July 2008

Managing Stormwater in Your Community

A Guide for Building an Effective Post-Construction Program

Center for Watershed Protection

EPA Publication No: 833-R-08-001

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Foreword

Stormwater management is witnessing a growth in creative approaches. Stormwater managers across the country are incorporating stormwater treatment into landscapes and streetscapes. Stormwater is being captured and reused for a variety of beneficial uses. Stormwater treatment is being incorporated from the rooftop to the conveyance system to the stream edge. Stormwater is being integrated with land use plans to enhance community benefits and water quality. A variety of professionals—engineers, landscape architects, community planners, hydrologists, and public works staff (to name a few)—are now engaged in the challenge of managing stormwater in innovative ways.

At the same time, many communities are trying to build adequate programs to meet regulatory and community demands. Stormwater managers are trying to tackle complex issues with limited budgets and staffing.

In putting together the guide, we have polled local stormwater managers from across the country and gleaned important lessons and tips. It is our hope that this guide will provide stormwater professionals with practical guidance, insights, and tools to build effective programs.

The guide is accompanied by several downloadable "tools." The tools are designed to be used and modified by local stormwater managers to help with program implementation. The tools are described in more detail in Chapter 1, and can also be downloaded from the Center for Watershed Protection at ***www.cwp.org/postconstruction***.

A note on web links: We have provided numerous web links within the document to ease the task of finding relevant resources. However, links tend to become unreliable through time, especially for references to individual documents (such as pdfs). If you find a broken link, try to shorten the link to the relevant agency or department name to search for the document or page. Also, contact ***center@cwp.org*** to report broken links.

Contents

The following electronic tools are available at www.cwp.org/postconstruction:

Tool 1 – Post-Construction Stormwater Program Self-assessment

Tool 2 – Program and Budget Planning Tool

Tool 3 – Post-Construction Stormwater Model Ordinance

Tool 4 – Codes and Ordinances Worksheet

Tool 5 – Manual Builder

Tool 6 – Checklists

Tool 7 – Performance Bond Tool

Tool 8 – BMP Evaluation Tool

Tables

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Post-Construction Stormwater Management Glossary: *Towards a Common Language*

As stormwater management has evolved, so has the language used to describe certain practices and techniques. At this point, the terminology of stormwater can be confusing—largely because multiple terms are used to describe similar and overlapping concepts. Are we building stormwater BMPs, stormwater treatment practices, or structural measures? Is our innovative design approach known as low-impact development, better site design, environmental site design, non-structural measures, or green infrastructure?

This guide uses certain terminology, and it is important to understand the meaning of these terms as it relates to the material within the guidance. This is not an attempt to be definitive with regard to the terminology, as it is certain to evolve over time. Also, the list below is not exhaustive, as a much fuller list of terms can be found in most stormwater ordinances, regulations, and manuals, including the Post-Construction Model Ordinance provided in Tool 3 (***www.cwp.org/postconstruction***).

Combined Sewer Overflow (CSO)

Combined sewer systems are sewer systems that collect both stormwater runoff and sanitary sewage in the same pipe to be carried to a wastewater treatment plant. Wet weather events can sometimes cause these combined sewer systems to exceed their hydraulic capacity and result in a combined sewer overflow (CSO). A CSO can result in untreated human and industrial waste, toxic materials and debris being discharged to nearby streams, rivers, lakes or estuaries, impacting water quality and aquatic habitat. CSOs can cause beach closings, shellfishing restrictions and other water body impairments.

Environmental Site Design (ESD)

Environmental Site Design (ESD) is an effort to mimic natural systems along the whole stormwater flow path through combined application of a series of design principles throughout the development site. The objective is to replicate forest or natural hydrology and water quality. ESD practices are considered at the earliest stages of design, implemented during construction and sustained in the future as a low maintenance natural system. Each ESD practice incrementally reduces the volume of stormwater on its way to the stream, thereby reducing the amount of conventional stormwater infrastructure required. Example practices include preserving natural areas, minimizing and disconnecting impervious cover, minimizing land disturbance, conservation (or cluster) design, using vegetated channels and areas to treat stormwater, and incorporating transit, shared parking, and bicycle facilities to allow lower parking ratios.

The Center for Watershed Protection has published information on this concept using the term "Better Site

Design." For more information, see: *Better Site Design: A Handbook for Changing Development Rules in Your Community*, Center for Watershed Protection, Inc. ***www.cwp.org*** > Online Store > Better Site Design.

Green Infrastructure

Green infrastructure refers to natural systems that capture, cleanse and reduce stormwater runoff using plants, soils and microbes. On the regional scale, green infrastructure consists of the interconnected network of open spaces and natural areas (such as forested areas, floodplains and wetlands) that improve water quality while providing recreational opportunities, wildlife habitat, air quality and urban heat island benefits, and other community benefits. At the site scale, green infrastructure consists of site-specific management practices (such as interconnected natural areas) that are designed to maintain natural hydrologic functions by absorbing and infiltrating precipitation where it falls.

Additional information on green infrastructure is available from EPA at ***www.epa.gov/npdes/greeninfrastructure***.

Low-Impact Development (LID)

Low-Impact Development (LID) is a stormwater management approach that seeks to manage runoff using distributed and decentralized micro-scale controls. LID's goal is to mimic a site's predevelopment hydrology by using design techniques that infiltrate, filter, store, evaporate, and detain runoff close to its source. Instead of conveying and treating stormwater solely in large end-of-pipe facilities located at the bottom of drainage areas, LID addresses stormwater through small-scale landscape practices and design approaches that preserve natural drainage features and patterns. Several elements of LID—such as preserving natural drainage and landscape features—fit right into the Green Infrastructure approach. Additional information on LID is available at ***http://www.epa.gov/owow/nps/lid***.

Municipal Separate Storm Sewer System (MS4)

A Municipal Separate Storm Sewer System (MS4) is a publicly owned conveyance or system of conveyances that discharges to waters of the United States or waters of the state, and is designed or used for collecting or conveying stormwater. Conveyances can include any pipe; ditch or gully; or system of pipes, ditches, or gullies, that is owned or operated by a governmental entity and used for collecting and conveying stormwater. Discharges from MS4s are regulated under the NPDES municipal stormwater program (Phase I and Phase II).

Non-Structural BMP

Non-structural BMPs are used in lieu of or to supplement structural BMPs. Non-structural measures may include minimization and/or disconnection of impervious surfaces; development design that reduces the rate and volume of runoff; restoration or enhancement of natural areas such as riparian areas, wetlands, and forests; and vegetated areas that intercept roof and driveway runoff. In this regard, "non-structural BMP" is a generic term for many of the techniques under the umbrellas of Green Infrastructure and Low-Impact Development. Non-structural BMPs can also refer to program elements aimed at changing behaviors that lead to polluted runoff. Examples include storm drain stenciling, outreach programs, and yard fertilizer education programs.

Post-Construction Stormwater

This terminology is used to distinguish stormwater practices used during site construction (otherwise known as "construction stormwater" or "erosion and sediment control") from those that are used on a permanent basis to control runoff once construction is complete ("post-construction stormwater"). Construction stormwater is minimum measure #4 in the Phase II municipal stormwater permit program, and post-construction stormwater is minimum measure #5.

Smart Growth

Smart Growth refers to coordinated planning to support economic, community and environmental goals. Smart Growth focuses on planning where development is located in relationship to urban infrastructure and environmental features, and is a big-picture way to manage the overall footprint of impervious surfaces at the neighborhood, watershed, and community scales. Smart Growth encourages infill and redevelopment within designated areas as a way to keep the development footprint from expanding across important rural and natural resources areas. Smart Growth also encourages the coordination of utility plans, transportation plans, economic development plans, stormwater codes, design guidelines, and other policies to achieve the best outcomes for the economy and environment. For more information visit: ***http://www.epa.gov/smartgrowth/***

Stormwater BMP

BMP refers to "best management practice." It is a generic term that has been used interchangeably with stormwater practice or stormwater treatment practice. Stormwater BMPs can be either "structural" or "non-structural."

Structural BMP

Structural BMPs generally require construction supported by engineering plans, and become permanent features of the landscape. Examples include ponds, wetlands, underground or surface chambers or filters, bioretention areas, swales, and infiltration trenches.

Total maximum daily load (TMDL)

A Total Maximum Daily Load (TMDL) is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources.

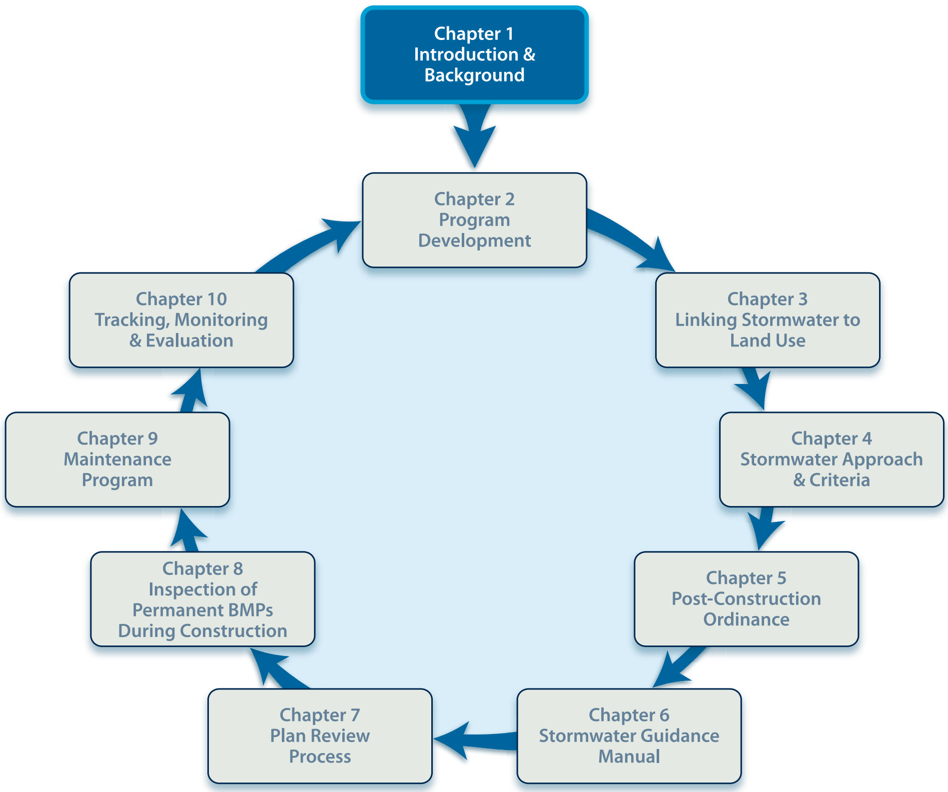
A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and nonpoint sources. The calculation must include a margin of safety to ensure that the waterbody can be used for the purposes the State has designated. The calculation must also account for seasonal variation in water quality.

Watershed Management

A watershed is the land area from which water drains into a stream, channel, lake, reservoir, or other body of water. Many communities are using the watershed management framework to address the intersection of land development and water quality/quantity. Watershed management often involves multi-jurisdictional collaboration to identify and address cross-boundary water quality problems and flooding.

Chapter 1

Introduction and Background



What's In This Chapter

- Post-Construction Stormwater Basics and the Guidance Manual
- Relationship of Post-Construction Stormwater Management to:
    - Construction Stormwater Management
    - Impaired Waters (TMDLs)
    - Combined Sewer Overflows
    - Stormwater Retrofitting
- Regulatory Background
- Current Trends and Recommendations for Post-Construction Stormwater Management

Download Post-Construction Tools at:
www.cwp.org/postconstruction

1.1. Introduction

Communities across the country are increasingly viewing stormwater management as an opportunity to improve the environment, create attractive public and private spaces, engage the community in environmental stewardship, and remedy the ills of the past, when development took place with inadequate stormwater controls.

While stormwater management has enjoyed a higher profile in recent times, communities across the country are striving to build the programmatic capabilities to effectively manage stormwater and meet regulatory requirements, such as Phases I and II of the National Pollutant Discharge Elimination System (NPDES) municipal stormwater permit program.

Many local programs have a strong emphasis on the stormwater basics of providing flood control and adequate drainage. Recently, many stormwater programs have become more sophisticated and "greener" by incorporating channel protection, groundwater recharge, protection of sensitive receiving waters, control of the overall volume of stormwater runoff, and use of natural systems and site design techniques to control runoff.

Water quality impacts from urban runoff can be significant. Many streams, lakes, and estuaries in urban areas are impaired due to urban runoff (***http://iaspub.epa.gov/waters10/attains_nation_cy.control***). Impervious surfaces, disturbed soils, and managed turf associated with urban development can have multiple impacts on water quality and aquatic life. These impacts are summarized in **Table 1.1**.

Urban development can also impact the post-development hydrograph discharging to urban streams (**Figure 1.1**). Compared to the pre-development condition, post-development stormwater discharges can increase the runoff volume, increase the peak discharge, and decrease the infiltration of stormwater, which thereby decreases baseflow in headwater streams. These changes to stream hydrology result in negative impacts on channel stability and the health of aquatic biological communities. Common problems include bank scouring and erosion, increased downstream flooding, and loss of in-stream habitat for macroinvertebrates, fish, and other organisms.

Table 1.1. Summary of Development Impacts on Water Resources

Increases in:	Decreases in:
Impervious cover, compacted soils, managed turf, and other land covers that contribute pollutants	Health and safety of receiving waters
Stormwater volume	Groundwater recharge
Stormwater velocity	Stream channel stability
Pollutant loads	Health, safety, and integrity of water supplies, reservoirs, streams, and biological communities
Stream channel erosion	Stream habitat

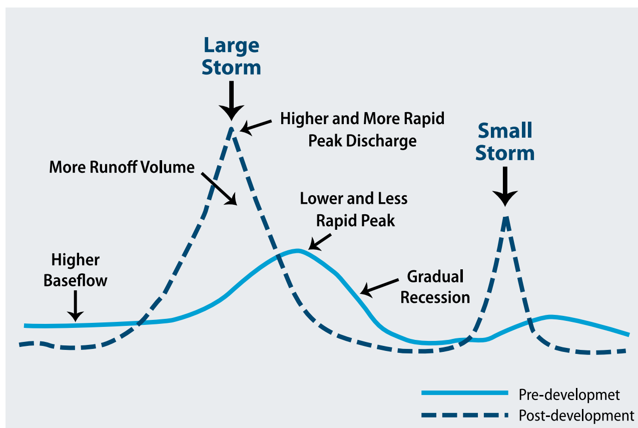


Figure 1.1. Urban development increases runoff volume, peak discharge, and time to peak

Purpose and Audience for this Guide

This guide is intended for Phase II NPDES Municipal Separate Storm Sewer System (MS4) communities (which are required to establish a post-construction program), as well as other smaller unpermitted MS4s that are interested in protecting local water resources. Other entities responsible for implementing post construction controls, such as military bases, transportation departments, and school districts, will also find this guide useful. Stormwater Phase I and other communities already implementing a post-construction program could benefit from the program assessment described in **Section 2.2** and other sections of the guide to help them identify key areas for improvement.

Finally, this guide is intended for multiple audiences within a local government. The guide recognizes the important link between overall comprehensive land use planning and the more technical components of a stormwater program. Often, land use planners and stormwater managers do not collaborate on large-scale land use and development issues. However, the activities of both groups have a profound impact on the health of watersheds and receiving waters. The guide, and especially **Chapter 3**, is meant to bridge this gap and promote a stronger link.

What's in the Guide

The guide contains chapters that address key elements of a post-construction program, and also several companion "tools." The tools are designed to be downloaded and adapted by local programs to help build program capabilities. The chapters and tools in the guide are listed in **Table 1.2**. **Figure 1.2** portrays the chapters of the guide in graphical format, showing the cyclical or iterative nature of the various program elements.

Table 1.2. Contents of Post-Construction Guidance Manual

Chapters	Description
Chapter 1 Introduction and Background	Introduces the contents of the guide and related tools. Provides a brief regulatory background on post-construction stormwater management.
Chapter 2 Post-Construction Program Development	Provides the stormwater manager with an understanding of the community and watershed components of a stormwater plan and introduces a program self-assessment tool. *Companion to Tool 1: Self-Assessment and Tool 2: Program and Budget Planning Tool*
Chapter 3 Land Use Planning as the First BMP: Linking Stormwater to Planning	Examines the link between stormwater and land use planning. Details how to build a more effective program through integrated stormwater and planning tools. *Companion to Tool 4: Codes and Ordinance Worksheet*
Chapter 4 Developing a Stormwater Management Approach and Criteria	Introduces a recommended stormwater management approach and how to distill this approach into criteria for a stormwater ordinance and guidance manual. *Companion to Tool 5: Manual Builder*
Chapter 5 Developing a Post-Construction Stormwater Ordinance	Works through the nuts and bolts of building a stormwater ordinance and illustrates major decision points. *Companion to Tool 3: Model Ordinance*
Chapter 6 Developing a Stormwater Guidance Manual	Reviews stormwater policy and design guidance from A to Z. Includes tips for building a manual that best suits the community. *Companion to Tool 5: Manual Builder*
Chapter 7 The Stormwater Plan Review Process	Delves into the anatomy of a good review process and how to use it to ensure good BMP design and long-term maintenance. *Companion to Tool 6: Checklists*
Chapter 8 Inspection of Post-Construction BMPs during Construction	Offers guidance on the process for initial installation of post-construction BMPs during the construction phase. *Companion to Tool 6: Checklists and Tool 7: Performance Bonds*

Table 1.2. Contents of Post-Construction Guidance Manual *(continued)*

Chapters	Description
Chapter 9 Developing a Maintenance Program	Explores three models for a maintenance program and provides tips for an effective program. *Companion to Tool 5: Manual Builder, Tool 6: Checklists and Tool 7: Performance Bonds*
Chapter 10 Tracking, Monitoring, and Evaluation	Reviews the development of measurable goals and milestones. Provides guidance on program evaluation, annual reports, and preparing for a possible program audit. *Companion to Tool 8: BMP Evaluation Tool*
Tools	**Description**
Tool 1 Post-Construction Stormwater Program Self-assessment	Evaluates the current status of the program, and where it needs to go. This checklist tool can be used to set short- and long-term goals.
Tool 2 Program and Budget Planning Tool	Provides planning milestones and assists with development of planning-level budget figures using a spreadsheet.
Tool 3 Post-Construction Stormwater Model Ordinance	Provides model language to build or enhance the ordinance. Language is keyed to three levels of program sophistication.
Tool 4 Codes and Ordinance Worksheet	Assesses zoning, subdivision, and other codes in the context of impervious cover creation and ability to promote effective stormwater management through design.
Tool 5 Manual Builder	Provides links to the best design and program resources around the country. Useful for stormwater managers who are developing a manual or adapting an existing manual.
Tool 6 Checklists	Provides detailed checklists for plan review, best management practice (BMP) installation during construction, and maintenance. The checklists address both structural and nonstructural stormwater BMPs.
Tool 7 Performance Bond Tool	Supplies templates that can be adapted to develop a performance bond for the program—an effective tool to ensure good BMP installation.
Tool 8 BMP Evaluation Tool	Asks the right questions when it comes to verifying the performance of various BMPs, especially proprietary devices.

Download Tools at: ***www.cwp.org/postconstruction***

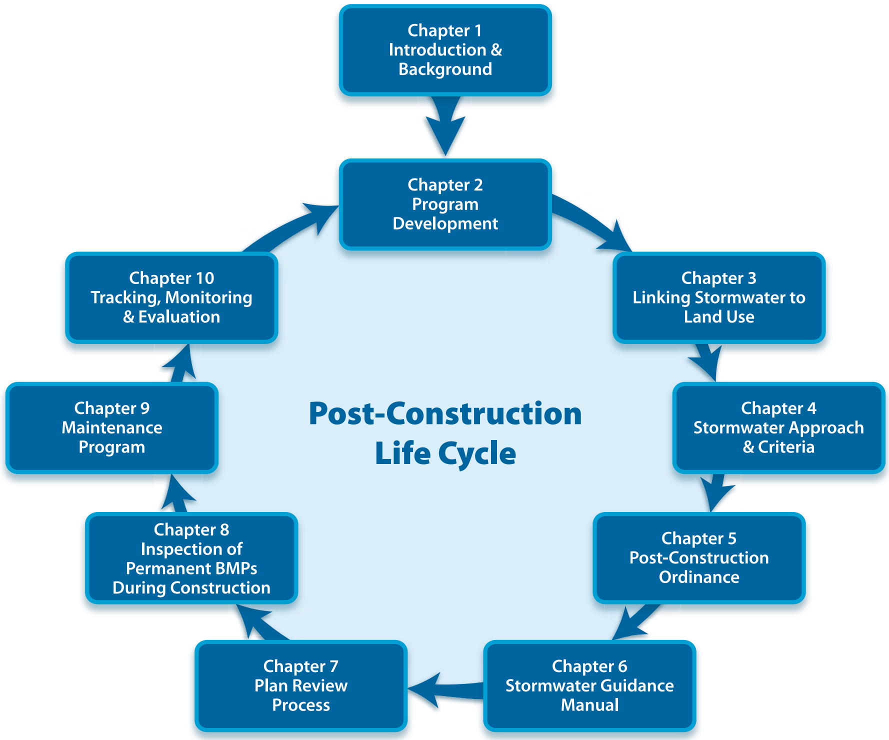


Figure 1.2. The Post-Construction Stormwater Life-Cycle, as presented in this guide. The program elements are presented in a cyclical or iterative format, as programs evolve.

1.2. Relationship of Post-Construction to Construction Stormwater (Erosion and Sediment Control)

This guide addresses runoff from projects after the construction phase is complete. Stormwater runoff from projects during active construction is typically addressed through requirements for stormwater pollution prevention plans (SWPPPs) and erosion and sediment control BMPs. Guidance on developing SWPPPs for construction projects is available from EPA (see *Developing Your Stormwater Pollution Prevention Plan: A Guide for Construction Sites* at ***http://www.epa.gov/npdes/swpppguide***).

A local program must carefully consider the relationship between construction and post-construction stormwater. Construction stormwater BMPs listed in a SWPPP are designed to minimize impacts during the active construction phase, and they do not always translate into BMPs applicable for post-construction. Post-construction BMPs must treat runoff from the newly constructed or redeveloped site, including runoff from roads, parking lots, yards, rooftops, and other land uses associated with development.

In some cases, construction and post-construction BMPs can be located in the same area, such as a sediment control basin or trap converted to a permanent stormwater BMP. Colocating construction and post-construction BMPs can help a designer follow natural drainage patterns, can be an economical approach, and often works when proper construction sequencing and standards are followed (see **Table 1.3** for more details).

However, increasingly, it is being found that construction and post-construction BMPs should be located on different parts of the site and have different sizing and design criteria. For instance, post-construction BMPs might involve practices distributed across the site, such as bioretention and infiltration practices. In this case, the post-construction BMP locations must be carefully protected during the construction phase in order to preserve the soil structure necessary for long-term BMP effectiveness. Also, the post-construction BMPs must be installed in the proper construction sequence—***after*** contributing drainage areas are stabilized—in order to prevent construction sediment runoff from clogging the newly installed bioretention or infiltration practices. **Figure 1.3** portrays typical coordination needs between construction and post-construction stormwater planning.

Table 1.3 notes several other dos and don'ts with regard to coordinating construction and post-construction BMPs.

1.3. Relationship of Post-Construction to Impaired Waters (TMDLs)

Under the authority of section 303(d) of the Clean Water Act, waterbodies that do not meet water quality standards are considered "impaired" and a "Total Maximum Daily Load" (TMDL) study must be conducted. This study computes the pollutant load that a waterbody can receive and still meet water quality standards, and it allocates this load to various point and nonpoint sources. Authorized states and tribes administer the TMDL program.

Currently, thousands of impaired waters are listed on state 303(d) lists. The most common sources of impairment associated with stormwater include sediment, pathogens (bacteria), nutrients, and metals (**USEPA, 2007**). Stormwater and urban and suburban runoff are significant contributors to impairments nationwide and the leading cause of impairments within some regions (**USEPA Region 5, 2007**). For this reason, EPA and relevant state agencies are increasingly motivated to create a stronger link between TMDLs and stormwater permits, such as MS4, construction site, and industrial permits. Future rounds of MS4 permit coverage will seek more targeted and/or stringent stormwater controls for impaired watersheds within the jurisdiction of MS4s.

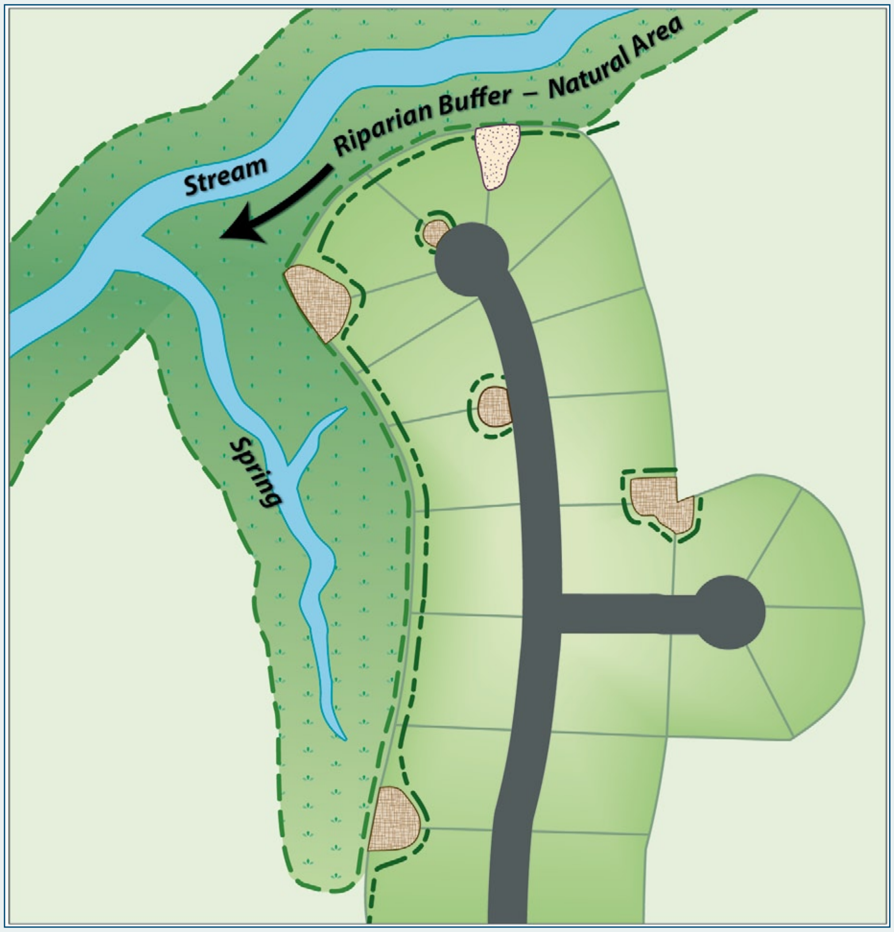
Table 1.3. Coordination Between Construction and Post-Construction Stormwater

DO:

- Coordinate plan review for construction and post-construction BMPs.
- Make sure the Limits of Disturbance (LODs) for the SWPPP (construction stormwater plan) are coordinated with natural areas and open-space areas that are supposed to be protected per the post-construction plan.
- Make sure that areas designated for post-construction BMPs are protected from disturbance and compaction during construction and are noted in the SWPPP. This is especially true for infiltration and bioretention practices that depend on an undisturbed soil structure.
- Colocate construction and post-construction BMPs where it makes sense and won't compromise the integrity of post-construction BMPs. Good candidates for colocation include:
  - Basins that will be converted from construction to post-construction configurations by dredging construction sediments and modifying outlet structures
  - Sediment traps that will be converted to bioretention/filtration (or another BMP) when, after drainage areas are stabilized, construction sediments are removed and the basin floor is excavated to a deeper layer (below the original sediment trap invert) with good soils for infiltration
  - Other cases where the local program staff can ensure the integrity of the post-construction BMPs
  - Care should especially be taken with infiltration facilities to avoid conflicts between construction and post-construction BMPs and compaction of soils.
- Make sure that inspectors and contractors are aware of both construction and post-construction BMPs to be installed at a site.

DON'T:

- Approve a SWPPP that conflicts with a post-construction stormwater plan in terms of protection of natural areas, tree protection, limits of disturbance, etc.
- Colocate construction and post-construction BMPs where soil compaction and sedimentation will damage the integrity of the post-construction BMP.
- Suspend inspections or release performance bonds until the post-constructions BMPs have been installed correctly.



Riparian buffer/natural area boundary

Colocated construction-phase sediment basin and post-construction BMP.

Post-construction bioretention/infiltration area — Soil must be protected during construction. Do ***not*** use for construction-phase BMPs *unless specific conditions are met (Table 1.3)*.

Limits of Disturbance (LOD) for construction-phase SWPPP — Must protect riparian buffer and post-construction infiltration area. Fencing recommended.

Figure 1.3. Construction stormwater and post-construction stormwater plans must be coordinated to protect post-construction design features and BMPs

For the local stormwater manager, this will require an effort to tailor certain stormwater criteria and BMPs to help meet TMDL pollutant-reduction benchmarks. **Chapter 4** (**Table 4.17**) provides more detail on creating a stronger link between stormwater criteria and TMDLs.

1.4. Relationship of Post-Construction to Combined Sewer Overflows (CSOs)

Many communities in the past built combined sewer systems that collect both stormwater runoff and sanitary sewage in the same pipe to be carried to a wastewater treatment plant. Wet weather events can sometimes cause these combined sewer systems to exceed their hydraulic capacity, resulting in combined sewer overflows (CSOs). A CSO can result in untreated human and industrial waste, toxic materials, and debris being discharged to receiving waterbodies, impacting water quality and aquatic habitat. CSOs cause beach closings, shellfishing restrictions, and other waterbody impairments. Combined sewer systems serve roughly 772 communities containing about 40 million people. (See EPA's NPDES Web site, accessed November 2007: ***www.epa.gov/npdes/cso***)

EPA's Combined Sewer Overflow Control Policy is the national framework for the control of CSOs through the NPDES permitting program (***www.epa.gov/npdes/pubs/owm0111.pdf***). The Policy includes a set of Nine Minimum Control Measures designed to address the causes of CSOs and limit their occurrence:

1. Monitoring to effectively characterize impacts from CSO discharges
2. Proper operation and maintenance programs
3. Maximum use of the collection system for storage
4. Review and modification of pretreatment programs
5. Maximizing flows to the wastewater treatment plant
6. Prohibiting dry weather CSO discharges
7. Control of solids and floatable materials
8. Pollution prevention programs
9. Public notification

Many of the measures required for CSO control can be directly related to post-construction stormwater management. For instance, the volume and frequency of CSO events can be reduced by implementing stormwater management practices that reduce the volume and rates of runoff. Treatment of stormwater runoff before it enters the combined sewer system also reduces the level of pollutants potentially discharged in an overflow event. Pollution prevention programs focused on reducing the exposure of pollutants to runoff entering a combined sewer system also help eliminate excess nutrients and other pollutants.

1.5. Relationship of Post-Construction to Stormwater Retrofitting

Stormwater retrofitting refers to a series of techniques that help to restore watersheds by providing stormwater treatment in locations where practices previously did not exist or were ineffective. Stormwater retrofits are typically installed at older, existing stormwater facilities, within the conveyance system, above or below outfalls, at stormwater hotspots, and at other locations that are close to the source of runoff. The intent is to capture and treat stormwater runoff ***before*** it is delivered to the receiving waters (**Schueler et al. 2007**).

Retrofitting spans the regulatory and non-regulatory sides of post-construction stormwater management:

- In a *regulatory* sense, the MS4 requirements pertain to new development and redevelopment projects. Redevelopment cases, in particular, are places where retrofitting can play a major role. For instance, existing stormwater facilities and/or conveyance systems can be retrofitted to provide better water quality treatment.
- In the *non-regulatory* context, retrofitting is a critical tool to help achieve watershed restoration goals, especially in watersheds where much of the development took place prior to modern stormwater management. For these communities, a retrofit program can be built into the overall post-construction program to help fulfill MS4 commitments.

When tailored to a community's watershed needs, retrofitting can help meet multiple objectives. For instance, a retrofitting program can reduce runoff volumes in combined sewer systems; help reduce the amount of trash and floatables reaching waterbodies; support downstream stream restoration projects; help solve existing flooding, erosion, and water quality problems; and provide key demonstration and outreach projects (Schueler et al. 2007).

Table 1.4 lists several ideas for how retrofitting can be integrated with the six minimum measures in the Phase II MS4 program.

To assist communities with a retrofitting program, the Center for Watershed Protection has produced a comprehensive guidance manual on stormwater retrofitting:

Urban Stormwater Retrofit Practices, Version 1.0, Urban Subwatershed Restoration Manual Series, Manual 3 (August 2007). ***www.cwp.org*** > Resources > Controlling Runoff & Discharges > Stormwater Management > National/Regional Guidance.

Table 1.4. Integrating Stormwater Retrofitting with the Six Minimum Measures

Minimum Measure	How Retrofitting Can Help
1. Public Education and Outreach	► Use high-visibility public sites for retrofit projects and include educational signage and interpretation. ► Use retrofit demonstration sites for outdoor classrooms, educational events, and field trips.
2. Public Participation and Involvement	► Get citizen advisory committees involved in establishing retrofit objectives and candidate locations. ► Use volunteer labor to help with retrofit project light construction, planting, mulching, and maintenance.
3. Illicit Discharge Detection and Elimination	► Use the retrofit field reconnaissance process to look for illicit discharges.
4. Construction Site Runoff Control	► Use retrofit projects to demonstrate proper erosion and sediment control to the development community. ► Look for construction sites during the retrofit field reconnaissance process, and conduct follow-up inspections.
5. Post-Construction Runoff Control	► Establish retrofitting protocols for redevelopment sites. ► In some cases, have a developer do an on-site or off-site retrofit to satisfy post-construction requirements. ► In some cases, collect a fee-in-lieu payment from a developer to help pay for strategic retrofits in the watershed. ► Build retrofitting into the facilities planning, capital improvements, and facilities maintenance program.
6. Pollution Prevention and Good Housekeeping	► Include pollution prevention and landscape stewardship projects in the retrofit program. Start with public sites, such as schools, parks, and public works yards, and incorporate findings into ongoing maintenance activities. ► Look for opportunities to retrofit water quality treatment at municipal stormwater hotspots, such as vehicle maintenance, fueling, public works, and grounds maintenance facilities. ► Use stormwater retrofit projects to set a good example for the development community and public.

1.6. Regulatory Background for Post-Construction Stormwater

Both Phase I and Phase II of the NPDES stormwater program require municipalities to develop and implement programs to address stormwater runoff from areas of new development and redevelopment (i.e., post-construction runoff). The Phase I post-construction requirements are at 40 CFR Part 122.26(d). There are approximately 1,000 Phase 1 permittees across the country (**U.S. GAO, 2007**).

The stormwater Phase II post-construction requirements are at 40 CFR 122.34(b)(5) and listed in **Table 1.5**. Because the Phase II regulations apply to smaller communities, there are many more of them, currently numbering over 5,000 nationally (**U.S. GAO, 2007**). Additionally, nontraditional MS4s in urbanized areas such as military bases, public universities, and other governmental facilities are also regulated under Phase II.

Authorized states and EPA regions use these Phase I and Phase II regulations as the basis for developing permit requirements for MS4s. The NPDES MS4 permits provide more detailed requirements that MS4s must meet. In response to these permit requirements, MS4s develop detailed plans (often called Stormwater Management Plans) that describe the activities and milestones that the MS4 will meet over the five-year permit term.

Some states also have developed post-construction standards and/or stormwater guidance manuals to implement the stormwater regulations. **Tool 5: Manual Builder** includes information on many state stormwater manuals and their associated Web sites.

The NPDES MS4 requirements are one of the various federal, state, and local regulations and programs that influence stormwater management and land development practices. **Table 1.6** lists other drivers that have some connection to stormwater management. A local program must understand this complex regulatory environment to avoid conflicts and build a sustainable program. Legal issues, such as court rulings involving negligence and nuisance, can also drive the implementation of stormwater management at the local and state levels.

1.7. Current Trends and Recommendations for Post-Construction Stormwater Management

The Center for Watershed Protection recently conducted research that canvassed local government stormwater professionals across the country (**CWP, 2006**). Respondents provided local information and insights on a range of post-construction issues. Almost 100 different local governments across 30 states responded, and the vast majority of respondents were from Phase II communities.

Table 1.7 provides a summary of the current status and trends in post-construction stormwater management based on this research. The table also lists recommended actions and references the appropriate chapters of this guide for more detailed information.

Table 1.5. EPA Stormwater Phase II Minimum Measure for Post-Construction Stormwater Management in New Development and Redevelopment (40 CFR 122.34(b)(5))

(i) You must develop, implement, and enforce a program to address stormwater runoff from new development and redevelopment projects that disturb greater than or equal to one acre, including projects less than one acre that are part of a larger common plan of development or sale, that discharge into your small MS4. Your program must ensure that controls are in place that would prevent or minimize water quality impacts.

(ii) You must:

(A) Develop and implement strategies which include a combination of structural and/or non-structural best management practices (BMPs) appropriate for your community;

(B) Use an ordinance or other regulatory mechanism to address post-construction runoff from new development and redevelopment projects to the extent allowable under State, Tribal or local law; and

(C) Ensure adequate long-term operation and maintenance of BMPs.

(iii) Guidance: If water quality impacts are considered from the beginning stages of a project, new development and potentially redevelopment provide more opportunities for water quality protection. EPA recommends that the BMPs chosen: be appropriate for the local community; minimize water quality impacts; and attempt to maintain pre-development runoff conditions. In choosing appropriate BMPs, EPA encourages you to participate in locally-based watershed planning efforts which attempt to involve a diverse group of stakeholders including interested citizens. When developing a program that is consistent with this measure's intent, EPA recommends that you adopt a planning process that identifies the municipality's program goals (e.g., minimize water quality impacts resulting from post-construction runoff from new development and redevelopment), implementation strategies (e.g., adopt a combination of structural and/or non-structural BMPs), operation and maintenance policies and procedures, and enforcement procedures. In developing your program, you should consider assessing existing ordinances, policies, programs and studies that address storm water runoff quality. In addition to assessing these existing documents and programs, you should provide opportunities to the public to participate in the development of the program. Non-structural BMPs are preventative actions that involve management and source controls such as: policies and ordinances that provide requirements and standards to direct growth to identified areas, protect sensitive areas such as wetlands and riparian areas, maintain and/or increase open space (including a dedicated funding source for open space acquisition), provide buffers along sensitive water bodies, minimize impervious surfaces, and minimize disturbance of soils and vegetation; policies or ordinances that encourage infill development in higher density urban areas, and areas with existing infrastructure; education programs for developers and the public about project designs that minimize water quality impacts; and measures such as minimization of percent impervious area after development and minimization of directly connected impervious areas. Structural BMPs include: storage practices such as wet ponds and extended-detention outlet structures; filtration practices such as grassed swales, sand filters and filter strips; and infiltration practices such as infiltration basins and infiltration trenches. EPA recommends that you ensure the appropriate implementation of the structural BMPs by considering some or all of the following: pre-construction review of BMP designs; inspections during construction to verify BMPs are built as designed; post-construction inspection and maintenance of BMPs; and penalty provisions for the noncompliance with design, construction or operation and maintenance. Storm water technologies are constantly being improved, and EPA recommends that your requirements be responsive to these changes, developments or improvements in control technologies.

Table 1.6. Other Regulatory Drivers That Influence Post-Construction Stormwater

Regulatory Driver	Link With Post-Construction Program
Federal (many programs passed down to states for administration)	
NPDES Stormwater Permits for Construction *www.epa.gov/npdes/stormwater/construction*	Applies to stormwater discharges from sites with disturbance of 1 acre or greater. Requires control of sediment and erosion and other wastes at the site. Operators must develop and implement a stormwater pollution prevention plan (SWPPP). Provides opportunity for local program to coordinate construction and post-construction phases in plan review, inspection, and maintenance.
NPDES Stormwater Permits for Industrial Activities *www.epa.gov/npdes/stormwater/msgp*	Applies to stormwater discharges from certain categories of industrial activity. Requires site-specific SWPPP. Post-construction program should ensure that new industrial facilities are designed to prevent pollution and treat stormwater runoff from industrial areas.
Other NPDES Permits (e.g., wastewater discharge, etc.) *www.epa.gov/npdes*	Regulates discharges of process wastewater from municipal, commercial, and other wastewater treatment facilities.
Combined Sewer System – Long-Term Control Plan (NPDES) *www.epa.gov/npdes/cso*	Requires plan to address and minimize overflows from combined systems to waters of the U.S. Some communities have both an MS4 and a combined sewer system, and management practices should be coordinated. For instance, practices that limit the volume of stormwater discharges can also help reduce the incidence of CSOs. In addition, treatment practices such as street sweeping and catch basin cleaning can reduce floatables and sediment in CSOs.
Total Maximum Daily Load (TMDL) *www.epa.gov/owow/tmdl*	Addresses impaired waters through a program that develops total maximum daily loads (TMDLs). A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. Post-construction programs specify stormwater practices, retrofits, and/or site-based load limits for development and redevelopment that can address the pollutant(s) identified in the TMDL.
Source Water Assessment Program, Wellhead Protection Program, and Underground Injection Control Program *www.epa.gov/ogwdw*	Identifies and maps potential threats to water supply sources, and recommends protection plans. Stormwater facilities and retrofits can help protect water supply watersheds and wellhead areas. Certain practices may be limited, such as infiltration within wellhead protection areas. Hotspot land uses and discharges may be restricted.
Federal Wetland Permits (Section 404) *www.epa.gov/wetlands*	Regulates the discharge of dredged and fill material into waters of the United States, including wetlands. Stormwater practices that negatively impact streams and wetlands require permitting and are subject to denial. May push programs and site choices into low-impact development strategies to avoid impacts. Stormwater plans may have to be coordinated with mitigation plans required through the wetland permitting process.
Coastal Zone Management Program (CZMP) *http://coastalmanagement.noaa.gov*	Sets out planning goals and milestones for designated coastal zones. Stormwater controls should be coordinated with state-specific coastal zone management plans, which may include BMP performance standards. Nonstructural measures, such as wetland and marsh protection, can be incorporated into stormwater strategy to mesh with CZMP objectives.

Table 1.6. Other Regulatory Drivers That Influence Post-Construction Stormwater *(continued)*

Regulatory Driver	Link With Post-Construction Program
Homeland Security *www.dhs.gov* and *www.epa.gov/watersecurity*	Includes protection of drinking water supplies and wastewater systems as elements of the homeland security efforts of EPA and DHS. The Federal Emergency Management Agency (FEMA) is also a Homeland Security agency, and participation in the National Flood Insurance Program (NFIP) can be influenced by floodplain development policies and stormwater management.
National Flood Insurance Program *www.fema.gov/about/programs/nfip*	Allows local program to set standards for stormwater facilities located in floodplains (especially if fill is required) to ensure that flood conveyance is not impeded. Stormwater facilities may be factored into local floodplain modeling
State (variable by state)	
Dam Safety Program	Establishes regulatory overlay for impounding structures over a certain size or capacity, requiring regulatory coordination between local and state programs.
State Erosion and Sediment Control and Stormwater Programs	Provides performance and/or technology standards for construction stormwater plans and facilities. In most cases, requires coordination between construction and post-construction program elements, such as plan reviews and inspections.
State Water Supply Criteria	Where present, establishes standards for water supply planning and management that may include buffers and setbacks and/or stormwater treatment criteria. These should be coordinated with the local program.
State Scenic River, Open Space, Reforestation, and Resource Protection Programs	Where present, includes state-specific goals with link to stormwater management, such as setbacks from particular rivers.
State Well and Septic Permitting Programs	Provides standards for location of wells and septic fields that may impact on-lot practices, such as rain gardens and dry wells.
Regional	
Specific Regional Efforts; e.g., Chesapeake Bay, Great Lakes, Puget Sound	Where present, provides regional plans and programs that may have goals, objectives, and/or standards that influence a local stormwater program.
Local	
Existing Codes for Erosion Control, Stormwater, Zoning, Subdivision, Standing Water and Weeds (Nuisance), etc.	Establishes local rules for development density, streets, setbacks, etc. These codes may either support or impede stormwater program goals that aim to reduce impervious cover.
Greenway, Open Space, Recreation Plans, etc.	Provides planning framework that offers opportunity for coordination between stormwater and planning (e.g., riparian restoration in conjunction with greenway development, stormwater demonstration sites at public parks).

Table 1.7. Current Trends and Recommended Actions for Post-Construction Program

Current Trends	Recommended Actions
Post-Construction Program Development	
▶ Most Phase II MS4s operate program with $10K to $50K budget. ▶ General fund constitutes most of budget. ▶ Most programs have two or fewer staff working on post-construction stormwater.	Develop a post-construction program plan and budget to achieve a desired level of service. Seek a dedicated source of funding, such as a stormwater utility, for post-construction stormwater management. See **Chapter 2, Tools 1, 2.**
Linking Stormwater to Land Use Planning	
▶ For many programs, stormwater managers do not work closely with land use planners. ▶ Stormwater is considered after major land use decisions have been made.	Build stronger link between stormwater program and the comprehensive plan and land use decisions. Use watersheds to organize stormwater and land use. See **Chapter 3, Tool 4.**
Stormwater Management Approach & Criteria	
▶ Most local programs address flooding, and an increasing number also deal with water quality and channel protection. ▶ Fewer programs address groundwater recharge, reduction in overall runoff volume, or protection of sensitive receiving waters.	Develop a more holistic approach for post-construction stormwater management, including site design, source controls, stormwater practices, and protection of sensitive receiving waters. Distill a stormwater approach into criteria to be incorporated into ordinances and design guidance manuals. See **Chapter 4, Tool 3**.
Post-Construction Stormwater Ordinance	
▶ Approximately half of Phase II MS4s have adopted ordinance.	Adopt a post-construction stormwater ordinance in conjunction with or separate from ordinances for construction stormwater (erosion and sediment control) and illicit discharge detection and elimination. See **Chapter 5, Tool 3**.
Post-Construction Stormwater Guidance Manual	
▶ About 75% of states have some type of stormwater manual, but many manuals are out-of-date. ▶ Most state and local manuals ***do not*** provide incentives or credits for low-impact development and innovative practices.	Develop local design guidance, referencing the most appropriate state, regional, or local manual for BMP design standards. If not already provided, build in credits for low-impact development and innovative BMPs. See **Chapter 6, Tools 5, 8**.
Stormwater Plan Review Process	
▶ Most programs lack adequate staff to fully review stormwater plans. ▶ The average plan reviewer reviews 70 to 100 plans per year. ▶ Stormwater is considered late in the development review process.	Develop adequate in-house staffing or consider outsourcing the review function. Use pre-submittal meetings and concept plans to ensure that stormwater is considered early in the site planning process. See **Chapter 7, Tool 6**.

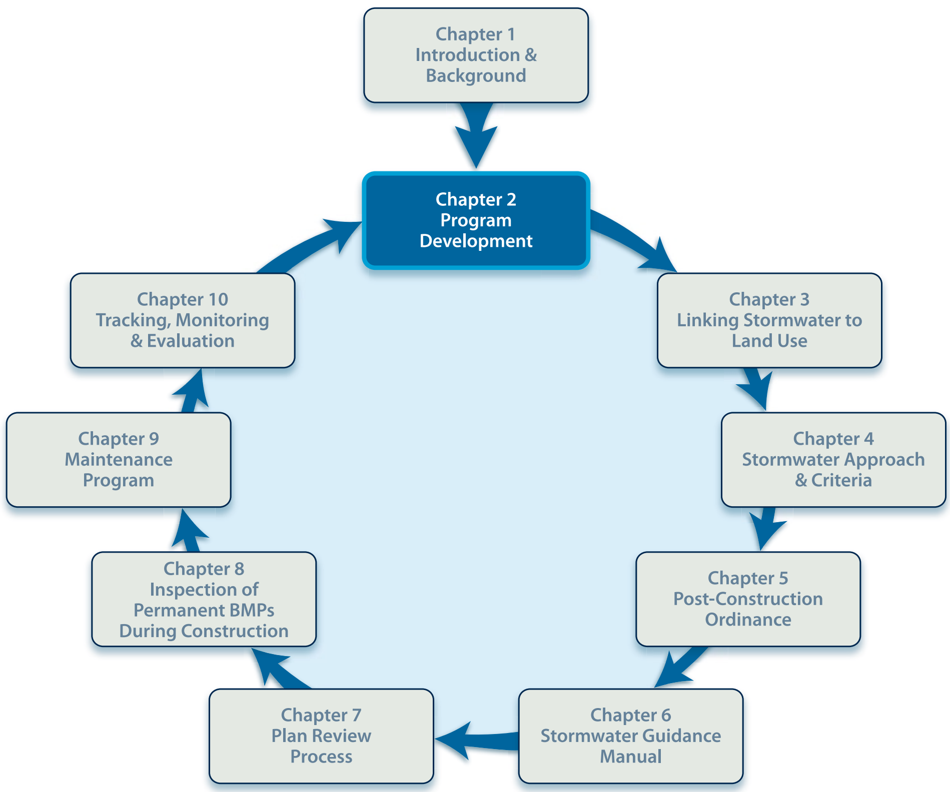
Table 1.7. Current Trends and Recommended Actions for Post-Construction Program *(continued)*

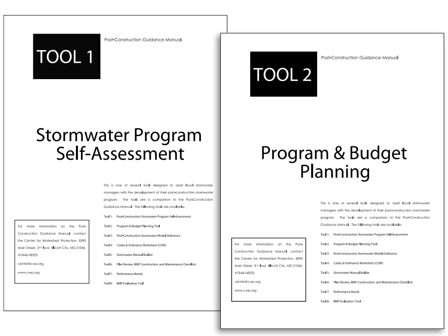
Current Trends	Recommended Actions
Inspection of Post-Construction BMPs During Installation	
► Most local programs conduct general construction inspections but might not focus on proper installation of post-construction BMPs. ► Many post-construction BMPs are not installed correctly.	Inspect post-construction BMPs at critical installation milestones. Develop standard forms and checklists for inspection staff. Establish adequate enforcement procedures. See **Chapter 8, Tools 6, 7**.
Post-Construction Maintenance	
► Most Phase II MS4s do not have an established maintenance program. ► Over half of programs do not use maintenance agreements. ► Lack of maintenance is the single most important cause of failure for BMPs and stormwater programs.	Clearly assign maintenance responsibility through policies, maintenance agreements, and easements. Develop a maintenance inspection and tracking program. Conduct outreach to responsible parties. See **Chapter 9, Tool 6**.
Program Tracking, Monitoring, and Evaluation	
► MS4s must establish measurable goals. ► Although annual reports are submitted, many programs do not evaluate their programs or develop useful indicators of success.	Develop a combination of outcome-based and output-based minimum measures to gauge program success and develop annual reports. Use evaluations to set program priorities, build public support, and demonstrate compliance. Maintain proper documentation to prepare for a potential regulatory audit. See **Chapter 10**.

Download Tools at: ***www.cwp.org/postconstruction***

Chapter 2

Post-Construction Program Development—Assessing Your Program





Companion Tools for Chapter 2
Download Post-Construction Tools at:
www.cwp.org/postconstruction

What's In This Chapter

- Assessing Your Watershed & Community
  - Geographic Information
  - Demographic Information
  - Water Resources Information
- Conducting a Post-Construction Program Self-Assessment
- Post-Construction Program Planning
  - Developing a Post-Construction Program Plan
  - Stormwater Program Funding Options

2.1. Assessing the Watershed and Community

The first step in developing a post-construction stormwater program is to collect several types of basic information about the watershed and community to help make informed decisions on priorities and pollutants of concern:

- Geographical
- Demographic/community
- Water quality

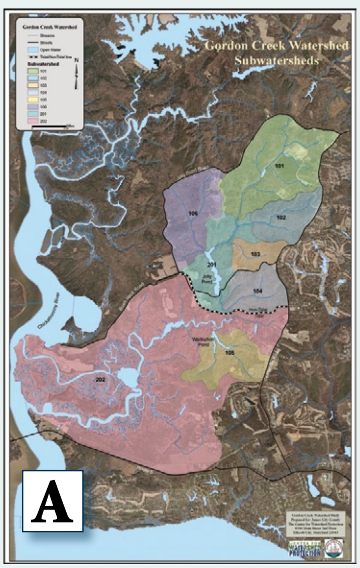
The list below is a starting point; additional information will likely be needed to address the unique issues in a particular community.

Geographical Information

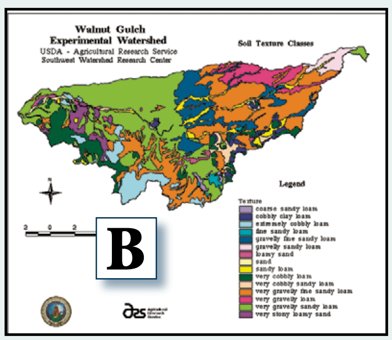
A locality's planning or public works departments will likely have many maps and other relevant geographical information. For example, soil, slope, geology, floodplain, and other natural hazard maps can identify areas where new development is most appropriate and where it should be avoided. Key information to collect includes:

- Maps
  - – watersheds
  - – floodplains
  - – soils
  - – land use
  - – land cover
  - – water resources (rivers, lakes, wetlands, etc.)
  - – source water protection areas
  - – roads
- Precipitation
- Areas prone to flooding

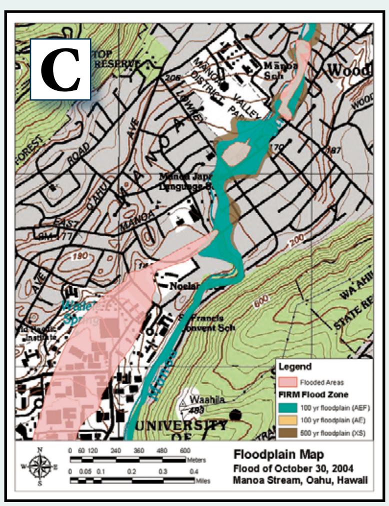
Several examples of these types of maps are shown in **Figure 2.1**.



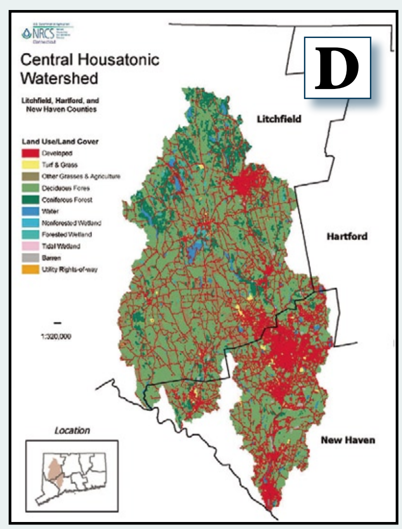
Source: Center for Watershed Protection
www.cwp.org



Source: USDA, Agricultural Research Service
http://www.tucson.ars.ag.gov/unit/gis/soils.html



Source: USDA, Natural Resource Conservation Service
http://manoawatershed.oceanit.com/NRCS/index.php



Source: USDA, Natural Resource Conservation Service
http://www.ct.nrcs.usda.gov/programs/CSP/landuse-landcover-housatonic.html

Figure 2.1. Example maps for post-construction program development: (A) watershed delineation, (B) soils, (C) floodplain delineation, (D) land use/land cover

Demographic and Community Information

It is important to understand the community's current population and land use in order to identify where growth is occurring and opportunities for redevelopment. In addition, the program should address anticipated future growth. Will it be primarily residential on the urban fringe, urban redevelopment, or another form? A stormwater manager should also analyze the past 1–3 years of recent construction projects to assess relative site size (very large mixed use projects vs. relatively small commercial/residential development), type (residential vs. commercial), and other issues. Key information to collect includes:

- Current population
- Anticipated population growth/change
- Current land use and zoning
- Proposed changes to land use
- Build-out analysis showing full development potential of existing zoning (see **Figure 2.2** for an example)
- Impervious cover
- Construction projects (number, type, etc.)
- Transportation, utility, and infrastructure plans

Water Quality Information

Water quality information will help identify the pollutants of concern and associated impaired waterbodies in the community and surrounding area. The post-construction program should be designed to reduce these pollutants of concern and specifically address impaired waterbodies. Key information to collect includes:

- Monitoring stations
- Groundwater: location of public wells, source water protection areas, etc.
- Existing water quality criteria and designated uses
- 303(d) impairments
- TMDLs
- Areas of local concern, such as eroded channels or water quality problem areas
- Other local waters in need of protection: high-value streams, lakes, and reservoirs

See **Figure 2.3** for examples of these types of maps.

After collecting information on the watershed and community, the next step is to conduct a program assessment of the post-construction program.

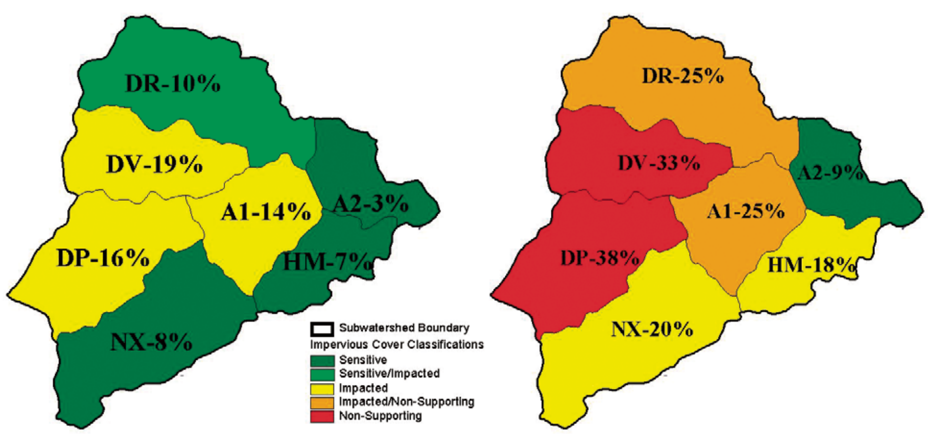


Figure 2.2. The map on the left shows existing impervious cover by watershed. The map on the right shows future impervious cover based on a build-out analysis using existing zoning codes in the Appoquinimink watershed (Source: Kitchell, 2003)**. The impervious cover classifications are based on the Center for Watershed Protection's Impervious Cover Model** (CWP, 2003a)**.**

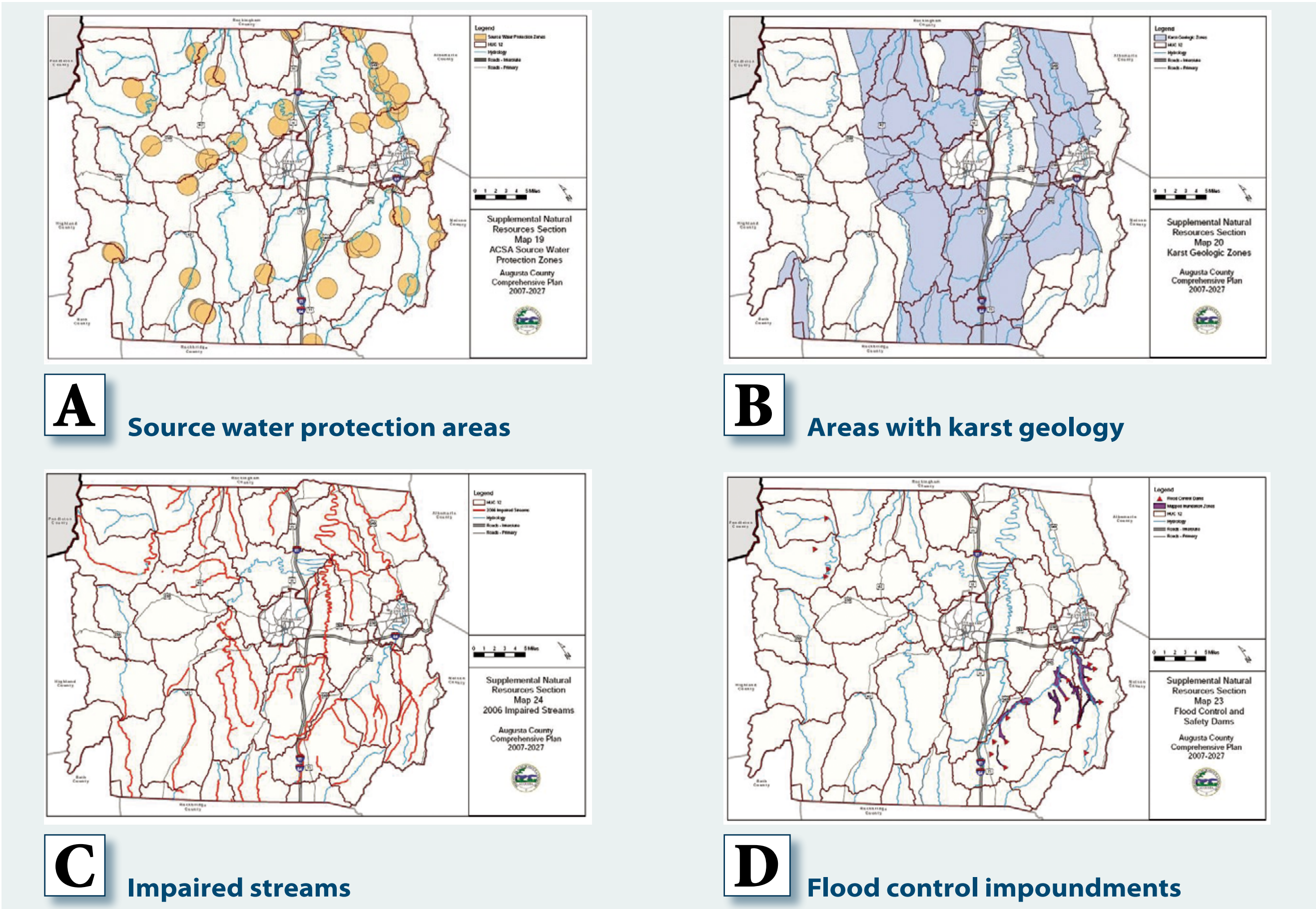


Figure 2.3. Examples of mapping of water resources information from Augusta County, Virginia (County of Augusta, 2007)

2.2. Conducting a Post-Construction Program Self-Assessment

Tool 1: Program Self-Assessment is a tool to help assess the existing status of a post-construction program and to identify key action items to address identified gaps. The program assessment asks questions to evaluate the program based on a continuum of program sophistication. The questions are divided into three subgroups, or types of communities:

Group A (Initiating the Program). These communities are initiating a stormwater management program, which might be a variation of an existing drainage and engineering program or an entirely new program. The elements in this subgroup should be accomplished by the end of the first permit term.

Group B (Enhancing the Program). Communities at this stage have a stormwater management program in place, but seek program enhancement to meet new stormwater rules or address growing stormwater issues. The elements in this group represent important enhancements that are necessary for an effective program.

Group C (Advancing the Program). Communities at this stage have more advanced stormwater programs that focus on a more refined match of BMPs to stormwater-related impacts, incorporating monitoring and innovative land and watershed planning techniques.

The Program Self-Assessment tool (**Tool 1**) includes instructions on how to complete the program assessment. For identified gaps, the stormwater manager is directed to specific chapters of this guide to help identify both short-term and long-term action items and measurable goals.

Before embarking on any self-assessment, however, it is important to scope out the state and NPDES requirements that apply to the post-construction program. Specific requirements for post-construction that are included in the MS4 permit should be addressed in the program self-assessment and action items.

Note that in addition to the Program Self-Assessment tool, the stormwater manager can also refer to EPA's *MS4 Program Evaluation Guidance* when conducting a post-construction assessment. Chapter 4.5 of the evaluation guide addresses post-construction programs. Although written primarily for EPA and state inspectors, the evaluation guide is also helpful for municipalities that wish to conduct a self-assessment of their stormwater program. A copy of the *MS4 Program Evaluation Guidance* is available at ***www.epa.gov/npdes/stormwater***.

2.3. Post-Construction Program Planning

After collecting information on the community and watershed and conducting a program self-assessment, the stormwater manager will need to develop the post-construction program (or enhance an existing program). The first decision will be to articulate overall goals for post-construction stormwater runoff in the community.

Some example goals of the program could include:

- Meet regulatory requirements.
- Improve water quality and habitat conditions in the community's watersheds (rivers, streams, lakes, coastal waters, wetlands).
- Address flood risks and potential property damage.
- Improve the planning and development process.
- Support redevelopment within infill and enterprise zones.
- Integrate local plans and ordinances to ensure comprehensive watershed planning.
- Encourage site planning and stormwater techniques, such as low-impact development and green infrastructure practices, that best replicate pre-development hydrologic conditions.

For many communities, multiple goals guide program development. Deciding on the overall goal(s) for post-construction will help to design an effective program.

Developing The Post-construction Program Plan

The community and watershed assessment and post-construction program self-assessment (**Tool 1**) will identify the potential "gaps" in the post-construction program. Not all gaps need to be addressed right away. These gaps should be prioritized in relation to the resources needed and available to develop various program elements. A detailed post-construction program plan will help secure the resources and funding needed to implement the program.

A common program approach is to create a phased implementation plan. In this way, staff, resources, and budgets can be phased in over time—likely tied to the MS4 permit cycle.

Tables 2.1 through **2.3** provide a template for developing a comprehensive post-construction program plan. The three tables represent three different phases of program development:

- **Phase 1:** Program Development, Linking Stormwater to Land Use, and Adopting an Ordinance
- **Phase 2:** Developing or Adapting a Stormwater Guidance Manual and the Stormwater Plan Review Process
- **Phase 3:** Inspecting Permanent Stormwater BMPs During Construction, Developing a Maintenance and Inspection Program, and Tracking and Evaluating the Program

The tasks listed in each phase follow the chapters of this guidance manual, and the tables reference relevant manual sections and tools that can be used to assist with each subtask. These tables are meant to provide a template for a generic program, and each individual program should tailor the tasks and subtasks to its own program needs. (There is no "one size fits all" approach to stormwater program planning.)

Table 2.1. Phase 1 of a Comprehensive Program Plan

Phase I Task	Relevant Guide Section or Tool
1. Program Development	
1.a. Assess Watershed and Community	2.1
1.b. Conduct Program Self-Assessment	2.2, Tool 1
1.c. Develop Program Goals, Plan, and Budget	2.3, Tool 2
1.d. Develop and Implement Public Involvement Strategy	All Chapters
1.e. Hire Core Program Staff	2.3
2. Link Stormwater to Land Use	
2.a. Establish Links to Planning Department	3.7
2.b. Evaluate Existing Land Use Codes	3.6, Tool 4
2.c. Assess Integrated Stormwater/Land Use Tools	3.8
2.d. Adopt Land Use Policies That Support Water Quality Goals	Ch. 3
3. Adopt or Amend Stormwater Ordinance	
3.a. Develop Stormwater Approach and Relevant Criteria for the Community	Ch. 4
3.b. Identify MS4 Permit Requirements and Commitments	1.6, state general permits
3.c. Identify State, Regional, or National Model Ordinance	5.1, Tool 3
3.d. Decide Whether to Integrate Ordinance with Construction Stormwater and IDDE	5.2
3.e. Develop and Implement Stakeholder Participation Plan	5.5
3.f. Develop Draft Ordinance	Ch. 5, Tool 3
3.g. Estimate Plan Review, Inspection, and Maintenance Resource Burden	Chs. 7, 8, 9
3.h. Adopt Ordinance Through Public Process	Ch. 5

Table 2.2. Phase 2 of a Comprehensive Program Plan

Phase 2 Task	Relevant Guide Section or Tool
4. Develop and/or Utilize Relevant Stormwater Guidance Manual(s)	
4.a. Scope Out Design Guidance Task	6.4
4.b. Identify Local, State, or Regional Manual to use as Model or By Reference	6.11, Tool 5
4.c. Decide Whether to Integrate Manual with Construction Stormwater (erosion and sediment control manual)	1.2, 6.4
4.d. Develop and Implement Stakeholder Participation Plan	6.13
4.e. Develop/Reference Policy and Procedures Manual	6.5, Tool 5
4.f. Develop/Reference Technical Design Manual	6.6 – 6.10, Tool 5
4.g. Adopt the Manuals Through Public Process	6.12, 6.13
4.h. Provide Training on Use of Manuals	6.13
4.g. Update the Manuals at Least Every 5 Years	6.4, 6.12
5. Create or Enhance Stormwater Plan Review Process	
5.a. Scope Out Plan Review Process	7.3
5.b. Decide Whether to Do Review In-House or Outsource	7.5
5.c. Create Flowchart or Map Out Review Process	7.4
5.d. Create Forms, Applications, Instruction Materials, and Checklists for Applicants and Review Staff	7.4 – 7.5, Tool 6
5.e. Forecast Staff Needs and Acquire Staff	7.5, Tool 2
5.f. Provide Training for Review Staff and Design Consultants	7.5
5.g. Develop Web-based or Other Tracking System to Track Plans and Approvals	7.5, 10.6
5.h. Set Up Performance Bond Process, Forms, and Tracking System	Tool 7
5.i. Review Stormwater Plans	Ch. 7, Tool 6

Table 2.3. Phase 3 of a Comprehensive Program Plan

Phase 3 Task	Relevant Guide Section or Tool
6. Inspect Permanent Stormwater BMPs During Construction	
6.a. Scope Out Inspection Process	8.3
6.b. Decide Whether to Use In-House Inspectors or Contractors	8.5
6.c. Create Checklists, As-Built Certification Forms, and Other Forms Needed for Inspection	8.5, Tool 6
6.d. Forecast Staff Needs and Acquire Inspection Staff or Use Existing Staff	8.5, Tool 2
6.e. Provide Training for Inspectors and Contractors	8.5 – 8.6
6.f. Develop Web-based or Other Tracking System to Track Inspections and Enforcement Actions	10.6
6.g. Inspect BMPs During Construction	Ch. 8
7. Develop Maintenance and Inspection Program	
7.a. Scope Out Maintenance Program	9.3
7.b. Decide on Maintenance Approach and Make Level of Service Policy Decisions	9.3, 9.4
7.c. Decide Whether to Use In-House Inspectors or Contractors or Rely on Responsible Parties for Maintenance Inspections	9.4
7.d. Decide Whether to Use In-House Resources, Contractors, or Responsible Parties for Routine and Structural Maintenance Tasks and Repairs	9.4
7.e. Create Checklists, Inspection Forms, and Enforcement Tools	9.4, Tool 6
7.f. Forecast Staff and Equipment Needs and Acquire Resources	9.4, Tool 2
7.g. Create and Disseminate Outreach Materials for Responsible Parties	9.6
7.h. Develop Web-based GIS or Other Tracking System to Track Inspections and Enforcement Actions	10.6, 10.7
7.i. Inspect BMPs for Maintenance	9.5
7.j. Conduct Maintenance Tasks	9.5
8. Track, Evaluate, and Monitor the Program	
8.a. Scope Out Evaluation and Monitoring Tasks	10.3–10.5
8.b. Decide on Measurable Goals and Tracking Indicators	10.4–10.9
8.c. Develop Tracking and Reporting Tools to Track Key Indicators	Ch. 10
8.d. Write Annual Reports for Program Compliance and Other Program Reports and Documents	10.10
8.e. Maintain the Tracking System	Ch. 10

Tool 2: Program and Budget Planning Tool is a spreadsheet tool that enables the user to fill in the staffing needs and expenses, other program expenses, and potential revenue sources for each task and sub-task identified in **Tables 2.1** through **2.3**. This is not a detailed budgeting tool, but it can help with program planning, goal setting, and phasing. This tool should be modified by stormwater managers to fit the needs and characteristics of their individual programs.

Another key program planning step is to ensure that staff assigned to the program have the right skills or can be trained to acquire them. Most local programs have engineers working in administrative and technical capacities (**CWP, 2006**). Other personnel skills that may be relevant for a post-construction program include:

- Land use and planning
- Budget planning and management
- Geographic information systems (GIS), global positioning systems (GPS), database
- Construction, inspections, facilities maintenance
- Capital project management
- Water quality and biology
- Hydrology
- Legal

It is also important for the post-construction program to have a lead department, division, or point of contact within the government or agency structure. Since post-construction often involves multiple staff functions and departments, the lead agency provides overall coordination and communication, and takes responsibility for meeting program milestones. The lead agency is often a public works department, but lead agencies may also be departments or divisions for community development, water and wastewater, environmental programs, stormwater utilities, or elected boards (**CWP, 2006**).

2.4. Stormwater Program Funding Options

Stormwater program managers have a wide range of funding sources to finance implementation of these programs, from general funds to dedicated sources like stormwater utilities. The program manager must assess each funding source to ensure it meets the stormwater program needs. The National Association of Flood and Stormwater Management Agencies (NAFSMA), under a grant from EPA, has developed *Guidance for Municipal Stormwater Funding*. This document helps municipalities address the procedural, legal, and financial considerations in selecting and developing stormwater financing approaches. The document is available at ***www.nafsma.org***.

Candidate stormwater program funding sources include:

- Stormwater utilities
- General funds
- Clean Water State Revolving Fund (CWSRF) loans
- Fees
- Taxes
- Grants
- Debt financing
- Local improvement districts
- Developer participation
- Additional fees (impact, plan review and inspection, fee in lieu of on-site construction, system development fees/connection charges)

Each of these funding sources has advantages and disadvantages that have to be evaluated for compatibility with local needs. Furthermore, there are many other factors to examine when evaluating each funding source, such as state or local requirements, drainage infrastructure needs, and the political climate.

Stormwater Utilities

A common source of funding for stormwater management programs is the use of stormwater utilities and stormwater fees. Property owners are charged fees for the amount of stormwater produced on their property.

A stormwater utility is a mechanism to fund the cost of operations and capital projects directly related to the control and treatment of stormwater, including staffing, permitting, inspections, public education, watershed planning, and other program management costs. The fees are typically based on factors that influence stormwater runoff, such as amount of impervious surface, for a property and calculated using a predetermined classification, such as the equivalent residential unit (ERU), or another rate-setting methodology. In addition, the utility is administered and funded separately from the revenues in the general fund, which ensures a reliable source of funding for stormwater management.

Establishing a stormwater utility is a complex undertaking, and it requires careful planning and public outreach to be successful. The process usually involves conducting feasibility studies and system inventories, developing administrative and billing systems, mounting extensive public information campaigns, developing policies on credits and exemptions, adopting ordinances, and implementing the utility.

General Fund

The traditional source of funding for stormwater management programs is the jurisdiction's general fund. These monies are usually generated from a variety of sources, including taxes (e.g., income, sales and property taxes), exactions (e.g., franchise fees on utilities), and federal/state revenue sharing, and are simply appropriated for specific purposes, including stormwater management, through the normal budget process.

In some cases, the revenues appropriated by the general fund are sufficient to provide financial support for the entire stormwater program. However, this source of revenue is used to fund many other programs, and revenues are variable and unpredictable. Elected officials must determine the relative priority of stormwater management versus numerous other needs and services. The unpredictable, political, and limited nature of the general fund has pushed many stormwater managers to pursue the stormwater utility approach.

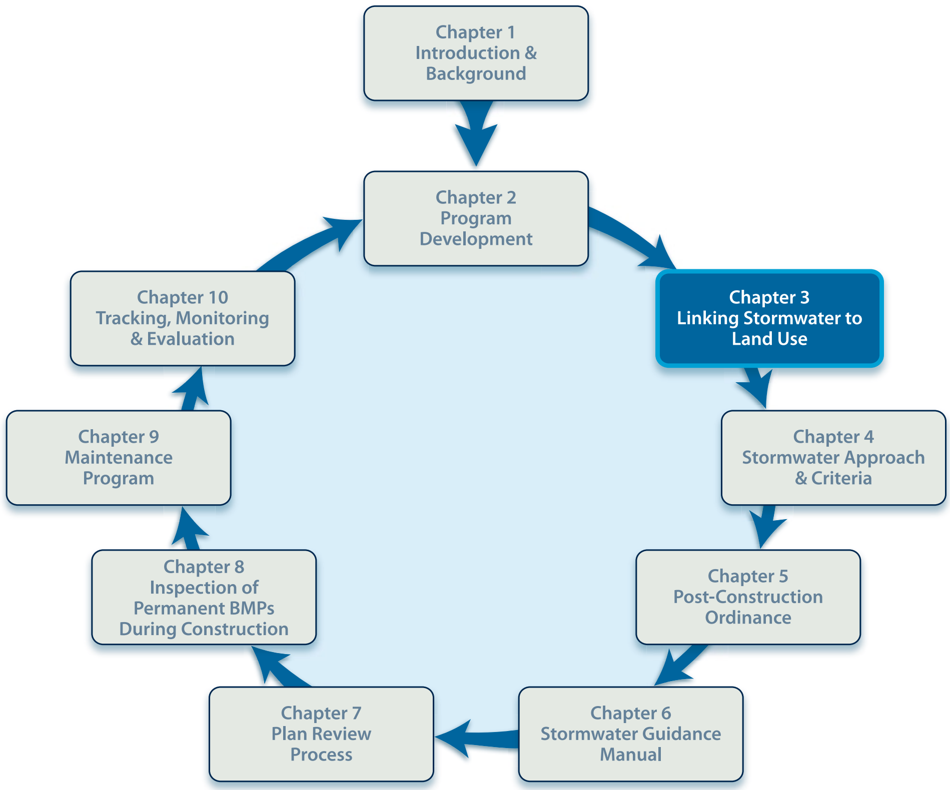
Other Sources of Funding

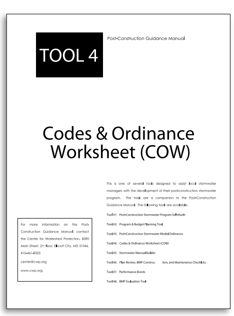
Other funding sources are one-time grants (federal, state, or local), loans or bonds, state revolving funds, and additional fees that can cover costs of erosion and sediment control, structural stormwater management, upgrades or improvements to the program, operation and maintenance of sewers, acquisition of environmentally sensitive land, and other environmental initiatives.

Municipalities also have the option of using additional funding strategies, such as impact fees, plan review and inspection fees, fee-in-lieu payments, and system development fees/connection charges to fund the stormwater management program. Impact fees transfer the cost of roads, sewers, stormwater treatment, and other facilities needed for development directly to developers and can relieve financial pressures on the budget. In addition, plan review and inspection fees can be charged to cover the costs of reviewing development plans, inspecting BMPs, and ensuring that development plans are properly implemented. Another funding strategy is to develop a fee-in-lieu program whereby developers pay a fee to the local program in lieu of partial or full on-site compliance with BMP requirements. The local program, in turn, uses the funds to conduct stormwater and watershed projects, such as stormwater retrofits, stream and wetland restoration, and regional projects.

Chapter 3

Land Use Planning as the First BMP: Linking Stormwater to Land Use





Companion Tools for Chapter 3
Download Post-Construction Tools at:
www.cwp.org/postconstruction

What's In This Chapter

- Why stormwater managers should engage in land use decisions
- Planning at different scales
  - Regional
  - District or neighborhood
  - Site level
- A process for integrating stormwater and land use planning
  - Understand the role of impervious cover and other watershed factors
  - Examine and evaluate land use codes
  - Develop relationships between stormwater managers, land use planners, and other officials
  - Use watersheds are organizing units
- Considering climate change in the stormwater/land use program

3.1. Introduction

Increasingly, communities are looking for ways to maximize the opportunities and benefits associated with growth while minimizing and managing the environmental impacts of development. Balancing these priorities is playing out in planning commission meetings, boardrooms, mayors' offices, and public meetings throughout the United States. Stormwater managers can, and should, be central players in such conversations. Where and how development occurs can dramatically affect a community's watersheds, infrastructure, and water supplies. Effectively engaging in these discussions can help communities better balance development decisions with environmental protection.

The barrier, however, is where and how to engage in development decisions. Traditionally, the practice of stormwater management has been limited to site-level approaches. However, stormwater management is evolving beyond engineered approaches applied at the site level to an approach that looks at managing stormwater at the regional, district/neighborhood, and site scales.

By looking at stormwater management at various scales, stormwater managers can influence the development debate in a number of ways. For example, they can, and should, be active in helping a community craft policies and incentives to direct development to already disturbed or degraded land. Redeveloping a parking lot, abandoned mall, or already degraded site allows a community to enjoy the benefits of growth without increasing net runoff. In this way, engaging in growth and development discussions can be considered the "first stormwater best management practice."

The purpose of this chapter is to highlight opportunities where stormwater managers can engage in broader growth and development decisions. Every community is unique and has it own vision of its character. Certainly, a development discussion concerning redevelopment of an aging downtown area will cover issues substantially different from those of a rural town struggling to maintain its character. Both communities, however, will discuss policies and regulations, such as road and street width, building setbacks, parking requirements, and open space requirements, that can have a direct impact on stormwater runoff.

This chapter seeks to highlight those development-related policies and regulations and describe how stormwater managers might effectively engage and influence land use decisions.

3.2. Why Should Stormwater Managers Engage in Land Use Decisions?

Many stormwater managers do not see engaging in land use decisions as part of their job. Indeed, the past few decades of stormwater management have focused on using control and treatment strategies that are largely hard-infrastructure-engineered, end-of-pipe, and site-focused practices concerned primarily with peak flow rate and suspended solids concentration control.

Where and how communities grow affects water quality. The collective experience of communities across the United States demonstrates that looking only at site-level practices will not repair damaged waterbodies and will likely put more streams on impaired lists over time.

Indeed, factors at the site, district/neighborhood, and regional scales can drive the creation of unnecessary impervious cover and other land cover conditions that produce excessive runoff. These factors are embedded in a community's land use codes and policies. A comprehensive approach to stormwater management should therefore include an examination of a locality's land development regulations, policies, and ordinances to better align with water quality goals.

For example, a subdivision ordinance dictates minimum houses per acre, street width, and the distance a house is set back from the road. All of these measures create impervious surface. It is for the municipality to determine whether the creation of this impervious surface and the generation of the associated runoff are appropriate. In this way, the municipality aligns its subdivision regulations with its stormwater goals.

Table 3.1 lists common land use development regulations, codes, and policies that could be reviewed for consistency with stormwater goals. These documents are also needed to complete the "Codes and Ordinance Worksheet," which is a tool to assist with the systematic review of codes and policies for consistency with model development principles (see **Tool 4**).

A comprehensive approach to stormwater management involves developing stormwater management practices that can be applied at the regional, district/neighborhood, and site scales. It also involves looking at where and how development occurs within the community. This is best done by examining common land development regulations and policies that dictate the location, quantity or density, and design of development.

3.3. Planning at Different Scales

Decisions about where and how to grow are the first, and perhaps most important, development decisions related to water quality. A comprehensive stormwater management approach supports an interconnected network of open spaces and natural areas (such as forested areas, floodplains and wetlands) that improve water quality while also providing recreational opportunities and wildlife habitat. These open spaces must be balanced with areas where growth and development are appropriate. Traditionally, stormwater managers have engaged at the development site level by restricting development within the riparian buffer, wetlands, or other critical natural features. However, engaging in this issue at the district/neighborhood scale or regional scale can have a greater water quality benefit.

A 2006 EPA study found that, conceptually, higher-density development can be more protective of regional water quality than lower-density scenarios because less stormwater and associated pollutants are produced on a per-unit basis (**USEPA, 2006a**). **Figure 3.1** illustrates how dense developments, although they have a high site-level impervious cover, can result in a lower watershed impervious cover compared to a scenario where development is equally spread out across the watershed. For example, in scenario C development is directed to 1/8-acre lots in a small

Table 3.1. Common Land Use Development Regulations, Codes, and Policies That Can Drive Impervious Cover

- ***Zoning ordinance*** specifies the type of land uses and intensity of those uses allowed on any given parcel. A zoning ordinance can dictate single-use, low-density zoning, which spreads development out throughout the watershed, creating excess impervious cover.
- ***Subdivision codes*** or ordinances specify specific development elements for a parcel: housing footprint minimums, distance from the house to the road, the width of the road, street configuration, open space requirements, and lot size—all of which can lead to excess impervious cover.
- ***Street standards or road design guidelines*** dictate the width of the road for expected traffic, turning radius, the distance for other roads to connect to each other, and intersection design requirements. Road widths, particularly in new neighborhood developments, tend to be too wide, creating considerable impervious cover.
- ***Parking requirements*** generally set the minimum, not maximum, number of parking spaces required for retail and office parking. Setting minimums leads to parking lots designed for peak demand periods, which can create acres of unused pavement during the rest of the year.
- ***Minimum setback requirements*** can spread development out by leading to longer driveways and larger lots. Establishing maximum setback lines for both residential and retail development brings buildings closer to the street, reducing the impervious cover associated with long driveways, walkways, and parking lots.
- ***Site coverage limits*** can disperse the development footprint and make each parcel farther from its neighbor, leading to more streets and roads and thereby increasing total impervious cover throughout the watershed.
- ***Height limitations*** limit the number of floors for any building. Limiting height can spread development out if square footage cannot be met by vertical density.

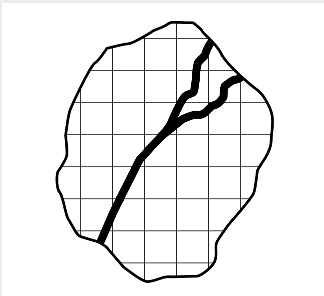
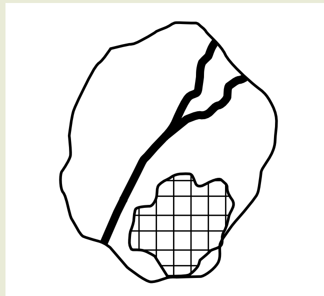
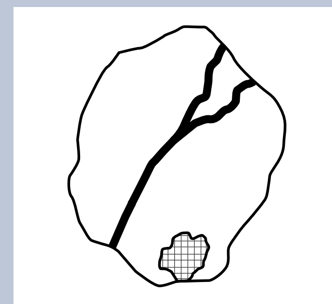
Scenario A	Scenario B	Scenario C
		
10,000 houses built on 10,000 acres produce:	10,000 houses built on 2,500 acres produce:	10,000 houses built on 1,250 acres produce:
10,000 acres x 1 house x 18,700 ft^3/yr of runoff =	2,500 acres x 4 houses x 6,200 ft^3/yr of runoff =	1,250 acres x 8 houses x 4,950 ft^3/yr of runoff =
187 million ft^3/yr of stormwater runoff	**62 million ft^3/yr of stormwater runoff**	**49.5 million ft^3/yr of stormwater runoff**
Site: 20% impervious cover	**Site: 38% impervious cover**	**Site: 65% impervious cover**
Watershed: 20% impervious cover	**Watershed: 9.5% impervious cover**	**Watershed: 8.1% impervious cover**

Figure 3.1. Watershed impervious cover at different development densities (Source: U.S. EPA, 2006a)

portion of the watershed, resulting in 65% impervious cover for the development site but only 8% impervious cover for the entire watershed. If an equivalent number of development units are spread out over the entire watershed (scenario A), the development has a lower impervious cover but the watershed has a much higher impervious cover, 20%.

The following sections describe potential approaches a stormwater manager can take to address stormwater at the regional, district/neighborhood, or site scale.

Regional Stormwater Management Approaches

Stormwater managers should begin to address stormwater at a regional scale by doing the following:

Preserving open space and critical ecological features. Preserving open space is critical to maintaining water quality at the regional level. Large, continuous areas of open space reduce and slow runoff, absorb sediments, serve as flood control, and help maintain aquatic communities. Preserving ecologically important land, such as wetlands, buffer zones, riparian corridors, and floodplains, is critical for regional water quality.

Encouraging development in already-degraded areas. Perhaps the biggest opportunity for any stormwater manager is to work with local governments to develop a range of policies and incentives to direct development to already degraded areas. Communities can enjoy a significant reduction in regional runoff if they take advantage of underused properties, such as infill, brownfield, or greyfield sites (sites in abandoned or underutilized commercial areas) (**Congress for New Urbanism, 2001**). Redeveloping already degraded sites such as abandoned shopping centers or underutilized parking lots rather than paving greenfield sites for new development can dramatically reduce total impervious area and water quality impacts.

Using land efficiently. Using land efficiently reduces and better manages stormwater runoff by putting development where it is most appropriate and reducing total impervious area. For example, by directing and concentrating new development in areas targeted for growth, communities can reduce or remove development pressure on undeveloped parcels and protect sensitive natural lands and recharge areas.

District or Neighborhood Stormwater Management Approaches

Stormwater at the district or neighborhood scale can be addressed through approaches, like the following:

Mixed use and transit-oriented development. Mixing land uses can have direct effects on reducing runoff because mixed-use developments have the potential to use surface parking lots and transportation infrastructure more efficiently, requiring less pavement. Transit-oriented development can help protect water quality by reducing (1) land consumption due to smaller site footprints, (2) the number of parking spaces, and (3) average vehicle miles traveled, which in turn reduces atmospheric sources of pollution that can end up in receiving waters. Because higher-density development is clustered around transit stops, the need for developing land elsewhere in a region can be reduced (if the proper policies and controls are in place).

Green streets. The green streets concept is a streetscape design with multiple functions that integrates the “natural” and the “manmade.” Green street streetscapes facilitate natural infiltration wherever possible and therefore have less impervious surface such as concrete and asphalt. They allow for greater use of vegetation and other attractive materials, such as crushed stone and pavers, which can help to create an identifiable community character.

Parking requirements. Another strategy to reduce impervious cover is to assess parking requirements, particularly those for parking lots. Better balancing parking demand and supply could help remove some of the excess spaces. Some communities have found that “park once,” shared parking strategies, and allowing on-street parking can help balance parking supply and demand. In 2006 EPA published *Parking Spaces/Community Places: Finding the Balance Through Smart Growth Solutions*. This document highlights approaches that balance parking with broader community goals (**USEPA, 2006b**).

Open-space amenities. In recent decades Americans have demonstrated their preference for living near or adjacent to parks or other open-space areas by their willingness to pay a premium for housing near these amenities (**Trust for Public Land, 1999**). Nationwide, easy access to parks and open space has become a measure of community health. These district/neighborhood open spaces can also serve critical stormwater functions, such as providing buffer areas for stormwater quality or areas to reduce stormwater flooding.

Site-level Stormwater Management Approaches

After minimizing runoff at the regional and district/neighborhood scales, stormwater management finally turns to the site scale. Many of the remaining chapters in this guide focus on site-level stormwater strategies. For instance, **Chapter 4** includes a recommended stormwater management approach that is largely relevant to the site scale.

Smart Growth Approaches to Stormwater Management

Table 3.2 lists various EPA publications about the relationship between planning and water quality that are relevant to water resources and stormwater management. It should also be noted that EPA’s *National Menu of Stormwater Best Management Practices* lists many Smart Growth and site design techniques among post-construction best management practices (BMPs; see **Table 3.3**). EPA encourages a mix of structural, nonstructural, and planning techniques to address the post-construction minimum measure.

The remainder of this chapter introduces a process for integrating stormwater with land use planning. In other words, it outlines how a stormwater program can consider land use as the “first BMP” by integrating ideas and techniques that engage the stormwater manager in land use issues.

Table 3.2. EPA Publications Related to Water Resources and Stormwater
Note: See ***www.epa.gov/smartgrowth*** for more information.

Using Smart Growth Techniques as Stormwater Best Management Practices, EPA 231-B-05-002. December 2005.
www.epa.gov/smartgrowth/stormwater.htm
A guidance document that reviews nine common smart growth techniques and examines how they can be used to prevent or manage stormwater runoff.

Protecting Water Resources with Higher-Density Development, EPA 231-R-06-001. January 2006.
www.epa.gov/smartgrowth/water_density.htm
A guidance document that helps communities better understand the impacts of higher- and lower-density development on water resources. The findings indicate that low-density development might not always be the preferred strategy for protecting water resources.

Parking Spaces/Community Places, EPA 231-K-06-001. January 2006.
http://www.epa.gov/smartgrowth/parking.htm
A guidance document that helps communities explore new, flexible parking policies that can encourage growth and balance parking needs with their other goals.

*Protecting Water Resources with Smart Growth***,** EPA 231-R-04-002. May 2004.
www.epa.gov/smartgrowth/water_resource.htm
A guidance document intended for audiences that are already familiar with smart growth concepts and want specific ideas on how smart growth techniques can be used to protect water resources. Suggests 75 policies that communities can use to grow in the way that they want to while protecting their water quality.

Stormwater Guidelines for Green, Dense Redevelopment, December 2005.
www.epa.gov/smartgrowth/emeryville.htm
A City of Emeryville, California, grant product that is geared specifically to developers and designers. These guidelines offer ways to meet requirements to treat stormwater from development projects.

*Solving Environmental Problems through Collaboration: A Case Study of the New York City Watershed Partnership***,** EPA 231-F-06-005. June 2006.
www.epa.gov/innovation/collaboration
A fact sheet that provides a summary of the partnership, which works closely with government and nongovernmental partners to protect the drinking water supply of 9 million people while promoting economic viability and preserving the social character of the communities in the upstate watershed.

*Growth and Water Resources***,** EPA 842-F-02-008. September 2005.
www.epa.gov/smartgrowth/pdf/growthwater.pdf
A fact sheet that explains how land use affects water resources and offers resources and tools for communities.

Growing Toward More Efficient Water Use: Linking Development, Infrastructure, and Drinking Water Policies, EPA 230-R-06-001. January 2006.
www.epa.gov/smartgrowth/water_efficiency.htm
A guidance document that focuses on the relationships among development patterns, water use, and the cost of water delivery and includes policy options for states, localities, and utilities that directly reduce the cost and demand for water while indirectly promoting smarter growth.

*Smart Growth for Clean Water***.** National Association of Local Government Environmental Professionals, Trust for Public Land, ERG. 2003.
www.resourcesaver.com/file/toolmanager/CustomO93C337F42157.pdf
A grant product that offers ideas for using smart growth to advance clean water goals based on the experiences of communities across the nation.

Potential Roles for Clean Water State Revolving Fund Programs in Smart Growth Initiatives, EPA 832-R-00-010. October 2000.
www.epa.gov/owm/cwfinance/cwsrf/factsheets.htm
A guidance document that describes options for states to use their Clean Water State Revolving Funds to support more environmentally sound growth and development.

Table 3.3. EPA's *National Menu of Stormwater Best Management Practices*: Selected Post-Construction BMPs Consistent with Smart Growth and Site Design Strategies
www.epa.gov/npdes/menuofbmps

- Conservation Easements
- Development Districts
- Eliminating Curbs and Gutters
- Green Parking
- Green Roofs
- Infrastructure Planning
- Low-Impact Development and Green Design Strategies
- Narrower Residential Streets
- Open-Space Design
- Protection of Natural Features
- Redevelopment
- Riparian/Forested Buffer
- Street Design and Patterns
- Urban Forestry

3.4. A Process for Integrating Stormwater and Land Use

The following four steps are recommended to begin integrating stormwater with land use:

1. Understand the role of impervious cover and other watershed factors at the regional, district/neighborhood, and site scales.
2. Examine and evaluate land use codes for drivers of excess impervious cover and land disturbance.
3. Develop relationships between stormwater managers, land use planners, and other officials.
4. Use watersheds as organizing units for the linked stormwater/land use program.

The following sections discuss each step in more detail.

3.5. Step 1: Understand the Role of Impervious Cover and Other Watershed Factors at the Regional, District/Neighborhood, and Site Scale

Impervious cover has become one of the most important indicators of overall watershed health because it is relatively easy to measure and the correlations with stream health have been documented for small watersheds draining first- to third-order streams (e.g., 2 to 20 square miles) (**CWP, 2003a; Schueler et al., in review**). Thus, controlling overall impervious cover at the watershed or community level is one of the chief strategies currently employed to limit stormwater impacts.

Though development in various watersheds is highly varied, research finds that indicators of stream health decline with increasing impervious cover (**CWP, 2003a; Schueler et al., in review**). **Figure 3.2** presents a conceptual model that expresses the impervious cover/stream health relationship as a "cone" that is widest

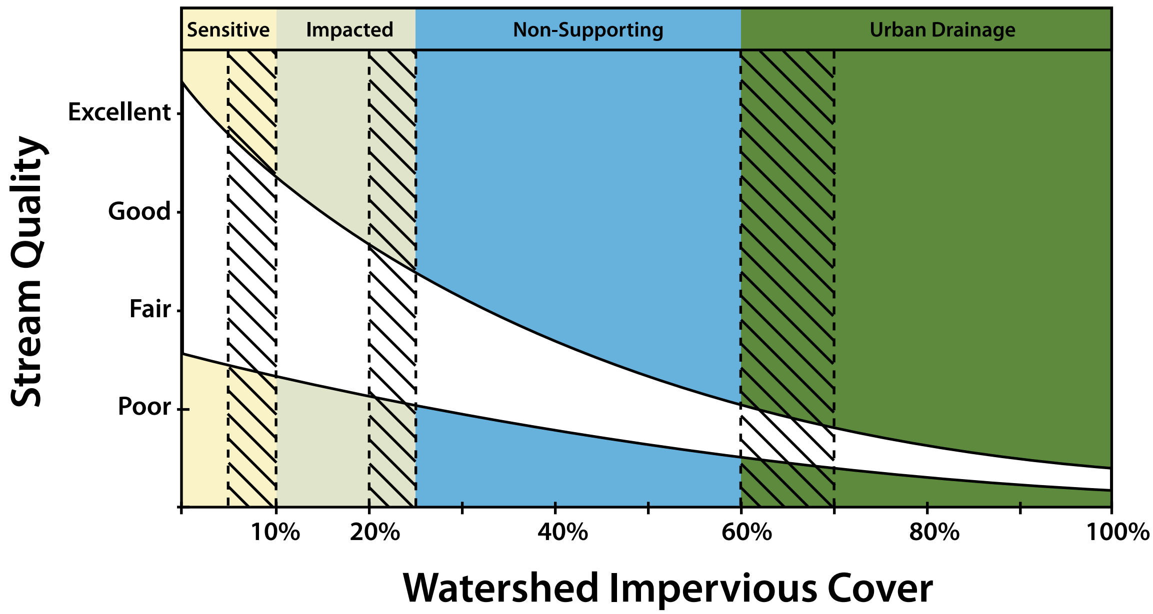


Figure 3.2. Conceptual model illustrating the relationship between impervious cover and stream health. (Source: Schueler et al., in review)

at lower levels of impervious cover and progressively narrows at higher levels of impervious cover (**Schueler et al., in review**).

The cone width is greatest at lower levels of impervious cover (e.g., less than 10 percent), reflecting the wide variability in stream response found in less-urban watersheds. The expected quality of streams in this lower range of impervious cover is generally influenced more by other watershed metrics, such as forest cover, road density, extent of riparian vegetative cover, and cropping practices (**CWP, 2003a**). At higher levels of impervious cover, the cone is narrower because most streams in highly impervious, urban watersheds exhibit fair or poor stream health conditions (i.e., the correlation between impervious cover and stream health is stronger) (**Schueler et al., in review**).

The model also illustrates how impervious cover can be used to classify and manage subwatersheds according to four categories of stream health: sensitive, impacted, non-supporting, and urban drainage. The transitions between management categories are shown as ranges (e.g., 5%–10%, 20%–25%, 60%–70%) as opposed to sharply defined thresholds, since most regions show a generally continuous but variable gradient of stream degradation as impervious cover increases (**Schueler et al., in review**).

Stormwater and watershed managers should define their own ranges based on actual monitoring data for their region, the stream indicators of greatest concern, and the predominant predevelopment regional land cover (e.g., crops or forest). This model can be used to make initial predictions about stream health based on impervious cover, coupled with supplemental field monitoring to confirm or refine the diagnosis. In addition, impervious cover should not be the sole metric used to predict stream quality, especially at the lower ends of subwatershed impervious cover.

Other watershed metrics—such as watershed forest cover, riparian forest cover, agricultural land, wetlands, road crossings, and impoundments—can strongly influence watershed and stream health. Therefore, it is important to understand the relationship between these factors and stream health, and to develop strategies to manage them (e.g., adopting regulations that require conservation of forest buffers). Nevertheless, impervious cover remains an important watershed metric for stormwater managers to track and manage.

The factors that drive the proliferation of impervious cover within watersheds are often embedded within complex land development codes and standards. These same codes and standards can also influence other land cover metrics that affect watershed health, such as the amount and location of forest cover present in the watershed. Before undertaking a large-scale program review, it is helpful to understand the factors that shape impervious cover and other land cover types in the built environment.

As discussed earlier in this chapter, these factors operate at three different scales: (1) the region, (2) the district or neighborhood, and (3) the site. The actual codes and policies that operate at these three scales are examined in more detail in the following section.

3.6. Step 2: Examine and Evaluate Land Use Codes for Drivers of Excess Impervious Cover and Land Disturbance

As explained at the beginning of this chapter, there are factors at the site, district/neighborhood, and regional scales that are hidden drivers of impervious cover. The next step in the process of linking stormwater to land use planning is to pry into these codes and policies to see if they can be made more consistent with overall stormwater management goals. For instance, if the local zoning code requires wide streets with curbs and gutters, perhaps alternative designs with less pavement and more vegetation should be considered.

Table 3.4 lists the most common local development codes and documents that should be reviewed for consistency with stormwater goals. These documents are also needed to complete the "Codes and Ordinance Worksheet," which is a tool to assist with the systematic review of codes and policies for consistency with Better Site Design model development principles (see **Tool 4**).

Table 3.4. Key Local Documents to Review for Consistency with Stormwater Goals

- Zoning ordinance
- Subdivision codes
- Subarea or district master plans
- Street standards or road design manual
- Parking requirements
- Building and fire regulations/standards
- Stormwater management or drainage criteria
- Buffer or floodplain regulations
- Environmental regulations
- Tree protection or landscaping ordinance
- Erosion and sediment control ordinances
- Public fire defense master plans
- Grading ordinance

The following sections highlight some of the most common local code and policy issues that might conflict with good stormwater management. **Chapter 5** goes into more detail on developing appropriate stormwater codes and how to identify inconsistencies with existing regulations.

Code and Policy Issues That Drive Impervious Cover at the SITE SCALE

Many codes and policies at the site scale can inadvertently increase impervious cover. For example, *setback requirements* can lead to inefficient use of land by spreading development out and creating the need for longer driveways. *Height limits* can spread development out if square footage cannot be met by going up. Site coverage limits can disperse the development footprint and make each parcel farther from its neighbor, leading to more public infrastructure. Many different *parking requirements*, including the following, increase impervious cover:

- ***Parking standards.*** Most land development codes contain detailed specifications on parking requirements that are based on bulletins from the Institute of Transportation Engineers (ITE). The bulletins, which are updated regularly, estimate parking demand for various uses, which are then translated into site plan requirements. These requirements are often listed as minimums. Often the number of spaces is driven by a few high-volume shopping days each year, and the studies used to estimate parking demand are often carried out in areas where the automobile is the only mode of transportation considered. In addition, the extra spaces trigger additional imperviousness in the form of drive aisles, access lanes, and turn lanes from roadways.

- ***Parking requirements for redevelopment.*** Older buildings might have fewer spaces than required in updated parking codes. Redevelopment of an older building often triggers the more recent requirements. Where the older buildings are on small lots, parking minimum requirements can be a barrier to redevelopment.
- ***Financial requirements.*** Developers who seek financing often meet resistance to the idea of supplying fewer spaces from lenders, who equate extra parking spaces with lower financial risk.
- ***District-wide and shared parking.*** Perhaps one of the larger, often unexplored drivers of excess parking is the practice of assessing parking needs one development project at a time. This precludes the ability to arrange efficient parking supply among users.
- ***Use of streets.*** Some localities are discovering on-street spaces as excess capacity for meeting parking needs. The imperviousness is already there, and thus using streets can alleviate the need to construct more parking.

Code and Policy Issues That Drive Impervious Cover at the DISTRICT/NEIHBORHOOD SCALE

At the district or neighborhood scale, impervious cover can be driven by policies such as separated use policies, street design practices, and subdivision design. These drivers are further discussed below:

- ***Separated uses.*** The zoning convention of assembling development projects consisting of a single use (e.g., all housing in subdivisions or all commercial uses in office parks) has been widely studied for impacts on travel, transportation, and congestion. According to the Bureau of Transportation Statistics, Americans average four trips per day, totaling on average 40 miles of travel, mostly in a personal vehicle. These trips, to commute, shop, and recreate, are used as input to models for parking requirements, travel demand, and the like. For stormwater, these separated uses result in an increased need for transportation infrastructure, and its related imperviousness.
- ***Street design.*** In the 1950s and 1960s, roadway design practices began to favor a less networked, "hierarchical" street design. Within housing subdivisions, the individual, smaller streets feed into collector roads, which then lead, often through only one intersection, to arterials. This type of system concentrates traffic onto fewer roads, which increases the pressure to build large public roads or widen existing roads originally planned for rural traffic patterns.
- ***Street and roadway widths.*** Early roadway standards established minimum lane widths for rural highways. Wider lanes were needed to provide the sight clearance and maneuvering space needed for higher speeds. Over time, these widths were integrated into local street standards.

  Roadway imperviousness is not limited to lane widths. The size of turning and queuing lanes is also governed by standard formulas. The wider street standards brought with them higher design speeds. These speeds, in turn, dictate the size of intersections and curb radii, which are referred to as "intersection geometry" in transportation handbooks. For a full discussion of street geometry and its relationship to site development, see ***http://safety.fhwa.dot.gov/ped_bike/univcourse/swless06.htm***.
- ***Subdivision design.*** Residential subdivision codes are the primary example of a district code. Subdivision codes (which are typically supported by enabling legislation at the state level) include requirements for roadways, drainage, open space, building alignments, lot sizes, and many other features.

  Planners have been working on improvements to subdivision codes to eliminate some of the commonly noted drawbacks, such as excessive site clearance and the lack of mixed use. Planned unit developments (PUDs) often add a mixed-use component to subdivisions, while conservation subdivisions strive to lessen environmental impacts by clustering home sites and preserving open space within residential areas. Nevertheless, conventional subdivision design still dominates site planning and residential construction. A 2004 study on subdivisions found street, driveway, and site imperviousness composed up to 50% of the total development site (**Local Government Commission, 2004**).

Code and Policy Issues That Drive Impervious Cover at the REGIONAL SCALE

Impervious cover drivers at the regional scale can include lack of coordination between units of government, state standards, and transportation requirements at the state/federal level. These drivers are further discussed below:

- ***Lack of regional governance structures.*** Jurisdictional boundaries often have the effect of spurring competition, not cooperation. This competition for tax base often leads to dispersed growth. With stormwater, the permitted agency is in many cases a relatively small unit of government, such as a township or village. Decision-making at this level is rarely coordinated at the watershed scale.
- ***Codes and standards at the state level.*** States often set requirements that result in a larger development footprint. For example, school siting standards often require at least 20, 50, or even 100 acres for new schools. School districts often find that the only parcels of this size are in undeveloped areas. School construction then generates new development interest in the surrounding area.
- ***Split responsibility for transportation.*** States are usually responsible for Interstates, state highways, and sometimes local roads. Localities might be responsible for local roads and district/neighborhood streets. Often, it is difficult to coordinate transportation and land use planning among the different agencies. Decisions to expand or improve transportation systems at the state level can run counter to local land use priorities.

3.7. Step 3: Develop Relationships Between Stormwater Managers, Land Use Planners, and Other Officials

If land use is to effectively become the "first BMP" for a stormwater program, it is imperative that stormwater managers form closer working relationships with

- Land use planners
- Transportation planners
- School officials
- Parks and recreation staff
- Public facility engineers
- Emergency management officials
- Other local officials

In many jurisdictions, the stormwater managers might have limited interaction with other municipal staff who have an impact on the stormwater program. The stormwater manager is likely housed within a public works or engineering department. If he or she is engaged in site plan review, the main focus is at the site scale. The stormwater manager might also work on capital projects involving drainage or other infrastructure.

Meanwhile, land use planners are customarily located in planning and community development departments. They engage most closely with zoning issues, such as setbacks and parking requirements, and they are also responsible for developing and revising the community's land use and comprehensive plans. They might also be involved in community-wide issues like economic development, housing, and transportation.

A more effective approach would promote integration across departments and professions, with the comprehensive plan being one of the primary mechanisms for working together. This integration would encourage more involvement on stormwater issues early in the planning process. For example, stormwater managers could be involved in the following areas:

- ***Land use.*** Stormwater managers might be called upon to estimate the stormwater and flooding impacts of growth alternatives, to point out opportunities to use low-impact and redevelopment alternatives, and to offer suggestions on which areas of land might be best suited for handling stormwater. In rural and suburbanizing areas, stormwater managers might be asked to assess various build-out scenarios for future growth and watershed management.

- ***Redevelopment.*** Because redevelopment is commonly more complex than new development, many comprehensive plans attempt to reduce barriers to redevelopment such as the limited space for stormwater BMPs at many urban redevelopment sites. Stormwater departments might be asked to design district-wide or shared facilities and/or tailored site-level BMPs suited to ultra-urban settings.
- ***Transportation.*** Transportation plans can be coordinated with stormwater by considering linear transportation projects within the context of watersheds and surrounding development. Sometimes, stormwater strategies can serve both transportation and development needs, and transportation projects might also be able to provide land or mitigation funds for protected or restored natural resources areas. Stormwater managers might also want to engage transportation engineers on innovative stormwater techniques that can be incorporated into the road section or right-of-way.
- ***Economic development.*** The funding of stormwater and flood control projects might provide a strong economic incentive for development and redevelopment decisions. Stormwater managers might be asked to work with economic development staff to see where improvements meet water and business development needs.
- ***Parks and open space.*** Stormwater managers might be asked to identify parcels with high value for stormwater management. In urban areas, these parcels might need to serve several purposes, so stormwater programs could be called upon to work with parks, recreation, habitat, or water supply organizations.

Table 3.5 describes several mechanisms to build better relationships between stormwater managers, land use planners, and other local officials.

Table 3.5. Tips for Building Relationships Between Stormwater Managers, Land Use Planners, and Other Local Officials

Include both land use planners and stormwater managers in pre-concept and/or pre-application meetings for potential development projects.
Use local government sites (e.g., schools, regional parks, office buildings, public works yards) as demonstration sites for innovative stormwater management. Form a team that includes land use planners, stormwater managers, parks and school officials, and others to work out the details.
Include stormwater managers in the comprehensive plan process so that overall watershed and stormwater goals can be incorporated.
Make sure that both land use planners and stormwater managers are involved in utility and transportation master planning.
Involve stormwater managers in economic development planning, especially for enterprise zones, Main Street projects, and other projects that involve infill and redevelopment. Encourage stormwater managers to develop efficient watershed-based solutions for these plans.
Develop cross-training and joint activities that allow land use planners, stormwater managers, and transportation, utility, and capital project planners to explore how various land use/stormwater processes can be better integrated.
For staff training, bring in speakers who are knowledgeable about stormwater management. Alternatively, encourage land use planners, stormwater managers, and other local officials to attend training on this topic as a team.

3.8. Step 4: Use Watersheds as Organizing Units for the Linked Stormwater/Land Use Program

Another critical tool for linking stormwater with land use is to consider land use policies in a watershed context. Each watershed is unique and has its own challenges, including:

- Important local resources, such as drinking water supplies, recreational uses, and sensitive features, such as wetlands, cold-water fisheries, and coastal bays
- Waterbodies listed as "impaired" on state Total Maximum Daily Load (TMDL) lists
- Streams and waterbodies that are currently healthy; future actions should ensure that they stay that way.
- Streams and waterbodies that are currently degraded, characterized by channel erosion and/or flooding, and/or have existing water quality problems; future actions should aim to restore watershed functions where feasible
- Watersheds that lie completely within a single jurisdiction versus those that cross one or more jurisdictional boundaries

There is no one-size-fits-all approach for integrating stormwater, land use, and watersheds. **Table 3.6** outlines various regulatory, site design, and policy strategies that can help with this integration.

Tables 3.7 and **3.8** synthesize the strategies presented in **Table 3.6** into a management framework and present a menu of options to consider. These tables list recommended strategies based on both watershed (**Table 3.7**) and land use (**Table 3.8**) characteristics. The tables also list other approaches that should be scrutinized because they might run counter to overall stormwater and land use goals.

Table 3.6. Regulatory and Site Design/Policy Strategies to Integrate Stormwater, Land Use, and Watersheds

Regulatory Tools
Overlay zoning. Overlay zoning is a technique to "overlay" more protective standards over land with existing zoning. This procedure can be helpful to stormwater managers who need special protection in a discrete area within the watershed. Examples are drinking water supply watersheds, wellhead protection areas, areas subject to flooding, and watersheds for critical resources, such as wetlands and special recreational areas. The overlay zone typically designates allowable land uses and performance standards (see below).
Special use permits. In zoning codes, there are often two lists—allowable uses and uses allowed by special use permit. Stormwater managers might want to explore the use of special use permits to apply BMPs for certain uses (e.g., stormwater hotspots, direct discharges to wetlands).
Performance standards. Performance standards are usually associated with particular land use categories, and they can also be tied to special use permits, overlay zoning, and/or rezoning applications. Examples of performance standards are minimizing clearing and grading, minimizing creation of new impervious surfaces, tree preservation or canopy targets, protection of riparian buffers, and septic system location and design.
Special stormwater criteria. Special stormwater criteria would likely reside in the stormwater ordinance and/or design manual. These are criteria that are specifically tailored to discharges to sensitive receiving waters. Examples would be temperature control for trout streams, more aggressive nutrient management for drinking water supplies and wetlands, groundwater protection criteria for wellhead protection areas, special detention criteria for flood-prone areas, and pollution prevention measures for stormwater hotspots. (See **Chapter 4** for more detail on special stormwater criteria.)
Site Design and Policy Tools
Compact development. Compact development seeks to meet a certain level of development intensity on a small footprint. Communities might be seeking this type of design to support walkability, transit station access, reduced infrastructure costs, or for water resource protection. Compact designs can be used in any development setting from ultra-urban retrofits to rural village centers.

Table 3.6. Regulatory and Site Design/Policy Strategies to Integrate Stormwater, Land Use, and Watersheds *(continued)*

Site Design and Policy Tools
Street design. Many state departments of transportation are issuing "context-sensitive" alternatives for street design. These designs include narrow streets and consider multiple transportation modes. For transportation planners, the narrow streets are aimed at slower speeds and neighborhood design models. Stormwater managers thus have overlapping interests in better street design.
Utility planning. The rational and planned expansion of public water, sewer, and other utilities is critical for both land use planning and stormwater management. Utility extensions will likely encourage future growth at higher densities. Utility extensions should be planned for areas designated for infill, redevelopment, and future growth. On the other hand, utility restrictions should be considered for sensitive watersheds.
Mixed-use development. Highly separated uses (e.g., retail, schools, housing, jobs) are implicated in highly dispersed development. A high degree of automobile-supporting infrastructure, which can be over 50% of development-related imperviousness, is "built in" because walking and other modes of travel cannot be effectively supported. Bringing the uses closer together can lower the number and length of auto trips or support trip substitution. Less roadway and parking can translate into a lowered overall development footprint.
Infill. Communities are increasingly interested in targeting development to areas where the surrounding land is already developed and served by public utilities. An example is developing housing surrounding a mall or office park. This "infilling" can satisfy a high degree of development demand in an efficient manner.
Redevelopment. One of the strongest watershed strategies is reusing (and improving) vacant or underused sites that are already under impervious cover. This is not only an urban strategy, but can work for abandoned sites in rural areas as well. Programs such as downtown revitalization, Main Street programs, and brownfield redevelopment programs support these efforts.
Conservation development. Conservation development is a strategy that can work in various development contexts (e.g., urban, suburban) to coordinate and conserve open space. For stormwater, a particular emphasis may be placed on riparian buffers, forest protection, and open-space areas that capture and disperse runoff.
Purchase and transfer of development rights (PDR, TDR). PDR programs purchase development rights from landowners and are particularly targeted to areas or watersheds where rural character and natural resources should be protected. TDR programs set up development rights markets whereby some landowners (in rural or sensitive watersheds) can sell their development rights to landowners in areas where growth, infill, and redevelopment are encouraged.
Fee-in-lieu programs for stormwater. In certain areas, stormwater management goals cannot be met solely with on-site stormwater BMPs. Watershed-based approaches are needed to address issues that extend beyond the site boundary. Examples would be areas with existing flooding or drainage problems, impaired watersheds, and watersheds with streambank erosion problems. In these cases, a fee-in-lieu payment or offset fee can be collected from developers to partially offset full on-site compliance. The local stormwater program then uses the accumulated fees to conduct needed watershed repairs and improvements. (See **Chapter 4** for more information on watershed-based stormwater management approaches and criteria.)

Table 3.7. **Integrated Stormwater and Land Use Strategies Based on *Watershed Characteristics***

Watershed Characteristics	Integrated Strategies to Consider[a]	Approaches That May NOT Be Appropriate
Special receiving waters: drinking water, trout streams, wetlands, etc.	▶ Overlay zoning and performance standards ▶ Conservation development ▶ Special stormwater criteria ▶ Low-impact development ▶ Purchase of Development Rights (PDR) ▶ "Sending" area for Transfer of Development Rights (TDR)	▶ Large-lot zoning (disperses and spreads out development impacts) ▶ Relying solely on stormwater ponds and basins ▶ Urban road sections ▶ Utility and transportation expansions
Existing flooding problems	▶ Overlay zoning and performance standards ▶ Special stormwater criteria ▶ Low-impact development ▶ Street design ▶ Fee-in-lieu program	▶ Relying solely on site-by-site stormwater approaches that are not coordinated at watershed scale ▶ Wide roads, urban road sections
Impaired streams (303(d) listed) or other water quality problems	▶ Special stormwater criteria ▶ Special use permits for certain uses (e.g., hotspots) ▶ Performance standards ▶ Low-impact development ▶ Conservation development	▶ Relying solely on stormwater ponds and basins ▶ Urban road sections

[a] See **Table 3.6** for brief descriptions of the various strategies.

Table 3.8. **Integrated Stormwater and Land Use Strategies Based on *Land Use Characteristics***

Land Use Characteristics	Integrated Strategies to Consider[a]	Approaches That May NOT Be Appropriate
***Urban core*: incentive/ enterprise zones, redevelopment zones, town centers, brownfields**	▶ Waivers and variances ▶ Fee-in-lieu program for watershed projects ▶ Compact and mixed-use development ▶ Infill and redevelopment incentives ▶ Low-impact development ▶ "Receiving" area for Transfer of Development Rights (TDR)	▶ Impervious cover limits ▶ Aggressive open space requirements ▶ Large-lot zoning ▶ Ambitious on-site infiltration requirements
***Urbanizing*: designated for future growth, planned utility and/ or transportation expansions**	▶ Fee-in-lieu program for watershed projects ▶ Compact and mixed-use development ▶ Conservation development ▶ Low-impact development ▶ Street design, Green Streets ▶ Good stream buffering ▶ Performance standards ▶ "Receiving" area for TDR	▶ Large-lot zoning ▶ Conventional development standards that disperse the development footprint
***Rural*: desire to maintain rural character and working farms, special or unique natural resources**	▶ Conservation development ▶ Aggressive stream buffering ▶ Performance standards ▶ Special stormwater criteria ▶ Low-impact development ▶ "Sending" areas for TDR	▶ Use of waivers and variances ▶ Urban road sections ▶ Utility and transportation expansions ▶ Conventional development standards

[a] See **Table 3.6** for brief descriptions of the various strategies.

3.9 Considering Climate Change in the Stormwater and Land Use Program

Many of the assumptions that stormwater managers use for runoff and storm system design might become outdated if climate change predictions become a reality (**Funkhouser, 2007; Oberts, 2007**). For example, such stormwater mainstays as the "design storm" will need to be scrutinized to ensure that future stormwater designs are responsive to changing climate conditions.

Integrated stormwater and land use solutions have an important role to play in this challenging task. It is safe to assume that we cannot rely solely on "hard" or technological solutions to deal with such climate change scenarios as more frequent flooding and more prolonged droughts. Solutions more rooted in land use planning will have to play a role. These will include improved floodplain management, urban stormwater forestry, and strategies to promote more efficient development layouts—to promote greater efficiency in stormwater management, water conservation, *and* energy consumption.

EPA's climate change Web site (***http://www.epa.gov/climatechange***) includes comprehensive information on the many different issues affecting climate change. EPA's National Water Program is developing a strategy on climate change that describes how best to meet clean water and safe drinking water goals in the context of a changing climate (***http://www.epa.gov/water/climatechange***).

Stormwater managers and land use planners can work together on important adaptations to climate change. Some of these adaptations will need to respond to changing hydrologic realities (hydrologic adaptations); others will have to be coordinated with broader policy initiatives to respond to climate change (policy adaptations). **Table 3.9** provides several conceptual ideas for how integrated stormwater and land use tools can help adapt to both the natural resources and policy outcomes of climate change.

3.10. Relating Stormwater and Land Use to This Guidance Manual

Certainly, there are challenges to integrating stormwater and land use planning. They include coordination across multiple departments, coordination among multiple permitted agencies and jurisdictions, and political forces that compel land use decisions away from a watershed approach. However, the value of managing the landscape by linking land use practices to water quality protection is that long-term solutions that reduce stormwater impacts throughout the region are created.

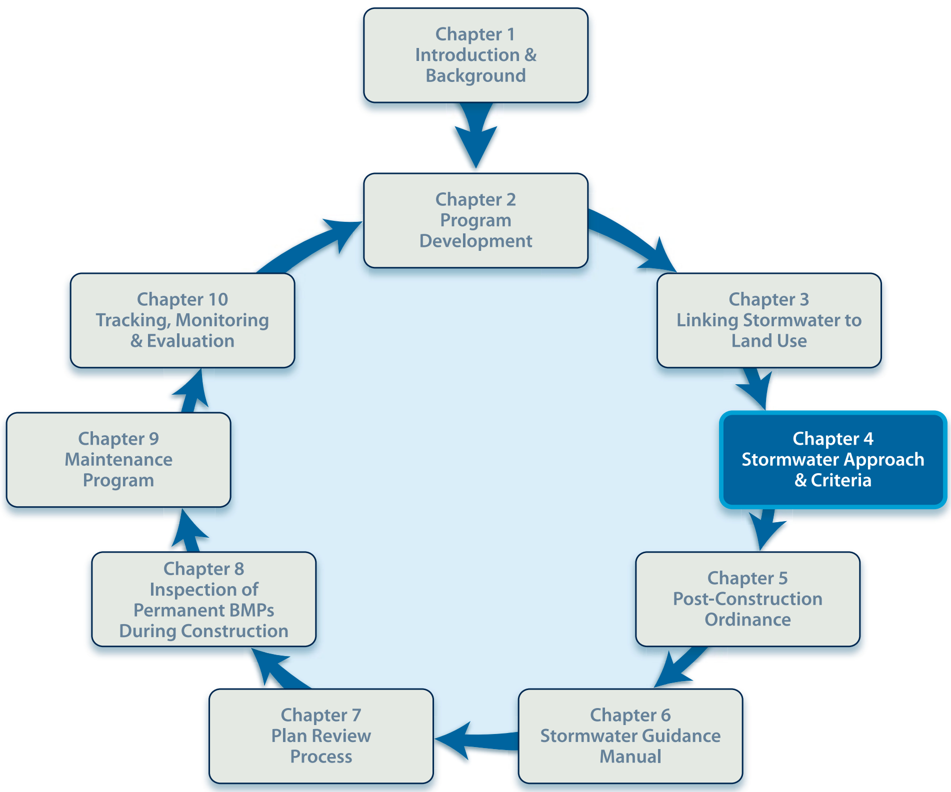
As local stormwater managers endeavor to build programs that are responsive to local conditions, state permit requirements, and existing practices, they should keep land use in mind as the "first BMP." Perhaps the simplest step is to forge stronger working relationships with land use planners and other local officials. This chapter can be a discussion starter for stormwater managers and land use planners as they begin important deliberations on how integration can and should take place at the local level.

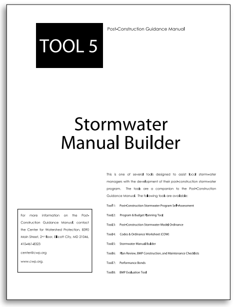
Table 3.9. Climate Change and Conceptual Land Use/Stormwater Adaptations

Hydrologic Adaptations	
More frequent flooding	► Remap floodplains based on "new" frequent and infrequent events. ► Adopt stringent regulations to restrict development within floodplains. ► Develop mitigation programs to remove susceptible structures from floodplains. ► Conduct more frequent cleaning of storm sewer infrastructure in urban areas to maintain hydraulic capacity. ► Ensure that all new development has overland relief in case of system failure. ► Model storm sewer infrastructure using new climate scenarios and coordinate with emergency response plans.
More prolonged droughts	► Extend rainwater harvesting beyond individual rooftop scale to neighborhood/ community scale. Use stormwater as a resource. ► Develop drought-resistant planting plans for BMPs and municipal landscaping. ► Promote urban forestry and forest protection to promote shade and retention of moisture. ► Incorporate groundwater recharge into all BMPs where safe and feasible.
Increased temperature of runoff	► Include trees and other plantings in BMP designs. ► Develop methods to reduce "straight-piping" of runoff to streams; use disconnection methods to direct runoff to buffers, planted areas, pervious parking, forested BMPs, etc. ► Develop impervious limits and minimum tree canopy requirements for special temperature-sensitive receiving waters (e.g., high-value trout streams).
More combined sewer overflows	► Incorporate volume-reduction measures across landscape: individual homes, streets, businesses, etc. These can include rain gardens, rainwater harvesting, dry wells, etc. ► Strategically locate and use open-space areas for runoff capture to reduce flows into system.
Policy Adaptations	
Reduce carbon emissions	► Promote compact development and reduce vehicle trips/miles. ► Provide stormwater incentives for redevelopment close to urban centers and more stringent requirements for new (greenfields) development that requires more driving. ► Provide stormwater credits for transit and bicycle facilities at development sites. ► Consider the embodied energy of BMP materials and installation (e.g., plastic/wood components, land cleared for BMPs) as a BMP selection criterion.
Increase carbon sequestration	► Use urban forestry as a stormwater BMP. ► Incorporate trees into all or most new BMPs. ► Design integrated stormwater/carbon sequestration facilities; incorporate planting maintenance plans that maximize carbon uptake.
Increase clean, renewable energy sources	► Incorporate small-scale power generation into some BMP and storm sewer designs that have adequate head. ► Colocate neighborhood-scale stormwater BMPs with solar, wind, and other renewable-energy facilities.

Chapter 4

Developing a Stormwater Management Approach and Criteria





Companion Tools for Chapter 4
Download Post-Construction Tools at:
www.cwp.org/postconstruction

What's In This Chapter

- A recommended stormwater management approach
- Developing stormwater management criteria
  - Natural resources inventory
  - Runoff reduction
  - Water quality
  - Channel protection
  - Flood control
  - Redevelopment
- Developing a rainfall frequency spectrum
- Special stormwater criteria for sensitive receiving waters
- A watershed-based stormwater approach

4.1. Clarifying the Stormwater Management Approach

Chapter 2 described some fundamental steps to plan a post-construction stormwater program, and **Chapter 3** described a holistic approach for integrating stormwater with land use planning.

The next steps in program development are to put all the pieces in place to have an operational program. These include:

- Adopt or amend a stormwater ordinance.
- Develop, amend, or reference a stormwater guidance manual.
- Create a stormwater plan review process.
- Inspect permanent stormwater BMPs during initial installation and construction.
- Develop a maintenance program.
- Track, evaluate, and report on the program.

Before jumping into these tasks, it is important to clarify the overall stormwater management approach that the program will take. Stormwater management has seen many innovations in recent years. Each community should evaluate various approaches and figure out the best way to move the program forward and protect receiving waters.

This chapter outlines some basic techniques to:

- Select a stormwater management approach that will guide the program (**Section 4.2**)
- Develop stormwater management criteria to be used in ordinances and design guidance (**Sections 4.3** and **4.7**)
- Use rainfall data to link stormwater criteria to particular rainfall events (**Section 4.4**)
- Add criteria for special receiving waters (**Sections 4.5** and **4.7**)
- Consider incorporating a watershed-based approach for stormwater (**Section 4.6**)

Table 4.1 outlines some critical decisions that stormwater managers should explore to develop a local stormwater approach.

4.2. A Recommended Stormwater Management Approach

Most stormwater programs rely heavily on conventional end-of-pipe treatment of stormwater. Although these BMPs are a critical component of stormwater management, there is a broader range of options to consider. Many opportunities are missed by simply collecting and treating runoff ***after*** it has already been generated. In fact, there are many techniques to reduce stormwater impacts at the front end through site design and source control methods.

In this respect, there is a recommended hierarchy of stormwater treatment methods:

- **First, reduce runoff through design**: Use site planning and design techniques to reduce impervious cover, disturbed soils, and stormwater impacts. Use techniques such as conservation design, protecting critical open space and natural drainage features, and disconnecting a site's impervious cover to reduce the generation of stormwater runoff. At a broader community and watershed scale, this might also mean encouraging infill and development within targeted zones while preserving open spaces and functional landscapes beyond those areas (see **Table 4.2**).
- **Second, reduce pollutants carried by runoff**: Use source control and pollution prevention practices to reduce the exposure of pollutants to rainfall and runoff. Examples include keeping impervious surfaces clean, educating homeowners on proper yard waste and fertilization methods, handling and storing chemicals properly, and collecting and recycling hazardous chemicals (see **Table 4.3**).
- **Third, capture and treat runoff**: Design stormwater BMPs to collect and treat the stormwater that is generated after applying the site design and source control methods described above. Some stormwater collection and treatment can be in small-scale, distributed practices close to the source of runoff. Examples include rain gardens, filter strips, and pervious parking. Site designers should attempt to blend this approach with more conventional practices—such as ponds, stormwater wetlands, and filters—to come up with the most effective BMP design (see **Table 4.4**).

Table 4.1. Critical Decisions to Identify a Stormwater Management Approach

Land Use	What is the best way to integrate stormwater with land use? **Chapter 3** provides a detailed discussion on this important link.
Site Design	To what extent should the program promote and give credit for good site design practices, such as: ▶ Open space conservation ▶ Reduction of impervious surfaces and site disturbance ▶ Riparian, wetland, and waterway buffers ▶ Disconnection of impervious surfaces ▶ Site reforestation ▶ Desirable infill and redevelopment Although many stormwater programs would like to see these types of practices, fewer provide the programmatic and regulatory incentives to make it happen.
Source Controls and Pollution Prevention	While the conventional approach to stormwater management is to collect and treat runoff at some point downstream from the source, a more comprehensive approach is to reduce or eliminate the exposure of pollutants to runoff in the first place. Examples of source control and pollution prevention practices include: ▶ Street sweeping ▶ Pet waste education programs ▶ Household hazardous waste collection ▶ Spill containment and response A local program must decide how to incorporate these practices.
Conventional Stormwater BMPs	Some stormwater BMPs, such as ponds and basins, have been around for a long time. The local program must determine how to promote a better mixture of conventional and innovative practices (see below).
Low-Impact Development and Green Infrastructure BMPs	Many innovative practices can be distributed across the site and can do a good job of reducing runoff volumes and overall stormwater impacts. However, appropriate stormwater criteria and credits must be in place in order for developers and site designers to use the innovative practices. Also, the local program must have the administrative, plan review, inspection, and maintenance capabilities to ensure that conventional and innovative practices are properly designed, installed, and maintained
Special Receiving Waters	Not all watersheds are created equal. Some watersheds might require some customized approaches to stormwater management. Examples include: ▶ Nutrient control for lakes, water supply reservoirs, and wetlands ▶ Pollution prevention for groundwater supply areas ▶ Additional stormwater controls for impaired waters The community must identify special receiving waters and address these unique conditions in the stormwater criteria.
Site-by-Site or Watershed-Based	Most communities address stormwater on a site-by-site basis as development takes place. However, some programs have found that they can better address watershed impacts and promote more cost-effective BMPs with a watershed approach. Programs that want to pursue this approach should create the planning, regulatory, and financial tools to make it work.
Stormwater Management Criteria	All the decisions listed above in this table must be distilled into understandable and achievable criteria that are established in the stormwater ordinance and, ideally, discussed in detail in a stormwater guidance manual. Traditionally, most stormwater programs had criteria for flood control. However, today's programs are expected to also address water quality, downstream channel protection, and perhaps runoff reduction, groundwater recharge, and natural resources protection.

Table 4.2. Hierarchy of Stormwater BMP Selection—Site Planning and Design

1. Site Planning and Design

First, reduce runoff through design:
Plan the site to reduce stormwater runoff volume and impacts through design techniques.

- Preservation and/or Restoration of Undisturbed Natural Areas
- Preservation of Riparian Buffers, Floodplains, and Shorelines
- Preservation of Steep Slopes
- Preservation of Porous and Erodible Soils
- Preservation of Existing Topography
- Prairie/Meadow Restoration
- Site Reforestation
- Soil Amendments/Soil Rejuvenation
- Avoidance of Sensitive Areas
- Reduced Clearing and Grading Limits
- Conservation Development
- Reduced Roadway Lengths and Widths
- Shorter or Shared Driveways
- Shared Parking
- Reduced Building Footprints
- Reduced Parking Lot Footprints
- Reduced Setbacks and Frontages
- Use of Fewer or Alternative Cul-de-Sacs
- Use of Natural Drainageways
- Incentives for Infill and Redevelopment Within Targeted Development Zones

Photo courtesy of Pat Devlin

See **Tool 4: Codes and Ordinance Worksheet** for guidance on modifying local development codes to allow these practices.

Also see:
Better Site Design: A Handbook for Changing Development Rules in Your Community, Center for Watershed Protection, Inc.
www.cwp.org > Online Store > Better Site Design

Using Smart Growth Techniques as Stormwater Best Management Practices, U.S. EPA.
http://www.epa.gov/smartgrowth/stormwater.htm

Table 4.3. Hierarchy of Stormwater BMP Selection—Source Control Practices

2. Source Control and Pollution Prevention Practices

Second, reduce pollutants carried by runoff:
Reduce exposure of pollutants to rainfall and runoff through source control and pollution prevention practices.

Residential	Nonresidential
Natural Landscaping	Covered Loading Areas
Tree Planting	Covered Fueling Areas
Yard Waste Composting	Covered Vehicle Storage Areas
Septic System Maintenance	Storm Drain Disconnection
Driveway Sweeping	Downspout Disconnection
Street Sweeping	Street Sweeping
Household Hazardous Waste Collection Programs	Covered Dumpsters
Car Fluid Collection and Recycling Programs	Covered Materials Storage Areas
Downspout Disconnection	Secondary Containment Structures
Pet Waste Pickup	Spill Response Plans
Storm Drain Marking	Signage
	Employee Training

See Manual 8, *Pollution Source Control Practices, Urban Subwatershed Restoration Manual Series*,
Center for Watershed Protection, Inc.
www.cwp.org > Online Store > Subwatershed Restoration Manuals

Table 4.4. Hierarchy of Stormwater BMP Selection—Stormwater Collection and Treatment

3. Stormwater Collection and Treatment

Third, capture and treat runoff:
Collect and treat stormwater runoff through small-scale distributed practices (close to the source of runoff) and other structural BMPs.

Small-Scale Distributed Practices	Other Structural BMPs
Downspout Disconnection	Infiltration Devices
Impervious Cover Disconnection	Larger Bioretention Areas
Rainwater Harvesting	Extended Detention Ponds
Rain Gardens	Wet Ponds
Small Bioretention Areas	Constructed Stormwater Wetlands
Dry Wells	Engineered Swales
French Drains	Filtering Practices
Green Rooftops	Manufactured BMPs
Porous and Pervious Pavement	
Stormwater Planters	
Vegetated Filter Strips	
Vegetated Channels/Swales	

Photo courtesy of Tim Schueler

See **Tool 5: Manual Builder** for guidance on good design references.

The local program should strive to provide standards and guidelines for all three categories of stormwater treatment. **Tables 4.2** through **4.4** provide candidate BMPs and resources for each category. **Tool 5: Manual Builder** provides links to design manuals across the country that provide good examples.

4.3. Developing Stormwater Management Criteria

Stormwater management criteria are the technical core of a stormwater ordinance (**Chapter 5**) and a major focus of stormwater guidance manuals (**Chapter 6**). They establish the design objectives for BMPs, and they will influence directly the types and sizes of these practices.

The list below describes the technical stormwater criteria that are adopted by stormwater programs around the country within ordinances and design guidance. **Tool 3: Model Stormwater Ordinance** contains model language for each of these criteria. It is important to note that the Phase I and II MS4 permit program is concerned largely with criteria that help meet water quality standards (1 through 4 below). Flood control (5) is historically a more common and locally applied criterion.

1 – Natural Resources Inventory (NRI)*:* identify the site's critical natural features and drainage patterns early in the site planning process.

2 – Recharge and/or Runoff Reduction (RR): maintain groundwater recharge rates and/or reduce post-development runoff volume by a set amount.

3 – Water Quality Volume (WQV): capture and treat runoff from the water quality storm to remove certain target pollutants.

4 – Channel Protection (CP)*:* design the stormwater system so that conveyances and outfalls are stable and will not erode downstream channels or cause damage to downstream habitats.

5 – Flood Control (FC): control peak rates to reduce downstream flooding. The criterion can have two components:

Overbank (Minor Storm) Flood Control: provide storage for storm events that might cause routine flooding to downstream property, conveyance systems, and drainage infrastructure.

Extreme (Major Storm) Flood Control: provide storage for infrequent but large storm events that might cause downstream flooding and damage and/or enlarge the boundaries of the floodplain.

6 – Redevelopment*:* provide flexibility for redevelopment sites where stormwater compliance might be more difficult and can be met through a variety of strategies. A redevelopment criterion provides flexibility in meeting criteria 1 through 5 above where a site meets the definition of redevelopment.

A unified approach is the most effective way to develop stormwater management criteria and present them within the local ordinance and/or guidance manual. The goal of a unified framework is to develop a consistent approach for designing BMPs that can:

Perform effectively: Manage the range of stormwater flows and volumes that will actually mitigate local stormwater problems; protect public health and safety; and reduce flood, water quality, and channel erosion hazards.

Perform efficiently: Manage just enough runoff volume to address the problems but not over-control them. Providing more stormwater storage is not always better, and it can greatly increase construction costs and consume valuable land.

Be simple to administer: Be understandable, relatively easy to calculate with current hydrologic models, and workable over a range of development conditions and intensities. In addition, stormwater management criteria should be clear and straightforward, and backed up by the local stormwater ordinance, to avoid needless disputes between design engineers and plan reviewers when they are applied to development sites.

Promote multipurpose, integrated stormwater design: Allow for flexible and creative design to integrate into community aesthetics, enhance property values, and serve multiple purposes (such as stormwater and recreation).

Be flexible to respond to special site conditions: Define certain site conditions or development scenarios where individual stormwater sizing criteria may be relaxed or waived when they are clearly inappropriate or infeasible.

Figure 4.1 graphically portrays a unified, or nested, approach for the six stormwater management criteria listed above.

The "nesting" of the criteria portrayed in **Figure 4.1** can best be understood by considering the overall volume of runoff generated by a site. Each of the stormwater management criteria relates to a certain volume of the overall runoff volume to be managed. For instance, runoff reduction and water quality management usually entail capturing a smaller volume of water than channel protection and flood control. However, the volume of runoff that is infiltrated, captured, and/or treated in a water quality BMP can reduce the overall volume that remains to be treated for downstream channel protection and flood control. Put another way, a site that maximizes runoff reduction through infiltration, soil absorption, and capture and reuse can reduce the size and possibly the need for larger, structural storage devices like pond and basins.

The criteria outlined in this section should be considered as candidate (or potential) criteria for a local program. The criteria should be adapted to local conditions (soils, geology, water table, etc.), the level of program sophistication, and local goals and concerns. **Table 4.5** provides some guidance for adapting the criteria to unique conditions, such as good (or poor)

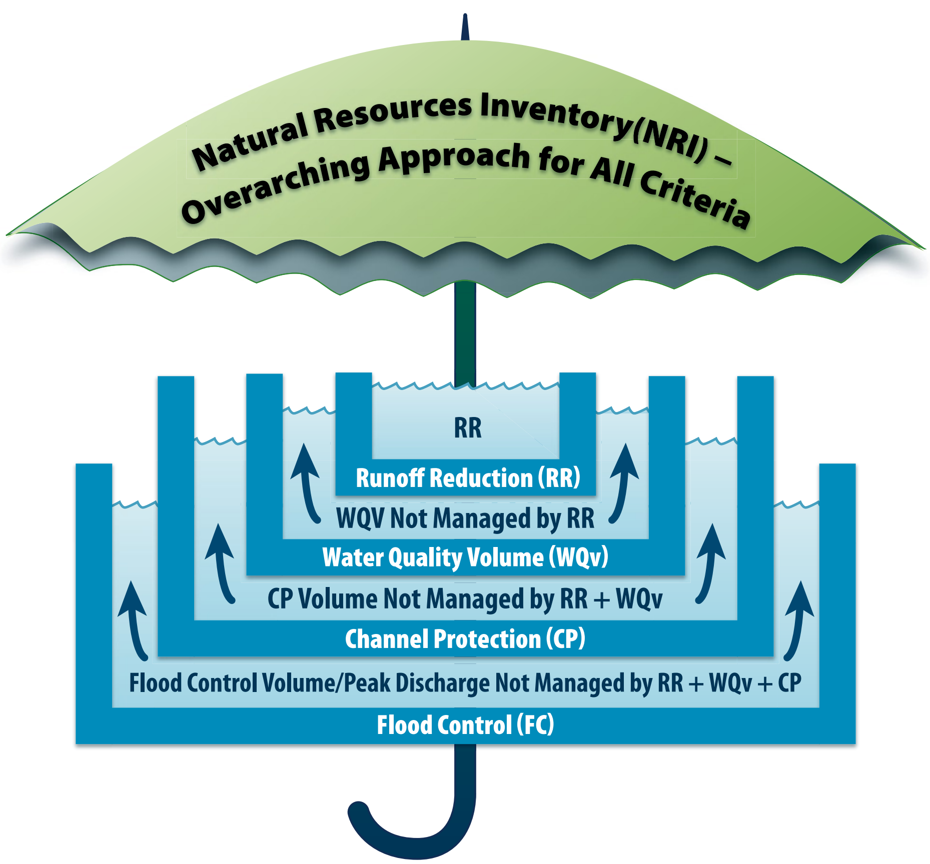


Figure 4.1. Graphic representation of the nested approach to stormwater management criteria

Table 4.5. Suggested Adaptations for Stormwater Management Criteria in Different Settings

Variable Settings for Stormwater Management	Possible/Conceptual Adaptations to Stormwater Criteria
Generally good soils for infiltration; few constraints, such as shallow bedrock	▶ Apply criterion 1 (natural resources) as a planning and site design tool. ▶ Collapse criteria 2 through 4 (runoff reduction, water quality, and channel protection) into a single criterion for ***Runoff Reduction***. ▶ Define the Runoff Reduction Volume as the 1-year, 24-hour rainfall depth, or a similar criterion adopted by the local program. ▶ Each site should maximize runoff reduction through infiltration, canopy interception, evaporation, transpiration, and/or rainwater harvesting. ▶ Any fraction of the Runoff Reduction Volume that cannot feasibly be eliminated from site runoff should be treated through extended detention[a] or extended filtration.[b] ▶ Allow Runoff Reduction waivers for sites where it is not feasible. Require that the full Runoff Reduction Volume be treated in an applicable water quality BMP. ▶ Apply criterion 5 (flood control) where it is needed to protect downstream property, conveyance systems, and infrastructure. If applicable, allow a reduction in the required volume for all or part of volume reduced through Runoff Reduction BMPs.
Arid climates	▶ Generally follow the guidance above for areas with good infiltration potential; rely on a balanced approach of infiltration and evaporation. Provide waivers where infiltration is not feasible or advisable. ▶ Select BMPs based on criteria including ability to reduce sediment loads. ▶ Apply criterion 5 (flood control), ensuring that large, damaging storm events have safe conveyance to an adequate downstream system.
Generally poor soils for infiltration; possible other constraints such as high water table or shallow bedrock	▶ Apply criterion 1 (natural resources) as a planning and site design tool. ▶ Apply criterion 2 (runoff reduction) to establish a minimum, or modest, level of performance for runoff reduction, such as reducing the first 0.5 inch of runoff from the post-development condition (or an appropriate local standard). In some locations, infiltration might not be a feasible runoff reduction method. ▶ Allow waivers for sites where runoff reduction can be proven to be infeasible (the volume should still be required to be treated for water quality; see below). ▶ Apply criterion 3 (water quality) to a prescribed "water quality volume." This should be the 90th percentile rainfall event (see **Table 4.9**) or an applicable local standard. ▶ Apply criteria 4 and 5 (channel protection, flood control) where they are needed to protect downstream channels, property, conveyance systems, and infrastructure. If applicable, allow a reduction in the required volume for all or part of volume reduced through runoff reduction and water quality BMPs.

Table 4.5. Suggested Adaptations for Stormwater Management Criteria in Different Settings *(continued)*

Variable Settings for Stormwater Management	Possible/Conceptual to Adapt Stormwater Criteria
Karst	► Combine criteria 1 (natural resources) and 2 (runoff reduction) as a planning and site design tool. Include identification of sinkholes and karst features in early site layout, with possible setbacks from these features. Promote infiltration across broad landscape areas (such as open space, swales, and soil amendment) instead of concentrating site runoff to small, engineered infiltration BMPs. Provide credits for sites that do a good job with site design. ► Apply criterion 3 (water quality) to a prescribed "water quality volume." This should be the 90th percentile rainfall event (see **Table 4.9**) or an applicable local standard. Require pretreatment and/or lining for BMPs sited on karst with shallow soil cover. ► Apply criteria 4 (channel protection). Develop special provisions for discharges to sinkholes and areas with no downstream surface channel to handle increased site runoff. ► Apply criterion 5 (flood control) where it is needed to protect downstream property, conveyance systems, and infrastructure. If applicable, allow a reduction in the required volume for all or part of volume reduce through site design, water quality, and channel protection BMPs.
Watersheds with an extensive existing ditch system (past agricultural practices)	► Adapt criterion 1 (natural resources) to include ditch restoration and/or naturalization as a possible post-construction BMP. Practices can include adding sinuosity, restoring prior-converted wetlands, and streambank and riparian planting. ► See other cases in this table for options for criteria 2 and 3. ► Criteria 4 and 5 (channel protection, flood control) should consider ditch capacity. As with criterion 1, ditch restoration can play a role in meeting channel protection, and possibly flood control, objectives.
Redevelopment	► Allow flexible compliance strategies for all criteria based on specific program goals and site conditions.

[a] Extended detention includes stormwater BMPs that capture runoff and release it slowly over an *extended* period, usually 12 to 24 hours. The goal is to maintain a flow rate and velocity that do not damage downstream channels.

[b] Extended filtration includes stormwater BMPs that capture runoff and delay its release until after most of the site runoff for a given storm has passed to the downstream system. Examples are bioretention and water quality swales with underdrains that delay delivery of stormwater from small sites to the downstream system by six hours or more.

soils for infiltration, karst, arid climates, and locations with extensive ditch systems. The categories in the table are fluid in that more than one category may apply to a given community, and not every possible scenario is identified. Also, the adaptations in the table are for illustrative purposes; a stormwater manager must choose the most appropriate criteria and adaptations for the local program.

Tables 4.7 through **4.12** at the end of this chapter provide more detail for each of the six stormwater management criteria. These tables are most useful for assembling language and standards for stormwater ordinances and guidance manuals (again, local adaptations are strongly encouraged). The tables provide potential standards and candidate BMPs that can be used to meet each of the criteria. Finally, the tables provide links to programs, design manuals, or existing resources that provide examples of the criteria. (**Tool 5: Manual Builder Tool** contains additional examples.)

4.4. Developing a Rainfall Frequency Spectrum

Rainfall Frequency Spectrum (RFS) curves (which are also known as "rainfall distribution plots") are useful tools to assist stormwater managers with the development of stormwater management criteria, particularly the criteria that relate to smaller storm events (runoff reduction or recharge, water quality).

The RFS helps to link the various criteria with particular rainfall events. For instance, if the local water quality criteria relate to treatment of runoff from the 90th percentile storm event, an RFS curve will help establish this particular rainfall depth. **Figure 4.2** provides guidance on creating RFS curves, and **Table 4.6** provides rainfall depth frequency statistics for cities across the United States.

4.5. Special Stormwater Criteria for Sensitive Receiving Waters

One of the unique development situations for which basic stormwater management criteria may be modified is when sensitive receiving waters must be protected. This recognizes the fact that not all stormwater discharges are created equal, and that certain watersheds require a customized approach.

There has been a trend in recent years to develop special stormwater criteria to protect sensitive water resources **(CWP, 2006)**. Special stormwater design criteria have been created by state and local stormwater management programs to protect each of the following:

- Lakes and water supply reservoirs
- Cold water fisheries (trout and salmon streams)
- Groundwater
- Wetlands
- Impaired waters

Special stormwater design criteria typically make use of one or more of the following strategies:

- Enhancing stormwater BMP design features to provide a higher level of pollutant removal (e.g., sizing, internal geometry, vegetation, pretreatment, multiple treatment methods, etc.).
- Adding runoff reduction, groundwater recharge, and/or downstream analysis to provide greater protection from streambank erosion.
- Requiring the use of certain stormwater BMPs to provide additional protection for sensitive receiving waters (e.g., requiring specific stormwater BMPs at known stormwater hotspots to reduce pollutant loads).
- Instituting special design criteria for individual stormwater BMPs to enhance performance or diminish downstream impacts (e.g., for cold water fisheries, to mitigate stream warming caused by stormwater ponds).
- Establishing restrictions on where stormwater BMPs may be located at a site and where they may discharge.

Additional information on each of the special stormwater design criteria is presented in **Tables 4.13** through **4.17** at the end of this chapter.

4.6. A Watershed-Based Stormwater Approach

An emerging trend for stormwater programs is to move beyond the site-by-site design and installation of BMPs. Some programs enhance the site-by-site approach with a master stormwater plan or watershed-based plan. Such a plan integrates what is required at the site level with broader watershed projects to achieve certain watershed objectives.

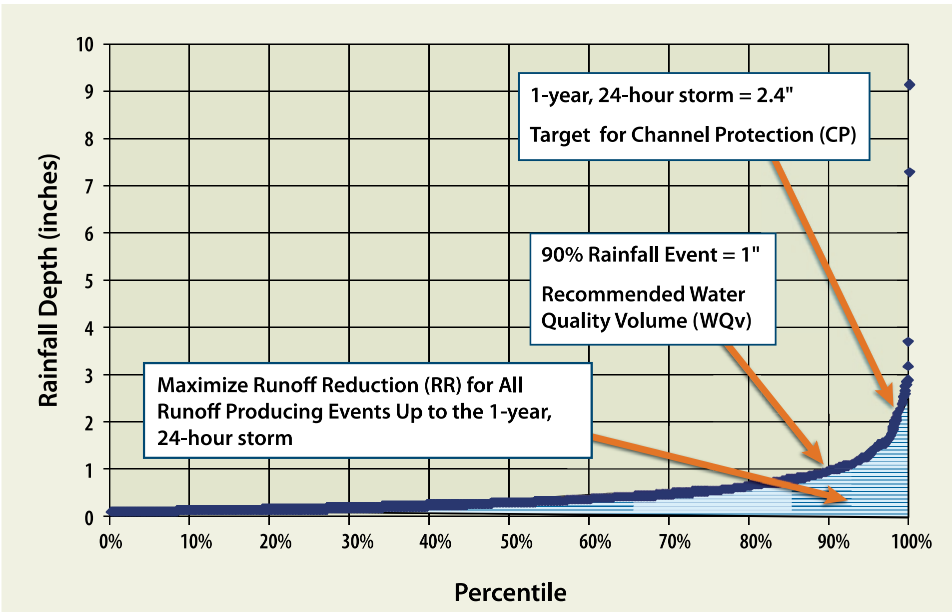
For instance, the plan might specify stream and riparian restoration projects, stormwater retrofits, impervious disconnection programs, wetland preservation, subregional BMPs, and/or watershed outreach activities. A site that is being developed within the subject watershed might contribute funds, land, or design support to a watershed project in lieu of (or, in some cases, as a supplement to) the installation of on-site BMPs. **Figure 4.3** shows several examples of watershed-based stormwater projects.

The stormwater ordinance must establish the authority to allow contributions to regional or

A Rainfall Frequency Spectrum (RFS) is a tool that stormwater managers should use to analyze and develop local stormwater management criteria and to provide the technical foundation for the criteria.

Over the course of a year, many precipitation events occur within a community. Most events are quite small, but a few can create several inches of rainfall. An RFS illustrates this variation by describing how often, on average, various precipitation events (adjusted for snowfall) occur during a normal year.

The graph below provides an example of a typical rainfall frequency spectrum and shows the percentage of rainfall events that are equal to or less than an indicated rainfall depth. As shown, the majority of storm events are relatively small, but there is a sharp upward inflection point that occurs at about 1 inch of rainfall (90% rainfall event). The 90% rainfall depth is the recommended standard for the Water Quality Volume (see **Table 4.7**).



Rainfall Frequency Spectrum for Minneapolis-St. Paul, MN (1971–2000) with several noteworthy rainfall events identified (adapted from MSSC, 2005).

Guidance on creating an RFS is provided below. If a community is large in area or has considerable variation in elevation or aspect, the RFS analysis should be conducted at multiple stations.

1. Obtain a long-term rainfall record from an adjacent weather station (daily precipitation is fine, but try to obtain at least 30 years of daily record). NOAA has several Web sites with long-term rainfall records (see ***http://www.nesdis.noaa.gov***). Local airports, universities, water treatment plants, or other facilities might also maintain rainfall records.
2. Edit out small rainfall events than are 0.1 inch or less, as well as snowfall events that do not immediately melt.
3. Using a spreadsheet or simple statistical package, analyze the rainfall time series and develop a frequency distribution that can be used to determine the percentage of rainfall events less than or equal to a given numerical value (e.g., 0.2, 0.5, 1.0, 1.5 inches).
4. Construct a curve showing rainfall depth versus frequency, and create a table showing rainfall depth values for 50%, 75% 90%, 95% and 99% frequencies.
5. Use the data to define the Water Quality storm event (90th percentile annual storm rainfall depth). This is the rainfall depth that should be treated through a combination of Runoff Reduction (**Table 4.6**) and Water Quality Volume treatment (**Table 4.7**).
6. The data can also be used develop criteria for Channel Protection (**Table 4.8**). The 1-year storm (approximated in some areas by the 99% rainfall depth) is a good standard for analyzing downstream channel stability.
7. Other regional and national rainfall analysis such as TP-40 (NOAA) or USGS should be used for rainfall depths or intensity greater than 1 year in return frequency (e.g., 2-, 5-, 10-, 25-, 50-, or 100-year design storm recurrence intervals).

Figure 4.2. Creating a Rainfall Frequency Spectrum (RFS) to assist with development of stormwater management criteria

Table 4.6. Rainfall Statistics and Frequency Spectrum Data for Select U.S. Cities

City	Precipitation		Rainfall event: Depth in inches[a]				
	Annual Inches	Days[b]	50%	75%	90%[c]	95%	99%[d]
Atlanta, GA	50	77	0.5	0.9	1.6	2.1	3.4
Knoxville, TN	48	85	0.4	0.7	1.2	1.5	2.4
New York City, NY	44	74	0.4	0.7	1.2	1.7	2.7
Greensboro, NC	43	73	--	--	1.6	--	2.7
Boston, MA	43	76	0.4	0.6	1.2	1.6	2.6
Baltimore, MD	42	71	0.4	0.8	1.2	1.6	2.5
Buffalo, NY	41	88	0.3	0.5	0.8	1.1	1.8
Washington, DC	39	67	0.4	0.8	1.2	1.7	2.4
Columbus, OH	39	79	0.3	0.6	1.0	1.3	2.1
Kansas City, MO	38	63	0.4	0.7	1.1	1.7	3.2
Seattle, WA	37	90	--	--	1.3	1.6	1.7
Burlington, VT	36	79	0.3	0.5	0.8	1.1	1.7
Dallas, TX	35	32	--	--	1.1	--	3.2
Austin, TX	34	49	--	--	1.4	--	3.2
Minneapolis, MN	29	58	0.3	0.6	1.0	1.4	2.4
Coeur D'Alene, ID	26	88	0.2	0.3	0.5	0.7	1.1
Salt Lake City, UT	17	44	0.2	0.4	0.6	0.8	1.2
Denver, CO	16	37	--	--	0.7	--	--
Los Angeles, CA	13	22	--	--	1.3	--	--
Boise, ID	12	38	--	--	0.5	--	--
Phoenix, AZ	8	29	--	--	0.8	--	1.1
Las Vegas, NV	4	10	--	--	0.7	--	0.8

Notes: Dashed lines indicate no data available to compute.

[a] Excludes rainfall depths of 0.1 inch or less.

[b] Average days per year with measurable precipitation.

[c] The 90% storm is frequently used to define the water quality volume.

[d] The 99% storm is an approximation of the 1-year storm in some areas (but is not an exact replication because the statistical analysis is different). The 1-year, 24-hour storm is frequently used as a design storm for downstream channel protection. The recommended approach is to conduct an analysis of the runoff generated by the 1-year, 24-hour storm to derive channel protection criteria.

Urban Stormwater Retrofits

Stream and Riparian Restoration

Rooftop Disconnection Programs

Innovative BMPs at Municipal Facilities

Photo courtesy of Albemarle County, VA

Enhancements to Regional BMPs

Watershed Outreach Activities

Figure 4.3. Several examples of projects that can be included in a watershed-based stormwater management program that goes beyond site-by-site compliance

watershed projects, and any general conditions for their application. Technical elements can be in the stormwater guidance manual.

A local stormwater program can incorporate a regional or watershed approach through the following means:

- ***Pro rata share***. The stormwater ordinance specifies that projects within the drainage area (or "service" area) of a regional or watershed project pay a pro rata share contribution in lieu of complying with on-site requirements (at least in part). Generally, such contributions may be used only to reimburse construction costs. The mechanics of such a program (calculation of the "share" based on discharge, pollutant loads, or impervious cover) should be included in the guidance manual.
- ***Fee in lieu***. The ordinance may specify that projects that meet certain criteria may (or must) pay a fee that contributes to a watershed project in lieu of some on-site requirements. The fee procedure and calculations should be included in the guidance manual, with provision for the fee to reflect realistic project costs that will probably increase over time. As opposed to the pro rata share approach, the fee may be able to be used for a wider range of project costs, including design, construction, and maintenance.
- ***Capital improvement program/local implementation***. Even if new development and redevelopment projects do not contribute funds or other services to the implementation of watershed projects, the local program may still wish to adopt a watershed approach that can be implemented in parallel with required BMPs at development sites. In urbanized and urbanizing watersheds, stormwater retrofitting or stream restoration might be important strategies to address impacts from existing development. Individual projects should be identified in a watershed plan or stormwater master plan, with implementation strategies tied to the capital improvement program, grants, cost-share programs, and other funding sources.

4.7. Detailed Stormwater Management Criteria Tables

The following tables provide more detailed guidance on specific language and standards that can be adapted for stormwater management criteria. **Tables 4.7** through **4.12** address the six criteria introduced in **Section 4.3**. **Tables 4.13** through **4.17** specify additional criteria for special receiving waters. The tables provide potential standards; however, it is important for local stormwater managers to assess and adapt the most appropriate standards.

The detailed tables address the following criteria:

Basic Criteria

Table 4.7 – Natural Resources Inventory (NRI)

Table 4.8 – Runoff Reduction (RR)

Table 4.9 – Water Quality Volume (WQv)

Table 4.10 – Channel Protection (CP)

Table 4.11 – Flood Control (FC)

Table 4.12 – Redevelopment

Special Receiving Waters

Table 4.13 – Lakes and Water Supply Reservoirs

Table 4.14 – Trout and Salmon Streams

Table 4.15 – Groundwater

Table 4.16 – Wetlands

Table 4.17 – Impaired (TMDL-Listed) Waters

Table 4.7. Stormwater Criteria for Ordinances and Design Guidance: Natural Resources Inventory

Criterion 1: Natural Resources Inventory (NRI) – Conduct inventory of site natural features.	
Explanation	As a first step in site planning, identify natural resources elements that should be protected in order to reduce stormwater impacts *by design*. These elements include natural drainage features, riparian buffers, wetlands, steep slopes, soils with high infiltration capacity, significant forest, prairie patches, trees, and natural communities. A local or state program can provide stormwater credits for conserving these features and/or using site design techniques to mitigate impacts on natural resource features. The effect of the credit is to reduce the required stormwater volume or treatment requirements for Runoff Reduction, Water Quality Volume, Channel Protection, and Flood Control (see Criteria 2 through 5, **Tables 4.8** through **4.11**).
Potential Standards	Identify NRI features on a concept stormwater plan. Provide credits for designs that protect or restore NRI features.
Candidate BMPs to Meet Standards	► Open space conservation, preservation, reforestation ► Conservation of soils with high infiltration capacity ► Riparian, wetland and waterway buffers ► Conservation easements ► Open space or conservation design ► Green Infrastructure and Smart Growth planning at community and regional scales
Examples from Existing Programs – See Tool 5: Manual Builder for more examples and links	*Pennsylvania Stormwater Best Management Practices Manual*, Ch. 4, Integrating Site Design and Stormwater Management ***http://www.depweb.state.pa.us/watershedmgmt/cwp/view.asp?a=1437&q=529063&watershedmgmtNav=|*** *New Jersey Stormwater Best Management Practices Manual*, Ch. 2, Low-Impact Development Techniques ***http://www.njstormwater.org/bmp_manual2.htm*** *Minnesota Stormwater Manual*, Ch. 11, Applying Stormwater Credits to Development Sites ***http://www.pca.state.mn.us/water/stormwater/stormwater-manual.html*** *Georgia Green Growth Guidelines*, Section 1, Site Fingerprinting Utilizing GIS and GPS ***http://crd.dnr.state.ga.us/content/displaycontent.asp?txtDocument=969*** *Urban Watershed Forestry Manual Series*, Parts 2 and 3, Center for Watershed Protection and USDA Forest Service ***www.cwp.org*** > Resources > Special Resource Management > Urban Forestry *Forest Conservation Technical Manual: Guidance for the Conservation of Maryland's Forests During Land Use Changes Under the 1991 Forest Conservation Act*, Metropolitan Washington Council of Governments (Not available online.)

Table 4.8. Stormwater Criteria for Ordinances and Design Guidance: Runoff Reduction

Criterion 2: Runoff Reduction (RR) – Reduce volume of post-development runoff.	
Explanation	Some amount of the post-development runoff should be permanently reduced through disconnecting impervious areas, maintaining sheetflow to areas of natural vegetation, infiltration practices, and/or collection and reuse of runoff. More stringent criteria should apply to sensitive receiving waters. Groundwater recharge/infiltration requirements should not apply to stormwater hotspots and contaminated soils and should be adjusted as appropriate for sites in close proximity to karst, drinking water supply wells, building foundations, fill slopes, etc. Areas characterized by high water table, shallow bedrock, clay soils, contaminated soils, and other constraints should evaluate how much runoff can practically be reduced and modify the recommended standards accordingly.
Potential Standards	**Option 1: Groundwater Recharge/Infiltration** Replicate the pre-development recharge volume, based on regional average recharge rates for hydrologic soil groups. ▶ **Residential Sites**: Post-development recharge = 90% of pre-development recharge ▶ **Nonresidential Sites**: Post-development recharge = 60% of pre-development recharge **Option 2: Overall Runoff Reduction** ▶ No increase in the overall runoff volume compared to the pre-development condition for all storms less than or equal to the 2-year, 24-hour storm, OR ▶ Capture and remove from the site hydrograph the volume of water associated with the 80th percentile storm event (or a locally appropriate and achievable standard—this might be the 90th percentile storm event for areas with good infiltration potential).
Candidate BMPs to Meet Standards	▶ Site design that reduces and disconnects impervious cover ▶ Soil amendments, soil rejuvenation ▶ Rainwater collection and reuse ▶ Pervious parking ▶ Bioretention ▶ Rain gardens, on-lot infiltration practices ▶ Infiltration swales, trenches, and basins ▶ Enhanced filter strips (with soil amendments and vegetation) ▶ Green roofs
Examples from Existing Programs – See Tool 5: Manual Builder for more examples and links	*Wisconsin Post-Construction Stormwater Management* ***http://dnr.wi.gov/runoff/stormwater/post-constr*** *Pennsylvania Stormwater Best Management Practices Manual*, Ch. 3, Stormwater Management Principles and Control Guidelines ***http://www.depweb.state.pa.us/watershedmgmt/cwp/view.asp?a=1437&q=529063&watershedmgmtNav=|*** *Etowah Habitat Conservation Plan—Stormwater Management Policies* ***http://www.etowahhcp.org/policies.htm*** *Best Management Practices for Stormwater Quality*, American Public Works Association, Kansas City Metro Chapter ***http://www.kcapwa.net/kcmetro/Specifications.asp*** *Better Site Design: A Handbook for Changing Development Rules in Your Community*, Center for Watershed Protection, Inc. ***www.cwp.org*** > Online Store > Better Site Design

Table 4.9. Stormwater Criteria for Ordinances and Design Guidance: Water Quality Volume

Criterion 3: Water Quality Volume (WQv) – Capture and treat large percentage of annual pollutant load.	
Explanation	Post-development runoff that is not permanently removed through the application of the RR criterion (Criterion 2, **Table 4.8**) should be captured and treated in a water quality BMP. This standard applies to the *Water Quality Volume* (WQv), or the volume of runoff that contains most of the annual pollutant load. More stringent criteria should apply to sensitive receiving waters. States, regions, or localities should evaluate the pollutants of concern that should drive BMP selection and design. Nationally, the most common pollutants of concern include sediment, particulate, soluble nutrients (phosphorus and nitrogen), and bacteria. BMPs or combinations of BMPs that achieve the highest pollutant load reduction for the pollutants of concern should be selected.
Potential Standards	WQv = runoff volume generated by the 90^{th} percentile storm event, based on regional rainfall frequencies (see **Section 4.4**). All runoff removed through the RR criterion (see Criterion #2 in **Table 4.8**) counts toward treating the WQv. The remainder must be treated in an acceptable water quality BMP.
Candidate BMPs to Meet Standards	► Filtering practices—bioretention, sand filters, manufactured filters ► Water quality swales, dry swales ► Linear stormwater wetlands ► Stormwater ponds ► Vegetated filter strips ► Green roof
Examples from Existing Programs – See Tool 5: Manual Builder for more examples and links	*Maryland Stormwater Design Manual* ***http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater*** *Maine Stormwater Best Management Practices Manual, Volume II, Phosphorus Control in Lake Watersheds: A Technical Guide to Evaluating New Development* ***http://www.maine.gov/dep/blwq/docstand/stormwater/stormwaterbmps*** *California Stormwater Best Management Practice Handbooks: New Development and Redevelopment*, California Stormwater Quality Association ***http://www.cabmphandbooks.com***

Table 4.10. Stormwater Criteria for Ordinances and Design Guidance: Channel Protection

Criterion 4: Channel Protection (CP) – Convey stormwater to protect downstream channels	
Explanation	The stormwater system should be designed so that increased post-development discharges that are ***not*** mitigated through application of Criteria 1 through 3 will not erode natural channels or steep slopes. This will protect in-stream habitats and reduce in-channel erosion. Conveyance systems can be designed to reduce stormwater volume, create non-erosive velocities, incorporate native vegetation, and, in some cases, restore existing channels that are degraded. This design process involves careful analysis of the downstream system, beginning with the site's position within a watershed or drainage area. First, compare the size of the on-site drainage area *at each of the site's discharge points* to the total drainage area of the receiving channel or waterway. Note that the point of analysis might not always be the property boundary of the site, but the point where the site's discharge joins a natural drainage swale, channel, stream, or waterbody. The recommended standard below presents a tiered system for CP compliance based on the site/ drainage area analysis discussed above.
Potential Standards	At each discharge point from the site, if the on-site drainage area is ***less*** than 10% of the total contributing drainage area to the receiving channel or waterbody, the following Tier 1 performance standards must apply: **Tier 1 Performance Standards** ► Wherever practical, maintain sheetflow to riparian buffers or vegetated filter strips. Vegetation in buffers or filter strips must be preserved or restored where existing conditions do not include dense vegetation (or adequately sized rock in arid climates). ► Energy dissipaters and level spreaders must be used to spread flow at outfalls. ► On-site conveyances must be designed to reduce velocity through a combination of sizing, vegetation, check dams, and filtering media (e.g., sand) in the channel bottom and sides. ► If flows cannot be converted to sheetflow, they must be discharged at an elevation that will not cause erosion or require discharge across any constructed slope or natural steep slopes. ► Outfall velocities must be non-erosive from the point of discharge to the receiving channel or waterbody where the discharge point is calculated. At each discharge point from the site, if the on-site drainage area is ***greater*** than 10% of the total contributing drainage area to the receiving channel or waterbody, then the Tier 1 performance standards must apply ***plus*** the following Tier 2 performance standards: **Tier 2 Performance Standards** ► Sites greater than 10 acres (or a site size deemed appropriate by the local program) must perform a detailed downstream (hydrologic and hydraulic) analysis based on post-development discharges. The downstream analysis must extend to the point where post-development discharges have no significant impact (and do not create erosive conditions) on receiving channels, waterbodies, or storm sewer systems. ► If the downstream analysis confirms that post-development discharges will have an impact on receiving channels, waterbodies, or storm sewer systems, then the site must incorporate some or all of the following to mitigate downstream impacts: (1) Site design techniques that decrease runoff volumes and peak flows. (2) Downstream stream restoration or channel stabilization techniques, as permitted through local, state, and federal agencies. (3) 24-hour detention of the volume from post-development 1-year, 24-hour storm (the volume is stored and gradually released over a 24-hour period). Runoff volumes controlled through the application of RR and WQv measures (Criteria 2 and 3, **Tables 4.8** and **4.9**) may be given credit

Table 4.10. Stormwater Criteria for Ordinances and Design Guidance: Channel Protection *(continued)*

Variable Settings for Stormwater Management	Possible/Conceptual to Adapt Stormwater Criteria
Potential Standards (continued)	(toward meeting storage requirements. Discharges to cold water fisheries should be limited to 12-hour detention. ► Sites less than 10 acres (or a site size deemed appropriate by the local program) must use a combination of the mitigation techniques listed above and verify that stormwater measures provide 12- to 24-hour detention of the volume from post-development 1-year, 24-hour storm (again, allowing credits through the application of RR and WQv measures). A detailed downstream analysis is not required unless the local program identifies existing downstream conditions that warrant such an analysis.
Candidate BMPs to Meet Standards	► Water quality swales ► Grass swales ► Level spreaders and energy dissipaters ► Riparian and floodplain restoration ► Bioretention with extra volume of soil media and/or underdrain stone ► Pervious parking with underground storage ► Outfall designs that use natural channel and velocity reduction features ► Ponds and pond/wetland systems that provide peak flow control
Examples from Existing Programs – See Tool 5: Manual Builder for more examples and links	*Stormwater Management Manual for Western Washington*, Volumes I and V ***http://www.ecy.wa.gov/programs/wq/stormwater/manual.html*** *Bioretention Design Spreadsheet*, North Carolina State University, Stormwater Engineering Group ***http://www.bae.ncsu.edu/stormwater/downloads.htm*** (system to assign detention credit to bioretention) *Integrated Stormwater Management Design (iSWMD™) for Site Development*, Ch. 1, Stormwater Management System Planning and Design, North Central Texas Council of Governments ***http://iswm.nctcog.org*** *Henrico County, Virginia Environmental Program Manual*, Ch. 9, Minimum Design Standards, 9.01, Energy Dissipater ***http://www.co.henrico.va.us/works/eesd***

Table 4.11. Stormwater Criteria for Ordinances and Design Guidance: Flood Control

Criterion 5: Flood Control (FC) – Provide peak rate control for larger storms.	
Explanation	Peak rates should be controlled in order to reduce downstream flooding. The standard depends on where a property is situated within a watershed and the design storms that typically cause flooding in the community. Flood control is customarily a local, regional, or state-driven criterion. The Flood Control criterion can address one or both of the following, depending on community priorities: ▶ **Overbank Flood Protection**: Prevent nuisance flooding that damages downstream property and infrastructure. ▶ **Extreme Flood Control**: Maintain boundaries of the pre-development 100-year floodplain, and reduce risk to life and property from infrequent but extreme storms. Waivers to the Flood Control criteria should be considered for: ▶ Discharges to large waterbodies ▶ Small sites (< 5 acres in size) ▶ Some redevelopment projects ▶ Sites subject to floodplain study that recommends alternative criteria ▶ Sites where on-site detention will cause a downstream peak flow increase compared to pre-development levels due to coincident peaks from the site and watershed Communities should evaluate their existing flood control criteria to avoid costly over-control of peak rates that has marginal downstream benefits.
Potential Standards	**Overbank (Minor Storm) Flood Protection:** The post-development peak rate of discharge for the 10-year, 24-hour storm must be reduced to the pre-development peak rate. New structures or crossings within the floodplain must have adequate capacity for the ultimate (build-out) condition. (NOTE: Minor storm flood control events vary around the country, usually ranging from the 2-year to the 10-year event.) **Extreme (Major Storm) Flood Control:** The post-development peak rate of discharge for the 100-year, 24-hour storm must be reduced to the pre-development peak rate. (NOTE: Major storm flood control events vary around the country, usually ranging from the 25-year to the 100-year event.)
Candidate BMPs to Meet Standards	▶ Ponds and pond/wetland systems that provide peak flow control ▶ Some underground structures ▶ As applicable, storage under parking lots or within ball fields, open space, etc. ▶ Floodplain and riparian management and restoration, preventing structures within the 100-year floodplain
Examples from Existing Programs – See Tool 5: Manual Builder for more examples and links	*Georgia Stormwater Management Manual*, Volume 2 ***http://www.georgiastormwater.com*** Floodplain Management Association ***http://www.floodplain.org***

Table 4.12. Stormwater Criteria for Ordinances and Design Guidance: Redevelopment

Criterion 6: Redevelopment – Provide flexibility to meet criteria for redevelopment conditions.	
Explanation	Redevelopment projects can present unique stormwater challenges due to existing hydrologic impacts, compacted soils, generally small size and intensive use, and other factors. Local programs should examine flexible standards for redevelopment, so that stormwater requirements do not act as a disincentive for desirable redevelopment projects. This is especially important within designated redevelopment zones, downtown revitalization zones, enterprise zones, brownfield sites, and other areas where infill and redevelopment is promoted through local policies and incentive programs. At the same time, redevelopment offers a unique opportunity to achieve incremental water quality and/or drainage improvements in previously developed areas where stormwater controls might be few or nonexistent. Redevelopment is one of the few chances to address existing impairments.
Potential Standards	Redevelopment projects must use one or a combination of the following approaches for stormwater compliance: ► Reduce existing impervious cover by at least 20%. ► Provide runoff reduction and water quality treatment (Criteria 2 and 3) for at least 30% of the site's existing impervious cover and any new impervious cover. ► Use innovative approaches to reduce stormwater impacts across the site. Examples include green roofs and pervious parking materials. The local program can exercise flexibility with regard to sizing and design standards for sites that are attempting to place new practices into a site with existing drainage infrastructure. ► Provide equivalent stormwater treatment at an off-site facility. ► Address downstream channel and flooding issues through channel restoration and/or off-site remedies. ► Contribute to a watershed project through a fee-in-lieu payment.
Candidate BMPs to Meet Standards	► See T**ables 4.7** through **4.11** for various stormwater criteria ► Off-site mitigation may also include stream or wetland restoration, stormwater retrofits, and regional stormwater solutions
Examples from Existing Programs – See Tool 5: Manual Builder for more examples and links	*City of Philadelphia Stormwater Management Guidance Manual*, Ch. 2, Applicability and Approval ***http://www.phillyriverinfo.org*** *Critical Area 10% Rule Guidance Manual*, Maryland Critical Area Commission ***http://www.dnr.state.md.us/criticalarea/guidancepubs*** *Developments Protecting Water Quality: A Guidebook of Site Design Examples*, Santa Clara Valley Urban Runoff Pollution Prevention Program ***http://scvurppp-w2k.com/Default.htm***

Table 4.13. Special Stormwater Criteria for Lakes and Water Supply Reservoirs

Urban watersheds can produce higher unit area nutrient loads from stormwater runoff compared to other watersheds (**Caraco and Brown, 2001**). Therefore, special stormwater criteria might be needed if the receiving waters in urban watersheds are sensitive to excess nutrients. Nutrient-sensitive waters include lakes, water supply reservoirs, estuaries, and coastal areas.

Several state, regional, and local stormwater programs have developed special stormwater design criteria for nutrient-sensitive waters that require development activities to create *no net increase* in pollutant loads from the pre-development condition ***or*** to meet site-based load limits (e.g., no more than 0.28 pound/acre/year of total phosphorus). These criteria focus on achieving this goal using site design techniques and stormwater BMPs with a proven rate of pollutant removal efficiency.

If a designer cannot meet the total removal requirement on-site, the site owner can be allowed to pay an offset fee for the difference. This fee is set as the cost of removing an equivalent amount of pollutants elsewhere in the watershed.

Several states that require stormwater pollutant load reduction to protect sensitive waters are listed below.

Maine:	To protect sensitive lakes
New York:	To protect unfiltered surface water supply
VA/MD:	To reduce nutrients delivered to Chesapeake Bay from shoreline development
Minnesota:	To protect sensitive lakes

Photo courtesy of U.S. Army Corps of Engineers

For detailed guidance, consult the following resources:

Maine Stormwater Best Management Practices Manual, Volume II, *Phosphorus Control in Lake Watersheds: A Technical Guide to Evaluating New Development*
http://www.maine.gov/dep/blwq/docstand/stormwater/stormwaterbmps

Minnesota Stormwater Manual, Ch. 10, Unified Stormwater Sizing Criteria (Section 9, Lakes)
http://www.pca.state.mn.us/water/stormwater

Graphic courtesy of Tim McCabe

Table 4.14. Special Stormwater Criteria for Trout and Salmon Streams

Several state and local stormwater programs have developed special stormwater design criteria to protect trout and salmon streams. Trout and salmon populations are extremely sensitive to stream habitat degradation, stream warming, sedimentation, stormwater pollution, and other impacts associated with development. In addition, some poorly designed or located stormwater BMPs can induce stream warming that can harm trout or salmon populations. Without special design criteria, these sensitive water resources might not be adequately protected from problems associated with stormwater runoff.

Some common examples of special design criteria aimed at protecting trout and salmon streams include:

- Requiring the protection and/or restoration of riparian forest buffers
- Requiring groundwater recharge and/or runoff reduction
- Requiring downstream channel protection at development sites (although extended detention times should be limited to less than 12 hours)
- Restrictions on the use of stormwater ponds and wetlands that can cause stream warming
- Preference toward the use of infiltration and bioretention practices
- Requiring that stormwater BMPs be constructed “off-line” so they are located away from the stream
- Requiring that pilot channels, outflow channels, and pools be shaded with trees and shrubs
- Requiring that stormwater BMPs be planted with trees to maximize forest canopy cover
- Requiring that stormwater BMPs be located away from the streamside forest buffer to maximize forest canopy cover and shading in riparian areas
- Requiring pretreatment of roadway runoff to reduce sediment and road salt and sand discharges to receiving streams

Individual stormwater BMP design specifications can also be modified to prevent:

Large, unshaded permanent pools or shallow wetland areas

Extended detention times that are longer than 12 hours

Extensive riprap or concrete channels

Construction of BMPs in on-line or in-stream configurations

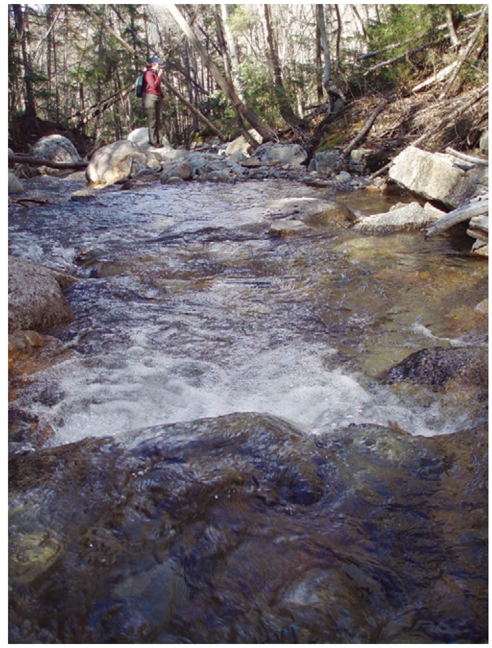


Photo courtesy of U.S. Fish & Wildlife Service

Photo courtesy of U.S. Fish & Wildlife Service

For more information, see the North Carolina State University publication *Stormwater BMPs for Trout Waters* (Jones and Hunt, 2007) ***http://www.bae.ncsu.edu/stormwater/pubs.htm***

Dane County, Wisconsin, Erosion Control and Stormwater Management Manual, Ch. 3, Stormwater (Section 3.8, Thermal Control) (2007) ***http://www.danewaters.com/business/stormwater.aspx***

Table 4.15. Special Stormwater Criteria for Groundwater

Groundwater is a critical water resource because many residents depend on groundwater for their drinking water and the health of many aquatic systems depends on steady recharge. For example, during periods of dry weather, groundwater sustains flows in streams and helps to maintain the hydrology of wetlands.

Because development creates impervious surfaces that prevent natural recharge, a net decrease in groundwater recharge rates can be expected in urban watersheds.

Communities that rely on groundwater as a drinking water supply have protected groundwater supplies and headwater streams by developing special criteria to require the infiltration of a certain volume of stormwater runoff and require the use of pretreatment for all stormwater BMPs. They have also required the use of low-impact development techniques, such as impervious disconnection, soil amendments, open space protection, and/or the maintenance or restoration of a certain amount of "recharge-friendly" land cover, especially forest.

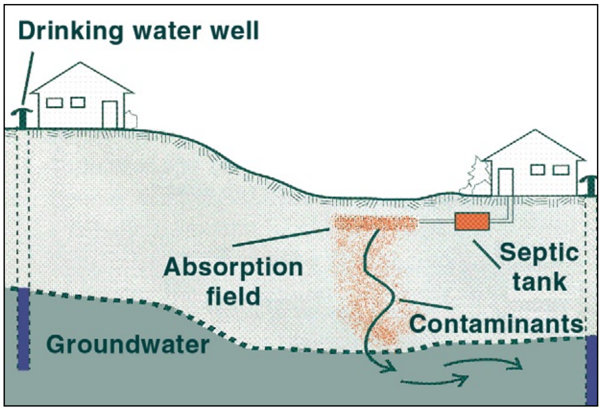
However, runoff from urban land uses and activities can degrade groundwater quality if it is directed into the soil without adequate treatment. Soluble pollutants, such as chloride, nitrate, copper, dissolved solids, and hydrocarbons can migrate into groundwater and potentially contaminate groundwater supplies. Communities should take care to ensure that groundwater supplies are both maintained with groundwater recharge and protected from contamination.

The list below contains examples of "stormwater hotspots." At these types of sites, infiltration should be discouraged and source control and pollution prevention measures adopted to minimize spills, leaks, and illicit discharges.

For examples of stormwater criteria and standards to protect groundwater, see **Tool 5: Manual Builder**.

Potential Stormwater Hotspots (**CWP and MDE, 2000**)

- Vehicle salvage yards and recycling facilities
- Outdoor vehicle service and maintenance facilities
- Outdoor vehicle and equipment cleaning facilities
- Fleet storage areas (bus, truck, etc.)
- Industrial sites
- Marinas (service and maintenance)
- Outdoor liquid container storage
- Some outdoor loading/unloading facilities
- Public works storage areas
- Commercial container nursery
- Large chemically managed turf areas



Graphic courtesy of Nick Evans

Table 4.16. Special Stormwater Criteria for Wetlands

Wetlands are recognized for the many important watershed functions and services they perform, and their direct disturbance is closely regulated. However, indirect impacts associated with stormwater, such as altered water level fluctuations and increased nutrient and sediment loads, are not routinely regulated or even acknowledged. Stormwater inputs can alter the hydrology, topography, and vegetative composition of wetlands **(Wright et al. 2006)**. For example, increased frequency and duration of inundation can degrade native wetland plant communities or deprive them of their water supply. The deposition of sediment carried by urban stormwater can have the same effect, causing replacement of diverse species with monotypes of reed canary grass or cattails.

Cappiella et al. (2005) have developed a framework for protecting sensitive natural wetlands, including special stormwater criteria for discharges to wetlands. This information can be found at the Center for Watershed Protection's Wetlands Web Site:
www.cwp.org > Resources > Special Resource Management > Wetlands & Watersheds

Photo courtesy of U.S. Fish & Wildlife Service

Table 4.17. Special Stormwater Criteria for Impaired (TMDL-Listed) Waters

Under the Clean Water Act, water quality standards, which consist of both narrative and numeric criteria, are established to protect the physical, chemical, and biological integrity of surface waters and maintain designated uses. If water quality monitoring indicates that these water quality standards are not being met and that designated uses are not being achieved, surface waters may be added to a list of impaired waters.

When a surface water is listed, a Total Maximum Daily Load (TMDL) study and implementation plan are scheduled for development. Using water quality sampling and computer modeling, a TMDL study establishes pollutant load reductions from both point and nonpoint sources needed to meet established water quality standards.

There is increasing emphasis among state and federal permitting agencies to create stronger links between TMDLs and stormwater permits, such as MS4 permits (**USEPA, 2007; USEPA Region 5, 2007a, 2007b**). With successive rounds of MS4 permits, permitted agencies will very likely need to apply more stringent stormwater criteria in impaired watersheds and/or provide a better match between particular pollutants of concern and selected BMPs.

Strategies for Local Stormwater Managers to Address TMDLs Through Special Stormwater Criteria

Depending on the nature of the TMDL and the implementation plan, local stormwater criteria can help address TMDL requirements. The following three general approaches are discussed in order of decreasing sophistication. There are other approaches that can applied, and a local program may find that a hybrid approach is most applicable.

- Site-Based Load Limits
- Surrogate Measures for Sources of Impairment
- Presumptive BMP Performance Standards

1. Site-Based Load Limits

Some pollutants that are the basis for TMDLs are understood well enough that site-based load calculations can be done for each development and redevelopment site. These pollutants generally include sediment, phosphorus, and nitrogen (in some areas, other pollutants, such as ammonia, fecal coliform bacteria, and other pollutants can be added to the list if adequate local or regional studies have been conducted) (**MSSC, 2005**). If site-based load limits are to be used, the TMDL and local stormwater program should have the following characteristics:

- The TMDL allocates a load reduction target to urban/developed land (preferably separating out existing developed land from estimates of future developed land).
- The local program uses (or plans to use) a method, such as the Simple Method (**CWP and MDE, 2000**), that allows for the calculation of pollutant loads for a particular site development project.
- The local, regional, or state manual (or policy document) contains a method to assign pollutant removal performance values to various structural and nonstructural BMPs. Low-Impact Development (LID) credits are another positive factor so that LID practices can be incorporated.

The general process for calculating site-based load limits is as follows:

1. Based on the wasteload allocation (WLA) and load allocation (LA) in the TMDL, develop a site-based load limit for the pollutant of concern. The local program must allocate the total load reduction goal for urban/developed land to existing and future urban/developed land within the impaired watershed. The program should consider having a more flexible standard for redevelopment projects because the standard will usually be more difficult to meet for these projects.

   *Example: Site-based load limit = 0.28 pounds/acre/year for total phosphorus (**Hirschman et al. 2008**)*

   That is, if each newly developed site meets the standard of 0.28 pound/acre/year, the load reduction goal for new urban/developed land can be met.

   *In this context, other measures—such as stormwater retrofits and restoration projects—might have to be applied for existing urban/developed land (see Step 5 below and **Schueler et al. 2007**).*

2. For each development site, the applicant should calculate the post-development load for the pollutant of concern using a recognized model or method. Most use impervious cover as the main basis for calculating loads, although other land covers (e.g., managed turf) are also important contributing sources.

   Example: Post-development total phosphorus load = 0.55 pound/acre/year

Table 4.17. Special Stormwater Criteria for Impaired (TMDL-Listed) Waters *(continued)*

3. Next, the required load reduction is computed by comparing the post-development load to the site-based load limit, and an appropriate BMP is selected.

   Example: Load reduction = post-development load – site-based load limit

   0.55 – 0.28 = 0.27 pound/acre/year (load that must be removed to meet the load limit standard)

   Selected BMPs should be capable of removing the target load reduction. One way to determine this is to calculate the load leaving the BMP based on the expected effluent concentration and the effluent volume for the design storm (or on an annual basis).

4. Select a combination of structural and nonstructural BMPs that can be documented to meet the required load reduction. If the local program and/or TMDL implementation plan encourages LID, then these practices should be assigned load reduction credits (see **Section 6.10**).

5. If the entire load reduction cannot be achieved (or is impractical) on the particular site, the applicant might be eligible to implement equivalent off-site BMPs within the impaired watershed. These off-site BMP may be implemented by the applicant on developed land that is currently not served by stormwater BMPs. Alternatively, the applicant can pay an appropriate fee (fee in lieu) to the local program to implement stormwater retrofits within the impaired watershed. In either case, full on-site compliance is being "traded" to implement other BMPs that can help achieve TMDL goals.

The local program would have to apply this technique to a variety of local plans to gauge achievability and feasibility across a range of development scenarios.

A good real-world example of this approach (although not specific to impaired watersheds) is Maine's *Phosphorus Control in Lake Watersheds: A Guide to Evaluating New Development* (Interim Draft, 12/10/2007).
http://www.maine.gov/dep/blwq/docstand/stormwater/stormwaterbmps

2. Surrogate Measures for Sources of Impairment

If site-based load limits cannot be used because of the type of impairment (e.g., aquatic life) or limited data, surrogates that have a strong link to the cause of impairment can be used. For instance, various TMDLs have used impervious cover and stormwater flow as surrogates for stormwater impacts on aquatic life, stream channel stability, and habitat (**USEPA, 2007**). In these cases, the surrogates are relatively easy to measure and track through time. The TMDL might have a goal to reduce impervious cover and/or to apply BMP treatment to a certain percentage of impervious cover within the impaired watershed.

A local stormwater program could apply the surrogate approach through a tiered implementation strategy for new development and redevelopment (see also **Section 4.2**):

- FIRST, minimize the creation of new impervious cover at the site through site design techniques. Preserve sensitive site features, such as riparian areas, wetlands, and important forest stands.
- SECOND, disconnect impervious cover by using LID and nonstructural BMPs.
- THIRD, install structural BMPs to reduce the impact of impervious cover on receiving waters.

3. Presumptive BMP Performance Standards

Perhaps the most widespread and simplest method to link TMDL goals with stormwater criteria is to presume that implementation of a certain suite of BMPs will lead to load reductions, and that monitoring and adaptive management can help adjust the appropriate template of BMPs over time (**USEPA, 2007**; **USEPA Region 5, 2007a**). This strategy acknowledges that data are often too limited to draw a conclusive link between particular pollutant sources and in-stream impairments. However, as more data become available and TMDL implementation strategies are refined, a more quantitative method, such as the two noted above, should be pursued.

There are a wide variety of "presumptive" BMPs that can be included in local stormwater criteria for an impaired watershed, and these should be adapted based on the pollutant(s) of concern:

- Stream/wetland/lake setbacks and buffers
- Site reforestation
- Soil enhancements
- Incentives for redevelopment

Table 4.17. Special Stormwater Criteria for Impaired (TMDL-Listed) Waters *(continued)*

- Requirements for runoff reduction (see **Table 4.8**)
- Implementation of LID
- Requirements for BMPs with filter media and/or vegetative cover
- Enhanced sizing and/or pre-treatment requirements
- Required BMPs at stormwater hotspots or particular land use categories (e.g., marinas, industrial operations)
- Contribution to stormwater retrofit projects within the watershed

The providing channel protection criterion (see **Table 4.10**) is highly recommended for receiving waters that are impaired by sediment or sediment-related pollutants. Given the importance of channel erosion in the sediment budget of urban streams, it is critical to control erosive flows from development projects.

For more information on linking TMDLs to stormwater permits, see:
Total Maximum Daily Loads with Stormwater Sources: A Summary of 17 TMDLs, EPA 841-R-07-002
http://www.epa.gov/owow/tmdl

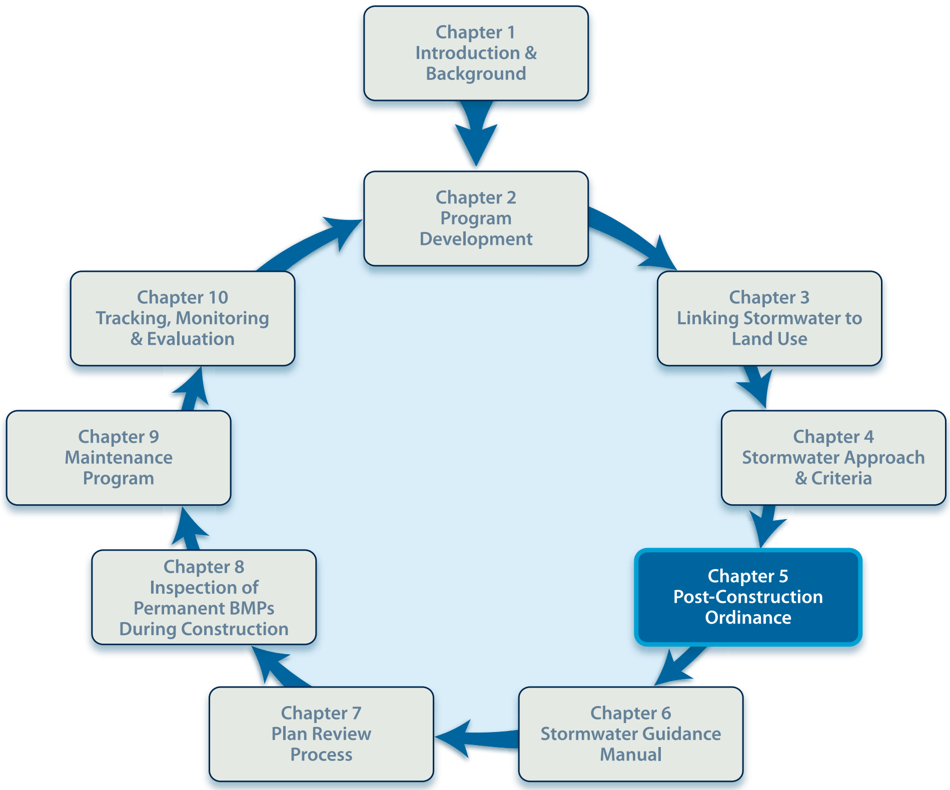
Total Maximum Daily Loads and National Pollutant Discharge Elimination System Stormwater Permits for Impaired Waterbodies: A Summary of State Practices, USEPA Region 5
http://www.epa.gov/R5water/wshednps/topic_tmdls.htm

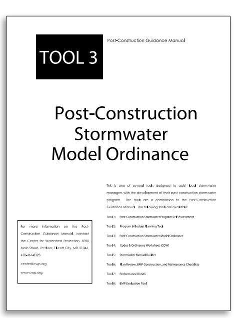
Linking TMDLs and the Implementation of Low Impact Development/Green Infrastructure Practices, USEPA Region 5

For a comprehensive primer on stormwater retrofitting in existing urban/developed land, see:
Urban Stormwater Retrofit Practices, Manual 3, Urban Subwatershed Restoration Manual Series, Center for Watershed Protection, ***www.cwp.org*** > Resources > Controlling Runoff & Discharges > Stormwater Management > National/Regional Guidance.

Chapter 5

Developing a Post-Construction Stormwater Ordinance





Companion Tools for Chapter 5
Download Post-Construction Tools at:
www.cwp.org/postconstruction

What's In This Chapter

- Framework for the stormwater ordinance
- Scoping out the right ordinance for the community
- Anatomy of a stormwater ordinance
  - Regulatory structure elements
  - Design elements
  - Plan review elements
  - Maintenance elements
  - Inspection & enforcement elements
  - Tips and milestones for building the stormwater ordinance
- Involving the public in ordinance adoption

5.1. Framework for the Stormwater Ordinance

General Status and Trends

The stormwater ordinance is the backbone of a local program. It provides the legal foundation for all other program elements, including design standards, development review procedures, inspections, maintenance, and enforcement. Many local programs begin to build their stormwater programs by developing and adopting a local ordinance. While this is often an early step, it can also be one of the most difficult. As a local regulation, the ordinance must have political support, and this often involves garnering public support through education and outreach efforts.

Recent research on NPDES Phase II programs revealed that about half have adopted some form of stormwater ordinance. Most of these programs were able to adopt their local ordinance in 3 years or less (**CWP, 2006**). Programs that have not yet adopted a stormwater ordinance note various reasons, including lack of funding, lack of staff, lack of political support, and lack of guidance from the state level.

Assess Existing Ordinances

Most communities have existing codes in place that address stormwater or drainage in some fashion. However, existing codes might not support or, in fact, might be inconsistent with the stormwater goals that are expected and required under NPDES MS4 permits.

Chapter 3 outlines some of the most common inconsistencies between typical local codes and a "modern" stormwater program (e.g., one that promotes good site design, reduction in impervious cover and disturbed soils, and innovative BMPs to minimize stormwater impacts). Several of these inconsistencies are shown graphically in **Figure 5.1**. These inconsistencies can be particularly acute if the local program wishes to promote low-impact development (LID) practices.

Tool 4 contains a more thorough "Codes and Ordinance Worksheet" that can be used to systematically review existing codes and identify inconsistencies with design approaches that reduce stormwater impacts. In many cases, the local program can work to eliminate these inconsistencies. Some changes to existing codes will be more difficult than others. For instance, it would be difficult to change zoning standards that are tied to statewide uniform building codes, but more straightforward to change local standards.

Using Model Ordinances

Many state and regional agencies have model stormwater ordinances. Many state-level ordinances specify the technical criteria to be adopted at the local level, although local adaptation and customization are expected. Also, many localities begin their ordinance development process by looking to good examples from neighboring communities.

Finding and using the most appropriate model is an important early step in efficiently adopting an ordinance. This step is also an early opportunity to engage the local legal staff in the development of a stormwater ordinance. **Tool 3** is a model stormwater ordinance that can serve as a good starting point (see **Figure 5.2**).

Ordinances and Design Standards

The recommended approach for most local programs is for the ordinance to reference appropriate design standards (see **Chapter 6**) but not contain these standards within the code language itself. The reasons for this are as follows:

- Design standards should be updated based on local lessons and improvements in technology. It can be a burden on the local program to amend the ordinance each time a design change is sought. Alternatively, design documents that are amended through an administrative procedure, with ample public involvement and input, are more likely to remain as living documents.
- As design standards evolve, they will contain standard diagrams, computations, and examples. It is quite burdensome to include these elements within the confines of a legal document, such as an ordinance.
- The ordinance should remain simple and readable for the widest possible audience. A separate design standards document can be written for technical audiences, such as design consultants and plan reviewers.

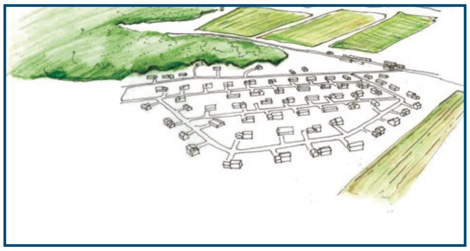
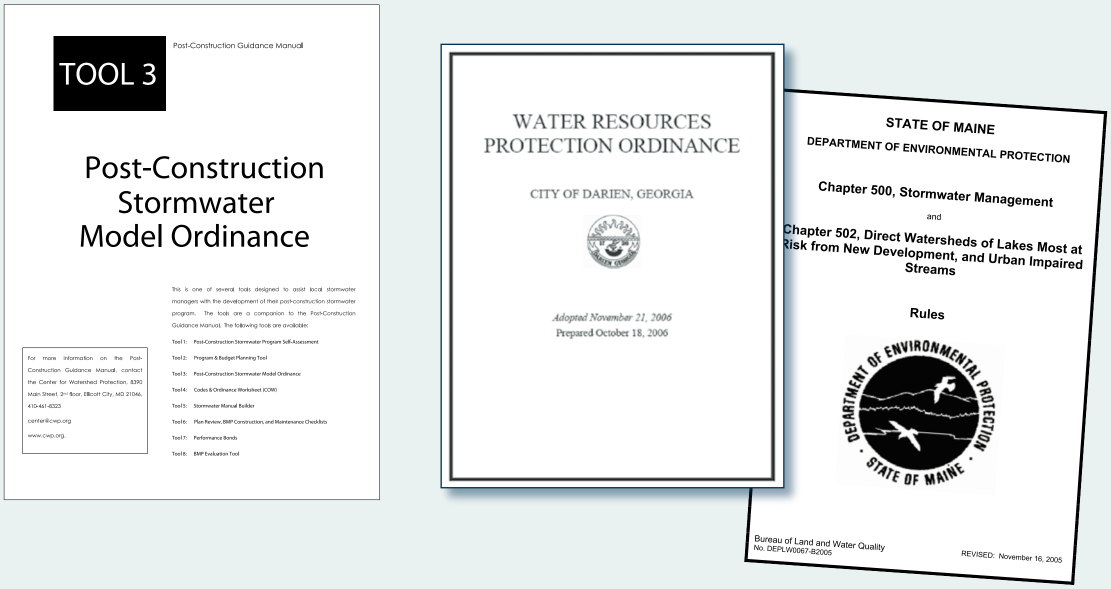
THE LOCAL CODE MAY *REQUIRE* THIS	BUT *NOT ALLOW* THIS
Subdivision with no open space  *Graphic courtesy of Rennaissance Planning Group*	**Open-space design**  *Graphic courtesy of Rennaissance Planning Group*
Curb and gutter on roads 	**Swales and grass channels** 
Parking lot islands not used for stormwater 	**Parking lot bioretention areas**  *Photo courtesy of Sanitation District #1 of Northern Kentucky*
Stormwater BMPs address only flood control 	**Stormwater BMPs address water quality and resource protection** 
Nonstructural BMPs and LID not allowed 	**Nonstructural BMPs and LID given credit** 

Figure 5.1. **Existing codes may conflict wth progressive stormwater management**



Other model ordinances to protect local aquatic resources can be found at CWP's Stormwater Managers' Resource Center (SMRC): ***http://www.stormwatercenter.net***

Information on state-by-state stormwater regulations can be found at the stormwater authority.org Web site: ***http://www.stormwaterauthority.org***

Figure 5.2. Tool 3: Model Post-Construction Stormwater Ordinance. Other state and regional ordinances are available around the country

If this approach is taken, the ordinance must be clear that the relevant design standards are contained in the *latest version* of the design document, or within the design manual *that is updated from time-to-time*. This will ensure that, as the design standards change, the ordinance requirements will attend to the most up-to-date version.

Chapter 6 specifically addresses the topic of developing a stormwater guidance manual or revising an existing state or regional manual to meet local needs.

5.2. Getting Started: Scoping Out the Right Ordinance for the Community

There are many decisions to make when crafting an ordinance. Many of these will be highlighted and clarified during program planning and goal setting. However, it is quite another challenge to translate general goals and intentions into legal language.

Before mounting the task of drafting the ordinance, it is important to scope out the unique circumstances in a given community. These local conditions might be based on the pace and type of development expected; natural conditions, such as soils and slopes; or institutional factors, such as the availability of a state model ordinance and/or design manual. The following scoping questions will help the stormwater manager frame the type of ordinance (or ordinance revisions) that is right for the community.

1. ***Is there a state or regional model ordinance based on the state's MS4 permit requirements? Is adoption of this ordinance mandatory or voluntary?***
   If the stormwater manager chooses to (or is required to) use a model ordinance, the drafting job is simplified. However, the ordinance can still be tailored to local conditions and needs. For instance, special stormwater criteria or additional maintenance provisions might be appropriate for the local ordinance.

2. ***Do existing local codes pertain to drainage and/or stormwater?***
   Existing codes will likely need to be augmented or overhauled to be consistent with the stormwater program's current goals and objectives. Refer to **Tools 1** and **4** (**Stormwater Program Assessment** and **Codes and Ordinance Worksheet**) for guidance on evaluating existing codes.

3. ***Should the stormwater program be integrated with erosion and sediment control for construction sites and/or illicit discharge detection and elimination?***
   Some level of integration is important. Logical avenues for integration include a joint ordinance, a combined development review process, and an integrated inspection/enforcement program. Design manuals for erosion and sediment control and post-construction stormwater might be separate in some jurisdictions to avoid confusion and to keep the size of the manuals manageable.

4. ***What are the permit commitments with regard to adopting an ordinance?***
   The Phase II regulations state that stormwater requirements must be implemented "by ordinance or other regulatory means." The permit may entail a specific action and schedule (e.g., adopt stormwater ordinance by Year 3 of the permit).

5. ***What are the environmentally significant or sensitive resources in the community: drinking water reservoirs, sole source aquifers, areas subject to flooding, estuaries, wetlands, cold-water fisheries, recreational lakes and rivers, impaired waters, pristine streams, or other resources?***
   Although Phase I and II communities must comply with regulatory requirements, the best way to promote a program to the local community is to base it on local resources. One way to enhance the ordinance is to include special stormwater criteria (or watershed-based criteria) for locally important resources (see **Chapter 4** for more detail).

5.3. The Anatomy of a Stormwater Ordinance

Table 5.1 outlines the basic elements of a stormwater ordinance, arranged into five categories. Subsequent sections of this chapter describe each element in more detail. **Tool 3: Model Stormwater Ordinance** provides a template for a comprehensive stormwater ordinance.

Table 5.1. Basic Elements of a Stormwater Ordinance

Category 1: Regulatory Structure Elements
The ordinance can be seen as the engine for a stormwater program. All other program elements must tie back to adequate or enabling language in the stormwater ordinance. Basic regulatory elements include: ► Legal authority and purposes ► Definitions ► Applicability for stormwater requirements ► Exemptions ► Waivers
Category 2: Design Elements
The ordinance's design elements influence the type, size, and design of various BMPs that can be used to comply with the ordinance, including: ► Stormwater management criteria ► Regional stormwater and watershed approaches
Category 3: Development Review Elements
The development or plan review process is the chief compliance tool for a stormwater program. The ordinance establishes: ► Plan submission and review requirements ► Requirement for a performance bond at plan approval
Category 4: Maintenance Elements
The ordinance must help lay the groundwork for long-term maintenance. Important ordinance linkages to maintenance include: ► Easements for stormwater treatment and access to BMPs ► Maintenance agreements to assign long-term responsibility, as well as operation and maintenance plans ► Maintenance inspection and reporting requirements
Category 5: Inspection and Enforcement Elements
Enforcement tools provided in the ordinance are paramount for a successful program. Important enforcement considerations include: ► Inspections for permanent BMPs ► Penalties and remedies for noncompliance

Category 1: Regulatory Structure Elements

An effective ordinance must include regulatory elements to establish basic regulatory parameters as described below.

Legal Authority and Purposes

This section establishes the legal authority for a locality to manage stormwater, and it is often tied to state enabling legislation or general police powers of the jurisdiction. The purposes section establishes the goals of the ordinance, which should be tied to overall program goals. In general, these sections will be specific to the locality and based on state or federal regulations as well as local goals.

Several examples of items that might be covered in the purposes section are listed in **Table 5.2**.

Table 5.2. Purposes Section of a Stormwater Ordinance

- Reduce flooding from land development to protect stream channels, property, and public safety.
- Minimize increases in water pollution caused by stormwater runoff from land development.
- Protect the ecological integrity and quality of stream networks, surface water, and groundwater.
- Ensure that the types, locations, and function of stormwater management measures are consistent with the overall growth management goals of the community.
- Ensure that all stormwater management measures are properly maintained.

Definitions

This section provides commonly understood and legally binding definitions. These terms should be defined consistently across other related guidance and regulatory documents.

Applicability for Stormwater Requirements

The applicability provisions dictate how many sites will be captured in the regulatory process versus those that are exempt. A local program with existing staff resources, budget, and community interest will likely choose a finer mesh size (to catch more sites) than one without such assets. Applicability is an important consideration because it determines how many sites will be subject to plan review and site inspections. This decision might also dictate how many BMPs will require ongoing maintenance by a community. Other considerations are whether criteria will apply to single-family lots and all redevelopment sites.

EPA's Phase II MS4 stormwater regulations apply to new development and redevelopment projects that disturb 1 or more acres, and most state programs have adopted this same threshold. Local programs might want or need to adhere to the 1-acre-disturbed threshold. However, other programs might expand coverage by using criteria that address other stormwater concerns, such as:

- Impervious cover
- Land disturbance smaller than 1 acre
- Number of lots in a subdivision
- Watershed characteristics

Table 5.3 lists a range of stormwater applicability criteria in use around the country (**CWP, 2006**).

The applicability section should state that the threshold applies only to projects that are not part of a larger common plan of development. A phased project should consider the entire area being developed under the various phases.

Exemptions

Exempt projects are categorically excluded from stormwater requirements (as opposed to variances, which are evaluated case by case). Some exemptions are based on state code provisions; for instance, runoff from agricultural operations is exempt in some states.

Be careful: Exemptions often turn into loopholes. For example, "logging" and "farm" roads being built under an exemption have been known to turn into subdivision streets at a later time. Also, hardship should not be the basis for exemptions.

Table 5.4 lists the most common exemptions allowed in stormwater ordinances.

Table 5.3. **Examples of Stormwater Ordinance Applicability Criteria in Use Around the Country**

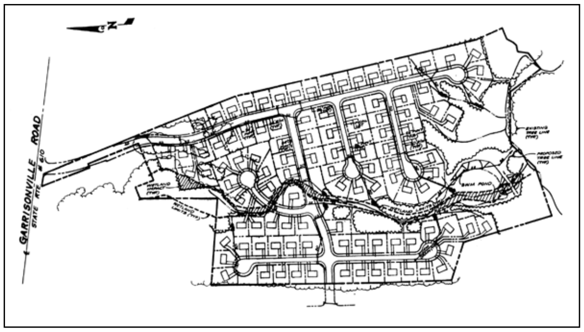
Type of Threshold and Ranges of Values from Surveyed Communities	
Impervious Cover	
LOW THRESHOLD (more sites covered by ordinance): 100 square feet **HIGH THRESHOLD** (fewer sites): 20,000 square feet	
Land Disturbance	
MOST COMMON: 1 or more acres disturbed (NPDES Phase II MS4 requirement) **LOWER THRESHOLDS** (more sites covered): Any land disturbance 2,500 square feet or more disturbed 20,000 square feet or more disturbed	
Number of Lots	
LOW THRESHOLD (more sites covered): 1 or more lots **HIGH THRESHOLD** (fewer sites): 10 or more lots	
Variable	
Case-by-case: ► All commercial and subdivision plats, plus lot drainage plans ► Any new connection to the storm sewer system ► 2,500 square feet of new impervious ***or*** 1,000 square feet of impervious added to existing development ► 5,000 square feet disturbed or any new or replacement impervious cover ► Parking lots with 10 or more spaces ***or*** 10 or more homes	

Table 5.4. Common Exemptions in Stormwater Ordinances

- Projects that are *exclusively* for agricultural or forestry purposes. (Note: The term "exclusively" is necessary to avoid creating loopholes.)
- Single-family structures, ***or*** additions or modifications to single-family structures, that are not part of a larger project.
- Projects that predate the effective date of the ordinance.
- Other land uses that might be under the purview of other agencies or requirements, such as mining, oil and gas operations, and state/federal agency projects.
- Temporary projects, such as road and utility maintenance. However, there is some debate about whether all temporary projects should be exempt, or whether these represent opportunities for incremental improvements in post-construction stormwater treatment.

Variances

As described above, variances are considered on a case-by-case basis. They may be granted for a number of reasons, including:

- They allow the elected officials to perform their discretionary duties, such as when overall public benefit outweighs strict adherence to the ordinance.
- They allow flexibility in unusual circumstances where strict compliance isn't practical.

It is important to recognize that granting a variance does not necessary allow the applicant to avoid any and all attempts to address stormwater impacts. The code must specify the conditions or mitigation measures that justify granting a variance. Elected bodies should routinely attach conditions to the granting of a variance. For instance, the applicant might be required to contribute land or funds for off-site mitigation or to provide on-site stormwater treatment with an innovative practice.

By nature, variances should be limited and applied very selectively. There are, however, legitimate cases where the use of variances is warranted, including:

- Variances for water *quantity* in situations where stormwater detention would not be beneficial (e.g., along major floodplains) and/or would cause more environmental damage than benefit (e.g., locating a detention pond in a natural drainage system). In cases like these, it is important for the applicant to demonstrate that there will be no adverse impacts on downstream channels, structures, or property.
- Variances to allow redevelopment within enterprise zones, existing town centers, or other areas where redevelopment is critical to achieve joint economic development and land use objectives. In some cases, redevelopment projects will have trouble meeting all on-site stormwater requirements, and these requirements can act as a disincentive for some redevelopment projects. In these cases, the program must balance the advantages of having the redevelopment with the need for full on-site stormwater compliance. (See **Chapter 3** for more discussion on stormwater and land use.)

In all cases, a fee should be associated with applying for a variance. The fee can cover the staff time needed to process the waiver and, with more sophisticated programs, can also be applied to off-site or watershed projects (conducted by the local program or developer) in lieu of full on-site compliance. For example, Maryland's Critical Area Program specifies an "offset fee" based on a site's phosphorus loading (**CWP, 2003b**). The fee can be applied by the jurisdiction to retrofit or watershed projects identified in a watershed plan.

Category 2: Design Elements

The ordinance provides the general objectives of design (criteria), while a separate design guidance manual can contain the specific design information. The design portion of the ordinance can also include the regulatory structure for a regional or watershed-based stormwater program.

Design Criteria

Design criteria establish the design objectives for BMPs, and they will influence directly the types and sizes of these practices. Programs are expected to establish criteria that attempt to maintain pre-development hydrologic conditions, such as controlling peak flows and the rate and volume of runoff.

Traditionally, most programs had criteria for water quantity (flood) control. More recently, water quality criteria have become more widespread and are an important ordinance element for MS4s. Also, some communities have additional criteria for locally important resources, such as cold-water fisheries, groundwater, coastal waters, and drinking water supplies. These are considered "Special Stormwater Criteria" and can be adapted for other resources, including wetlands and impaired waters.

The criteria in the ordinance should remain fairly simple, with technical detail reserved for the design or guidance manual. **Chapter 4** contains a more detailed discussion and description of stormwater management criteria that can be included in a stormwater ordinance, and **Chapter 6** provides information on developing stormwater guidance manuals. In addition, **Tool 3: Model Stormwater Ordinance** contains model language for stormwater management criteria.

Category 3: Plan Review Elements

Chapter 7 provides detailed guidance on the stormwater plan review process. However, most plan review functions must tie back to legal authority and requirements established in the ordinance. These elements include both the mechanics of the review process (e.g., submission requirements and allowable review periods) and all the documentation that should be tied to approval of a stormwater plan (e.g., maintenance agreements, easements).

Plan Submission and Review

At its basic level, the plan review section outlines the requirement for plans to be submitted, the schedule for review, and general conditions for approval. Approving the plan can be a locality's last chance to influence several important issues, such as ensuring long-term access to BMPs and assigning maintenance responsibility. The ordinance should establish the plan approval process as a mechanism to secure needed documents for the long-term viability of site BMPs.

A comprehensive plan submission and review section might include the elements listed in **Table 5.5**, based on a program's goals and level of sophistication.

Category 4: Maintenance Elements

The ordinance's role with respect to long-term maintenance includes the following:

- Ensure that maintenance agreements are recorded during the development review process. These agreements (or other ordinance language) should specify right-of-entry for inspections.
- Ensure that each approved stormwater BMP has an adequate operation and maintenance plan, with practical maintenance checklists and schedules. These plans can be a component of the recorded maintenance agreement.
- Ensure that easements for maintenance and access are platted during the development review process.
- Establish maintenance inspection and reporting requirements.

The other functions of the ordinance in establishing a maintenance program may include provisions for compliance, design, and designation of the responsible party:

- Establish penalties and remedies for noncompliance with required maintenance tasks (see below under "Penalties and Remedies").
- Establish a general guideline that all stormwater BMPs must incorporate design elements to reduce maintenance and prevent failure (although specific design guidelines should be in the design manual).
- Establish the responsible party for maintenance. In many cases, the ordinance will include a definition for "responsible party" and allow for various scenarios—private owners, owners' associations, a government agency or utility, or another private or public entity specified in the maintenance agreement.
- Establish the requirement for a maintenance "escrow" account or certificate of financial capability to be established by the responsible party.

Chapter 9 contains more detailed guidance on establishing a stormwater maintenance program.

Table 5.5. Plan Submission and Review Elements in a Stormwater Ordinance

- Statement that other permits (building and/or grading permits) may not be issued until a stormwater plan has been approved.
- Requirement for a concept or preliminary plan (this is critically important for plans that have the potential to incorporate low-impact development).
- Requirement for a final plan.
- Process for accepting plans as complete based on a checklist (which can be contained in the design manual; see **Tool 6: Checklists** for specific examples).
- Requirement that plans be certified by qualified professionals.
- Review schedule (e.g., 7 days to determine that a plan is complete and 30 days for review).
- Procedure for amending approved plans.
- Coordination with other federal, state, and local reviews (e.g., erosion and sediment control/construction stormwater permits, wetland and stream permits). For instance, include a statement that grading or building permits cannot be issued until all necessary permits have been obtained.
- Requirement for necessary drainage and access easements for facilities and conveyances.
- Designation of a responsible party for long-term maintenance.
- Requirement that a maintenance agreement be recorded prior to plan approval. This may also include maintenance plans for each type of facility (practical maintenance activities and schedules).
- Requirement for the posting of a performance bond or other surety prior to issuance of building or grading permits. See **Tool 7: Performance Bonds**.
- Requirement for as-built plans that must be certified by a professional engineer and approved prior to release of performance bonds.
- Authority and fee schedule for collecting plan review fees. (The fee schedule may include inspection or other permit fees as well.)

Category 5: Inspection and Enforcement Elements

The enforcement elements of the ordinance are critical to a successful program. The ordinance should provide various compliance and enforcement tools for different circumstances. **Tool 3: Model Stormwater Ordinance** contains suggested enforcement and penalty language.

Inspection for Permanent Controls

The inspection section of the ordinance outlines the requirements for responsible parties to inspect and report on permanent stormwater controls. These inspections should be tied closely with construction-phase inspections (erosion and sediment control). Ideally, one inspection section would cover both functions if the ordinances are combined.

The ordinance should be clear about who is responsible for conducting inspections—the responsible party, a local government department, or a combination—and the type and frequency of reporting that must be submitted by the applicant.

Inspection language should establish authority for local program staff to access sites and carry out any enforcement actions (see Penalties and Remedies). Inspection requirements for permanent controls should include:

- Periodic inspections during construction/installation of permanent controls
- As-built inspection to certify that permanent measures are installed according to approved plans and stabilized
- Periodic maintenance inspections for the life of the measure (e.g., at least annually and in response to complaints)

- Minimum reporting requirements (actual inspection checklists should be in the design manual; see **Tool 6: Checklists**)

More sophisticated programs might provide for a system of private certified inspectors that receive training and certification from the stormwater program and inspect sites on behalf of responsible parties.

Penalties and Remedies

Various options to seek compliance should be established in the ordinance to allow flexibility for different circumstances. Penalties and remedies for stormwater can be combined with the construction-phase (erosion and sediment control) and possibly illicit discharge penalties. However, different enforcement tools will likely be used during active construction (e.g., stop work orders) than during the post-construction maintenance period (e.g., civil penalties).

Table 5.6 lists and describes the various penalties and remedies to include in a stormwater ordinance. Often, a local program will use more informal compliance methods as a first line of defense. These might include verbal warnings and warning letters. If these early attempts do not achieve the desired results, enforcement can escalate to the more formal mechanisms noted in **Table 5.6**.

Table 5.6. Types of Penalties and Remedies

Type	Description
Notice of violation (NOV)	Written notice served on the responsible party stating the cause of the violation, remedial steps to be taken, a schedule for compliance, and consequences for noncompliance (e.g., stop work, revoking of permits, and pursuit of civil and/or criminal penalties).
Stop work order	Provision for the enforcing agency to stop work on a site if the responsible party fails to comply with an NOV. A stop work order is more effective for erosion and sediment control (construction-phase stormwater) than for post-construction stormwater.
Civil penalties or charges	Civil penalties can impose charges for specific violations. The ordinance can include a schedule of civil penalties (specific charges linked to specific types of violations), and inspectors can use this schedule in "ticket book" fashion when in the field. Civil penalties provide more flexibility than criminal penalties.
Criminal penalties	Criminal penalties establish violations as misdemeanors, subject to specific fines and/or imprisonment. Each day the site is not in compliance is considered a separate violation. Although criminal penalties represent the biggest "hammer" in the enforcement toolbox, most programs resort to them rarely and could find it difficult to garner the political support to use such penalties.
Withholding other permits or approvals	Perhaps the biggest motivator to comply during the construction process is withholding certificates of occupancy or other approvals until all measures have been properly installed. This tool would not apply to long-term maintenance, however, and might also present timing challenges for the applicant and jurisdiction (e.g., site work lags behind building and occupancy).
Revoking or suspending other permits or approvals	This tool is similar to withholding permits, but it applies to permits or approvals that have already been granted (e.g., building or grading permits). The appropriate permit or authorization can be suspended until the required actions are taken, at which point the permit is reinstated. This tool can be quite effective, but implementing it usually takes political support.
Performance bonds	Performance bonds are not an enforcement tool in the strict legal sense, but many programs use them to motivate compliance. Bonds can be particularly useful for a stormwater program because their duration can cover the proper installation of stormwater measures plus a reasonable period thereafter to ensure that practices function properly. The bond concept can also be expanded to maintenance in the form of a maintenance bond, escrow, or other financial guarantee that must be posted by the responsible party. In the ordinance, the performance bond section would likely not be in the penalties section but rather in the plan submission and review section.

5.4. Tips and Milestones for Building the Stormwater Ordinance

Table 5.7 lists 10 important tips and milestones for developing and adopting a stormwater ordinance. The table lists each milestone, appropriate internal and external parties that are customarily involved with that milestone, and an average time frame for the task. Of course, the actual timeline and parties involved will vary from community to community.

5.5. Involving the Public in Ordinance Development and Adoption

The purpose of public participation in the ordinance development process is to garner public, and ultimately decision-maker, support for (1) the idea that a stormwater ordinance is indeed needed (and required) in the community and (2) the adoption of an ordinance by the elected officials. The public participation process should add value to the final product by incorporating stakeholder input, ideas, and comments on how the ordinance can best meet local needs while being responsive to state and federal requirements.

A short list of public participation methods particularly tailored to the ordinance development process is provided in **Table 5.8**. The strengths and weaknesses of each method are derived, in part, from **Randolph (2004)**. As noted in the table, there is a trade-off between the degree of participation and the number of stakeholders that can be included in the process. For instance, an advisory committee or ordinance roundtable has a high degree of participation by a limited number of stakeholders compared to a Web site or public service announcement. The table lists the methods based on the degree of participation required, from high to low.

When developing the public participation strategy, stormwater managers should be mindful of the important "internal" stakeholders that will help with ordinance development, adoption, and implementation. These internal stakeholders or agencies can include (but might not be limited to) the following agencies:

- ***Planning and community development*** to coordinate plan review procedures and design standards.
- ***Public works department*** to verify responsibility for long-term maintenance and the placement of stormwater BMPs in relation to public rights-of-way and easements.
- ***Legal staff*** to check consistency with federal and state regulations and permits, check legal language, and assist with compliance and enforcement tools.
- ***Finance department*** to assist with fees, performance bonds, and tracking.
- ***Information/GIS technology*** to assist with posting public information materials, maps, and program tracking.

Table 5.7. Tips and Milestones for Building the Stormwater Ordinance

Ordinance Milestone	Appropriate Parties	Time Frame
1. Assess existing codes—zoning, subdivision, drainage, stormwater.	▸ Stormwater authority ▸ Planning/community development department ▸ Stakeholder group	3–6 months
2. Determine permit commitments for stormwater ordinance.	▸ Stormwater authority ▸ State MS4 coordinator	1 week
3. Identify relevant state and/or regional model ordinance or design manual.	▸ Stormwater authority ▸ State/regional agencies ▸ State MS4 coordinator ▸ Stakeholder group	1 month
4. Make decisions about programmatic integration with erosion and sediment control, illicit discharge detection and elimination, and land use planning.	▸ Stormwater authority ▸ Other local departments involved with aspects of the stormwater program ▸ Planning/community development department ▸ Stakeholder group	6 months–1 year
5. Devise and execute a public and stakeholder participation strategy for ordinance development and adoption.	▸ Stormwater authority ▸ Outreach expert (internal or external) ▸ Legal staff ▸ Local leadership (elected and appointed officials) ▸ Other internal and external stakeholders	1–3 years
6. Examine options and make decisions about applicability threshold, exemptions, waivers, and design criteria.	▸ Stormwater authority ▸ Stakeholder group ▸ Consultant, if appropriate	3–6 months
7. Determine whether the ordinance should allow or require low-impact development measures through variances and/or in design criteria.	▸ Stormwater authority ▸ Stakeholder group	3–6 months
8. Determine whether off-site or watershed projects are an appropriate site compliance mechanism in the community.	▸ Stormwater authority ▸ Stakeholder group ▸ Watershed organizations ▸ Consultant, if appropriate	1–2 years
9. Project annual plan review, inspection, and maintenance work loads based on applicability threshold and development rates. Translate to budget and staffing needs.	▸ Stormwater authority ▸ Public works department ▸ Planning/community development department ▸ Locality's finance/budget office	1–3 months
10. Adopt and implement the ordinance	▸ Stormwater authority ▸ Legal staff ▸ Elected officials	Entire Process: 1–3 years

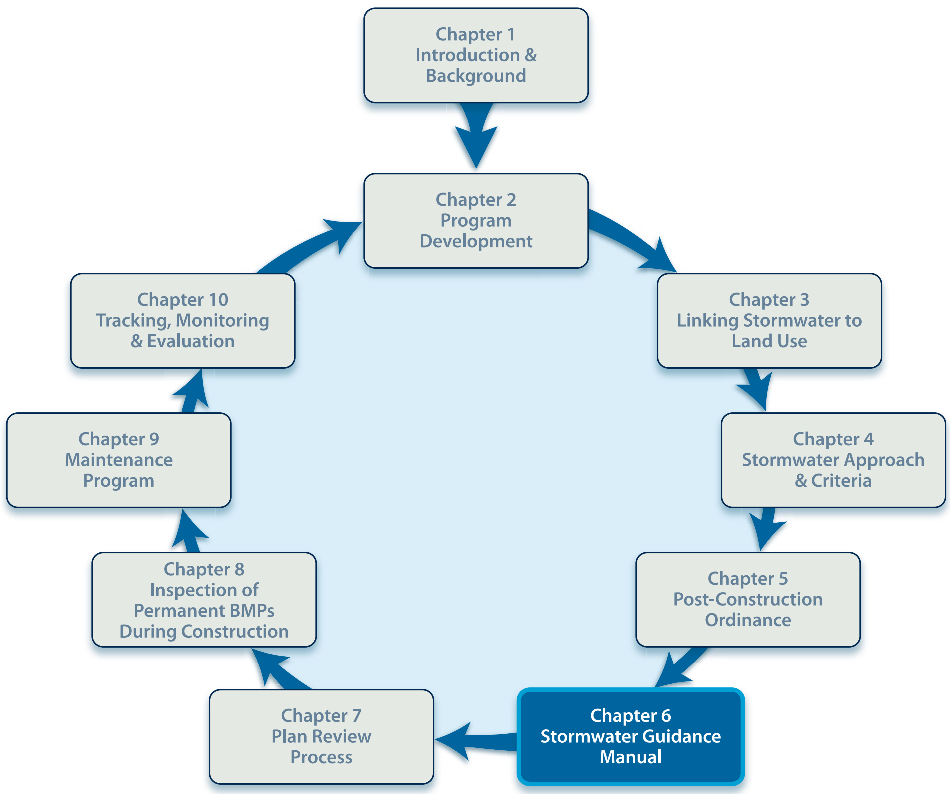
Table 5.8. Public Participation Techniques for Ordinance Development

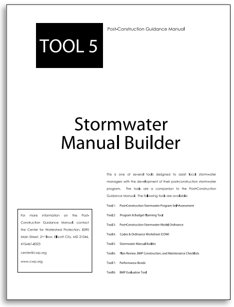
Technique and Degree of Participation	Strengths	Weaknesses
High Degree of Participation		
Advisory Committee or Codes Roundtable: Key stakeholders meet throughout the process and might even have a limited research or writing role. A full codes roundtable process involves various subcommittees.	► Can build constituency by incorporating an education process for the committee members. ► Provides for continuity throughout the process. ► Good tool for soliciting both technical and value-based input. ► A successful committee process can be very influential for decision-makers (especially if they are involved in the process). ► Good way to include legal staff, an important and often overlooked stakeholder, early in the process.	► Difficult to achieve full representation of all stakeholders. ► Requires high degree of commitment of participants (some stakeholders cannot attend numerous meetings). ► Labor-intensive for staff, unless outside facilitation and technical support are provided.
Focus Group(s): One-time meeting of a diverse group to gauge reaction to ordinance approach and specific actions.	► Multiple focus groups can reach a variety of interests. ► Can focus on specific issues. ► Can be designed to be interactive. ► As with committees, can be used to engage legal staff early in the process.	► As with committees, it can be challenging to fully represent all interests.
Moderate Degree of Participation		
Field Trips, Outreach Events, Workshops: A range of events that are experiential, visual, and interactive.	► Can have a "seeing is believing" impact. ► Can be more interactive than formal hearings. ► Provides good media opportunities. ► Adds fun to the process.	► Good design is essential to have an impact—need to involve education and outreach specialists. ► Primarily reaches only those who want or happen to show up.
Low Degree of Participation		
Public Meetings and Hearings: Usually a more formal setting to present ideas or drafts and receive comments.	► Often a necessary step in the latter phases of the process. ► Can be efficient use of staff time.	► Difficult to build in meaningful interaction. ► Vocal naysayers can dominate and appear to be the loudest voice. ► Can lead to unfounded perceptions about certain individuals or groups because there is limited or no opportunity to interact and share ideas.
Public Information Materials: Might include Web sites, brochures, press releases, and other media.	► Efficient way to reach the greatest number of people.	► Isn't really a form of "participation" and may have limited impact. ► Can be perceived as biased.

A more complete menu of public involvement strategies for MS4s can be found at EPA's Web site: *www.epa.gov/npdes/stormwater/menuofbmps*

Chapter 6

Developing Stormwater Guidance Manuals





Companion Tools for Chapter 6
Download Post-Construction Tools at:
www.cwp.org/postconstruction

What's In This Chapter

- Overview of stormwater guidance manuals
- General status and trends in stormwater guidance manuals
- Scoping out development of a stormwater guidance manual
- Outlining the policy and procedures manual
- Outlining the stormwater design manual
  - List of recommended BMPs
  - Stormwater BMP design specifications
  - Stormwater BMP computations and models
  - Leveling the playing field between LID and conventional practices: stormwater credit systems
- Building a stormwater manual: the manual builder tool
- Tips for stormwater guidance manual project management
- Involving the public in developing the stormwater guidance manual

6.1. Introduction

Collectively, all the technical information contained in the design standards and guidelines will help ensure that the regulations and requirements that are spelled out in the ordinance are effectively implemented on the ground. Ultimately, the information contained within the stormwater design standards and guidelines will influence:

- How well stormwater management will be integrated with site planning and design
- How both structural and nonstructural stormwater best management practices (BMPs) will address the stormwater management criteria established in the ordinance
- The size, appearance, functionality, and safety of stormwater BMPs, including how they are landscaped and whether they are designed to reduce mosquito breeding and other nuisance conditions
- How easily stormwater BMPs can be accessed for maintenance, and the frequency and type of maintenance tasks required

Design standards and guidelines need to be spelled out in detail to ensure that both the designer and plan reviewer have all the tools and information they need to properly select, design, review, and approve structural and nonstructural BMPs. This detailed guidance is most efficiently and effectively provided within the context of a stormwater guidance manual.

Fortunately, most states and many regional agencies have some type of stormwater guidance manual that can be referenced or adapted by the local program. This is likely the most cost-effective approach for providing design information. Many existing manuals, however, do not have up-to-date guidance and specifications for low-impact development, stormwater credits, BMP selection and sizing, criteria for sensitive receiving waters, treatment of stormwater hotspots, and other features. For this reason, a local stormwater program may want to, over time, develop a local addendum or design supplement, or work with relevant state or regional agencies to add this information to existing manuals. Larger jurisdictions or more sophisticated programs might find developing their own design guidance manual desirable.

6.2. Stormwater Guidance Manuals: An Overview

A stormwater guidance manual is the ideal repository for all the detailed technical information associated with stormwater design. Other options are available, such as providing standards in the ordinance or in a variety of separate technical and policy documents. This option might be suitable for small communities or communities that are in the early stages of building a stormwater program. However, consolidating the design standards and guidelines into a well-organized stormwater guidance manual ultimately leads to a more efficient and effective stormwater program.

The most effective stormwater guidance manuals contain two parts:

1. ***The policy and procedures manual*** outlines administrative documents and procedures for the stormwater plan review, inspection, and maintenance process.
2. ***The stormwater design manual*** contains the detailed standards and guidance needed by designers and plan reviewers to select, design, review, and approve both structural and non-structural stormwater BMPs at development sites.

In some cases, the two types of manuals are separate documents. In others, the manuals are combined into one comprehensive stormwater guidance manual.

Many off-the-shelf resources are available to help stormwater programs develop both types of manuals. This chapter provides practical advice on how to customize these resources to develop effective stormwater design standards and guidelines.

6.3. General Status and Trends

The following general conditions prevail with regard to stormwater guidance manuals (**CWP, 2006**):

- Many communities, and in particular MS4s, provide some type of guidance in a manual or in the stormwater ordinance. Many refer to a state or regional manual that is already in use.

- Nearly three-quarters of U.S. states have some type of design manual, but many of the standards and BMPs have not kept up with recent innovations.
- Most manuals do not provide incentives or credits for the use of low-impact development and/or nonstructural BMPs.
- Most existing manuals address standards for peak rate (flood) control and water quality treatment. Fewer manuals also address groundwater recharge, runoff reduction, downstream channel stability, or special criteria for sensitive receiving waters (e.g., wetlands).

6.4. Getting Started: Scoping Out the Development of Stormwater Guidance Manuals

The first step in developing a stormwater guidance manual is to consider some key decisions about the manual. Several important scoping questions are provided below.

1. ***Is there an existing state or regional stormwater design manual that can be referenced to serve as the local manual?***

   As stated, an existing state or regional stormwater guidance manual can be incorporated by reference by a local program. As of fall 2006, approximately 36 states, the District of Columbia, and several Canadian provinces and U.S. territories had developed statewide stormwater guidance manuals. (See **Section 6.11** and **Tool 5: Manual Builder** for additional information on existing state and regional stormwater manuals.) In many cases, a stormwater program may still want to issue a local design supplement to adequately address any technical details or local issues that are not discussed in the state or regional manual.

   If a state or regional design manual is not available as a reference, a local stormwater program can still make use of the numerous off-the-shelf resources that are available to develop a stormwater design manual (see **Section 6.11**).

2. ***If there is an existing state or regional stormwater design manual that can be used as a reference, does it contain mandatory design standards or voluntary guidelines or recommendations about the design of stormwater BMPs?***

   Many existing state and regional stormwater design manuals are guidance documents that contain general recommendations about the design of stormwater BMPs but no mandatory design standards that must be used at the local level. Most state manuals are not "regulations," per se, but they can be referenced by a local stormwater ordinance to tie particular design standards to the ordinance. The bottom line is that, in many cases, local action is required to "activate" the preferred design standards. Local program staff should confer with state agency staff on the regulatory status of existing manuals and then make strategic decisions about which material to incorporate by reference (with or without local adaptations) in local codes and design guidance documents.

3. ***If there is an existing state or regional stormwater design manual that can be used as a reference, does it include all the technical design guidance necessary to facilitate the program?***

   Many state and regional stormwater manuals developed in the 1980s and 1990s do not contain guidance on all the elements that should be included in the local stormwater program. Because stormwater management is a constantly evolving field, these older guidance manuals might provide little or no guidance for items that are now considered essential parts of a program, such as the use of low-impact development, source controls, nonstructural BMPs, and landscaping and maintenance plans. If the state or regional manual to be used as a reference does not adequately address these items, or any other items that might be outlined in a local ordinance, a local stormwater design supplement should be developed to properly address them.

4. ***How much educational or background material should be provided to design consultants and plan reviewers in the community?***

   If the information contained in the stormwater guidance manual will be new to the community, more educational information may need to be provided in the manual. Background information on design equations and illustrative design examples that guide users through the selection and design of stormwater BMPs may need to be provided. This information is extremely valuable to those who might be seeing the information for the first time, and it serves as a great reference for local design consultants.

5. ***Should information about post-construction stormwater BMPs and erosion and sediment control practices be combined into a single manual?***

   If a community lacks both an erosion and sediment control (ESC) guidance manual and a stormwater guidance manual, it can be tempting to combine the two into a single document. A unified stormwater manual can lead to greater integration of these two programs and may provide a platform from which to launch public education and outreach efforts. If a unified stormwater manual is created, great care should be taken to ensure that the manual is kept as concise and well-organized as possible.

6. ***What process will be used to update the manual periodically?***

   At their best, stormwater manuals are living documents that can be revised as new technologies and procedures become available. A premeditated and scheduled update process will facilitate maintenance of a modern manual. Updates should be done as frequently as possible to keep up with innovations in stormwater technologies and approaches, regulations, computer software, and other rapidly changing subjects. At a minimum, manuals should be updated every 5 years. Also, it is important that any stormwater ordinances that refer to the design manual include language to reference the *"most recent version"* or *"the design manual, as may be updated from time to time."*

   Standing committees that inform and guide the update process can also be helpful. Early decisions about the manual's format will influence the ease of performing updates. For instance, a manual in an online or three-ring binder format—where modifications are fairly simple to incorporate—may be easier to update than a bound document. Whatever format is used, care should be taken to place the date and version number on each page of the manual so that users know they are working with the most current version (this applies especially to online and electronic versions).

6.5. Outlining the Policy and Procedures Manual

After consideration of the key scoping questions presented above, the next step in developing a stormwater guidance manual is outlining the technical content to be included in the manual.

As noted in **Section 6.2**, this chapter suggests dividing the manual content into two major sections: (1) policy and procedures (P&P) and (2) stormwater design. This section presents information on outlining the P&P component. **Sections 6.6** through **6.11** address the stormwater design manual components.

A P&P manual should contain the forms, checklists, and flowcharts that support the implementation of the local stormwater ordinance. An effective manual accomplishes the following:

- Clarifies how the local stormwater ordinance applies to new development and redevelopment projects and describes which development activities are exempt from the requirements of the ordinance.
- Outlines the local project review process and highlights the materials and documentation that must be submitted to facilitate efficient plan review.
- Describes the local stormwater BMP construction and maintenance inspection program and defines when and how stormwater BMPs will be inspected during and after construction.
- Highlights how stormwater BMPs will be tracked and monitored by the local stormwater program.

- Includes procedures and forms to be used for the local program's enforcement program, as outlined in the ordinance.

A P&P manual should be well organized and relatively concise. Probably the most intuitive way to organize the manual is to separate it into sections or chapters that focus on the individual elements of a local stormwater program. For example, one section can be dedicated to the plan review process, while another can be dedicated to the stormwater BMP inspection program. A typical P&P manual outline is provided in **Table 6.1,** and **Table 6.2** describes some of this content in more detail.

6.6. Outlining the Stormwater Design Manual

The design manual contains standards and guidance on the selection of stormwater BMPs, the sizing and design of structural and nonstructural BMPs, and the use of hydrologic, hydraulic, and water quality models for design.

A well-organized design manual can help ensure that the requirements of the local stormwater ordinance are adequately and accurately implemented during project design. Although the ordinance might define the general stormwater management criteria for a development site, the design manual should provide the detail necessary to select, design, and size a BMP or series of BMPs that meet the requirements of the

Table 6.1. Typical Policy and Procedures Manual Outline

- **Introduction**
  - Purpose of Manual
  - Relationship of Manual to Local Stormwater Ordinance
- **Ordinance Applicability**
  - Regulated Development Activities
  - Exempted Development Activities
- **Stormwater Plan Review Process**
  - Application and Submittal Requirements
  - Plan Review Flow Chart
  - Plan Review Checklists
  - Schedule of Other Potentially Required Permits (e.g., state, federal)
  - Information about Maintenance Agreements and Plans
  - Information about Deeds of Easement
  - Performance Bond Program Information
  - Project Closeout Information (e.g., As-Built Plans, Certificates of Completion)
  - Schedule of Plan Review Fees
  - Waiver and Fee-in-Lieu Program Information (e.g., Alternative Compliance)
- **Installation of Post-Construction Stormwater BMPs**
  - Inspection Procedures and Frequencies
  - Inspection Checklists
  - Enforcement, Violations, and Penalties
- **Stormwater BMP Maintenance Inspection Program**
  - Inspection Procedures and Frequencies
  - Inspection Checklists
  - Tracking and Monitoring Program for Stormwater BMPs
  - Enforcement, Violations, and Penalties

Table 6.2. **Policy and Procedures Manual Content**

Stormwater Plan Review Process

- ***Applications and Documents***: An outline of the overall plan review process, a plan review flow chart, application forms and submittal checklists, submittal and review timelines, procedures for amending development plans, and an outline of the decision appeals process (see **Chapter 7** for more detail).
- ***Checklists***: Checklists for plan review, including checklists for individual stormwater BMPs that may be used as part of a stormwater plan.
- ***Permit Coordination***: Information about how local project review will be coordinated with other applicable local, state, and federal permits programs for activities in wetlands, streams, and floodplains, as well as a schedule of other potentially applicable local, state, and federal permits.
- ***Maintenance Agreements***: Information about maintenance agreement and plan requirements, standard maintenance agreement forms, and procedures for recording agreements.
- ***Operation and Maintenance (O&M) Plan Templates***: Templates for O&M plans that are specific to each type of structural and nonstructural BMP. The templates should include maintenance activities and frequencies for routine and structural maintenance and should reference any legal agreements in place that guide maintenance. **Tool 6: Checklists** can help guide the development of BMP-specific O&M templates.
- ***Easements***: Information about stormwater, drainage, and access easements, including a definition of when and where they must be provided and what their dimensions must be, standard deeds of easement, and procedures for recording easements.
- ***Performance Bonds***: Information about local performance bond or "guarantee" programs, including specific program requirements, standard bond forms, a bond value computation form, and an outline of bond release procedures (see **Tool 7**).
- ***Project Closeout***: Information about project closeout, including requirements for as-built plan submittal and review, and procedures for issuing stormwater certificates of completion.
- ***Fees***: A schedule of fees for the plan review process.
- ***Waivers***: An outline of the local waiver and fee-in-lieu program, including program requirements, procedures for approving waivers and fees-in-lieu, and a schedule of fees.

Chapter 7 of this manual contains additional discussion about the stormwater plan review program.

Installation of Post-Construction Stormwater BMPs

- ***Inspection Schedule***: Procedures for standard construction inspections and times when BMP construction inspections will occur (e.g., initial site inspection, critical BMP installation stages, final site inspection, as-built confirmation).
- ***Checklists***: Documentation procedures for inspections, including standard construction inspection checklists.
- ***Enforcement***: Requirements for correcting inadequacies found during construction inspections and enforcement tools that are available for use by the local stormwater program.

Chapter 8 of this guidance contains additional discussion about the development of a stormwater BMP construction inspection program.

Stormwater BMP Maintenance

- ***Inspection Schedule***: Procedures for standard maintenance inspections (e.g., either by the stormwater program or self-inspections by the owner/operator) and how often the inspections will occur.
- ***Checklists***: Documentation procedures for inspections, including standard maintenance inspection checklists.
- ***Monitoring***: Information about how the results of maintenance inspections will be monitored over the long term.
- ***Enforcement***: Requirements and timelines for correcting inadequacies found during inspections and enforcement tools that are available for use by the stormwater program.

Chapter 9 of this guidance contains additional discussion about the development of a post-construction maintenance program.

ordinance. In this regard, the design manual serves as the "users' guide" for program compliance.

Subsequent sections of this chapter provide more guidance on the recommended elements of a design manual, including:

- List of recommended BMPs (**Section 6.7**)
- Stormwater BMP design specifications (**Section 6.8**)
- Stormwater BMP computations and models (**Section 6.9**)
- Stormwater credit systems (incentives for LID) (**Section 6.10**)
- The Manual Builder Tool (**Section 6.11**)

Table 6.3 presents the outline of a typical stormwater design manual.

Table 6.3. Typical Design Manual Outline

- **Introduction**
  - Purpose of Manual
  - Relationship to Local Stormwater Ordinance
- **General Stormwater Management Information**
  - Why Stormwater Matters
  - General Principles for Stormwater Management
  - How Local Conditions Affect Stormwater Management
- **Stormwater Management Criteria**
  - Stormwater Management Criteria
  - Special Stormwater Design Criteria for Sensitive Receiving Waters
- **Stormwater BMP Selection**
  - Approach to Stormwater BMP Design and Selection
  - Stormwater BMP Selection Guidance and Selection Matrices
  - List of Recommended Stormwater BMPs
  - Use of Proprietary Stormwater BMPs
- **Stormwater BMP Standards and Specifications**
  - Site Requirements/Feasibility
  - Conveyance
  - Pretreatment
  - Treatment
  - Landscaping
  - Safety Features
  - Maintenance Reduction Features
- **Stormwater BMP Design Methods and Computations**
  - Acceptable Hydrologic, Hydraulic, and Water Quality Models
  - Required Modeling and Design Assumptions
  - Design Examples
- **Stormwater Credit Program Information**
  - Available Low-Impact Development (LID) Credits and Applications
  - Credit Computation Procedures
  - LID Fact Sheets (if not included in Specifications section)
- **Appendices (e.g., Design Tools and Resources)**
  - Approved Plant Lists
  - Computer-Aided Design and Drafting (CADD) Details
  - Soil and Geotechnical Investigation Guidance
  - Other technical support for local program

6.7. Design Manual: List of Recommended BMPs

In addition to outlining the local approach to BMP selection, the stormwater design manual should include a list of structural and nonstructural BMPs that are recommended for use in the community. A general approach for the BMP list may be a tiered process, such as the following:

- Specifically list BMPs that are good matches for the community in terms of pollutant removal performance, maintenance burden, aesthetics, community acceptance, and other factors. The manual's design specifications will focus on these BMPs.
- Establish an open-ended process for the acceptance of other BMPs that developers and design consultants might ask to use for particular applications. The process should request consistent information and be equitable for the various parties seeking authorization to use various BMPs. (See **Tool 8: BMP Evaluation Tool** for a suggested process.)
- Provide a more rigorous set of guidelines or restrictions for BMPs that have proven difficult, have led to complaints, have an unusually high maintenance burden, and/or have had performance problems.

Table 6.4 provides some general guidance on determining an appropriate set of recommended BMPs.

6.8. Design Manual: Stormwater BMP Design Specifications

This section of the design manual should contain stormwater BMP design specifications and typical details for each of the individual site design, source control, and structural stormwater BMPs. These specifications are very important because they influence the performance, appearance, safety, maintenance burden, and community benefits provided by the final product. Stormwater BMP specifications are intended to make sure the right practice is installed in the right situation.

Nowhere else in the design manual will there be such a conflict between the need to be prescriptive and the opportunity to offer designers more flexibility to come up with creative solutions for a site. This is a situation where the stormwater manager needs to concentrate on wordsmithery—particularly with respect to words like *shall* and *should* because these words define which specifications are mandatory and which are merely optional or encouraged.

Most stormwater BMP fact sheets address the following items:

Site Requirements/Feasibility: These specifications ensure that a stormwater BMP is used only in an appropriate setting where it can work effectively. Common feasibility factors include:

- Minimum or maximum contributing drainage area
- Slope
- Available head
- Soil infiltration rate
- Depth to water table
- Depth to bedrock

Conveyance: These specifications deal with the plumbing into and out of the stormwater BMP and its connection to the storm drain system or discharge to a stream network. The primary goals are to prevent erosion at inlets and outlets, provide safe overflow and adequate conveyance for storms that exceed the water quality volume, and ensure the right volumes are diverted for stormwater treatment.

Pretreatment: Pretreatment is absolutely essential for all types of structural stormwater BMPs to keep sediment out of the main treatment cell, although the type, form, and volume of pretreatment practices often differ between practices. Good stormwater specifications tend to be numeric and prescriptive with respect to pretreatment requirements, and they clearly specify acceptable forms of pretreatment.

Treatment: The performance of most stormwater BMPs is not governed by only the size of the water quality volume provided. Other design factors, such as geometry, flow path, media, and residence time, should be clearly specified to ensure adequate performance.

Table 6.4. Developing a Recommended BMP List

The following criteria should be considered when determining a community's recommended BMPs. Not all BMPs can score high across all of these criteria, but desirable BMPs provide a sufficient level of performance for most of them.	
Provide reliable pollutant removal performance	The BMP should employ a sequence of pollutant removal mechanisms that maximize the removal of key pollutants of concern. BMP performance can be evaluated on the basis of removal efficiency, effluent concentration, and the documentation of pollutant removal design features (e.g., pretreatment, filtering, settling,). See **Tool 8: BMP Evaluation** for more guidance on BMP performance.
Have a sustainable maintenance burden	Both routine and nonroutine maintenance tasks should promote longevity, and the life cycle costs should be manageable so that future owners can maintain the BMP.
Be acceptable to the public	The BMP should be viewed by adjacent residents and business owners as an attractive community amenity and/or landscape feature that adds to rather than detracts from property values.
Confer multiple community benefits	The BMP should do more than just treat stormwater; it should also promote community greening, recreation, and stormwater education.
Creatively use vegetation	The BMP should use trees and vegetation to promote cooling, shading, screening, and other landscape functions and should avoid the extensive use of irrigated turf.
Create habitat but reduce nuisances	The BMP should create both aquatic and terrestrial habitat and should be designed to avoid nuisance problems such as resident geese and mosquito breeding.
Have no unanticipated negative impacts on the environment	The BMP should not create any negative environmental impacts, such as stream warming or groundwater contamination.

Landscaping: Enhancing the appearance and community benefits of a stormwater design is frequently overlooked in BMP specifications. The trend in recent years is to require landscaping plans for every practice and to provide detailed landscaping guidance in a manual appendix.

Safety: Stormwater specifications should be clear on how safety hazards, such as deep pools, sharp drop-offs, riser access, and other safety problems will be minimized in both design and construction. The trend in recent years has been to manage risk by preventing unsafe contours and using dense vegetation to control access to certain areas (rather than excluding people through unsightly fences). Given potential liability concerns, communities should be very clear and specific about what is required to protect public safety.

Maintenance: Good stormwater specifications focus on criteria to reduce the maintenance burden for the stormwater BMP and make maintenance tasks easier to perform. Including good maintenance-reduction criteria in stormwater specifications reduces the long-term maintenance burden and life-cycle cost of BMPs. Specifications should always make sure that future owners have easy access to the parts of the practice that need to be inspected and maintained. **Table 6.5** lists several examples of maintenance-reduction design specifications. Chapter 9 provides additional information on maintenance design recommendations, as well as various approaches for maintenance responsibility.

Tool 5: Manual Builder can be used to find good examples from around the country for BMP design specifications.

6.9. Design Manual: Stormwater BMP Computations and Models

This section of the manual provides detailed guidance on the actual design of stormwater BMPs by outlining required design assumptions; providing an overview of the acceptable hydrologic, hydraulic, and water quality

Table 6.5. Examples of Maintenance Reduction Criteria (CWP and MDE, 2000; CWP, 2004)

- Access paths within easements, with load-bearing capacity suitable for maintenance equipment, should extend to all major stormwater BMP features, including the pretreatment facility, inflow points, outfall, filter beds, embankment, and riser area. Maintenance access paths should be at least 12 feet wide, have a maximum slope of 15%, and be appropriately stabilized (e.g., reinforced turf) to withstand maintenance equipment and vehicles.
- Pretreatment facilities should be designed to allow for sediment removal and regular maintenance. For example, use a hard surface such as concrete pavers for the bottom of a sediment forebay. For underground practices, locate a large manhole opening directly over the sedimentation chamber and ensure that a vactor truck can access the manhole. Maintenance clean-out elevations should be physically marked on pretreatment structures.
- Stormwater ponds and wetlands should be designed to allow for sediment removal and provided with a designated on-site disposal area or, at minimum, an on-site dewatering area.
- Filtration and infiltration practices should be designed to allow for filter bed removal and replacement.
- Outlet structures must be located within embankments for maintenance or emergency access and should be accessible during storm events.
- Access to outlet structures must be provided by lockable manhole covers and, if necessary, manhole steps within easy reach of valves and other controls.
- Principal spillways must be equipped with a trash rack that provides access for maintenance.
- Stormwater ponds, wetlands, and infiltration practices must be equipped with an underdrain system that can completely drain the treatment cell within 24 hours. The underdrain must be equipped with an adjustable valve and should be over-designed (one pipe size greater than the required design diameter). Underdrain valve controls must be located inside the outlet structure at a location where they will not normally be inundated.
- Low-flow orifices must have a minimum diameter of 3 inches and must be adequately protected from clogging by an acceptable external trash rack. Use of non-clogging low-flow orifice designs, such as the reverse-slope pipe in a permanent pool or the perforated half-round corrugated metal pipe (CMP), is recommended. Perforated pipe covered with filter cloth is not recommended because of the potential for clogging.
- Infiltration practices must have an observation well consisting of an anchored, 6-inch-diameter perforated PVC pipe with a lockable cap.
- Stormwater ponds and wetlands must have a staff gauge (graded measuring stick) to consistently measure the depth of sediment and the permanent pool elevation.
- A warranty must be provided with all landscaping installations.
- Proprietary BMPs should be covered by a maintenance contract with a qualified maintenance firm before a certificate of occupancy is issued.
- See **Chapter 7** for additional information on stormwater maintenance programs.

models that can be used for design; and providing a number of design examples to illustrate the required local approach.

The foundation of stormwater design is understanding the relationship between the characteristics of a particular drainage area and the stormwater runoff that passes over it. In particular, the relationship between land cover and stormwater quality and quantity must be analyzed. A hydrologic, hydraulic, or water quality model is needed whenever an estimate of these stormwater characteristics is needed for stormwater BMP design.

The design manual should provide guidance on acceptable hydrologic, hydraulic, and water quality models. The design manual should also identify the assumptions that must be made during modeling and BMP design. This last item is particularly important—modeling assumptions play a significant role in stormwater BMP design. Some examples of typical modeling assumptions are presented in **Table 6.6**.

Table 6.6. Examples of Typical Modeling and Design Assumptions

- The Rational Method (Q=CiA) will be acceptable for drainage areas less than 20 acres.
- For drainage areas greater than or equal to 20 acres, the most recent update of TR-55, TR-20, and/or HEC-HMC will be used as basis of design.
- Predevelopment land use will be considered to be forest or meadow in good condition, regardless of the actual condition at the time of application.
- Hydrologic parameters will reflect the ultimate build-out of the land development project, and the land development project as a whole; individual lots will not be considered separate land development projects.
- Runoff calculations for all off-site areas will be based on existing land use conditions or anticipated future land use conditions.
- Site impervious cover will be directly measured from the site plan.
- For determination of soil runoff characteristics, areas that are hydrologically disturbed and compacted will be changed to the next hydrologic soil group (one that has higher runoff potential; for instance, change a "B" soil to a "C" soil).
- The length of overland flow used in time of concentration calculations will be no greater than 150 feet (pervious cover) or 75 feet (impervious cover).
- Rainfall data, as approved by the local stormwater program, will be used for rainfall volume, storm distribution, return frequency, and event duration.

Some interaction between stormwater designers and stormwater program staff is needed to gain consensus on acceptable models and modeling assumptions.

Modeling Overview

A wide variety of models are available for performing hydrologic and hydraulic calculations, and these models are used for many purposes. The most common uses include:

- Characterize stormwater runoff in terms of peaks and volumes
- Predict the impacts of watershed changes
- Determine the effects of stormwater management practices
- Perform hydraulic design
- Provide input to other models

The decision to use a model, and which model to use, is an important part of stormwater management planning. Even though there are no clear rules on how to select the right model, a few simple guidelines can be stated:

1. Define the problem and determine what information is needed and what questions need to be answered.
2. Use the simplest method that can answer the questions and that has an acceptable level of accuracy.
3. Do not try to fit the problem to a model, but try to select a model that fits the problem.
4. Question whether increased accuracy is worth the increased effort. (With the advances in computer technology, computational cost is hardly an issue anymore.)
5. Do not forget the assumptions underlying the model used, and do not read more significance into the simulation results than is actually there.

Hydrologic models are used to estimate runoff volumes, peak flows, and the temporal distribution of runoff at a particular location resulting from a given precipitation record or event. Essentially, hydrologic models are used to predict how the site topography, soil characteristics, and land cover will cause runoff either to flow relatively unhindered through the system to a point of interest or to be delayed or retained somewhere upstream. Many hydrologic models also include relatively simple procedures to route runoff hydrographs through storage areas or channels, and to combine hydrographs from multiple watersheds.

Hydraulic models are used to predict the water surface elevations, energy grade lines, flow rates, velocities, and other flow characteristics throughout a drainage network that result from a given runoff hydrograph or steady flow input. Generally, the output (runoff) from a hydrologic model is used as the input to a hydraulic model. The hydraulic model then uses various computational routines to route the runoff through the drainage network, which might include channels, pipes, control structures, and storage areas.

Combined hydraulic and hydrologic models provide the functions of both hydraulic models and hydrologic models in one framework. A combined model takes the results from the hydrologic portion of the model and routes them through the hydraulic portion of the model to provide the desired estimates.

A variety of common hydrologic and hydraulic models are summarized in **Table 6.7**. **Table 6.8** provides more detail about these models and their applications (**Akan and Houghtalen, 2003**; **Huber et al. 2006**).

Table 6.7. Summary of Hydrologic and Hydraulic Models

Model or Tool	Input Complexity	Continuous Modeling	Public Domain
Rainfall-Runoff Calculation Tools: peak flow, runoff volume, and/or event hydrograph calculations only			
Rational Method (equation)	Low	No	Yes
Hydrologic Models: rainfall-runoff simulation, reservoir and channel routing			
TR-55	Low	No	Yes
HEC-HMS	Medium	Yes	Yes
WinTR-20 (or TR-20)	Medium	No	Yes
Hydraulic Models: water surface profile determination along waterways and through structures			
CulvertMaster	Low	No	No
FlowMaster	Low	No	No
HEC-RAS	Medium	Yes	Yes
WSPRO	Medium	No	Yes
Combined Hydraulic and Hydrologic Models: rainfall-runoff results automatically input into hydraulic calculation module			
HydroCAD	Medium	No	No
PondPack	Medium	No	No
EPA-SWMM	Medium/High	Yes	Yes
XP-, PC-, MIKE- SWMM	Medium/High	Yes	No

Table 6.8. Description and Applications for Various Models

Rational Method

The rational method is a simple calculation of peak flow based on drainage area, rainfall intensity, and a non-dimensional runoff coefficient. The peak flow is calculated as the rainfall intensity in inches per hour multiplied by the runoff coefficient and the drainage area in acres. The peak flow, *Q*, is calculated in cubic feet per second as $Q = CiA$, where *C* is the runoff coefficient, *i* is the rainfall intensity, and *A* is the drainage area. This method is best used only for simple approximations of peak flow from small watersheds.

TR-55, Urban Hydrology for Small Watersheds
Win TR-55

Technical Release 55 (TR-55): Urban Hydrology for Small Watersheds was developed by the U.S. Department of Agriculture (USDA) Soil Conservation Service (SCS), now the Natural Resources Conservation Service (NRCS), in 1975 as a simplified procedure to calculate storm runoff volume, peak rate of discharge, hydrographs, and storage volumes. In 1998 Technical Release 55 and the computer software were revised to what is now called WinTR-55. WinTR-55 is a single-event, rainfall-runoff small watershed hydrologic model. The WinTR-55 generates hydrographs from both urban and agricultural areas at selected points along the stream system.

WinTR-55 is available on the NRCS Web site. The model and support documentation can be downloaded for free at: ***http://www.wsi.nrcs.usda.gov/products/W2Q/H&H/Tools_Models/WinTR55.html***

HEC-HMS

HEC-HMS is a rainfall-runoff model developed by the U.S. Army Corps of Engineers to compute runoff hydrographs for a network of watersheds. The model evaluates infiltration losses, transforms precipitation into runoff hydrographs, and routes hydrographs through open channel routing.

The HEC-HMS program is available to the public and can be downloaded from the U.S. Army Corps of Engineers Web site: ***http://www.hec.usace.army.mil/software/hec-hms***

TR-20

Technical Release No. 20 (TR-20): Computer Program for Project Formulation Hydrology was developed by the hydrology branch of the USDA Soil Conservation Service in 1964. TR-20 is a single-event rainfall-runoff model that is typically used with a design storm for rainfall input. The program computes runoff hydrographs, routes flows through channel reaches and reservoirs, and combines hydrographs at confluences of the watershed stream system.

The TR-20 program is available to the public and can be downloaded from the NRCS Web site: ***http://www.wsi.nrcs.usda.gov/products/W2Q/H&H/Tools_Models/WinTR20.html***

HEC-RAS

HEC-RAS is a river hydraulics model developed by the U.S. Army Corps of Engineers to compute one-dimensional water surface profiles for steady or unsteady flow. Computation of steady-flow water surface profiles is intended for floodplain studies and floodway encroachment evaluations. Unsteady flow simulation can evaluate subcritical flow regimes, as well as mixed flow regimes including supercritical, hydraulic jumps, and drawdowns. Sediment transport calculation capability will be added in future versions of the model.

The HEC-RAS program is available to the public and can be downloaded from the U.S. Army Corps of Engineers Web site: ***http://www.hec.usace.army.mil/software/hec-ras***

WSPRO

WSPRO is a model for water surface profile computations developed by the U.S. Geological Survey. The model evaluates one-dimensional water surface profiles for systems with gradually varied, steady flow.

The WSPRO program is available to the public and can be downloaded from the U.S. Geological Survey Web site: ***http://water.usgs.gov/software/wspro.html***

Table 6.8. Description and Applications for Various Models *(continued)*

CulvertMaster

CulvertMaster is a hydraulic analysis program for culvert design. The model uses the Federal Highway Administration's Hydraulic Design of Highway Culverts methodology to provide estimates for headwater elevation, hydraulic grade lines, discharge, and culvert sizing.

CulvertMaster is a proprietary model that can be obtained from Bentley Systems, Inc.:
http://www.bentley.com/en-US/Products/CulvertMaster

FlowMaster

FlowMaster is a hydraulic analysis program used for the design and analysis of open channels, pressure pipes, inlets, gutters, weirs, and orifices.

FlowMaster is a proprietary model that can be obtained from Bentley Systems, Inc.:
http://www.bentley.com/en-US/Products/FlowMaster

HydroCAD

HydroCAD is a computer-aided design program for modeling the hydrology and hydraulics of stormwater runoff. Runoff hydrographs are computed using the SCS runoff equation and the SCS dimensionless unit hydrograph. HydroCAD has the ability to simulate backwater conditions by allowing the user to define the backwater elevation before simulating a rainfall event.

HydroCAD is a proprietary model that can be obtained from HydroCAD Software Solutions, LLC: ***http://www.hydrocad.net***

PondPack

PondPack is a program for modeling and design of the hydrology and hydraulics of stormwater runoff and pond networks. Rainfall analyses can be conducted using a number of synthetic or historical storm events, using methods such as SCS rainfall distributions, intensity-duration-frequency curves, or recorded rainfall data. Outlet calculations can be performed for outlets like weirs, culverts, orifices, and risers. The program can assist in determining pond sizes.

PondPack is a proprietary model that can be obtained from Bentley Systems, Inc.:
http://www.bentley.com/en-US/Products/PondPack

SWMM-Based Programs

The Storm Water Management Model (SWMM) was originally developed for the U.S. Environmental Protection Agency (EPA) in 1971 by Metcalf and Eddy, Inc., Water Resources Engineers, Inc., and the University of Florida. SWMM is a dynamic rainfall-runoff and water quality simulation model, primarily but not exclusively for urban areas, for single-event or long-term (continuous) simulation.

SWMM is a comprehensive computer model for analysis of quantity and quality problems associated with urban runoff. It can be used for planning and design. The planning mode is used for an overall assessment of urban runoff problem or proposed abatement options.

The SWMM program is available to the public and can be downloaded from the U.S. Environmental Protection Agency's Web site:
http://www.epa.gov/ednnrmrl/models/swmm

The proprietary shells, XP-SWMM and PC-SWMM, provide the basic computations of EPA-SWMM with a graphic user interface, additional tools, and some additional computational capabilities. XP-SWMM is available on the XP Software company Web site:
http://www.xpsoftware.com

PC-SWMM is available on the Computational Hydraulics International Web site:
http://www.computationalhydraulics.com

References: Akan and Houghtalen, 2003; ARC, 2001; Hydrocomp Inc., 2008; MSSC, 2005; PA DEP, 2006; Huber et al. 2006.

6.10. Design Manual: Leveling the Playing Field between Low-Impact Development (LID) and Conventional Practices—Stormwater Credit Systems

Oftentimes, low-impact development practices (LID) are not used because there is no local system to get them approved on development plans. Even if all parties involved (plan reviewers, developers, design consultants) are interested in LID practices, they cannot be fully incorporated unless they are considered coequal to more conventional practices, and their benefits for water quality and runoff reduction are counted in the local compliance process.

Most conventional BMPs have well-defined sizing and water quality computation procedures by which the local reviewer can establish compliance. However, computational methods for LID are more uncertain and less widely known and accepted.

Even with these difficulties, there are benefits to be derived from incorporating LID into site design, including:

- In some cases, LID can be more economical for the developer while still providing effective stormwater treatment (if properly designed, implemented, and maintained).
- These measures can also reduce the size and/or footprint of conventional, structural stormwater conveyance and treatment systems needed at a site.
- Most LID techniques have aesthetic benefits and can enjoy wider homeowner acceptance compared to certain conventional practices. For instance, a restored riparian buffer and grass channels are usually more acceptable to the public than a conventional "backyard" basin.
- Use of LID allows the site designer to tailor stormwater solutions to the particular conditions and opportunities at the site. For example, if a site has many unbuffered streams or open spaces previously used for agriculture, restoration plans can become part of the stormwater mix.
- Certain LID techniques can be coordinated with land use strategies to protect water resources. An example is encouraging shared parking, and thus a reduced parking lot footprint, in areas where the locality wishes to encourage infill and redevelopment.

An emerging way to incorporate LID into stormwater compliance systems is to consider the ability of various practices to reduce the overall volume of runoff. "Runoff reduction" tends to level the playing field between LID and conventional practices because it provides a common denominator that can be ascertained for a fuller range of practices than are typically allowed in local and state stormwater manuals.

Runoff reduction can be defined as the total annual runoff volume reduced through canopy interception, soil infiltration, evaporation, transpiration, rainfall harvesting, engineered infiltration, or extended filtration. By nature, BMPs that reduce the overall volume of runoff also reduce pollutant loads, and they can also help mitigate other stormwater concerns, such as downstream channel erosion and reduced groundwater recharge.

Chapter 4 (Table 4.8) provides more detail on runoff reduction as a stormwater management criterion. **Table 6.9** lists the runoff reduction capabilities of various conventional and LID practices based on an extensive literature search (**Hirschman et al. 2008**). The values in the table are generally average annual runoff reduction rates from research studies, and they pertain chiefly to smaller storm events (e.g., 90^{th} percentile rainfall event or less—equivalent to the "water quality volume"; see **Table 4.9**).

Various state programs are updating their stormwater regulations and handbooks to incorporate the principles of runoff reduction. **Hirschman et al. (2008)** provides a comprehensive compliance system, including a spreadsheet tool, that can be used or adapted to provide credit for runoff reduction practices. This system is based specifically on reduction in nutrient loads, but it could be adapted to other pollutants of concern (see ***www.cwp.org*** > Resources > Controlling Runoff & Discharges > Stormwater Management > National/Regional Guidance).

Table 6.9. Runoff Reduction for Various BMPs

Stormwater Practice	Runoff Reduction Rates from Literature (%)[a]
Green Roof	45–60
Rooftop Disconnection	25–50
Raintanks and Cisterns	Amount captured and reused
Pervious Parking	45–75
Grass Channel	10–20
Bioretention	40–80
Dry Swale	40–60
Wet Swale	Less than 10%
Infiltration	50–90
Extended Detention Pond	0–15
Soil Amendments	50–75
Filter Strip; Sheetflow to Open Space	50–75
Filtering Practice	Less than 10%
Constructed Wetland	Less than 10%
Wet Pond	Less than 10%

[a] Ranges of values are for different design components that vary in their ability to promote runoff reduction. For instance, bioretention that is designed for infiltration into the subsoil has a higher runoff reduction rate than bioretention with an underdrain, where infiltration rates are less.

Also, values represent average annual reductions based on research studies. The values are relevant chiefly for smaller storm events—approximately the 90th percentile rainfall event or less. Some runoff reduction can also be achieved for larger events (channel protection and/or flood control runoff events), but the values would likely be adjusted depending on site runoff characteristics.

Source: **Hirschman et al. 2008**.

A number of other state and local stormwater programs have crediting procedures for LID that a stormwater program can tailor to its own needs. References and web links to several of these programs are provided in **Tool 5: Manual Builder**. See also the resources listed in **Tables 4.7** and **4.8** concerning site natural resource inventories and runoff reduction criteria.

The design manual plays a critical role in establishing a stormwater credit system. The manual should describe each credit, indicate how it is computed, outline required site conditions, highlight restrictions to where it can be applied, and conclude with a numerical design example.

Not all credits are available for each development site, and certain site-specific conditions must be met to receive each credit. These minimum conditions include site factors like maximum flow length or contributing area. These "eligibility criteria" help to avoid situations that lead to runoff concentration, erosion, and possible drainage complaints. An example of eligibility criteria needed to receive a stormwater credit for grass channels is provided in **Table 6.10**.

As an additional resource, **Tool 6: Checklists** provides plan review, construction, and maintenance inspection checklists for various nonstructural practices that can be considered for stormwater credits.

Experience in other states has shown that it can take a while for both local plan reviewers and engineering consultants to understand and effectively use stormwater credits during site design and plan review. Adoption of credits is particularly difficult in communities where stormwater design occurs long after site layout, giving designers and plan reviewers little chance to apply LID techniques and the corresponding credit system.

Four ingredients appear to be important in establishing an effective local credit system:

- Strong interest and some experience in the use of LID techniques.
- A development review process that emphasizes early stormwater design consultations during and prior to initial site layout. Such procedures as pre-submittal meetings and concept plans are strongly encouraged.
- Effective working relationships between plan reviewers and design consultants.
- A commitment by both parties to field verification to ensure that credits are not a paper exercise.

If a community feels that it has many of these ingredients in place, the local program should start to develop a stormwater credit system.

Table 6.10. Eligibility Criteria for Grass Channel Credit

Eligibility: A qualifying grass channel meets the following criteria:

- Primarily serves low to moderate residential development, with a maximum density of 4 dwelling units per acre
- The bottom width of the channel should be between 4 and 8 feet wide.
- If suitable soil amendments are provided for channels in C/D soils, the 20% runoff reduction rate may be used. For channels in A/B soils, soil amendments are not needed so long as soils are protected during site construction.
- Channel side-slopes should be no steeper than 3H:1V
- The longitudinal slope of the channel should be no greater than 2%. (Checkdams or a terraced swale design may be used to break up slopes on steeper grades.)
- The maximum contributing drainage area to any individual grass channel should be 5 acres.
- The dimensions of the channel should ensure that runoff velocity is non-erosive during the 2-year design storm event and safely convey the local design storm (e.g., 10-year design event).
- Designers should demonstrate that the channel will have a maximum flow velocity of 1 foot per second during a 1-inch storm event.

See **Tool 5: Manual Builder** for additional stormwater credit design references.

For a fuller overview of the topic of stormwater BMP performance for both conventional and innovative practices, see EPA's online ***Urban BMP Performance Tool***: ***www.epa.gov/npdes/urbanbmp***

6.11. Building a Stormwater Manual: The Manual Builder Tool

Once the scope of the local stormwater guidance manual has been determined and a manual outline developed, the next step is to actually build the manual. This section provides information about the development of a stormwater guidance manual and information on how to use existing state and regional stormwater manuals and existing off-the-shelf stormwater resources.

At the outset, the stormwater manager should keep in mind several do's and don'ts of manual writing that have been acquired through hard-won experience across the country. These tips are profiled in **Table 6.11**.

There are a significant number of existing state, regional, and local stormwater management guidance manuals that can be used to develop a local manual.

Tool 5: Manual Builder was created to help stormwater managers sort through these existing manuals to find the information they need to most efficiently develop a local manual.

A total of 51 state, regional, and local stormwater management guidance manuals were reviewed to develop the **Manual Builder** tool. These manuals are listed in **Table 6.12**. If the manuals were stacked on top of each other, the pile would be more than 10 feet high (see **Tool 5** for links to these documents on the Internet). The stack would contain tens of thousands of pages of material, much of which is redundant or recycled from other manuals.

To help stormwater managers most efficiently find the information they need to build a stormwater guidance manual, the **Manual Builder** tool indexes existing design and policy and procedures manuals by the best examples in a variety of topic areas, as listed in **Table 6.13**.

Stormwater managers can use the tool to quickly find good information on the topics they are most interested in. Once the most appropriate material is identified, it can be customized to fit local conditions.

Table 6.11. Manual Writing Do's and Don'ts

Do:

- Clearly indicate what is required, recommended, or merely encouraged.
- Keep the manual as concise as possible.
- Describe why the management of post-construction stormwater is important.
- Organize the manual in such a way that users can quickly find the information they need.
- Provide documentation to support the local stormwater management criteria and design requirements.
- Check every equation three times.
- Allow the manuals to be revised administratively.
- Place the date and version number on each page of the manual so users know they are working with the most current version.
- Consider making the manual available on a CD or as a Web-based document to better facilitate distribution.
- Place design tools and resources in appendices, where they can be added or removed as necessary.
- Solicit input from the design and development community. Consider forming a technical review committee composed of municipal staff and outside stakeholders.

Don't:

- Include a lot of unnecessary background information.
- Expect folks to read the manual from cover to cover.
- Randomly cut and paste from another manual without careful adaptation.
- Scatter requirements for an individual BMP throughout the manual. Instead, develop individual fact sheets for each BMP that identify all the important selection, design, construction, and maintenance information.
- Present stormwater management criteria and design requirements without providing corresponding design methodologies and documentation.
- Make the manual more than about 2 inches thick.
- Ignore the input and comments from the local stormwater design and development community.

Table 6.12. Directory of State and Local Stormwater Manuals Reviewed

State Manuals	
Alabama	*Alabama Handbook for Erosion Control, Sediment Control and Stormwater Management on Construction Sites and Urban Areas*
Alaska	*Alaska Stormwater Pollution Prevention Plan Guide*
British Columbia	*Stormwater Planning: A Guidebook for British Columbia*
California	*New Development and Redevelopment Stormwater Best Management Practice Handbook*
Colorado	*Erosion Control and Stormwater Quality Guide*
Connecticut	*2004 Connecticut Stormwater Manual*
Delaware	*Green Technology: The Delaware Urban Runoff Management Approach*
District of Columbia	*Stormwater Management Guidebook*
Florida	*Florida Development Manual: A Guide to Sound Land and Water Management*
Georgia	*Georgia Stormwater Management Manual*
Guam	*Northern Mariana Islands and Guam Stormwater Management Manual*
Idaho	*Catalog of Stormwater BMPs for Idaho Cities and Counties*
Illinois	*Illinois Urban Manual*
Iowa	*Iowa Stormwater Management Manual*
Kansas	*Protecting Water Quality: A Field Guide to Erosion, Sediment and Stormwater Best Management Practices for Development Sites in Missouri and Kansas*
Kentucky	*Best Management Practices (BMPs) for Controlling Erosion, Sediment, and Pollutant Runoff from Construction Sites: Planning and Technical Specifications Manual*
Maine	*Stormwater Management for Maine*
Maryland	*Maryland Stormwater Design Manual*
Massachusetts	*Stormwater Management Handbook*
Michigan	*Guidebook of Best Management Practices for Michigan Watersheds*
Minnesota	*The Minnesota Stormwater Manual*
Mississippi	*Planning and Design Manual for the Control of Erosion, Sediment, and Stormwater*
Missouri	*Protecting Water Quality: A Field Guide to Erosion, Sediment and Stormwater Best Management Practices for Development Sites in Missouri and Kansas*
Nevada	*Handbook of Best Management Practices*
New Hampshire	*Innovative Stormwater Treatment Technologies Best Management Practices Manual*
New Jersey	*New Jersey Stormwater Best Management Practices Manual*
New York	*New York State Stormwater Management Design Manual*
North Carolina	*Draft Manual of Stormwater Best Management Practices*
North Dakota	*A Guide to Temporary Erosion Control Measures for Contractors, Designers and Inspectors Handbook of Best Management Practices*
Northern Mariana Islands	*Northern Mariana Islands and Guam Stormwater Management Manual*
Ohio	*Rainwater and Land Development Manual*
Ontario	*Stormwater Management Planning and Design Manual*
Oregon	*Biofilters for Stormwater Discharge Pollution Removal*

Table 6.12. Directory of State and Local Stormwater Manuals Reviewed *(continued)*

State Manuals	
Pennsylvania	*Stormwater Best Management Practices Manual*
Rhode Island	*Rhode Island Stormwater Design & Installation Standards Manual*
South Carolina	*South Carolina Stormwater Management and Sediment Control Handbook for Land Disturbing Activities*
Tennessee	*Erosion and Sediment Control Handbook*
Vermont	*Vermont Stormwater Management Manual*
Virginia	*Virginia Stormwater Management Handbook*
Washington	*Stormwater Management Manual for Eastern Washington*
Washington	*Stormwater Management Manual for Western Washington*
West Virginia	*West Virginia Erosion and Sediment Control Best Management Practice Manual*
Wisconsin	*Wisconsin Stormwater Manual*
Wyoming	*Urban Best Management Practices for Nonpoint Source Pollution*
Local Manuals	
Albemarle County, Virginia	*Design Standards Manual*
Austin, Texas	*Drainage Criteria Technical Manual*
Austin, Texas	*Environmental Criteria Technical Manual*
Baltimore, Maryland	*Baltimore City Stormwater Management Manual*
Columbus, Ohio	*Stormwater Drainage Manual*
Dane County, Wisconsin	*Dane County Erosion Control and Stormwater Management Manual*
Urban Drainage and Flood Control District (Denver, Colorado)	*Urban Storm Drainage Criteria Manual*
Eugene, Oregon	*Stormwater Management Manual*
Kansas City Metro Area	*Best Management Practices for Stormwater Quality*
Knoxville, Tennessee	*Land Development Manual*
Knoxville, Tennessee	*BMP Manual*
Lake County, Illinois	*Technical Reference Manual*
Lake County, Ohio	*Bioretention Guidance Manual*
Lexington-Fayette County, Kentucky	*Stormwater Manual*
Los Angeles, California	*Development BMP Handbook*
Philadelphia, Pennsylvania	*Stormwater Management Guidance Manual*
Portland, Oregon	*Stormwater Management Manual*
North Central Texas Council of Governments	*Design Manual for Site Development*
San Diego, California	*Land Development Manual*
Stafford County, Virginia	*Stormwater Management Design Manual*

Note: See Stormwater Manual Internet Directory in **Tool 5**.

Table 6.13. Summary of the Manual Building Tool

Topic Areas for Design Manual	Topic Areas for Policy and Procedures Manual
▶ Stormwater Management Criteria – Stable Conveyance/Channel Protection – Flood Control – Groundwater Recharge – Water Quality ▶ Special Criteria for Sensitive Receiving Waters – Groundwater Protection – Surface Water Protection – Trout Stream Protection – Wetland Protection – Site-Based Pollutant Load Reduction ▶ Special Criteria for Tricky Development Situations – Ultra-Urban/Small Site Practices ▶ Pollution Source Control/Hotspot Management ▶ Smart Growth ▶ Low-Impact Development ▶ BMP Selection Matrices ▶ BMP Fact Sheets ▶ Detailed BMP Design/Performance Specifications – Bioretention – Filtration – Infiltration – Open Channels – Stormwater Ponds – Stormwater Wetlands – Green Rooftops – Porous Pavement – Rain Barrels – Rain Gardens – Experimental/Proprietary BMPs ▶ Hydrologic and Hydraulic Models ▶ Design Examples ▶ Stormwater Credits ▶ Detailed Landscaping Guidance ▶ Detailed BMP Operation and Maintenance Requirements ▶ Karst Topography ▶ Arid/Semi-Arid Climate ▶ Cold Climate	▶ Ordinance Applicability – Redevelopment Criteria – Single-Family Lot Criteria ▶ Application/Submittal Requirements ▶ Plan Review Process ▶ Plan Review Checklists ▶ Permit Coordination ▶ Maintenance Agreements and Plans ▶ Deeds of Easement ▶ Performance Bonds ▶ Waiver/Fee-in-Lieu Programs ▶ Construction Inspection Procedures ▶ Construction Inspection Checklists ▶ Maintenance Inspection Procedures ▶ Maintenance Inspection Checklists ▶ Violations, Enforcement and Penalties

6.12. Tips for Stormwater Guidance Manual Project Management

Scoping And Budgeting for the Manual

This section provides some insights on how a stormwater manager can most effectively scope, budget, and schedule the manual-building and adoption process. In general, the basic steps in the manual-building process consist of:

1. Scoping the Manual (see **Section 6.4)**
2. Outlining the Manual (see **Sections 6.5 and 6.6)**
3. Building the Manual (see **Sections 6.7** through **6.11**)
   - Policy and Procedures Manual
   - Design Manual
4. Collecting Input from Stakeholders
5. Adopting the Manual
6. Training Designers and Plan Reviewers on the Manual
7. Maintaining and Updating the Manual

Since Steps 1 through 3 of the manual building process were detailed earlier in this chapter, this section generally addresses the subsequent steps. However, one key decision that affects the entire manual-building process is determining which steps can be done in-house and which can be assigned to a consultant or subcontractor. The total effort is obviously tied to whether the stormwater guidance manual must be built from scratch or whether an existing state or regional manual can be adopted as a reference.

Table 6.14 provides some general estimates of the staff time and estimated time frame needed to complete each step in the manual-building process, using several assumptions.

In most cases, the manual-building effort will be a blend of in-house labor and contracting effort. The pros and cons of using either form of labor are compared in **Table 6.15**. Some tips on getting the most out of a stormwater consultant are presented in **Table 6.16**.

Maintaining and Updating the Manual

Experience has shown that the first edition of a new stormwater guidance manual is never perfect; errata, clarifications, and policy interpretations are needed from day one. Stormwater managers should always budget some time and money to maintain and update the manual. Changes can be made efficiently if the manuals are posted on the Web (but make sure to number and date each new release). It is also helpful to maintain a user e-mail database so that stormwater managers can quickly notify users about any new releases.

It is recommended that communities update their stormwater manuals at least once every 5 years. This update should include full stakeholder input and focus on improving the effectiveness of the stormwater management program. Also, language in the stormwater ordinance should provide reference to *"the most recent version"* of the manual so that updated material in the manual is covered by the ordinance.

6.13. Involving the Public in Developing the Stormwater Guidance Manual

This section provides information on involving stakeholders in the stormwater manual development process, as well as training both design consultants and plan reviewers on use of the manual once it is developed.

Involving Stakeholders in the Manual-building Process

Because the stormwater guidance manual will be used by the local design community, the manual-building process offers an excellent opportunity to engage this community. Local design consultants, provided that they are familiar with the concepts presented in the manual, can contribute information on what works and doesn't work and give practical insight into the selection and design of stormwater BMPs. Often these discussions can be very productive and can help build a more effective manual.

The manual-building process is also an opportunity to engage other stakeholders by inviting their input and providing them with insight into the local stormwater approach. It can be helpful to expand the stakeholder group to include interests outside the local design community to get a broader level of input and additional opinions on important policy decisions.

Table 6.14. Projected Staff Effort for Each Step of the Manual-Writing Cycle [a]

Manual Building Step	Estimated Staff Effort [e] (days)	Time Frame to Complete (weeks)
1. Scoping the Manual		
a) Manual scoping	5 to 8 days	1 to 3 weeks
b) Scope of work	3 to 5 days	2 to 3 weeks
c) Contracting process	5 to 10 days	4 to 12 weeks
2. Policy and Procedures Manual		
a) No procedures exist	30 to 60 days	12 to 24 weeks [b]
b) Need to add a few	10 to 15 days	8 to 12 weeks [b]
c) Mmost already exist	5 to 8 days	4 to 8 weeks [b]
3. Engineering Design Manual		
a) Start from scratch	150 to 250 days	24 to 72 weeks
b) Major supplement	50 to 100 days	12 to 36 weeks
c) Minor supplement	10 to 25 days	12 to 24 weeks
4. Stakeholder Input		
a) Tech committee	15 to 30 days [c]	12 to 24 weeks
b) Expanded input	Varies	Varies
5. Manual Adoption		
	10 to 15 days	13 to 26 weeks
6. Manual Training		
	15 to 30 days [d]	12 to 24 weeks
7. Manual Maintenance		
a) Initial revision	10 to 20 days	2 to 4 weeks
b) Overhaul during permit	25 to 40 days	12 to 36 weeks

Notes and Assumptions

[a] These projections are illustrative only and should be carefully checked.
[b] Time frame may expand if review by municipal attorney is needed.
[c] Assumes an average of 30 hours staff time per meeting.
[d] Assumes 40 hours per training session.
[e] To get probable consultant cost, convert days to hours and multiply hours by a $100 to $125 hourly rate.

Table 6.15. Pros and Cons of Using In-House and Consultant Labor to Build a Stormwater Management Guidance Manual

In-House Labor	Consultant Labor
Pros	
► Often less expensive ► Ensures greater ownership and understanding ► Can tailor to particular local project review process ► Can tailor to local high-value water resources	► Potential to create a comprehensive and professional-looking manual ► Can bring outside expertise/resources to bear ► Can get it done faster ► Can be perceived as more objective by stakeholders
Cons	
► Will take longer to complete ► Regular responsibilities of staff make it difficult to complete ► Staff may not have necessary expertise ► Professional-looking graphics (e.g., CADD) may be hard to produce	► No municipal ownership of manual after contract is over ► Contracting process can add significant cost to project ► Local firms may not have necessary expertise ► Can be difficult to keep updated if text and graphics are in complicated format

Table 6.16. Getting the Most from a Manual Consultant

- Ask the scoping questions in Section 6.4 to define the manual content before developing a scope of work.
- Use the scope of work to define specifically what you want in your manual before you approach a consultant.
- Determine which tasks are cheaper to do in-house (meeting logistics, inviting stakeholders, coordinating review comments, compiling the project review manual).
- Beware of scope creep. It is better to ask for less and get good quality than to ask for the Cadillac version that exceeds available budget.
- Remember that a lot of meetings and manual revisions will be needed. Make sure you get cost estimates for each.
- Use the consultant to research current options for BMPs and approaches you are not familiar with.
- Think about requiring a double consultant team—a local consultant that is thoroughly familiar with the existing development review process and local stormwater BMPs and a non-local consultant that has demonstrated experience with stormwater designs not currently used in the community.
- If a combination of in-house and consultant labor is used, make sure to assign a single person to coordinate the team effort between the agency and consultant, and make roles and responsibilities clear in the scope of work.
- Strive for a multidisciplinary team (in-house and consultant) with experience in engineering, regional planning, landscape architecture/horticulture, soils and geology, and other disciplines relevant to the stormwater BMPs you want to include in the manual.
- Use a technical or stakeholder committee to give structured input and feedback to the consultant, but make sure the input is compiled and organized clearly by the in-house project manager.

Table 6.17 presents a list of key stakeholders who should be involved in the manual-building process.

Table 6.17. Key Local Stakeholders to Involve in the Manual-Building Process

Consulting engineers	Wetland regulators
Local engineering associations	Landscape architects
Contractors	Public health authorities (re. mosquitoes)
Developers	Local road/highway engineers
Homebuilders	Surveyors
Watershed groups	Homeowner associations
Smart Growth groups	Economic development agencies
Plan reviewers and inspectors	

A range of methods can be used to solicit input from stakeholders during the manual-building process:

- **Technical review committee**: The most traditional method is to assemble a group of stormwater stakeholders to provide input on the scope of the local stormwater manual and to review various drafts as the manual is written. The group can serve as a "standing committee" to help with training and in updating the manual in the future. The committee approach can be quite time-intensive, and it often requires multiple meetings before final consensus is achieved.
- **Focus groups**: This approach seeks to gain input from a select group of experts or stakeholders during a one-time meeting to gauge reaction to proposed manual approaches and key stormwater issues.
- **Field trips, outreach events, workshops**: A dose of stormwater education is often helpful to get stakeholders to understand stormwater issues and practices. These events are experiential, visual, and interactive, and they help the group get a first-hand look at both stormwater problems and solutions.
- **Stormwater site tours and visual tours**: Many stakeholders are hesitant to accept new stormwater BMPs if they have not yet been applied in the community. This reluctance can be overcome by arranging tours in other communities where innovative practices have been effectively used. A more low-cost approach is to develop a visual tour using PowerPoint slideshows of innovative practices from other communities or regions. Check the Center for Watershed Protection's Stormwater Center Web site for an extensive catalog of stormwater images (*www.stormwatercenter.net*).
- **Demonstration BMPs in New Municipal Construction**: Localities may consider demonstrating innovative practices in municipal construction projects as a strategy to gain greater acceptance. This approach of leading by example can help overcome barriers to practice adoption.
- **Public Meetings and Hearings**: These formal settings might be required to give notice, accept comments, or present testimony to formally adopt the manuals. Stormwater managers should not rely solely on these formal meetings to get stakeholder input (since they are customarily held near the end of the rule-making process). Instead, they should consider investing in some of the informal stormwater education methods mentioned above.

Table 6.18 presents some helpful tips aimed at assisting stormwater managers in collecting useful input from stakeholders and making the most of the stakeholder input process.

Training Designers and Plan Reviewers

Many communities get so involved in building the stormwater manual that they are too exhausted or cash-strapped to train their own plan reviewers and engineers on how to actually use it. At the same time, design consultants are notoriously busy and will be sacrificing billable time to learn the information in the manual. Communities will need to allocate time for training plan reviewers and design consultants. Otherwise, municipal staff will end up training design consultants on a piecemeal basis during every plan submittal. Training is a sound investment because it can help reduce future plan review time and result in fewer resubmittals. **Table 6.19** outlines some tips on designing effective training programs for the new stormwater manual.

Table 6.18. Tips for Making the Most of the Stakeholder Input Process

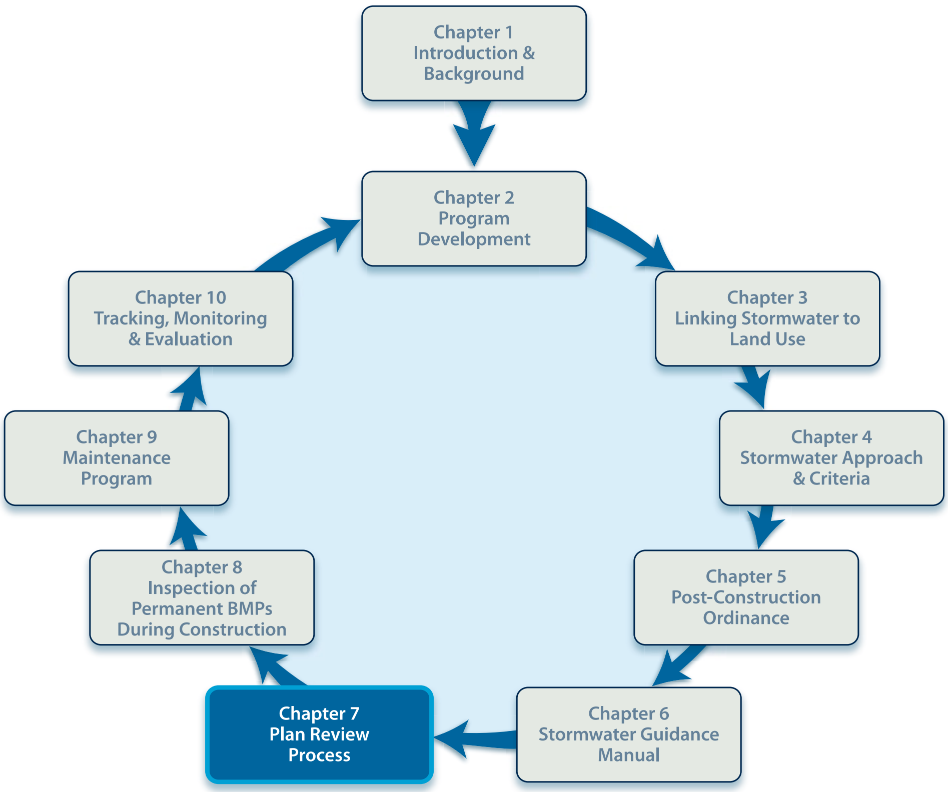
- Keep an up-to-date mailing and notification list for the regulated community (e.g., developers and designers).
- Develop technical support documents or issue papers to support design decisions.
- “Sell” the environmental and economic benefits of new stormwater approaches.
- Use demonstration sites at municipal facilities to “show off” innovative practices and desired approaches.
- Post manual drafts and technical committee comments on the agency Web site so they can be easily accessed.
- Be open to change throughout the manual-writing process.
- Carefully log all comments received and track how each one was handled, and make this record available to stakeholders.
- Develop and communicate clear procedures for keeping the manual updated.
- Make sure to recognize the volunteer efforts of stormwater stakeholders who participate in the manual review process.
- Communicate clearly to decision-makers the intent of the manual to aid compliance (and not to impose additional requirements).

Table 6.19. Tips for Effective Manual Training

- Start with your own plan review and inspection staff. They are the core group that will end up training much of the local design community.
- Provide incentives for designers to attend training sessions, and indicate how attending the training can get their plans approved more quickly and with fewer revisions.
- Conduct short training work sessions at convenient times for the busy professional.
- Use real development sites for design examples.
- Clearly specify what’s new and different in the manual.
- Train consultants in new modeling techniques.
- Administer multiple-choice tests to measure proficiency with the manual.
- Always ask stakeholders what their training needs are, and incorporate their responses into the next training.
- Recognize innovative local designers and include them in the training program.
- Focus on the practices you really want to promote.
- Provide opportunity to discuss stormwater issues and policies that are ***not*** contained in the new manual.
- Get feedback to improve future training sessions.

Chapter 7

The Stormwater Plan Review Process



Companion Tools for Chapter 7s
Download Post-Construction Tools at:
www.cwp.org/postconstruction

What's In This Chapter

- Current trends and issues with stormwater plan review
- Scoping out the best review process for a local stormwater program
- The anatomy of a typical stormwater plan review process
- Tips for building an effective stormwater plan review process
- Involving the public in development review

7.1. Introduction

Previous chapters covered program planning, adopting a stormwater ordinance, and developing a stormwater guidance manual. The next step is to have a plan review process that ensures that the stormwater standards and specifications are translated correctly onto development plans.

Approval of a stormwater plan is an important milestone. After plans are approved, making changes to the situation "on the ground" can be very difficult. Therefore, the plan review and approval process is the best opportunity to get things right with stormwater design.

A well-organized stormwater plan review process can help ensure that:

- Stormwater BMP designs meet the standards and specifications in the ordinance and design manual and are being properly applied to the project site.
- Stormwater plans incorporate innovative practices, such as site design techniques and low-impact development, early in the planning process.
- BMPs are sited within easements and have adequate access for inspection and maintenance.
- Adequate maintenance agreements that assign long-term maintenance responsibility are in place.
- The stormwater BMP plan approval is coordinated with other necessary environmental permits for erosion and sediment control, streams, wetlands, floodplains, and dams.
- Approved stormwater BMPs are covered by performance bonds to ensure proper installation in the field.
- The location and specifications of approved stormwater BMPs are properly documented at each site so that inspection and maintenance staff will have the necessary information.
- The review process generates the appropriate amount of user fees to help defray development review costs.

Although requiring water quality BMPs on development projects may be a relatively new function within a local agency, most local governments have experience with general development plan review. A stormwater plan review process does not have to be created from scratch. The biggest challenges are securing an adequate and well-trained staff and integrating stormwater reviews with other local reviews for drainage, utilities, erosion control, roads, and site layout.

This chapter provides practical guidance for building a stormwater plan review process. The chapter addresses:

- Current trends and issues with stormwater plan review
- Scoping out the best review process for a local program
- The anatomy of a typical review process
- Tips for building an effective process
- Involving the public in stormwater plan review

7.2. Current Trends and Issues with Stormwater Plan Review

The number of stormwater plans reviewed by a local program on an annual basis ranges from fewer than 10 to more than 1,000 (**CWP, 2006**). The actual number could be higher when all resubmissions are included.

The true test of "plan burden" is how many plans are assigned to each reviewer. Many programs do not have enough staff to conduct a thorough review of all the plans submitted. The majority of programs have fewer than 1.5 full-time employees (FTEs) assigned to the review of stormwater plans. In addition, many of these reviewers must also review other types of plans, such as erosion control and road plans.

The number of plans each FTE reviews on an annual basis ranges from around 15 to over 200, with the average reviewer checking from 70 to 100 plans per year (**CWP, 2006**). Some local programs use consultants to review stormwater plans; the review fees are paid by the applicant.

7.3. Getting Started: Scoping the Stormwater Plan Review Program

The first task in building or retooling a program to review stormwater plans is to scope out what changes must be made in the existing stormwater management program and what additional components are necessary. A list of scoping questions is provided below to assist stormwater managers in making these decisions.

1. ***What level of integration is desired between stormwater and other local reviews?***

   The question pertains to whether stormwater plan reviews should be conducted by a special agency, often outside the usual development review department. On the one hand, having stormwater reviews performed by an engineering or public works department (often external to the planning or community development office) can allow the stormwater review to be performed by a technically trained, engaged stormwater professional. On the other hand, this type of segregation between site plan and stormwater reviews can make it difficult to consider stormwater design early enough in the development process because the stormwater review may become a sidebar at the final plan stage. This type of segregation is particularly problematic if the program wishes to promote low-impact development and/or stormwater credits (see **Chapter 6**), which require a link to early design decisions.

2. ***Based on the expected plan load, what will be the likely distribution between large sites, small sites, redevelopment, and single-family lots?***

   If the program staff knows the types of plans that it will receive, a better match can be made between staff resources and the types of plan review conducted. For instance, large, sophisticated projects with complex computation packages will likely require review by an engineer or someone under the close supervision of an engineer. Alternatively, single-family lot plans and small commercial sites can be reviewed by a competent (and trained) engineering or planning technician.

3. ***What is the current level of stormwater knowledge and training among plan reviewers and design consultants in the community?***

   If stormwater is new and unfamiliar to the review staff and consultants, the program staff will have to spend more time on education and training on basics (e.g., sources of pollution, runoff calculations) and specifics (e.g., particular BMP specifications).

4. ***How will the program balance plan review with inspection and maintenance responsibilities in terms of program staff and resources?***

   Plan review demands can overwhelm a local program, consuming staff time to the point where the program is unable to provide adequate services for inspection and maintenance. Even a well-crafted and reviewed plan means little if it is not followed in the field. Local stormwater managers should strive for a balance between desktop review and field inspections.

5. ***What is the level of citizen interest in and concern about development in the community?***

   Many state and local laws require public access to information, and the Phase II MS4 requirements include public involvement. The development review process is a prime program element where public involvement can and should be built in. Neighboring property owners, citizens groups, and other community interests will want to know what plans have been submitted and how they are being reviewed. If BMPs are allowed on or adjacent to residential lots, citizens will want to know what they are for, if they are temporary or permanent, and whether they can be modified. Public involvement during development review involves use of appropriate technology, such as a Web-based tracking system, and an attitude of openness within the review agency.

7.4. The Anatomy of Stormwater Plan Review

Figure 7.1 outlines a generic plan review process for stormwater. Of course, particular local procedures vary in complexity and the degree of interdepartmental coordination. As depicted in the figure, the

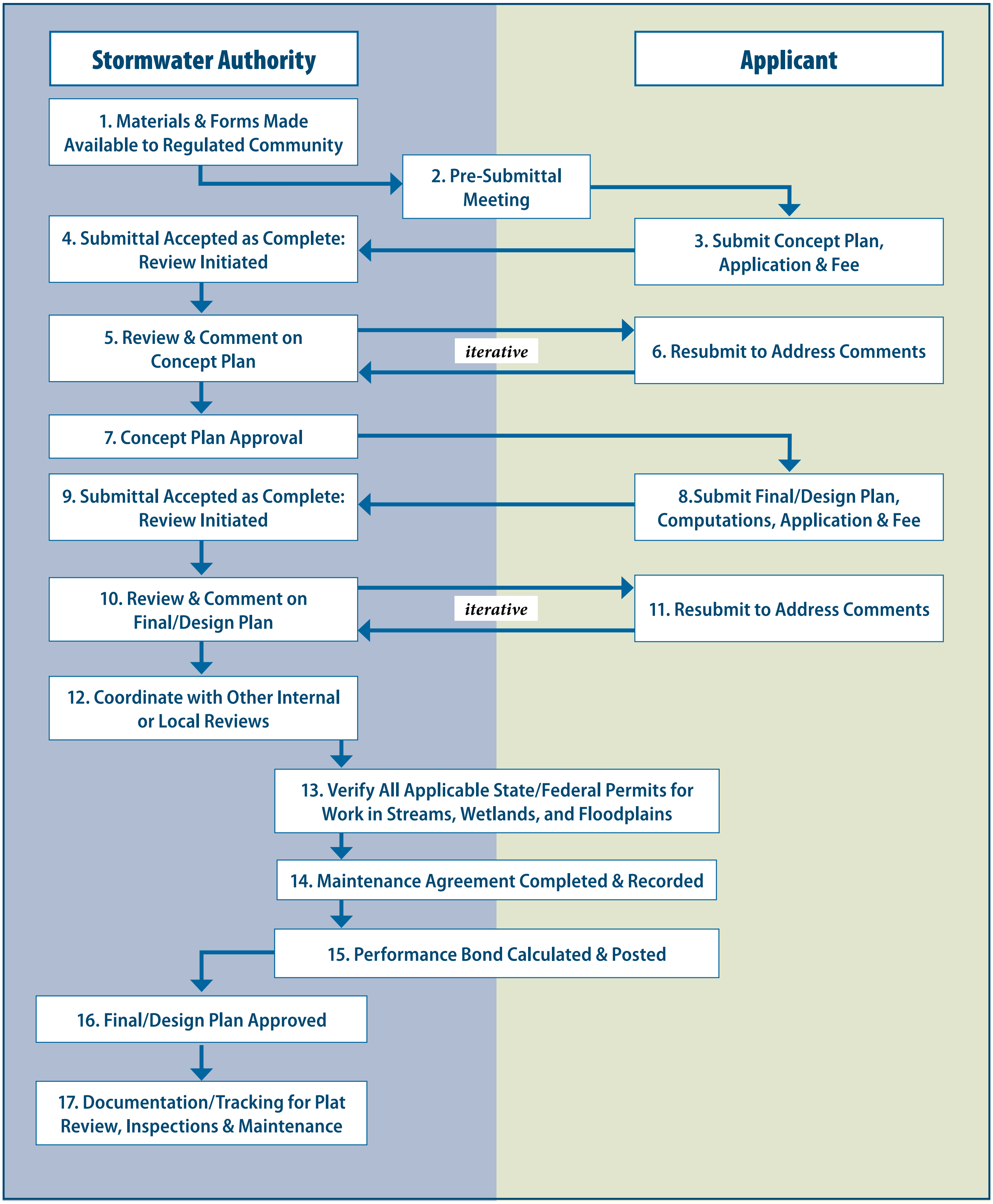


Figure 7.1. Typical stormwater plan review process

department or agency that reviews stormwater plans (the *stormwater authority*) is responsible for certain actions, while other actions are the responsibility of the developer/applicant or are a shared responsibility (those that straddle the figure's centerline). **Table 7.1** provides a brief description of each step outlined in **Figure 7.1**.

Table 7.1. Brief Description of Tasks in Stormwater Review Flowchart

1. Materials and Forms Made Available to Regulated Community	The regulated community needs to know what is expected. The following materials and forms should be provided: ► Submittal application and fee payment form ► Review flowchart and schedule ► Plan submittal and review checklists ► Contact information for relevant personnel.
2. Pre-Submittal Meeting	A pre-submittal meeting can be voluntary or mandatory, and it can be in the office or field. It gives the applicant a chance to sit down with reviewers to scope out relevant questions and can lead to better submittals and quicker compliance. It is also a critical step for plans that use low-impact development (LID) or stormwater credits.
3. Submit Concept Plan, Application and Fee	A Concept Plan provides the opportunity for the applicant to put basic stormwater design ideas on paper, and it gives the reviewer something to react to before the applicant expends the time and resources preparing more complex engineered plans and computations. Again, this is a critical step for plans that use LID and stormwater credits. The stormwater reviewer should coordinate with staff who might be reviewing other components of the site plan or subdivision plat. Also, some preliminary computations (e.g., impervious area anticipated, preliminary pre- and post-runoff volumes) are appropriate for this stage.
4. Submittal Accepted as Complete	Often, stormwater plans go through several unnecessary rounds of review because the original application is not complete. The Stormwater Authority should ensure that elements on the Concept Plan Checklist are submitted prior to initiating a formal review (see **Tool 6: Checklists**).
5. Review and Comment on Concept Plan	The Stormwater Authority checks the Concept Plan to see if the proposed design is adequate, so that the final plan can comply with the standards. Critical items to check are whether the proposed number, type, and approximate size of practices are adequate; whether critical areas (wetlands, floodplains, streams) are identified and protected according to standards; and whether other permits (e.g., wetlands) are likely to be required. If the program allows or encourages low-impact development or nonstructural credits (see Chapter 6), the Concept Plan should be used to identify which stormwater credits will be used in particular locations.
6. Resubmit to Address Comments	As shown in **Figure 7.1**, the comment and resubmittal process is iterative. Ideally, it can be accomplished in two rounds or less for the Concept Plan stage (two submittals and two reviews).
7. Concept Plan Approval	The Stormwater Authority should take some type of formal action on the Concept Plan, so that all parties know that it is time to proceed to final Design Plan.
8. Submit Final/Design Plan, Computations, Application and Fee	The Design Plan customarily includes a project narrative, plans, all necessary computations, and other permit documentation (i.e., certification statement, professional engineers stamp, proof of other permits). Based on the ordinance, a fee is collected for the initial submittal and/or for each resubmittal and review.
9. Submittal Accepted as Complete	Again, the Stormwater Authority should check the plan against the Design Plan checklist to verify that it is complete prior to initiating review.

Table 7.1. Brief Description of Tasks in Stormwater Review Flowchart *(continued)*

10. Review & Comment on Final/ Design Plan	This is a detailed review to verify compliance with all standards in the ordinance and design manual. Critical elements are computations, proper sizing and locating of BMPs, materials and specifications, protection of critical areas, and coordination with erosion and sediment control plans.
11. Resubmit to Address Comments	This step is, again, an iterative process. Two rounds should be sufficient for most Design Plan reviews, especially if the Concept Plan successfully establishes basic, agreed-upon parameters for the design.
12. Coordinate with Other Internal or Local Reviews	Coordination with other reviews and/or departments should be ongoing so that stormwater BMP designs, LID, and stormwater credits can be considered early in the review process and not as an afterthought once all road alignment, lot layout, and utility decisions have been made on the site or subdivision plan. **Table 7.2** lists the other local permits and plans that typically must be coordinated with stormwater plans.
13. Verify Applicable State & Federal Permits	Often multiple agencies are looking at the same site plan for different reasons, and in many cases there are no formal means to coordinate the various reviews. For instance, if the Army Corps of Engineers has jurisdiction over a stream or wetland that is proposed to be affected by the plan, the Stormwater Authority should make sure that the Corps is in the loop while reviewing the stormwater plan. **Table 7.2** lists typical state and federal permits that should be coordinated with local stormwater plans. The applicant should be responsible for furnishing relevant documentation to show compliance with these various permit programs.
14. Maintenance Agreement Completed & Recorded	A maintenance agreement obligates the responsible party to ongoing maintenance of BMPs, and it should be recorded with the property deeds. The responsibility for the maintenance agreement is often shared, with the applicant filling out and signing the agreement and the Stormwater Authority making sure that it is recorded at the courthouse.
15. Performance Bond Calculated & Posted	A performance bond or surety is posted to provide a financial guarantee that the BMPs on the erosion and sediment control and stormwater plan are actually installed in the field (and maintained for a certain duration). Most programs require that the bond be posted prior to approval of the final plan. Programs differ on whether the bond amount is computed by the applicant or the Stormwater Authority (see **Tool 7: Performance Bonds**).
16. Final/Design Plan Approval	This is often the last chance for the Stormwater Authority to have input into the design before the start of project construction, and to confirm that maintenance agreements and performance bonds are in place. The Stormwater Authority should provide written approval and put an approval date and stamp on the plan.
17. Documentation/Tracking	Once the plan is approved, the project moves to the inspection phase to verify that BMPs on the plan are installed correctly in the field. Proper and centralized documentation should be provided so that inspectors—and ultimately the parties responsible for maintenance—can locate the BMPs and understand their specifications without having to dig through multiple file drawers or work through numerous departments. See **Table 7.3** for a description of adequate documentation. Many localities have developed electronic or GIS-based tracking systems to assist with geo-locating BMPs and tracking inspection findings, enforcement actions, etc.

Table 7.2. Typical Local, State, and Federal Plans and Permits that Should Be Coordinated with Review of Stormwater Plans

Local Permits/Plans	State/Federal Permits
▶ Site plans and easement plats (showing drainage and access easements) ▶ Subdivision plats ▶ Grading and drainage plans ▶ Erosion and sediment control plans ▶ Road plans ▶ Floodplain permits ▶ Well and septic permits, if applicable	▶ NPDES (or state equivalent) construction stormwater permits (greater than 1 acre disturbed) ▶ NPDES (or state equivalent) industrial stormwater general or individual permits ▶ Army Corps of Engineers (section 404) and/or state stream and wetland permits ▶ Wellhead protection/source water permits ▶ Dam safety permits

As mentioned in Step 17 of **Table 7.1**, adequate documentation should be prepared to transfer the project to the inspection phase. **Table 7.3** lists the documents that constitute such a package.

Table 7.3. Documentation for Transferring Project to Inspections and Maintenance

- Project information: name of project, location, file or tracking number, file location
- Plan reviewer contact information
- Information from stormwater plan: number and type of practices (structural and nonstructural), where they are located, design computations, details, approved as-built plans
- Copy of any stormwater credits applied to site
- Copy of plat showing drainage and access easements and any deeds of easement
- Copy of recorded maintenance agreement denoting responsible party
- Maintenance plans approved as part of stormwater plan and/or maintenance agreement
- Performance bond form and computation sheet (or link to database)
- Copy of other relevant permits (streams, wetlands, floodplains, dam safety)

7.5. Tips for Building an Effective Stormwater Plan Review Process

The following section provides eight tips for building a more effective plan review process.

Tip #1 Start with "big picture" policy decisions

As stated, most programs already conduct some type of development review function, so may also have a set of formal or informal policies in place. In some cases, however, these policies are not well articulated or communicated to the regulated community. Adding stormwater reviews to the existing review process can be an opportunity to develop or clarify these policies.

Table 7.4 lists some pertinent policy considerations for the stormwater plan review process.

One particularly interesting option for development review is to use consultants to review plans. Two programs polled as part of stormwater program research employ this strategy (**CWP, 2006**). **Table 7.5** outlines some of the pros and cons of using consultant reviews based on the experience of these programs.

Table 7.4. Important Policy Questions for Stormwater Plan Review

- How can the plan review process be structured so that stormwater design is considered early in the review process? This is particularly important for consideration of Smart Growth incentives, LID, and/or nonstructural stormwater credits.
- Should erosion and sediment control and post-construction stormwater management plan reviews be combined?
- Would the program benefit from contracting some or all stormwater plan review functions to a private contractor?
- What are appropriate schedules and goals for plan review turnaround times? What level of staffing is needed to accomplish this?
- Will site visits by plan reviewers be conducted, and for which sites?
- Will pre-submittal meetings be voluntary or mandatory?
- If proprietary BMPs are accepted for use in the community, what guidelines or requirements will apply to approve their use on a particular plan?
- How will applicants and the public have access to plans and review comments?
- What type and frequency of training are necessary to adequately educate plan reviewers and applicants?
- Will field inspectors have any role in the plan review process, and plan reviewers in the inspection process?
- How will public projects be reviewed? Should public projects be expected to lead by example?

Table 7.5. Trade-offs in Having Consultants Review Plans

PROS	CONS
► Frees up local government staff for other tasks (e.g., program development, inspections, maintenance, master planning). ► Leverages highly skilled reviewers (e.g., P.E.s). ► Additional staff is made available for high plan load times. ► Responsiveness and turnaround time are generally very good. ► Deadlines are usually met. ► Reviewers interact only with applicants, so political and public pressure are reduced.	► Consultant staff can't make policy decisions, so coordination and communication with local staff can be tricky. ► Can be difficult for consultants to coordinate with other local reviews early in the review process. ► Review fees are variable and usually higher (based on consultant time/fees for each plan). ► There is a learning curve for applicants to get used to the system.

Tip #2 **Anticipate plan review load**

According to stormwater program research (**CWP, 2006**), a typical reviewer's plan load is approximately 70 plans per year. Individual reviewers who review more than 100 plans per year may have trouble providing a thorough review and/or meeting review deadlines.

The ability of a local program to develop an efficient and effective stormwater plan review program is a function of adequately anticipating the number of plans that will be submitted, the complexity of the plans (e.g., large sites with multiple practices versus small, simpler sites). Large, complex plans can easily take 8 hours for an initial review and 4 hours for each resubmittal. Simpler and smaller sites can likely be reviewed in 6 hours for the initial submittal and 2 to 4 hours for resubmittals.

A related factor is the turnaround time that must be met for each review. The stormwater ordinance should have a basic review schedule; most allow 30 to 60 days for review of a submitted plan (after the plan is accepted as complete). In addition, the leadership of the agency might have unofficial goals related to customer service that become *de facto* review deadlines. Developers and design consultants will always want the shortest turnaround time possible, but it is preferable to set a realistic goal and meet it than to promise a more ambitious schedule and chronically fall short.

Once plan review loads are estimated, a program must ensure an adequate level of staffing and develop an outreach strategy so that reviewers and applicants clearly understand the review process.

Tip #3 Develop forms and checklists for reviewers and applicants

In the development review process, the main customers are the applicants that are submitting plans. A smooth process will rely on providing clear instructions and managing expectations. **Table 7.1 (Step 1)** provides some information on the types of forms that are recommended to aid the submittal process. One type of form that is sometimes overlooked is the fee form. If a program is not collecting plan review fees, it is missing out on a source of revenue that is generated by the "users" rather than general taxpayers.

Another critical type of form is the plan review checklist. **Tool 6: Checklists** provides plan checklists for both concept plans and final design plans. These checklists (or versions modified by individual programs) can be provided to applicants to help with plan preparation. Reviewers can also use them to verify that an initial submittal is complete and ready for review.

Tool 6 also contains plan review checklists that are specific to particular types of BMPs. Once the reviewer verifies that all relevant information has been submitted, the specific checklists can be used to help review details and specifications on the plan. These checklists address both structural and nonstructural practices. The checklists can also be used as a sort of routing slip if various reviewers are checking different aspects of the same plan. **Table 7.6** lists the BMPs for which checklists are provided in the tool, and **Figure 7.2** illustrates the types of checklists included.

Table 7.6. Plan Review Checklists Provided in Stormwater Checklist Tool

Structural Stormwater BMPs	Nonstructural Stormwater BMPs
▶ Bioretention ▶ Filtration Systems ▶ Infiltration Systems ▶ Open Channels ▶ Ponds ▶ Wetlands	▶ Natural Area Conservation and Restoration ▶ Sheetflow to Buffer ▶ Impervious Area Disconnection ▶ Grass Channels

Another area of variability and potential conflict between reviewers and designers is the type and format for computations. Reviewing design computations can be difficult when there is no standard format and computations are submitted as stacks of computer output. A standard computation submittal package can help both applicants and reviewers know what is expected. **Table 7.7** outlines a recommended computation submittal package.

Tip #4 Hold Pre-Submittal Meetings

Even at the concept plan stage, the developer or design consultant has spent a good deal of time developing the site layout and even picking stormwater BMPs. He or she might not be aware of site design alternatives that could reduce both runoff and cost. Also, the developer or design consultant might not be aware of available stormwater credits for LID or nonstructural measures. The best way to communicate this information early in the design process is through a pre-submittal meeting (**Figure 7.3**). Often this is the only meaningful way to introduce these concepts early enough in the process to effect real design changes.

The pre-submittal meeting can be held in the office or at the site, and it can be voluntary or mandatory, depending on the preferences and capabilities of the local program. Pre-submittal meetings are also the appropriate time to communicate with applicants about other relevant permits (e.g., construction stormwater, wetlands and streams, floodplain, dam safety). The meeting can be used to promote the

Concept Plan Checklist

B. Project Plans S = Satisfactory U = Unsatisfactory N/A = Not Applicable				
Item	S	U	N/A	Comments
1. Existing and proposed topography (minimum 2-foot contours or local standard)				
2. Existing and proposed stormwater management system				
a. Catchments				
b. Drainage areas & flowpaths				
c. Stormwater management practices: types identified and adequate surface area allocated on plan				
d. Proposed drainage and maintenance access routes and easement locations				
e. Stream reaches				
f. Proposed channel modifications				
3. Predominant soil types				
4. Existing land cover/land use and proposed limits of disturbance				
5. Resource protection areas (e.g. sensitive streams, wetlands and lakes)				

Final Design Plan Checklist

C. Design Computations S = Satisfactory U = Unsatisfactory N/A = Not Applicable				
Item	S	U	N/A	Comments
1. Pre-development hydrologic/hydraulic analysis (show methodology and supporting calculations)				
a. Drainage areas and design points				
b. Land use, soil type and impervious cover assumptions				
c. Curve number assumptions				
d. Flow paths and times of concentration				
e. Summary of design storms analyzed				
f. Peak runoff rates				
g. Total runoff volumes				
2. Post-development hydrologic/hydraulic analysis (show methodology and supporting calculations)				

Structural BMP Plan Review Checklist

Key Questions		
Item	X	Comments
1. Type of facility (check all that apply)		
a. Infiltration		
b. Filtration		
c. Bioretention		
d. Extended Detention (storage for Cpv, Qp, Qf)		
2. Facility Location		
a. Surface		
b. Underground		
3. Filtration Media		
a. No filtration media (e.g. dry well)		
b. Sand		
c. Bioretention Soil		
d. Peat		
e. Other		

Nonstructural BMP Plan Review Checklist

Key Questions		
Item	X	Comments
1. Type of conservation area		
a. Forest		
b. Prairie		
c. Other		

A. Project Plans S = Satisfactory U = Unsatisfactory N/A = Not Applicable				
Item	S	U	N/A	Comments
1. Plan view depicts the boundaries of the conservation area relative to existing and proposed features. And includes the following:				
a. Limits of existing natural area				
b. Average slope of natural area				
c. Root zones for specimen trees				
d. Type, size, and condition of existing vegetation				

Figure 7.2. **Tool 6: Checklists includes checklist tools for concept plans, final design plans, structural BMPs, and nonstructural BMPs**

Table 7.7. Recommended Computation Submittal Package (derived from Claytor, 2006)

- Cover: Project title, client, nature of computations
- Project vicinity map
- Watershed delineation for pre- and post-development conditions with travel times (times of concentration), land use, and soils
- Soils survey map
- Narrative of stormwater management system
- Summary of hydrology and hydraulics
- Table of drainage areas, curve numbers (CNs), time of concentration (Tc), peak discharges (pre- and post-construction) that summarizes the performance of proposed stormwater measures.
- Detailed hydraulic calculations (hydraulic calculations of outlet orifice, weirs, spillways, etc.)
- Hydrologic analyses (e.g., area CN calculation spreadsheets, practice sizing equations, model run outputs)
- Other calculations (e.g., inflow channel sizing, outfall channel, downstream analyses, dam breach assessments, filter diaphragm sizing, groundwater mounding analyses, structural calculations)
- Site photographs
- List of permit requirements and how project is in compliance (including permits needed for construction stormwater, streams and wetlands, floodplains, stream buffers, wellhead protection, and dam safety and other relevant permits)
- Supporting data (as applicable)
  - Soil test pits and/or borings
  - Pollutant monitoring data
  - Groundwater elevation data
  - Habitat evaluations
  - Tree surveys
  - Threatened and endangered species
  - Receiving water classification (e.g., 303(d) listing, cold-water fishery)

Figure 7.3. Hold a pre-submittal meeting to review stormwater alternatives

idea of avoiding impacts on sensitive resources rather than going through a lengthy permit process.

Finally, the pre-submittal meeting can be a time for stormwater managers and land use planners to sit in the same room with applicants and fully discuss the idea of using site planning and Smart Growth techniques to avoid stormwater impacts (see **Chapter 3** for more details on this topic).

Tip #5 **Reward good actors**

Plan reviewers and applicants are often in conflict about the time it takes to review a particular submittal. For most applicants, review time is a critical issue. Therefore, incentives that incorporate expedited reviews might be an attractive option. A lot of review time is lost when a single plan must undergo multiple submittals and reviews before the plan is deemed sufficient. Some programs use submittal checklists and standard runoff and water quality computation tables as tools to promote expedited review. Plans that are submitted with complete and accurate information are moved to the top of the stack (especially resubmittals of plans that have already been reviewed at least once).

Another justification for expedited review is to promote innovative practices, such as low-impact development. Plans that go the extra mile and incorporate design features that are encouraged by the local program can be given priority review status.

Two important points attend to an expedited review procedure: (1) ensure that the process is equitable and that all applicants are eligible, and (2) make sure that an expedited review is still a thorough review. Reviewers must still have enough time to make sure that all details and specifications are in accordance with appropriate standards.

Tip #6 **Provide training for reviewers and design consultants**

Both design consultants and local review staff typically work under the constant strain of deadlines. The paradox is that without adequate training, the quality of plan submittals decreases, the time needed for each review increases, and the overall number of submittals needed to get a single project through the process increases. In the end, the available time is used less efficiently than if the training were provided (**Figure 7.4**).

Chapter 6 provides some tips for training of design consultants in the context of a design manual. Many of these tips can be adapted for general training on the development review process and can also be used to train reviewers as well.

Figure 7.4. **Provide training for plan reviewers and design consultants**

Tip #7 **Set up a documentation and tracking system**

It is critical to track the receipt of plans, review comments, resubmittals, approvals, maintenance agreements, performance bonds, drainage easements on plats, and the relationship between approval of a stormwater plan and other internal approvals. If there is an existing system for site plans and plats, investigate whether stormwater plan tracking can be added easily to the system.

Tracking plan submittals and reviews can help to accomplish the following:

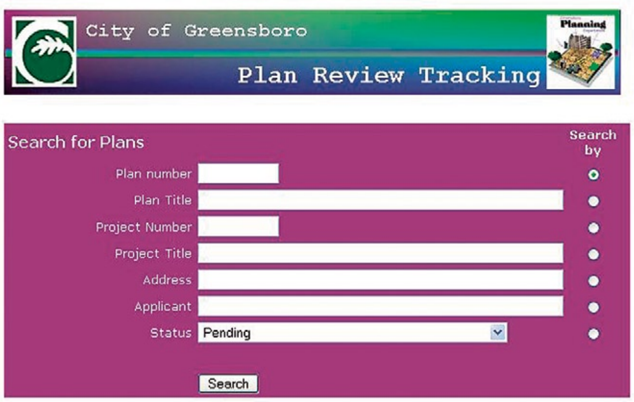
- Helps local stormwater managers keep track of plans and workloads, and provides feedback on review times and staffing needs.
- Allows applicants to track their submittals through the process at any given time. Some programs provide this information on the Internet.

- Assists the program with reporting of measurable goals in the MS4 permit. (For example, counting plans and reviews is one of the easier metrics to report; such a system can also help with public involvement goals.)
- Allows the program to comply with record-keeping and open government requirements.

Many localities, including the following, are shifting to Web-based systems for tracking projects:

- City of Greensboro, North Carolina's online plan tracking system (**Figure 7.5**): ***http://www.ci.greensboro.nc.us/PlanReview***
- City of Omaha, Nebraska's online system for construction inspections and citizen complaints: ***http://www.pcwperosioncontrol.org/public***

Chapter 10 provides additional information on general stormwater tracking, monitoring, and evaluation.



Source: *www.ci.greensboro.nc.us/PlanReview/PlanSearchFull.asp*

Figure 7.5. Example of Web-based plan review tracking system from the City of Greensboro, North Carolina

Tip #8 Integrate development review and inspections

A field inspector "inherits" a plan from the reviewer, and the two will likely have different perspectives about the project. Inspectors can be quite good at anticipating problems related to construction sequence, conflicts with utilities, equipment access, and other issues that can become problems in the field.

On the other hand, the inspector's job is to ensure that the project is built to the specifications and details on the plan, and the inspector might not have the leeway or inclination to apply flexibility in certain circumstances. The reviewer might have a better sense of the ultimate BMP design purpose and can help the inspector ensure that construction and installation meet that purpose. The reviewer can also apply judgment about when to notify the applicant's design consultant if field modifications are necessary.

In short, the plan review process should allow for two-way communication and coordination between reviewers and inspectors. The following are several simple strategies to enhance this coordination:

- Invite inspectors to team review meeting for individual plans.
- Have reviewers and inspectors attend the same training, and include both design and construction issues.
- Have plan reviewers attend pre-construction meetings for projects they reviewed.
- Encourage reviewers to periodically go on inspection rounds with inspectors.

7.6. Involving the Public in Stormwater Plan Review

Public involvement during stormwater review will likely be tied to a broader public involvement and notification process for development review in general. This process is likely to have a nominal level of public involvement built in through the formal notification and public hearing requirements included in local or state codes. However, stormwater managers should strive for a public involvement process that goes beyond minimum legal mandates. Public involvement should add value to the process by incorporating a broad set of ideas early in the review cycle. The process should also aim to make stakeholders feel that their input has meaning and is not collected as a mere formality. The development review process is also an excellent venue for incorporating public education and outreach efforts that also fulfill MS4 requirements.

Table 7.8 lists stakeholders that are customarily involved in the stormwater review process and various strategies that can be incorporated into a meaningful public involvement program. The table lists stakeholder in different categories:

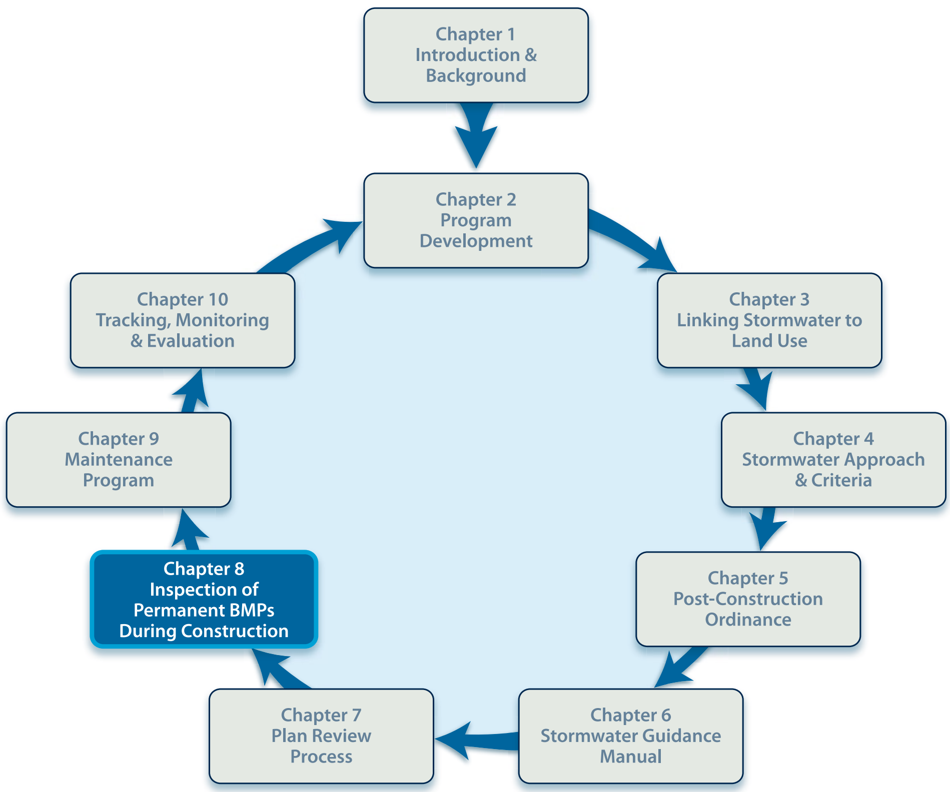
- ***Primary stakeholders*** are those who are involved directly in the review process for a particular property, such as the applicant, the applicant's design consultant, and adjacent property owners. These parties often have the most to gain or lose from the approval or disapproval of a plan.
- ***Review process stakeholders*** are other departments or agencies that have a role in reviewing the overall development proposal (for environmental and other compliance issues). Communication and coordination with these stakeholders is important to ensure an efficient process.
- ***Other stakeholders*** are additional parties that should be included in a transparent process. These stakeholders might have general interest in development issues within the neighborhood or community, and they might wish to speak at public hearings if given the opportunity.

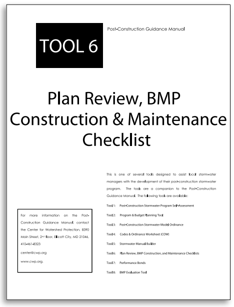
Table 7.8. Key Stakeholders in Stormwater Development Review and Selected Strategies

Stakeholder Group	Public Involvement Strategies
Primary Stakeholders	
▶ Applicant ▶ Applicant's design consultant ▶ Adjacent property owners ▶ Elected officials and/or planning boards that must approve plans	▶ Electronic or Web-based plan and comment tracking and public notification of plan status ▶ Training and workshops on stormwater plan content, especially information that may be new to the local community (e.g., LID, stormwater credits) ▶ Early notification and fact sheets for adjacent owners ▶ Roundtable process to amend local codes to promote LID and innovative practices (also include other stakeholders listed below)
Review Process Stakeholders	
▶ Planning department ▶ Public health agency (well and septic approval) ▶ Water and sewer utility ▶ Floodplain administrator ▶ Erosion control administrator ▶ Zoning enforcement agency (standing water) ▶ Local/state transportation department ▶ Army Corps of Engineers ▶ State/regional regulatory agencies (wetlands) ▶ Parks/greenway administrator	▶ Training and workshops on stormwater, and on the role planners have in reducing stormwater impacts by influencing design (e.g., reducing impervious cover) ▶ Joint review meetings where various agencies can express their views and concerns ▶ Joint site visits with other departments/agencies ▶ Cross-training with relevant departments
Other Stakeholders	
▶ Local environmental groups ▶ Local builders' association ▶ Property owners and residents in vicinity of project ▶ General public	▶ Web-based system on review process and plans in the review mill ▶ Public notification when waivers are granted ▶ Fact sheets on BMPs and "urban legends" (e.g., mosquito breeding) ▶ Community meetings for specific plans before they reach public hearing stage

Chapter 8

Inspection of Permanent Stormwater BMPs During Construction




TOOL 6

Plan Review, BMP Construction & Maintenance Checklist

Companion Tools for Chapter 8
Download Post-Construction Tools at:
www.cwp.org/postconstruction

What's In This Chapter

- Current trends with inspection programs
- Scoping out an effective local inspection program
- The anatomy of a typical inspection process
- Tips for building an effective inspection program
- Involving the public in the inspection process

8.1. Introduction

Previous chapters discussed program planning, adopting a stormwater ordinance, developing stormwater design guidelines, and the plan review process. Each chapter represents a building block of a local post-construction stormwater management program.

The next important step for a local stormwater program is to ensure that BMPs that are approved through the plan review process are built correctly at the site. This involves careful inspection of the BMP installation process while site construction is taking place.

For the purposes of terminology, this chapter discusses the installation of permanent (post-construction) BMPs during site construction, with the goal of having the permanent BMPs installed correctly and becoming operational at the end of the construction phase. This chapter does ***not*** address the broader issue of construction stormwater (erosion and sediment control) measures. Guidance on developing construction stormwater pollution prevention plans (SWPPPs) is available from EPA (see *Developing Your Stormwater Pollution Prevention Plan: A Guide for Construction Sites* at ***http://www.epa.gov/npdes/swppguide***).

An effective construction inspection process can help ensure that:

- Stormwater BMPs are built according to approved plans and specifications.
- Future maintenance needs of stormwater BMPs are reduced to the greatest extent possible.
- Low-impact development techniques are properly implemented. Areas of the site shown on the plan to be preserved are not disturbed during construction (including soils that should not be compacted).
- Proper materials and construction techniques are used.

This chapter provides practical guidance for building an effective program to inspect permanent stormwater BMPs during construction and ensure proper installation by addressing:

- Current trends with inspection programs
- Scoping out an effective local inspection program
- The anatomy of a typical inspection process
- Tips for building an effective inspection program
- Involving the public in the inspection process

8.2. General Status, Trends, and Issues with Inspection of Permanent Stormwater BMPs During Construction

Although most local stormwater programs conduct some type of inspection during construction, many do not adequately follow through to ensure that post-construction BMPs are installed correctly (**CWP, 2006**). A minority of programs use tools, such as performance bonds and as-built plans, to ensure proper BMP installation.

Many BMP failures are due to construction and installation problems, and most can be avoided through an enhanced inspection effort. As an example, **Figure 8.1** illustrates several construction-related problems that might occur during the installation of various bioretention BMPs.

8.3. Getting Started: Scoping Out a Program to Inspect Stormwater BMPs During Construction

The first task in building or retooling a program to inspect post-construction stormwater BMPs during construction is to make key decisions about the inspection program. A list of scoping questions is provided below.

1. ***Does the department or agency already inspect construction sites?***

   Many local programs already conduct some form of inspection of stormwater BMPs during construction. Of those that don't, many might work with departments or agencies that already conduct some type of inspection program at active construction sites, whether for erosion and sediment control (ESC), forest conservation, wetland protection, or building inspection. If these programs are already in place, a local stormwater program might be able to integrate a stormwater BMP construction inspection program into one of them.

Bioretention swale, installed too early during active construction, has become clogged with sediment.

Bioretention area does not drain because of improper soil media, soils compacted during installation, and/or filter fabric under media.

Curb inlets to bioretention swale have eroded because of improper sizing of stone.

High plant mortality has occurred because improper species were substituted during construction.

Site runoff by-passes bioretention swale because of small elevation changes during construction.

Some site runoff by-passes bioretention because of inadequate slope of filter strip.

Figure 8.1. Common issues with installation of post-construction BMPs, using bioretention as an example

2. ***What is the current level of knowledge among inspectors about the design and installation of post-construction BMPs?***

   Regardless of whether municipal staff perform the inspections or private inspections are authorized, it is critical that the inspectors be adequately trained in the proper design and installation of all stormwater BMPs that might be used in the community. The inspectors must not only understand the specifications "on paper" but also understand how they translate in the field. This might require basic surveying and other field skills (e.g., determining whether a detention pond is being constructed at the proper elevation with the correct slopes). Inspectors must be familiar with:

   - Material specifications for the BMPs
   - Installation schedule for the BMPs
   - BMP construction or installation techniques
   - BMP operation and maintenance requirements

   The inspector should also have a working knowledge of commonly used proprietary BMPs in order to ascertain whether they are being installed and used correctly.

3. ***How often will stormwater BMPs on active construction sites need to be inspected?***

   The required inspection frequency for some local programs might be determined by the stormwater ordinance. Other programs might not have formal requirements but might set goals for how often they will inspect stormwater BMPs on active construction sites (e.g., once every 2 weeks, as triggered by construction milestones, and as construction is completed).

4. ***Is there an existing tracking system for inspections and enforcement actions that can be modified to include the inspection of stormwater BMPs during construction?***

   There should be a method for tracking the inspections and enforcement actions taken so that appropriate follow-up can be conducted. If a system exists to track other types of construction inspections (e.g., ESC inspections), that system can be modified to include the inspection of post-construction BMPs during construction. Tracking the type and location of each post-construction BMP installed is critical to assist in the inspection of the BMPs during ***and*** after construction.

8.4. The Anatomy of a Program to Inspect Stormwater BMPs During Construction

Figure 8.2 illustrates the basic process for inspecting the installation of post-construction BMPs. Of course, particular local requirements or guidelines could affect the complexity of the process illustrated in the figure. As depicted in the figure, the department or agency charged with site inspections (the *Stormwater Authority*) is responsible for certain actions, while other actions are the responsibility of the applicant/contractor or are a shared responsibility (those that straddle the figure's centerline). Information and guidance for each step identified in **Figure 8.2** are provided in **Table 8.1**.

8.5. Tips for Developing an Effective Program to Inspect Stormwater BMPs During Installation

Once the stormwater manager has a good understanding of the stormwater BMP inspection process, the following eight tips can help establish an effective program to inspect stormwater BMPs during construction.

TIP #1 Determine Who the Site Inspectors Will Be

The key consideration is to determine who will conduct the inspections. There are a number of legitimate options for a local program to consider:

- Existing construction inspection staff (e.g., ESC, building inspection staff)
- Plan review staff
- Dedicated post-construction BMP inspection staff
- Contractors retained by the local program
- Contractors or on-site representatives retained by the owner/developer

Each is described in more detail below, and **Table 8.2** outlines several pros and cons of each option.

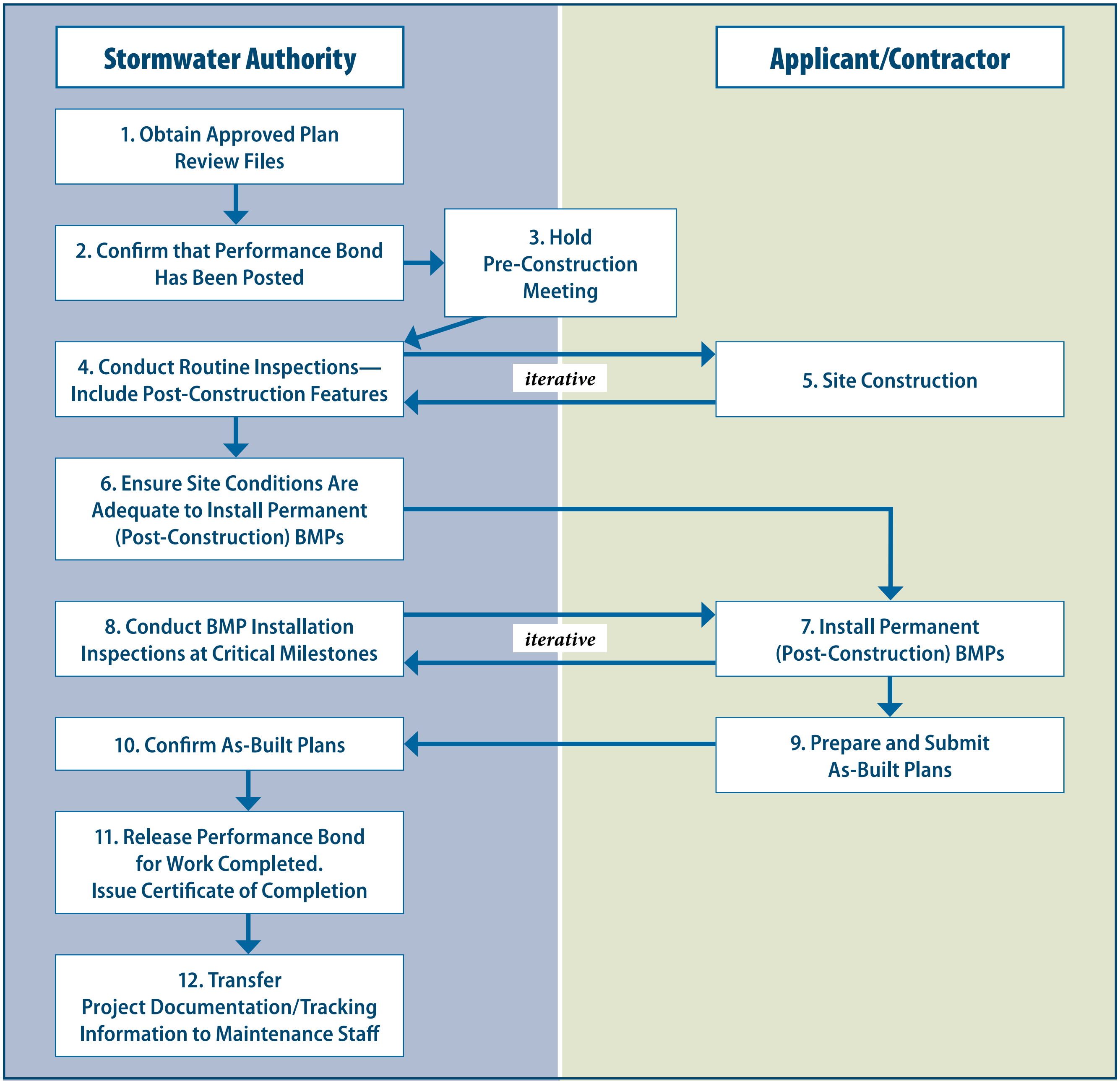


Figure 8.2. Typical process for conducting inspections of post-construction BMPs during construction

Table 8.1. Brief Description of Tasks in Construction Inspection Process Flowchart

1. Obtain Approved Plan Review File	The approved plan review file should be obtained from the plan reviewers. The following materials and information should be contained within the plan review file: ► Summary of how the requirements of the local stormwater ordinance are met ► List of all BMPs (structural and nonstructural) to be used at the development site ► Plan set illustrating the types, locations, and specifications of stormwater BMPs used at the site ► Permits ► Contact information for contractors and design engineers ► Construction schedule
2. Confirm That Performance Bond Has Been Posted	The applicant should post an adequate performance bond or surety before approval of the final plan (see **Chapter 7**). Inspection staff should ensure that the bond has been posted before any construction activities begin. For more information, see **Tool 7: Performance Bonds**.
3. Hold Pre-Construction Meeting	A pre-construction meeting should be held prior to any construction activity. The meeting should review the stormwater BMPs to be installed, critical construction milestones, and the sequence of construction. It is recommended that the following parties attend the meeting: ► Owner/developer and/or representative ► Site construction superintendent ► Relevant construction contractors (e.g., grading) ► Site plan reviewer ► Stormwater BMP inspector ► Erosion and sediment control inspector
4. Conduct Routine Inspections—Include Post-Construction Features	Project site visits and inspections should be conducted according to an established inspection schedule. These routine inspections can be conducted on a regular basis (e.g. weekly, biweekly) or at important milestones. Site inspections should ensure that post-construction features are accounted for during the construction process. Examples include: ► Riparian buffers and natural areas identified on the post-construction plan are ***not*** disturbed. ► Areas/soils identified on the post-construction plan for infiltration (or bioretention) are ***not*** disturbed or compacted, unless the plan's construction sequence allows for co-location of construction and post-construction facilities (see **Chapter 1** for more discussion on this topic). ► Permanent BMPs are not installed or converted prematurely during active grading or before drainage areas are stabilized. ► Information about post-construction BMPs that involve individual lots is communicated to site contractors, subcontractors, and lot builders.
5. Site Construction	See no. 4 above. The contractors should be aware of post-construction features that might need to be protected during site work. Contractors should be aware of both structural and nonstructural BMPs approved for the site.
6. Ensure Site Conditions Are Adequate to Install Permanent (Post-Construction) BMPs	Many post-construction BMPs cannot be installed until drainage areas are stabilized with vegetation. Infiltration and bioretention facilities are particularly sensitive to sediment loads during construction. Other post-construction BMPs, such as ponds, are likely to be converted from erosion control basins, and conversion should take place only after the erosion control phase is complete. The inspector must communicate clearly to the contractor about the timing and scheduling for the installation of post-construction BMPs. This might take place as different phases of the project are stabilized.

Table 8.1. Brief Description of Tasks in Construction Inspection Process Flowchart *(continued)*

7. Install Permanent (Post-Construction) BMPs	Once site conditions are adequate, per the inspector's verbal or written communication, the contractor should install the post-construction BMPs according to the approved plans and specifications.
8. Conduct BMP Installation Inspections At Critical Milestones	Although inspectors cannot be on-site during the entire BMP installation process, it is critical that inspections take place at critical milestones. These milestones might include: ► Grading for post-construction BMPs ► Modifications to embankments, risers, and spillways ► Construction of forebays or pretreatment cells ► Placement of underdrain systems ► Testing and installation of soil or filtering media ► Planting, final grading, final stabilization **Tool 6: Checklists** includes checklists that inspectors can use during the installation of structural and nonstructural BMPs. It might be prudent to have inspectors sign off at key milestones before the contractor proceeds with BMP installation.
9. Prepare & Submit As-Built Plans	Once BMP installation is complete, as verified by the inspector, the applicant's design consultant prepares an as-built plan for each stormwater BMP based on actual site conditions. This plan can take the form of a "red-lining" approved design plan to note any discrepancies. The design professional also certifies that the constructed BMP meets or exceeds plan specifications. It is important for the as-built plan to confirm: ► Placement of BMPs within easements ► Proper sizing, dimensions, and materials ► Elevations of inlets, outlets, risers, embankments, etc. ► Vegetation per the planting plan ► Location of permanent access easements
10. Confirm As-Built Plans	The inspector and the plan reviewer both sign off on the as-built plan, and any discrepancies are noted.
11. Release Performance Bond for Work Completed. Issue Certificate of Completion	Once the inspector has confirmed that the BMP is properly installed per the plans and specifications and is in good working order, the relevant portion of the performance bond can be released. It is prudent to wait approximately 60 days and/or after two storm events to release the bond to ensure that vegetation is established and the BMP functions properly during storms. Upon release of the bond, some programs also issue a certificate of completion, which provides good documentation for both the owner/responsible party ***and*** the maintenance inspection staff that BMP installation is complete.
12. Transfer Project Documentation/ Tracking Information to Maintenance Staff	Once BMP installation is complete, the stormwater program will begin the next phase of inspections. These regular maintenance inspections may be conducted by construction inspection staff, dedicated maintenance staff, or agents of the owner. See **Chapter 9** for more information on maintenance inspection requirements. The following information should be provided to the maintenance inspection staff and the party responsible for long-term maintenance during transfer of the project: ► Approved as-built plans ► Recorded maintenance agreement and plan ► Construction photographs and map of photo stations ► Construction plans ► Design computations and any as-built modifications ► Contact information for responsible maintenance party

Table 8.2. Pros and Cons of Using Different Inspection Options

PROS	CONS
Using Existing Construction Inspection Staff	
► Efficient use of staff. ► Helps with integration of minimum measures 4 and 5 (construction and post-construction stormwater) for MS4s. ► Allows inspectors to stay with project through entire construction cycle.	► May stretch existing staff beyond their capabilities; post-construction might not get adequate attention. ► Inspection milestones for stormwater and building construction might not coincide.
Using Existing Plan Review Staff	
► Plan reviewers are familiar with BMP designs. ► Reviewers can judge necessary field changes.	► Deadlines for plan reviews may conflict with being on-site at critical construction milestones. ► Reviewers will always have less time to spend in the field compared to inspectors.
Using Dedicated Post-Construction Inspection Staff	
► Inspectors can concentrate on post-construction BMPs. ► Best method to ensure proper BMP installations.	► May be inefficient to have specialization of inspectors. ► Requires additional communication and coordination between inspectors with different responsibilities (e.g., ESC, post-construction, building).
Using Contractors Retained by the Local Program	
► Frees up local government staff for other tasks, ► Trained and certified inspectors can improve the quality of inspections, especially if they also have design experience. ► Inspector observations are made independent of political pressures.	► Private inspectors do not have enforcement authority; local staff will need to get involved in enforcement actions. ► Private inspectors might have business relationship with the developer or contractor, which might cause a conflict of interest. ► Coordination with other inspectors and plan reviewers is more difficult. ► Cost might be high for the local program, unless reimbursed by inspection fees.
Using Contractors or On-Site Representatives Retained by the Owner/Developer	
► Frees up local government staff for other tasks. ► Cost is born by the owner or developer. ► Local program can concentrate on training and certification.	► Local government must still police and audit the work of on-site representatives. ► Quality of inspections might decline if on-site representative is an employee of the developer or contractor, as opposed to a qualified third-party contractor. ► Local government must have clear-cut enforcement procedures based on inspection reports.

Using Existing Construction Inspection Staff

One option for local stormwater programs is to integrate a post-construction BMP inspection program with an existing construction inspection program. Many local stormwater programs already have or work with departments or agencies that already conduct some type of inspection program at active construction sites, whether for ESC, forest conservation, or wetland protection. These programs can be integrated with a post-construction BMP inspection program to maximize resources and staff time.

Other types of inspection staff, such as building inspectors, could be used as well, but care must be taken to ensure that they visit the site at the appropriate times and are properly trained. The timing of building inspections might not necessarily coincide with the need for inspection of post-construction BMPs (i.e., stormwater BMPs might be in place before the building of the structure begins).

Using Existing Plan Review Staff

Using plan review staff to conduct site inspections can be a very effective way to ensure that the most viable BMPs are approved and built according to correct specifications. Plan review staff are usually familiar with the BMP designs and should be able to determine whether BMPs are being installed according to the approved plans. They would also be best equipped to request plan and design changes in the field if it appears the approved design is no longer adequate. However, this staffing integration option would involve field work during construction for the engineers and plan reviewers, and this might be an additional responsibility and require more time per project.

Using Dedicated Post-Construction Inspection Staff

If construction inspections are currently not conducted in the community or are conducted by staff who are unable to conduct additional inspections for post-construction BMPs, dedicated staff might need to be employed to perform this task. These staff members might have other duties, but their primary focus would be on the proper installation of post-construction BMPs. This approach has some benefits: (1) the inspector can focus on a single task while performing the inspections; (2) the inspector is trained specifically regarding the design and installation of post-construction BMPs; and (3) follow-up and enforcement are easier if the inspector can concentrate on BMP installation as opposed to multiple other issues at the site.

Using Contractors Retained by the Local Program

An additional option for local stormwater programs is to hire a contractor to perform inspections of post-construction BMPs. These outside contractors function in much the same way as dedicated construction inspection staff, but the local program contracts the work out instead of hiring new staff members.

Using Contractors or On-Site Representatives Retained by the Owner/Developer

Some programs require that the engineers who design stormwater BMPs "self-inspect" their own BMPs during construction. The design engineers should understand the intent of the BMP design and be able to ascertain whether the appropriate methods and specifications are employed during installation of the BMP.

Another self-inspection option is to require a hired on-site representative to inspect and report on BMP installation progress. This approach is used in ESC programs around the country. In most cases, on-site representatives should be third-party consultants retained by the owner or developer. The certified inspector is required to regularly inspect BMPs and certify in writing that they are installed according to plans and specifications. These reports are submitted to the stormwater program and/or kept on-site for reviews during spot-check inspections by the local program. The self-inspections can be used as the sole method of inspection or as a supplement to the stormwater program's regular inspections.

It is important to note that self-inspections and third-party inspections do not relieve stormwater program staff of all inspection responsibilities. Under this system, it is critical to have a training and certification program to authorize the private parties who are conducting inspections. The local program is also responsible for policing the system, detecting abuses, reviewing inspection reports, and conducting periodic co-inspections to ensure appropriate performance levels.

TIP #2 Anticipate Inspection Loads and Staffing Requirements

The ability of a local stormwater program to conduct effective inspections of stormwater BMPs during the construction phase is a function of the number of projects being simultaneously constructed, the complexity of each project (e.g., large development sites with multiple stormwater BMPs as opposed to small sites with one or two stormwater BMPs), the technical competence of the inspectors, the number of inspectors, and the enforcement tools available to each inspector.

As stated in **Chapter 7**, a typical stormwater program can expect to review between 70 and 100 development plans each year. This number, of course, is based on the rate of development in a community and the specific applicability of regulations contained in the stormwater ordinance. Getting a good handle on this number, and the size and scope of particular developments, allows the stormwater manager to project the number of construction sites that will be active during any given year. This projection allows for the allocation of inspection staff and resources.

In addition, if there is a mandated inspection frequency for stormwater BMPs during construction (e.g., every 2 weeks, at the inception and conclusion of the project), this must be considered as well when determining the staff and resource needs for the program.

TIP #3 Develop Forms and Checklists for Inspectors

Proper documentation is essential to track inspection findings, as-built confirmation, and enforcement actions. Inspection checklists are crucial not only to track findings but also to ensure that multiple inspectors are performing consistent BMP reviews. It is also recommended that the checklists be signed by the inspector and the contractor's on-site representative receiving the checklist at the time of the inspection. **Tool 6: Checklists** provides inspection checklists for structural and nonstructural BMPs. The checklists provided in the tool are listed in **Table 8.3** and shown graphically in **Figure 8.3**.

Table 8.3. BMP Construction Checklists Provided in Tool 6: Checklists

Structural Stormwater BMPs	Nonstructural Stormwater BMPs
► Bioretention	► Natural Area Conservation and Restoration
► Filtration Systems	► Sheetflow to Buffer
► Infiltration Systems	► Impervious Area Disconnection
► Open Channels	► Grass Channels
► Ponds	
► Wetlands	

Checklists can be in hard-copy format, with duplicates provided to the contractor's on-site representative or superintendant. Increasingly, however, local inspection programs are using portable devices or laptops coupled with GPS technology to record inspection findings. This can save time with reentering data from field checklists into an inspection database.

TIP #4 Develop An Adequate Enforcement Plan and Enforcement Tools for Inspectors

Upon completion of an inspection, the developer and contractor should be informed of the results of the inspection and any corrections that need to be made. The letter should include basic information (e.g., date of inspection, people present during the inspection, a copy of the inspection checklist), outline any repairs/changes that need to be made, and state when any changes/repairs need to completed. It is hoped that the developer and contractor will respond promptly to the letter; sometimes they will not. In these cases, inspectors must have the legal authority to enforce the requirements of the local stormwater program. The inspection of post-construction BMPs during

Installation of Structural BMPs—Example: Infiltration & Bioretention (excerpt)

D. Installation S = Satisfactory U = Unsatisfactory N/A = Not Applicable				
Item	S	U	N/A	Comments
1. If off-line facility, flow diversion structure installed according to plans				
2. Pretreatment facility installed according to approved plans				
3. Inlet(s) and inlet protection installed				
4. Structural components (e.g. foundation, walls) installed according to plans				
a. Materials tested per local requirements				
5. Liner installed correctly, if applicable				
6. Filter bed composition, depth and installation conforms to approved plans and				
7. Riser/outlet structure installed correctly				
a. Location, dimensions and type of riser are correct				
b. Riser equipped with removable trash rack				
c. Location, dimensions and type of low flow orifice are correct				
d. Low flow orifice installed correctly and adequately protected from clogging				
e. If a filtration system, underdrain system installed correctly				
8. Emergency overflow structure/spillway installed according to plans				

Installation of Non-Structural BMPs—Example: Grass Swales (excerpt)

D. Installation S = Satisfactory U = Unsatisfactory N/A = Not Applicable				
Item	S	U	N/A	Comments
1. After erosion and sediment controls are removed, drainage area to grass channels matches area shown on plans				
2. Grass channels match the dimensions and slopes shown on the plans.				
3. Erosion control blanket or turf reinforcement mat installed properly, if applicable				

E. Vegetation S = Satisfactory U = Unsatisfactory N/A = Not Applicable				
Item	S	U	N/A	Comments
1. Topsoil mixture, soil amendments, and soil compaction complies with plan				
2. Vegetation complies with approved planting plan and specifications				

Figure 8.3. Tool 6: Checklists includes construction/installation checklists for structural and nonstructural BMPs

construction should not be added to an inspector's workload without providing the inspector with the necessary enforcement tools to implement the program.

The enforcement mechanisms that are potentially available to a site inspector are numerous, but they must be backed up by the local stormwater ordinance or other applicable local codes and ordinances. (For example enforcement language, see **Tool 3: Model Stormwater Ordinance**.) Typical enforcement tools include:

- Inspection results summary form letter
- Violation "ticket book" with administrative (civil) fines
- Notice to comply
- Notice of violation
- Stop work order
- Summary of civil/criminal penalties
- Process for withholding release of performance bond
- Process for withholding release of other approvals/permits (e.g., occupancy permit)

An enforcement tool package can be included in the policy and procedures manual (see **Chapter 6**) and provided to site inspectors. Some tools will be forms or letter templates; others will be information sheets that summarize processes and procedures. For example, a tool might describe the local program's civil and/or criminal penalties or outline the process for withholding the release of performance bonds or other approvals and permits.

TIP #5 Use Inspectors to Confirm As-Built Plans and Transfer the Project to the Maintenance Inspection Staff

Although the acceptance of as-built plans is primarily a plan reviewer function, construction inspectors can play a key role in confirming the accuracy of as-built plans and adding documentation to the file that might be extremely useful for the maintenance inspection staff who will ultimately inherit inspection responsibilities.

As-built plans should be prepared by qualified engineers and surveyors to verify that post-construction BMPs have been installed according to plans and specifications. Inspection staff should confirm these as-built plans and take photographs of as-built conditions. Doing so will provide useful documentation and help answer questions when future maintenance issues are identified (**Figure 8.4**).

In some programs, the staff that inspects post-construction BMPs during construction is the same staff that inspects them afterwards for maintenance purposes. In other cases, different staff members, facility owners, or private responsible parties are used to perform maintenance inspections. See **Chapter 9** for more information about BMP maintenance requirements.

A special case might exist when proprietary BMPs are installed. When transferring these projects to the maintenance program, some stormwater managers require additional documentation beyond as-builts to help ensure long-term maintenance. At this stage, the local program can require verification of maintenance contracts or a limited-duration (e.g., 3 years) maintenance bond to jump-start actual maintenance of these devices (especially if the designs are maintenance-intensive).

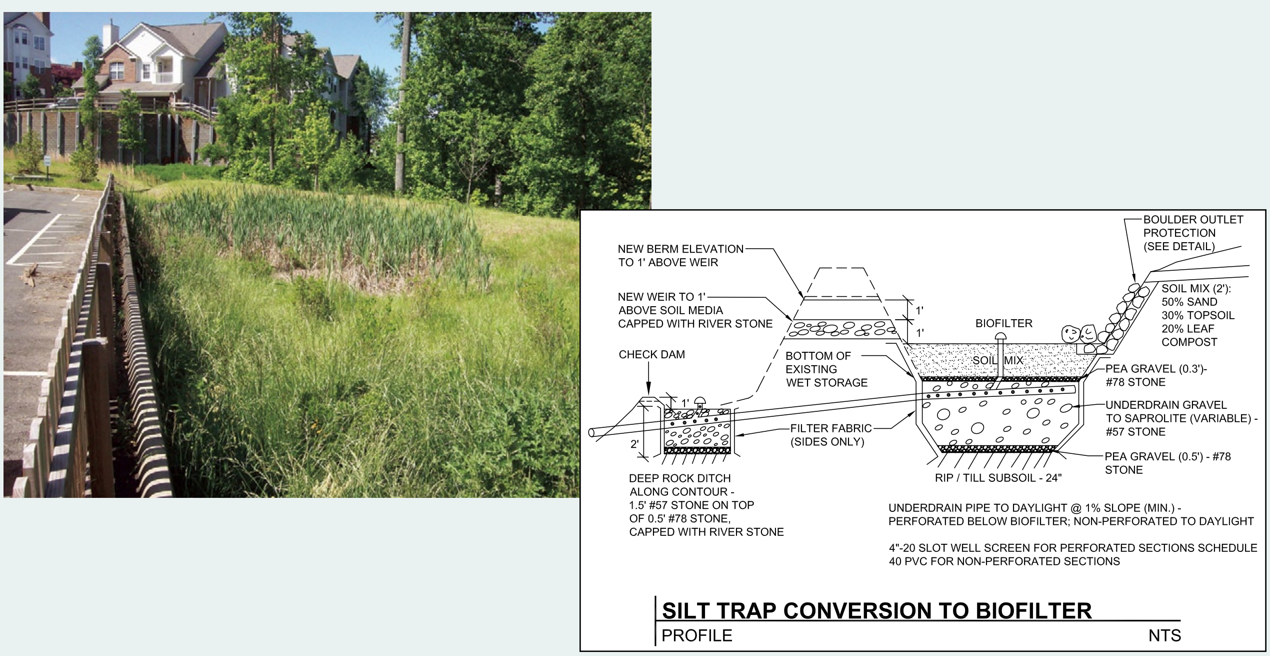


Figure 8.4. Construction inspectors should be involved in confirming as-built plans

TIP #6 **Provide Training for Inspectors**

Construction inspectors must possess the skills to assess conditions that could impact stormwater quality, as well as the skills to assess the effectiveness of BMPs. The stormwater manager should develop and implement a stormwater BMP training program and also take advantage of existing training offered at the regional or state level. A training program should address the following:

- Site construction sequencing
- Requirements and content of stormwater pollution prevention plans (SWPPPs)
- Design and function of post-construction BMPs (structural and nonstructural)
- Material specifications
- BMP installation techniques and sequencing of installation steps
- Confined space training, especially in communities where there are numerous underground practices
- Unique issues associated with proprietary devices
- Common pitfalls in construction that affect the functioning of stormwater BMPs
- Local, state, and federal regulations that require post-construction stormwater management (e.g., NPDES regulations)
- Inspection protocols/process, for both contractors and agency staff
- Enforcement response plan and tools

Some stormwater programs are offering training and certification for contractors as well as municipal inspectors. This approach helps to ensure that contractors are installing and inspecting BMPs appropriately to maintain compliance and are better able to communicate with agency inspection staff if there are compliance problems.

TIP #7 **Integrate Plan Review and Inspections**

Plan review and construction inspection staff and processes should be integrated to the greatest extent possible. This integration will help to minimize conflicts between the plan review and construction inspection processes and maximize the benefits of both.

As described earlier, the construction inspector's job is to ensure that the project is built according to the specifications and details shown on the approved plan. The inspector might not have the inclination or authority to require changes in the field to account for unique site characteristics and conditions. The plan reviewer might have a better sense of the purpose of the BMP design and its ultimate functionality and therefore can help the inspector ensure that the construction of the BMP is consistent with its purpose. The reviewer can also apply judgment as to when to notify the developer's engineer of needed design modifications based on field conditions.

Integration should allow for communication and coordination between the site inspectors and plan reviewers (**Figure 8.5**). **Table 8.4** lists several simple strategies to enhance this coordination.

Figure 8.5. Co-inspections by construction inspectors and plan reviewers can help resolve BMP installation issues

Table 8.4. Methods to Integrate Construction Inspections and Plan Review

- ► Invite inspectors to team review meeting for individual development plans,
- ► Have reviewers and inspectors attend the same training, and include both design and construction issues.
- ► Have reviewers attend pre-construction meetings for projects they reviewed.
- ► Encourage reviewers to periodically go on inspection rounds with inspectors.

8.6. Involving the Public in Stormwater BMP Inspections

Often, the public is a critical component in the ESC inspection process. People are well aware if mud is being tracked on their street or if a silt fence is not working. It is harder for a neighbor to identify that a post-construction BMP is not being installed according to specifications, although this can become very apparent ***after*** construction is complete if the neighbor experiences increased flooding (for example). Nevertheless, the public can be great source of general information about stormwater issues in the neighborhood—areas that flood, how runoff patterns change during construction, and the like—and their input can be helpful to generate "red flags" about the stormwater design of a project.

The more the public is educated about stormwater BMPs, the more helpful they can be. Therefore, it is important to provide training, workshops, fact sheets, and other outreach materials. In addition, providing information online about specific projects will allow public access to development information.

Obvious public stakeholders include developers and contractors. It is important to listen to their concerns and input regarding BMPs that work well and those that are difficult to install or maintain. **Table 8.5** lists key stakeholders in the post-construction BMP inspection process, along with several strategies that can be employed for public involvement. The table lists the following categories of stakeholders:

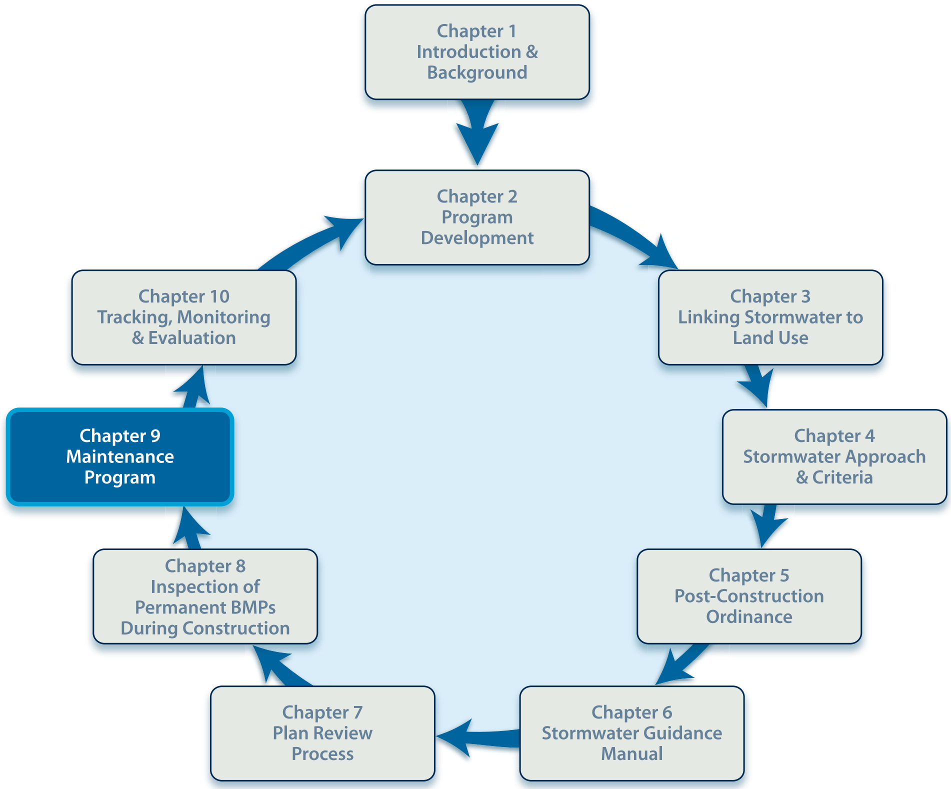
- ***Primary stakeholders*** are those who are involved directly in the BMP construction and installation process, including contractors and, in some cases, the applicant's design consultant.
- ***Inspection coordination stakeholders*** are other departments or agencies that play a role in inspecting the site during construction or in verifying that various site plan elements or permit conditions are implemented. Coordination with these stakeholders is important to avoid giving conflicting messages to the contractor.
- ***Other stakeholders*** are parties that might have an interest in a particular site or construction issues in general (e.g., adjacent property owners, builders, watershed groups).

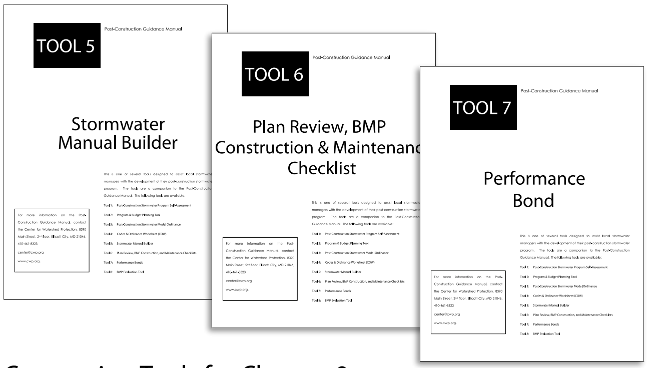
Table 8.5. Key Stakeholders in Post-Construction BMP Inspection and Selected Strategies

Stakeholder Group	Selected Public Involvement Strategies
Primary Stakeholders	
► Applicant ► Applicant's design consultant ► Contractor(s)	► Electronic or Web-based plan tracking ► Training and workshops on BMP construction for contractors and citizens, especially information that may be new to the local community (e.g., LID, stormwater credits)
Inspection Coordination Stakeholders	
► Erosion control inspector/administrator ► Forest conservation inspector ► Dam safety inspectors ► Building inspectors ► Army Corps of Engineers/local wetland and waterways inspectors	► Joint pre-construction meetings ► Joint site visits ► Joint enforcement mechanisms ► Cross-training with relevant departments
Other Stakeholders	
► Local environmental groups ► Local builders' association ► Property owners and residents in vicinity of project ► General public ► Adjacent property owners	► Training for citizens about proper construction methods ► Web-based system on construction inspection and compliance ► Requirement for public access to records ► Fact sheets for adjacent owners ► Hotline for receiving complaints

Chapter 9

Developing a Maintenance Program





Companion Tools for Chapter 9
Download Post-Construction Tools at:
www.cwp.org/postconstruction

What's In This Chapter

- Framework for stormwater maintenance programs
- Current status and trends in stormwater maintenance
- Scoping out the maintenance program
- Three maintenance approaches
  - Private maintenance
  - Local program maintenance
  - Hybrid approach
- Tips for developing an effective maintenance program – from the drafting board to the field
- Public involvement in the maintenance program

9.1. Introduction

Framework for Stormwater Maintenance Programs

A great deal of effort is involved at the front end of developing a stormwater program. Getting stormwater best management practices (BMPs) included on design plans and constructed properly in the field is a major accomplishment, but it is only the beginning of the actual life of the BMPs. Ongoing maintenance is needed to ensure that the BMPs will continue to perform as designed. In fact, lack of adequate maintenance is the primary shortcoming for most local stormwater programs across the country.

Local stormwater managers are increasingly aware that infrastructure for stormwater BMPs requires maintenance. And, as with any infrastructure, deferred maintenance can increase costs and negatively affect receiving waters; unmaintained BMPs will ultimately fail to perform their design functions and might become a nuisance or pose safety problems. Local governments inherit problems arising from deferred maintenance. Therefore, developing and implementing an effective maintenance program is essential.

This chapter reviews existing stormwater maintenance programs and common challenges associated with implementing such programs. Three approaches to maintenance are discussed in detail: (1) private property owner maintenance, (2) local government maintenance, and (3) shared maintenance between public and private entities.

This chapter also discusses BMP design and construction considerations that affect maintenance and offers tips for conducting inspections. In addition, it presents strategies for public involvement in maintaining BMPs.

9.2. Current Status and Trends in Stormwater Maintenance

Only a small percentage of local programs have developed basic operational maintenance programs. Common pitfalls of stormwater maintenance programs include the following (**CWP, 2006**):

- Lack of funding
- Uncertainty of the physical location of BMPs
- Inability to track responsible parties
- Lack of dedicated inspection staff
- Designs that are not conducive to easy maintenance
- Lack of compliance and enforcement authority
- Owners unaware of their maintenance responsibilities

Historically, maintenance activities are difficult to implement for the reasons outlined in **Table 9.1**.

9.3. Getting Started—Scoping Out the Maintenance Program

The following questions are designed to assist stormwater managers in scoping out their maintenance program responsibilities. **Table 9.2** is a maintenance program service matrix that may help a local program manager scope out the types and level of service for the program.

1. How large is the maintenance task?

Local programs cannot develop a maintenance program until an inventory of existing and anticipated future BMPs is conducted. Programs must also determine what elements of the drainage infrastructure should be included in the maintenance program. For example, will the maintenance program be limited to the actual BMPs, or will it also include conveyance systems (pipes and ditches), discharge points, floodplains, and/or stream channels?

An important part of the inventory is assessing the physical and regulatory condition of the system. The physical condition includes the stability and functionality of BMPs and conveyances. The regulatory condition addresses whether BMPs and conveyances are located within easements, have proper maintenance access, and are covered by maintenance agreements or covenants.

2. Who is responsible for maintenance?

Assigning maintenance responsibility is one of the most important policy decisions, and the question may have multiple answers. For instance, the

Table 9.1. Common Maintenance Pitfalls

Insufficient funding	At the root of many maintenance problems is the lack of a stable, long-term funding source. Depending on the level of service a community provides, performing BMP inspection and maintenance can be expensive. It is a real challenge for many communities to know what resources are needed to fund maintenance and repairs and to develop a system that provides consistent funding over the long term.
Uncertainty of the physical location of BMPs	In many communities, the location of stormwater BMPs and conveyance infrastructure has not been tracked as they are constructed. Typically, many communities are not aware of the total number of practices within their boundaries, or whether the BMPs approved have actually been constructed.
Inability to track responsible parties	Even if a community (or local government) is able to track the location of a BMP, the land ownership often changes hands, and the community might not know who the current owner is at a given time. Another common problem is that a homeowners association (HOA) can change leadership or dissolve over time, leaving no real mechanism to maintain existing BMPs.
Lack of dedicated inspection staff	Inspecting and maintaining stormwater BMPs is potentially a full-time job, but few communities have a full-time inspector on staff. As a result, repairs are often ordered in response to citizen complaints, rather than as a part of a comprehensive maintenance plan. Thus, many of the practices that are "out of sight" (e.g., underground practices) go without needed maintenance, resulting in a significant loss of pollutant-removal capability.
BMP designs that are not conducive to easy maintenance	Many BMPs have been constructed without design features that reduce the maintenance burden over time. Examples include inadequate maintenance access, insufficient pretreatment, inlets and outlets prone to clogging, and designs that require confined space entry for maintenance. Lack of adequate design for maintenance increases the frequency of needed maintenance activities, and it hampers the ease with which maintenance and inspections can be conducted.
Lack of compliance and enforcement authority/access	Although many communities have maintenance requirements incorporated into a stormwater ordinance, many also lack the real teeth to ensure that maintenance actually happens. Important compliance issues include escalating enforcement procedures (as problems become increasingly severe), maintenance access, and legal authority to inspect and to compel maintenance.
BMP owners unaware of maintenance responsibility	As a property changes hands, maintenance agreements and other documents outlining maintenance needs are easily lost or buried within property deeds. This leaves practice owners unaware of long-term BMP maintenance responsibilities and costs.

local government or an associated utility may be responsible for BMPs on public land and within public rights-of-way, but maintenance for BMPs on private land may be a shared responsibility. This decision may depend on the status of easements, maintenance agreements, and whether maintenance tasks are aesthetic or structural.

3. What is the current status of legal tools for maintenance?

Local programs must have the legal authority to require maintenance of BMPs, or it is likely that maintenance duties will be neglected. The proper legal authority includes: assigning maintenance responsibility through legally binding agreements, adequate access to BMPs, and enforcement mechanisms. See **Chapter 5** and **Tool 3: Model Ordinance** for more guidance on developing a post-construction ordinance.

4. What "level of service" is desired for the maintenance program?

The level of service defines the frequency and scope of maintenance. For example, will BMP inspections take place on an annual or semiannual basis? Will this vary based on the size and type of BMP, whether the facility is public or private, and other factors such as the threat of flooding if maintenance does not occur? Will maintenance be performed in response to complaints or emergencies, or will it be based on inspection reports or on a preset schedule? **Table 9.2** outlines several key level of service decisions.

Table 9.2. Maintenance Program Service Matrix. System components and maintenance response can increase as programs mature. The matrix is a tool to set priorities and plan for future program expansions.

(**+**) means that services are cumulative (level of service includes all previous tasks).

Program Level of Service	Drainage System Element Included in Maintenance Program	Maintenance Task	Maintenance Response	Inspectors	Inspection Response	Program Feedback Based on Inspections and Maintenance Experience
LOWER ↓ HIGHER	BMPs on public land and within public rights-of-way + High-priority, high-risk, and/or large BMPs on private land with necessary easements and agreements + All or most BMPs on private land within easements and covered by deeded maintenance agreement + Completely private BMPs + All conveyances (pipes, ditches, flood plains)	Repair immediate threats to public health and safety + Repair structural items: erosion, outfalls, clogged or broken pipes + Also include routine maintenance: mowing, weeding, removal of trash and debris, replacement of vegetation + Program includes system to retrofit or reconstruct BMPs	React to complaints and emergencies + Establish schedule for mowing and trash/debris removal + Conduct maintenance in response to inspection reports, checklists, and performance criteria	Rely on owners and HOAs to inspect Public inspectors send report to responsible party Co-inspections with public inspector and responsible party System of certified private inspectors with spot inspections and compliance checks by public agency	Complaint-driven Every 3 years Annual or semiannual More frequent for high-priority BMPs	Feedback is anecdotal + Feedback used to modify list of recommended BMPs in design manual based on maintenance burden + Feedback used to modify design standards in manual to reduce maintenance burden through initial design

5. Who is responsible for structural versus routine maintenance?

This question is related to the level of service. There are two types of maintenance: structural and routine. Structural maintenance consists of repairing plumbing, parts, and infrastructure, and it is typically costly. Routine maintenance involves removing accumulated trash and debris and managing vegetative growth (see **Table 9.3**).

Table 9.3. **Examples of Structural and Routine Maintenance**

Structural Maintenance Items	Routine Maintenance Items
▶ Clogged or broken pipes ▶ Missing or broken parts (e.g., valves, seals, manholes) ▶ Cracked concrete ▶ Erosion at outfall or on banks ▶ Regrading or dredging ▶ Landscaping needs complete refurbishment	▶ Mowing ▶ Removal of small amounts of sediment ▶ Removal of vegetative overgrowth and woody plants ▶ Removal or trash and yard debris ▶ Replacing dead or diseased landscaping ▶ Control of invasive plants

Many programs assign responsibility for routine maintenance to the landowner or responsible party (e.g., homeowners' association, or HOA) while retaining responsibility for structural items. As programs become more sophisticated, routine repairs by the local program are favored because performing routine maintenance prevents serious and more costly repairs in the future.

6. Should the local program use in-house resources, a contractor, or both to perform maintenance tasks?

Local program managers who operate large, public facilities may use in-house staff to conduct BMP maintenance in conjunction with operating and managing utilities, buildings, and roads. For many smaller programs, however, employing private contractors is more efficient than hiring new staff and purchasing equipment. Another option is entering into an agreement with a water and sewer utility, neighboring jurisdiction, or transportation agency to share maintenance responsibilities and maximize economies of scale in the use of equipment and personnel.

7. How will maintenance compliance be tracked, verified, and enforced?

Local stormwater ordinances (see **Chapter 5**) and program tracking and evaluation systems (see **Chapter 10**) are key components of a strong program. Before a stormwater plan is approved, each plan should have a recorded maintenance agreement that can be used to help track maintenance. Checklists can then be used to determine whether performance criteria have been met (see **Tool 6: Checklists**). Finally, when maintenance is not performed, mechanisms to enforce compliance must be in place.

9.4. Three Maintenance Approaches

There are three general approaches that communities can use to implement a stormwater maintenance program:

1. Private property owners are responsible for performing stormwater BMP maintenance. (The local program provides oversight and guidance.)
2. The local program is responsible for performing maintenance.
3. A hybrid consisting of both public and private entities responsible for various maintenance tasks.

Table 9.4 outlines the characteristics of each approach, as well as typical program budgets and funding mechanisms. Most stormwater programs include features from all three approaches.

Approach 1: Private Maintenance

Using this approach, private landowners or HOAs are primarily responsible for routine maintenance and major structural repairs. Public maintenance, where it does occur, is limited to facilities on public property.

Placing maintenance responsibility in the hands of individual property owners, HOAs and business

Table 9.4. Three Maintenance Program Approaches

Typical Program Characteristics	Typical Annual Maintenance Program Budget Range[a]	Typical Funding Mechanisms
1. Private Maintenance		
► Property owners and homeowners associations responsible for maintenance ► Less costly for local program, but often is a neglected program element ► Legal and program tools needed to establish responsibility: ordinance, maintenance agreement, easements, and compliance tools ► Strong outreach and education needed for effective program	$5K to $100K	General fund Plan review and inspection fees Maintenance bonds or escrow accounts
2. Local Program Maintenance		
► Local program responsible for most maintenance functions ► Owners may be responsible for routine tasks (mowing, picking up trash, aesthetics) ► Requires highest budget and staff commitment ► More common in cities and towns with established public works function and jurisdiction over roads and drainage	$100K to $1.5M	Stormwater utility Other utility (e.g., sewer) rates Transportation maintenance funds General fund
3. Hybrid Approach: Blend of Public and Private Maintenance		
► Local government maintains facilities on public land and/or major private facilities within easements, while private parties are responsible for facilities on most private property ► Most common maintenance approach ► Can be cost-effective, but still requires local government budget and staffing	$50K to $300K	Stormwater utility Capital improvement program General fund

[a] Maintenance program budget figures were derived from research on local stormwater programs, primarily Phase II MS4s, conducted in 2005 (**CWP, 2006**). Because most programs are still in the early stages of program development, these figures represent nominal costs associated with a maintenance program, and do not include other costs, such as the cost of stormwater capital improvement projects. Costs will increase as program responsibilities and accountability increase. Typically, larger municipalities, such as Phase I communities, have much larger maintenance budgets.

owners significantly reduces the costs to the municipality and may be the best option for small communities that cannot afford to allocate staff and crews to maintain BMPs. The local program still plays a significant role under this option, however, by educating property owners and HOAs, tracking maintenance, and initiating enforcement when needed. If the program fails to fulfill these roles, an inadequate level of maintenance is inevitable.

The following six steps outline a general process for establishing a private maintenance program:

Step 1: Develop Program Documents

The program's legal and administrative foundation must be established in the stormwater ordinance (**Chapter 5**), design or policy manual (**Chapter 6**), and other forms and applications.

A preliminary list of necessary documents is provided in **Table 9.5**.

Table 9.5. Legal and Administrative Foundation for a Maintenance Program

Stormwater Ordinance	Design/Policy Manual	Other Forms and Application
Requirement for responsible party to maintain BMPs		Maintenance handbook or guide for responsible parties
General design standard to include maintenance reduction features	Detailed maintenance reduction design specifications (see **Chapter 6**)	
Requirement for a maintenance agreement or covenant recorded with property deed	Standard (template) maintenance agreement	
Requirement for easements	Standard easement deed and specifications (when required, width, rights of grantor and grantee)	
Maintenance inspection frequency and reporting	Maintenance checklists and sample operation and maintenance (O&M) plans	
Requirement for performance bond to cover initial installation and period of operation (e.g., 2 years)	Performance bond forms (see **Tool 7: Performance Bonds**)	
Compliance and enforcement tools	Notice of Violation letter template Schedule of civil and/or criminal penalties	Civil penalty "ticket book" for inspectors

Step 2: Verify maintenance provisions during stormwater plan review

As noted in **Chapter 7**, the plan review process should ensure that all necessary documents are in place when a project is approved. These include:

- Maintenance agreements, including the identity of a responsible party and the applicable parcel(s), which are recorded in the property deed (examples of maintenance agreements can be accessed with **Tool 5: Manual Builder**)
- Operation and maintenance (O&M) plans, which are part of the approved plan and/or maintenance agreement
- Easements, which are accurate and shown on the final property plat
- Performance bonds, if applicable (see **Tool 7: Performance Bonds**)

Step 3: Develop Outreach Materials and Programs for Design Consultants and Responsible Parties

Educating homeowners, HOAs, and businesses about BMP maintenance is critical. Often, property owners are unaware of what a BMP is, how it functions, and what is required for maintenance. When development is proposed for a new site, the following educational outreach efforts should be conducted:

- ***During Plan Development***: A municipal staff person should work with the developer, contractor, or design consultant to develop a maintenance plan for each BMP. At the pre-construction meeting, the parties should review the maintenance plan, maintenance responsibilities, and schedules.
- ***During Ongoing Maintenance***: A municipality typically provides technical assistance to HOAs and businesses after the plan is developed. Technical assistance may include providing lists of local contractors who conduct maintenance or repairs, developing a budget for maintenance, providing maintenance handbooks written for citizens, and accompanying owners or contractors during routine and post-repair inspections. Some programs, such as "Adopt-A-Pond," develop citizen-friendly guides, training opportunities, and recognition and awards for participants.

Step 4: Develop Inspection Procedures

There are three basic approaches for maintenance inspections:

1. ***Local program staff conducts inspections***: This option requires the most time, staff, and funding, but it provides local programs with the best control over inspections.
2. ***Local program hires contractors to conduct inspections***: This approach reduces staff time, but it requires contract management and quality control to ensure that thorough inspections are conducted. Local program staff members are responsible for compliance and enforcement.
3. ***Private parties responsible for inspections***: Responsible parties can conduct inspections with in-house personnel (or HOA volunteers) or by hiring a contractor. This approach still requires the local program staff to conduct spot inspections and to ensure overall compliance. Under this scenario, the local program could sponsor an inspector training and certification program to promote consistency and quality control.

Step 5: Establish a Tracking System

Regardless of whether the municipality or the property owner is performing the BMP maintenance, tracking maintenance activities is important. Automated systems could be established to send notices to property owners when inspections and routine maintenance should be performed, or when an inspection by a municipal staff person reveals specific maintenance needs (see **Figure 9.1**).

After changes in property ownership, updating responsible party information is an important, but often difficult, tracking function. Often, no formal mechanisms are in place for notifying local programs when a property with a deeded maintenance agreement is sold. The local program must work with the real estate office or send frequent (annual) notices to responsible parties requesting updated information.

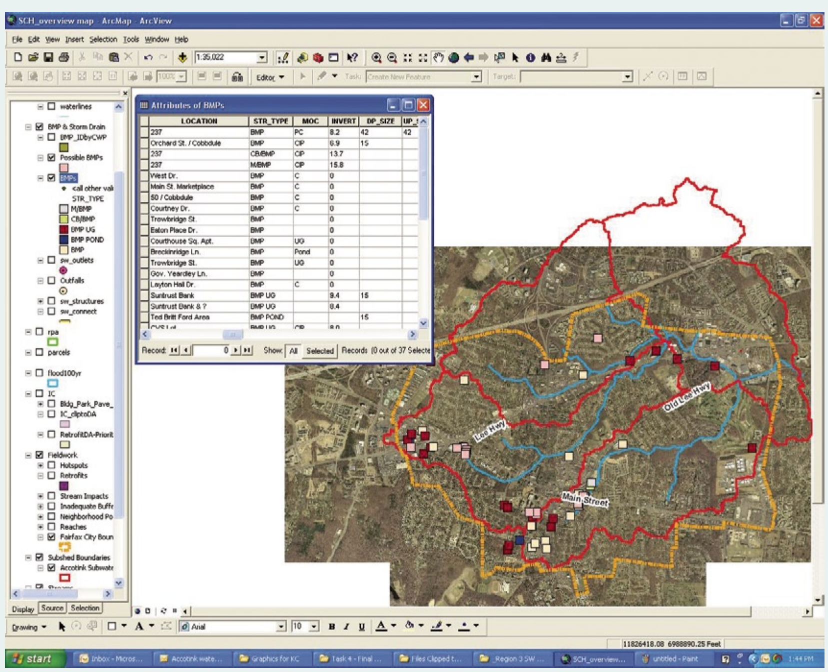


Figure 9.1. Many BMP tracking systems use GIS and related databases to track location, ownership, condition, and other BMP characteristics (Source: CWP, 2006; Graphic: Albemarle County, VA)

Step 6: Administer Compliance and Enforcement Procedures

The municipality is responsible for enforcement actions when maintenance activities are not conducted. Language in ordinances must specifically define maintenance enforcement procedures and timelines. Typically, municipalities are responsible for educating property owners about these procedures.

A tiered enforcement procedure is often best. Initially, responsible parties can be notified, verbally or in writing, of inspection and maintenance tasks. If needed repairs are not performed accordingly, a more formal notice of violation that outlines specific tasks and a schedule can be issued. In cases of continued noncompliance or negligence, or where lack of maintenance poses a threat to public health and safety (e.g., potential dam breach), penalties and fines may be assessed and issued.

Table 9.6 summarizes several compliance and enforcement methods that can be used for BMP maintenance.

Table 9.6. Review of Available Compliance Methods

Method	Stage of Compliance	Description
Maintenance agreement	Recorded at project review. Used during life of BMP as basis for other enforcement measures.	This agreement is a contract between a local government and a property owner designed to guarantee that specific maintenance functions are performed. A maintenance agreement usually specifies that, in cases of noncompliance, the local program can enter the property to make necessary repairs and assign applicable costs to the owner. Examples of maintenance agreements can be accessed with **Tool 5: Manual Builder**.
Performance bond	Posted at project review. Usually used during construction and initial installation of BMPs. Can be extended to cover initial period of post-construction maintenance (e.g., 2 years)	In a typical stormwater management performance bond, a site developer or property owner guarantees that construction of stormwater BMPs will be completed in accordance with the terms of a stormwater ordinance and approved stormwater design plan. Should the site developer or property owner fail to meet the performance measures, the bond ensures that enforcement action can be taken by the jurisdiction at the developer's or property owner's expense (see **Tool 7: Performance Bond**).
Notice of Violation (NOV)	First stage of enforcement after inspection and documentation of noncompliance	As a first step in the compliance process, the owner or responsible party is sent an NOV outlining the nature of the violation, the specific actions needed to come into compliance, a schedule for completing the remedies, and subsequent penalties that can be imposed if the actions are not taken.
Civil penalty	Escalating level of enforcement if NOV does not lead to compliance and bond has been released	As an incentive for compliance, a municipality can levy a monetary penalty for noncompliance. This penalty can be a fixed amount, or the amount could increase with the severity of the violation or the frequency of recurrence.
Criminal penalty	Alternative to civil penalties when remedies listed above are not adequate	A criminal penalty can be levied for more serious cases in which a party can be considered intentionally or knowingly negligent.
Maintenance escrow requirement	Not common, but could be effective tool at completion of construction	A property owner is required to post a cash escrow, letter of credit, or other acceptable form of performance security in an amount that would cover costs associated with maintenance and repair or replacement in the event of BMP failure.

Approach 2: Local Program Maintenance

Using this approach, the local program is responsible for BMP maintenance. This approach is not widespread among MS4 communities, primarily because of the high costs, extensive staffing, and administrative burden placed on the program. This approach, however, has advantages: Enforcement issues can be avoided, and the local program has more control over when and how maintenance takes place. In many cases, municipalities can transition from private maintenance (Approach 1) to local program maintenance (Approach 2) as the program matures. This transition would require the local program to inventory existing BMPs and conveyance systems to determine immediate maintenance needs.

In general, this approach requires local programs to collect and manage detailed information about each BMP, maintain a team of dedicated staff, and secure funding.

A typical process for establishing this type of program is outlined below.

Step 1: Inventory BMPs

Local programs must inventory BMPs, including collecting information on the physical condition of the structures and determining whether the BMPs are within easements (or under fee-simple ownership) and have adequate maintenance access. **Table 9.7** lists typical items that should be included in a BMP inventory.

Step 2: Establish Maintenance Policies and Funding

This step requires critical policy-making decisions, which serve as the foundation for program budget and staffing and for determining level of service. A typical decision may include determining responsibility for structural versus routine maintenance (see **Table 9.3).** In most communities, simple aesthetic and routine tasks, such as mowing and trash removal, are performed by the property owner or responsible party. These activities require equipment and staffing, and they are more challenging for municipalities to undertake on a frequent or routine basis. See **Table 9.2** for additional level of service policy decisions.

Table 9.7. BMP Inventory Checklist

Physical Condition	Programmatic Condition
► Type of BMP ► BMP Design Features: size of practice, drainage area, treatment area/ volume, design storm(s), pipe sizes, etc. ► Structural stability of dams/impoundments, if applicable ► Integrity of pipes and risers ► Condition of emergency spillway or by-pass channel ► Manholes and inlets in place and locked (if necessary) ► Standing water or nuisance conditions ► Sedimentation or sediment buildup ► Evidence of clogging, ponding (infiltration, bioretention, filters) ► Evidence of dumping (trash, yard debris) ► Status of vegetation ► Water enters and exits BMP per design ► BMP is built according to design (e.g., dimensions, size, elevations)	► Is BMP within easement? Are easement dimensions adequate? Any utility easements (that may interfere with BMP function or maintenance)? ► Any existing maintenance agreements in force? ► Maintenance access platted and exists in good condition on ground?

Step 3: Secure Easements for New BMPs during Plan Review

Securing easements after a project is built and after properties are occupied is time-consuming and has uncertain results. Therefore, program managers should strive to secure easements during the review of stormwater plans. This requires the stormwater reviewer to coordinate with the department or staff person that reviews property plats. To be of legal standing, the easement must be shown on the plat of record.

Programs that promote low-impact development (LID), dispersed, and distributed practices—possibly on individual lots—may have to develop LID-specific easement policies and procedures. There are legal, administrative, and logistical considerations for having easements cover these types of practices, and for the long-term access and maintenance of the practices. The local program may want to consider a "hybrid" approach (see below) for certain categories of BMPs.

Table 9.8 provides some considerations for securing stormwater easements.

Step 4: Secure Easements and Agreements for Existing BMPs

Depending on the level of service, securing agreements to access and maintain BMPs in the existing inventory may be necessary. Many existing BMPs require costly repairs to achieve a good operating status. It is not uncommon for the local program to assume responsibility for the BMPs only after the private party (1) conducts maintenance of the BMP to a minimum performance level and (2) provides legal access and easement documents.

This element of the program can be very time-consuming. It requires documenting the condition of BMPs, negotiating with multiple property owners, and involving legal staff and often elected officials. For these reasons, securing easements and agreements for existing BMPs will likely be a phased program. A scoring or ranking system can help a program set priorities for this task.

Table 9.8. Considerations for Stormwater Easements

Easements should cover: ► BMPs ► Enough land around BMPs for construction equipment to enter and maneuver. This includes access to dams, risers, safety benches, forebays, and outlets, as appropriate. ► For ponds, a setback (e.g., 25 feet) from the flood (100-year) pool area ► Access routes for maintenance ► According to program policies, conveyances and structures associated with BMPs
For drainage easements, the easement width should increase as the top width of the channel or depth of the pipe increases. For instance, increase the easement width in increments of 5 feet for pipes that are 10, 15, 20 feet deep, etc.
Ensure that access routes are of adequate width (minimum of 12 feet) and acceptable longitudinal slope (15% or less). Surfacing should be based on anticipated frequency of use and types of equipment. Although gravel may be a suitable surface, consider pervious surfaces, such as reinforced turf or paver blocks, that do not increase the site's impervious cover.
Make sure easements are recorded on the property plat and in the deed.
Easement agreements or deeds of easement will help specify the rights and responsibilities of both the easement holder and the owner. For instance, the deed or agreement can spell out that the owner is responsible for mowing and routine maintenance, and that fences and other obstructions are not permitted.
For examples of easement specifications and documents, see **Tool 5: Manual Builder**.

Step 5: Train Inspectors

Inspector training and certification are essential for a program that conducts most of its maintenance operations. Inspectors need to be well versed in the use checklists (see **Tool 6: Checklists**) and provide feedback on maintenance activities to program managers (**Figure 9.2**).

Step 6: Develop a Tracking System

Tracking BMP maintenance is essential for both local programs and private property owners. In large communities, tracking systems are technically advanced and use linked systems comprising geographic information systems (GIS), global positioning systems (GPS), and hand-held data collectors. However, simpler GIS and hard-copy file formats can also be used. **Table 9.9** lists items that are appropriate for local programs to track.

Another critical task is collecting data about specific maintenance activities and their costs. Tracking systems can monitor costs for performing inspection and maintenance services. These data can assist local programs in estimating future expenses and developing more cost-effective means to accomplish tasks.

Step 7: Perform and Document Maintenance Activities

It is common for all but the largest communities to rely, at least partially, on outside contractors to conduct maintenance and repair activities because of the overhead equipment costs and specialized skills needed to conduct the full range of maintenance activities (**Figure 9.3**). One alternative is to form a separate organization or special "district," such as a stormwater utility, that is responsible for all maintenance and inspections. Another option is to include stormwater maintenance responsibilities in an existing utility, such as a water and sewer authority. Such a utility or district would have a dedicated funding source to ensure longevity.

Approach 3: Hybrid of Public and Private Maintenance

A blend of public and private maintenance, the most common approach for local programs, provides maximum flexibility for assigning maintenance responsibilities. Programs using this approach are typically shifting some maintenance activities from HOAs and other private parties to local programs because the private entities have proved incapable of performing all maintenance activities. Often, a particular problem or high-profile complaint to elected officials causes the shift to occur.

The process for building a hybrid program contains elements of approaches 1 and 2, and program managers should refer to the steps in this chapter for those approaches. A supplemental step is relevant to hybrid programs.

Figure 9.2. Inspector training helps inspectors understand the function and maintenance needs of BMPs

Table 9.9. Tracking Items for a Municipally Operated Maintenance Program

- Inspection dates and reports
- BMP locations
- General condition of BMPs (see **Tool 6: Checklists**)
- BMP features: size of practice, drainage area, treatment volume/design storm, age, pipe sizes, etc.
- Photos
- Information needed to prioritize maintenance tasks. For instance, the inspection process can categorize BMP maintenance needs as (1) no action, (2) routine maintenance needed, (3) major maintenance needed, or (4) remediation/reconstruction needed. This type of BMP triage system is necessary to allocate available resources.
- Maintenance work orders
- Maintenance schedules and/or documentation on tasks completed
- Costs for various maintenance tasks
- Available BMP feedback or evaluation data that can help program managers amend the list of approved BMPs or particular BMP design features
- Good retrofit opportunities

Figure 9.3. Use municipal staff, contractors, or both to perform maintenance tasks

Supplemental Step: Be Clear about Various Maintenance Responsibilities

Maintenance responsibilities must be clearly outlined for program success. One danger of a hybrid system is that maintenance responsibilities are not systematically assigned and communicated. Local program staff must understand who is responsible for maintenance tasks and must ensure that private parties understand their role. **Table 9.10** provides some recommendations on how to clarify roles and responsibilities.

Table 9.10. Methods to Assign and Communicate Maintenance Responsibilities

- Make explicit policy decisions based on program goals and the characteristics of the community. Don't assume that all parties will know what they're supposed to do.
- Use a deed of easement or easement agreement to clearly outline rights and responsibilities. See also **Table 9.8**, **Considerations for Stormwater Easements**.
- Use a maintenance agreement that clearly outlines responsibilities for routine versus structural maintenance.
- Develop a guidebook or other outreach materials geared toward HOAs and responsible parties.
- Explain maintenance responsibilities during co-inspections.
- Include maintenance information on the program Web site.

Table 9.2 lists components of maintaining the drainage system, which could be assigned to the local program or private parties for maintenance. Assuming that most or all of the functions in **Table 9.2** must be performed by some party, the local program must delegate responsibilities. Local program staff would also monitor all private-party activities to ensure that appropriate inspection and maintenance tasks are performed.

9.5. Tips for an Effective Maintenance Program—From the Drafting Board to the Field

Maintenance must be considered throughout the entire stormwater program—from early program policy decisions, to design standards, to the development review process, and, most important, to inspection of BMPs in the field. The following section provides tips on how to tailor design and field procedures to consider long-term maintenance needs. **Figure 9.4** shows some good and bad examples of design features related to maintenance.

This section is divided into two subsections:

1. ***On the Drafting Board***: Tips for developing design standards and for acknowledging and accommodating long-term maintenance needs during the initial design process.
2. ***In the Field***: Procedures for inspecting BMPs to ensure proper maintenance.

On the Drafting Board—Design Standards and the Design Process

Tip #1 Authorize BMPs That the Program Is Prepared to Maintain

Selecting or approving the right stormwater BMP is key to ensuring success. Historically, poor selection of BMPs contributed to failures and chronic maintenance problems. Adding nonstructural BMPs, such as conserving natural areas, restoring riparian areas, and disconnecting impervious surfaces, to the list of approved BMPs can also help reduce maintenance costs.

Designing BMPs as multifunctional and aesthetically pleasing facilities promotes maintenance because the public uses and takes interest in these areas. For instance, BMPs that are designed as components of greenways, walking trails, recreation areas, parks, streetscapes, and courtyards have a higher likelihood of receiving maintenance.

Table 9.11 outlines some of the key maintenance considerations for various BMPs. Specific design features are addressed in **Chapter 6.**

Tip #2 Develop BMP-Specific Maintenance Plans

Maintenance plans can be incorporated into approved design plans and/or as a component of maintenance agreements. Maintenance plans should identify the responsible party, include a list and schedule for both routine and structural maintenance, and outline any legal mechanisms in place

Poor Examples	Good Examples
 **Maintenance Access and Safety**: Steep side slopes make maintenance difficult and are a safety hazard.	 *Photo courtesy of Tim Schueler* **Maintenance Access and Safety**: Shallow sides slopes and wetland benches are a maintenance and safety feature.
 *Photo courtesy of Tim Schueler* **Practice Selection**: Underground BMPs can be out of sight, out of mind when it comes to maintenance.	 **Practice Selection**: Nonstructural BMPs, such as riparian restoration, can be low-maintenance options and community amenities.
 **No Pretreatment**: Without pretreatment, sediment can enter the main treatment cell and inlets can erode.	 **Pretreatment**: Forebays and pretreatment cells help protect the main pond and ease future maintenance.

Figure 9.4. Examples of Poor and Good Maintenance Features Related to the Design Process

Poor Examples	Good Examples
 **Not a Community Amenity**: Unsightly basins in residential areas tend to become nuisances and generate complaints.	 **Community Amenity**: Stormwater BMPs, such as this rain garden, can be designed as amenities, with plantings, interpretive signage, and public access.
 **No Planting Plan**: Lack of plants and landscaping make BMPs unattractive and undesirable to maintain.	 **Planting Plan**: Plants are being added to this regional basin to enhance aesthetics and water quality functions.
 **Poor Conveyance**: Improperly designed conveyances become maintenance problems in the future.	 **Good Conveyance**: Good conveyance design can include check dams, vegetation, and adequate channel lining.

Figure 9.4. Examples of Poor and Good Maintenance Features Related to the Design Process *(continued)*

that guide long-term maintenance (i.e., maintenance agreements, easements, and/or deeds of easement). **Tool 6: Checklists** can assist with typical maintenance tasks for specific categories of BMPs.

Tip #3 **Provide Runoff Pretreatment**

Pretreatment refers to the techniques used to provide storage or to filter out coarse materials before stormwater enters the BMP. Proper pretreatment preserves a greater fraction of the water treatment volume over time and prevents large particles from clogging orifices, filter material, and infiltration sites. The specific techniques and volumes of stormwater treated vary by the type of BMP used. Common pretreatment practices include forebays, vegetated filter strips, stone filter strips (for higher velocities), and grass channels. One important consideration for pretreatment is that these practices usually require frequent maintenance, such as sediment and trash removal.

Tip #4 **Carefully Design Conveyance Systems**

High flows into, through, and out of the BMP often cause erosion and increase maintenance burdens. To minimize erosion, designs should consider inlet and outlet protection, conveyance channels, and seepage prevention.

Conveyance channels can be an important part of the treatment train and require special design considerations to minimize maintenance. They can also be a maintenance burden, particularly if sediment accumulates within the channel or if flows cause erosion within the channel.

Tip #5 **Ensure Long-Term Maintenance Access**

Site access must be safe and must provide enough room for construction vehicles to perform maintenance. Access should include a dedicated easement that guarantees right of entry. These requirements are adequate for filtration and open-channel devices, but the access requirements for aboveground or open-air BMPs, and for surface treatments, are slightly different.

For example, for ponds and wetlands, it is important that the access paths/roads have adequate width (12-foot minimum is common) and appropriate longitudinal slopes (maximum of 15% is recommended) to allow maintenance vehicles to enter and turn around.

Programs can also consider surface treatments, such as reinforced turf, that do not increase a site's impervious cover. Maintenance access should extend to the forebay, safety bench, and outlet/riser area. Risers should be located in embankments for access from land, and they should include access to all elements via a manhole and steps.

Tip #6 **Include Safety Features**

The best overall approach is to select BMPs that include safety features. Many BMPs do not involve standing water, steep dropoffs, or large risers and barrels, and they should be considered as the best options.

When ponds or basins are used, however, the design should incorporate safety features that prevent easy access to confined spaces (e.g., risers and barrels), limit drowning hazards associated with permanent pools of water, and protect the BMP from vandalism.

Many communities use fences to prevent access to ponds or basins. Alternative approaches include the use of mild side slopes, wetland or safety benches, or thick vegetation.

Riser structures can also be used, but methods to reduce vandalism must be implemented. Riser manholes should be locked, and any openings in the riser should be covered with an appropriate trash rack. In addition, the operator valves for pond drains should be chained and locked to prevent unauthorized use.

Tip #7 **Plan for Sediment Removal and Disposal**

Removing sediment and debris is a common maintenance item for ponds, wetlands, and other types of BMPs. Minor debris removal is relatively simple, but removing large quantities of sediment can be a major and costly undertaking. Design features should enhance access, as described above, and include features that minimize removal efforts. For example, a pond drain is an important design feature that allows

Table 9.11. Key Maintenance Considerations for Various BMPs

Type of Practice	Overall Maintenance Burden*	Key Maintenance Considerations
Stormwater Ponds	M	► Periodically remove and dispose of sediments ► Control woody vegetation on dam ► Repair slumping, animal burrows, and seepage associated with dam ► Prevent clogging of orifices ► Prevent unauthorized access to deep water areas, risers, pipes, and manholes due to safety concerns ► Manage vegetation and remove trash ► Prevent standing water and mosquito habitat (mostly associated with dry extended detention ponds)
Stormwater Wetlands	M	► See above for ponds ► Manage invasives
Filtration Practices	H	► Prevent clogging of filter surface through frequent cleaning and removal of top layer ► Replace filter media when clogged ► Pump out sedimentation chamber (e.g., sand filters) ► Use confined-space entry procedures for some designs
Infiltration Practices	M – L	► Repair and restore clogged practices ► Prevent standing water
Bioretention	M	► Prune, replace, and enhance vegetation ► Replace mulch layer frequently ► Keep inflow points (e.g., curb cuts) flowing and free of sediment and debris ► Replace filter surface or install wick drains if clogged ► Keep underdrain clear ► Control impacts from road salt and snow plows in cold climates
Open Channels	M	► Remove sediment periodically ► Manage vegetation ► Repair erosion after heavy storms ► Clear debris from upstream face of check dams, if applicable ► Minimize standing water and mosquito habitat
Proprietary Devices	H	► Conduct frequent to periodic pump-outs and disposal; requires approved disposal method for liquids and solids ► Clean or replace cartridges, filter media, etc., depending on device ► Repair clogged orifices and by-passes ► Use confined-space entry procedures for some designs

Table 9.11. Key Maintenance Considerations for Various BMPs *(continued)*

Type of Practice	Overall Maintenance Burden*	Key Maintenance Considerations
Natural Area Conservation and Restoration	L	▶ Prevent encroachments, such as dumping yard waste, cutting of trees, clearing, and minor encroachments (sheds, decks, etc.) ▶ Manage invasives
Sheetflow to Buffer or Open Space (e.g., Preserving Open Space Designed to Intercept and Treat Runoff)	L	▶ Maintain runoff as sheet flow; repair erosion rills and gullies ▶ Maintain energy dissipators, level spreaders, and other devices to maintain sheet flow ▶ Prevent adjacent uses from piping runoff through open space or buffer
Impervious Area Disconnection	M	▶ Ensure runoff enters pervious area ▶ Remove sediment and debris build-up at points where runoff enters pervious area ▶ Prevent adjacent uses from piping through or around pervious area ▶ Manage vegetation in pervious area ▶ Maintain any “structural” elements in design: level spreaders, energy dissipators, rain gardens, etc.
Grass Channels	M – L	▶ Remove sediment periodically ▶ Repair erosion after heavy storms ▶ Manage vegetation ▶ Minimize standing water and mosquito habitat

* L = low; M = medium; H = high

maintenance crews to drain ponds or wetlands before removing accumulated sediment.

At sites where sediment loads are expected to be high, designers should designate a dewatering and storage area on the site. If on-site storage is not practicable, sediment can be used elsewhere after dewatering, unless the material was generated from a stormwater hot spot (e.g., gas station). In this case, a Toxicity Characteristic Leachate Procedure (TCLP) or other analytical analysis should be performed on the removed sediment to determine if it meets the criteria of a hazardous waste and thus requires special handling and disposal.

Underground or proprietary BMPs—such as vaults, chambers, and other structures that require accumulated material to be pumped out—require special consideration because inspection and maintenance staff could be required to have confined-space training to satisfy OSHA safety requirements. Also, some types of proprietary devices require frequent maintenance to perform as designed, so maintenance contracts are essential when such BMPs are specified on plans.

Finally, disposal operations must be carefully planned. Some pump-outs result in a waste material that is composed of both liquids and solids. Wastewater plants do not customarily accept wastewater with solids, and sanitary landfills do not usually accept any liquids or saturated sediments. Therefore, maintenance plans must generate a waste material that meets the various disposal requirements.

Tip #8 Include Planting Plan

All BMP designs should incorporate plantings to improve both function and aesthetics. If designed correctly, planting plans can reduce future maintenance liabilities. Landscaping can help prevent access to ponds by geese and children, stabilize banks, and prevent upland erosion. Ponds may rely on adjacent trees and shrubs, or on planted tree mounds within wetlands, for shading to reduce ambient water temperatures.

Planting plans designed for bioretention should identify and recommend species that can tolerate wet and dry conditions. All BMP designs should incorporate landscaping to improve function and aesthetics. All planting plans should specify a care and replacement warranty.

In the Field—Maintenance Consideration During Inspection and Maintenance Activities

Tip #9 Require As-Built Plans

After construction is completed, qualified engineers and surveyors should prepare as-built drawings of BMPs for a permanent record of the structures. The as-built plans are a critical element of future inspections. See **Chapter 8** for more details on the as-built process.

Tip #10 Use Benchmarks and Markers

Benchmarks must be established for tracking and monitoring BMPs. For example, in ponds and wetlands, sediment markers (graded measuring sticks) placed in forebays or permanent pools can be used to consistently measure the depth of sediment during inspections. Similar markers can be used to ensure that the elevation of the permanent pool remains relatively constant over time. Sediment clean-out markers should also be used in underground vaults and in the sediment chambers of sand filters.

Tip #11 Inspect LID Measures, Source Controls, and Nonstructural BMPs in Addition to Structural Practices

Program managers may incorrectly assume that nonstructural BMPs, such as vegetated measures, do not require routine inspection and maintenance. However, proper maintenance is essential for continued performance. Like structural BMPs, restored natural and riparian areas, disconnected impervious surfaces, grass channels, and similar practices can fail if inspections and monitoring are not routinely conducted.

For instance, sediment buildup and debris at entry points may prevent sheet flow from reaching pervious areas or buffers. Vegetation used to restore natural areas may not have adequate survival rates. Landowner practices and behaviors, such as dumping yard waste and rerouting roof drains, may compromise the function of the nonstructural BMP. For all these reasons, inspection and maintenance procedures should be applied to LID and nonstructural measures.

Tip #12 Use Inspection Checklists

A community should use standard inspection checklists to record the condition of all stormwater BMPs. It is easier for communities to track maintenance activities electronically, using either a database or spreadsheet, rather than relying on paper files. Well-designed checklists can be integrated within maintenance databases to prioritize maintenance, track performance over time, and relate design characteristics to particular problems.

Tool 6: Checklists provides templates for maintenance checklists based on the type of BMP, including LID and nonstructural practices. Program managers can use these templates to customize their own maintenance checklists.

Tip #13 Take Photographs

Inspectors should take photographs of all BMPs. In addition, specific problem areas should be photo-documented. For example, a recommended list of photographs for a BMP pond would include:

- Vehicle access points
- Overview of areas or related structures surrounding the pond
- Pretreatment areas
- Wetland planting areas, if applicable

- Inlets
- Overview of principal spillway, upstream and downstream faces of embankments, and emergency spillway
- Downstream outfall(s) from BMP
- Any problem areas identified

Tip #14 **Document Repair Items**

Inspectors should clearly document items that require repairs. Notations on design plans and physical markers, such as spray painting the key areas of concern, can help maintenance crews locate and correct problems. In addition, the inspector should use a copy of the as-built plan to mark potential corrections and problem areas. The marked-up as-built plan should be stored digitally or in a paper file system. Such record keeping can be used on the follow-up inspection and will help confirm that maintenance was performed correctly.

Neglected repairs, or missing or damaged structures, may pose immediate safety concerns. Examples include a missing manhole cover over a drop inlet, a damaged grate at a large inflow or outfall pipe, or damaged fencing around a pond with steep slopes, which may allow unauthorized and unsafe access. Furthermore, repairs related to dam safety and flooding hazards must be implemented immediately. For example, if a BMP shows signs of embankment failure, or if an inspector is unsure, a qualified engineer should investigate the situation immediately and appropriate actions must be taken. Similarly, cracks in a concrete riser that drains a large area may pose a safety threat and should be repaired immediately.

9.6. Public Involvement in the Maintenance Program

Educational outreach programs can improve compliance with maintenance requirements. Local governments should provide residential or commercial property managers with BMP inspection training and workshops on how to perform basic maintenance. **Table 9.12** provides a list of typical stakeholders and strategies for involving them in a maintenance program. The following are some strategies:

Co-Inspections

Municipal staff can accompany property owners and/or third-party contractors on inspections to help identify maintenance needs. During these inspections, the local program staff can educate the public, one on one, about general stormwater concerns and specific BMP functions. These inspections can also provide in-field training to private inspectors, thereby promoting thoroughness and consistency.

Education and Adopt-A-BMP Programs

Communities can establish a volunteer program for BMP maintenance by recruiting motivated individuals, service groups, neighborhood associations, and school groups. This approach works well for highly visible BMPs that have safe and easy access. Typically, volunteers perform simple inspections and light maintenance tasks such as trash pickup and weed removal. The volunteers also report serious problems or more labor-intensive maintenance needs to the local program manager. Certificates of accomplishment, prizes, publicity, or other incentives can be used to recruit volunteers and provide a rewarding experience.

Several communities sponsor **Adopt-A-Pond** programs to provide citizens and responsible parties with guidance and resources for maintaining and improving stormwater ponds. An example of such a program from Hillsborough, Florida, can be found at: ***http://www.hillsborough.wateratlas.usf.edu***

The Adopt-A-Pond program could be broadened to include other types of stormwater BMPs.

Table 9.12. Key Stakeholders in Stormwater Maintenance & Selected Strategies

Stakeholder Group	Selected Public Involvement Strategies
Primary Stakeholders	
► Private responsible party or HOA ► Public agency inspectors ► Public agency maintenance crews	► Co-inspections with responsible party and public inspector ► Brochures and mailings to responsible parties ► Workshops, certifications, plaques, and other forms of recognition for responsible parties ► Adopt-A-BMP programs with training and certification ► Workshops for inspectors with field component ► Workshops, certification, and recognitions for maintenance crews
Other Stakeholders	
► Private sector contractors performing inspections for responsible parties ► Private sector contractors performing maintenance tasks for responsible parties ► Elected officials ► Residents of neighborhoods with BMPs	► Training and certification programs ► Periodic updates for elected officials to tout benefits of maintenance program (e.g., cost savings through proactive maintenance) ► Hotline for maintenance questions and concerns from the public ► General information brochures or Web sites on "what to expect from your neighborhood BMP" ► Fact sheet on BMPs, mosquitoes, and West Nile virus

Hotline or Web-Based System for Complaints and Concerns

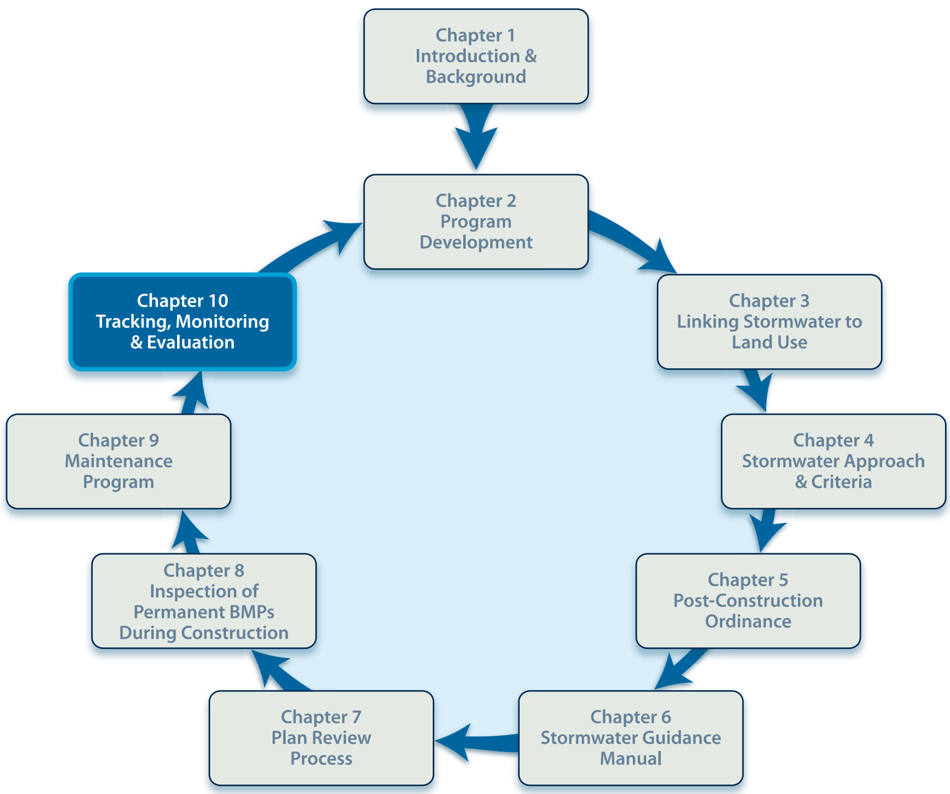
A telephone hotline, or a Web site with a reporting form, is a good tool for increasing citizen involvement. Using these methods, citizens can notify local program staff about specific maintenance issues, request an inspection, or ask technical questions. In response, local programs must establish a procedure for addressing these reports or queries quickly. The hotline or Web site should be advertised in utility inserts, the government pages of the phone book, on the municipal Web site, and through other communication channels.

Workshops, Training, and Certification for Inspectors

Training workshops can help standardize the inspection process by reviewing objectives, procedures, and follow-up actions. In addition, peer-to-peer training enhances communication because inspectors can share challenges and problem-solving related to real field experiences. Training tied to inspector certification can also be a motivator to encourage others to participate. A program can issue certificates and maintain lists of certified inspectors for future field work.

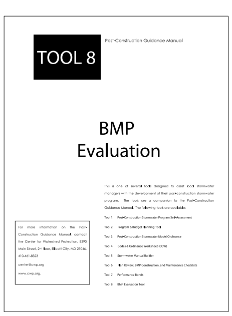
Chapter 10

Tracking, Monitoring, and Evaluation



What's In This Chapter

- Current status and trends in tracking, monitoring and evaluation
- A framework for post-construction tracking, monitoring and evaluation
- Establishing measurable goals
- Selecting and tracking indicators of success
- Program indicator tracking
- Stormwater infrastructure tracking
- Land use/land cover tracking
- Water resources monitoring and modeling tracking
- Annual reporting and program inspections and audits



Companion Tools for Chapter 10
Download Post-Construction Tools at:
www.cwp.org/postconstruction

10.1. Introduction and Overview

The ultimate goal of the Phase II MS4 program is to implement practices that protect and improve water quality. MS4 programs can assess their progress using measures of success, such as achieving measurable goals, assessing the extent and condition of stormwater practices, evaluating the effectiveness of BMPs, and demonstrating compliance with the MS4 permit. Some of the chief purposes for program tracking, monitoring, and evaluation include:

- Identifying and implementing program improvements on an ongoing basis to better protect water resources
- Documenting program status for annual reports required under the MS4 permit
- Striving to make the program more cost-effective
- Preparing for a possible regulatory inspection or audit
- Documenting program value and accomplishments to the public and elected officials
- Ensuring the best progress toward meeting a resource-based goal

This chapter provides an overview of techniques to track progress, including program tracking goals and indicators, water quality monitoring, and program reporting.

10.2. Current Status and Trends in Tracking, Monitoring, and Evaluation

Although many programs have a system to catalogue BMPs, few make the effort to look at the bigger picture of program accomplishments and milestones through time. A relatively small number use program evaluation tools, stream assessments, stream monitoring, BMP monitoring, or load reduction estimates to gauge success and track the progress of the program (**CWP, 2006**).

10.3. A Framework for Post-Construction Tracking, Monitoring, and Evaluation

Stormwater programs should continuously evolve to reflect new information learned as the program is implemented. A crucial part of this process is developing a system that consistently and quantitatively measures the program's performance. **Figure 10.1** illustrates a step-by-step process for tracking, monitoring, and evaluation.

This iterative process ensures that even if the initial goals established for a program prove to be unachievable, the program can adjust and continue to move forward. In addition, if some actions, projects, or approaches do not achieve their stated aims or are not cost-effective, adjustments can be made as the program evolves. This process is necessary to achieve improvements in water quality and aquatic habitats. Finally, it supports the documentation of program efforts, which can be helpful in both annual reporting and regulatory inspection and audit procedures.

10.4. Establishing Measurable Goals

Measurable goals are design objectives or goals that quantify the progress of program implementation and the performance of BMPs. They are objective markers or milestones that the local program, and the permitting authority, will use to track the stormwater program's effectiveness.

Measurable goals should include, where appropriate, the following three components:

- The activity to be completed
- A schedule or date of completion
- A quantifiable target by which to measure progress

While this section provides a brief overview of techniques to establish measurable goals (i.e., the *activity to be completed*), the remainder of the chapter focuses on specific tracking measures that help quantify whether the target has been met.

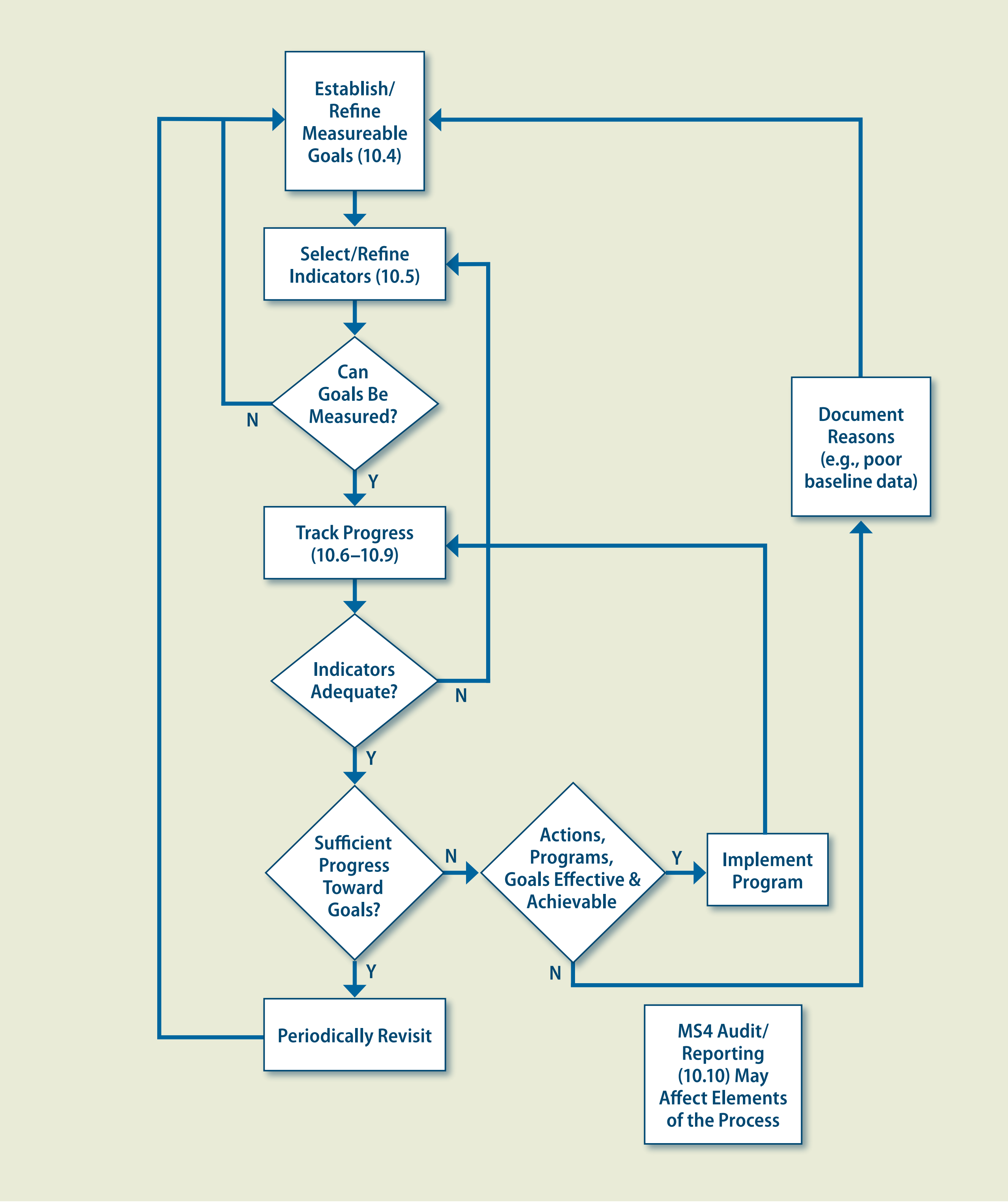


Figure 10.1. **Post-construction tracking, monitoring, and evaluation framework**

A program's success can be gauged by achieving a combination of *outcome-based* and *output-based* goals (See **Table 10.1**).

- ***Outcome-based goals*** focus on the ultimate desired outcomes for the program, such as improving stream health, improving water quality, or reducing pollutant loads by a specific amount. These goals are critical because they are the reason behind developing a program. At the same time, it can be difficult for an MS4 to commit to these outcome-based goals for several reasons. These goals often take a long time to achieve (longer than the typical permit cycle), and they can be difficult to measure or predict. In addition, achieving these goals often depends on a combination of efforts and events, some of which may be beyond the direct control of the MS4.

  MS4 programs should select a handful of outcome-based goals that it considers challenging but achievable and then track them over the course of multiple permit cycles. Including these goals will help focus and motivate the program to strive to have a positive impact on receiving waters.

- ***Output-based goals*** focus on the activities that achieve these outcomes, such as adopting an ordinance, reviewing development plans for stormwater, and inspecting all BMPs to ensure that they are functioning properly. These goals represent a checklist of items, and they are typically controlled directly by the MS4. These output-based goals ensure that the basic regulatory requirements are met; they also support achieving the broader outcome-based goals identified by the MS4.

Baseline data, such as current water quality conditions, number of BMPs already implemented, or the public's current knowledge or awareness of stormwater management, inform the development of both outcome—and output—based goals. During the initial development of a stormwater program, some data might be unavailable. **The Stormwater Program Self-Assessment (Tool 1)** and **Program and Budget Planning (Tool 2)** can help the MS4 assess its current program resources and thus help define *output-based* goals. Other data, such as past public polls or existing stream monitoring data, if available, can also help refine *outcome-based* goals.

Useful references for measurable goals include the following:

- **Tool 1**: Stormwater Program Self-Assessment
- **Tool 2**: Program and Budget Planning
- USEPA, *Measurable Goals Guidance for Phase II and Small MS4s*: ***www.epa.gov/npdes/pubs/measurablegoals.pdf***
- California Stormwater Quality Association (CASQA), *Municipal Stormwater Program Effectiveness Assessment Guidance, 2007*: ***www.casqa.org***

10.5. Selecting and Tracking Indicators of Success

Indicators of success should be related directly to and support the measurable goals established at the program's onset. The selection of indicators will influence the record-keeping functions of the program. Consequently, these indicators should be relatively simple to measure and track over time.

A set of "base" indicators are needed to track many aspects of the program. Base indicators are fundamental measures that most programs should adopt. They can be supplemented by one or more additional measures (supplemental indicators) that are tailored to the specific needs, measurable goals, and degree of sophistication of a specific program. **Table 10.2** lists some examples of base and supplemental indicators. The table divides the indicators into the following categories:

Program (Section 10.6.)
Program indicators track the progress of program milestones, including permit compliance. Examples include passage of an ordinance, adoption of manuals, manual updates, or maintenance activities conducted. These indicators track many of the output-based goals that the program identifies.

Stormwater Infrastructure (Section 10.7.)
The tracking system for *stormwater infrastructure* is a map-based system that documents the location, construction, and condition of stormwater

Table 10.1. Examples of Measurable Goals for Post-Construction Practices: Keyed to Chapters of this Guide
NOTE: "XX" refers to a number to be identified by the specific MS4.

	Output-Based Goals	Outcome-Based Goals
Chapter 2. Program Development	▶ Develop maps with relevant environmental information (such as watershed boundaries, soils, land use). ▶ Conduct a program self-assessment. ▶ Secure a funding mechanism	
Chapter 3. Land Use Planning as the First BMP	▶ Adopt a stream buffer ordinance. ▶ Revise zoning and subdivision codes to remove barriers to low-impact development (LID) and conservation design. ▶ Restrict development in sensitive watersheds. ▶ Remove unnecessary barriers for infill and redevelopment within targeted redevelopment zones.	▶ Retain or increase XX miles of forested stream buffer within sensitive watersheds. ▶ Conserve XX acres of open space. ▶ Reforest XX acres of land in critical environmental areas. ▶ Maintain XX% of forest cover in sensitive watersheds.
Chapter 4. Stormwater Management Approach and Criteria	▶ Develop a stormwater program that includes improving site design, source controls, and structural BMPs. ▶ Develop specific stormwater management criteria that address regulatory requirements and local issues for inclusion in ordinances and design guidance.	▶ XX% reduction in target pollutant (modeled or measured) in watershed A. ▶ XX% reduction in post-development runoff volume for new development sites. ▶ Progress toward meeting water quality standards in watershed B by 2015.
Chapter 5. Stormwater Ordinance	▶ Adopt a post-construction stormwater ordinance.	
Chapter 6. Stormwater Guidance Manuals	▶ Develop a stormwater guidance manual ***or*** provide local adaptations to a regional or state manual. ▶ Incorporate guidance on LID practices.	▶ XX% of new development sites that use LID to better match pre-development hydrologic conditions ▶ XX% of developed land treated by post-construction BMPs
Chapter 7. Plan Review Process	▶ Develop a plan review and plan submittal checklist. ▶ Train staff and design consultants. ▶ By the end of the permit cycle, XX% of new plans are consistent with design criteria by the second submittal.	▶ XX pounds of the target pollutant (or percent) removed based on approved post-construction BMPs (modeled)
Chapter 8. Inspection of Post-Construction BMPs During Construction	▶ Inspect all sites at least three times during construction. ▶ Develop checklists for staff inspectors. ▶ Train contractors on key construction requirements for stormwater BMPs.	▶ 100% of installed BMPs are built according to standards and are operational before turning over maintenance to responsible parties

Table 10.1. Examples of Measurable Goals for Post-Construction Practices: Keyed to Chapters of this Guide *(continued)*
NOTE: "XX" refers to a number to be identified by the specific MS4.

Chapter 9. Maintenance	► Develop a formal maintenance inspection schedule with priorities based on the type, size, or "risk" of various BMPs. ► Inspect each stormwater BMP at least annually, or according to program schedule. ► Inspect high-priority stormwater BMPs on more frequent basis, according to program schedule. ► Inspect all preexisting (pre-ordinance) BMPs by year 2 of permit cycle. ► Address critical maintenance deficiencies within 2 months of initial inspection.	► XX lb of sediment removed from stormwater catch basins each year. ► XX lb of pollutant(s) of concern removed by properly functioning stormwater BMPs (modeled).

BMPs, stormwater outfalls, and other stormwater infrastructure. This system helps the MS4 to track BMP installation; prioritize maintenance activities; and document program compliance.

Land Use/Land Cover (Section 10.8.)

Land use/land cover is an important measure of success because it can help guide program decisions regarding future zoning, management practices, and habitat protection decisions.

Water Resources Monitoring and Modeling (Section 10.9)

Water resources indicators measure the health of waterbodies *directly* (e.g., in-stream monitoring) or *indirectly* (e.g., water quality modeling). Water quality monitoring and modeling, conducted by the MS4 or another entity (e.g., federal or state agency, watershed association, university) are essential to gauge the success of the program.

Subsequent sections of this chapter describe these indicators in more detail.

10.6. Program Indicator Tracking

Program indicator tracking is an accounting of program measures and milestones taken by the MS4 to achieve its goals. Program tracking also includes an internal tracking system to guide the plan review process.

Program Measures and Milestones

Measures and milestones are the activities required in the stormwater program's NPDES permit or activities set as measurable goals. The tracking system acts as a checklist of items accomplished, and it is useful in annual reporting and as a direct measure of the program's progress over time. Example measures include the following:

- Completion of a post-construction program self-assessment (see **Tool 1**)
- Enactment of a stormwater ordinance
- Development or adaptation of a stormwater guidance manual (see **Tool 5**)
- Development of a stormwater plan review process
- Number of post-construction plans reviewed
- Number and type of structural post-construction BMPs installed
- Number and type of non-structural post-construction BMPs installed
- Number of inspections of post-construction BMPs conducted during initial BMP installation
- Number of post-construction BMPs inspected for maintenance
- Number of post-construction BMPs maintained
- Sediment removed from BMPs and storm drain inlets

Table 10.2. **Indicators of Post-Construction Stormwater Program Success**

	Base Indicators Recommended for all Programs	Supplemental Indicators/ Records[a]
Program Indicators	► Date of ordinance adoption/revision ► Number of plans reviewed ► Number and type of post-construction BMPs approved on plans ► Number of staff dedicated to program; dates of staff hiring ► Budget amount dedicated to the program. ► Number of BMP installation/maintenance inspections ► Frequency of maintenance inspections based on BMP type or priority ► Number of practices maintained ► Number of maintenance actions	► Watershed plan development ► Average plan review time ► Collection of plan review fees, amount collected, allocation of revenues ► Pounds of sediment and trash removed from stormwater practices ► Public awareness of stormwater issues (as measured by a survey)
Stormwater Infrastructure	► Number and location of all outfalls ► Number and location of installed post-construction BMPs ► Drainage and stormwater maintenance easement maps. ► Number and location of BMPs requiring maintenance. — Routine — Structural/repair — Emergency/high-priority	► Map of storm drain infrastructure ► Number, location, and condition of LID practices ► Detailed data from maintenance reports, such as: — Number of practices with sediment accumulation > 50% of capacity — Number of practices with failing embankments — Number of practices with clogged filter beds
Land Use/Land Cover	► Impervious cover ► Land use ► Land cover ► Total area developed ► Zoning	► Assessment of key habitat factors ► Location of key habitat areas/special resources ► Acres of forest/meadow/prairie preserved during development ► Number and type of stormwater hotspots
Monitoring and Modeling	► Water quality conditions from available monitoring and modeling (e.g., TMDLs, state, university, volunteer monitoring)	► Annual pollutant load from the MS4 (modeled) ► Average pollutant concentrations (in-stream monitoring) ► Habitat scores from stream assessments ► Pollutant removal of individual practices (monitored)

[a] The items in this column serve only as examples; the list is not exhaustive. Indicators should be customized by the specific program.

Many of these measures are simply checklist items (e.g., "enactment of a stormwater ordinance") that require no detailed data tracking. Other measures, however, require ongoing record-keeping, usually by several different departments within a community (e.g., "sediment removed from storm drain inlets"). These measures will require significant coordination to ensure that the desired data are collected on a regular basis and in a usable format. (See **Figure 10.2** for an example.)

Plan Review Tracking

Most municipalities already have a system in place to track their plan review process. Several commercial systems are available, or a municipality can develop its own database system. The primary purposes of these plan review tracking systems are (1) to track the current status of plans and where they are in the plan approval process and (2) to ensure that all post-construction requirements on submitted plans have been met. (See **Figure 10.3** for an example form used to collect and track information about new development projects.)

The plan review tracking system can also be constructed to measure land use change over time. If the MS4 strives to use the tracking system in this way, plan review forms and documentation need to be customized to ensure that the desired data are readily available. For example, if the form includes data like the acres of forest and wetland disturbed or acres of impervious cover created by a project, these data can then be aggregated to characterize the land use changes associated with new development within the MS4.

See **Chapter 7** for more information on the stormwater plan review process.

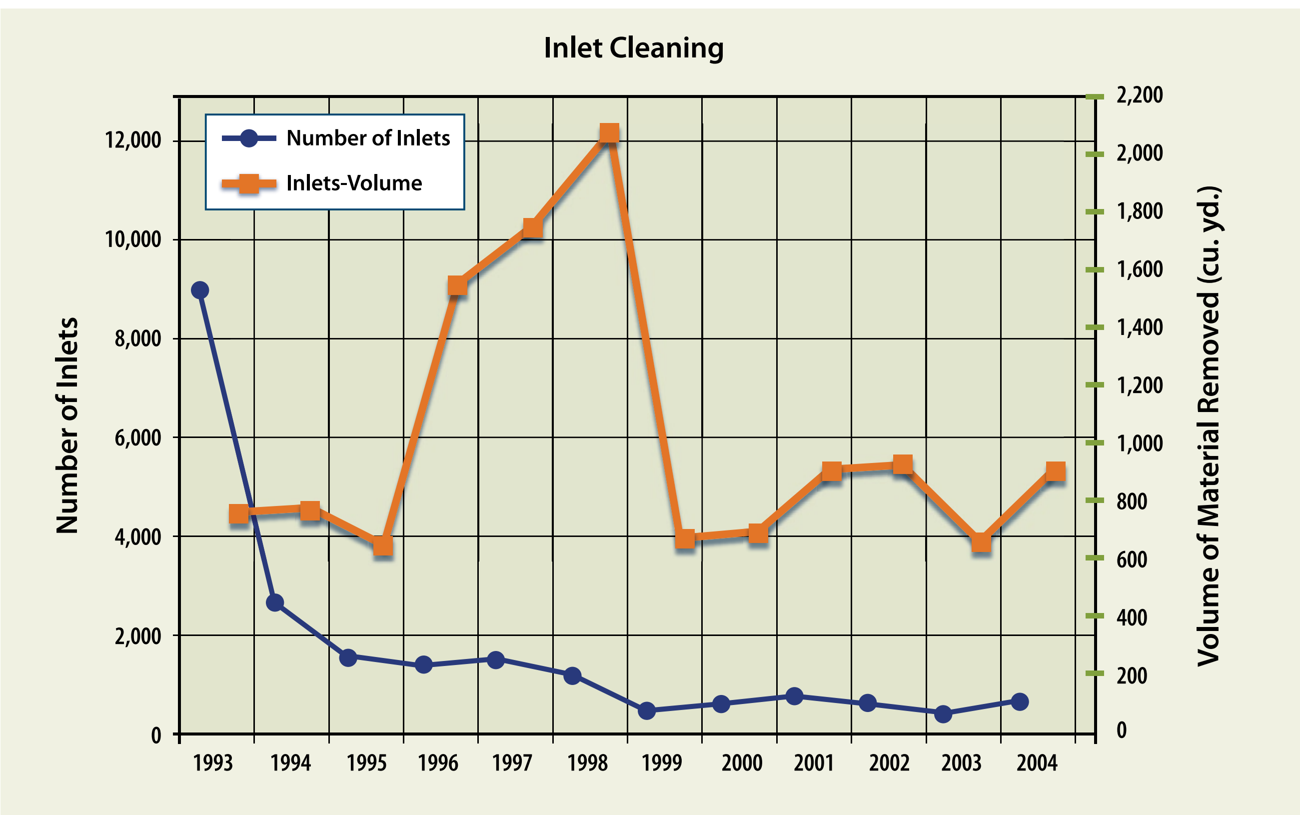


Figure 10.2. Inlet cleaning data derived from maintenance records

THE CITY OF SAN DIEGO

City of San Diego
Development Services
1222 First Ave., MS-302
San Diego, CA 92101
(619) 446-5000

Storm Water Requirements Applicability Checklist

FORM DS-560
MARCH 2008

Project Address:	Assessor Parcel Number(s):	Project Number *(for City Use Only)*

Complete Sections 1 and 2 of the following checklist to determine your project's permanent and construction storm water best management practices requirements. This form must be completed and submitted with your permit application.

Section 1 - Permanent Storm Water BMP Requirements:

If any answers to Part A are answered "Yes," your project is subject to the "Priority Project Permanent Storm Water BMP Requirements," and "Standard Permanent Storm Water BMP Requirements" of the Storm Water Standards Manual, Section III, "Permanent Storm Water BMP Selection Procedure." If all answers to Part A are "No," and any answers to Part B are "Yes," your project is only subject to the Standard Permanent Storm Water BMP Requirements. If every question in Part A and B is answered "No," your project is exempt from permanent storm water requirements.

Part A: Determine Priority Project Permanent Storm Water BMP Requirements.

Does the project meet the definition of one or more of the priority project categories?*

1.	Detached or attached residential development of 10 or more units	❑ Yes	❑ No
2.	Developments of heavy industy greater than 1 acre	❑ Yes	❑ No
3.	Commercial development greater than 1 acre	❑ Yes	❑ No
4.	Automotive repair shop	❑ Yes	❑ No
5.	Restaurant	❑ Yes	❑ No
6.	Hillside development greater than 5,000 square feet	❑ Yes	❑ No
7.	Project within, directly adjacent to or discharging to receiving waters within Water Quality Sensitive Areas	❑ Yes	❑ No
8.	Parking lots greater than or equal to 5,000 square feet or with at least 15 parking spaces, and potentially exposed to urban runoff	❑ Yes	❑ No
9.	Streets, roads, highways, and freeways which would create a new paved surface that is 5,000 square feet or greater	❑ Yes	❑ No
10.	Significant redevelopment over 5,000 square feet	❑ Yes	❑ No
11.	Retail gasoline outlets	❑ Yes	❑ No

* *Refer to the definitions section in the* Storm Water Standards *for expanded definitions of the priority project categories.*

Limited Exclusion*: Trenching and resurfacing work associated with utility projects are not considered priority projects. Parking lots, buildings and other structures associated with utility projects are priority projects if one or more of the criteria in Part A is met. If all answers to Part A are "No", continue to Part B.*

Part B: Determine Standard Permanent Storm Water Requirements.

Does the project propose:

1.	New impervious areas, such as rooftops, roads, parking lots, driveways, paths and sidewalks?	❑ Yes	❑ No
2.	New pervious landscape areas and irrigation systems?	❑ Yes	❑ No
3.	Permanent structures within 100 feet of any natural water body?	❑ Yes	❑ No
4.	Trash storage areas?	❑ Yes	❑ No
5.	Liquid or solid material loading and unloading areas?	❑ Yes	❑ No
6.	Vehicle or equipment fueling, washing, or maintenance areas?	❑ Yes	❑ No

Figure 10.3. **The City of San Diego's plan review process tracking form**

Useful references for program tracking include the following:

California Stormwater Quality Association (CASQA), *Municipal Stormwater Program Effectiveness Assessment Guidance*, 2007: ***www.casqa.org***

Center for Watershed Protection, *Smart Watershed Benchmarking Tool*: ***www.cwp.org***

10.7. Stormwater Infrastructure Tracking

The stormwater infrastructure tracking system is a map-based database that tracks the location and condition of BMPs, outfalls, conveyance structures, and other stormwater infrastructure attributes. This tracking system should include a field inspection and survey program for stormwater infrastructure. The tracking system is integral to the stormwater program for the following reasons:

- Detailed knowledge of stormwater practice location and condition is needed to ensure ongoing maintenance.
- Long-term condition and performance of specific BMPs and BMP design elements can help to inform the future BMP design process.
- BMP condition can reflect the effectiveness of the program.
- Integration of BMP data with land use data can be used to develop models that estimate pollutant removal on a watershed- or MS4-wide basis (see **Section 10.9**).
- As a supplemental benefit, mapping of outfalls and infrastructure will support the Illicit Discharge Detection and Elimination (IDDE) program.

Because a stormwater infrastructure inventory program can be an ambitious and costly undertaking, it can be phased over time. For instance, the program can start with newly installed BMPs and major outfalls, followed by older BMPs, minor outfalls, and conveyance elements. Data should include a photo log of infrastructure elements that are keyed to markings made on the actual infrastructure elements in the field.

All data entered into the database should be verified and updated over time through field inspections. For example, the quality of the location data can be enhanced through the use of hand-held global positioning system (GPS) units during ongoing operation and maintenance (O&M) activities, as well as when new stormwater infrastructure elements are added (see **Figure 10.4**).

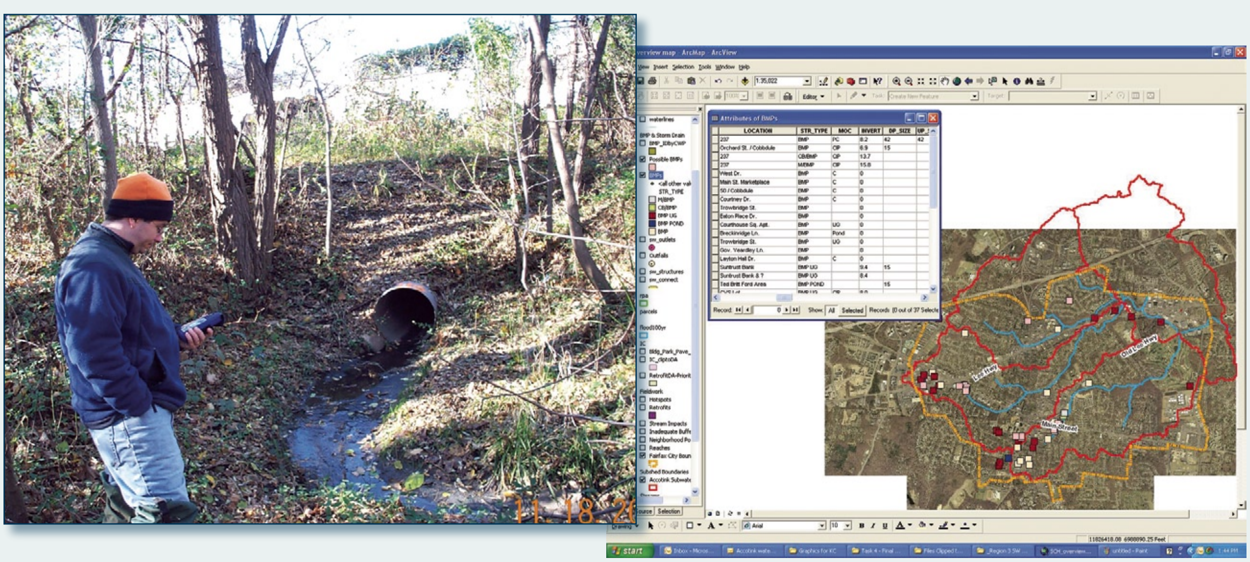


Figure 10.4. Global positioning systems (GPS) linked with geographic information systems (GIS) are excellent tools for tracking stormwater infrastructure

The specific data collected during field inspections can be used to determine what percentage of practices meet particular stormwater practice performance goals, such as:

- Sediment forebays should be no more than half full of sediment.
- Vegetation should cover at least 80% of the surface area of bioretention and wetland BMPs.
- Emergency spillways should be clear of debris and obstructions.
- Open channels should be stable (not eroding) and free of sediment deposits.

These data are also used as triggers for when maintenance should be performed by the municipality or the responsible party (see **Chapter 9**).

In parallel with physical infrastructure mapping, the MS4 needs a readily available, accurate, and preferably digital mapping layer of any easements and property boundaries. These data help in determining which practices have adequate maintenance access, and they help in identifying situations where a new agreement with a private property owner is needed to conduct regular inspections and maintenance.

10.8. Land Use/Land Cover Tracking

The ultimate effectiveness of any program needs to be evaluated in the context of changing land use. In addition, many of the codes and policies implemented as a part of a post-construction stormwater program, such as implementation of LID or open space design techniques, can directly affect future land use. Consequently, updating basic land use layers is critical to understanding the actual benefits of the program.

Baseline data, including a good measure of impervious cover, land use, land cover, and developed areas, should be developed early in the process. These data should then be overlaid with zoning data or another estimate of future land use. Taken together, these data can help identify sensitive watersheds, as well as areas of potential growth.

Ultimately, these data help to inform decisions about redevelopment policies, zoning, and stormwater criteria. They also help the community to understand realistic pollutant reduction goals in the context of existing land use and future development pressures. Finally, these land use layers help the MS4 identify areas for potential stormwater retrofits. (See **Chapter 2** for more discussion on mapping and data needs to build a program.)

These basic land use and land cover data can be supplemented with additional data that can help the MS4 better understand habitats and pollutant loading potentials. Some examples include stream, wetland, or forest assessments that identify high-value resources, or locations of stormwater hotspots that identify key pollutant load sources.

Land use and land cover data should be continuously updated. A plan review tracking system (**Section 10.6**) can be a direct source of information, as long as the existing and current land uses are accurately recorded for each development plan. As these data are updated, the MS4 can periodically reevaluate progress toward watershed-wide goals identified at the program's onset.

10.9. Water Quality Monitoring and Modeling Tracking

Water Quality Monitoring

Water quality monitoring is the ultimate tool to measure the effectiveness of a stormwater program. Two basic types of monitoring can be conducted:

1. ***Watershed Assessment Monitoring:*** This monitoring takes place at the broad scale of the watershed to establish baseline or general conditions. Monitoring can consider a range of indicators, including *biological* (e.g., macroinvertebrates, fish), *physical* (e.g., flow, suspended sediment, stream channel stability), and/or *chemical* (e.g., phosphorus, trace metals, bacteria). Watershed assessment monitoring is appropriate for all stages of program development, but particularly in the planning stage to help identify major water quality issues and threats.

2. ***Targeted Monitoring***: Once general issues have been identified, the program can undertake targeted monitoring to identify particular source areas, causes of elevated pollutant levels, or risks to stream health. In this way, program resources can also be targeted to actual land uses and sources that are causing the problem. This type of monitoring can focus on a few good water quality variables to measure effectively, rather than trying to track a long list of indicators. For example, monitoring for a swimming beach that is impaired by bacteria should monitor *E. coli* at the swimming area, nearby storm drain outfalls, and tributary streams.

Developing a program to conduct water quality monitoring for a local stormwater program can be challenging. Some of the significant challenges include the following:

- The dynamic and variable nature of stormwater quantity and quality is difficult to capture in a stormwater monitoring program.
- Municipal stormwater programs usually encompass large areas of land with multiple land uses and many different outfalls to receiving waters.
- Water quality monitoring programs, especially at a large scale, can be expensive and staff-intensive.
- It can be difficult to link a measured water quality result to a BMP or action by the jurisdiction.

Some level of water quality monitoring is important for post-construction programs. Depending on program sophistication and level of funding, the MS4 may develop a phased approach to monitoring, beginning with relatively simple techniques (perhaps using citizen volunteers) and progressing to more complex systems (see the resources in **Table 10.3**). Other ideas are to pool resources with other jurisdictions, local universities, watershed groups, and/or relevant state agencies.

Another type of monitoring involves evaluating the performance of selected BMPs. For example, if a developer proposes a new BMP that the local program staff is not familiar with, he or she can be asked to conduct monitoring to demonstrate the BMP's effectiveness. **Tool 8: BMP Evaluation** is designed to help stormwater managers ask the right questions and obtain the necessary monitoring data for verifying BMP performance. **Law et al. (2008)** provides a study design for monitoring the performance of individual BMPs.

Water Quality Modeling

Water quality modeling can also be used to estimate pollutant loads, and to measure progress based on programs implemented by the MS4. Several models are available, ranging from simple spreadsheet models to complex in-stream models. Unlike monitoring data, water quality models are not a direct measure of in-stream water quality. However, a simple, easily updated model can provide enhancements to a monitoring program:

- Models allow the community to forecast benefits of a particular action, and they can be used to customize measurable goals at the outset of the permit cycle.
- If data on land use and stormwater practices and other relevant data are available, models can be used to track progress over time.
- Unlike in-stream monitoring data, which are subject to seasonal or annual weather conditions, models can be used to predict progress without the "noise" introduced by these climate variations.
- Simplified models can be a relatively inexpensive tool when compared with the level of monitoring data needed to detect trends in water quality.

Table 10.3 presents some monitoring and modeling resources available from various organizations.

Table 10.3. Monitoring and Modeling Resources for Municipal Stormwater Programs

General Water Quality Monitoring	USEPA, *Monitoring Guidance for Determining the Effectiveness of Nonpoint Source Controls* (Sept. 1997, EPA 841-B-96-004).
	USDA-NRCS, *National Handbook of Water Quality Monitoring* ***http://grande.nal.usda.gov/wqic/cgi-bin/retrieve_wq_record.pl?rec_id=1015***
	Several resources for volunteer monitors available at: ***www.epa.gov/owow/monitoring/volunteer***
Stormwater Monitoring	Southern California Coastal Water Research Project, *Model Monitoring Program for Municipal Separate Storm Sewer Systems in Southern California* ***ftp://ftp.sccwrp.org/pub/download/PDFs/419_smc_mm.pdf***
	Dr. Robert Pitt, University of Alabama, *National Stormwater Quality Database* ***http://rpitt.eng.ua.edu/Research/ms4/Paper/Mainms4paper.html***
BMP performance monitoring	USEPA, *Urban BMP Performance Tool* ***http://cfpub.epa.gov/npdes/stormwater/urbanbmp/bmpeffectiveness.cfm***
	USEPA, ASCE, et al., International Stormwater BMP Database, *Urban Stormwater BMP Performance Monitoring: A Guidance Manual for Meeting the National Stormwater BMP Database Requirements* ***www.bmpdatabase.org***
	Center for Watershed Protection, *Pollutant Removal Performance Database* ***www.cwp.org*** > Resources > Controlling Runoff & Discharges > Stormwater Management
	Stormwater Manager's Resource Center, *Environmental Indicator Profile Sheet: BMP Performance Monitoring* ***http://www.stormwatercenter.net/intro_monitor.htm***
Pollutant Load Models	USGS, *SLAMM (Source Loading and Management Model)* ***http://wi.water.usgs.gov/slamm***
	Center for Watershed Protection, *WTM (Watershed Treatment Model)* ***www.cwp.org*** > Resources > Watershed Management > Desktop Analysis
	USEPA, *BASINS (Better Assessment Science Integrating Point and Nonpoint Sources)* *www.epa.gov/waterscience/basins/*
	Center for Watershed Protection, *The Simple Method* ***http://www.stormwatercenter.net/intro_monitor.htm***
Overall Monitoring Guidance	Center for Watershed Protection, *Monitoring to Demonstrate Environmental Results: Guidance to Develop Local Stormwater Monitoring Programs Using Six Example Study Designs* ***www.cwp.org***

10.10. Annual Reporting and Program Inspections & Audits

Annual Reporting

All NPDES-permitted stormwater programs must submit a report (typically, on an annual basis) documenting activities in compliance with the permit. EPA's Phase II regulations require that these annual reports include the following:

- Status of compliance with permit conditions
- Assessment of the appropriateness and effectiveness of the identified BMPs
- Status of the identified measurable goals (see **Table 10.1**)
- Results of information collected and analyzed, including monitoring data submitted during the reporting period
- Summary of stormwater activities planned during next reporting cycle
- Proposed changes to the Stormwater Management Plan (SWMP), along with justification
- Other entities responsible for implementing aspects of the stormwater program
- Change in people implementing and coordinating the SWMP

The most common problem with annual reports is that stormwater programs use them simply to report activities and do not analyze the data to determine whether program changes are necessary (i.e., the iterative approach). For example, if the stormwater program reports that it inspected 12 detention basins and 10 were in need of maintenance, the program should assess and describe in the annual report why so many needed maintenance. Perhaps it was the first time the basins were inspected in many years, or the basins might have been designed incorrectly. If necessary, changes to the stormwater program should be made to address any identified deficiencies.

The program can report findings using various techniques. **Figure 10.5** illustrates several examples; see also the maintenance reporting examples in **Table 10.1**.

MS4 Audits

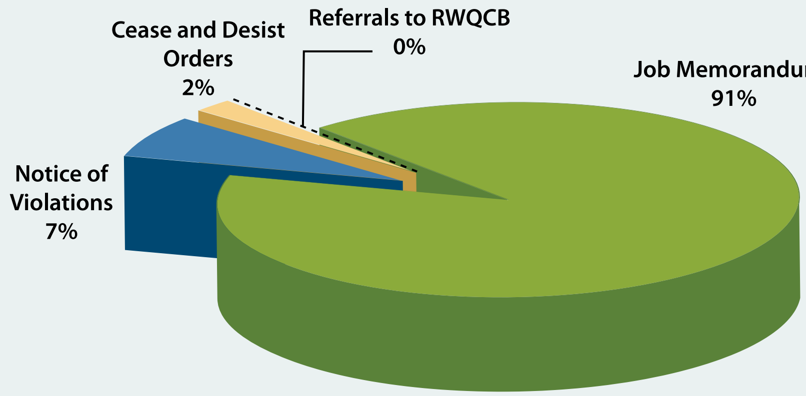
Regulatory agencies regularly conduct inspections and audits of MS4 programs. The goal of those audits is to assess compliance with NPDES permit conditions (across all six minimum measures). This type of audit is different from the post-construction program self-assessment (**Tool 1**) described in Chapter 1, which can be useful to help MS4 staff prepare for a regulatory audit by assessing existing status of the stormwater program and mapping out a future course and program direction.

EPA has developed a guidance manual for state and EPA staff on how to conduct MS4 audits (see *MS4 Program Evaluation Guidance* available at ***www.epa.gov/npdes/stormwater***). Although the audience for this manual is the parties conducting the audit, it is also useful for MS4 staff to know what to expect and how to prepare for an audit.

For stormwater programs that are audited by a state regulatory agency or EPA (or their contractors), **Table 10.4** presents some tips on how to prepare.

The following are some common findings from past MS4 audits conducted by EPA:

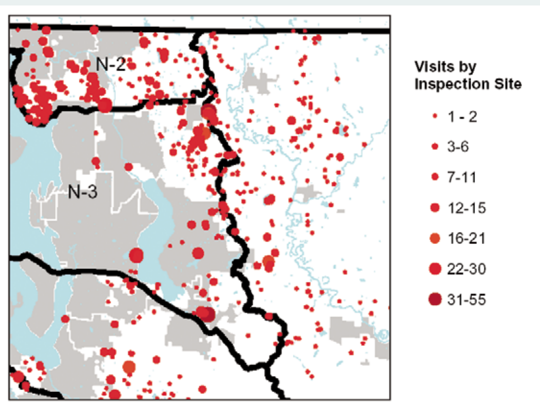
- ***Inadequate standards to address post-construction.*** Many MS4 audits have found post-construction programs that lack specific standards or procedures to adequately address post-construction runoff.
- ***Lack of an adequate stormwater planning document.*** A stormwater management plan is the document that guides all stormwater activities at a municipal level; however, sometime these plans are out-of-date or missing.
- ***Inadequate measurable goals.*** Measurable goals are supposed to be quantifiable and specific; however, some municipalities use measurable goals as a reporting measure but not a planning tool.
- ***Lack of stormwater pollution prevention plans for municipal facilities.*** Municipal facilities often conduct many activities that can affect stormwater quality. A well-written plan helps identify practices that minimize exposure of pollutants to runoff and educate municipal staff on their use.



A. Show results graphically (**Source: County of Ventura, 2007**).

New BMP retrofit just after construction. *New BMP retrofit after first storm.*

B. Use photos to help illustrate activities *(Source: County of Fairfax, 2003)*



C. Use GIS data to show location or intensity of activity *(Source: King County, WA, MS4 Annual Report)*

Figure 10.5. Examples of how stormwater activities can be reported: (A) graphically, (B) with photos, (C) with GIS data

Table 10.4. Preparing for an MS4 Audit by a Regulatory Agency

Before the audit	► Complete the program self-assessment (**Tool 1**). ► Review NPDES permit requirements, program-specific measurable goals, and other program commitments. ► Analyze potential weaknesses and address them, to the extent possible, before the audit. ► Brief municipal staff and management on the audit. ► Review and organize stormwater records. ► Visit municipal facilities to prepare them for an audit visit.
During the audit	► Answer the auditors' questions truthfully. ► Ask questions (What is their expectation? What are others doing?) ► Be prepared to take auditors to municipal maintenance facilities and construction sites.
After the audit	► Brief municipal staff and management on the results. ► Begin addressing deficiencies found (even before the audit report is received).

- ***Inadequate legal authority.*** Some municipalities lack adequate legal authority to ensure program implementation.

Although a regulatory audit can have negative connotations for a local program, with the right preparation and attitude, an audit can be transformed into a beneficial experience. For example, it can allow MS4 program staff to educate state and EPA regulatory staff about the unique issues and challenges they face in implementing the program, and can highlight key accomplishments. The audit can present an opportunity to educate elected officials and department heads about the resources needed to carry out a good stormwater program. It can also be used as a catalyst to get various local departments working together toward common stormwater goals. Finally, the audit presents an opportunity to identify key program gaps (e.g., record-keeping, enforcement, inspections, and maintenance) and strategies to strengthen the program. To realize these benefits, the local program staff will have to allocate enough staff time and resources to make the audit a meaningful experience.

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