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1. Introduction

1.1 Overview of Standards Manual

The South Washington Watershed District (SWWD) Standards Manual is an outgrowth of the SWWD 2007 Watershed Management Plan (WMP). The updated plan sets forth new standards applicable to development and re-development activities within the watershed. These standards provide the endpoints—or targets—for managing runoff and protecting water resources. To provide guidance on meeting these endpoints, this Manual is written for a variety of audiences including land developers and their engineers, city staff, and other technical professionals working within the watershed.

1.1.1 Scope and Purpose

Because endpoints vary across the watershed, the analysis of applicable standards for projects change across the District. New tools and approaches, such as watershed maps, are incorporated into the WMP to set and evaluate these endpoints. Project designers and engineers must incorporate design elements into engineering plans to meet these endpoints. However, a long-standing issue for the District has been a lack of consistency in modeling approaches and assumptions which affect how stormwater facilities are designed. The transition into new standards provides an excellent opportunity to resolve this issue.

There are two primary purposes of the Standards Manual:

- Address and establish consistency in water quality and quantity modeling approaches; and
- Provide guidance on means and methods for achieving watershed standards.

The scope of the Standards Manual is intended to address only those standards established within the District. Many sources of information are available to provide background and overall context for items such as modeling tools and techniques, or site design approaches and considerations. This Manual does not seek to repeat these topics in depth, but instead to glean the most salient components and illustrate how they are applicable in the District.

The scope of the Standards Manual is also intended to illustrate the preferred methods and tools to develop and apply techniques for evaluating the endpoints for projects. It is intended to provide a common bridge between the preferred methods and those used by others. For this reason the Manual focuses on illustrations for a single tool, such as using the P8 Urban Catchment Model, as preferred methods for water quality analysis. It is not practical or relevant to describe all the details for use of a preferred tool.

1.1.2 Manual Updates and Administration

New tools and techniques may emerge which are not currently covered by this Manual. Unforeseen issues relevant to implementing the standards may be identified through use of this Manual. The endpoints themselves may be modified subsequent to further technical analysis. For these reasons, the Manual and its contents may be periodically updated.

New versions of the Standards Manual will be recognized by a change in Volume number. The most recent version of the Standards Manual will be available for download from the website hosted by the SWWD (www.swwdmn.org). It is intended that an automated email broadcast will be issued to relevant parties as new volumes are published. The email broadcast will contain a brief summary of the content change. Ideally only a few pages would be required to be updated or switched, preventing the need for an entire Manual to be discarded and replaced.

1.2 Watershed Standards, Guidance, and District Rules

1.2.1 How to Use this Manual

This Manual should be used as a guide for understanding expectations for modeling tools and design constraints for projects within the District. Most often, a project means an activity relating to land development. However, projects also can relate to studies or analyses performed by member cities. This Manual should be used by those individuals seeking further clarity regarding mechanics of evaluating standards set forth in the WMP or needing guidance on appropriate tools and modeling parameters to achieve consistency in watershed analyses.

This Manual is not intended to replace the currently adopted watershed Rules. Similarly, the Manual does not integrate the Rules into this narrative. The Manual is used as an intermediate guidance document between the WMP and current watershed Rules. However, an outgrowth of this guidance document is that the Manual will serve as the foundation for a future Rule Update to be initiated by the District. Authority for establishing and upholding a preferred process for site design and modeling approaches is provided to this guidance document by criteria outlined in the approved WMP.

To most effectively use this Manual, individuals should identify their primary issue and then find the chapter relevant to that issue. This Manual is intended to provide a series of chapters dedicated to particular topics. Often these topics are related, and developing a linear narrative to a circular process (one with no obvious clear beginning) can result in making subjective choices about where and when to introduce information.

A separate document is anticipated to help introduce these topics and issues in a way that is more palatable to a layperson, or one who is unfamiliar with the watershed and its standards. This document, referred to as a “Developers Packet,” is a starting point for individuals considering a land development project in the watershed. It is envisioned as a tool for member cities to provide to developers. In this way, the Packet will facilitate and ideally streamline the process of site design, design review, and project approval.

1.2.2 Summary of Watershed Standards

The philosophy underlying the approach to the District standards is focused on addressing variability within the watershed. The quality of resource types can vary, as can the physical characteristics, across the landscape. The philosophy generally ensures that projects are not required to do more than their “fair share” to address water resource issues. At the same time, there are certain sensitive areas where more restrictive measures are required. The standards:

- Are variable because of a varying landscape;
- Are resource based (receiving water, and to some degree, groundwater); and,
- Include NPDES Phase II Permit as the minimum, including activities for construction sites as well as outcomes from Nondegradation Analyses within the watershed.

Unless otherwise noted, the District standards apply to all land alterations (projects) which remove cover or disturb a surface area of one acre or more, regardless of the amount of existing or new impervious cover. The watershed standards for resources are summarized Table 1.1. Note that other procedural requirements, such as submittal deadlines, are established for projects proposed in the watershed. These requirements can be found in the adopted Rules, or in the Developers Packet.

Table 1.1 – Summary of standards and applicability to projects (adapted from Table 6.1 of 2007 WMP)

Standard	*WMP Section*	*Applicability*	*General Comment*
NPDES Minimum Water Quality	N/A	All projects meeting criteria of NPDES Permit	
Stormwater Peak Runoff Rate	Section 6.6.2	New and redevelopment, public improvements	Maintain predevelopment rates, maximum CN of 62
Stormwater Runoff Volume	Section 6.6.3	New development only	Maintain existing annual infiltration capacity of site
Allowable Total Phosphorus Load	Section 6.6.4	New and redevelopment, public improvements	Relevant for drainage to lakes or Mississippi River
Wetland Protection Standard	Section 6.4.3	New and redevelopment, public improvements	Inundation, duration, bounce, and nutrient load criteria
Critical Storage Areas	Section 6.7	Not redevelopment	Maintain existing floodplain and flood storage capacities
Regional Assessment Locations	Section 6.8	New and redevelopment, public improvements	Review process by District at key watershed locations
Utilization of Infiltration	Section 6.9	New and redevelopment, public improvements	On-site infiltration limited to 10-acre drainage, or 1-inch runoff temporary storage
Open Channel Stability	Section 6.10	New and redevelopment, public improvements	Allowable velocity approach to ensure channel stability
Bluff Buffers	Section 6.11	Not public improvement	60-foot buffer for slopes exceeding 15% along a watercourse

1.2.3 Comparable Volume Control Standard

The SWWD volume control standard generally ensures that projects are not required to do more than their “fair share” to address water resource issues. At the same time, there are certain sensitive areas where more restrictive measures are required. The standard is based on an annual timescale, to be consistent with federal programs (NPDES Phase II non-degradation and TMDL). The SWWD standard provides projects with flexibility in BMP techniques to attain volume control on an annual basis, which varies geographically.

Member cities have asked that the SWWD volume control standard be simplified to a non-variable uniform requirement. Administrative ease is the benefit to a single uniform standard however there may be environmental trade-offs in areas where this standard is aggressive relative to pre-project conditions. A single uniform standard places more burden and less choices on the project to achieve the standard.

The SWWD will accept a comparable standard for achieving the SWWD volume control requirement. The comparable standard is volume control to mitigate at least one (1) inch of runoff from all impervious surfaces within the proposed project boundary. Meeting this comparable standard means the SWWD standard is also met or exceeded. To satisfy this comparable standard, structural on-site volume control BMPs must be utilized and must have total storage capacity to retain the runoff volume as specified by the standard. Use of non-structural BMPs for volume control is only applicable towards meeting the SWWD annual volume control standard. Regardless of the standard, all projects are expected to utilize the design requirements and project analysis methods as described within this Manual.

1.2.4 Alternative Assessment for Volume Control

Through the development of the Standards Manual, the SWWD worked very closely with member cities to evaluate the feasibility of meeting SWWD standards for projects in a variety of settings. Select “case studies” indicated the ability to successfully meet applicable standards. However, for those infrequent instances where full volume control compliance may not be feasible, the SWWD has elected to establish an alternative assessment for ascertaining whether a project proponent has completed due diligence in mitigating the impacts of stormwater runoff from a site.

Circumstances may occur where the physical conditions of the landscape, such as soil type, may present challenges for fully mitigating changes in runoff volume. Other instances may occur where planned land use is not fully compatible with structural volume control techniques. The screening and selection of BMPs is further elaborated in Chapter 2. While some level of runoff volume control will always be possible, the SWWD recognizes there may be certain infrequent instances where a proposed project may not be able to fully attain compliance with established standards requiring volume control.

The alternative assessment will evaluate the degree to which a project site can mitigate runoff volume and nutrient load. The assessment is based on the “effective” impervious area of a site after all feasible BMPs are employed. The “effective” impervious area is a theoretical calculation of raw impervious surface that would be needed to generate the equivalent amount of runoff volume, or nutrient load, exported from the project site after the BMPs are employed.

If a project proponent believes their project will need to be considered for an alternative assessment, the SWWD should be contacted prior to submitting project review materials. The SWWD will work with the proponent to confirm the merits of the request for an alternative assessment. If the project circumstances merit an alternative assessment, the SWWD will provide a spreadsheet and work with the proponent to identify thresholds for stormwater mitigation that are acceptable for protecting water quality.

When the project satisfies the on site requirements, assessed through alternative means, a cash dedication (or, “pay-in-lieu”) program will be applied. The target of a cash dedication program should always be within the same watershed. The SWWD expects the inclusion of a cash dedication program with well-defined standards in a member city Local Surface Water Management Plan will provide local flexibility to establishing adequate monetary targets for a cash dedication program.

2. Selecting and Incorporating Site Design Elements (BMPs)

2.1 Overview

This Section is intended to provide guidance and establish consistency regarding selection, design, and evaluation of site design elements to meet the required stormwater runoff volume and nutrient controls as specified in Chapter 6 of the Watershed Management Plan (WMP). The site design elements include structural and nonstructural urban Best Management Practices (BMPs). The expected audience for the Section includes developers, developer's agents, City staff and watershed district staff.

The information presented is not intended to be an exhaustive analysis of selecting, designing and evaluating urban BMPs. Rather, the focus of this section is specifically those BMPs believed most useful and appropriate for attaining the standards of the South Washington Watershed District (SWWD) within their WMP. The content is customized to reflect the specific aspects of site design elements which are of paramount concern to the watershed, such as design criteria and performance estimation. Because the intention is not to duplicate the content of the many existing urban stormwater design manuals, only the information considered relevant to the SWWD is presented here.

For a broader discussion of stormwater BMPs, the reader is encouraged to obtain and review the publications used for developing this Section. The content presented here is based primarily on the following sources:

- The 2005 Minnesota Stormwater Manual Version 1.0 (Minnesota Pollution Control Agency)
- Considerations in the Design of Treatment Best Management Practices (BMPs) to Improve Water Quality (US EPA, 2002)
- The International Stormwater Best Management Practice (BMP) Database (1999-2005) (American Society of Civil Engineers)

Other stormwater references previously published for Minnesota including:

- Urban Small Sites Best Management Practice Manual (Metropolitan Council, 2001)
- Protecting Water Quality in Urban Areas (Minnesota Pollution Control Agency, 2000)

2.2 BMP Decision Analysis

2.2.1 Screening Tools

The District recognizes that there are a variety of BMPs from which to choose when constructing new development (e.g., residential, commercial, or industrial), as well as during redevelopment and public improvement projects. Not all BMPs are appropriate for all areas of the District, and a “one-size-fits-all” approach for mitigating impacts of developments can be problematic due to variations in land use, resource vulnerability, and environmental concerns. It is the District’s intent to provide a framework for a holistic approach (i.e., structural and nonstructural) to selecting multiple site design elements that can reduce the stormwater runoff impact associated with developments and redevelopment areas. Therefore, the SWWD is providing guidance on various BMPs from a landscape context, specific to the District. However, it is ultimately the responsibility of the design professional to ensure that site design elements are engineered and incorporated in a manner consistent with applicable regulations and standard practices.

The design professional is ultimately responsible for appropriate use of site design elements.

This section presents screening tools to assess various soil, geologic, environmental, and land use factors which can pose substantive problems for the implementation of specific BMPs within the SWWD; i.e., potential exclusion areas for certain BMPs because of an increased risk of poor performance or failure. The omission of a specific BMP within this section is not intended to exclude the use of that BMP within the watershed. The information presented is intended to provide guidance on the logic and review process used by the SWWD to evaluate the appropriate use of various BMPs when completing development reviews. Adhering to the recommendations presented herein is expected to result in a more timely and streamlined review process by the SWWD.

The first recommended screening tool for BMP selection is the evaluation of land use. Different land use factors can influence the suitability of BMP applications. A generalized suitability assessment of land use types and BMP applications is shown in Table 2.1. While the level of detail in this table is coarse, it illustrates that all land uses have certain limitations for structural BMP applications.

At a more refined level of detail, a second recommended screening tool for BMP selection is the evaluation of landform physical features. This is illustrated in Table 2.2, which captures the general physical factors that can impact BMP applications. The table shows that certain physical factors, such as depth to water table or soil type, can restrict the ability to successfully incorporate a BMP.

Similar to information presented in Table 2.2, a decision tree is presented in Figure 2.1 to illustrate BMP screening based on watershed characteristics. The decision tree captures physical factors such as soil type, drainage area, and bedrock / water table depth. This decision tree is quite useful because it illustrates that some nonstructural BMPs, such as disconnecting impervious area flow paths, can be universally applied despite limiting physical factors in the watershed.

*Table 2.1 Land Use and BMP selection.**

BMP Type	BMP Design	Rural	Residential	Roadways and Highways	Commercial / High Density	Hotspots	Ultra Urban
Pond	Micropool ED	✓	✓	✓	⊘	△	☒
	Wet Pond	✓	✓	✓	⊘	△	☒
	Wet ED Pond	✓	✓	✓	⊘	△	☒
	Multiple Pond	✓	✓	⊘	⊘	△	☒
	Pocket Pond	✓	⊘	✓	⊘	☒	☒
Wetland	Shallow Marsh	✓	✓	⊘	⊘	△	☒
	ED Wetland	✓	✓	⊘	⊘	△	☒
	Pond/Wetland	✓	✓	☒	⊘	△	☒
	Pocket Marsh	✓	⊘	✓	⊘	☒	☒
Infiltration	Infiltration Trench	⊘	⊘	✓	✓	☒	⊘
	Shallow I-Basin	⊘	⊘	⊘	⊘	☒	⊘
Filters	Surface Sand Filter	☒	⊘	✓	✓	▽	✓
	Underground SF	☒	☒	⊘	✓	✓	✓
	Perimeter SF	☒	☒	⊘	✓	✓	✓
	Organic SF	☒	⊘	✓	✓	▽	✓
	Pocket Sand Filter	☒	⊘	✓	✓	▽	✓
	Bioretention	⊘	⊘	✓	✓	▽	✓
Open Channels	Dry Swale	✓	⊘	✓	⊘	▽	⊘
	Wet Swale	✓	☒	✓	☒	☒	☒
	Grass Channel	✓	⊘	✓	⊘	☒	⊘

✓	Yes. Good option in most cases.
⊘	Depends. Suitable under certain conditions, or may be used to treat a portion of the site.
☒	No. Seldom or never acceptable.
△	Acceptable option, but may require a pond liner to reduce risk of groundwater contamination
▽	Acceptable option, if not designed as an exfilter

**Adapted from The Stormwater Managers Resource Center STP Selection Matrix 1. (www.stormwatercenter.net)*

*Table 2.2 Physical Feasibility and BMP selection.**

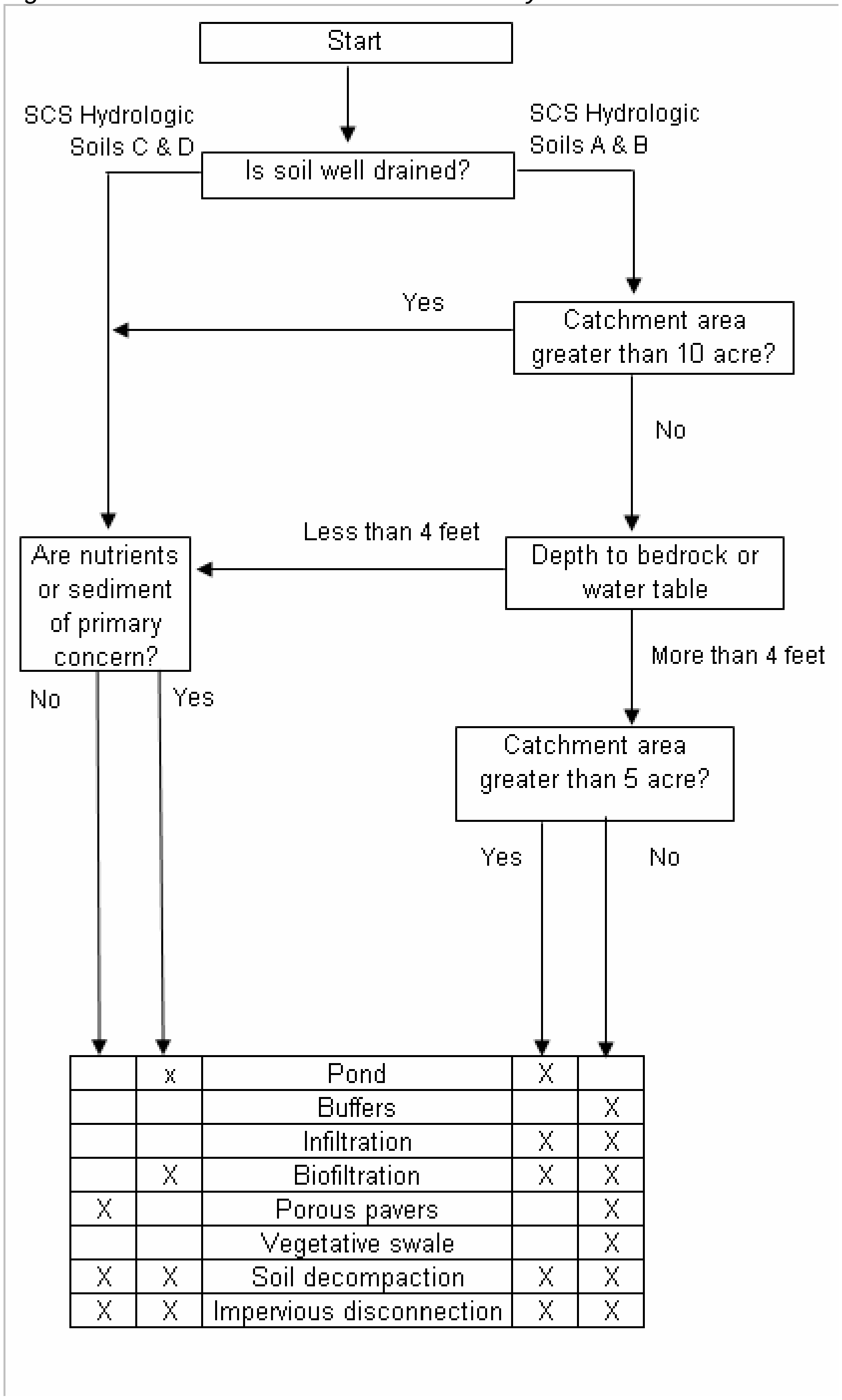
BMP Type	BMP Design	Soils	Water Table	Drainage Area (acres)	Site Slope	Head (ft)
Pond	Micropool ED	HSG A soils may require pond liner.	2 foot separation if hotspot or aquifer	10 min*	No more than 15%	6 to 8 ft
	Wet Pond			25 min*		
	Wet ED Pond					
	Multiple Pond					
	Pocket Pond	OK	below WT	5 max**		4 ft
Wetland	Shallow Marsh	HSG A soils may require liner.	2 foot separation	25 min	No more than 8%	3 to 5 ft
			if hotspot			
	ED Wetland					
	Pond/Wetland		or aquifer			
	Pocket Marsh	OK	below WT	5 max		2 to 3 ft
Infiltration	Infiltration Trench	f_c > 0.5 inch/hr	4 feet	5 max	No more than 6%	1 ft
	Shallow I-Basin			10 max		3 ft
Filters	Surface Sand Filter	OK	2 feet	10 max **	no more than 6%	5 ft
	Underground SF			2 max **		5 to 7ft
	Perimeter SF			2 max **		2 to 3 ft
	Organic SF			5 max**		2 to 4 ft
	Pocket Sand Filter			5 max **		2 to 5 ft
	Bioretention	Made Soil				5 ft
Open Channels	Dry Swale	Made Soil	2 feet	5 max	No more than 4%	3 to 5 ft
	Wet Swale	OK	below WT	5 max		1 ft
	Grass Channel	OK	2 feet	5 max		1 ft

Notes: OK= not restricted, WT= water table, PT = pretreatment, f_c *=soil permeability*

** unless adequate water balance and anti-clogging device installed*
*** drainage area can be larger in some instances.*

**Adapted from The Stormwater Managers Resource Center STP Selection Matrix 2. (www.stormwatercenter.net)*

Figure 2.1 Stormwater BMP Selection Suitability Decision Tree

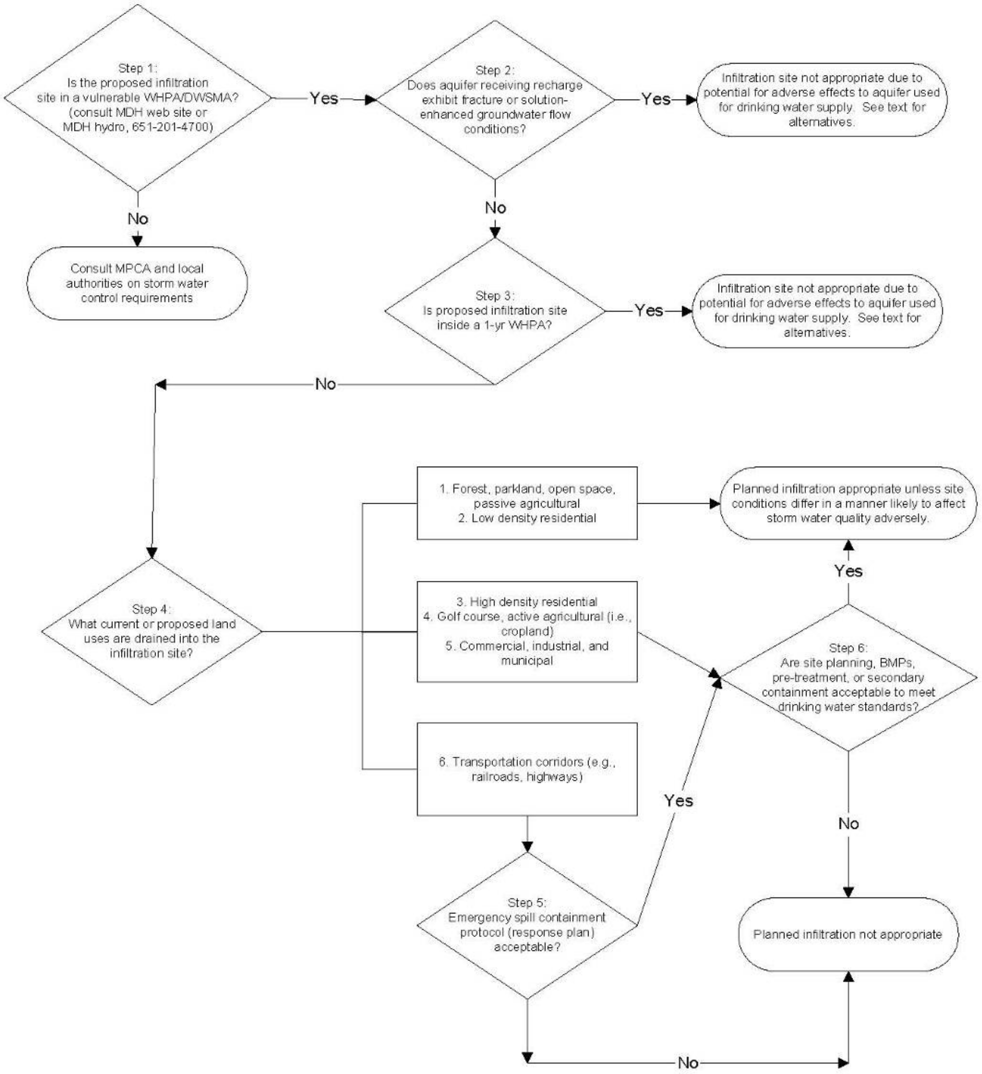


	x	Pond	X	
		Buffers		X
		Infiltration	X	X
	X	Biofiltration	X	X
X		Porous pavers		X
		Vegetative swale		X
X	X	Soil decompaction	X	X
X	X	Impervious disconnection	X	X

Adapted from Idaho Department of Environment Quality, and based on page 181 of Urban Runoff Quality Management (1998, Water Environment Federation and American Society of Civil Engineers).

The use of infiltration practices to control runoff volume and nutrient loads has been subject to considerable scrutiny. Thus, materials of a very high level of detail are available to help screen the suitability of using this type of BMP. A flow chart by the Minnesota Department of Health is presented in Figure 2.2 to help design professionals further evaluate the suitability of applying infiltration BMPs in a watershed. Also, see Section 3.5 for a discussion using maps to help assess suitability for local infiltration.

*Figure 2.2 Infiltration Suitability Screening Guide**



**This figure is a Minnesota Department of Health flow chart for evaluating proposed stormwater infiltration projects in areas with vulnerable groundwater.*

One additional screening tool for BMP selection is provided in Table 2.3. This table shows a general rating of BMPs for their ability to mitigate the affects of development, redevelopment, and public improvements. The table illustrates which BMPs can be used to mitigate the increase in pollutant load, the increase in peak discharge, and the increase in annual runoff volume. Incorporation of site design elements not presented in this table (or Manual) will be considered on a case-by-case basis.

Table 2.3 General Summary of BMP Efficiency for Site Mitigation

Best Management Practice	*Ability for Volume Reduction*	*Ability for Nutrient Reduction*
Detention Ponds	None	Moderate
Buffers	None	None
On-site Infiltration	High	High
Regional Infiltration	Not Preferred	Not Preferred
Biofiltration	None	High
Porous Pavers	High	High
Swales	Low	Low
Soil Decompaction	Moderate	Moderate
Impervious Disconnection	Moderate	Moderate

**Numeric values are presented in Table 2.4.*

2.2.2 Checklist for Site Impact Analysis

Design professionals must use a practical approach to protect water quality from the effects of land development. A practical approach includes incorporating appropriate stormwater practices and methods. Thus, selection of BMPs should focus on design suitability (land use and landscape features) as well as targeted pollutant removal characteristics. The tables and decision trees in Section 2.1.1 can assist in quickly screening for the selection of appropriate or suitable practices and methods.

The process of selecting which BMPs are appropriate for use in specific areas of the District is also influenced by the resource requirements established in watershed standards. A combination of several BMPs may ultimately be required to meet the resource standard set forth. The BMP decision analysis is not complete until a site impact analysis is completed.

A site impact analysis determines the nutrient or volume control endpoint for any given site based on the resource standards established. A site impact analysis should consider the following steps as a guide for assessing site design requirements:

1. Identify the type of project and locate the project in the watershed.

   The District crosses multiple soil types and contains certain areas that have limiting factors, such as a well head protection area or karst areas. This step will narrow the variety of BMPs that are appropriate for your project. Only new development projects have a mandatory volume control standard, as opposed to redevelopment or public improvement projects

2. Understand, incorporate or address NPDES requirements.

   This is the minimum standard for construction activities and serves as the baseline for stormwater runoff mitigation. Watershed requirements are in addition to this regulation.

3. Determine the receiving water (e.g., do you drain to a lake, wetland, or Mississippi River) and the required level of nutrient control.

   Different standards for nutrient control are established for different receiving waters. This step will determine the stringency of the nutrient load reduction required for the project. Required load reductions that are greater than 60% means volume control will be needed to meet the standard.

   For each wetland management class, standards have been developed for allowable stormwater runoff inflows (water quality standard, specifically TP) and allowable alterations to wetland hydroperiod (volume control standard). See Table 6.3 in the WMP for a summary of the wetland protection standards.

   Lakes are classified by the SWWD based upon monitoring data that reveals the waterbody's current level of nutrient enrichment, clarity, and susceptibility to change due to adverse watershed inputs. See Table 6.4 in the WMP for a summary of lake and Mississippi River nutrient load standards.

4. Determine the required level of volume control based on predevelopment conditions.

   Volume control across the watershed varies based on soil type and existing land use. Every new development project is required to incorporate volume control to meet existing annual hydrologic conditions. Estimated post-development runoff volumes are expressed as a fraction of rainfall and compared to the map of annual runoff coefficients. This step will determine the stringency of the runoff volume reduction required for the project.

   Predevelopment conditions are based on land use classes (as developed by the Metropolitan Council) for the year 2000. This was integral to creating Map 6.2 in the WMP which shows estimated annual runoff coefficients. Predevelopment conditions for new development, re-development, and public improvements are also defined in Table 6.1 of the WMP.

5. Determine the annual nutrient load and runoff coefficient from the proposed project.

   Using the preferred modeling methods in Chapter 5, determine the site impacts before any mitigation measures. Estimate the annual nutrient load and runoff volume generated by the proposed project based upon the unmitigated proposed conditions.

6. Determine and design to meet the limiting site design requirement.

   Each new development project will be required to provide runoff volume control measures, and often to provide nutrient control measures. In many cases, regardless of the type of project, volume control in order to meet a required nutrient load reduction may in fact be the limiting site design requirement. A spreadsheet tool is available to assist with this assessment. Examples are provided in the Developer's Packet.

The most important tool in performing the site impact analysis is the SWWD website. The website will provide downloadable maps, spreadsheets, and example calculations for the site impact analysis to aide the BMP selection process. The geographic location of the project site will indicate which wetland or lake may ultimately receive the stormwater from the development. The use of maps and other tools to be implemented on the website is described in Chapter 3.

2.3 Overview of BMP Design

The following sections of the Standards Manual are intended to provide specific guidance on the design and evaluation of BMPs to mitigate water quality impacts. The sections include BMPs most commonly used or anticipated in the watershed. Other BMPs may be incorporated on projects, subject to SWWD review and acceptance. Thus the SWWD encourages innovative approaches for water quality management. However, this component of the Standards Manual establishes consistency and uniformity in design, evaluation, and implementation.

A brief definition is provided to illustrate each BMP. Design criteria are presented which reflect the SWWD's desired components for BMP engineering approaches, and performance estimation and benefits are quantified. The performance estimation (i.e., pollutant removal efficiency) of an urban BMP is usually estimated based upon computer models when designing and sizing the BMP. Less often, empirical evidence through the collection and analysis of monitoring data within the field can be used for performance estimation. Once constructed, a BMP may perform differently—sometimes less efficiently than anticipated—compared to modeled estimates which rely on theory and mathematical equations. Precipitation and environmental factors also influence the performance of a BMP.

Recognizing these circumstances, the SWWD has established an expected range for estimated annual benefit for any given BMP mitigating the affects of stormwater runoff. (Note that these expected ranges are based on modeling with site-specific adjustments made to input parameters. See Section 5.3 for more details.) A summary table (Table 2.4) is provided at the end of this Chapter illustrating BMP estimated performance and empirically derived typical performance. For structural approaches, these values are for the use of a single BMP alone. However, the tandem benefit of using of non-structural BMPs is included in Table 2.4. Treatment train approaches using multiple BMP techniques will have a larger cumulative benefit on mitigating runoff impacts.

2.4 Detention Ponds

2.4.1 Definition and Scope

A detention pond is a constructed basin situated to receive local stormwater runoff and hold designated volumes of runoff for specified periods of time. Stormwater ponds or detention ponds have some of the most predictable water quality performance capabilities of any stormwater treatment practice. This is in large part due to the hydraulic residence time and settling dynamics provided, which allows pollutants to fall to the bottom of a pond. While generally not as significant as sedimentation, biological uptake by aquatic plants is another important pollutant removal mechanism. Detention ponds have a relatively straight forward design and have the added benefit of potential wildlife habitat and aesthetic enhancement. They can be used during construction as a temporary sedimentation basin. Detention ponds do have some limitations that need to be taken into consideration. They take up a relatively large amount of space, have some possible safety concerns, and are not appropriate for areas with high water tables or areas that have bedrock near the surface. They are not appropriate for use when water temperature is a concern since they tend to increase water temperatures and may cause impact on its receiving water.

2.4.2 Design Criteria

Several pertinent design manuals and documents provide guidance relative to the design criteria for detention ponds. The design criteria established by the SWWD, in addition to the locational features identified in Section 2.2 BMP Decision Analysis, are:

- To promote settling and provide space for sediment accumulation, the average depth of the permanent pool should be 3-4 feet, with a maximum depth of 10 feet.
- Basin side slopes are not to exceed 1V:3H above and below the normal water level.
- A 10-foot wide bench with a maximum slope of 10:1 should be constructed extending into the pond from the normal water level.
- Buffer width must average 20 feet. See Section 2.5 for buffer averaging.

Additional information can be found in:

- The 2005 Minnesota Stormwater Manual, Version 1.0
- Minnesota Pollution Control Agency General Stormwater Permit for Construction Activity

2.4.3 Performance Estimation and Benefit

Volume Control Benefit

Detention ponds are not acceptable for meeting the volume control standard. While there may be pond seepage and evapotransipiration losses, these can be quite variable and often difficult to reliably quantify. The District prefers other methods for controlling runoff volume. Infiltration shelves or sand filters adjacent to a pond should have sufficient physical separation so as not to be considered as one functional design element.

Nutrient Control Benefit

The detention pond is expected to be sized to meet the specified design criteria. This criteria often results in modeled nutrient removal approaching 60% annual efficiency. Additional BMP's must be implemented to attain further nutrient removal if needed to meet the standards for a given project. The expected performance benefit is established based on data summarized in the Minnesota Stormwater Manual. The expected performance benefit accounts for long-term decline in BMP performance due to sedimentation and addresses inherent fluctuations in the ratio of particulate and dissolved phosphorus fractions which are assumed constant in models.

2.5 Buffers

2.5.1 Definitions and Scope

Buffers are a specific requirement of the SWWD wetland standards. The required buffer widths are variable, dependent on the size (in acres) and management class of the wetland. For projects not involving a wetland, buffers incorporated as part of site design elements are strongly encouraged by the District, but are not required. However, the scope of this section is intended to provide guidance on meeting buffer requirements for projects impacting wetlands.

Buffers are unmown, undisturbed vegetated areas next to waterbodies that are protected or reestablished to connect upland habitats to wetlands. A buffer uses vegetation to slow down runoff velocities and filter out sediment and other pollutants. Buffers also provide essential habitat for feeding, roosting, breeding, and rearing of young birds and animals; and cover for safety, movement, and thermal protection for many species of birds and animals.

2.5.2 Design Criteria

Buffer widths for wetland projects must conform to the requirements based on wetland size and management class. All buffer areas are measured from the delineated wetland edge as marked in the field.

- To the greatest extent possible, buffers should be identified and planned in a manner that maintains connections with adjacent undisturbed area(s) to promote connectivity and linear corridors.
- Use of existing vegetation as buffer area shall be considered adequate provided the buffer area has had a continuous, dense layer of vegetation in place for at least 10 consecutive years prior to submittal of proposed project to SWWD.
- Buffers may consist of trees, shrubs, perennial grasses, wildflowers, or a combination of plant forms.
- For areas where buffers are to be reestablished, appropriate native wetland seed mixes specified by the Board of Water and Soil Resources are preferred.
- All buffer areas (existing, and proposed if needed) must be shown on plan sheets, and proper vegetation fencing to protect buffers shall be identified.

- Buffer areas shall be identified by permanent monument or similar signage acceptable to the watershed.

The SWWD Comprehensive Wetland Management Plan is a resource to further guide preferred approaches for wetland buffer protection and / or establishment.

2.5.3 Performance Estimation and Benefits

No specific nutrient or volume control benefits are assigned to buffers at this time. In lieu, developed areas that sheet flow to buffers around wetlands can follow the performance estimation and benefits assigned to impervious disconnection, discussed in Section 2.12.

While water quality benefits are generally associated with buffers, the widely varying buffer widths required (and allowed, given averaging) and soil types make performance estimation tenuous at best. The specific science and data needed to derive accurate modeling and estimation of benefits for buffers anticipated in the watershed is presently not available.

2.6 On-Site Infiltration

2.6.1 Definitions and Scope

Many areas of the watershed are favorable for implementing on-site infiltration (WMP Map 6.4). On-site infiltration facilities are generally considered those which receive drainage from up to ten acres, or can provide temporary maximum storage for up to one inch of runoff depth generated from the total contributing impervious area. These facilities are intended to mimic the natural predevelopment hydrology of a project area and reduce the impacts associated with urbanization.

There are multiple types of on-site infiltration designs, including: dry wells, infiltration trenches, underground infiltration systems, and the standard infiltration basin. On-site infiltration generally consists of natural or constructed basins located in permeable soils that capture, store, and infiltrate a calculated volume of stormwater runoff. The calculated volume of stormwater runoff is often associated with a particular design event, and the amount of stormwater infiltrated depends on the design selected. However, the SWWD evaluates volume control on an average annual basis rather than a design event. Section 2.6.3 provides a relationship between design event sizing and annual volume (and nutrient) control.

Infiltration systems are susceptible to clogging by sediment and organic debris. These systems are also not ideal for areas with high sediment or pollutant loads or for areas with steep slopes. These systems are not acceptable on a site that has high geologic sensitivity (such as less than three feet to bedrock).

2.6.2 Design Criteria

Several pertinent design manuals and documents provide guidance relative to the design criteria for on-site infiltration. The SWWD produced “Guidance on Specific Infiltration Techniques” (EOR, 2002) which contains six fact sheets and supporting examples and diagrams. The specific design criteria established by the SWWD, in addition to the locational features identified in Section 2.2 BMP Decision Analysis, are:

- Onsite infiltration systems must be designed off-line and must completely draw down within 48 hours after a rain event, to prevent nuisance standing water conditions.
- Pretreatment by a sediment basin, filter strip, grass channel or similar item is required. Sheet flow of runoff over vegetation or shallow routing through swales is preferred for at least 25 feet. However, use of structural units, such as hydrodynamic separators for sediment reduction upstream of infiltration, is accepted.
- A percolation test must be conducted on the site to ensure that the soils are suitable for an infiltration design. General methods include analysis of two presoaked holes, each 24 inches deep and 6-12 inches wide. The underlying soil type must be suitable for infiltration, with a minimum infiltration rate of 0.2 inches per hour.
- Soil borings must be done to a depth of at least twice the depth of the design, or a minimum of 10 feet.
- Infiltration basins must be designed with a minimum of three feet between the bottom of the basin and the seasonally high water table or bedrock layer.
- Setbacks to buildings and property lines must be a minimum of 10 feet. Setbacks to private wells, public wells, and septic system drain fields and tanks must be 150 feet.
- Infiltration basins will not be accepted in areas of active karst topography.
- Infiltration basins must be designed with an overflow device feature. Underground systems must have an observation well feature to assess water levels.

See 2005 Minnesota Stormwater Manual for further recommendations.

2.6.3 Performance Estimation and Benefit

Volume Control Benefit

The performance estimation for on-site infiltration will vary with the sizing of the feature. The estimated range for volume control benefit is 90-100% reduction in annual runoff volumes for basins that are capable of temporarily storing up to 1-inch of runoff from the impervious area in the site. Similarly, the estimated range for volume control benefit for infiltration basins capable of storing up to a ½-inch of runoff is 90-100% reduction in annual runoff volumes. These benefits are principally derived both by continuous simulation modeling but also supported by literature evaluating BMPs and small storm events.

The modeling evaluated a range of land use conditions and long-term precipitation patterns. While the performance estimation range is generally similar between the two infiltration basin sizing criteria, this does not imply they function equally in all circumstances. The ranges are a general summary of the analysis, intended to provide guidance to a designer or project proponent.

Recall from Section 1.2.3 that a comparable standard is volume control to mitigate at least one (1) inch of runoff from all impervious surfaces within the proposed project boundary. Meeting this comparable standard means the SWWD standards is also met or exceeded.

Nutrient Control Benefit

The performance estimation of on-site infiltration for nutrient control will vary with sizing of the feature, phosphorus concentrations in runoff, and the phosphorus concentrations in stormwater volume bypasses around the system. Until better information is available, nutrient control benefits from on-site infiltration should parallel the volume control benefit.

2.7 Regional Infiltration

2.7.1 Definitions and Scope

Regional infiltration facilities are generally considered those which receive drainage from greater than ten acres, or can provide temporary maximum storage for more than one inch of runoff depth from the total contributing impervious area. These facilities generally tend to concentrate runoff into one location and as such do not truly mimic the natural predevelopment hydrology of a project area. Regional infiltration basins typically serve primarily to provide flood control benefits and mitigate downstream water level issues. The concentrated volume of water diverted to centrally located regional infiltration basins may increase the risk for groundwater impact.

2.7.2 Design Criteria

No specific design criteria are currently established for regional infiltration systems. As such, proposed regional infiltration systems will be evaluated on a case-by-case basis, starting with the requirements set forth in the Watershed Management Plan, which includes Map 6.5 Regional Infiltration Suitability. Washington County's publication "Integrating Groundwater & Surface Water Management – South Washington County" (Barr Engineering, 2005) is another resource that will be used to evaluate regional infiltration systems. The spreadsheets and maps developed in that project can be used to guide design criteria and performance standards for regional infiltration.

Several natural regional infiltration basins exist in the watershed. Most notable is the CD-P85/CD-P86 system and its role in serving the District's Northern subwatershed. Other natural regional infiltration systems include CD-P76, CD-P82, and the Tank Farm. It is generally anticipated that the establishment and use of dedicated regional infiltration systems for stormwater management will likely arise through municipal local water planning, and not on a project basis at the development scale. Projects should incorporate on-site BMPs where feasible.

2.7.3 Performance Estimation and Benefits

The use of regional infiltration basins to control volume and nutrient loads from proposed projects is not preferred by the watershed. Instead, projects should incorporate on-site BMPs where feasible. The determination of volume and nutrient control benefits depends highly on the characteristics of the regional basin including soils and storage capacity. As such, performance estimation and benefits will be evaluated on a case-by-case basis.

2.8 Biofiltration

2.8.1 Definitions and Scope

Biofiltration is a water quality and water quantity control BMP that uses the chemical, biological, and physical properties of plants and soils to treat stormwater. Biofiltration relies on an outlet feature such as a drain tile to route water downstream. Sometimes referred to as bioretention, it is a flexible site design element that is easily integrated into the landscaping allowing for creativity during incorporation. This BMP is used in situations when infiltration is impractical and / or infeasible. It offers opportunities for filtration, storage, and water uptake by vegetation. It can be very effective at removing sediment; however, it is susceptible to clogging, so pretreatment is recommended. Its space requirement is often only a small portion of the drainage area and it is well suited for the treatment of highly impervious areas. This BMP is often parallel in function to sand filters and, for the purposes of performance estimation, can be considered comparable.

2.8.2 Design Criteria

Several pertinent design manuals and documents provide guidance relative to the design criteria for detention ponds. The preferred design criteria considered paramount by the SWWD, in addition to the locational features identified in Section 2.2 BMP Decision Analysis, are:

- Drainage area should be less than or equal to one acre maximum per filtration design practice.
- As with infiltration systems, the BMP should not temporarily store water longer than 48 hours.
- Currently, plant species selection, engineered soil medium, and outlet features are at the discretion of the designer but must meet approval of the District. The District prefers a homogenous soil mix of 85-88 percent construction sand; 8 to 12 percent fines (silt and clay) and 3 to 5 percent organic matter.
- The slope to the filtration basin and the basin should be vegetated preferably with grass. Grass on the side slopes should be mowed periodically to check for erosion.
- Pretreatment by a grassed swale, forebay or other BMP is required.
- Suitable soils for the Biofiltration BMP are hydrologic soil groups A and B. Sites with soils that have a hydrologic soil group of C and D should be evaluated by a licensed professional or soils expert to determine their suitability.
- The maximum slope of the contributing area to the biofiltration basin is 5%.
- Overflow should be controlled so that it is non erosive at the outlet point.
- Setback from well and septic systems should be a minimum of 50 feet.

See 2005 Minnesota Stormwater Manual as well as Plants, for Stormwater Design, for further design recommendations.

2.8.3 Performance Estimation and Benefit

Volume Control Benefit

No volume control benefit is allowable for biofiltration. The use of biofiltration is generally considered for treatment of particulate—and to a lesser degree dissolved—pollutants. Since it is used in areas where on-site infiltration is impractical and / or infeasible, the BMP is intended to route water downstream. It is acknowledged that some stormwater can be temporarily stored in the surficial soils of a biofiltration feature and is subsequently lost to the atmosphere by evapotranspiration. This loss is inherently very difficult to consistently and accurately quantify, and is marginal in terms of the overall proportion of runoff that is conveyed downstream.

Nutrient Control Benefit

The performance estimation of biofiltration for nutrient control will vary with sizing and design elements of the feature. Other variables affecting the performance include phosphorus concentrations in runoff and the phosphorus concentrations in stormwater volume bypasses around the system. Provided that the biofiltration basin can temporarily store at least ¼-inch of runoff while filtration occurs, up to 60% annual removal of total phosphorus can be claimed from biofiltration practices. This is based on studies performed by the University of Maryland, and the USEPA (2002).

2.9 Porous Pavements

2.9.1 Definitions and Scope

Porous pavement is a general term used to describe a system comprising a load-bearing, durable surface together with an underlying layered structure that temporarily stores water prior to infiltration or drainage to a controlled outlet. This BMP system can reduce the amount of runoff by allowing water to pass through surfaces that would traditionally be designed as impervious. A variety of products and approaches can be used for this system ranging from permeable pavements (special mixes of asphalt), concrete and brick products, block pavers, or even reinforced turf grass systems. This BMP system is typically used in low traffic areas including overflow parking, driveways, emergency vehicle lanes, and pedestrian areas. Additionally, roof areas can be piped into the storage area directly. Water can either infiltrate into the ground, if soil permeability rates allow, or be conveyed to other BMPs or a stormwater trunk system by an under-drain.

2.9.2 Design Criteria

Several pertinent design manuals and documents provide guidance relative to the design criteria for porous pavements. The design criteria established by the SWWD, in addition to the locational features identified in Section 2.2 BMP Decision Analysis, are:

- Contributing runoff from offsite should be limited to a 3:1 ratio of impervious area to porous pavement area, not to exceed five acres of total contributing drainage.
- For infiltration purposes, soils in the area that the porous pavement is applied should have field verified permeability rates greater than 0.3 inches per hour.

- Likely traffic loadings (if any) must be properly evaluated to ensure sufficient load-bearing capacity for operation of the system.
- The use of porous pavements is restricted to gentle slopes.
- Discharge over the porous pavement should be sheet flow, or similar uniform distribution of runoff at low velocities, to ensure maximum contact with the pavement.

See 2005 Minnesota Stormwater Manual for further design recommendations.

2.9.3 Performance Estimation and Benefit

Volume Control Benefit

The performance estimation for porous pavements will vary with the subgrade sizing of the feature. These benefits are essentially considered parallel to on-site infiltration basins. The estimated range for volume control benefit is 90-100% reduction in annual runoff volumes for basins that are capable of temporarily storing up to 1-inch of runoff from the impervious area in the site. Similarly, the estimated range for volume control benefit for infiltration basins capable of storing up to a ½-inch of runoff is 90-100% reduction in annual runoff volumes.

As outlined in the Minnesota Stormwater Manual Issue Paper F, the area in which the porous pavement is applied can be subtracted from the total impervious area when computing the site runoff. At least 10% of the impervious area on the site must be porous pavement to receive benefit.

Nutrient Control Benefit

The performance estimation of on-site infiltration for nutrient control will vary with sizing of the feature, phosphorus concentrations in runoff, and the phosphorus concentrations in stormwater volume bypasses around the system. Until better information is available, nutrient control benefits from on-site infiltration should not parallel the volume control benefit.

As outlined in the Minnesota Stormwater Manual Issue Paper F, half of the surface area in which the porous paver can be applied may be subtracted from the total site impervious area when computing TP loads. At least 10% of the impervious area on the site must be porous pavement to receive credit.

2.10 Swales

2.10.1 Definitions and Scope

As described in the 2005 Minnesota Stormwater Manual and other references there are a variety of types of swales, including: grass channels, dry swales, wet swales, and filter strips. Grass channels slow velocities and reduce peak discharges by infiltrating runoff for a water quality storm as well as a 2-year design storm. Grass channels do not provide adequate treatment to act as a stand alone BMP. Dry swales retain the entire water quality volume that filters through 30 inches of prepared soil to an underdrain. Dry swales prevent standing water. Wet swales act like a shallow wetland treatment system. They treat the entire water quality treatment volume in a series of cells. Filter strips use vegetation to slow runoff velocities and filter out sediment and other pollutants. Runoff is directed from a parking area into a long filtering system composed of a stone trench, grass strip, and a longer naturally vegetative strip.

2.10.2 Design Criteria

Several pertinent design manuals and documents provide guidance relative to the design criteria for swales. The design criteria established by the SWWD, in addition to the locational features identified in Section 2.2 BMP Decision Analysis, are:

- Any of these types of swales may be implemented in the District; however, the credit received for them will be limited.
- Swales should be a minimum length of 100 feet and ideally up to 200 feet long.
- Long contact times should be promoted. As such, flow velocities in a swale should be equal to or less than 1.5 feet per second for up to a 2-year rain event. Slopes may not exceed 6% and ideally should be 2% or less.
- The maximum contributing drainage area to a water quality swale is 5 acres. Drainage areas above this are permitted but will not be considered for water quality benefit.

See 2005 Minnesota Stormwater Manual for further design recommendations.

2.10.3 Performance Estimation and Benefit

Volume Control Benefit

Generally, grassed swales with no specific engineering elements for infiltration (i.e. no amended soils, no check dams, etc.) are considered having minimal volume control benefit. The expected range for volume control benefit for swales is 15% annual reduction, provided adequate modeling and evaluation assumptions are developed. A volume control benefit allowable for swales engineered for volume control will be considered on a case-by-case basis but generally are not typically expected to exceed 60% volume control performance.

Volume control benefits for swales are inherently difficult to consistently estimate and predict. In part this is due to the variety of swale types, as well as other landscape features such as slopes, soils, and vegetation. A paucity of data on volume control benefits for swale features presents challenges to verifying performance estimations developed through modeling. Estimated performance of swales using water quality models is based on hydraulic residence time and infiltration rates, but typically the models are not intended to accurately compute peak flow rates or flow through swales.

Nutrient Control Benefit

The performance estimation of swales for nutrient control will vary with the design parameters and site conditions. Until better information is available, nutrient control benefits from on-site infiltration should not exceed the volume control benefit. Literature indicates that performance estimations of total phosphorus removal of up to 30% are allowable for all swale types, except for a dry swale which may be expected to remove up to 60% total phosphorus (equal to biofiltration system performance).

2.11 Soil Decompaction

2.11.1 Definitions and Scope

As land is developed infiltration rates decrease because soil is often heavily compacted through the construction process in several ways, by: equipment that is working on the site to cut, fill, and work the site to achieve the desired elevations and the existing topsoil being stripped to expose compacted subsoils, the compaction from the tires and tracks of the equipment, and the purposeful compaction for the engineering of road, ponds, or building pads. Other areas of the development site are compacted as the equipment moves from lot to lot.

Compaction is an important factor in generating runoff, and efforts can be made to alleviate these impacts by improving the physical condition of the soil. This is done by increasing pore space and improving the infiltration capacity of the soil. Studies have shown (Chow et at., 2000) that deep plowing can reduce runoff rates of soils that have been compacted. Addition of compost can be considered a method to mitigate soil compaction and are accepted by the District.

2.11.2 Design Criteria

Several pertinent documents referenced in this section provide guidance relative to the methods for soil decompaction. The design criteria established by the SWWD, in addition to the locational features identified in Section 2.2 BMP Decision Analysis, are:

- There are many approaches to soil decompaction that exist, and the SWWD is willing to consider a variety of reasonable methods. Generally, the District prefers to accept deep tilling as a effective method for reversing the effects of the compaction.
- Construction specifications should include a soil bulk density determination to be conducted after the deep tilling occurs to ensure performance by the contractor (i.e. that a reduction in bulk density has been achieved).
- A specific target for a decompacted bulk density is not required. This is because the bulk density for the parent soil material will vary based on soil type; clay soils will generally have a lower bulk density than sandy soils (clay = 1.3 g/cc vs. sand = 1.6 g/cc).
- The intent to use soil decompaction as a stormwater BMP must be clearly stated in the grading plan and in construction specificiations.
- Deep tilling should be at least 18 inches deep.
- Compost or similar soil amendment (minimum of 4 inches in depth) can be added prior to placement of sod in pervious areas to help reduce runoff volume and mitigate the impacts of decompaction.

Further discussion of soil decompaction can be found in: *Balausek, J.D. 2003. Quantifying Decreases in Stormwater Runoff from Deep Tilling, Chisel Plowing, and Compost-Amendment.*

2.11.3 Performance Estimation and Benefit

Volume Control Benefit

The performance estimation for soil decompaction will vary with the soil type present. The estimated range for volume control benefit is 25-30% reduction in annual runoff volumes. Little data, either theoretical or empirical, is established to guide annual runoff volume control benefits from soil decompaction methods. Estimated performance of soil decompaction is based on curve number adjustments. Given that by properly incorporating soil decompaction, representative curve numbers decrease to the adjacent hydrologic soil group. This changes the characterization of the imperviousness of a site.

Nutrient Control Benefit

A paucity of data exists on the nutrient control benefits associated with soil decompaction. Until better information is available, the estimated range for nutrient control benefit is expected to be 25-30% annual reduction. It is acknowledged that different land use areas (e.g. lawns, boulevards, parks) are capable of generating phosphorus concentrations in different proportions. Indeed the soil type and composition can greatly influence nutrient runoff dynamics for any given land use such as residential lawns. For these reasons, it is clear there is substantial uncertainty, thus lack of reliable predictability, on the role of soil decompaction on nutrient control.

2.12 Impervious Disconnection

2.12.1 Definitions and Scope

Urbanized areas have drainage features which typically include direct pathways for stormwater runoff from impervious surfaces to flow to the trunk conveyance system. Interrupting direct pathways of flow by routing runoff onto or through pervious areas is a way to disconnect impervious surfaces from trunk conveyance systems. Disconnecting the drainage of impervious surfaces such as parking lots, driveways, or rooftops from the trunk system will decrease runoff volumes and improve water quality. The adjacent pervious areas can provide varying treatment depending on the areas slope, soils and contributing drainage area.

2.12.2 Design Criteria

Several pertinent design manuals and documents provide guidance relative to the design criteria for detention ponds. The design criteria established by the SWWD, in addition to the locational features identified in Section 2.2 BMP Decision Analysis, are:

- The maximum contributing impervious flow path length should be equal to the minimum length of pervious area over which the runoff is spread.
- The maximum amount of impervious area that can be disconnected is 25% of the total area considered / illustrated as directly connected impervious.
- Directly connected impervious areas proposed as “disconnected” such as parking lots, roadways, etc. must be clearly identified on drainage plan sheets by means of flow arrows, symbols, or other similar notation.

- Roadway sections with rural designs (no curb and gutter) where runoff flows into ditch systems is not considered disconnected from the trunk system.
- For sheet flow conditions, the slopes receiving discharge from proposed "disconnected" impervious areas must be less than 5%.
- Areas that have a hydrologic soil group of C or D should have an onsite evaluation to determine their permeability, which can range widely within on soil group. At minimum, implementing soil decompaction should also be considered for prior to routing drainage to the area. (Tandem benefits are illustrated in Table 2.4).

For proposed residential projects, impervious disconnection can only be incorporated for features that will be constructed during site preparation activities. It cannot be assumed that residential lots will have disconnected imperviousness, since installation of lot-specific features (orientation of downspouts, on-going use of rain barrels, etc.) is generally not under direct control of the project agent.

The 2005 Minnesota Stormwater Manual describes recommendations for impervious disconnection in Issue Paper F.

2.12.3 Performance Estimation and Benefit

Volume Control Benefit

The performance estimation for impervious disconnection will vary with the soil type present. The estimated range for volume control benefit is 10-15% reduction in annual runoff volumes. Little data, either theoretical or empirical, is established to guide annual runoff volume control benefits from impervious disconnection methods. Estimated performance of impervious disconnection is based modeling analysis using the P8 Urban Catchment Model to illustrate the relationships observed between impervious disconnection and annual runoff reduction. The maximum volume control benefit assumes the greatest practical amount of impervious disconnection is 15% of total impervious area.

Nutrient Control Benefit

A paucity of data exists on the nutrient control benefits associated with disconnection of impervious surfaces. Until better information is available, modeling suggested the estimated range for nutrient control benefit is 15-20% annual reduction.

2.13 Other BMPs

Numerous other BMPs are available to mitigate the effects of stormwater runoff quality and quantity on downstream resources. Even though a BMP may not be specifically addressed in this Chapter, it can still be considered and proposed by the site designer. Such BMPs will be evaluated on a case-by-case basis. If it is apparent to the SWWD that sufficient need is expressed for written guidance to standardize design criteria and performance estimation, this Manual will be updated as appropriate.

Other BMPs for consideration include: hydrodynamic separators or similar proprietary devices; green roof systems; and rain barrels, cisterns, or other similar features.

Table 2.4 Expected Benefits for Site Design Elements (BMPs)

Best Management Practice for Site Design	*Expected Range for Estimated Annual Benefit:*		*Empirical Typical Nutrient (TP) Pollutant Removal Efficiency*
	Volume Reduction	*Nutrient (TP) Load Reduction*	
Detention Ponds	0	60%	50% [1]
Buffers	0		
On-site infiltration, ½-inch	90 - 100%		65% [2]
On-site infiltration, 1-inch	90 - 100%		
Regional infiltration	Case by case evaluation		
Biofiltration / Sand filter	0	60%	50% [3]
Porous Pavers, ½-inch	90 - 100%		n/a
Porous Pavers, 1-inch	90 - 100%		n/a
Swales, Dry	60%	60%	8 – 99% [4]
Swales, Conventional	15%	30%	34% [5]
Soil Decompaction	25 – 30%		n/a
Impervious Disconnection	10 - 15%	15 - 20%	n/a
Tandem: Decompaction and Disconnection	35 - 40%	40 - 45%	n/a

NOTE:
(A) ½-inch means runoff volume equal to ½-inch depth spread across the entire *contributing* area (pervious and impervious).
(B) 1-inch means runoff volume equal to 1-inch depth spread across the entire *impervious* area.

1. From Minnesota Stormwater Manual Table 10.6 for Flow-Through Pond.
2. From Minnesota Stormwater Manual Table 10.6 for Infiltration.
3. From Minnesota Stormwater Manual Table 10.6 for Bioretention, Underdrain.
4. From California Stormwater BMP Handbook, Section TC-30, page 4.
5. From US EPA BMP Design Considerations (2002) Table 4-1.

NOTE: Extensive summaries of runoff reduction and pollutant reduction percentages are available in: Center for Watershed Protection & Chesapeake Stormwater Network Technical Memorandum: The Runoff Reduction Method. (2008).

3. Use of Standards Maps to Evaluate Site Requirements

Standards included in the SWWD 2007 WMP rely strongly on the use of maps to reflect the varying nature of resources across the watershed. The maps characterize the sensitivity or condition of a physical resource. Several maps included in the WMP also illustrate the management requirements associated with the resource, as expressed in the Plan's narrative. This Chapter elaborates on how to use the maps, in conjunction with written standards, to assess requirements for projects.

3.1 Understanding Data Access Procedures

3.1.1 Overview

The maps included in the WMP convey information across the entire watershed. Maps are intended to be actively used by project proponents when evaluating site design constraints. Map images are supported by databases containing detailed information. Project proponents can access and retrieve the data used to construct the maps, and use mapping or drafting software to select and identify resource information relative to their own area of interest.

Expectations are that the existing SWWD web page (http://www.swwdmn.org) will serve as the primary tool or mechanism for disseminating map and database information. This will be achieved through the development of new tools on the web page. These tools will enable users to identify an area of interest or view data sources to obtain more information. The following sections discuss concepts of the interactive tools that will be developed.

3.1.2 Subwatershed-Based Querying

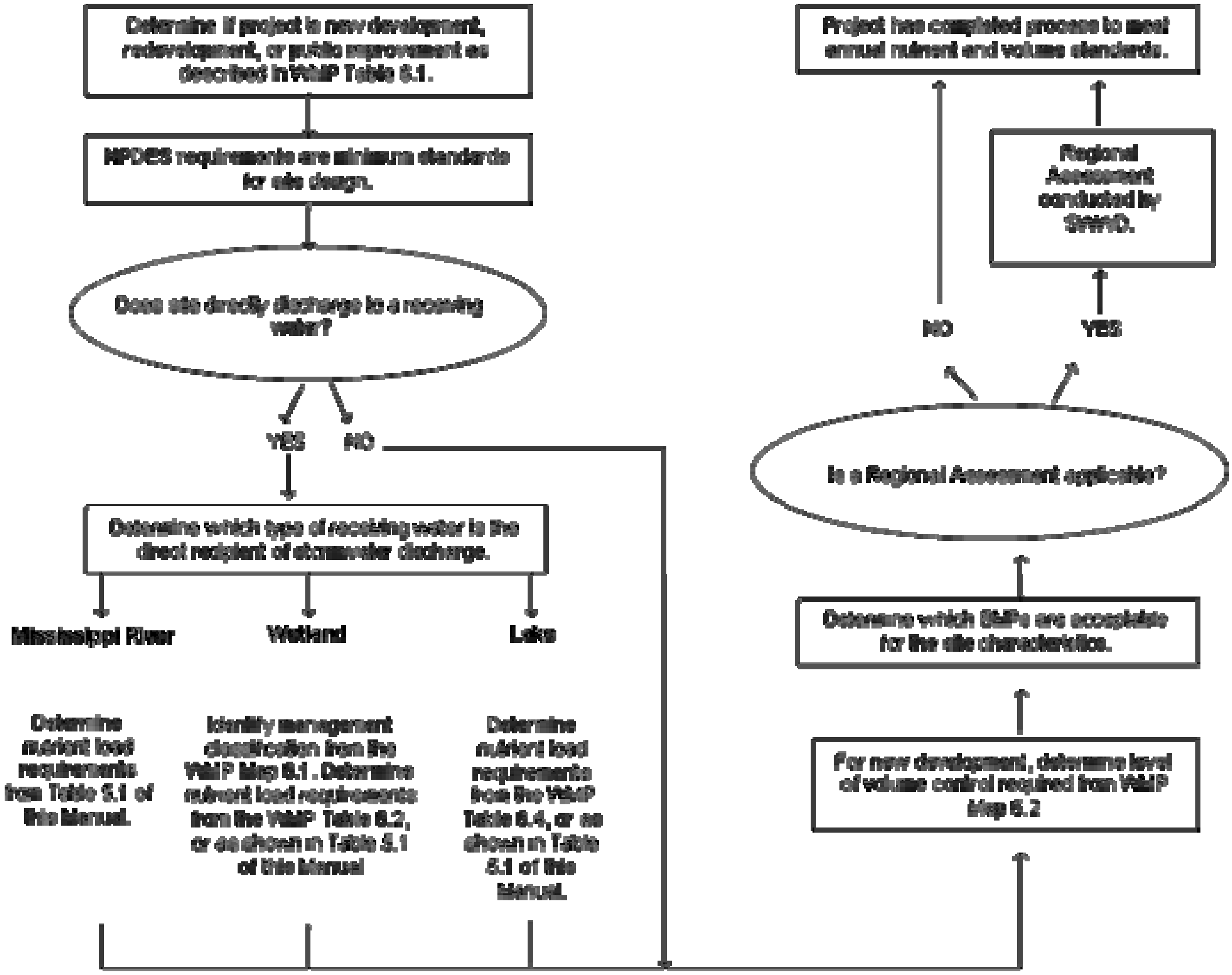
An internet-based linked map will be created and structured based on five major subwatershed drainage areas. The linked map will be supported by lookup tables founded on the five major drainage areas. Users will be requested to select an area and once a subwatershed area is selected, users will be presented with a lookup table specific to the subwatershed. These lookup tables will provide users with standards, requirements, and other guidance information applicable to each specific drainage area. Hyperlinks will be used as the method to access plan requirements and maps, as well as retrieve database source information.

3.1.3 Recommended Process

Resources, and the required stormwater control requirements, vary across the watershed. It is intended that project proponents will evaluate the different resources affected by their proposed project, and understand the requirements associated with each resource at that location. All requirements must be met but the project proponent is responsible to determine and design for which requirement is most limiting to their site design. The variability across the watershed means that the volume control requirement may be most limiting at one site while the nutrient load requirement may be most limiting at another site.

Procedurally a project proponent may evaluate their various requirements in any order or fashion desired. However, a process is illustrated (Figure 3.1) to provide guidance on a recommended approach.

Figure 3.1 Decision process for using Standards maps



3.2 Inventoried Wetlands and Designated Classification

Three management classes have been established for wetlands in the watershed. Stormwater control requirements for each class have been established addressing both runoff quality and runoff quantity.

It is first recommended to determine if a wetland is located within the proposed project site. Visual inspection of a static copy (i.e. printed) wetland map can be used for this process. Or, digital files may be retrieved from the website and used to develop a custom map with a project boundary superimposed.

If a wetland resource is not within the proposed project site, evaluate if the nearest downstream wetland will be a primary receiving water for discharge from your site. A primary receiving water means there is no existing structural stormwater treatment between discharge from your site and the wetland. Wetlands which are primary receiving waters are subject to the wetland standards.

Identified wetlands not currently inventoried must be classified and mapped as described in the WMP.

3.3 Estimated Annual Runoff Coefficients

Estimated annual runoff coefficients vary substantially across the watershed. Values have been determined through a modeling process, and the results projected into a polygon map of the watershed. At this scale, estimated annual runoff coefficients cannot be determined by visual inspection of a static map. However, project proponents are responsible for determining the overall existing runoff coefficient across their project site.

The steps to use this map are identical in process to deriving an area-weighted (or composite) curve number. The recommended approach is as follows:

1. Retrieve the runoff coefficient digital GIS layer from the website to project the map into a software system.

2. Superimpose the proposed project boundary (this would not include any off-site drainage) to the polygon map.

3. Extract the runoff coefficient values associated with each polygon within the project boundary by using the “clip” tool in GIS.

4. Export the “clipped” attribute table as a database file. Open the database file in Excel and develop an area-weighted runoff coefficient. This is done by standard practice for compositing spatial data (multiply each land use polygon area by its coefficient, sum the products, and divide by total project area).

3.4 Regional Assessment Locations

Regional assessment locations are identified points indicating the need for additional management of stormwater (peak flow, runoff volume, pollutant loads, or other criteria) beyond on-site conditions. The points reflect where existing data is available, or where future data analysis is anticipated. Available data stems from either monitoring or modeling efforts.

It is not intended for a project proponent to perform their own analysis of on-site impacts to regional assessment locations. The regional assessment location analysis will be implemented by the SWWD with their current modeling tools. The process is intended as a screening to identify whether additional on-site management of stormwater is warranted. Regional assessment location information is made available so that project proponents can have early awareness as to whether their project may potentially require additional design coordination with the SWWD.

It is first recommended to determine if a regional assessment location is located immediately downstream of the proposed project site. Immediately downstream generally means within the same minor subwatershed. Visual inspection of a static copy (i.e. printed) assessment location map can be used for this process. Or, digital files may be retrieved from the website and used to develop a custom map with a project boundary superimposed.

If a regional assessment locations is situated immediately downstream of the proposed project site, it is recommended to review information in the associated database. The information will inform the project proponent as to the nature of the assessment criteria (e.g. peak flow) and the targeted benchmark for stormwater management. Again, this is to inform the project proponent of potential additional design coordination efforts.

If a project proponent believes that no regional assessment location has bearing on their proposed project, no investigation is recommended. However, it does not necessarily preclude a regional assessment analysis by the SWWD, or that additional design coordination will be pursued.

3.5 On-Site Infiltration Potential

Small scale localized infiltration is the focus of the on-site infiltration potential map, Map 6.4 from the WMP. The map is based on extensive analysis of soils and geologic conditions in Washington County. The map indicates areas that are physically suitable for on-site infiltration, and the results are projected into a grid map of the watershed. Every grid is 100 square meters, equivalent to 2.5 acres.

It is recommended that project proponents review the map to help guide the location of infiltration features to assist in addressing volume control requirements. While the scale of the map is quite fine (2.5 acre grids) most areas are either high or very high in their physical suitability to incorporate infiltration. Visual inspection of a static map may suffice for most projects.

Project proponents are responsible for assessing their overall infiltration suitability across their project site. Project areas which may overlap grid cells that are moderate or less in their suitability are recommended for closer scrutiny. This can be achieved by retrieving digital files from the website to develop a custom map with a project boundary superimposed. Areas of moderate suitability or less should generally be avoided for infiltration because while surficial soil information may indicate high permeability, the map suitability also incorporates bedrock conditions not always evaluated during infiltration suitability screening.

The on-site infiltration potential map is intended to be used as a screening tool. It is the project proponent's responsibility to ensure appropriate location and design of infiltration features. Various other references and guidance sources are discussed in the WMP and in the previous chapter regarding screening and selection of infiltration approaches. If infiltration is not a feasible option to meeting volume control, other methods for volume control are available and are discussed in Chapter 2.

3.6 Regional Infiltration Suitability

It is generally not intended or encouraged for project proponents to consider designing or establishing regional infiltration features as a stormwater management approach. Instead, it is anticipated that regional infiltration evaluation and implementation might be considered at the municipal level as part of broader city planning, or potentially by the SWWD. The map is intended to help guide the decision making process for use of regional infiltration features.

The regional infiltration map contains approximations of significant geologic features that may be of value to project proponents. In particular, sinkholes or fault zones can signify areas where land excavation should be considered with great caution. It is recommended for project proponents to perform a visual inspection of a static copy (i.e. printed) map showing the regional infiltration suitability. Proposed project areas near sensitive areas, such as sinkholes, may warrant further evaluation and geologic investigation.

4. Hydrology Methods for Site Design and Project Analysis

This chapter is intended to provide guidance on preferred methods for watershed hydrologic analyses using different tools. The chapter provides information on fundamental elements of hydrologic analyses regardless of the tool used. Also, guidance is given specific to models which are event based and those which are of continuous simulation. It is anticipated that the former will tend to relate more to land development projects while the latter will relate more to studies and analyses by member cities.

4.1 Design Storm

A design storm is a precipitation event generally considered representative of a certain condition. The three parameters associated with the design storm event condition are a recurrence interval (frequency), total depth, and total duration. Since rainfall and resultant runoff are generally considered randomly occurring events, hydrologic design generally incorporates a risk-based approach. That is, facilities are designed with capacity to accommodate a rainfall of a specified frequency or probability of occurrence. The storm runoff peak, flow duration, volume, and timing provide the basis for planning, design, and construction of stormwater management facilities.

4.1.1 Applicable References

The District recognizes several applicable references which provide rainfall information for engineering purposes:

- U.S. Weather Bureau Technical Paper 40 (Hershfield, 1961);
- Bulletin 71: Rainfall Frequency Atlas of the Midwest (Huff and Angel, 1992); and
- Minnesota Department of Transportation Drainage Manual (2000), which presents rainfall intensity-duration-frequency (IDF) tables and curves for the state.

These references and other sources of information are briefly discussed in the Minnesota Stormwater Manual. The District recognizes the applicability of synthetic rainfall distributions as developed by the Soil Conservation Service (now the Natural Resource Conservation Service), discussed in more detail in Section 4.1.3.

4.1.2 Relevant District Data

The District currently collects precipitation data at five sites across the watershed. Data is recorded in 15-minute intervals, generally from March through November. A Thiessen polygon map representing the spatial coverage of precipitation stations within the District is available in the Watershed Management Plan. In some cases for notable storm events, radar trace data has been developed and incorporated into geospatial grids for modeling purposes.

4.1.3 District Methods

The District has determined applicable rainfall depths and recurrence intervals for use in hydrologic modeling and design. These values are presented in Table 4.1 for use in the evaluation and design of all major stormwater facilities in the District. Major stormwater facilities generally include natural or artificial channels, and detention basins (wet or dry). In contrast, minor stormwater facilities are considered as streets, curb and gutter systems, or roadside swales. A discussion of small storm hydrology methods can be found in Section 4.3.2.4.

Table 4.1 – Applicable rainfall depths for hydrologic design

	2-Year	*10-Year*	*100-Year*
Rainfall Depth	2.8”	4.2”	6.3”
Probability	50%	10%	1%

In certain instances, a project may be required to undergo a critical duration analysis. The critical duration event is a storm event duration which typically leads to the largest peak discharge. Usually the critical duration is equal to the Time of Concentration for the drainage area. Rainfall depths associated with a critical duration analysis as presented in Table 4.2.

Table 4.2 – Rainfall depths for critical duration analyses

Duration	*1-Year Rainfall Depth (Inches)*	*2-Year Rainfall Depth (Inches)*	*10-Year Rainfall Depth (Inches)*	*100-Year Rainfall Depth (Inches)*
5 minutes	0.27	0.32	0.44	0.66
10 minutes	0.47	0.56	0.77	1.15
15 minutes	0.60	0.72	1.00	1.47
30 minutes	0.82	0.98	1.37	2.02
1 hour	1.04	1.25	1.73	2.57
2 hours	1.29	1.54	2.14	3.17
3 hours	1.42	1.70	2.36	3.49
6 hours	1.66	1.99	2.77	4.10
12 hours	1.93	2.31	3.21	4.75
18 hours	2.09	2.49	3.47	5.13
24 hours	2.22	2.65	3.69	6.30

The need for a critical duration analysis will be identified during the District's Regional Assessment check. Regional assessment locations are identified by the District in Map 6.3 of the WMP. The District will check the impact of a proposed project at the downstream assessment location for any regional concerns not identified during the site review process. Sensitive areas, for example the Wilmes Lake subwatershed, where the timing and magnitude of peaks are of strong concern, may benefit from a more detailed assessment of design storm events. Thus, Wilmes Lake is identified by the District in the WMP as a regional assessment location.

A critical duration analysis uses a convergence approach may be the most efficient, meaning the analysis begins with the event closest to the Time of Concentration. This event is compared against the 24-hour duration event and if different, an interative process is used to select event durations between the two events to begin converging on the largest modeled peak discharge.

The Soil Conservation Service (SCS) Type II distribution is a synthetic storm hyetograph for use in the United States for storms of 24-hours in duration. This distribution is preferred for all rainfall design event analyses. These distributions are more intense than those recommended by Huff and Angel for precipitation events and produce higher volumes and rates of runoff.

4.2 Hydrology Model Input Parameters

Models used to predict watershed hydrology are driven by landscape variables such as land cover, watershed Time of Concentration, soils, and more. This section includes a discussion of these input parameters. Details as it relates to specific modeling approaches are included in the following sections.

4.2.1 Applicable References

The District recognizes several applicable references which provide information for engineering and modeling purposes. These references are available to consult when deriving model input values:

- SCS Technical Release 55 (1986);
- SCS Soil Survey of Washington and Ramsey Counties (1980);
- Soil Survey Geographic (SSURGO) database for Washington County, Minnesota (http://soildatamart.nrcs.usda.gov/);
- LANDSAT data; and
- Minnesota Land Cover Classification System (MLCCS) data.

These references and other sources of information are briefly discussed in the Minnesota Stormwater Manual.

4.2.2 Relevant District Data

Currently the District collects data on infiltration facilities (both natural and constructed). The use of the data is detailed in Sections 4.3 and 4.4. The District also collects data on runoff volumes and discharge rates at numerous locations across the watershed.

4.2.3 District Methods

4.2.3.1 Drainage Boundaries

For consistency and standardization, the District prefers to be a clearinghouse for maintaining and distributing information on drainage boundaries. This relates to drainage boundaries for any hydrologic modeling in the watershed, whether pursuant to land development activities or otherwise. (The SWWD will amend drainage boundaries included in its watershed models where necessary based on survey data.)

For land development analyses, submittal of drainage boundaries determined for both existing and proposed conditions is required. Should there be no change in drainage boundary for these conditions, a note is required to that effect. Drainage boundaries shall be digitized, either in ESRI or GIS-compatible format. Relevant subwatersheds within the drainage boundaries shall be defined and sub-boundaries digitized. Hydrologic modeling efforts shall account for all areas contributing drainage to the project area. These “off-site” drainage areas shall be included in the delineation of drainage boundaries for the project area, and so noted. No specific naming convention is required to be followed.

4.2.3.2 Hydrologic Soil Group

Using the Soil Survey Geographic (SSURGO) database for Washington County, Minnesota is the preferred method for determining hydrologic soil groups. For non-agricultural land uses where the soil data show a combination of drained and undrained soil types (e.g. B/D), using the undrained soil type is preferred.

4.2.3.3 Land Cover and Land Use Data

Land cover and land use data can be obtained from city zoning documents or other sources such as the Metropolitan Council or the MPCA. Often of interest for hydrologic modeling is land use types associated with urbanized areas, and / or the associated impervious percentage. Tables provided in the SCS Hydrology Guide provide relationships between land use, general percent impervious, and curve numbers for different soil types. The information can also be used to provide inputs for water quality modeling purposes.

Through construction of a watershed-wide XP-SWMM model, the District has developed data relating land use to impervious cover for portions of the watershed (Section 4.4). The District also has developed information on impervious cover stemming from Stormwater Utility Fee implementation. For modeling consistency, the District prefers these resources to be considered as the primary source when characterizing land cover based on land use. Thus, model input parameters for land cover determined from standard resources are acceptable but may be modified to meet watershed-specific values.

Generally, average percent impervious surface by land use can be back-calculated from the composite curve number. The equation is solved as follows:

Percent Impervious = (Composite CN – Pervious CN)/ (Impervious CN – Pervious CN)

For residential land uses, the impervious area can be computed using the following regression equation ($R^2 = 0.98$) based on TR-55, where "x" is the average lot size in acres:

$$y = 17.112x^{-0.5942}$$

Land cover data (MLCCS) for developed areas can be related to an impervious percentage using Table 4.4. However, this data should only be used if it is demonstrated that other methods and resources are not applicable or appropriate.

Table 4.4 Relating MLCCS data to impervious cover

Land Cover – Developed	*Impervious Percent Value*
0-10%	5%
4-10%	7%
11-25%	18%
26-50%	38%
51-75%	63%
76-90%	83%
91-100%	96%

These approaches provide a general overview of methods available to characterize land cover based on land use type. More specifics are provided in the following sections.

4.3 Event-based Hydrologic Modeling

Event-based hydrologic modeling refers to evaluating hydrologic response from a single rainfall of a specified frequency, depth, and duration. Event-based models are most commonly used for planning and sizing of stormwater conveyance and storage facilities. It is generally anticipated that event-based modeling tools will mostly be used by developers or other project applicants.

4.3.1 Acceptable Tools

At minimum, the NRCS methodology for estimating watershed runoff and peak flow (i.e. a hydrograph) shall be used to evaluate event-based hydrology. A variety of proprietary software packages are available for this use, such as HydroCAD or PondPack. Analysis by any commonly used software package will be acceptable provided that it is used in conformance with specified District Methods. Tools based on the rational method or other deviations from the runoff hydrograph procedure are not acceptable because they do not provide an quantification of total runoff volume.

4.3.2 District Methods

4.3.2.1 Curve Number Selection

A runoff curve number (CN) value shall be selected from, or based on, values from Table 2-2 from SCS TR-55. Antecedent moisture condition II shall be assumed for all design event modeling. A weighted curve number is allowable for subwatershed modeling related to flood hydrology (2-inch depth rainfall or greater). Refer to Section 4.3.2.4 for CN values related to small storm hydrology.

For predevelopment conditions, the allowable range for a CN to reflect undeveloped conditions should fall within values of 52 – 62 and must not exceed a value of 62. Hydrologic soil groups for CN value selection shall be determined based on soil survey maps. Undeveloped lands with published curve numbers exceeding the maximum value, such as row crops or small grain cover types, should be evaluated using the value of 62 regardless of soil type. However, CN values listed under hydrologic soil group A will generally not be accepted where developed conditions are modeled (either as an existing developed condition or a future proposed condition). This accounts for soil compaction during mass grading and construction activities.

No exceptions are allowed to curve number selection for projects which incorporate the use of soil decompaction methods to improve infiltration, decreasing the frequency and magnitude of runoff volumes. In this circumstance, standard engineering practice for the evaluation and design of conveyance infrastructure is of paramount importance..

4.3.2.2 Time of Concentration

The preferred methods for calculating time of concentration (T_c) is to explicitly determined a value for each subwatershed that is modeled. Under no circumstance will “direct entry” of T_c be accepted; travel times must be computed. Travel time (T_t) is the time it takes water to travel from one location to another in a watershed. T_t is a component of T_c, which is time for runoff to travel from the hydraulically most distant point of the watershed to a point of interest within the watershed. T_c shall be computed by summing all the travel times for consecutive components of the drainage conveyance system.

4.3.2.3 Flood Hydrology Design Events

Applicable rainfall depths for modeling and design of major stormwater facilities are based on the 2, 10, and 100-year 24-hour storm events. Refer to section 4.1.3 for the analysis of design storm events relating to flood hydrology.

4.3.2.4 Small Storm Hydrology and Runoff Depths

Small storm hydrology refers to a water quality concept that typically the bulk of annual pollutant loading is derived from storms of approximately one-inch in depth or less. Many structural devices are often sized to address runoff from small storms. However, the use of a composite (weighted) curve number is inadequate for accurate hydrologic runoff computations of small storms. This approach underestimates total runoff peak flow volumes, and is due to a limitation in the equations developed in TR-55 to calculate runoff depth by curve number. The limitation of composite curve number calculations for small storms is clearly expressed by the NRCS in their documentation.

Pervious and impervious watershed areas shall be determined separately for each subwatershed and modeled separately for any storm event less than two inches in depth (approximately equivalent to a 2-year frequency and 6-hour duration). Impervious areas including sidewalks, building pads, or other features will be modeled as 100% directly connected to the conveyance system, which is a fundamental assumption of TR-55.

For infiltration basin analysis, calculation of runoff depth for a storm event is required. The total runoff volume (as computed per Section 4.3.2.4) shall be divided by the total contributing impervious area to determine a runoff depth.

4.3.2.5 Infiltration Rates

Use of a constant infiltration rate in event-based models can be based on soil types and published infiltration rates. Recommended design infiltration rates by soil type are presented in Table 8.5 of the Minnesota Stormwater Manual. Selection of appropriate infiltration rates for modeling is the responsibility of the designer, based on knowledge of existing and proposed site conditions. However, guidance on infiltration rates is available based on the District's field monitoring data.

> *Although a maximum infiltration rate of up to 0.65 inches per hours is specified for modeling, selection of appropriate infiltration rates for modeling is the responsibility of the designer.*

Analysis of the District's field monitoring data shows that the observed average infiltration rate for a constructed infiltration system in well-drained soils is 0.65 inches per hour. Use of a constant infiltration input value greater than 0.65 inches per hour is not accepted. While the District will consider a variance to the maximum acceptable average rate on a case-by-case basis, extra-ordinary field documentation will be required and significant review time will be invested, causing expense and delay to the proposed project.

4.4 Continuous Simulation Hydrologic Modeling

Continuous simulation hydrologic modeling is typically done for projects needing a greater level of detail during analysis, or where complicated hydraulics is involved. Watershed-wide modeling of urban areas is often performed using continuous simulation software. It is generally anticipated that continuous simulation modeling tools will mostly be used by city engineers, their staff or consultants.

4.4.1 Acceptable Tools

A variety of proprietary software packages are available for continuous simulation hydrologic modeling. The District has chosen to develop a watershed-wide hydrologic model using XP-SWMM proprietary software. Analysis by any commonly used software package will be acceptable provided that it is used in conformance with District Methods specified below.

4.4.2 District Methods

4.4.2.1 Runoff Method Modeling

The District constructs and executes XP-SWMM models consistently using a specific runoff method, the non-linear reservoir method. Other methods are available to users, such as the SCS method. However, the non-linear reservoir method is preferred. In building and maintaining a watershed-wide model, watershed input values using other runoff methods are translated to percent impervious. A reference table of percent impervious values is presented in Table 4.4.

A runoff curve number (CN) value shall be determined from Table 2-2 from SCS TR-55. Antecedent moisture condition II shall be assumed for all design event modeling. A weighted curve number is allowable for subwatershed modeling related to flood hydrology (2-inch depth rainfall or greater). Refer to Section 2.3.2.4 for CN values related to small storms hydrology.

Table 4.4 Land Use Percent Impervious Values for XP-SWMM Modeling in SWWD

Land use	*% Impervious*[1]	*% Impervious*[2]
Agricultural	7.1	7.1
Buildings/Parking Lots	100.0	n/a
Extractive	7.1	n/a
Farmsteads	7.7	7.7
Golf Course	6.0	n/a
Industrial and Utility	56.3	56.3
Institutional	24.0-60	60.0
Major Highway	50.0	50.0
Multifamily	38.0-68	68.0
Office	64.8	n/a
Park, Recreational, or Preserve	6.0	6.0
Retail and Other Commercial	40-65	64.8
Roads	100.0	n/a
Single Family Attached	35-56	56.0
Single Family Detached	39.0	35.0
Undeveloped	7.1	7.1
Water	100.0	100.0

[1] *Wilmes, Colby, and Bailey Lake Watersheds in Woodbury*
[2] *Central Draw watershed in Cottage Grove*

4.4.2.1 Infiltration Parameters

The preferred method for modeling infiltration in XP-SWMM utilizes Horton's equation. The maximum value preferred is 4 inches per hour, the minimum value is 0.35 inches per hour, with a decay of 0.0008 (in units of 1/sec). This is a general rate used for pervious areas. These parameters may change subsequent to future analyses.

4.4.2.2 Other Methods

Generally, preferred approaches as outlined for Design Storm (Section 4.1) and Hydrologic Input Parameters (Section 4.2) apply to continuous simulation modeling, e.g., curve number selection, time of concentration. As of this present Manual release (Volume 1), no further guidance is deemed necessary to help standardize continuous simulation modeling efforts. Further guidance on preferred methods will be provided as inconsistencies and issues are identified.

5. Water Quality Methods for Site Design and Project Analysis

5.1 Allowable Nutrient Loads

The District's WMP established a framework to set allowable nutrient loads for various receiving waters in the watershed. This included wetlands, lakes, and the Mississippi River. Establishing allowable nutrient loads generally removes the need for an analysis of existing conditions. Focusing on nutrient loads intrinsically provides control on sediment and pollutants associated with particulate matter. An annual timeframe is used to assess allowable nutrient loads.

5.1.1 Applicable References

The establishment of allowable nutrient loads is a process currently specific to the District. There are no published general references to help guide the use of this activity. No nutrient loads are currently established for receiving waters based on total maximum daily load (TMDL) analyses. Establishing allowable nutrient loads is also parallel to performing a nondegradation water quality analysis, which certain entities are required to complete. Currently, the Cities of Woodbury and Cottage Grove are required to complete this analysis. More information regarding the nondegradation analysis and TMDL efforts can be obtained from the Minnesota Pollution Control Agency.

5.1.2 Relevant District Data

The District collects data in several areas which relates to standards set for addressing allowable nutrient loads and other water quality analysis pursuant to District requirements:

- Field inventory establishing functions and values for District wetlands;
- Lake quality monitoring data; and
- Urban runoff quantity and quality monitoring data.

The use of this data is detailed in the following sections.

5.1.3 Summary of Load Control Requirements

Several tables in the Watershed Management Plan (Tables 6.3 and 6.4) illustrate nutrient load control requirements for various receiving waters. A current summary of established allowed nutrient loads is shown in Table 5.1. As new information is developed through completion of TMDL analyses or nondegradation analyses, the allowed nutrient loads will be updated as appropriate.

Table 5.1 Summary of established nutrient loads in the watershed.

Receiving Water	*Allowable TP Unit Load (pounds/acre/year)*
Rivers	
Mississippi River	0.22
Lakes	
Armstrong Lake	0.18
Colby Lake	0.34
La Lake	1.65 [1]
Markgrafs Lake	0.61
Powers Lake	0.06
Ravine Lake	0.04
Wilmes Lake	0.10
Wetlands	
Protect	Maintain predevelopment
Manage 1	60% post-development reduction
Manage 2	60% post-development reduction

[1] *Intended to reflect no increase above existing conditions load.*

These allowable nutrient loads apply equally to new developments, redevelopments, and public improvement projects. For lakes and the Mississippi River, the allowable loads apply in those cases to the nearest classified downstream receiving water body (i.e. lake) to which runoff will ultimately be discharged, regardless if an existing constructed stormwater pond will receive runoff prior to discharge to the lake or river. (Refer to Table 6.4 of the WMP for a full list of classified water bodies.) In contrast, the allowable nutrient load for wetlands only applies to projects when there is no current or proposed structural stormwater treatment between discharge from the site and the wetland.

The allowable phosphorus load established for the Mississippi River was developed after the Watershed Management Plan was drafted. The established load is based on data calculated by the Metropolitan Council in their report, Regional Progress in Water Quality (2004). The Metropolitan Council estimated that the phosphorus load increase through the Twin Cities on average was 140 metric tons, which translates to a unit load of 0.16 pounds per acre per year. To account for existing urban stormwater ponds which are assumed designed for 60% phosphorus removal, the unit load was scaled up by 40% to achieve an established unit load of 0.22 pounds per acre per year. (A TMDL analysis is currently underway for Lake Pepin and as such a nutrient load allocation revision is expected in the coming years.)

5.2 Deterministic Modeling

Deterministic modeling refers to tools which are static, whereby simplified fixed input values are used to represent a range of conditions. A single value is determined as an output from the model.

5.2.1 Applicable Deterministic Modeling Tools

The District will accept either PONDNET or the Simple Method as a tool for analyzing allowable nutrient loads. Other similar deterministic models may be accepted upon District review, provided it meets acceptable methodology (Section 5.2.2). At a minimum, the chosen tool must be entirely developed in an electronic spreadsheet file so that all formulas and equations are available for review.

5.2.2 Acceptable Deterministic Modeling Methodology

5.2.2.1 Annual Precipitation

A nearby gauging station with a considerable period of record is the Hastings Dam gauging station (station 213564). The period of record extends from 1933-2005. The recorded total annual precipitation depths span from roughly 15 inches to 42 inches. Total annual precipitation depth used in deterministic modeling shall be based on 30.0 inches, reflecting the 1971-2000 National Climate Data Center Normal value for this station.

5.2.2.2 Annual Runoff Coefficients

An annual runoff coefficient (Rv) is a unitless ratio of cumulative observed runoff at the watershed outlet versus cumulative precipitation depth upon a watershed area. It reflects the degree to which rainfall is infiltrated into the ground. A low annual runoff coefficient means that most rainfall does not leave the watershed as surface runoff. Runoff coefficient relationships are most strongly developed for urbanized landscapes.

Monitoring data in the watershed indicates low annual runoff coefficients are appropriate in characterizing annual hydrologic conditions, even for urbanized landscapes. Watershed monitoring data do not indicate a predictable linear relationship between percent impervious cover and annual runoff. However, data generally suggest runoff coefficients are inversely proportionate to drainage area. As landscape scale increases, so too does the amount of depressional storage and system loss components. Runoff coefficients are updated periodically as new monitoring data is available. Based on monitoring data of two small, urbanized drainage areas with minimal or no ponding (Fox Run and Tamarack sites), average annual runoff coefficients range from 0.10 to 0.22. Pooling the sites yielded a predicted average runoff coefficient of 0.17.

Acceptable methodology would include using an equation derived from the Simple Method to estimate an annual runoff coefficient. The regression equation is then used to determine annual runoff volumes based on site imperviousness.

For the SWWD, the runoff coefficients have been adjusted downward to more closely approximate watershed monitoring data. Any modeling based on the Simple Method must utilize the following equation:

Rv = 0.04+0.5*(impervious fraction)

5.2.2.3 Event Mean Concentrations

Pollutant concentrations in runoff are often expressed as an event mean concentration, or EMC. The EMC term recognizes that there is variability in pollutant concentrations found in different runoff events, but one general value is used to broadly express the concentration reflected in loads over the long-term. The variable concentrations found in runoff events are best described as a log-normal distribution, where a median value or a log-transformed mean are the appropriate measures of a central tendency such as an event mean concentration.

Watershed monitoring of runoff pollutant concentrations provides insight to water quality at regional locations. A range of land uses and land covers contribute to these regional locations. As well, the runoff routes through stormwater ponds and natural waterbodies before collection at regional locations. Watershed-wide models should strive to be within the 25th and 75th percentiles for mean concentrations at corresponding monitoring locations. However, modeling for development purposes should be based on literature values.

Acceptable pollutant concentrations for modeling raw runoff from different land uses should be based on Minnesota Stormwater Manual Table 8.7. For land uses not specifically defined in that table, literature values from other sources can be used provided they are appropriately referenced.

5.3 Continuous Simulation Modeling

Continuous simulation modeling refers to tools which are dynamic, whereby precipitation is modeled actively, usually on a hourly or daily time step, and are used to represent a range of environmental conditions.

5.3.1 Applicable Tools

5.3.1.1 Overview

The District will accept the P8 Urban Catchment Model as the preferred tool for analyzing allowable nutrient loads. P8 model release version 3.4 is the basis of this current manual volume. The P8 model is free for download at http://wwwalker.net/p8/. It is expected that project designers and engineers will retrieve and install the relevant files from this website to begin the modeling assessment.

The WinSLAMM tool can be used but is not the preferred tool. The WinSLAMM model has particular merits such as uncertainty analysis and a diverse array of source control practices. However, is it strongly empirical and is not a process-based model, it lacks watershed routing capability, and does not analyze winter conditions. Additional similar continuous simulation models may be accepted upon request of the District, provided it meets acceptable methodology. For tools other than P8, users must be able to demonstrate consistency in model inputs (e.g., annual rainfall depth, runoff concentration) in comparison to the preferred tool.

5.3.1.2 P8 Model Adjustments for SWWD

The SWWD has determined adjusted parameters within the P8 model release version 3.4 to reflect site-specific conditions, and to fully address the issue of watershed wide consistency in modeling. These adjustments incorporate results from establishing the SWWD volume control standard (Map 6.2 of the WMP) as well as runoff volume monitoring data analyzed within the WMP. In this way, projects using a “calibrated” P8 model would predict post-project runoff volumes at a scale consistent with the pre-development runoff volume standard established by the SWWD for new development.

To create an adjusted P8 model is available on the SWWD website, the following steps are required:

- Setting the impervious runoff coefficient (Rv) to 0.55;
- Setting the pervious CN to 45; and
- Removing 25% of the original overall impervious fraction (i.e. directly connected) and placing the removed fraction into what is considered indirectly connected impervious.

Further discussion and screen captures showing the relevant adjustments are provided in Appendix A of this Manual. For more detailed background information on the P8 model, please consult the model developer’s web site at http://wwwalker.net/p8/.

5.3.2 Acceptable Methodology

5.3.2.2 Precipitation

A continuous simulation model must use at least one full year of precipitation to assess nutrient load and runoff volume criteria. It is preferred to use a hydrologic water year which begins October 1 and terminates September 30. For the P8 Urban Catchment Model, the year reflecting “normal” conditions is the 1979 water year, starting October 1, 1978. This is used because the total rainfall depth is 29.5 inches, very similar to the 30-inch precipitation depth stated in for deterministic modeling in Section 4.2.2.1. The frequency distribution of rainfall depths for 1979 is also consistent with calculated normal conditions for Hastings Dam station.

Note that model precipitation input file names are not consequential, provided that the data is from the Minneapolis St. Paul airport station. For instance, file name “msp5095” is equally acceptable with “msp4989.”

5.3.2.2 Annual Runoff Coefficients

The linear equation between percent impervious and annual runoff volume (expressed as an Rv) shown in Section 5.2.2.2 is generally captured well by the adjusted P8 model. No assumption should be made in reducing the impervious fraction to account for non-connected imperviousness, unless simulating impervious disconnection as a proposed Best Management Practice. This is because the P8 model has already been pre-adjusted to site-specific conditions for the SWWD.

5.3.2.3 Event Mean Concentrations

Default values for event mean concentrations are provided in the P8 Urban Catchment model. For total phosphorus (TP), the default value of 0.300 mg/L corresponds well with values presented in the Minnesota Stormwater Manual (MSM) Table 8.7 for residential land use. For other land uses, the runoff TP concentration in the P8 model should be scaled (up or down) to generally reflect the values shown in Table 8.7. Instructions for adjusting the runoff TP concentration are noted within the model's user manual and help tools. As noted in Section 5.3.1, if using other District-approved continuous modeling tools, it must be demonstrated in model outputs that unmitigated runoff concentrations are reasonably consistent with Table 8.7 of the MSM.

5.4 Accounting for Site Design Elements

5.4.1 Overview of Accounting

Modeling tools are often used to quantify the benefit of site design elements (also known as Best Management Practices, or BMPs) incorporated to mitigate impacts from land development. A detailed discussion of site design elements is presented in Chapter 2. That chapter illustrates processes for choosing appropriate site design elements to achieve the nutrient and volume controls set forth by the watershed. Design criteria are presented for the site design elements, as well as guidelines for performance estimation.

The Minnesota Stormwater Manual (MSM) provides recommendations for site design accounting, presented as "stormwater credits," using a unified stormwater sizing criteria. This is a design event based approach which does not adequately address the temporal scale of nutrient and volume control standards of the watershed. Further, to meet a statewide audience, the recommendations included methods that did not rely on a modeling tool but instead were arithmetic in nature. For these reasons, the recommendations are not applicable to the SWWD, and a customized approach to guiding the process of accounting for site design elements is needed for the District.

5.4.2 Preferred Methods for Accounting

This section provides guidance on how to approach accounting for various site design elements using different modeling tools (i.e. PondNET vs P8 or WinSLAMM). Some tools are more adept than others at modeling the benefit of site design elements. However, some site design elements such as soil decompaction or buffer strips are not included in any currently available model.

It is intended that the designers and technical professionals use their judgment and training to adequately construct models for evaluating project impacts and the benefits of site design elements. However, there are certain methods that need to be established to ensure uniform evaluation of site design elements. Where no specific methods are set, it is generally intended that no value is gained by specifying preferred methods for accounting. Instead, expected ranges for estimated annual benefit for any given BMP mitigating the affects of stormwater runoff are intended to help screen site design elements which and corroborate modeling estimates.

5.4.2.1 Wet Ponds

Explicit nutrient removal modeling of wet detention ponds is available in PondNet, P8 Urban Catchment Model, and WinSLAMM. No special accounting needs to be incorporated to these models to estimate nutrient removal performance. No volume management benefit is associated with this BMP, so modeling is not applicable for this standard.

5.4.2.2 Buffers

In contrast to recommendations in the MSM, no water quality or volume control benefits are allowed by the watershed for buffers. Buffers are a specific requirement for projects impacting wetlands. For other projects with buffers, developed areas discharging through buffers (either existing or new) can be accounted as having disconnected impervious, provided the design criteria are met for impervious disconnection.

5.4.2.3 On-Site Infiltration

Nutrient removal and volume control benefits are both associated with on-site infiltration. Modeling for on-site infiltration systems can be explicitly performed in continuous simulation tools. Infiltration rates associated with modeling this BMP should reflect appropriate understanding of soils present and / or planned. Refer to Section 4.3.2.5 for more information on infiltration rate ranges.

Using PondNet or other deterministic methods to provide water quality modeling for on-site infiltration is not preferred. However, if an on-site infiltration basin is sized to store a ½-inch or 1-inch of runoff volume, reductions in nutrient and runoff volumes from the contributing drainage can be accounted by the maximum allowable performance estimates provided in Chapter 2.

Reductions in peak flow rates may be realized incidental to modeling this site design element as a pond or other similar feature in a water quantity model.

5.4.2.4 Regional Infiltration

The use of regional infiltration basins by individual projects is not preferred. Water quality and quantity benefits for proposed regional infiltration basins will be evaluated on a case-by-case basis. The appropriate tools and methods for any analysis will be prescribed by the District.

5.4.2.5 Biofiltration

Biofiltration provides nutrient removal benefits but volume control benefits are not allowed. Biofiltration is currently not a common feature in most continuous simulation models, or deterministic models. Accounting for biofiltration site design elements can be done by arithmetic computations. Provided that the biofiltration basin can temporarily store at least ¼-inch of runoff while filtration occurs, up to 60% annual removal of total phosphorus can be claimed from biofiltration practices.

Reductions in peak flow rates may be realized incidental to modeling this site design element as a pond or other similar feature in a water quantity model.

5.4.2.6 Porous Pavements

Nutrient removal and volume control benefits are both associated with porous pavements. Modeling approaches for porous pavement systems can be considered equivalent to on-site infiltration. As suggested by the MSM, one-half the surface area covered by porous pavements should be included in calculating the total proposed site impervious area for water quality modeling such as with P8.

Reductions in peak flow rates may be realized incidental to modeling this site design element as a pond or other similar feature in a water quantity model.

5.4.2.7 Swales

Depending on the type of swale, nutrient removal and volume control benefits of different degrees are associated with this BMP. Modeling for grass swales can be performed explicitly in the P8 model, provided that an appropriate and representative infiltration rate is selected based on field conditions. (Pollutant removal associated with filtration and settling due to channel vegetation settling is not explicitly incorporated by the P8 model.) For dry swales which use an underdrain to facilitate drainage up to 60% annual removal of total phosphorus can be claimed from the dry swale practice, provided that the swale can temporarily store at least ¼-inch of runoff while filtration occurs.

5.4.2.8 Soil Decompaction

Volume control benefits are directly associated with this BMP and, as an extension of reduced runoff, nutrient control benefits are indirectly associated with soil decompaction. Soil decompaction is not directly incorporated in currently available water quality software as a model feature. However, the annual runoff volume can be adjusted to account for decompaction. The preferred method for adjusting the annual runoff volume due to soil decompaction is by revising the calculated percent impervious coverage on a site.

Generally, a revised average percent impervious surface can be back-calculated from the composite curve number in a manner as follows:

Percent Impervious = (Composite CN – Pervious CN)/(Impervious CN-Pervious CN)

When soil decompaction methods are incorporated following design criteria in Chapter 2, the pervious CN value in the *denominator only* can be chosen from the next “higher” hydrologic soil group. The impervious CN is always 98, and the composite CN is always the original composite CN for the total area. The CN adjustment only applies to the *pervious* area affected by decompaction. If only half the total pervious area within the project area is addressed by this BMP, then the decompaction accounting is limited to only that portion.

For a typical single family residential development (impervious area is 38%) on HSG B soils, the composite CN can be 75 and the pervious CN in the numerator can be 61. To compute a revised percent impervious to use in modeling, the pervious CN in the denominator would be 39. The adjusted calculated percent impervious fraction is 24%. This assumes soil decompaction was applied to all pervious area (62% of the total site) within the project area.

NOTE: A spreadsheet to assist in computing soil decompaction benefits is available on the SWWD website. Further, this spreadsheet allows a project area to calculate a combined reduction in impervious fraction, when soil decompaction and impervious disconnection techniques are utilized in tandem. Recall that the SWWD approach to the P8 model requires users to specify a "baseline" proportion of the watershed area as indirectly connected (see Section 5.3.2.2). The spreadsheet incorporates calculations for these baseline adjustments and any further adjustments for non-structural practices.

Reductions in peak flow rates from a subcatchment of a water quantity model cannot be realized as an outcome of modified curve numbers used for this BMP.

5.4.2.9 Impervious Disconnection

The disconnection of impervious surfaces can be indirectly accounted in the P8 Urban Catchment Model and PondNet. It can also be done explicitly in WinSLAMM although this is not preferred because it is a "black box" feature in the model.

For proposed residential projects, impervious disconnection can only be modeled for features that will be constructed during site preparation activities. Unless demonstrated otherwise, it cannot be assumed that residential lots will have disconnected imperviousness, since installation of lot-specific features (orientation of downspouts, on-going use of rain barrels, etc.) is generally not under direct control of the project agent.

Impervious disconnection can be accounted in either PondNet or P8 by reducing the overall acreage of impervious fraction used. (If so, the agent will need to submit a plan sheet showing areas formerly connected, which are now modeled as disconnected and the associated pervious area which will receive the runoff.) In the P8 model, the portion of impervious acreage addressed by disconnection must be incorporated into the total pervious area so that the entire site is modeled. This is in contrast to the MSM which recommends that disconnected impervious areas are completely removed from any further analyses.

NOTE: A spreadsheet to assist in computing impervious disconnection benefits is available on the SWWD website. Further, this spreadsheet allows a project area to calculate a combined reduction in impervious fraction, when soil decompaction and impervious disconnection techniques are utilized in tandem. Recall that the SWWD approach to the P8 model requires users to specify a "baseline" proportion of the watershed area as indirectly connected (see Section 5.3.2.2). The spreadsheet incorporates calculations for these baseline adjustments and any further adjustments for non-structural practices.

Reductions in peak flow rates from a subcatchment of a water quantity model cannot be realized as an outcome of modified curve numbers used for this BMP.

5.4.2.10 Other BMPs

No specific guidance is required or available at this time for other BMPs. In the future, guidance may be provided for green roofs, hydrodynamic separators, rain barrels, or other features.

6. Floodplains, Storage and Hydraulics

This Chapter addresses design and management elements to meet District requirements for water conveyance and storage. Tools and recommended methods are presented to appropriately address flood control issues in the context of watershed planning, and other problems associated with conveying excess precipitation. These problems often tend to be regional in scale, crossing community or subwatershed boundaries.

This chapter does not incorporate guidelines or specific requirements for conveyance design or infrastructure engineering as it relates to member cities and their requirements. Guidance on topics related to catch basin spacing, trunk storm sewer sizing, or other such specifics is deferred to the member communities.

6.1 Floodplains and Critical Storage Areas

Floodplains are specifically defined in the WMP and in the District Rules. The areas around channels and waterways, including the area around lakes, marshes, lowlands, and ponding areas which would become inundated as the result of a 100-year precipitation event are considered floodplains. Critical storage area (or, critical detention area) is considered interchangeable with the term floodplain in reference to the floodplain definition.

Filling or development in identified critical storage areas, identified through hydrologic modeling and other means, is not allowed unless equivalent storage is demonstrated and provided within the same subwatershed. Equivalent storage is intended to mean providing the same reduction in peak flow, runoff volume or other important hydrologic characteristics.

New stormwater detention ponds, which by definition are critical storage areas, must be designed with an identified emergency overflow at 1 foot above the 100-year, 24-hour event (6.3-inches). All drawings must clearly show the direction of overflow and provide for adequate flowage easements. A minimum freeboard of 3 feet above the 100-year high water elevation (resulting from runoff generated by the 100-year, 24-hour precipitation event) and lowest opening elevation of a dwelling or structure must be provided for new ponds. Other floodplain requirements include:

- Floodplain Preservation – to be preserved by dedication and/or perpetual easement by the community in which they are located. Floodplain includes portions of the property that lie below one foot above the 100-year elevation. The 100-yr flood level must not be raised more than one-half foot.

- Floodplain Alteration – In landlocked areas, alterations to the land shall not limit the water storage capacity below the natural overflow.
- Outletting of landlocked and semi-landlocked basins must be coordinated with municipalities in conjunction with SWWD approved phasing plans in comprehensive and stormwater management plans.

Access to the floodplain information in the form of digital maps is provided on the SWWD website (www.swwdmn.org). These sources of information are available to allow a project proponent to determine if they are proposing activity within a floodplain or critical storage area.

Flood prone areas have been recently restudied by Washington County. This effort was administered by the Federal Emergency Management Area (FEMA) in cooperation with the Minnesota Department of Natural Resources. The original floodplain map has been modernized, meaning it contains updated estimations of 100-year water levels and is available in digital form for users. The map data pertains to riverine systems as well as landlocked basins.

The watershed-wide XP-SWMM modeling completed by the District also evaluated the extent of 100-year water levels for flood storage and conveyance areas. Critical storage areas are currently identified for the Northern and West Draw subwatersheds. Maps have been produced for select locations in these subwatersheds to depict the extent of storage areas. Note that in other areas maps may not necessarily be available, but estimated flood levels still may be known.

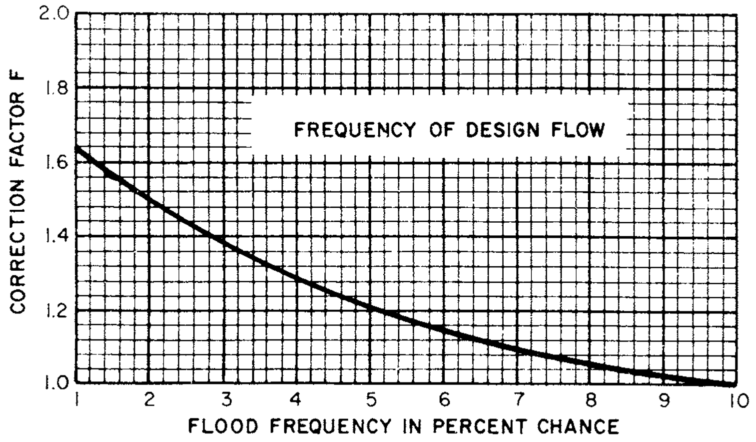
Any hydrologic and hydraulic modeling to be performed as a result of proposed filling or crossing of water resources of the District are expected to follow standard input methods as described in Chapter 4.

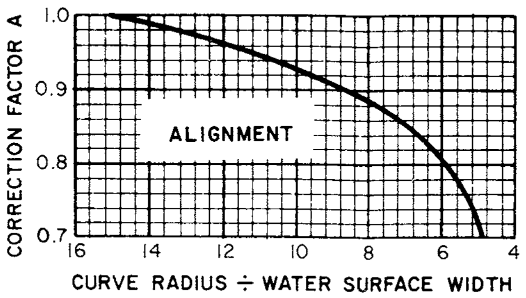
6.2 Open Channel Stability

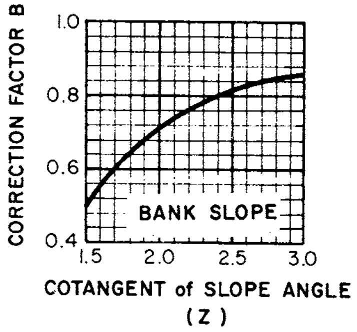
This Section provides guidance on methods for analyzing, computing, and ensuring channel stability for new stormwater discharges. Specific design criteria for open channels is generally deferred to member cities, except for freeboard and requirements detailed in the WMP. For new channel systems, whether intended solely for conveyance or also for water quality treatment, it is preferred to avoid riprap and hard armoring approaches to strengthen channel banks. Where appropriate, biodegradable or synthetic blankets (liners) are available for use in channel design.

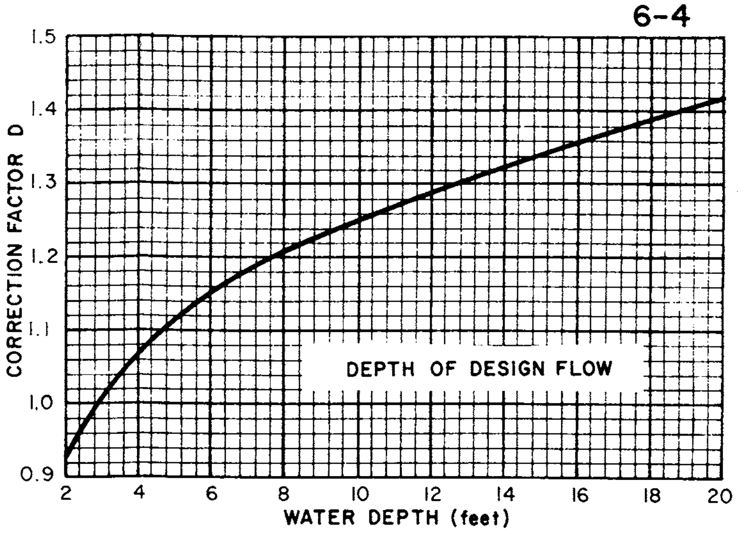
Natural open channels generally have two hydraulic benefits: they serve to convey water within the channel bank, and provide storage capacity in the form of a floodplain. Engineered channels, often in the form of swales or ditches, generally are intended to convey water to a known storage location. Ensuring the stability of open channels, either natural or engineered, is important for preventing erosion or channel failure. This can be done by calculating the critical velocity, which is the maximum allowable velocity before sediment particles are suspended into solution.

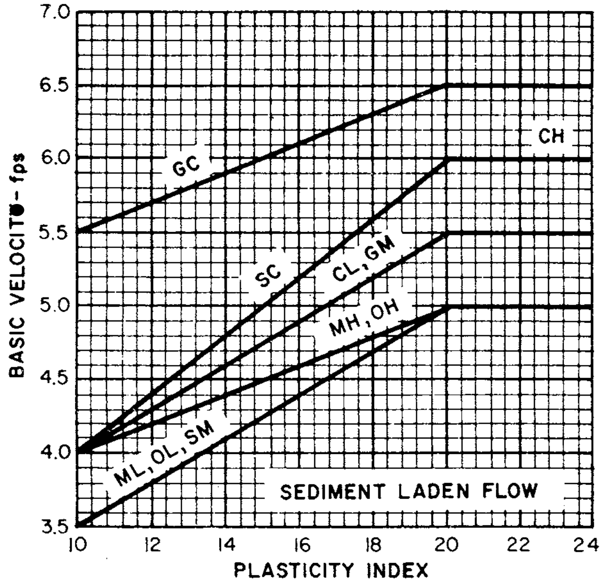
Several engineering methods can be used to evaluate channel stability. The District's preferred method is the allowable velocity approach. The allowable velocity is determined using a series of nomographs and channel characteristics as shown in Figure 6-2. This



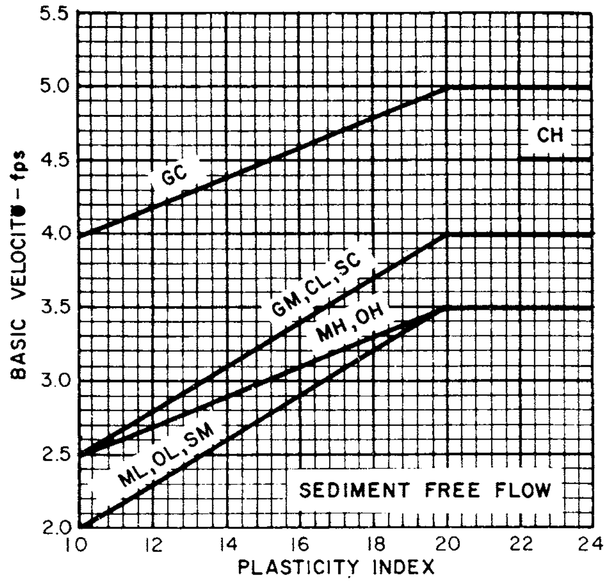








BASIC VELOCITIES FOR COHERENT EARTH MATERIALS (v_b)



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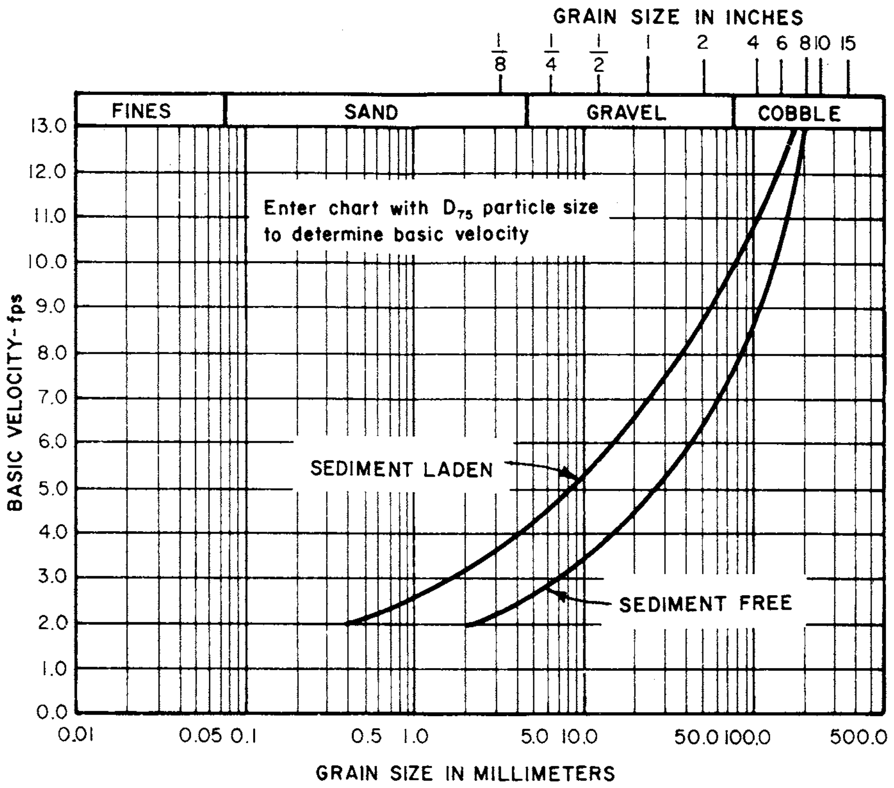
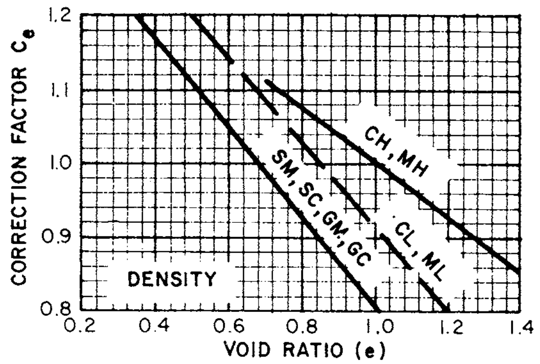


BASIC VELOCITY FOR DISCRETE PARTICLES OF EARTH MATERIALS (v_b)



NOTES:

1. In no case should the allowable velocity be exceeded when the 10% chance discharge occurs, regardless of the design flow frequency.

ALLOWABLE VELOCITIES FOR UNPROTECTED EARTH CHANNELS	
CHANNEL BOUNDARY MATERIALS	ALLOWABLE VELOCITY
DISCRETE PARTICLES	
Sediment Laden Flow	
$D_{75} > 0.4$ mm	Basic velocity chart value x D x A x B
$D_{75} < 0.4$ mm	2.0 fps
Sediment Free Flow	
$D_{75} > 2.0$ mm	Basic velocity chart value x D x A x B
$D_{75} < 2.0$ mm	2.0 fps
COHERENT EARTH MATERIALS	
PI > 10	Basic velocity chart value x D x A x F x C_e
PI < 10	2.0 fps

FIGURE 6-2

ALLOWABLE VELOCITIES FOR UNPROTECTED EARTH CHANNELS

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approach is based upon the testing of the erosive resistance of earthen channels. The key nomographs included in Figure 6-2 are those illustrating relationships between basic velocities and earth materials of the channel bank and bed.

General information is needed about the amount of fine material being carried in suspension. A full discussion of channel design is presented in NRCS Technical Release 25, Design of Open Channels, available at http://www.info.usda.gov/CED/ftp/CED/tr25.htm. The approach generally consists of:

- Determine the hydrology and hydraulics of the system. This includes estimating the peak flow rates for the 2-year recurrence event, as well as estimating stage-discharge-velocity relationships for the waterway being evaluated.
- Determine the properties of the earth materials forming the banks and bed of the waterway being investigated.
- Compare the design velocities for the 2-year event with the allowable velocities from charts, for the material forming the channel boundary.

The ability of an open channel to erode bank material will depend on whether the flow is sediment land or not. For open channels which only flow during wet weather conditions, the flow should be assumed to be sediment laden.

The channel is considered stable if the average channel velocity is less than the allowable velocity. The allowable velocity approach is applicable to vegetated and unvegetated channels with rigid boundaries. This means the stream channel remains essentially unchanged through the flow range of interest. Additional steps in the calculation procedure need to be applied for channel slopes exceeding 10% and banks exceeding 3:1.

Additional considerations to allowable velocities will be allowed for channels designed with reinforcing materials or products. The allowable velocity may be increased based on vendor performance specifications for a product, such as permanent blankets, or turf reinforcement mats. The use of hard armoring with rip rap is generally discouraged for most open channels.

7. Stormwater Utility Fee

This Chapter explains the Stormwater Utility Fee (SUF) established by the SWWD, and generally discusses how the SWWD SUF is calculated. Methods are shown for calculating SUF credits—and thus financial incentives—to property owners who choose to adopt runoff volume reduction practices on their site.

The SWWD collects a majority of its project fund revenue using a stormwater utility fee. A stormwater utility fee (SUF) is a property charge based on stormwater runoff characteristics for a type of land use. The basis of the current SUF mechanism is set forth in the “Stormwater Utility Update” final report (EOR, 2004). The SUF is labeled “SWWatershed” under special assessment in the property tax system on Washington County Tax statements.

The SWWD has set standards for controlling the amount of stormwater runoff volume for new development projects. In addition to this standard, the SWWD supports voluntary efforts to reduce the stormwater runoff volumes leaving a property. By providing a framework to reduce the SUF for a property based on volume control BMPs, the SWWD can motivate voluntary efforts to reduce stormwater runoff.

The purpose of this Chapter is to concisely describe the SUF assessment process, and illustrate the mechanism and application process for how reductions to the SUF can be attained.

7.1 Overview of Fee Assessment

7.1.1 Background

The SWWD Stormwater Utility project was first initiated in 1999. In 2003 the SWWD jurisdictional boundary was enlarged to include the East Mississippi Watershed Management Organization. Subsequently, a need was identified to develop a method of funding on a subwatershed basis.

There are two elements to the SWWD SUF funding process. The elements include:

- Weighted allocation of subwatershed project financing; and
- Separation of annual project implementation financing.

The financing for the two elements is predicated on the basis of two “management units,” administratively organized as the South Washington Watershed Management Unit and the East Mississippi Watershed Management Unit.

Subwatershed project financing relates to the Central Draw Overflow project. A weighted allocation of financing is achieved by distributing 25% of the total Overflow project cost across the entire South Washington Watershed Management Unit. The remaining 75% of the total Overflow project cost is assigned to the Northern subwatershed which is the contributing area.

For annual projects which are implemented in the South Washington Watershed Management Unit, SUF revenue is directly obtained from that Management Unit. Likewise, for annual projects implemented within the East Mississippi Watershed Management Unit, SUF revenue is directly obtained from that Management Unit

7.1.2 Fee Assessment Approach

A stormwater utility fee is a property charge based on stormwater runoff characteristics for a type of land use. The SWWD currently calculates the SUF based on a computed design storm runoff volume for a typical single family residential parcel. This computed runoff volume defines a unitless Residential Equivalency Factor (REF) with a value equal to one.

A key premise of the approach is that the typical single family residential parcel is associated with an average impervious percentage and acreage. The following criteria determine the total runoff for the unitless REF equavlent to one.

- Design event storm: 5-year frequency, 3.6-inch rainfall in 24 hours; and
- Typical single family residential parcel: 0.38 acres, 27.5% impervious.

Based on field checks done in the 2004 Stormwater Utility Update final report, it was determined that local new construction is creating a greater percent impervious per lot than the criteria for the REF. Thus the criteria may be adjusted in the future.

Stormwater runoff volumes increase as impervious cover increases, and as parcel size increases. This principle allows the REF to be scaled up or down according to impervious cover. Thus, the REF values are assigned to individual parcels based on their computed runoff volumes compared to a typical single family residential property. The REF value assigned to a parcel based on impervious cover is multiplied by the acreage of the parcel to obtain a Residential Equivalent Unit (REU) value. The REU for a parcel illustrates the number of typical single family residential parcels needed to generate an equivalent amount of stormwater runoff for that parcel. Thus, single family residential parcels are assigned a single REU value, not dependent on size of parcel.

7.2 Fee Reductions

There are two ways to reduce the SUF. The first is through an abatement of the fee, where the impervious percentage for a parcel is reassessed by the SWWD. The second way is through implementing BMPs to reduce the volume of runoff.

> *The ability to apply for a reduction to the stormwater utility fee is currently limited only to non-residential parcels.*

The ability to apply for a reduction to the stormwater utility fee is currently limited only to non-residential parcels, for two primary reasons. First, residential properties experience much higher frequency of ownership turnover. This presents administrative challenges to ensure that a residential BMP installed for reducing stormwater runoff (such as rain barrel) remains in place and functioning after sale of a property. Second, based on sampling of 100 parcels, single family residential lots are assumed to have a certain impervious percentage which sets the REF equal to one. Reassessing the impervious cover on a single family residential parcel to reduce the SUF is not administratively practical.

7.2.1 Fee Reduction Method

The purpose of the fee reduction structure is to provide a financial incentive framework for implementing volume control BMPs, thus motivating voluntary efforts to reduce stormwater runoff. Note that these volume control BMPs are not geared towards the 5-year design event which is the basis of the fee structure. Instead the benefit of the BMPs is generally more focused on small but frequent rain events which produce much of the runoff on an annual basis. Essentially the BMPs benefit water quality all year round. The fee reduction structure is based on annual reductions of stormwater runoff.

Three methods were identified to determine a fee reduction structure for the SUF. The first method identified is a literal translation of annual volume control to a financial benefit. The SUF for a parcel is reduced in direct proportion to the annual stormwater runoff reduction achieved. Thus if the annual runoff volume is reduced by 15 percent then the annual fee for the parcel is reduced by 15 percent.

The second method identified is an indirect translation of annual volume control to a financial benefit. The second method determines the annual stormwater runoff reduction achieved. Then, the reduced overall site impervious percentage that in effect would have generated that amount of runoff (had no BMP been implemented) is determined. The utility fee is thus calculated in direct proportion to this reduction in “effective” impervious percentage. For instance, a 15 percent volume reduction would have been attained by reducing the impervious cover of a parcel by 21 percent. Thus, the SUF reduction is indirectly translated from the annual volume control, and a 21 percent reduction is provided to the parcel. This method provides a greater financial incentive than the first method but is still based on the volume control achieved.

The third method is a subjective translation of annual volume control to a financial benefit. It builds on the second method of determining an “effective” impervious percentage after a BMP is implemented for volume control. However, the third method doubles the financial incentive provided to the parcel. Thus if a 21 percent reduction in effective impervious is attained, the SUF reduction is 42 percent. This method provides the greatest financial benefit but is distanced somewhat from the physical processes driving the stormwater runoff impact and control.

Currently the SWWD adopts the second method in providing reductions to the SUF based on the voluntary implementation of BMPs for non-residential parcels.

Currently the SWWD adopts the second method in providing reductions to the SUF based on the voluntary implementation of BMPs for non-residential parcels. The SWWD will continue to consider the implementation of any three methods discussed above, or develop new methods that may be more appropriate.

7.2.2 Applying for Re-determination

Prior to June 1st of any year, non-residential properties may request a re-determination of impervious cover to the SWWD Board, in writing. Request for re-determination after June 1st of the year will be considered for the following payable year. If the re-determination shows that the actual impervious percentage on-site is lower than what is being assessed, the annual SUF will be reduced to reflect the actual amount. If the re-determination results in a reduction of the annual SUF, the SWWD shall reimburse the property owner the difference between the assessed fee and the re-determined fee. There shall be no change to the SUF if the reassessment determines that the actual impervious percentage is greater than what is being assessed.

The parcel owner must submit a written request to the SWWD stating the desire for a re-determination. The request will be included in a regular meeting of the Board The SWWD will perform at its own expense the necessary efforts to evaluate the impervious percentage of a site which at times may involve the need to access the parcel. Upon completion of the re-determination, reimbursement of the SUF will be evaluated by SWWD staff and results presented to the Board for acceptance. If reimbursement is granted to the parcel, the parcel owner will be notified by letter stating the fee reduction.

7.2.3 Applying for BMP Credit

7.2.3.1 Process

Non-residential parcel owners may apply for a BMP credit, which is a reduction to the annual SUF based on the implementation of a stormwater volume control technique. An application form available on the SWWD website should be filled out and submitted to the District to begin the BMP credit process. Reductions (credits) to the SUF will be allocated to the parcel after the SWWD receives all required information and verifies the volume control technique is functioning. The steps in the overall process are as follows:

1. Non-residential parcel owner or agent completes the application and submits the form to the SWWD before any site work is performed. Applications can be received at any time.

2. The SWWD reviews the application to ensure the proposed BMP is suitable based on site conditions. If necessary, clarifying information is requested to fully understand the proposed BMP relative to the parcel.

3. The application is processed by the SWWD. The estimated credit to the SUF is calculated for the parcel based on the application submittal.

4. The applicant is notified that the proposed project qualifies for BMP credit to the volume control technique, and identifies the estimated amount of the credit. If necessary, a pre-project site visit is scheduled to verify site conditions.

5. The applicant implements the volume control technique on the parcel and notifies the SWWD after the project is complete and functioning. A post-project site visit is scheduled to confirm the BMP is functioning and to verify site conditions.

6. After finalization of appropriate documentation, the SUF credit to the parcel is processed by the SWWD.

7.2.3.2 Requirements

By initiating a voluntary volume control technique, the non-residential parcel owner is undertaking efforts from which they financially benefit over time. The efforts also benefit the watershed and water quality. To continue receiving the financial benefits, the BMP must successfully function into the future.

The following requirements are established to ensure that volume control efforts are successful:

1. The BMPs for a non-residential parcel should be identified and implemented based on guidance and design criteria identified within this Manual. Volume control benefits will be estimated by the SWWD for an applicant based on methods within this Manual.

2. For structural improvements that affect the existing storm sewer drainage infrastructure, a qualified professional engineering licensed in Minnesota shall perform design work. Appropriate building permits must also be obtained prior to start.

3. A BMP may be implemented for some, or all, of the parcel site. However, if that BMP receives off-site overland drainage from another parcel, the contributing off-site parcel does not receive credit unless it is a joint application.

4. The application must agree to the following:

    a. Developing, submitting, and implementing an on-going maintenance plan to successful functionality of the BMP.

    b. Annual self-reports to document the maintenance activities performed and identified the status of the BMP. Self-reports must be submitted to the SWWD by the last business day of January.

    c. Disclosing this BMP credit during any sale or ownership transfer of the parcel.

    d. Allowing access by the SWWD to inspect the status of the BMP, so long as due notice is provided.

5. If soil decompaction is pursued as a BMP, pre-project and post-project soil tests of bulk density must be performed and submitted by a competent soils scientist or professional engineer. The tests should show a minimum change of 15 percent in bulk density.

6. If disconnection of impervious area is pursued as a BMP, pre-project and post-project inspections of local drainage must be performed with the SWWD.

7. If a BMP is deemed by the SWWD as no longer adequately functioning, the original REU charge for the parcel may be reinstated. Similarly, if a parcel owner is not responsive in timely submitting the annual self-reports the SWWD may reinstate the original REU charge for the parcel.

8. Frequently Asked Questions

What is an allowable nutrient load?

The District's WMP established a framework to set allowable nutrient loads for various receiving waters in the watershed. Allowable nutrient loads specify the maximum amount of phosphorus that can leave a project site after construction. The designer is responsible to incorporate sufficient BMPs to ensure the nutrient load is met. The allowable nutrient load is expressed on a per acre basis so that the requirement can be scaled up according to the overall size of the project area.

Is there a difference between nutrient load requirements for wetlands and lakes?

Yes. For lakes and the Mississippi River, the allowable loads apply in those cases to the nearest downstream receiving water body (i.e. lake) to which runoff is ultimately be discharged, regardless if an existing constructed stormwater pond is will receive runoff prior to discharge to the lake or river. In contrast, the allowable nutrient load for wetlands only applies to projects when there is no current or proposed structural stormwater treatment between discharge from the site and the wetland.

What if part of my site drains to a wetland and the other part drains elsewhere (such as a classified lake, or to another pond)?

The nutrient control standard for each part of the project site will differ, depending on the receiving water. The volume control standard applies across the entire site regardless of the receiving water or drainage patterns.

Why is the District's annual volume control standard not based on a design event, such as ½-inch of runoff?

All of the District's standards are based on the actual resource, such as a lake or wetland. The same is true for the volume control standard which is based on the infiltration capacity of the land resource. While a "one-size-fits-all" design approach may provide an equal standard for projects, it is not fair because some projects may be required to do more than their fair share while others do less. Some areas of the watershed support more infiltration whereas some support less infiltration which generally is a function of soils and land use.

An annual volume control approach also provides more consistency with current stormwater regulations. This is specifically for member cities dealing with nondegradation requirements (NPDES Phase II MS4 permittees including Woodbury and Cottage Grove).

My project meets a local requirement for "abstracting" a certain depth of runoff. Does this satisfy the watershed volume control requirement?

Meeting the local requirement for "abstracting" (or infiltrating, or preventing) a certain depth of runoff does not automatically satisfy the watershed volume control requirement. However, the SWWD will accept a comparable standard for achieving the SWWD volume control requirement. The comparable standard is volume control to mitigate at least one (1) inch of runoff from all impervious surfaces within the proposed project boundary.

My project is located in an area where infiltration is not feasible. How can I address the volume control requirement?

Certain non-structural volume control techniques will always be feasible at a given site. However, for those infrequent instances where full volume control compliance may not be feasible, the SWWD has elected to establish an alternative assessment for ascertaining whether a project proponent has completed due diligence in mitigating the impacts of stormwater runoff from a site. If the project circumstances merit an alternative assessment, the SWWD will provide a spreadsheet and work with the proponent to identify thresholds for stormwater mitigation that are acceptable for protecting water quality.

If a project is required to maintain the existing annual runoff volume then why is a Stormwater Utility Fee still assessed?

Although existing annual runoff volumes may be maintained, infrastructure must still be constructed and installed to convey excess runoff from urbanized areas. The annual volume control approach typically targets runoff from small-to-moderate storm events. Larger storm events, such as a 10-year or 100-year recurrence storm, still generate substantially elevated runoff volumes and peak discharges compared to existing conditions. The Stormwater Utility Fee is assessed because of the infrastructure needed to convey or store excess precipitation from large magnitude storms.

If a project implements volume control does that count for rate control also?

Calculations for volume control techniques may include adjustments to water quality model input values such as curve numbers or percent imperviousness. These adjustments cannot be applied to hydrology / rate control calculations. This is due to a difference in temporal scales with which the controls are assessed. Volume control is calculated on an average annual basis and tends to target runoff from small storm events. Rate control is calculated on an event basis based on design events of large magnitude. Further, engineering based on rate control calculations is intended to prevent flood damage, and protect structures and public safety. These calculations must remain consistent with standard engineering practices.

What is the difference between a *primary* downstream receiving water and a *classified* downstream receiving water body?

A primary downstream receiving water body applies to wetlands. A primary downstream receiving water body means there is no existing structural stormwater treatment between discharge from your site and the wetland. Sites where runoff will flow to an existing stormwater treatment facility prior to discharge to a wetland are not subject to the wetland standards.

The term “classified” downstream receiving water body refers to classified lakes and the Mississippi River. Refer to Table 6.4 of the WMP. Standards must be met for a classified downstream receiving water body regardless if existing structural stormwater treatment will receive runoff prior to discharge.

When a site discharges stormwater directly to a wetland, which then in turn flows into a classified water body, the standards for the wetland will guide the site design requirements.

When a site drains to a classified lake, which then in turn flows into a downstream wetland or the Mississippi River, the standards for the classified lake will guide the site design requirements.

If my project will discharge to an existing regional infiltration basin, does the site still have to meet volume control requirements?

Yes. All site-specific requirements (rate control, volume control, nutrient control) will apply to the project site. The volume control requirement is intended to mimic the natural hydrology of a site before it is developed.

Can I use soil decompaction and impervious disconnection in tandem to meet water quality standards? If so, how?

Yes, provided that the physical area of the two proposed BMPs overlaps. Inputs to the water quality model can be adjusted using spreadsheets developed by the SWWD to assist in the assessment for nonstructural BMPs. Where there is overlap in the BMPs, the resulting modified percent impervious from one technique can then be further reduced in the water quality model to reflect the proposed benefit from the other technique. Generally, it is recommended to calculate the benefit for soil decompaction before estimating the additional benefit from impervious disconnection, however, this is not a requirement.

Appendix A.
Water Quality Modeling Example

Available Worksheets

Three electronic worksheet forms have been developed to provide a uniform method for assessing and reporting the water quality impacts of a proposed development project. The first form to use is a *summary worksheet* for assessing the level of nutrient and volume control requirements for a proposed project. The summary worksheet allows a project agent to understand how much nutrient and runoff volume control is required based on the downstream water body receiving discharge from the project.

A second form is a site *design worksheet* for reporting the BMPs used to achieve the required load and volume reductions. It allows the project agent to see the numeric endpoints required for their site, as determined from the first worksheet. The project agent can quantitatively assess their progress towards meeting the established standards based on the incorporation of site design elements. This second form must be submitted by the project agent to the District.

Third, a worksheet has been developed to assist in assessing the water quality benefits of potential non-structural BMPs. This worksheet aids in determining adjustments to water quality model input parameters when incorporating non-structural BMPs. Refer to Section 5.4.2 of the Standards Manual for more information.

These forms can be accessed through the SWWD web site.

Modeling Example Scenario

The baseline scenario for example calculations illustrating new development projects is based on the following assumptions:

- Approximately 80-acre Single Family Residential development
- Overall site impervious area is 38 percent, or approximately 30 acres
- Annual site rainfall is 29.5 inches

The process to determine what standards apply to each development scenario follows the steps described in Chapter 3 of the Standards Manual.

An Example from Start to Finish

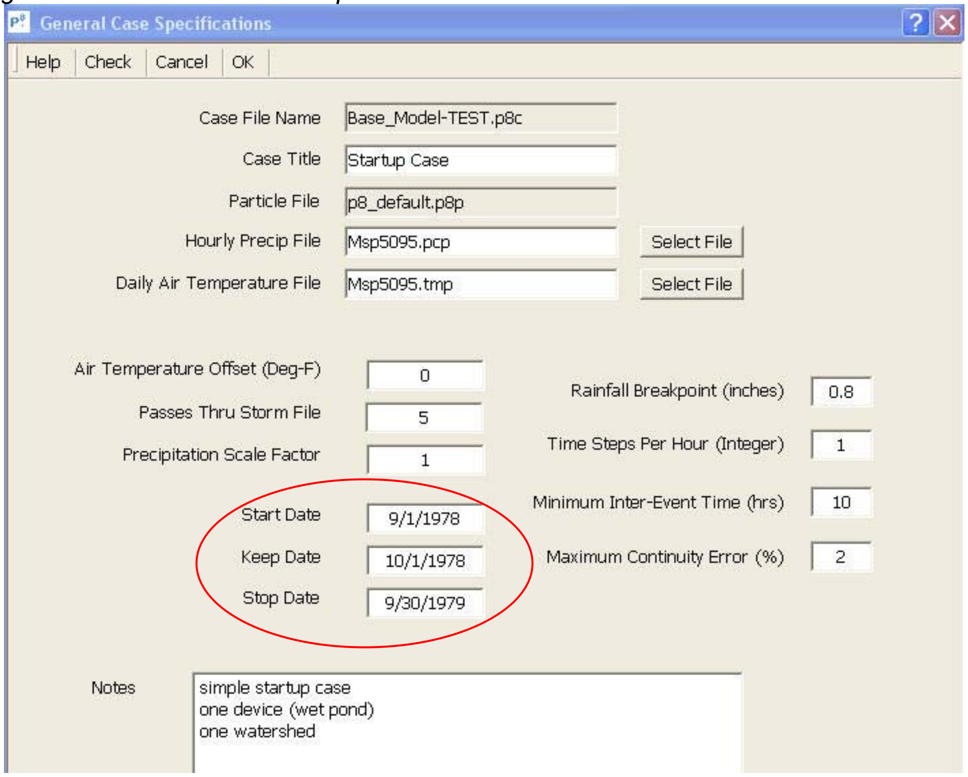
The hypothetical site is a new development project located in the southern portion of the SWWD. The development example is for a site that drains to a "protect" classified wetland. The water quality standard for this receiving water is to maintain predevelopment nutrient loading rates. This loading rate is simply a calculation of the predevelopment annual average runoff volume multiplied by the existing land use nutrient runoff event mean concentration. See Section 5.3.2.3 for more information regarding event mean concentrations. To meet the load requirement, volume control will be an integral part of the site design.

Modeling Prior to BMP Analysis

Water quality modeling is performed to determine the post-development impact of the example project prior to implementation of any BMPs. When the modeling is completed, the total annual nutrient load and the total annual runoff volume are entered into the design worksheet for assessing nutrient control requirements.

The P8 model, version 3.4, was used in this example to determine the untreated runoff volume and nutrient load. A series of screen captures from the P8 model has been provided to illustrate how the P8 model was set up for the base case. **Figure A-1** is the General Case specification screen. This is where precipitation and temperature files are specified. The specified inputs in this example reflect conditions for a normal water year (as described in the Standards Manual). Dates must be referenced as circled.

Figure A-1: P8 General Case Specification Screen.



Case File Name: Base_Model-TEST.p8c
Case Title: Startup Case
Particle File: p8_default.p8p
Hourly Precip File: Msp5095.pcp
Daily Air Temperature File: Msp5095.tmp

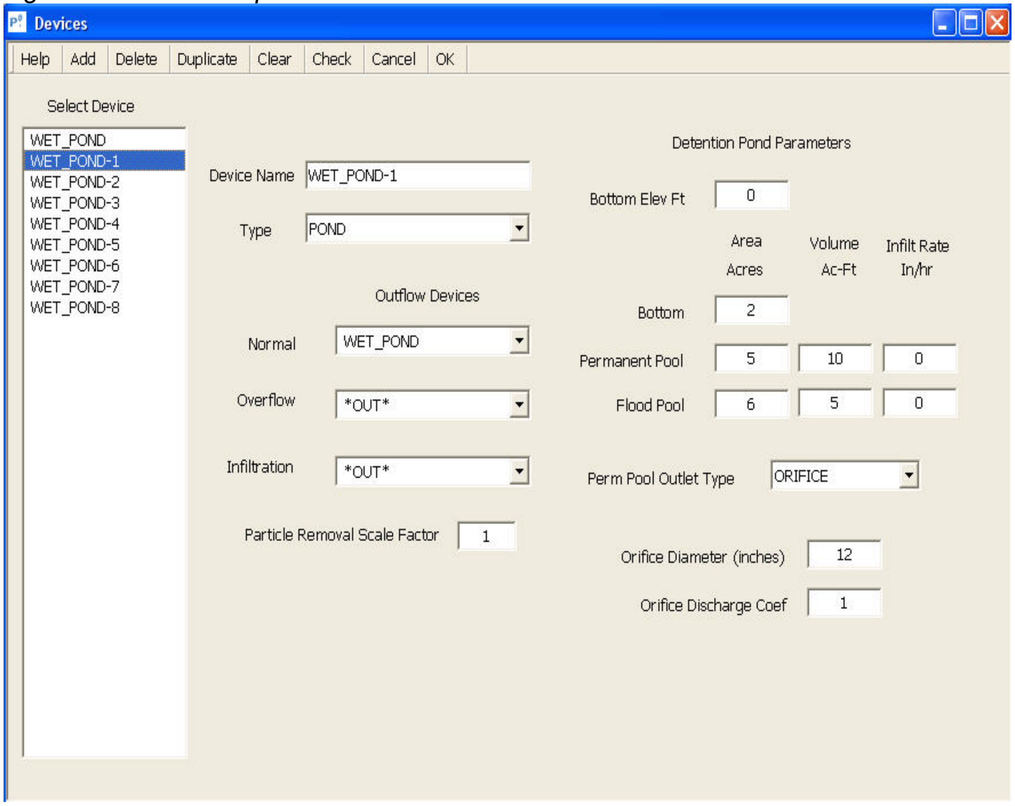
Air Temperature Offset (Deg-F): 0
Passes Thru Storm File: 5
Precipitation Scale Factor: 1
Start Date: 9/1/1978
Keep Date: 10/1/1978
Stop Date: 9/30/1979

Rainfall Breakpoint (inches): 0.8
Time Steps Per Hour (Integer): 1
Minimum Inter-Event Time (hrs): 10
Maximum Continuity Error (%): 2

Notes:
simple startup case
one device (wet pond)
one watershed

Figure A-2 is the Devices specification screen. This is where parameters for treatment devices are specified. The treatment devices can also be used to specify a general, or "dummy", device that receives runoff from the study watersheds. If this is the case, detailed parameters do not need to be specified as the device will only be used to track how much modeled runoff is entering the device. In this example, wet ponds were used as "dummy" devices.

Figure A-2: Devices Specification Screen.



Select Device
- WET_POND
- WET_POND-1
- WET_POND-2
- WET_POND-3
- WET_POND-4
- WET_POND-5
- WET_POND-6
- WET_POND-7
- WET_POND-8

Device Name: WET_POND-1
Type: POND

Outflow Devices
Normal: WET_POND
Overflow: *OUT*
Infiltration: *OUT*

Particle Removal Scale Factor: 1

Detention Pond Parameters
Bottom Elev Ft: 0

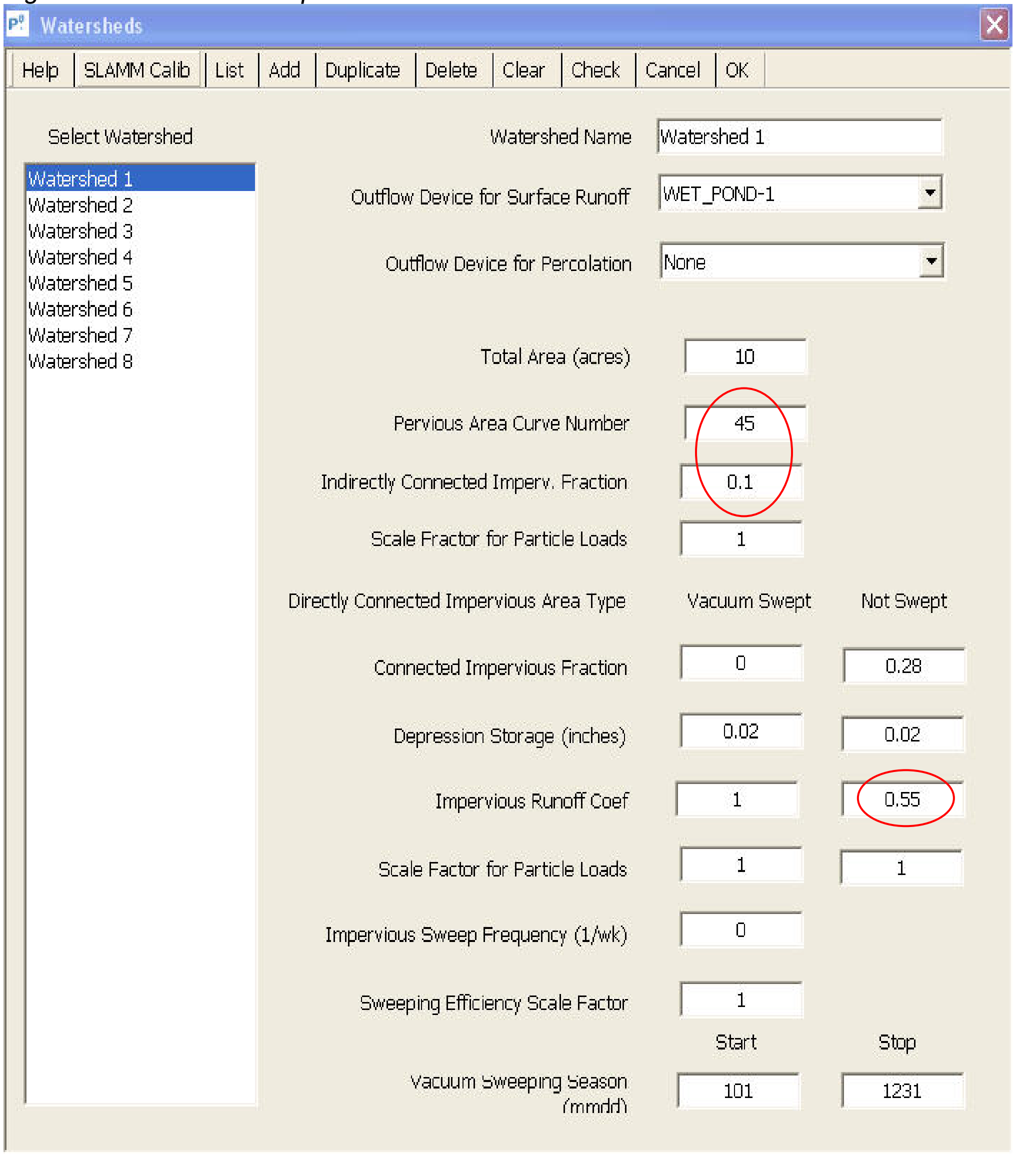
	Area Acres	Volume Ac-Ft	Infilt Rate In/hr
Bottom	2		
Permanent Pool	5	10	0
Flood Pool	6	5	0

Perm Pool Outlet Type: ORIFICE
Orifice Diameter (inches): 12
Orifice Discharge Coef: 1

Figure A-3 is the Watersheds specification screen. This is where parameters describing the study watersheds are entered, such as area, curve number, and depression storage. In this example, eight 10-acre subwatershed areas were used to represent various areas of the overall study 80-acre development area. These subwatersheds were specified to route surface runoff to the "dummy" devices, as described previously.

For this baseline case, the appropriate model parameters adjustments were made to establish a calibrated P8 model as described in Section 5.3.1.2. These adjustments are circled on Figure A-3. These adjustments relate to pervious area curve number, separation of the impervious fraction between that which is connected and indirectly connected, and impervious runoff coefficient. **Figure A-4** presents further illustration of separating impervious fraction for input to the model.

Figure A-3: Watersheds Specification Screen.



Watershed 1
Watershed 2
Watershed 3
Watershed 4
Watershed 5
Watershed 6
Watershed 7
Watershed 8

Watershed Name: Watershed 1
Outflow Device for Surface Runoff: WET_POND-1
Outflow Device for Percolation: None
Total Area (acres): 10
Pervious Area Curve Number: 45
Indirectly Connected Imperv. Fraction: 0.1
Scale Fractor for Particle Loads: 1

Directly Connected Impervious Area Type	Vacuum Swept	Not Swept
Connected Impervious Fraction	0	0.28
Depression Storage (inches)	0.02	0.02
Impervious Runoff Coef	1	0.55
Scale Factor for Particle Loads	1	1
Impervious Sweep Frequency (1/wk)	0	
Sweeping Efficiency Scale Factor	1	
	Start	Stop
Vacuum Sweeping Season (mmdd)	101	1231

Figure A-4: Separating Impervious Fraction Using Available Worksheet.

P8 Input:

Baseline:

Total Impervious fraction =					**0.38**	
Indirectly connected impervious =	0.25	x	0.38	=	**0.10**	0.1
Directly connected impervious =	0.75	x	0.38	=	**0.29**	0.28

The next step is to determine the runoff volume and nutrient loading control requirement for the study site, discussed in Section 3.3. The example project boundary is overlain on the annual runoff coefficient map, and the data are extracted to determine the area weighted runoff coefficient. The total area of the project and the area weighted runoff coefficient are entered into the summary worksheet. The receiving water type is located on the lower portion of the summary worksheet. The user finds the receiving water's allowed post-development site impact from the summary sheet for runoff volume and nutrient load, which is then entered into the design worksheet.

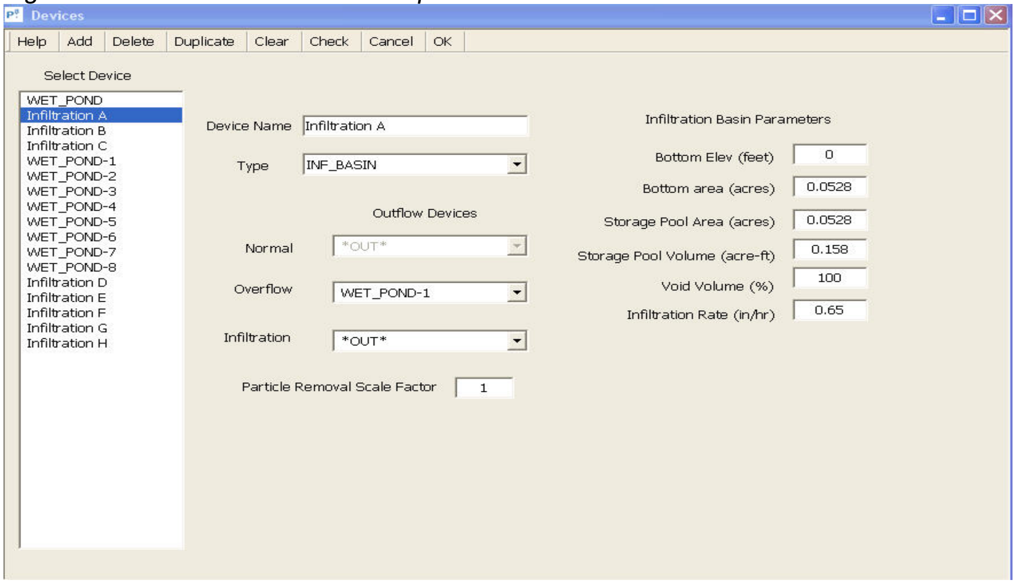
Based upon these two pieces of information entered into the project analysis, the amount of required reduction for nutrient loading and runoff volume mitigation is updated. The unmitigated post-development annual loads were modeled as 36.4 pounds of phosphorus and 45.0 acre-feet of runoff. In this example, the allowable annual loads for a "protect" category wetland are 6.8 pounds of phosphorus and 7.9 acre-feet of runoff volume. With these targets in mind, BMPs need to be incorporated into the site design to meet the required nutrient and volume reductions.

Modeling Structural BMPs and Evaluating Compliance

Two different management practice scenarios were used to illustrate the effect of using structural and/or non-structural practices.

The first scenario involved using only structural management practices. The practice of choice in this test was on-site infiltration sized for 1/2" of storm runoff and based off of a 0.65" infiltration rate. The screening tools described in the Design Manual were referenced prior to this application to make sure that infiltration practices made sense for this example site, and the infiltration rate was the maximum rate (based off of infiltration monitoring performed by the SWWD). The base case P8 model was set up to route runoff from the subwatersheds to infiltration basins that were sized appropriately to receive stormwater runoff. These changes are illustrated in **Figures A-5 and A-6**, which illustrate the change to the Devices and Watersheds specification screens for the first scenario, respectively.

Figure A-5: First Scenario Devices Specification Screen.



Select Device
WET_POND
Infiltration A
Infiltration B
Infiltration C
WET_POND-1
WET_POND-2
WET_POND-3
WET_POND-4
WET_POND-5
WET_POND-6
WET_POND-7
WET_POND-8
Infiltration D
Infiltration E
Infiltration F
Infiltration G
Infiltration H

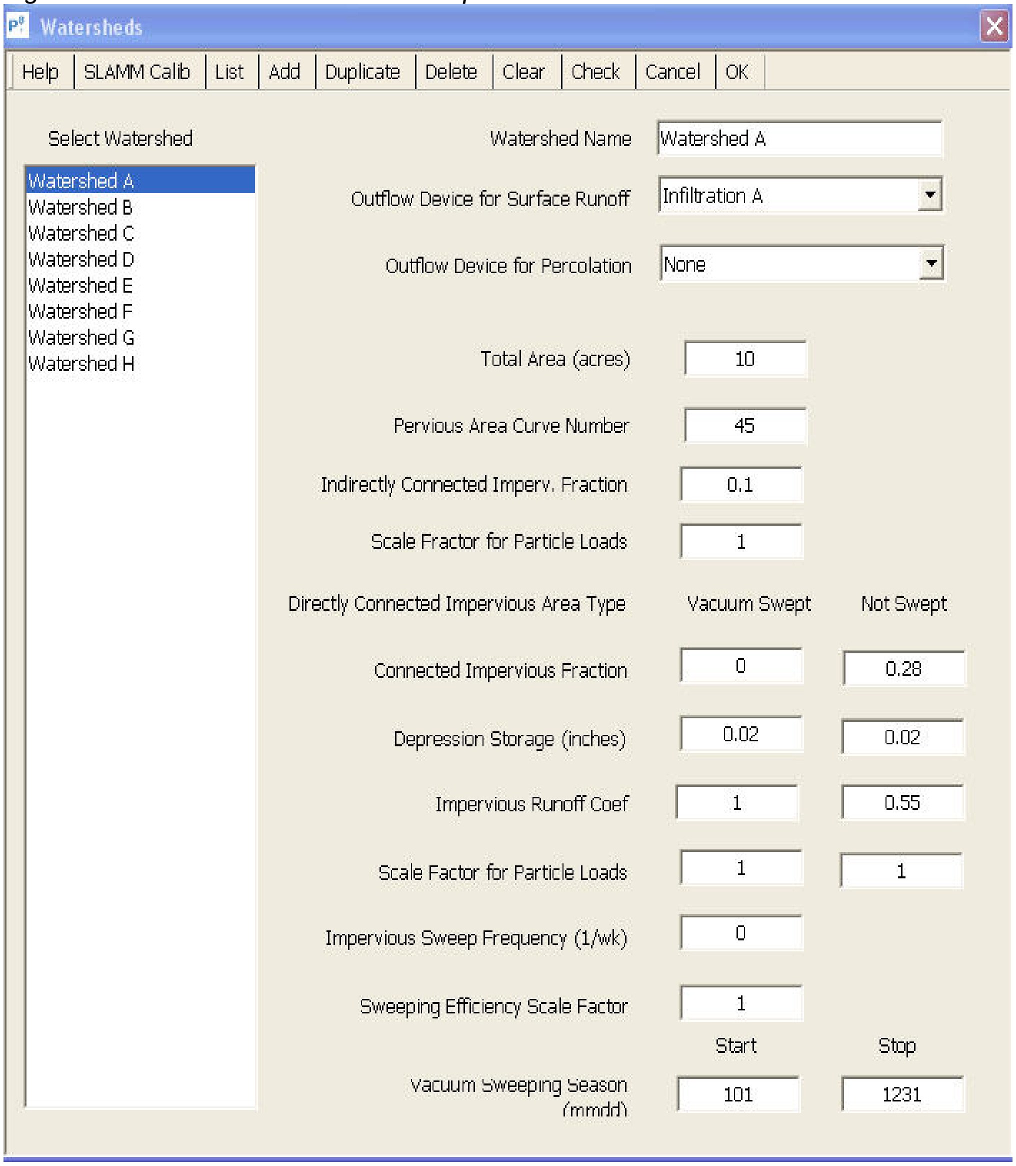
Device Name: Infiltration A
Type: INF_BASIN

Outflow Devices
Normal: *OUT*
Overflow: WET_POND-1
Infiltration: *OUT*

Particle Removal Scale Factor: 1

Infiltration Basin Parameters
Bottom Elev (feet): 0
Bottom area (acres): 0.0528
Storage Pool Area (acres): 0.0528
Storage Pool Volume (acre-ft): 0.158
Void Volume (%): 100
Infiltration Rate (in/hr): 0.65

Figure A-6: First Scenario Watersheds Specification Screen.



Select Watershed

- Watershed A
- Watershed B
- Watershed C
- Watershed D
- Watershed E
- Watershed F
- Watershed G
- Watershed H

Watershed Name: Watershed A

Outflow Device for Surface Runoff: Infiltration A

Outflow Device for Percolation: None

Total Area (acres): 10

Pervious Area Curve Number: 45

Indirectly Connected Imperv. Fraction: 0.1

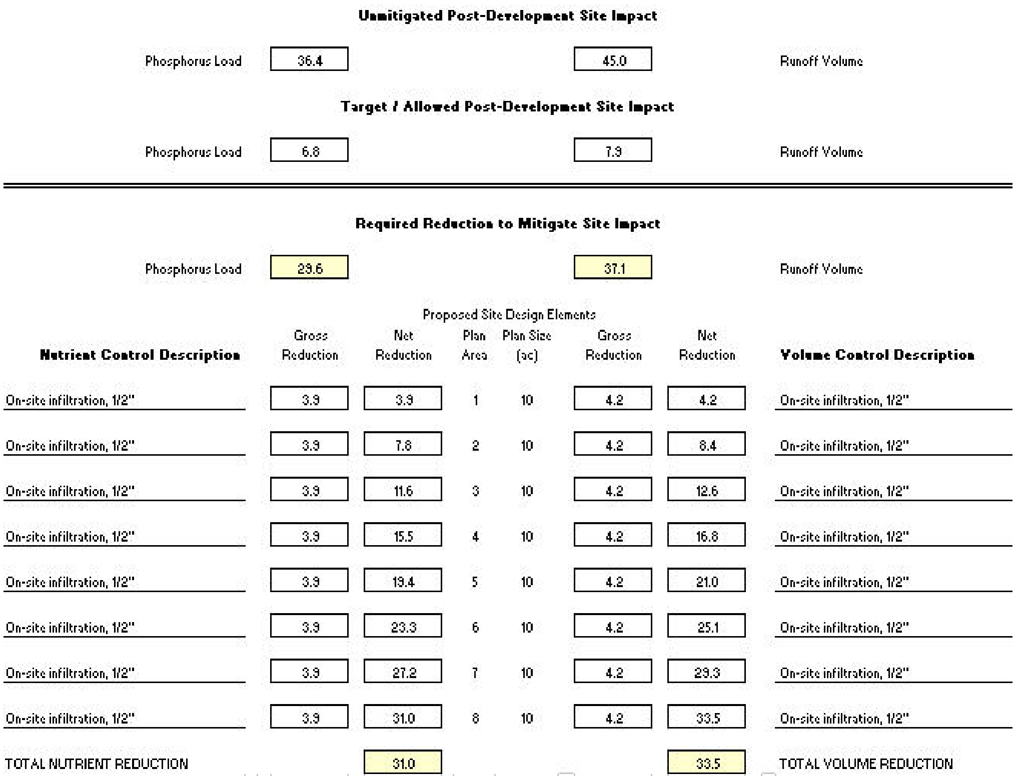
Scale Fractor for Particle Loads: 1

Directly Connected Impervious Area Type	Vacuum Swept	Not Swept
Connected Impervious Fraction	0	0.28
Depression Storage (inches)	0.02	0.02
Impervious Runoff Coef	1	0.55
Scale Factor for Particle Loads	1	1
Impervious Sweep Frequency (1/wk)	0	
Sweeping Efficiency Scale Factor	1	

	Start	Stop
Vacuum Sweeping Season (mmdd)	101	1231

The results from this simulation can be seen in **Figure A-7**, where the model output was used to update the design worksheet. It can be seen that the targeted nutrient reduction was met, but the volume reduction was not.

Figure A-7: Design Worksheet.



Unmitigated Post-Development Site Impact

Phosphorus Load	36.4	45.0	Runoff Volume

Target / Allowed Post-Development Site Impact

Phosphorus Load	6.8	7.9	Runoff Volume

Required Reduction to Mitigate Site Impact

Phosphorus Load	29.6	37.1	Runoff Volume

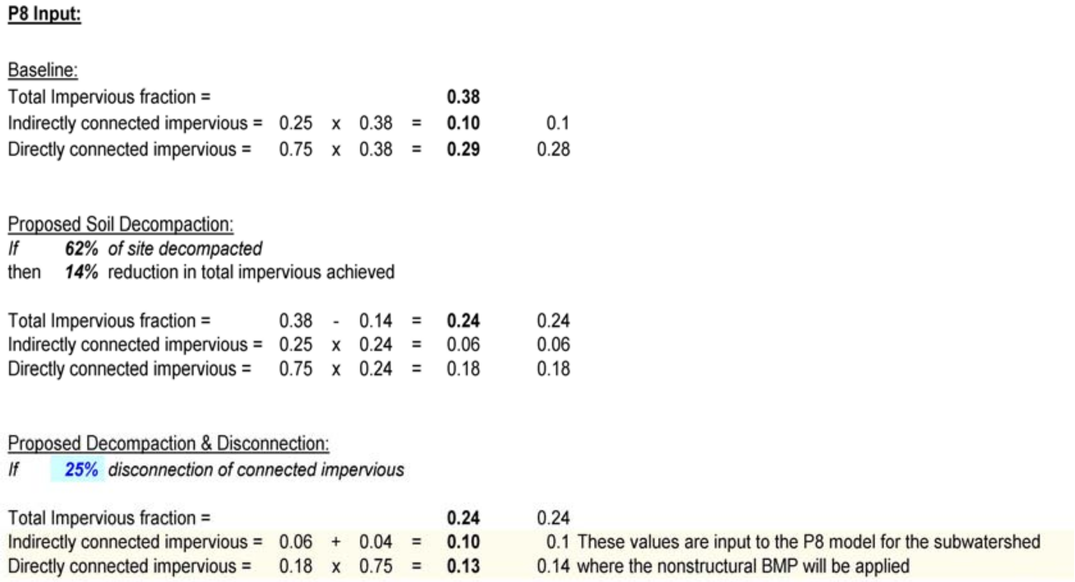
Proposed Site Design Elements

Nutrient Control Description	Gross Reduction	Net Reduction	Plan Area	Plan Size (ac)	Gross Reduction	Net Reduction	**Volume Control Description**
On-site infiltration, 1/2"	3.9	3.9	1	10	4.2	4.2	On-site infiltration, 1/2"
On-site infiltration, 1/2"	3.9	7.8	2	10	4.2	8.4	On-site infiltration, 1/2"
On-site infiltration, 1/2"	3.9	11.6	3	10	4.2	12.6	On-site infiltration, 1/2"
On-site infiltration, 1/2"	3.9	15.5	4	10	4.2	16.8	On-site infiltration, 1/2"
On-site infiltration, 1/2"	3.9	19.4	5	10	4.2	21.0	On-site infiltration, 1/2"
On-site infiltration, 1/2"	3.9	23.3	6	10	4.2	25.1	On-site infiltration, 1/2"
On-site infiltration, 1/2"	3.9	27.2	7	10	4.2	29.3	On-site infiltration, 1/2"
On-site infiltration, 1/2"	3.9	31.0	8	10	4.2	33.5	On-site infiltration, 1/2"
TOTAL NUTRIENT REDUCTION		31.0				33.5	TOTAL VOLUME REDUCTION

Modeling Non-Structural BMPs and Evaluating Compliance

The second scenario involved using only non-structural management practices. The same model case described in the previous scenario was used, except that soil decompaction and impervious disconnection BMPs were applied to all eight, 10 acre subwatersheds in tandem following the methods discussed in Sections 5.4.2.8 and 5.2.4.9. Curve numbers and the percent impervious were adjusted in the P8 model to simulate soil decompaction. Then, impervious disconnection was modeled after the decompaction technique was applied. The impervious fraction was adjusted to represent a 25% reduction of directly connected impervious area. The watershed parameters in the base case P8 model were adjusted accordingly. **Figure A-8** shows how the P8 parameter inputs were determined, and **Figure A-9** illustrates the change to the Watersheds specification screen for the second scenario.

Figure A-8: Methodology For Determining Second Scenario Inputs to the P8 Model.



P8 Input:

Baseline:

Total Impervious fraction =					**0.38**		
Indirectly connected impervious =	0.25	x	0.38	=	**0.10**	0.1	
Directly connected impervious =	0.75	x	0.38	=	**0.29**	0.28	

Proposed Soil Decompaction:

If ***62%*** *of site decompacted*
then ***14%*** reduction in total impervious achieved

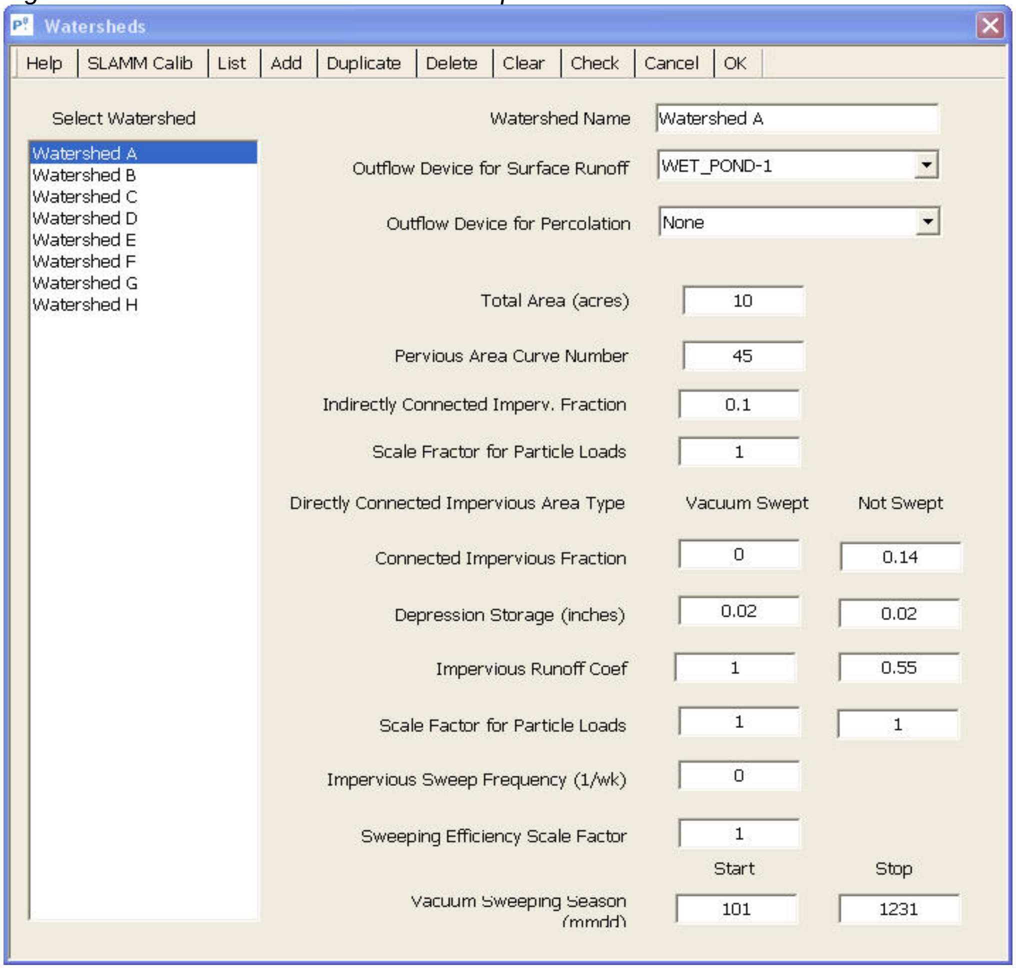
Total Impervious fraction =	0.38	-	0.14	=	**0.24**	0.24	
Indirectly connected impervious =	0.25	x	0.24	=	0.06	0.06	
Directly connected impervious =	0.75	x	0.24	=	0.18	0.18	

Proposed Decompaction & Disconnection:

If ***25%*** *disconnection of connected impervious*

Total Impervious fraction =					**0.24**	0.24	
Indirectly connected impervious =	0.06	+	0.04	=	**0.10**	0.1	These values are input to the P8 model for the subwatershed
Directly connected impervious =	0.18	x	0.75	=	**0.13**	0.14	where the nonstructural BMP will be applied

Figure A-9: Second Scenario Watersheds Specification Screen.



Select Watershed

- Watershed A
- Watershed B
- Watershed C
- Watershed D
- Watershed E
- Watershed F
- Watershed G
- Watershed H

Watershed Name: Watershed A

Outflow Device for Surface Runoff: WET_POND-1

Outflow Device for Percolation: None

Total Area (acres): 10

Pervious Area Curve Number: 45

Indirectly Connected Imperv. Fraction: 0.1

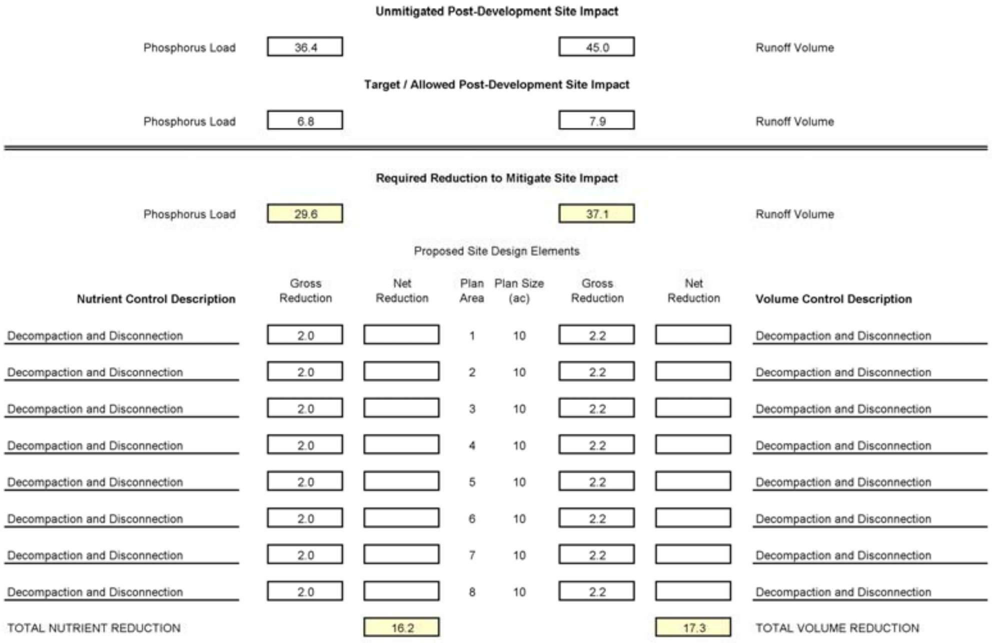
Scale Fractor for Particle Loads: 1

Directly Connected Impervious Area Type	Vacuum Swept	Not Swept
Connected Impervious Fraction	0	0.14
Depression Storage (inches)	0.02	0.02
Impervious Runoff Coef	1	0.55
Scale Factor for Particle Loads	1	1
Impervious Sweep Frequency (1/wk)	0	
Sweeping Efficiency Scale Factor	1	

	Start	Stop
Vacuum Sweeping Season (mmdd)	101	1231

The amount of benefit gained from using these two techniques can be seen in **Figure A-10**, where the project analysis and design worksheets have been combined. It can be seen that non-structural practices alone also do not meet the required amounts of nutrient and volume reductions.

Figure A-10: Non-Structural Practices Benefits.



Unmitigated Post-Development Site Impact

Phosphorus Load 36.4	45.0	Runoff Volume

Target / Allowed Post-Development Site Impact

Phosphorus Load 6.8	7.9	Runoff Volume

Required Reduction to Mitigate Site Impact

Phosphorus Load 29.6	37.1	Runoff Volume

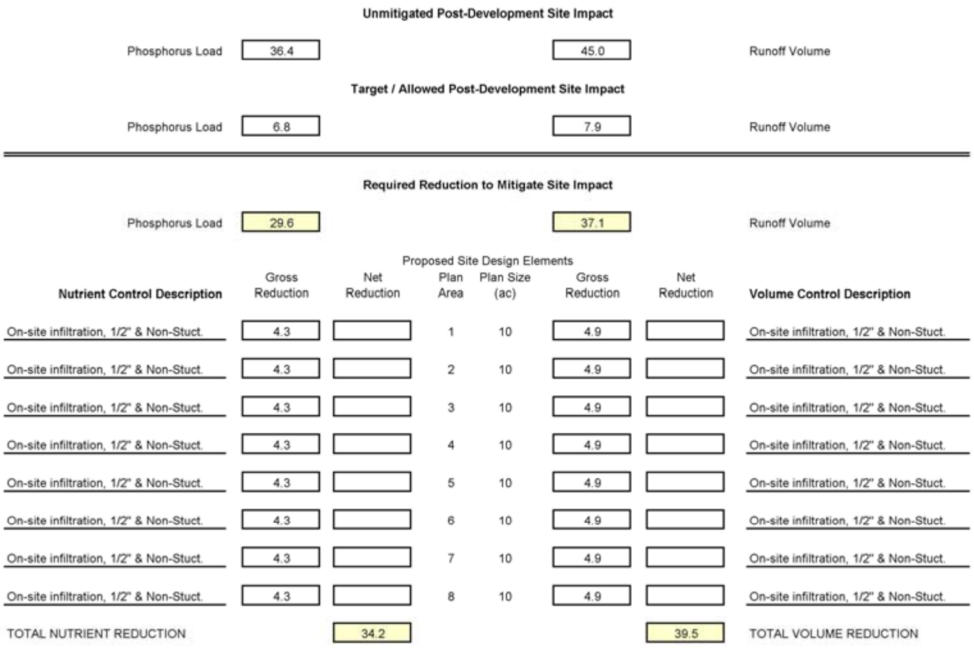
Proposed Site Design Elements

Nutrient Control Description	Gross Reduction	Net Reduction	Plan Area	Plan Size (ac)	Gross Reduction	Net Reduction	Volume Control Description
Decompaction and Disconnection	2.0		1	10	2.2		Decompaction and Disconnection
Decompaction and Disconnection	2.0		2	10	2.2		Decompaction and Disconnection
Decompaction and Disconnection	2.0		3	10	2.2		Decompaction and Disconnection
Decompaction and Disconnection	2.0		4	10	2.2		Decompaction and Disconnection
Decompaction and Disconnection	2.0		5	10	2.2		Decompaction and Disconnection
Decompaction and Disconnection	2.0		6	10	2.2		Decompaction and Disconnection
Decompaction and Disconnection	2.0		7	10	2.2		Decompaction and Disconnection
Decompaction and Disconnection	2.0		8	10	2.2		Decompaction and Disconnection
TOTAL NUTRIENT REDUCTION		16.2				17.3	TOTAL VOLUME REDUCTION

Modeling Mixed BMPs and Evaluating Compliance

The final scenario involved using a mix of structural and non-structural management practices. Techniques utilized in the previous two scenarios were combined. The non-structural management practices were applied to the subwatershed areas first, and the runoff was routed to the on-site infiltration basins sized for 1/2” of storm runoff. The device and watershed parameters from the base case P8 model were adjusted accordingly (refer to **Figures A-5 and A-9**). The results from this simulation can be found in **Figure A-11**.

Figure A-11: Structural and Non-Structural Practices Benefits.



Unmitigated Post-Development Site Impact

Phosphorus Load 36.4 | 45.0 Runoff Volume

Target / Allowed Post-Development Site Impact

Phosphorus Load 6.8 | 7.9 Runoff Volume

Required Reduction to Mitigate Site Impact

Phosphorus Load 29.6 | 37.1 Runoff Volume

Proposed Site Design Elements

Nutrient Control Description	Gross Reduction	Net Reduction	Plan Area	Plan Size (ac)	Gross Reduction	Net Reduction	**Volume Control Description**
On-site infiltration, 1/2" & Non-Stuct.	4.3		1	10	4.9		On-site infiltration, 1/2" & Non-Stuct.
On-site infiltration, 1/2" & Non-Stuct.	4.3		2	10	4.9		On-site infiltration, 1/2" & Non-Stuct.
On-site infiltration, 1/2" & Non-Stuct.	4.3		3	10	4.9		On-site infiltration, 1/2" & Non-Stuct.
On-site infiltration, 1/2" & Non-Stuct.	4.3		4	10	4.9		On-site infiltration, 1/2" & Non-Stuct.
On-site infiltration, 1/2" & Non-Stuct.	4.3		5	10	4.9		On-site infiltration, 1/2" & Non-Stuct.
On-site infiltration, 1/2" & Non-Stuct.	4.3		6	10	4.9		On-site infiltration, 1/2" & Non-Stuct.
On-site infiltration, 1/2" & Non-Stuct.	4.3		7	10	4.9		On-site infiltration, 1/2" & Non-Stuct.
On-site infiltration, 1/2" & Non-Stuct.	4.3		8	10	4.9		On-site infiltration, 1/2" & Non-Stuct.
TOTAL NUTRIENT REDUCTION		34.2				39.5	TOTAL VOLUME REDUCTION

This example shows only one instance of how various BMPs can be combined to reduce development impacts. Other combinations could provide the necessary reductions. Since this example development discharges to a wetland, appropriate analysis on discharge rate, inundation, and duration must be performed.