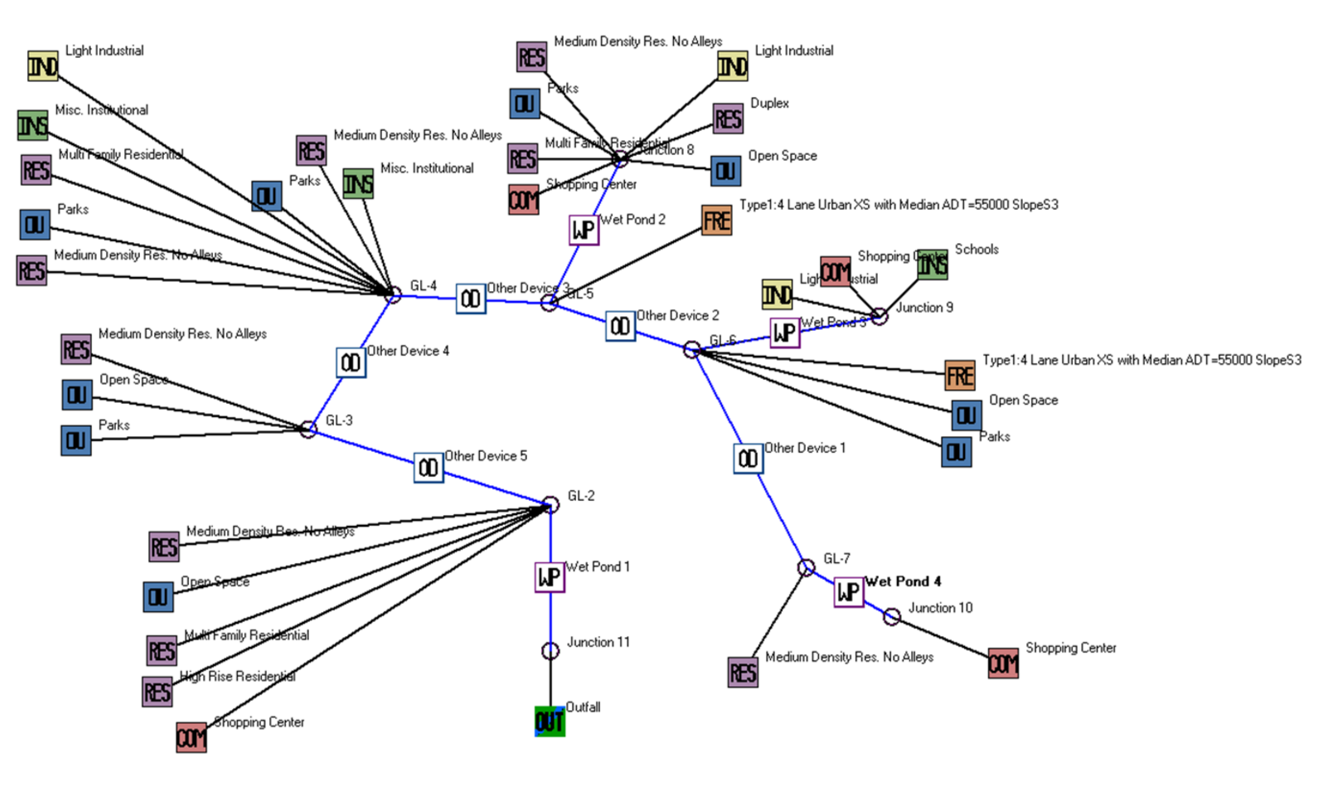


Image from Golden Lake Subwatershed Analysis – Anoka Conservation District

P8 Mass Balance Terms:

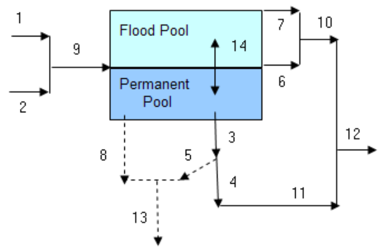
Version 3.4

File Edit Run List Charts Options Help Quit

Case Info | Explore | Output | Web | Device Types | Demo Case | About

Home | <-- Backward | Forward --> | Refresh | P8 Main | Online Help

P8 Mass Balance Terms



Term	Name	Description	
1	Inflows from Watershed	sum of all tributary watersheds	
2	Inflows from Upstream Devices	sum of outflows from all upstream devices	
3	Infiltration	outflow passing through bottom/sides of device	
4	Exfiltration	net outflow to groundwater	= term 3 - term 5
5	Filtration Removal	particle mass removed during infiltration (trapped in soil)	
6	Normal Outflow	controlled by hydraulic properties of outlet or swale	
7	Spillway / Overflow	occurs at max elevation, controlled by water budget	
8	Sedimentation / Decay	settling or other removal mechanisms	
9	Total Inflow	sum of inflows	= term 1 + 2
10	Surface Outflow	normal + spillway	= term 6 + 7
11	Groundwater Outflow	net outflow to groundwater	= term 4
12	Total Outflow	surface + groundwater	= term 10 + 11
13	Total Trapped	filtration + sedimentation	= term 5 + 8
14	Storage Increase	change in mass stored within device during time step	
15	Mass Balance Check	net mass balance error	= term 9 - 12 - 15 - 14

P8 online help guide

4. Example Field Investigation Codes

RRI SITE / PARCEL CODE SHEET

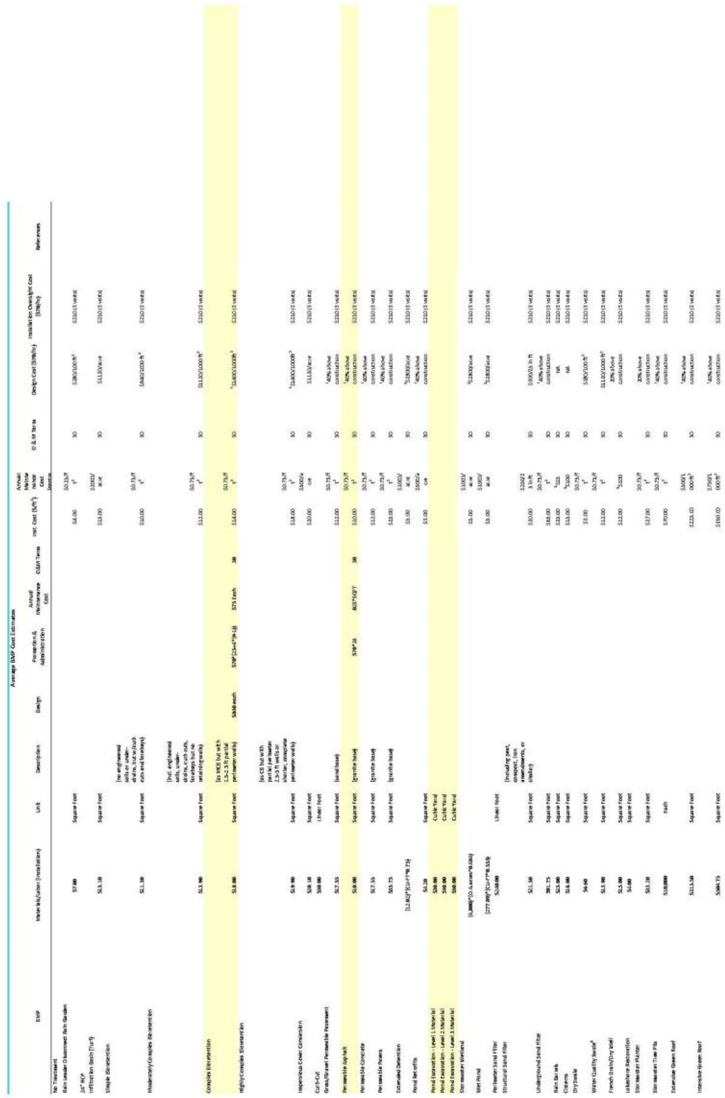
CODE	BMP
PND	Pond Retrofits
EXD	Extended Detention
WTP	Wet Pond
WET	Stormwater Wetland
INB	Infiltration Basin (regional treatment - e.g., recreational field with stormwater drained to it for infiltration)
SDC	Stormwater disconnect to pervious area
ICC	Impervious Cover Conversion
RBR	Rain Barrels
CIS	Cisterns
DWL	French Drain/Dry Well
WTS	Wet Swale (vegetated swale with no underdrain)
WQS	Water Quality Swale (Dry Swale (swale with filtration media and drain tile)
USF	Underground Sand Filter
SSF	Structural Sand Filter (a surface filter including peat, compost, iron amendments, or similar)
RDG	Rain Leader Disconnect Raingardens
BRA	Simple Bioretention (no engineered soils or under-drains, but w/curb cuts and forebays)
BRB	Moderate Bioretention (engineered soils, under-drains, curb cuts, forebays but no retaining walls)
BRC	Complex Bioretention (as BRB but with partial, or 1-3 ft retaining walls)
BRD	Highly Complex Bioretention (as BRB but with perimeter or 3-5 ft retaining walls)
STP	Stormwater Tree Pits
SP	Stormwater Planter
PPG	Grass/Gravel Permeable Pavement (sand base)
PPA	Permeable Asphalt (granite base)
PPC	Permeable Concrete (granite base)
PPP	Permeable Pavers (granite base)
EGR	Extensive Green Roof
IGR	Intensive Green Roof

CODE	SITE APROPRIATENESS BY FIELD INDICATOR
1	Prime: ideally situated within catchment, few physical constraints, little to no grading required, easy maint.
2	Alternate: a possible substitute for Prime location with oderate indicators
3	Poor: not suitable; porrly situated in catchment, too many constraints, extensive grading, difficult maint.

Example Site Code for RRI	
CODE	**DESCRIPTION**
1WQS	A perfect site/parcel for a Water Quality Swale
2BRB	An alternate site/parcel, after all Prime sitess have been pursued, for Moderate Bioretention
3	Do not pursue BMP placement of any type on this site/parcel

5. BMP Modeling Parameters and Cost Estimation

See P8 Guidance Document for Infiltration Basins



Average BMP Cost Estimates

BMP	Materials/Labor (Installation)	Unit	Description
No Treatment			
Rain Leader Disconnect Rain Garden	$7.00	Square Foot	
24" RCP			
Infiltration Basin (Turf)	$15.10	Square Foot	
Simple Bioretention			(no engineered soils or under-drains, but w/curb cuts and forebays)
Moderately Complex Bioretention	$11.30	Square Foot	
			(incl. engineered soils, under-drains, curb cuts, forebays but no retaining walls)
Complex Bioretention	$13.90	Square Foot	(as MCB but with 1.5-2.5 ft partial perimeter walls)
Highly Complex Bioretention	$18.00	Square Foot	(as CB but with partial perimeter 2.5-5 ft walls or shorter, complete perimeter walls)
Impervious Cover Conversion	$19.90	Square Foot	
Curb-Cut	$39.10	Square Foot	
Gravel/Paver Permeable Pavement	$38.00	Linear Foot	
Permeable Asphalt	$27.55	Square Foot	(sand base)
Permeable Concrete	$18.00	Square Foot	(granite base)
Permeable Pavers	$17.55	Square Foot	(granite base)
Extended Detention	$35.75	Square Foot	(granite base)
Pond Retrofits	(12.02)*(CU-FT*0.75)		
Pond Excavation - Level 1 Material	$4.20	Square Foot	
Pond Excavation - Level 2 Material	$38.00	Cubic Yard	
Pond Excavation - Level 3 Material	$38.00	Cubic Yard	
Stormwater Wetland	$38.00	Cubic Yard	
Wet Pond	(6,000)*(D.A.acres*0.485)		
Perimeter Sand Filter	(277.89)*(CU-FT*0.55)		
Structural Sand Filter	$238.00	Linear Foot	(including peat, compost, iron amendments, or similar)
Underground Sand Filter	$21.50	Square Foot	
Rain Barrels	$91.75	Square Foot	
Cisterns	$25.00	Square Foot	
Dry Swale	$16.00	Square Foot	
Water Quality Swale	$4.60	Square Foot	
French Drain/Dry Well	$13.90	Square Foot	
Lakeshore Restoration	$15.00	Square Foot	
Stormwater Planter	$4.00	Square Foot	
Stormwater Tree Pits	$33.30	Square Foot	
Extensive Green Roof	$10,000	Each	
	$315.50	Square Foot	
Intensive Green Roof	$504.75	Square Foot	

6. Catchment Profiles and How to Read Them

The following pages are the *Catchment Profiles*. These profiles provide the most important details of this report, including:

- Summary of existing conditions, including existing stormwater infrastructure, and estimated pollutant export to the receiving water body of interest
- Map of the catchment
- Recommended stormwater retrofits, pollutant reductions, and costs

The *Summary Table* found in the *Executive Summary*, above, is the compilation of all of the catchment profile information, sorted/ranked by highest value projects.

To save space and avoid being repetitive, explanations of the catchment profiles are provided below. We strongly recommend reviewing this section before moving forward in the report.

The analyses of each catchment considers up to three conditions relative to any existing treatment:

- Base conditions - Volume and pollutant loadings from the catchment landscape without any stormwater practices.
- Existing conditions - Volume and pollutant loadings after already-existing stormwater practices are taken into account.
- Proposed conditions - Volume and pollutant loadings after proposed stormwater retrofits.

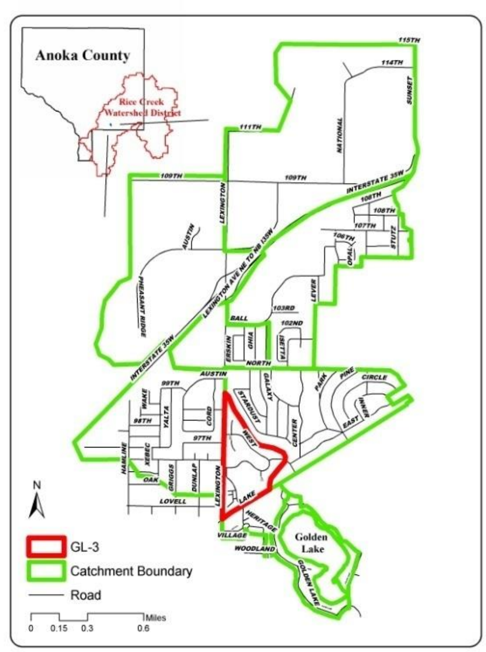
A subwatershed analysis may consider up to three geographic scales for modeling after the first round of catchments are eliminated from more detailed investigation (e.g., isolated areas). They are defined as follows from greater scope (more acreage and broader modeling assumptions) to finer detail (less acreage and fewer modeling assumptions:

- Network level analyses - Runoff volume and pollutant loads that reach the water body of interest after passing through an entire existing or proposed stormwater conveyance and treatment network. Typically, stormwater practices that are non-regional in their treatment capacity (e.g., distributed, off-line bioretention cells, stormwater tree pits, permeable pavements, etc.) are modeled with one typical, average set of design parameters and distributed uniformly over each catchments' acreage. Doing this assumes the designer will eventually select appropriate, locations that optimize practice BMP performance as it relates to drainage area effects. Regional treatment facilities (e.g., ponds) are either surveyed, use as-designed or as-built plan sets, or their designs are estimated. Treatment-train (in-series treatment) effects are taken into consideration. Depending on complexity, retrofit potential or limitations and the goals of the stakeholders, anywhere from 1 to multiple Network Scenarios may be presented.
- Catchment level analyses - Runoff volume and pollutant loads entering and exiting the catchment at the catchment outfall point. Most often this is reserved for those catchments that are directly connected to the receiving water body or have their own, independent regional treatment BMP handling its runoff before discharging to the water body of interest. In some cases, this approach may take the place of a full Network analysis when catchments do not share a common outfall point to the water body of interest. As with the *Network* analysis, non-regional BMP's are treated as if they are all the same design and uniformly distributed throughout the catchment and all potential in-series practices are considered.
- Project level analyses - Runoff volume and pollutant loads exiting the outlet(s) of proposed stormwater practices within the catchments. Most often this is reserved for those catchments that 1) are either too diverse in the land use to provide opportunities other that site-specific designs (e.g., extremely urban settings with diverse and challenging space limitations), 2) are too

limited in space to warrant recommending more than a manageable amount of projects to model individually or 3) the LGU has requested specific, detailed and highly accurate and precise performance models beyond what is typically done. As with the *Network* and *Catchment* analyses, all potential in-series practices are considered.

EXAMPLE Catchment A

Base Load Summary	
Acres	58.90
Dominant Land Cover	Residential
Parcels	237
Volume (acre-feet/yr)	18.37
TP (lb/yr)	25.00
TSS (lb/yr)	6461.00



DESCRIPTION

Catchment is primarily comprised of medium-density, single-family residential development…

EXISTING STORMWATER TREATMENT

Existing stormwater treatment practices within…

RETROFIT RECOMMENDATIONS

The two most significant projects that should be addressed are…

The bioretention designer should include the following design elements given the site conditions:

Average top area (sq ft)	250
Average bottom area (sq ft)	125
Side slopes	3:1 wher possible; retaining walls will be needed
Ponding depth (from curb cut invert to floor of RG)	12-inches
Curb cut	Min. 3-ft; a flume may be necessary
Engineered soils	30-inches 60:40 (washed sand:MNDOT Grade 2 compost)
Underdrain	4-inch perforated PVC, horizontal, set 1.50-ft off sub soils, within engineered soil media. To by plugged via a ball valve at outlet to CB (emergency draw down control only – allow full infiltration to occur by closing)
Pre-treatment forebay	Rain Guardian©

A narrative description of the recommended retrofit options and levels including design details assumed in modeling

Catchment locator map

Volume and pollutants generated from this catchment without any existing or proposed treatment

Different options and levels of treatment within the catchment

A narrative description of the catchment's current stormwater treatment capacity

A narrative description of the recommended retrofit options and levels including design details assumed in modeling

A narrative description of the catchment as it currently exists in terms of land use, soils, special conditions, etc.

Catchment locator map

Catchment ID banner

Volume and pollutants generated from this catchment without any existing or proposed treatment

Volume or pollutant removal this project will achieve.

Different options and levels of treatment within the catchment

A Catchment's Base Loading and Existing Treatment estimates (if any)

		EXISTING CONDITIONS		RETROFIT OPTIONS					
	Cost/Benefit Analysis	Base Loading	Treatment	*Marginal Network Treatment By BMP*					
				5 Raingardens		7 Raingardens		10 Raingardens	
Treatment	Existing BMP performance (%TP)		0.0%	New	New %	New	New %	New	New %
	TP (lb/yr)	35.2	0.0	1.9	5.4	2.5	7.1	3.4	9.5
	TS (lb/yr)	12366	0	850	6.9	1130	9.1	1490	12.0
	Volume (acre-feet/yr)	20.28	0.00	1.17	5.8	2.27	11.2	2.99	14.7
	Square feet of practice (or, CU FT of storage for WP, ED, SW)			1250		1750		2500	
Marginal Costs	BMP Type	No Treatment		Simple Bioretention		Simple Bioretention		Simple Bioretention	
	Materials/Labor/Design			$15,210		$21,210		$30,210	
	Unit Promotion & Admin Costs (each)			$290		$227		$175	
	Total Project Cost			$18,830		$25,176		$34,578	
	Annual O&M (total)			$938		$1,313		$1,875	
	Term Cost/lb/yr (30 yr)			$824		$861		$904	

The complete cost of getting the project in the ground from design to installation. Useful in budgeting and grant-writing.

Compare cost effectiveness of various project "levels" in these rows when considering treatment levels within a catchment. Also, compare cost effectiveness numbers between catchments.

Cost effectiveness of phosphorus removal, or *Life Cycle Cost* (LC):

Example:

$$\text{L.C.} = \frac{[(\text{Total Project Cost}) + (30 \text{ years} * \text{Annual O\&M \$})]}{(30 \text{ years} * \text{Annual lbs-TP Removed})}$$

8						
9						
10						

ith other projects in the same catchment because they are alternative opti

Map shows catchment boundaries, stormwater infrastructure, and the locations of proposed stormwater retrofits.

7. Example Catchment Ranking Form

Catchments A through Z: Summary of preferred stormwater retrofit opportunities ranked by cost-effectiveness with respect to total suspended solids (TSS) reduction. Volume and total phosphorus (TP) reductions are also shown. For more information on each project refer to the catchment profile pages in this report.

Project Rank	Catchment ID	Retrofit Type (refer to catchment profile pages for additional detail)	Projects Identified	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Total Project Cost	Estimated Annual Operations & Maintenance (2012 Dollars)	Estimated cost/ lb-TP/year (30-year)	Estimated cost/ 1,000lb-TSS/year (30-year)
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										

* Pollution reduction benefits and costs can not be summed with other projects in the same catchment because they are alternative options for treating the same source area.

8. Glossary of Terms

Subwatershed -

a subdivision based on hydrology corresponding to a smaller drainage area within a larger watershed

Catchment -

the smallest watershed management unit; defined as the area of a development site to its most downstream intersection (usually as a pipe or open channel outfall) with a stream; typically less than one square mile in area (640 acres)

WinSLAMM -

Windows Source Loading and Management Model (SLAMM)