

Stormwater Management Guidance Manual

Version 3.4 July 2026

PHILADELPHIA WATER DEPARTMENT

Stormwater Management Guidance Manual

Version 3.4

What is the Philadelphia Stormwater Management Guidance Manual?

The Philadelphia Stormwater Management Guidance Manual (the Manual, or SMGM) is a comprehensive resource for the development community in complying with the Philadelphia Water Department (PWD) Stormwater Regulations (Stormwater Regulations) and designing stormwater management on private property. The Stormwater Regulations require, and PWD design criteria for Stormwater Retrofits outline, on-site stormwater management for certain Development and Stormwater Retrofit projects, respectively, helping to improve the health and vitality of Philadelphia's waterways along with the City's own sizable clean water investments.

How will the Manual help me?

The Manual provides detailed guidance for the applicant on how to most quickly and efficiently comply with the Stormwater Regulations or meet PWD design criteria for Development, Stormwater Retrofits, and other construction projects. Using this Manual, the applicant will be able to do the following:

- **Determine if a project is regulated under the Stormwater Regulations** and, if so, what specific requirements need to be met;
- **Learn about new ways to incorporate green approaches** to stormwater management that provide benefits for Development and Stormwater Retrofit projects and expedite the stormwater approval process;
- **Design specific stormwater management practices** (SMPs) to meet the PWD's standards;
- **Prepare and submit** application materials;
- **Learn how to ensure proper installation** and protection of SMPs during construction activity; and
- **Obtain information** on post-construction and operations and maintenance (O&M) requirements.

Can I send PWD feedback on the Manual?

In addition to providing users with a fully searchable and downloadable Manual, the website allows for responsive and targeted content and layout updates. As the development community takes advantage of the new platform, PWD encourages the use of the Manual comment form provided on the website. Suggested changes, corrections, and other feedback will assist PWD in improving this resource through future versions.

Introduction

Introduction

The Philadelphia Stormwater Management Guidance Manual (the Manual, or SMGM) is a comprehensive resource for complying with Philadelphia Water Department (PWD) Stormwater Regulations (Stormwater Regulations). It includes criteria for Stormwater Retrofits and tips for designing stormwater management on private property—all to improve the health and vitality of Philadelphia's waterways along with the City's own sizable clean water investments.

At its core, the Manual provides detailed guidance for the applicant on how to quickly and efficiently comply with the Stormwater Regulations or meet PWD design criteria for Development, Stormwater Retrofits, and other construction projects. Using this Manual, the applicant will be able to do the following:

- Determine if a project is regulated under the Stormwater Regulations and, if so, what specific requirements need to be met;
- Learn about new ways to incorporate green approaches to stormwater management that provide benefits for Development and Stormwater Retrofit projects and expedite the stormwater approval process;
- Design specific stormwater management practices (SMPs) to meet PWD's standards;
- Prepare and submit application materials;
- Learn how to ensure proper installation and protection of SMPs during construction activity; and
- Obtain information on post-construction and operations and maintenance (O&M) requirements.

Furthermore, PWD acknowledges that climate change is here, and responsible stormwater management plays an important role in increasing Philadelphia's resilience. The climate-related impacts Philadelphia is already facing will only continue to grow over this century. Our city will experience more frequent and intense rainfall events, more extreme storms, higher air temperatures, rising sea levels, and possibly increased drought. Therefore, compliance with PWD's Stormwater Regulations is not only a requirement but is also the responsible strategy to pursue for the sake of our region's future environmental resiliency and sustainability.

Manual organization and purpose

The Manual provides the development community with detailed guidance on designing stormwater management systems to meet the Stormwater Regulations, understanding PWD's stormwater-related requirements and approval processes, and preparing submissions to PWD. The Manual also offers guidance on topics relating to the proper construction and maintenance of SMPs.

The Manual has six Chapters and a series of appendices. Chapters 1 through 4 focus on the stormwater design, submittal, and approval processes, while Chapters 5 and 6 discuss construction and post-construction topics. As design, submittal, and review processes are closely related, the applicant will find cross-referencing throughout the Manual, particularly between Chapters 2 and 3. The applicant should use each chapter as follows:

Table 1: How to use the chapters in this Manual

Chapter	How to Use
Chapter 1 – Stormwater Management Requirements ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1	Learn about the Stormwater Regulations and Stormwater Retrofits, determine if a project is subject to the Stormwater Regulations, and find out which requirements need to be met
Chapter 2 – Submission, Review, and Approval Procedures ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2	Understand the submission and review process for a project and get detailed guidance in preparing submissions to PWD
Chapter 3 – Site Design and Stormwater Management Integration ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3	Learn how to perform site assessments, including infiltration testing, and design stormwater management controls, including disconnected impervious cover and SMPs, to comply with the Stormwater Regulations
Chapter 4 – Stormwater Management Practice Guidance ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4	Obtain guidance on use, applicability, components, design requirements, materials specifications, construction sequencing, and O&M of specific SMPs, as well as pretreatment, inlet and outlet control systems, and landscaping that support SMP functions
Chapter 5 – Construction Guidance ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-5	Understand PWD's construction inspection process, identify common problems with SMP and Erosion and Sediment Control (E&S) construction, and prepare a Construction Certification Package and Record Drawings
Chapter 6 – Post-Construction and Operations and Maintenance Guidance ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-6	Understand PWD's SMP maintenance requirements, learn how to inspect, operate, and maintain SMPs and other stormwater controls, get detailed guidance on O&M Agreements, and apply for stormwater credits

The Appendices contain additional resources, including, but not limited to, watershed maps, submission checklists, a sample SMP Maintenance Guide, Infiltration Testing Logs, plant lists, Construction Certification Package templates, a sample Record Drawing, and Standard Details. A list of appendices is provided in the Manual table of contents.

Stormwater Regulations

PWD requires that many development sites in the City implement stormwater management controls. The Stormwater Regulations (**Appendix C** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/c-pwd-stormwater-regulations) define the specific requirements that need to be met for various types of development in the City. PWD's Stormwater Regulations fall into two categories, *Post-Construction Stormwater Management (PCSM) Requirements* and an *E&S Requirement*.

PCSM Requirements regulate how stormwater runoff leaves a project site in the built, or post-development, condition.

There are four PCSM Requirements:

- *Water Quality*, to recharge the groundwater table and reduce pollution in stormwater runoff;
- *Channel Protection*, to minimize channel erosion resulting from stormwater runoff by controlling the peak flow rates for medium-sized storms;
- *Flood Control*, to prevent, through peak flow rate control, flooding caused by large storm events that could lead to damage to life or property; and
- *Public Health and Safety Release Rate*, to minimize the impact of flooding in areas of the City with infrastructure capacity restrictions through peak flow rate control.

The E&S Requirement stipulates that practices be employed during construction to reduce any erosion and sedimentation that occur because of development activities.

Development Services

In 2021, PWD consolidated several programs to form the Development Services Unit (DSU), creating a consistent point of contact for the development community. DSU administers the Stormwater Regulations on behalf of the Department and is responsible for all PWD stormwater management programs for private property, including Stormwater Plan Review, Stormwater Inspections, Stormwater Enforcement, and Stormwater Billing and Incentives.

The Water Department strives to support development projects through transparent requirements and streamlined processes, while ensuring compliance and the protection of our city's infrastructure and water resources. Multiple PWD programs provide review and inspection services for building developments or other projects proposing connections to PWD's water or sewer system.

For any questions concerning PWD's development review process, applicants are encouraged to email **pwd_devservices@phila.gov**, call (215) 685-0798, or visit **Development Services** ☛ water.phila.gov/development.

Stormwater Plan Review

Stormwater Plan Review is responsible for administering PWD's Stormwater Regulations through review and approval of Post-Construction Stormwater Management Plans (PCSMPs). Its range of services include the following:

- Reviewing development plans for compliance;
- Ensuring that SMPs are correctly designed, installed, and maintained in accordance with the Stormwater Regulations;
- Coordinating with other PWD programs involved in the development review process to establish consistency across the Department and ensure required approvals are obtained;
- Acting as PWD's link to the larger development process in the City, most critically the Zoning and Building Permit process administered by the City of Philadelphia's Department of Licenses and Inspections (L&I). The applicant must receive approvals from PWD before a Zoning or Building Permit may be issued;
- Coordinating with other reviewing entities such as the Philadelphia City Planning Commission (PCPC), Philadelphia Streets Department (Streets Department), and the Pennsylvania Department of Environmental Protection (PA DEP), to ensure that consistent information is provided by the applicant to all agencies; and
- Preparing O&M Agreements for every project that installs SMPs under the Stormwater Regulations.

Contacting Stormwater Plan Review

PWD encourages the applicant to contact staff throughout the project's lifecycle, from preliminary planning through O&M. If additional clarity or discussion is required prior to initial submittal, the applicant is directed to **apply for a pre-application meeting** ☛ www.pwdplanreview.org/apply/login/portal_signup through the PWD Plan Review Portal. (First-time applicants may need to create a new user account.) Staff can be reached during normal business hours (8 a.m. to 5 p.m.) at (215) 685-6387 or **pwd.planreview@phila.gov**. Both the general phone line and email account are monitored regularly by staff. Before a reviewer has been assigned to the project, the applicant should use the general email account for all inquiries to ensure an efficient response time.

PWD Plan Review Portal

The **PWD Plan Review Portal** ☛ www.pwdplanreview.org website provides content separate from that of the **Development Services** ☛ water.phila.gov/development section of the main **PWD website** ☛ water.phila.gov and is used by both the regulated and voluntary Stormwater Retrofit programs. It contains specialized tools, including the **Reg Finder** ☛ www.pwdplanreview.org/reg_finder application to identify stormwater regulatory requirements, a Project Dashboard to submit stormwater plans and request pre-application meetings, and a **Project Application Status** ☛ www.pwdplanreview.org/apply/application/app_status page.

Stormwater Inspections and Stormwater Enforcement

PWD conducts inspections throughout the project lifecycle, during active construction activities as well as in the post-construction period, to ensure proper maintenance and long-term functionality of systems. In addition, PWD will take enforcement actions, as necessary, to seek corrective action for any violations found on the property.

Active construction:

- Lead a pre-construction meeting on-site at the commencement of construction to discuss the approved plans and necessary closeout documents;
- Inspect for adequate erosion and sediment controls throughout the duration of construction and earth moving activities;
- Verify that SMPs are installed according to the Approved PCSMP;
- Hold final inspection(s) at the close of construction to record information about the project's as-built conditions, which the applicant must incorporate into a Record Drawing; and
- Take enforcement action to ensure compliance with approved plans during construction.

Post-construction:

- Conduct post-construction inspections to ensure the SMPs and associated drainage areas are maintained and continue to function in accordance with the Approved PCSMP and O&M Agreement; and
- Take enforcement action if necessary to ensure compliance with approved plans and ensure long-term maintenance of SMPs and associated drainage areas.

Contacting Stormwater Inspections and Stormwater Enforcement

PWD assigns inspectors and enforcement coordinators to projects depending on district location and other workload factors. As such, the applicant is encouraged to contact the assigned staff member directly. General questions may be referred to Development Services at **pwd_devservices@phila.gov** or (215) 685-0798.

Stormwater Billing and Incentives

The Stormwater Billing and Incentives Program is responsible for assessing and adjusting the Stormwater Management Service Charge (Stormwater Charge) for parcels within the City of Philadelphia, based on the property classification, gross parcel area, and impervious parcel area. Additionally, the program administers credits and incentives programs to eligible property owners to reduce their Stormwater Charge. In total, the program provides the following services:

- Processes Appeals and Credits application forms to adjust Stormwater Charges, accurately reflecting the on-site conditions;
- Reviews and updates gross and impervious area delineations for Philadelphia's Stormwater Billing parcels, and maintains GIS data displayed on the **Stormwater Parcel Viewer** ☛ stormwater.phila.gov/parcelviewer;
- Works with the Office of Property Assessment (OPA), the Water Revenue Bureau (WRB), and property owners to adjust Stormwater Charges;
- Analyzes properties for existing conditions that may be favorable for natural stormwater management processes;
- Administers incentive programs, such as the Stormwater Grants Program that provides funding for voluntary stormwater management throughout Philadelphia;
- Reviews voluntary Stormwater Retrofit plans for compliance with PWD design standards for SMPs;
- Coordinates with other PWD programs involved in the Development Compliance and Stormwater Retrofit Review Path processes to establish consistency across PWD and ensure required approvals are obtained; and
- Coordinates with other reviewing entities, such as PA DEP, to ensure that consistent information is provided by the applicant to all agencies.

Contacting Stormwater Billing and Incentives

PWD encourages stormwater grant applicants to contact staff throughout the project lifecycle, from preliminary planning through O&M. If additional clarity or discussion is required, the applicant is encouraged to request a meeting. Most appointments are conducted virtually, though in-person meetings can be arranged on request. For a more formal pre-application meeting, the applicant is directed to **apply for a meeting** ☛ www.pwdplanreview.org/apply/login/portal_signup through the Plan Review Portal. (First-time applicants may need to create a new user account.)

Questions regarding credits and incentives should be directed during normal business hours (8 a.m. to 5 p.m.) to (215) 685-6070 or **pwd.stormwatercredits@phila.gov**. The general phone line and email account are monitored regularly by staff. Before a reviewer has been assigned to the project, the applicant should use the general email account for all inquiries to ensure an efficient response time.

Questions regarding accurate parcel billing can be directed during normal business hours (8 a.m. to 5 p.m.) to (215) 685-6244 or **pwd.stormwaterappeals@phila.gov**.

Stormwater Billing and Incentives web pages

Stormwater Billing and Incentives' web pages contain important information for property owners, the development community, stormwater vendors, and customers looking to assess, amend, or dispute their Stormwater Charge or apply for incentives for voluntary Stormwater Retrofit projects.

Stormwater Billing ☛ water.phila.gov/stormwater/billing provides clarity about how stormwater charges are calculated and includes detailed breakdowns of the parcel and account charges for all parcels in Philadelphia. From this page, customers can look up their individual stormwater charge, find information about filing an appeal, and **apply for the Stormwater Customer Assistance Program (CAP)** ☛ stormwater.phila.gov/parcelviewer.

Stormwater Incentives ☛ water.phila.gov/stormwater/incentives has information on the various programs and incentives that are offered to water customers in Philadelphia. From this page, the applicant can access detailed incentive pages, such as the **Stormwater Credits** ☛ water.phila.gov/stormwater/incentives/credits and **Stormwater Grants** ☛ water.phila.gov/stormwater/incentives/grants pages.

Stormwater Credits ☛ water.phila.gov/stormwater/incentives/credits includes descriptions of the different types of stormwater credits that are available to non-residential property owners. The page also includes links to resources such as the **Parcel Viewer** ☛ stormwater.phila.gov/parcelviewer, **Credits Explorer** ☛ stormwater.phila.gov/explore, information on **Stormwater Connect** ☛ water.phila.gov/stormwater/connect, forms for **applying** ☛ water.phila.gov/wp-content/uploads/files/form-b.pdf and **renewing** ☛ water.phila.gov/wp-content/uploads/files/form-c.pdf credits, and the ***Stormwater Management Service Charge Credits and Appeals Manual*** ☛ water.phila.gov/wp-content/uploads/files/stormwater-credits-appeals-manual.pdf (*Credits and Appeals Manual*). These resources help the property owner further understand the Stormwater Charge and connect with vendors who can assist with these forms.

Stormwater Grants ☛ water.phila.gov/stormwater/incentives/grants is specifically geared toward property owners looking to apply for a Stormwater Grant, which can offset the costs associated with a voluntary Stormwater Retrofit on their property. This page has information about how to apply for a Stormwater Grant, including updates on application deadlines, the **Stormwater Grants Application Guide** ☛ water.phila.gov/wp-content/uploads/files/stormwater-grants-application-guide.pdf, a link to **Stormwater Connect** ☛ water.phila.gov/stormwater/connect, and additional application resources.

Stormwater management in Philadelphia

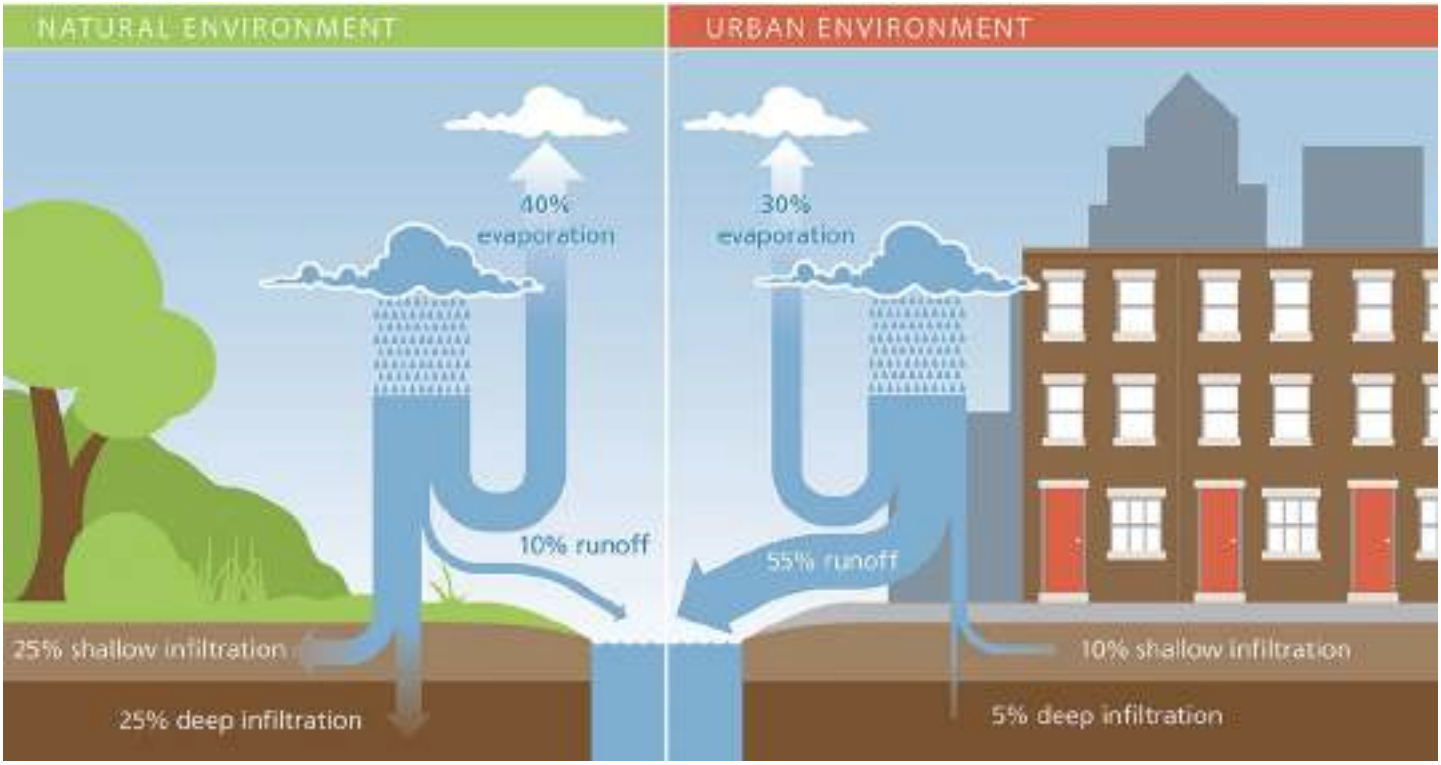
Unmanaged stormwater runoff—rainfall in developed areas that quickly "runs off" of impervious surfaces rather than soaking into the ground—negatively affects the aquatic and streamside habitats of streams and rivers in Philadelphia. These water bodies suffer from a variety of problems, and, as a result, many of Philadelphia's streams do not support healthy aquatic communities. Similarly, pollution from unmanaged stormwater that reaches the drinking water intakes on the Schuylkill and Delaware Rivers threatens the City's potable water supply.

In contrast, healthy streams and rivers have lower rates of erosion, plenty of flow during dry periods for fish and aquatic life, high water quality that supports both recreational uses such as swimming and fishing and potable water use, and flood less frequently and less severely. Clean, healthy rivers are a valuable community amenity that attracts residents and enhances the overall quality of life for residents. The goal of healthy and clean rivers in Philadelphia is an ambitious one, but one that PWD and its partners are resolutely working toward.

Stormwater and land development

Land development activities, such as the construction of new buildings, roads, driveways, and parking lots, can lead to increased stormwater runoff and pollution. As land is developed, increases in impervious areas (hard surfaces like rooftops, roads, and parking lots) limit the amount of rainfall infiltrating into the ground. Rates of evaporation are also reduced due to a lack of vegetation. Conversely, in "natural," undeveloped conditions, most rainfall either infiltrates or evaporates back into the air. As rainfall flows across the developed land surfaces, it picks up pollutants, such as sediment, fertilizers, pesticides, bacteria, metals, and oils, and flows directly into streams, rivers, or other bodies of water. Every acre of impervious cover in Philadelphia produces about 1 million gallons of polluted runoff per year, causing sewer overflows, degraded stream habitat, and water quality problems. Climate change exacerbates these issues as precipitation in the Northeast region of the U.S., including Philadelphia, is projected to become increasingly frequent and intense as warming continues.

Figure 1: Effects of urbanization on the hydrologic cycle



☛ water.phila.gov/wp-content/uploads/images/natural-vs-urban-runoff.jpg

These problems are not unique to Philadelphia; stormwater regulations are evolving around the country to address these and similar problems. These changing regulations include new approaches to stormwater management, which often require improvements in stormwater quality prior to discharge, reductions in the volume and rate of runoff, and reductions in stormwater-related erosion and sedimentation. Through these regulations, cities and developers are working together to prevent additional pollution and damage to waterways by controlling stormwater. Philadelphia's Stormwater Regulations ensure that the City has an effective, comprehensive stormwater program that meets State and Federal requirements and is adaptable to a changing regulatory context and a changing climate.

PWD's regulatory context

The City of Philadelphia is required, by a series of State and Federal regulations and mandates, to clean up its waterways. While PWD is investing billions of dollars to implement the bulk of the required upgrades, through the Stormwater Regulations (**Appendix C** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/c-pwd-stormwater-regulations) the Department also requires the development community to do its part to help manage stormwater. Table 2 provides an overview of the many State and Federal laws that require PWD to work toward cleaning up Philadelphia's waterways.

Table 2: Summary and objectives of PWD Regulations

Regulation	Objectives	How PWD meets these objectives
Clean Water Act (CWA) of 1972	Restore and maintain the chemical, physical, and biological integrity of the nation's waterways	• Implementing Combined Sewer Overflow (CSO) control and Municipal Separate Stormwater Sewer Systems (MS4) permit programs (descriptions below) • Reducing the quantity of sediment to Wissahickon Creek to under the siltation Total Maximum Daily Load
The Safe Drinking Water Act of 1974	To ensure safe drinking water for the public by establishing standards for water quality	• Investing in identifying and reducing major potential sources of contamination, including stormwater runoff, which could affect the drinking water supply • Reducing the amount of pollutants entering Philadelphia's source waters and treatment facilities through implementation of the Stormwater Regulations
The Pennsylvania Stormwater Management Act of 1978	Develop county-based stormwater management plans to ensure that stormwater is managed properly, particularly with regard to flooding	• Requiring that development activities comply with the Stormwater Regulations and other measurable benchmarks • Aligning Stormwater Regulations with Act 167 Plan requirements for local waterways
National Pollutant Discharge Elimination System (NPDES) MS4 Stormwater Regulations	Reduce and eliminate sources of pollution coming from municipally-owned separate sewer systems into the Nation's water bodies	• Implementing public water quality improvement projects such as SMPs and stream restoration projects • Implementing illicit discharge elimination programs • Implementing public outreach and education programs • Regulating development and industrial dischargers • Monitoring industrial and commercial dischargers
CSO Control Policy	Eliminate discharges of untreated wastewater through combined sewer overflows into the nation's waterbodies	• Implementing green stormwater practices, wastewater upgrades, and other improvements through *Green City, Clean Waters*, PWD's Long Term Control Plan Update (LTCPU) • Regulating development

Clean Water Act (CWA): The CWA of 1972 a.m. to restore and maintain the chemical, physical, and biological integrity of the nation's waterways. PWD is primarily charged with ensuring CWA compliance in Philadelphia and does so through a variety of activities, such as building and maintaining public stormwater infrastructure, regulating development, implementing municipal pollution prevention best practices, meeting pollutant discharge standards at sewage treatment plants, and monitoring industrial and commercial dischargers.

Combined Sewer Overflow (CSO) Control Policy: Published by the Environmental Protection Agency (EPA) in 1994, this policy established a national approach for controlling CSOs through the NPDES Permit program. CSOs occur when combined sewers (sewers that convey both stormwater and sewage in the same pipe) reach capacity as a result of stormwater runoff entering the pipe network during rain and snowmelt events. When this happens, the PA DEP permits Philadelphia, as is common with other cities containing combined sewer systems, to discharge excess untreated wastewater into nearby waterbodies. Communities with combined sewer systems are required to develop a Long-Term Control Plan to outline steps toward full compliance with the CWA. PWD submitted its original Long Term Control Plan in 1997. In 2006, PWD enacted Stormwater Regulations that included requirements to assist the City in addressing CSOs. Then, in June 2011, PWD and PA DEP entered into a Consent Order and Agreement (CO&A), a binding legal agreement that outlines the water quality targets the City needs to meet to reduce CSOs.

PWD prepared and submitted to PA DEP a LTCPU known as *Green City, Clean Waters*, to outline specific steps needed to implement the provisions of the CO&A. ***Green City, Clean Waters*** ☛ water.phila.gov/green-city outlines a 25-year, $2.4 billion plan to protect and enhance Philadelphia's combined sewer watersheds by managing stormwater with innovative green stormwater infrastructure. PWD's approach differs from the methods used by other cities to address CSOs, which typically involve building large, underground tunnels and storage tanks to temporarily hold combined sewer water so that it can eventually be treated by wastewater plants. In Philadelphia, this approach was found to be cost prohibitive for residents; it also did not meet restoration goals for the City's waterways.

PWD's CSO program requirements by the numbers

7,960,000,000,000 fewer gallons of CSO water released.

85% equivalent mass capture of specific pollutants, such as suspended solids and coliform bacteria, which means removing the same amount of pollutants that would be removed if stormwater were to pass through a wastewater treatment plant.

9,564 Greened Acres, each of which represents an acre of impervious cover within the combined sewer service area that has at least the first inch of stormwater runoff managed by stormwater infrastructure.

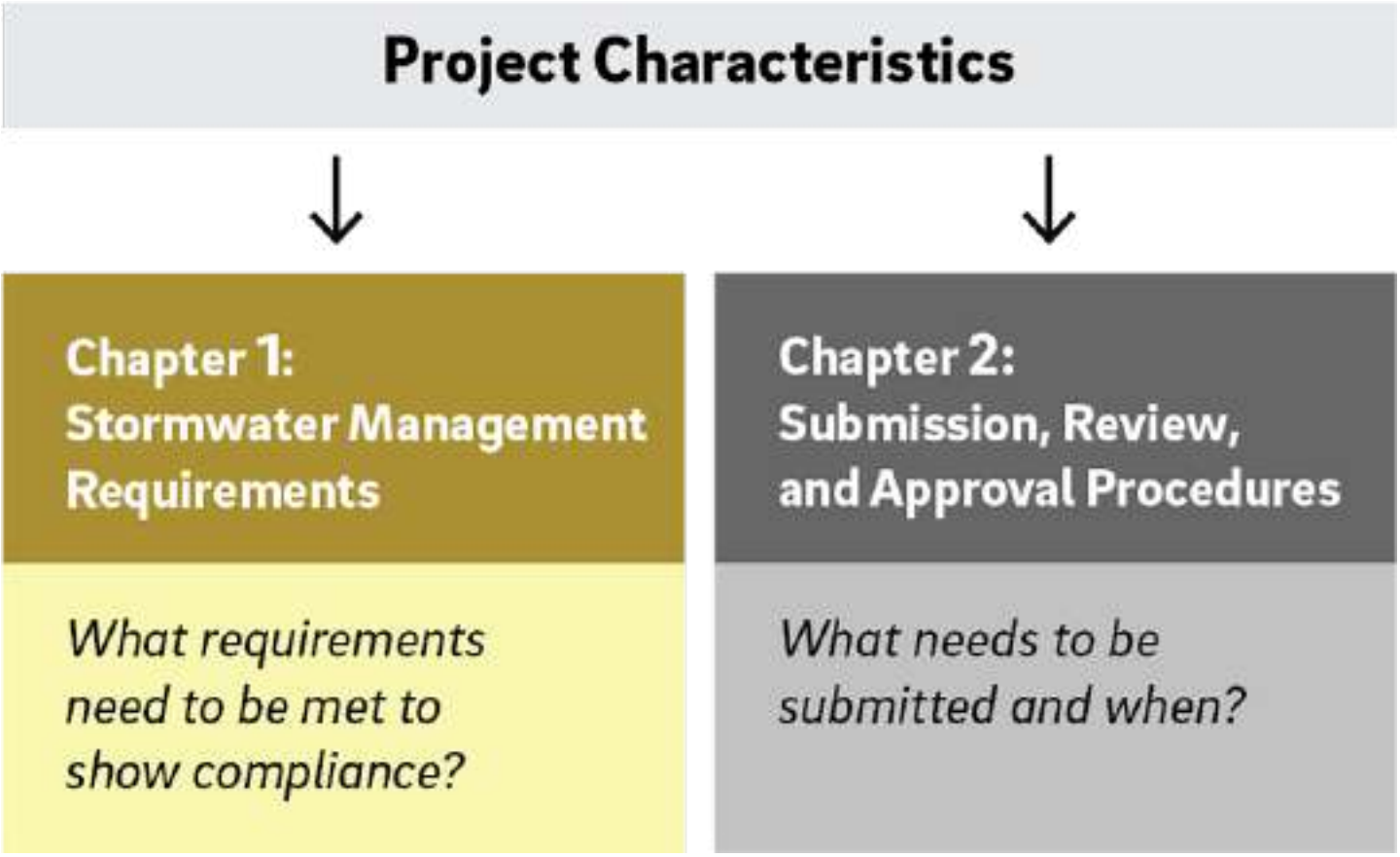
Quick tip

To determine if a project lies within a CSO area of the City, visit **CSOcast** ☛ water.phila.gov/maps/csocast.

Applicability and submission process

PWD's Stormwater Regulations cover a wide spectrum of development projects. Under the Stormwater Regulations, not all projects are subject to the same requirements. Some projects may need to meet multiple requirements, while others may be subject to only certain portions of the Stormwater Regulations (Figure 2). The application and review processes are different for different types of projects, as described below.

Figure 2: Where to find further information on applications and the review process



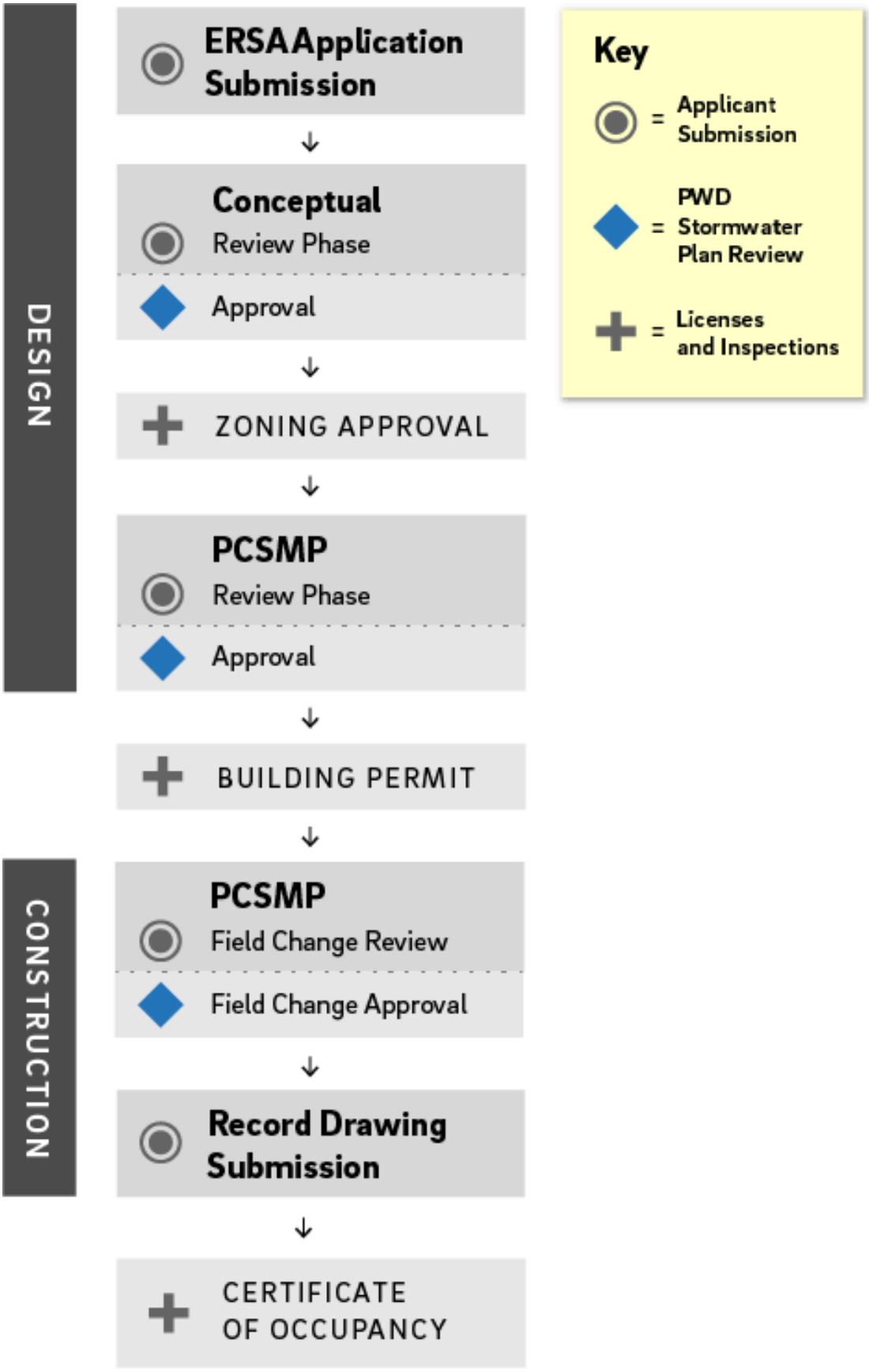
Understanding applicability

Stormwater Regulations applicability refers to which projects are subject to the Stormwater Regulations, which may not necessarily require on-site stormwater management. The regulatory applicability factors include the development type, watershed, and amount of earth disturbance associated with the project. Understanding the Stormwater Regulations' applicability to a project directly impacts the type of review PWD conducts, which PWD group reviews the project, and the subsequent submission requirements. The applicant should thoroughly review **Chapter 1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1 to understand PWD's definitions of these factors to determine if the Stormwater Regulations are applicable to a project, and to obtain guidance on how the Stormwater Regulations may be applicable.

Understanding the submission and review process

The final piece of understanding the Stormwater Regulations focuses on preparing submissions and navigating the review process. PWD organizes the different submission procedures and review processes into four Review Paths. Review Paths are a linear series of submission and review steps (Review Phases) taken to obtain stormwater management approval or exemption. There are four Review Paths, which are discussed in greater detail in **Section 2.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-2-review-paths. Figure 3 provides additional detail on the steps in PWD's stormwater review and approval process that occur during the design process for the Development Compliance Review Path. These steps are discussed in more detail within **Section 2.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-3-review-phases.

Figure 3: Stormwater approval process for projects on the Development Compliance Review Path showing relationship to major City approvals



Review process timelines and milestones

It is understandable that the applicant would be interested in how long the review process will take. As with many other aspects of PWD's program, it depends strongly on the type of project and its associated stormwater management requirements, submissions, and reviews. Upon submission of an Existing Resources and Site Analysis (ERSA) Application, and depending on the project's Review Path, there will be different Review Phases. For the Conceptual Review Phase, PWD strives to review all complete Conceptual Review Phase Submission Packages within five calendar days. For projects undergoing a PCSMP, E&S, PCSMP field change, or Record Drawing review, a review of complete Submission Packages within 15 calendar days is targeted. The fastest way to get a project through the review process is to provide PWD with a high-quality submission that meets all the submission requirements. Other strategies to streamline the process are to meet with PWD prior to submissions of larger and more complicated projects and to provide as much detail as possible about the project early in the review process.

Projects that fall under the Stormwater Retrofit Review Path, including those that have been awarded a Stormwater Grant with an approved Conceptual Plan in their grant application, may have different timelines. More information on Stormwater Retrofits can be found in **Section 1.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1/1-3-stormwater-retrofits, and Sections **2.2.4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-2-review-paths/#2.2.4 and **2.3.4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-3-review-phases/#2.3.4 contain information on the Stormwater Retrofit Review Path and Review Phase, respectively.

Preferred design approach

Chapter 3 ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3 and **Chapter 4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4 provide detailed guidance to the applicant in designing SMPs that comply with the Stormwater Regulations and PWD design requirements for Stormwater Retrofits. PWD offers the designer a standardized and systematic design process that is consistent for every project. This section provides a first look at PWD's preferred approach to stormwater management design.

SMP design approach

The SMPs discussed in this Manual incorporate a variety of technologies designed to manage stormwater. While non-structural options, such as reducing the amount of impervious cover and designing for disconnected impervious cover (DIC), are preferred strategies that the designer should consider before proposing SMPs, PWD recognizes that many development projects will need to use SMPs to comply with the Stormwater Regulations. In **Chapter 3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3 and **Chapter 4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4 of the Manual, PWD provides guidance for an array of SMPs that offer design solutions for many different types of sites.

Chapter 4 ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4 details eleven SMPs, along with pretreatment, inlet and outlet control components, and landscaping. It provides SMP-specific information on applicability and uses, components, design requirements, material specifications, and construction and maintenance guidance.

Infiltration first

When using SMPs to meet PWD's Water Quality requirement, the applicant must use infiltrating SMPs, which allow water to soak into the ground rather than holding and releasing it. Infiltration is the main focus of the Stormwater Regulations, as these SMPs also filter out pollutants and thus are the most beneficial for improving water quality. Infiltration SMPs must be utilized unless it is demonstrated that they are not feasible due to poor soils, bedrock, soil contamination or other site constraints. PWD requires that the applicant provide documentation of these conditions and request a waiver from the infiltration requirement via the Online Technical Worksheet. Specific requirements for soil and infiltration testing and other related issues are discussed in **Section 3.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-3-infiltration-testing-and-soil-assessment-for-smp-design.

Not all SMPs are created equal

To help developers select SMPs, PWD developed a hierarchy that uses ranking factors to prioritize acceptable SMPs. The SMP Hierarchy uses factors important to PWD's efforts to clean up Philadelphia's waterways as well as those of primary concern to developers such as ease of maintenance, cost, and impact on buildable area. A full discussion of the SMP Hierarchy is found in **Section 3.2.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-2-stormwater-management-design/#3.2.2, but a brief discussion of high, medium, and low-preference SMPs is provided below.

- *Highest-preference SMPs* are bioinfiltration and bioretention basins, porous surfaces, green roofs, and blue-green roofs. Projects required to comply with Stormwater Regulations that use only the highest-preference SMPs are eligible for an Expedited PCSMP Review (**Section 2.4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-4-expedited-pcsmp-reviews) and may elect to postpone infiltration testing until construction or receive an exemption from testing.



A bioinfiltration basin represents the Philadelphia Water Department's most preferred SMP.

- *Medium-preference SMPs* (subsurface infiltration, drainage wells, cisterns, blue roofs, and ponds and wet basins) often provide fewer triple bottom line benefits and may not last as long as more highly-preferred SMPs.

- *Lowest-preference SMPs* include various types of subsurface detention and media filter systems that are non-infiltrating and provide little-to-no triple bottom line benefits. Lowest-preference SMPs also tend to have relatively high O&M costs and may malfunction more frequently than other SMPs.



A subsurface detention basin represents one of the Philadelphia Water Department's least preferred SMPs.

1 Stormwater Management Requirements

Chapter 1 Stormwater Management Requirements

1.0 Introduction

The negative impacts of unmanaged stormwater runoff present a challenge to the City of Philadelphia. Such negative impacts include increased runoff pollutant concentrations, reduced groundwater recharge, increased stream channel and bank erosion, loss of aquatic habitat, increased flood frequency, and increased quantity, frequency, and duration of combined sewer overflows. In the United States, some of the largest increases in the frequency and intensity of extreme precipitation are already being observed in the Northeast U.S., which includes the Philadelphia region. Additionally, climate change projections for the Philadelphia region indicate that rainfall events will continue to increase in volume and intensity, leading to the potential for increased stormwater runoff and the exacerbation of negative impacts.

To confront these various challenges, the Philadelphia Water Department (PWD) has developed the **PWD Stormwater Regulations** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/c-pwd-stormwater-regulations (Stormwater Regulations) to ensure the City has an up-to-date and effective stormwater management program that meets State and Federal requirements and can be coordinated with the evolving regulations adopted by upstream municipalities. The Philadelphia Stormwater Management Guidance Manual (Manual) provides detailed information on how to efficiently comply with the Stormwater Regulations and PWD design criteria for development projects and other stormwater projects. Through compliance with the Stormwater Regulations and these design standards, each project helps to improve the health of Philadelphia's waterways and mitigate the effects of increasing rainfall from climate change.

Chapter 1, Stormwater Management Requirements, provides an overview of the Stormwater Regulations and design criteria and allows the applicant to determine if a project is regulated, and if so, which requirements apply to a particular project, based on the project's characteristics. Once the Stormwater Regulations' applicability to a project is determined, the applicant can find guidance on the necessary submission, review, and approval procedures in **Chapter 2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2.

Section 1.1 ☛ p. 3 contains guidance on the project characteristics that determine if a project is regulated, and if so, which requirements of the Stormwater Regulations apply to an applicant's project. The three key applicability factors that determine whether and which specific requirements of the Stormwater Regulations apply to a project are the following:

- Development Type – **Section 1.1.1** ☛ p. 4
- Watershed – **Section 1.1.2** ☛ p. 7
- Earth Disturbance – **Section 1.1.3** ☛ p. 9

Section 1.2 ☛ p. 13 provides guidance on how the Stormwater Regulations may be applicable to a project, allowing the applicant to determine the specific requirement(s) of the Stormwater Regulations to which a project would be subject. It contains an overview of the Stormwater Regulations, their objectives, and project-specific exemptions. Specific requirements and section references within this chapter are as follows:

- Post-Construction Stormwater Management Requirements – **Section 1.2.1** ☛ p. 14
  - Water Quality requirement
  - Channel Protection requirement
  - Flood Control requirement
  - Public Health and Safety Release Rate requirement
- Erosion and Sediment Control Requirement – **Section 1.2.2** ☛ p. 25

Section 1.3 ☛ p. 26 provides guidance on implementing a Stormwater Retrofit project. These projects are not subject to Stormwater Regulations and have different submission and review standards. This section provides additional information to interpret the Manual for these projects.

After determining the project's development type, watershed, and earth disturbance area using **Section 1.1** ☛ p. 3, the applicant will use this information in conjunction with the requirement-specific exemptions detailed in **Section 1.2** ☛ p. 13 to determine which Stormwater Regulation requirements apply to the project. If the applicant is working with a voluntary Stormwater Retrofit, they will also reference **Section 1.3** ☛ p. 26 for guidance on interpreting the Manual for their project.

1.1 Applicability Factors

This section contains guidance on the project characteristics that determine which portions of the **Philadelphia Water Department (PWD) Stormwater Regulations** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/c-pwd-stormwater-regulations (Stormwater Regulations) apply to an applicant's project. PWD requires submissions for all projects in the City of Philadelphia that generate earth disturbance of 5,000 square feet or more, yet not all projects will need to comply with all requirements of the Stormwater Regulations. There are three main factors that determine which requirements of the Stormwater Regulations apply to a project:

- Development type (**Section 1.1.1** ☛ p. 4),
- Watershed (**Section 1.1.2** ☛ p. 7), and
- Earth disturbance (**Section 1.1.3** ☛ p. 9).

These three project characteristics play an important role in determining how the Stormwater Regulations discussed in **Section 1.2** ☛ p. 13 are applied to a project. The applicant will use this section to identify the project's development type, watershed, and earth disturbance area. This information, in conjunction with the requirement-specific exemptions in **Section 1.2** ☛ p. 13 and clarifications provided for Stormwater Retrofits in **Section 1.3** ☛ p. 26, is necessary for determining applicability and the project's Review Path in **Chapter 2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2.

Of the three key applicability factors, one—earth disturbance—can change during the course of design and construction. If the earth disturbance threshold changes, the applicant must return to **Section 1.1.3** ☛ p. 9 to verify whether the project's applicability determinations have changed.

1.1.1 Development type

Development type plays a key role in determining if and how Post-Construction Stormwater Management (PCSM) Requirements (**Section 1.2.1** ☛ p. 14) will apply to a project.

Development is defined in the Stormwater Regulations as *any human-induced change to a tract of land, whether public or private. Development encompasses, but is not limited to, New Development, Redevelopment, Demolition, and Stormwater Retrofit. It includes the entire Development Site, even when the project is performed in phases*. The development types listed below are types that PWD recognizes, and the applicant can only select one development type when completing the ERSA Application (**Section 2.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-1-existing-resources-and-site-analysis).

New Development

New Development is defined in the Stormwater Regulations as a *Development project on a tract of land where structures or impervious surfaces never existed or were removed before January 1, 1970.* The improved tract of land refers to the area of on-site earth disturbance.

Redevelopment

Redevelopment is defined in the Stormwater Regulations as *Development on a tract of land that includes, but is not limited to, the demolition or removal of existing structures or impervious surfaces and replacement with new impervious surfaces. This includes replacement of impervious surfaces that have been removed on or after January 1, 1970.* The improved tract of land refers to the area of on-site earth disturbance.

Demolition

Demolition is defined in the Stormwater Regulations as a project that is limited to *the razing, or destruction, whether entirely or in significant part, of a building, structure, site, or object, including the removal of a building, structure, site, or object from its site or the removal or destruction of the façade or surface.*

Stormwater Retrofit

Stormwater Retrofit is defined in the Stormwater Regulations as *a project that is limited to the voluntary rehabilitation and/or installation of stormwater management practices (SMPs) on a property to better manage stormwater runoff.* Often, the motivation to initiate a Stormwater Retrofit project is to reduce the applicant's monthly Stormwater Management Service Charge (Stormwater Charge) by applying for stormwater credits (**Section 6.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-6/6-3-stormwater-credits). In addition, these projects are eligible to apply for a Stormwater Grant. For more information on how to apply, applicants are directed to visit the **Stormwater Grants** ☛ water.phila.gov/stormwater/incentives/grants website or contact **Stormwater Billing and Incentives** ☛ water.phila.gov/development/stormwater-plan-review/manual/introduction#6. For more information on how voluntary stormwater management may impact a project's requirements and review phases, the applicant is directed to **Section 1.3** ☛ p. 26.

Due to historic urbanization, New Development projects are uncommon in Philadelphia and must comply with the most stringent PCSM Requirements. The vast majority of development projects in Philadelphia are classified as Redevelopment projects. The applicant can submit supporting documentation (e.g., photographs, past permits, inspection reports, etc.) to confirm a redevelopment classification. If a Redevelopment project meets certain conditions, it may be exempt from the Flood Control and Channel Protection requirements. The applicant is referred to **Section 1.2** ☛ p. 13 for the Stormwater Regulations as well as requirement-specific exemptions.

Hybrid development types

It is possible for a project to fall under more than one development type, though only one can be selected on the ERSA Application (**Section 2.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-1-existing-resources-and-site-analysis). If an applicant is unsure which development type they should select on their ERSA Application, they should contact PWD. Some of the most common hybrid developments are described in the next section.

New and Redevelopment projects with voluntary Retrofit components

Development projects that must meet Stormwater Regulations may be eligible for incentives if they choose to go "above and beyond", managing more impervious area on their property than is required by Stormwater Regulations. Going "above and beyond" can result in additional stormwater credits and reductions on water bills for the property owner after the project is complete. The Stormwater Grant may be available to these projects.

A Stormwater Grant is for property owners with impervious area on their property that is not disturbed or included in the development project and Stormwater Regulations. The designer directs this drainage area to the SMP and meets all applicable design criteria. The grant may be used for design and construction funding for the additional stormwater management. During construction, the development contractor constructs any on-site structures needed for this management. PWD will later construct infrastructure, such as an inlet and junction box, within the ROW using separate, non-Grant funding.

Any applicant interested in incentive or grant opportunities for their project is urged to contact **Stormwater Billing and Incentives** ☛ water.phila.gov/development/stormwater-plan-review/manual/introduction#6 as early as possible in the design process. In addition, each development project submitted to PWD is analyzed for opportunities to over-size SMPs, and the applicant may be contacted by PWD regarding incentive funding. Additional information about funding available to development projects can be found on **PWD Stormwater Incentives** ☛ water.phila.gov/stormwater/incentives.

Development projects that must meet Stormwater Regulations that elect to include a voluntary retrofit component would follow the Development Compliance Review Path (**Section 2.2.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-2-review-paths#2.2.1) and should select "New Development" or "Redevelopment" on their ERSA Application. Development projects that do not need to meet the Stormwater Regulations will typically follow the Stormwater Retrofit Review Path (**Section 2.2.4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-2-review-paths#2.2.4) and should select "Stormwater Retrofit" on their ERSA Application. The project team will coordinate with both Stormwater Plan Review and Stormwater Billing and Incentives throughout review and construction in both scenarios.

Phased projects with Demolition then subsequent Development and/or Stormwater Retrofit construction

Many Development or Stormwater Retrofit projects begin with a demolition/site clearing phase. In most circumstances, the review of the demolition can occur within the review of the Development/Stormwater Retrofit. In these circumstances, the applicant would select "New Development," "Redevelopment", or "Stormwater Retrofit" on their ERSA Application and follow the appropriate Development Compliance or Stormwater Retrofit Review Path. If the demolition must occur prior to completion of the review, then the applicant will need to submit a separate ERSA Application using the "Demolition" development type and follow the Demolition Review Path.

Redevelopment of an earlier Development or Stormwater Retrofit project

Property is constantly being redeveloped in Philadelphia, whether the result of new ownership or when an existing owner wishes to make improvements to their own site. Before undertaking a Development or Stormwater Retrofit project, it is important to determine whether the land where the improvement is proposed was previously subject to Stormwater Regulations or managed stormwater through a voluntarily installed SMP. Most properties that fall into this category will have an Operations and Maintenance (O&M) Agreement recorded against the deed (**Section 6.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-6/6-1-property-owner-inspections-and-maintenance#6.1.2) and are also identified on the **Green Stormwater Infrastructure Projects Map** ☛ water.phila.gov/green-projects-map. If the land was previously subject to Stormwater Regulations or has an existing SMP on-site, the applicant must contact PWD prior to submitting their ERSA Application. This can have a significant impact on the project's Review Path and whether a new ERSA Application is required or if the improvement should be submitted as a PCSMP Field Change under an existing project tracking number.

Waterway encroachments

Waterway encroachments are projects that occur within streambanks or rivers with the purpose of repairing the waterway or an object within the waterway. These projects include streambank stabilization, dam removal projects, and bridge abutment repairs. Earth disturbance that occurs within the waterway will be exempt from the PCSM Requirements. However, ancillary earth disturbance that occurs outside of the waterway, such as trail improvements or other development activities, will be applicable to the PCSM Requirements.

1.1.2 Watershed

The watershed in which a project site is located plays an important role in determining how PCSM Requirements (**Section 1.2.1** ☛ p. 14) are applied to a project. For example, ongoing watershed-wide Pennsylvania Stormwater Management Act (Act 167) planning studies determine Flood Management Districts for controlling peak rates of runoff; watershed locations are also used to determine the applicability of the Channel Protection requirement for Redevelopment projects. For this reason, it is important that the applicant identify the correct watershed early in the design process. Watershed Maps in **Appendix D** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/d-watershed-and-phs-release-rate-maps provide a basic guide, but the applicant can also contact PWD to verify a site's watershed location.

There are seven major watersheds in Philadelphia:

- Darby and Cobbs Creeks,
- Delaware Direct,
- Lower Schuylkill River,
- Pennypack Creek,
- Poquessing Creek,
- Tookany/Tacony-Frankford, and
- Wissahickon Creek.

Watershed-based regulations are evolving to address stormwater challenges within Philadelphia. While the Stormwater Regulations apply to all New Development and Redevelopment projects that result in earth disturbance totals of 15,000 square feet or more (**Section 1.1.3** ☛ p. 9), watershed-specific regulations trigger the Stormwater Regulations at a lower disturbance threshold. Project sites located in the Darby and Cobbs Creeks Watershed and in the Wissahickon Creek Watershed are subject to additional watershed-specific stormwater management requirements. The latest information about **watershed-specific regulations** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/c-pwd-stormwater-regulations can be found on the **PWD Plan Review Portal** ☛ www.pwdplanreview.org.

Darby and Cobbs Creeks Watershed

Projects located in the Darby and Cobbs Creeks Watershed are subject to the provisions of the **Darby and Cobbs Creeks Watershed Act 167 Stormwater Management Plan** ☛ water.phila.gov/wp-content/uploads/files/Darby_Cobbs_WMP.pdf. Because the Stormwater Regulations were developed to comply with the plan for the Darby and Cobbs Creeks Watershed, all projects that propose 5,000 square feet or more of earth disturbance in the Darby and Cobbs Creeks Watershed are subject to the Stormwater Regulations and their associated PCSM Requirements (**Section 1.2.1** ☛ p. 14).

Wissahickon Watershed Overlay

To help reduce flooding, erosion, siltation, and channel enlargement resulting from development within the Wissahickon Creek Watershed, additional stormwater management requirements and impervious coverage limits may apply to projects within this watershed.

Projects located in the Wissahickon Creek Watershed are subject to the Philadelphia Code §14-510 / WWO, Wissahickon Watershed Overlay District. The applicability of these requirements depends on the location of the project within the watershed and the amount of impervious cover proposed in comparison to the existing impervious condition. A map of the Wissahickon Watershed Overlay (WWO) District can be found within the Code and can also be viewed using the City's **Atlas map** ☛ https://atlas.phila.gov/ tool.

For projects located within the WWO District, the Philadelphia City Planning Commission (PCPC) will determine if additional stormwater management requirements are applicable; however, PWD Stormwater Plan Review will be responsible for review of the PCSMP. The applicant is referred to **Section 2.6** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-6-pwds-role-in-philadelphias-development-process for more information on the WWO as it relates to project-specific requirements.

1.1.3 Earth disturbance

Earth disturbance is the primary factor that determines whether a project is subject to the Stormwater Regulations. It is also a primary factor in determining the applicability of PCSM Requirements (**Section 1.2.1** ☛ p. 14) and the E&S requirement (**Section 1.2.2** ☛ p. 25). As such, applicants must properly and accurately assess the limits of earth disturbance associated with development projects to determine applicable requirements and the Review Path required.

Any project proposing 5,000 square feet or more of earth disturbance must submit an E&S Plan to PWD for review and approval. While earth disturbance of 15,000 square feet or more triggers the PCSM Requirements for New Development or Redevelopment projects in most areas of the City, earth disturbance of 5,000 square feet or more triggers the PCSM Requirements for these project types in the Darby and Cobbs Creek Watershed. Some projects located in the Wissahickon Creek Watershed may also be required to comply with PCSM Requirements at even lower earth disturbance totals. The applicant is referred to **Section 1.1.2** ☛ p. 7 above for specific requirements regarding projects located within the Wissahickon Creek Watershed or the Darby and Cobbs Creeks Watershed.

Earth disturbance is defined in the Stormwater Regulations as *any construction or other activity that disturbs the surface of land*. Examples of activities that consist of, or can commonly involve, earth disturbance include, but are not limited to, the following:

- Excavation;
- Embankments;
- Land development;
- Subdivision development;
- Moving, depositing, stockpiling, or storing of soil, rock, or earth materials, except as excluded below;
- Demolition activity that results in the disturbance of the land beneath or surrounding a structure, including foundation or building slab removal;
- Concrete slab removal;
- Development above subsurface structures where earth, such as gravel or dirt, is exposed;
- Stormwater Retrofits that include SMP installation;
- Utility connections, including work in the public rights-of-way;
- Installation of new Streets;
- Street Maintenance Activities;
- New paving and full depth pavement replacement;
- Installation of E&S controls and construction-related disturbance located over existing pervious areas, such as establishment of rock construction entrances, stockpiles, silt fencing, construction vehicle paths, staging, and fill areas;
- Grading;
- Clearing and grubbing; and

Quick tip

A project may have multiple boundaries, each of which is significant when determining stormwater management applicability during the development process. For example, the parcel boundary, limits of earth disturbance, and area that must be managed for stormwater may all be different. Only the limit of earth disturbance is used to determine whether, and which PCSM Requirements of, the Stormwater Regulations apply to most projects.

- Landscaping.

Activities that are not typically classified as earth disturbance include the following:

- Interior building renovations;
- Temporary stockpiles or rock construction entrances located over existing impervious surfaces;
- Re-striping of paved areas; and
- Milling and repaving of existing paved areas, as long as the pavement subbase is not exposed during the milling process. The pavement subbase is defined as the layer of aggregate material laid on the subgrade, on which the base course layer is laid.

Some earth disturbance activities and their associated areas count toward the regulatory disturbance threshold for triggering PCSM Requirements, but are not required to be managed in the post-development condition. Such activities include the following:

- Demolition, provided the surface of the land is returned to a pervious condition;
- Waterway encroachment activities occurring within streambanks, rivers, or other waterways for the purpose of repairing the waterway. This can include streambank stabilization, dam removal, bridge abutment repairs, dredging, stream restoration, and erosion stabilization activities;
- Artificial turf areas specifically reserved for dog use;
- Certain water features, as determined by PWD, such as spraygrounds, swimming pools, and fountains that will be chlorinated; and
- Earth disturbance located beneath an undisturbed existing impervious superstructure, such as a highway overpass.

There are other earth disturbance areas that do not count toward the regulatory disturbance threshold for triggering PCSM Requirements and are not required to be managed in the post-development condition. When calculating the total limit of earth disturbance for a development project, the earth disturbance area associated with the following activities should not be counted toward the total disturbance value triggering the PCSM Requirements. These areas include:

- Street Maintenance Activities within an existing Street that do not result in increased impervious areas. Examples include sidewalk replacement, asphalt repaving, utility trenching, curb cuts, street tree planting, and installation of associated street features such as ADA ramps, light poles, signs, benches, decorative planters, and Green Stormwater Infrastructure (GSI);
- New sidewalk installation along an existing paved Street;
- Area disturbed for Stormwater Retrofit installation (**Section 1.3** ☛ p. 26); and
- Small Residential Developments.

Small Residential Development is defined as *a project proposing less than one acre of earth disturbance consisting of buildings used exclusively as one- or two-family dwellings.* Small Residential Development is exempt from PCSM Requirements. If a project proposes a total earth disturbance less than one acre and contains a mix of both Small Residential Development and other development types, the footprints of any buildings used exclusively as one- or two-family dwellings can be excluded from the regulatory disturbance threshold for triggering PCSM Requirements and are not required to be managed in the post-development condition. The applicant is referred to **Section 2.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-3-review-phases for more information.

Applicants who wish to claim exemption from PCSM Requirements because of the above-listed earth disturbance areas should delineate them separately on E&S Plans submitted to PWD as part of the Conceptual Review Phase.

Earth disturbance activities that are exempt from PCSM Requirements are still required to comply with all appropriate E&S submission and review requirements, which may include PWD approval of an E&S Plan. Submission of an ERSA application is required for all projects that propose more than 5,000 square feet of earth disturbance. The applicant is referred to **Chapter 2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2 for more information on submission requirements. Exemption of a project from PWD's PCSM Requirements does not necessarily imply that the project is also exempt from PCSM Requirements from other City and State agencies. The applicant is referred to **Section 2.6** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-6-pwds-role-in-philadelphias-development-process and **Section 2.7** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-7-pwd-and-pennsylvania-department-of-environmental-protection for more information.

Phased projects, common plans of development, and contiguous areas of earth disturbance

It is not uncommon for large real estate projects to be developed and permitted in phases. When phasing is proposed, PWD will look at the earth disturbance associated with the entire Development Site to determine applicable requirements under the Stormwater Regulations. The Development Site is defined in the Stormwater Regulations as *the land area where any Development activities are planned, conducted, or maintained, regardless of individual parcel ownership. It includes contiguous areas of disturbance across Streets and other rights of way, or private streets and alleys, during any stage of or on any portion of a larger common plan of development or sale.*

A project may be considered a "common plan of development" if it is associated with any announcement or piece of documentation (including a sign, public notice, hearing, sales pitch, advertisement, website, drawing, zoning request, etc.) or physical demarcation (including boundary signs, lot stakes, surveyor marking, etc.) indicating construction activities may occur on a specific plot. As an example, a redevelopment of a former industrial site that lays out streets, public parks, schools, areas of commercial development, and residential lots that may be sold to another developer are all considered part of the same development site.

Disturbance along multiple parcels separated by an existing street will not be considered contiguous in cases where the linking disturbance activity is limited to sidewalk replacement and/or improvements to PWD infrastructure such a Private Cost water or sewer extension or GSI installation.

Some Development projects may choose to phase portions of the proposed disturbance over time. These phased projects must document their phasing plan in their submitted PCSMP via the sequence of construction and the Construction Certification Package SMP Construction Certification Forms. Each phase of the project must be compliant with the Stormwater Regulations. SMPs may be constructed in advance of the complete Development, however they must be protected from construction sediment.

Being conservative

PWD often observes earth disturbances that occur during construction activity that exceed initial estimates provided on plans. To avoid costly delays, PWD recommends that the applicant be conservative when estimating the disturbance area at each stage of the review process. Should a site inspection reveal that 15,000 or more square feet of earth disturbance has occurred on a Redevelopment site, the site will be required to comply with the Stormwater Regulations and will be subject to the enforcement actions outlined in the Stormwater Regulations.

Should a site inspection reveal that more than one acre of earth has been disturbed, the site will be required to apply for a Pennsylvania Department of Environmental Protection (PA DEP) National Pollutant Discharge Elimination System (NPDES) Permit. The site will be subject to the enforcement actions outlined in the Stormwater Regulations until the applicant receives a NPDES Permit. The applicant is referred to **Section 2.7** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-7-pwd-and-pennsylvania-department-of-environmental-protection for more information on the interaction between PWD and PA DEP.

PWD should be contacted prior to plan submittal and before any construction activities whenever there are questions or a need for clarification regarding earth disturbance activities.

1.2 Stormwater Regulations

This section provides an overview of the Philadelphia Water Department (PWD) Stormwater Regulations (Stormwater Regulations), their objectives, and project-specific exemptions. After determining the project's development type, watershed, and earth disturbance area using **Section 1.1** ☛ p. 3, the applicant will use this information, in conjunction with the requirement-specific exemptions detailed in this section, to determine which portions of the Stormwater Regulations apply to the project.

The Stormwater Regulations can be found in **Appendix C** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/c-pwd-stormwater-regulations of this Manual. They have been developed in accordance with **Philadelphia Code §14-704(3)** ☛ https://codelibrary.amlegal.com/codes/philadelphia/latest/philadelphia_pa/0-0-0-293389 and consist of four main Post-Construction Stormwater Management (PCSM) Requirements: Water Quality, Channel Protection, Flood Control, and Public Health and Safety (PHS) Release Rate. In addition, all earth disturbance activity must comply with the Erosion and Sediment Control (E&S) requirements of the Pennsylvania Department of Environmental Protection (PA DEP), as specified in **25 Pa. Code §102.4** ☛ https://www.pacodeandbulletin.gov/display/pacode?file=/secure/pacode/data/025/chapter102/s102.4.html.

1.2.1 Post-Construction Stormwater Management Requirements

PCSM Requirements regulate how stormwater runoff leaves a project site in the built or post-development condition. PCSM Requirements have four components: Water Quality, Channel Protection, Flood Control, and PHS Release Rate requirements. All projects in the City of Philadelphia that generate earth disturbances of 15,000 square feet or more—or 5,000 square feet in the Darby and Cobbs Creeks Watershed—are subject to the PCSM Requirements and will follow the Development Compliance Review Path. The applicant is referred to **Section 2.1.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-1-existing-resources-and-site-analysis#2.1.2 for an explanation of, and further guidance regarding, Review Paths.

Water Quality

Background

The objectives of the Water Quality requirement are as follows:

1. Reduce pollution in runoff;
2. Recharge the groundwater table and increase stream base flows;
3. Restore more natural site hydrology; and
4. Reduce combined sewer overflows (CSOs) from the City's combined sewer systems.

The Water Quality requirement focuses on the removal of pollutants from stormwater runoff and is similar to requirements in surrounding states and other major cities across the country. Water quality benefits are provided, in part, by slowing down stormwater flow and allowing suspended solids to settle. Because some nutrients, metals, organics, and other contaminants are bound to these sediment particles, this basic treatment mechanism can have multiple benefits. Generally, the physical, chemical, and biological processes that take place in a system that incorporates soil, water, and plants provide the best water quality improvements.

Infiltration of stormwater runoff can significantly reduce pollutant loads reaching surface water and generally does not pose a threat to groundwater quality if there is sufficient separation from the water table. Infiltrating stormwater runoff also has a direct impact on reducing the quantity of water in the sewer system that can contribute to CSOs and pollution of receiving waters. As such, infiltration is a major focus of the Water Quality requirement.

Attenuation of stormwater flows also contributes to water quality goals. In combined sewer systems, CSOs must be reduced by implementing a slow-release rate set to match the area-weighted wet weather treatment rate of PWD's Water Pollution Control Plants. Therefore, when infiltration is not feasible, water quality improvement in combined sewer areas must be achieved not only by reducing runoff pollutant load concentrations, but also by managing the quantity and timing of stormwater discharge. Detention and slow-release strategies reduce peak flows in the combined sewer during wet weather events, thus lessening the frequency and magnitude of CSOs.

Requirement

The Water Quality requirement stipulates infiltration of the first 1.5 inches of runoff from all directly connected impervious areas (DCIA) within the limits of earth disturbance. This quantity of stormwater runoff is referred to as the Water Quality Volume (WQv). If infiltration is feasible on the project site, the Water Quality requirement must be met by infiltrating 100% of the WQv through stormwater management practices (SMPs).

One strategy to address the Water Quality requirement is to minimize the amount of DCIA, which reduces the WQv that must be treated on-site. DCIA can be reduced through the use of disconnected impervious cover (DIC), which includes green roofs; porous surfaces; and rooftop, pavement, and tree disconnections, which are outlined in greater detail in **Section 3.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-2-stormwater-management-design. Projects that propose to disconnect 95% or more of their post-development impervious area may qualify for an expedited Disconnection Green Review as described in **Section 2.4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-4-expedited-pcsmp-reviews.

Guidance for calculating the WQv and design requirements for DIC and SMPs can be found in **Chapter 3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3.

If infiltration is infeasible, or it can be demonstrated that infiltration would cause property or environmental damage, the method of compliance with the Water Quality requirement may differ depending on the type of sewershed in which a project is located. The applicant is referred to the sewershed maps in **Appendix D** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/d-watershed-and-phs-release-rate-maps to determine the sewershed in which their project is located. These maps are approximations of sewershed boundaries. The applicant must refer to their project's point of stormwater discharge when determining which requirements apply to their project.

If the applicant believes that infiltration is not feasible, a waiver from the infiltration requirement must be requested via the Online Technical Worksheet (**Section 3.4.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-4-how-to-show-compliance/#Worksheet) for PWD Stormwater Plan Review approval. The applicant is referred to **Section 3.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-3-infiltration-testing-and-soil-assessment-for-smp-design for guidance on determining and documenting infiltration feasibility. For projects featuring earth disturbance greater than one acre and seeking an infiltration waiver due to soil or groundwater contamination, PA DEP must evaluate the waiver request concurrently with PWD.

Quick tip

Property owners often find that by incorporating landscape elements to reduce their DCIA, they simultaneously increase their property value and retail sales, reduce crime, and improve mental health and worker productivity. For more information regarding the triple bottom line benefits of green stormwater management practices, the applicant is encouraged to visit the **National Resources Defense Council website** ☛ http://www.nrdc.org/water/commercial-value-green-infrastructure.asp.

Non-Infiltrating Projects Located in Combined Sewer Areas

For all areas served by a combined sewer and where infiltration has been judged infeasible for all or a portion of the WQv, 100% of the WQv that is not infiltrated must be routed through an acceptable pollutant-reducing practice and detained in each SMP for no more than 72 hours. 100% of the WQv that is not infiltrated must also be released from the site at a maximum rate of 0.05 cubic feet per second (cfs) per acre of associated DCIA.

Non-Infiltrating Projects NOT Located in Combined Sewer Areas

For all areas not served by a combined sewer—including separate sewer areas, direct discharge projects, and unsewered areas—for which infiltration is infeasible for all or a portion of the WQv, 100% of the WQv that is not infiltrated must be routed through an acceptable pollutant-reducing practice and detained in each SMP for no more than 72 hours. Acceptable non-infiltrating pollutant-reducing practices are listed in **Table 3.1-3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-1-site-assessment-and-stormwater-management-strategies/#Table_3.1-3.

Figure 1.2-1: Water Quality requirements

Infiltration Feasible	
PROJECT LOCATION	REQUIREMENTS
All	Infiltrate 100% of the WQv

Infiltration NOT Feasible	
PROJECT LOCATION	REQUIREMENTS
In Combined Sewer Area	100% of the WQv that is not infiltrated must be: • Routed through an acceptable pollutant-reducing practice* *AND* • Detained in each SMP for no more than 72 hours *AND* • Released from the site at a maximum rate of 0.05 cfs per acre of associated DCIA
Not In Combined Sewer Area	100% of the WQv that is not infiltrated must be: • Routed through an acceptable pollutant-reducing practice *AND* • Detained in each SMP for no more than 72 hours

* Not required for Stormwater Retrofit projects

The applicant is referred to **Section 3.4.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-4-how-to-show-compliance#3.4.1 for detailed information on how to demonstrate a project's compliance with the Water Quality requirement.

There are no exemptions from the Water Quality requirement.

Stormwater Retrofit projects should be designed to meet most of the Water Quality requirement design standards. For clarification on what requirements are applicable, the applicant is referred to **Section 1.3** ☛ p. 26 for more information.

Channel Protection

Background

In addition to influencing the quality of stormwater runoff, the rate and frequency of stormwater discharge also pose a threat to the downstream environment and infrastructure. Management of peak rates from smaller storm events is referred to as *Channel Protection* because one of its benefits is to reduce erosive flows in downstream channels.

The objectives of the Channel Protection requirement are as follows:

1. Protect the quality of stream channels and banks, fish habitat, and man-made infrastructure from the influence of the erosive forces and downstream sedimentation due to high stream velocities; and
2. Reduce the quantity, frequency, and duration of CSOs.

Requirement

The Channel Protection requirement stipulates the detention and release of runoff from the one-year, 24-hour Natural Resources Conservation Service Type II design storm event for all DCIA within the limits of earth disturbance at a maximum rate of 0.24 cfs per acre of associated DCIA in no more than 72 hours.

This requirement applies equally to rivers, streams, and sites discharging to drainage ditches, natural or man-made ponds, and sewers that ultimately discharge to receiving waters, even if this discharge is indirect.

The applicant is referred to **Section 3.4.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-4-how-to-show-compliance#3.4.1 for detailed information on how to demonstrate a project's compliance with the Channel Protection requirement.

Quick tip

The Water Quality and Channel Protection requirements are not additive; however, management of the WQv may reduce the storage volume needed to meet the Channel Protection requirement. The designer is referred to **Chapter 3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3 for more information on stormwater management design strategies.

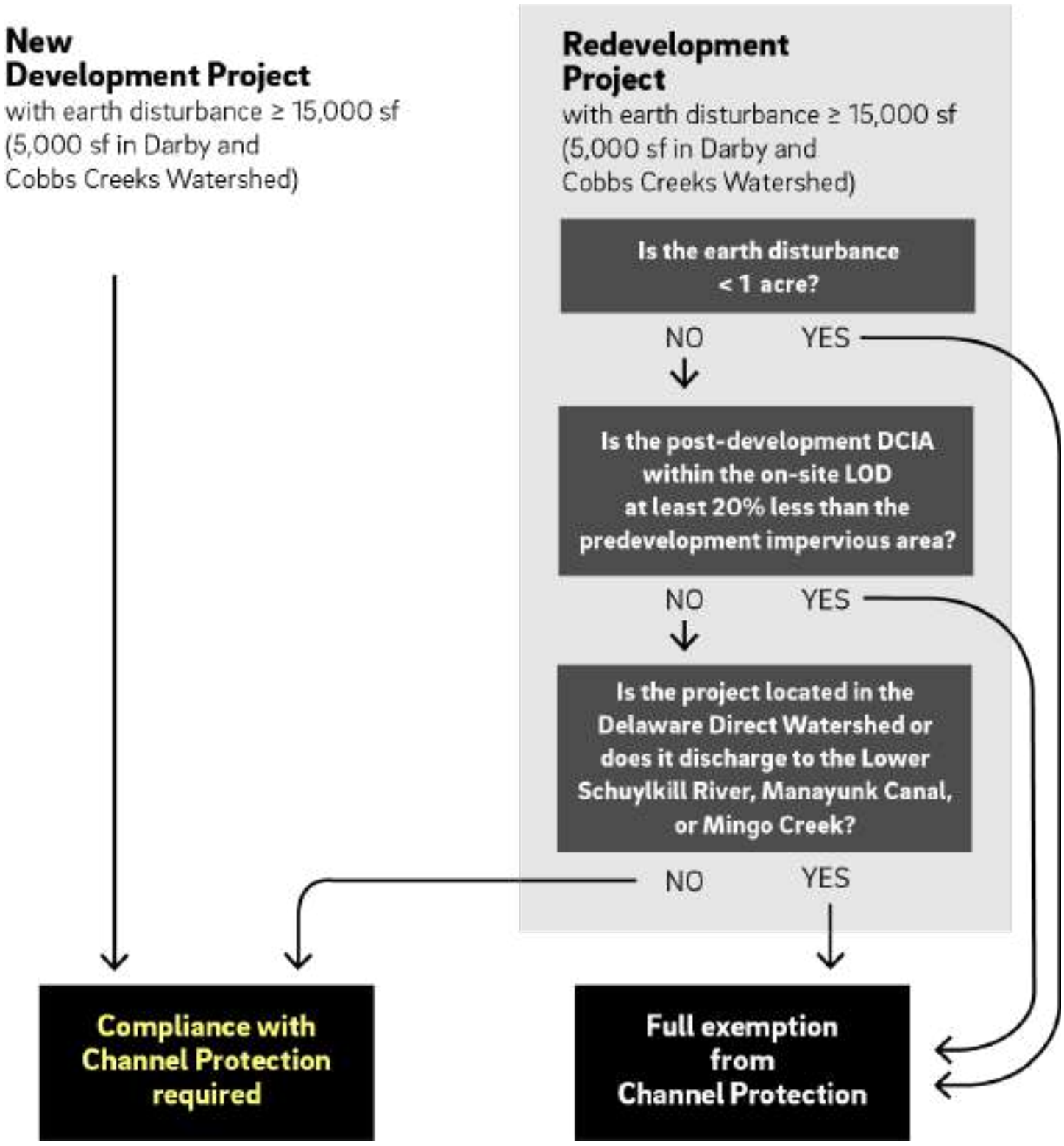
Exemptions

Projects meeting the following characteristics are exempt from the Channel Protection requirement:

- Redevelopment projects with less than one acre of earth disturbance.
- Redevelopment projects that reduce impervious area within the limits of earth disturbance (excluding public right-of-way) by at least 20%, based on a comparison of predevelopment impervious area to post-development DCIA.
- Redevelopment projects located in the Delaware Direct Watershed, or that discharge to the Lower Schuylkill River, Manayunk Canal, or Mingo Creek.

For the purposes of calculating impervious area reduction, the predevelopment impervious area is determined by the dominant land use for the ten years preceding the date of the project's Existing Resources and Site Analysis (ERSA) Application (**Section 2.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-1-existing-resources-and-site-analysis) submission. To claim a predominant land use differing from the existing condition, the applicant must submit a predominant land use plan, in addition to an Existing Conditions Plan, to PWD Stormwater Plan Review.

Figure 1.2-2: Channel Protection exemption conditions



Flood Control

Background

Uncontrolled large storm events have the potential to overwhelm the capacity of sewer infrastructure and receiving streams, particularly in areas that already experience high flows or have capacity limitations.

The objectives of the Flood Control requirement are as follows:

1. Reduce or prevent the occurrence of flooding in areas downstream of the development site, as may be caused by inadequate sewer capacity or stream bank overflow; and
2. Reduce the frequency, duration, and quantity of CSOs.

The Flood Control requirement is based upon the ongoing watershed-wide Pennsylvania Stormwater Management Act (Act 167) planning studies determining Flood Management Districts for controlling peak rates of runoff.

Requirement

The Flood Control requirement stipulates that a development project meet or reduce peak rates of runoff, as determined by its Flood Management District, from predevelopment to post-development conditions during certain storm events.

The applicant is referred to **Table 3.4-1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-4-how-to-show-compliance#Table_3.4-1 for a listing of Flood Management Districts and their associated rate reductions by storm event. Detailed information on how to demonstrate a project's compliance with the Flood Control requirement can also be found in this section.

Quick tip

One common tool developers employ to meet the 20% reduction in impervious area exemption condition is by installing a green roof. Green roofs help reduce annual energy costs, typically last twice as long as conventional roofs, and increase rental values. The applicant is referred to **Section 4.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-3-green-roofs for more information on green roofs.

Exemptions

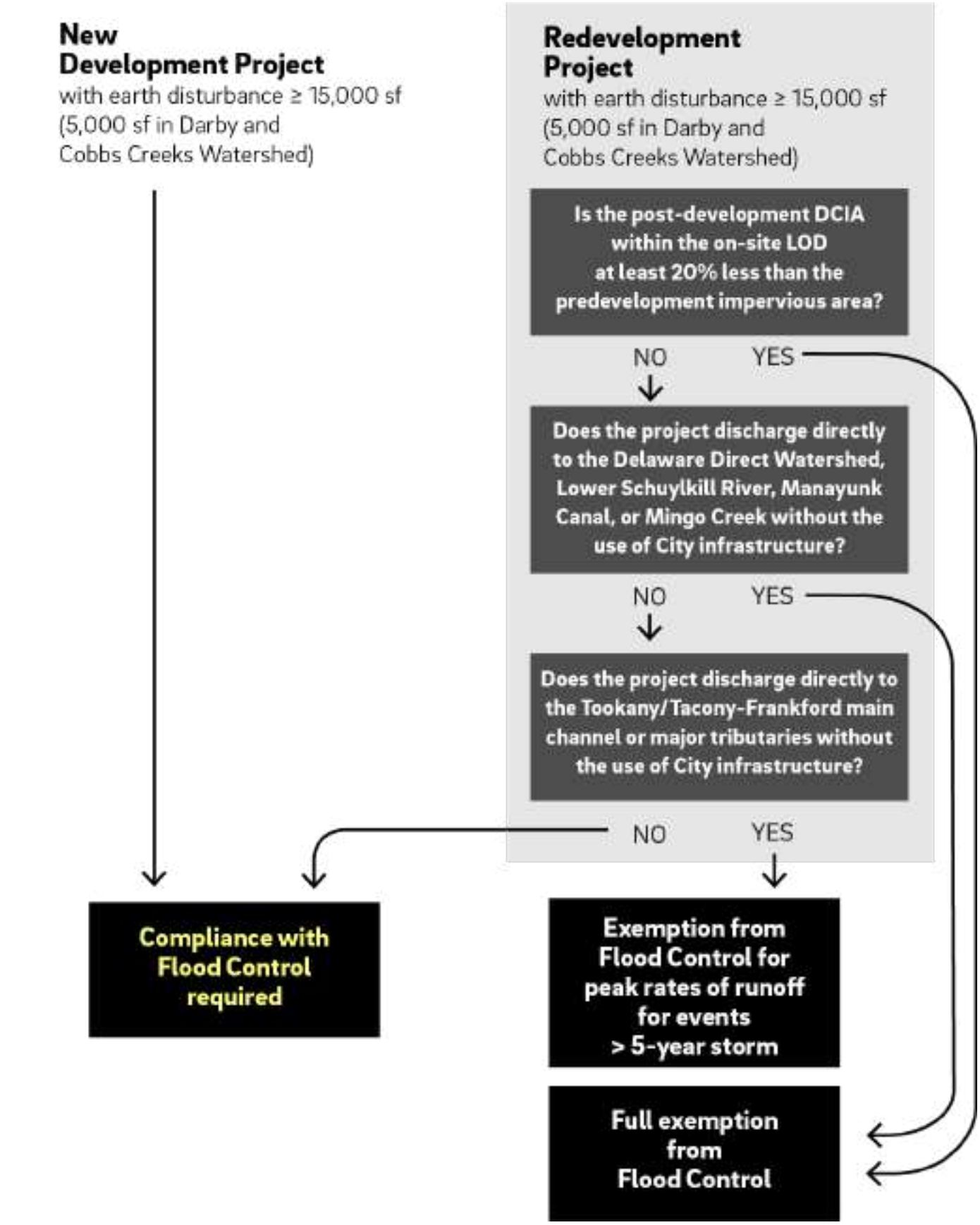
Projects meeting the following characteristics are exempt from the Flood Control requirement:

- Redevelopment projects that reduce impervious area within the limits of earth disturbance (excluding public right-of-way) by at least 20%, based on a comparison of predevelopment impervious area to post-development DCIA.
- Redevelopment projects located in Flood Management District C (**Appendix D** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/d-watershed-and-phs-release-rate-maps) that discharge directly to the Delaware Direct or Lower Schuylkill main channels without the use of City infrastructure. Location within the District C boundary does not automatically exempt a project from this requirement. To apply for this exemption, the applicant must provide PWD sufficient documentation regarding the proposed point of discharge as part of their application.

- Redevelopment projects located in District C-1 that discharge directly to the Tookany/Tacony-Frankford main channel or major tributaries without the use of City infrastructure. This exemption applies only to peak rates of runoff for storm events greater than the five-year storm. Location within the District C-1 boundary does not automatically exempt a project from this requirement. To apply for this exemption, the applicant must provide sufficient documentation regarding the proposed point of discharge as part of their application to PWD.
- Redevelopment projects located in the Delaware Direct Watershed, or that discharge to the Lower Schuylkill River, Manayunk Canal, or Mingo Creek, but are situated outside of District C and can discharge directly to the Delaware Direct or Lower Schuylkill main channels without the use of City infrastructure. Location within the Delaware Direct Watershed or Lower Schuylkill Watershed does not automatically exempt a project from this requirement. To apply for this exemption, the applicant must provide sufficient documentation regarding the proposed point of discharge as part of their application to PWD.

For the purposes of calculating impervious area reduction, the predevelopment impervious area is determined by the dominant land use for the ten years preceding the date of a project's ERSA Application (**Section 2.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-1-existing-resources-and-site-analysis) submission. To claim a predominant land use that differs from the existing condition, the applicant must submit a predominant land use plan along with an Existing Conditions Plan to PWD Stormwater Plan Review.

Figure 1.2-3: Flood Control exemption conditions



Public Health and Safety Release Rate

Background

In some areas, sewer capacity limitations have the potential to impact public health and safety. To address this, peak flow control beyond the requirements of the Channel Protection and Flood Control requirements is necessary in accordance with the PHS Release Rate requirement.

Requirement

Sites located in combined sewer areas with constrained sewer networks are required to comply with a maximum release rate (cfs per acre) for the one-year through ten-year storm events. This rate is determined by PWD based upon analysis of available pipe capacity for the project within the sewershed and will differ depending on the location of the project's sewer connection(s). The PHS Release Rate requirement applies to all areas within a project's limit of earth disturbance, pervious and impervious alike. The applicant is referred to **Appendix D** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/d-watershed-and-phs-release-rate-maps for a map of PHS Release Rate areas and their associated rates. Rates can also be found in the **Reg Finder** ☛ www.pwdplanreview.org/reg_finder.

1.2.2 Erosion and Sediment Control requirement

Background

While the four previously discussed Stormwater Regulations relate to PCSM Requirements, effective stormwater management is also critical during the construction stage. Clearing, grading, and other site development activities expose soil surfaces and leave them vulnerable to erosion. Soil erosion and sediment loss not only affect the development site, but can also block downstream inlets and sewers, causing localized flooding. Beyond flooding, this runoff carries sediment and associated pollutants to the City's Water Pollution Control Plants or receiving waters. These various impacts can contribute to flooding, maintenance concerns, and significant environmental issues.

Quick tip

An **Erosion & Sediment FAQ** ☛ water.phila.gov/wp-content/uploads/files/erosion-and-sedimentation-faq-for-contractors.pdf resource is available for contractors and applicants, and covers such topics as the importance of E&S controls, typical E&S control measures, E&S requirements based on earth disturbance, and failure to install and maintain E&S controls.

Requirement

The owner of a development site is responsible for ensuring that active construction activities are not in violation of 25 Pa. Code Chapters 92 and/or 102 or the Clean Streams Law, the act of June 22, 1937, P.L. 1987, 35 P.S. §691.1 et seq. At minimum, all earth disturbance must comply with the E&S requirements of the PA DEP as specified in 25 Pa. Code §102.4.

All projects proposing 5,000 square feet or more of earth disturbance are required to submit an E&S Plan for approval. Specific submittal preparation requirements vary depending on the limit of earth disturbance and project location. All E&S Plans must be prepared in accordance with PA DEP guidelines as laid out in the latest edition of the ***PA DEP Erosion and Sediment Pollution Control Program Manual*** ☛ https://www.dep.pa.gov/Business/Water/CleanWater/StormwaterMgmt/Stormwater%20Construction/Pages/E-S%20Resources.aspx (2012 or latest).

The applicant is referred to **Section 2.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-3-review-phases for more information on E&S Plan preparation and review requirements. At minimum, all projects, regardless of size, must install E&S controls appropriate for the site layout, neighboring features, and proposed disturbance activities.

1.3 Stormwater Retrofits

This section of the Philadelphia Water Department (PWD) Stormwater Management Guidance Manual (Manual) is intended to aid applicants and vendors who are developing Stormwater Retrofit projects in navigating the Manual and additional relevant resources. This section also highlights the differences between the Stormwater Retrofit Review Path and other Review Paths presented in **Section 2.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-2-review-paths.

1.3.1 Retrofit project applicability and initiation

As discussed in **Section 1.1.1** ☛ p. 4 of this Manual, development projects categorized as Stormwater Retrofits are defined as *the voluntary rehabilitation and/or installation of SMPs on a property to better manage stormwater runoff*. These projects are implemented by property owners who are motivated to:

- Lower their Stormwater Management Service Charge (Stormwater Charge) with **stormwater credits** ☛ water.phila.gov/stormwater/incentives/credits;
- Provide "Triple Bottom Line" benefits to their property's occupants that SMPs with green surface expressions can provide;
- Demonstrate commitment to sustainability or environmental stewardship goals; and
- Transform underutilized space on their property to benefit Philadelphia's waterways and health.

In order to be classified as a Stormwater Retrofit and not a different development type, the project must meet the following criteria:

- Development work and earth disturbance is limited to the installation of the approved stormwater management practice (SMP) and its components. Minor non-stormwater-related work may be approved if it does not meet the earth disturbance threshold for applying Stormwater Regulations in the project's watershed.
- Existing cover types in the predevelopment condition must remain consistent in the post-development condition, unless:
  - Impervious area (or area functioning as impervious area, such as compacted gravel) is converted to well-draining pervious grass area or a surface SMP. The new cover type must provide stormwater management benefits and generally comply with requirements within the ***Stormwater Management Service Charge Credits and Appeals Manual*** ☛ water.phila.gov/wp-content/uploads/files/stormwater-credits-appeals-manual.pdf (*Credits and Appeals Manual*) for open space stormwater credits (Applicants of Stormwater Retrofit projects proposing any depaving work are encouraged to contact Stormwater Billing and Incentives to confirm exemption from Stormwater Regulations); or
  - The earth disturbance involved with any site improvements or changes in cover type is less than 15,000 square feet (or the appropriate disturbance threshold for triggering Stormwater Regulations, dependent on the project's watershed).

Property owners who are interested in voluntarily managing stormwater on-site are encouraged to apply for a Stormwater Grant. More information about the Stormwater Grants program, including how to apply, is available on the **Stormwater Grants** ☛ water.phila.gov/stormwater/incentives/grants page. This page also provides a link to the **Stormwater Grants Application Guide** ☛ water.phila.gov/wp-content/uploads/files/stormwater-grants-application-guide.pdf, which outlines the requirements needed for a Stormwater Grant Application. These requirements include, but are not limited to, a Conceptual Stormwater Management Plan, environmental due diligence, and a project budget. If a Stormwater Retrofit project applies for a Stormwater Grant, their Stormwater Grant Application will serve as their Conceptual Review Phase, with their Stormwater Grant award serving as their Conceptual Approval. These Stormwater Grant projects will enter the Post-Construction Stormwater Management Plan (PCSMP) Review Phase after being awarded a Stormwater Grant unless their Conceptual Stormwater Management Plan significantly changes after their Stormwater Grant award.

Classification of a project as a Stormwater Retrofit is ultimately determined by the judgement of PWD staff. Once a project has been confirmed as a Stormwater Retrofit, it will be reviewed by Stormwater Billing and Incentives. The applicant is referred to Sections **2.2.4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-2-review-paths#2.2.4 and **2.3.4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-3-review-phases#2.3.4 for more information on how Stormwater Billing and Incentives reviews Stormwater Retrofit plans.

Stormwater Billing and Incentives can be reached during normal business hours (8 a.m. to 5 p.m.) at (215) 685-6070 or **pwd.stormwatercredits@phila.gov** for Credits and Incentives Program-related questions.

1.3.2 Retrofit project requirements and guidance

Stormwater Billing and Incentives reviews stormwater management plans for compliance with managing the first 1.5 inches of runoff, as described in the Post-Construction Stormwater Management (PCSM) Water Quality requirement of the Stormwater Regulations. Plans should also meet all criteria for the Erosion and Sediment Control Requirement listed in **Section 1.2.2** ☛ p. 25. To learn more about Stormwater Credit eligibility after completion of the Stormwater Retrofit project, the applicant is referred to **Section 6.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-6/6-3-stormwater-credits.
Stormwater Retrofit projects do not need to incorporate aspects from Flood Control, Channel Protection, or Public Health and Safety Release Rate requirements.

Applicants designing a Stormwater Retrofit project should reference **Section 1.2.1** ☛ p. 14 for understanding the full Water Quality requirement. However, key differences to note for Stormwater Retrofit reviews are listed below.

Administrative differences

- There are no review or approval fees for Stormwater Retrofit projects.
- There are no expedited reviews for Stormwater Retrofits. Certain SMP types and stormwater management strategies are considered more competitive in the Stormwater Grant award process.
- Stormwater Retrofits that receive Stormwater Grant funding will have additional timeline requirements. Applicants should follow recommendations in **Section 2.3.4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-3-review-phases#2.3.4 and contact the Stormwater Billing and Incentives team to review intended project timelines.

Technical design differences

- The applicant is encouraged to manage any feasible impervious drainage area on the private property, which is not limited to the earth disturbance area.
- The area within the limit of earth disturbance is not required to be managed. Earth disturbance is less indicative of the amount of stormwater management for Stormwater Retrofit projects than projects required to meet PCSM Requirements.
- Stormwater Retrofits are not required to implement pollutant-reducing practices in the combined sewer area of the city where infiltration is not feasible. These systems are only required for subsurface detention SMPs proposed in the Municipal Separate Storm Sewer System (MS4) for Stormwater Retrofits. Due to this Water Quality difference, Stormwater Retrofits do not consider roof runoff isolation as a design factor.
- Stormwater Billing and Incentives will review disconnected impervious cover (DIC) disconnection strategies on a case-by-case basis, as the majority of Stormwater Retrofits involve SMPs and depaving funded by Stormwater Grants. Tree credits, as described in this Manual, are not a credited stormwater management type for Stormwater Retrofit projects. However, tree canopies can be a strategy for obtaining stormwater credits on a property's stormwater bill, according to the ***Credits and Appeals Manual*** ☛ water.phila.gov/wp-content/uploads/files/stormwater-credits-appeals-manual.pdf. Additionally, some DIC features such as green roofs, may have different management requirements as a Stormwater Retrofit. For up-to-date information, the applicant should discuss any DIC strategies with Stormwater Billing and Incentives.

2 Submission, Review, and Approval Procedures

Chapter 2 Submission, Review, and Approval Procedures

2.0 Introduction

Chapter 2, Submission, Review, and Approval Procedures, outlines the steps required to obtain a Philadelphia Water Department (PWD) Stormwater Plan Review or a Stormwater Billing and Incentives approval, where PWD certifies that a project complies with, or is exempt from, the **PWD Stormwater Regulations** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/c-pwd-stormwater-regulations (Stormwater Regulations). Before using Chapter 2, the applicant must review **Chapter 1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1 to learn the basics of the Stormwater Regulations and understand the applicability factors that determine if the Stormwater Regulations apply to the project and, if so, which specific requirement(s) apply.

Using the three Stormwater Regulation applicability factors described in **Section 1.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1/1-1-applicability-factors along with the guidance in this chapter, the applicant can determine a project's required submission and review process to obtain stormwater management approval or exemption.

2.0.1 Understanding PWD's stormwater review process

Basic terms used in this chapter

Review Path – A linear series of submission, review, and approval/exemption procedures the applicant will navigate to demonstrate a project's compliance with, or exemption from, the Stormwater Regulations.

Review Phase – A step in a Review Path. Each Review Path has one or more Phases. Each Phase corresponds to one or more submissions of information for PWD's review.

Submission Package – A set of documents, such as plans, reports, calculations, worksheets, and forms, submitted to PWD at each Review Phase of each Review Path.

As stated in **Chapter 1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1, PWD reviews all projects in the City of Philadelphia that generate earth disturbance of 5,000 square feet or more. A project's Review Path varies depending on the type of project, the project's location, and the project's earth disturbance area. Projects will fall under one of four major Review Paths:

- **Development Compliance**
- **Development Exemption**
- **Demolition**
- **Stormwater Retrofit**

These Review Paths each have one or more Review Phases, and each Review Phase consists of the following:

1. A submission package from the applicant to PWD containing required information about the project
2. A PWD review of the applicant's submission package
3. Issuance of approval by PWD for the applicant to proceed to the next Review Phase or final approval if in the terminal phase
   OR
   Issuance of review comments by PWD to the applicant that must be addressed through resubmission by the applicant to PWD

2.0.2 How to use this chapter

Chapter 2 consists of seven sections, which are listed and described below. A first-time applicant is encouraged to read all sections sequentially, while others should feel free to use only the sections of Chapter 2 that are most appropriate for a given project.

- **Section 2.0 – Introduction** ☛ p. 1: The applicant can use this section to obtain general information on the PWD Stormwater Plan Review process, understand how to use Chapter 2, and to learn about ways to contact PWD Stormwater Plan Review and Stormwater Billing and Incentives, if necessary, throughout the process.
- **Section 2.1 – Existing Resources and Site Analysis** ☛ p. 4: The applicant can use this section to understand the submission requirements for an Existing Resources and Site Analysis (ERSA) Application, which is the starting point for every applicant submitting to PWD Stormwater Plan Review. The applicant must use this section first to determine which of four Review Paths is required for the project before proceeding to the following sections of this chapter.
- **Section 2.2 – Review Paths** ☛ p. 10: Once a project's Review Path has been determined, the applicant can use this section to find out more about the project's Review Path, including all Review Phases within the Review Path.
- **Section 2.3 – Review Phases** ☛ p. 16: The applicant can use this section to determine what materials need to be submitted to PWD at each Review Phase for each Review Path.
- **Section 2.4 – Expedited Post-Construction Stormwater Management Plan (PCSMP) Reviews** ☛ p. 57: The applicant can use this section to determine if, and how, their project can obtain approval more quickly.
- **Section 2.5 – PWD's Development Review Process** ☛ p. 63: The applicant can use this section to understand how other PWD units and PWD permit requirements may interact with the project's PWD Stormwater Plan Review approval.
- **Section 2.6 – PWD's Role in Philadelphia's Development Process** ☛ p. 64: The applicant can use this section to understand how other City departments and Zoning and Building Permit requirements may interact with the project's PWD Stormwater Plan Review approval.
- **Section 2.7 – PWD and Pennsylvania Department of Environmental Protection** ☛ p. 69: The applicant can use this section to understand how Pennsylvania Department of Environmental Protection (PA DEP) requirements interact with the project's PWD Stormwater Plan Review approval.

Having worked through Chapter 2 to gain an understanding of the applicable Review Path and submission requirements, the applicant may use **Chapter 3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3 to develop a stormwater management strategy that meets the project's stormwater management requirements.

If the applicant's project is a Stormwater Retrofit, Chapter 2 can be used to understand the review process for the project, which varies from the other Review Paths. Applicants are also encouraged to review **Section 1.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1/1-3-stormwater-retrofits of this Manual for more information on Stormwater Retrofit projects. They can also contact **Stormwater Billing and Incentives** ☛ water.phila.gov/development/stormwater-plan-review/manual/introduction#4 with any questions on how to apply this Manual to their project.

2.1 Existing Resources and Site Analysis

Every new regulated project, regardless of its Review Path, begins with the submission of the Existing Resources and Site Analysis (ERSA) Application to Philadelphia Water Department (PWD) Stormwater Plan Review.

Stormwater Grant projects begin with the Stormwater Grant Application, but need to follow the steps listed below in submitting an ERSA Application after notice of grant award for tracking purposes.

Section 2.1 describes the ERSA Application, lists all ERSA Application Submission Package components, and details the submission process. Furthermore, this section assists the applicant in determining their project's applicable Review Path, which is a necessary step in the completion of an ERSA Application.

2.1.1 ERSA Application

The ERSA Application is the first submission for all projects that require PWD Stormwater Plan Review approval or exemption. The ERSA Application is also the first submission for non-grant-funded Stormwater Retrofits. For grant-funded Stormwater Retrofits, the first submission will be the Stormwater Grant Application to Stormwater Billing and Incentives, not an ERSA Application.

The development of the ERSA Application requires the applicant to identify existing project site features, describe the proposed development site, identify all applicable **PWD Stormwater Regulations** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/c-pwd-stormwater-regulations (Stormwater Regulations), and determine the appropriate Review Path for the project. PWD Stormwater Plan Review uses the ERSA Application to define the existing conditions of the project site, to confirm the project's applicability within, or exemption from, the Stormwater Regulations, and to confirm the project's Review Path with the applicant. The applicant must note that design decisions that may occur after submission of the ERSA Application may impact a project's applicability to, or exemption from, the Stormwater Regulations, as well as the project's Review Path. If major changes are made to the project after the applicant submits an ERSA Application, the applicant must contact **PWD Stormwater Plan Review** ☛ water.phila.gov/development/stormwater-plan-review/manual/introduction/#4 to determine if a revised ERSA Application is needed before proceeding.

To assist in identifying stormwater regulatory requirements, PWD has made available to the applicant a **Reg Finder** ☛ www.pwdplanreview.org/reg_finder application, which provides useful project characteristic and applicability information at this early stage in the project's design.

ERSA Application Submission Package components

A complete ERSA Application Submission Package consists of the following components:

Figure 2.1-1: ERSA Application Submission Package components checklist

ERSA APPLICATION SUBMISSION PACKAGE Submission Package components checklist	
	ERSA Worksheet
	Site photographs
	Existing Conditions Plan
	Conceptual Review Phase Submission Package*

* Refer to **Section 2.3** ☛ p. 16 for Conceptual Review Phase Submission Package Requirements by Review Path

Stormwater Retrofit projects that already have Conceptual Approval may include the PCSMP Review Phase Submission Package instead. The applicant is referred to **Section 2.3** ☛ p. 16 for PCSMP Review Phase requirements.

ERSA Worksheet

- When submitting the ERSA application, the applicant must complete an online **ERSA Worksheet** ☛ www.pwdplanreview.org/apply/login/portal_signup via the Plan Review portal (First-time applicants may need to create a new user account). This worksheet provides interactive guidance to assist the applicant in providing all required project, contact, and owner information.
- The online ERSA Worksheet also guides the applicant through the process of determining the project's Review Path. Detailed information on determining a project's Review Path is included in **Section 2.1.2** ☛ p. 8.
- If the applicant intends for the project to be considered for an Expedited PCSMP Review or a stormwater management based zoning height or density bonus, this intent is declared as part of the ERSA Worksheet. The applicant is referred to **Section 2.4** ☛ p. 57 for more information on Expedited PCSMP Reviews and **Section 2.6** ☛ p. 64 for zoning bonuses.

Site photographs

A minimum of one color photograph from each accessible face of the parcel(s) looking into the site is required. The applicant is encouraged to submit additional photos as needed to best illustrate project site conditions to PWD.

Existing Conditions Plan

The Existing Conditions Plan contains information regarding the predevelopment state of the project site (i.e., site conditions at the time of ERSA Application). Proposed site and stormwater improvements are not depicted on the Existing Conditions Plan, as these are shown on the Conceptual Stormwater Management Plan. The specific requirements for Existing Conditions Plans are shown in **Appendix E, Table E-2** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/e-plan-and-report-checklists/table-e-2-existing-conditions-plan-requirements. Existing Conditions Plans must also meet all PWD general plan sheet requirements listed in **Appendix E, Table E-1** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/e-plan-and-report-checklists/table-e-1-general-plan-sheet-requirements.

Redevelopment projects that propose modifications to an existing project area that was subject to Stormwater Regulations or received Stormwater Grant funding for a Stormwater Retrofit project are advised to contact **PWD Stormwater Plan Review** ☛ water.phila.gov/development/stormwater-plan-review/manual/introduction/#4 as early as possible in the design process to ensure the Redevelopment will not impede regulatory compliance of the existing project or impact the project's Review Path (**Section 2.2** ☛ p. 10). Even if no modifications are proposed to an existing SMP, changes in cover type, such as converting area that was previously constructed as landscape to hardscape, can have significant impacts on the site's regulatory compliance. Applicants who are unsure whether their project site was previously subject to Stormwater Regulations or has an SMP on-site may check the **Green Stormwater Infrastructure Projects Map** ☛ water.phila.gov/green-projects-map.

Conceptual Review Phase Submission Package

Requirements of a Conceptual Review Phase Submission Package differ based on a project's Review Path. The applicant must first determine the project's Review Path, using **Section 2.1.2** ☛ p. 8, and then is referred to **Section 2.3** ☛ p. 16 for Conceptual Review Phase Submission Package requirements.

Submission process

The ERSA Application submission is initiated through the Project Dashboard on the **PWD Plan Review Portal** ☛ www.pwdplanreview.org. The online form guides the applicant through the ERSA Application submission process and allows the applicant to upload all necessary digital files: site photos, Existing Conditions Plan, and other plans required as part of the Conceptual Review Phase Submission Package.

Once projects are initiated online, a project tracking number is assigned, which is used by the applicant and PWD to track the review process as it proceeds. The applicant must reference this project tracking number for all subsequent correspondence.

Project tracking number

An example of a project tracking number is "FY16-EXAM-1234.01" where "FY16" is an abbreviation for the fiscal year in which the ERSA Application submission was made, "EXAM" is the first four letters of the project's name, "1234" is a unique numeric value, and "01" is associated with an initial project phase.

Throughout the submission process, the applicant is invited to contact **PWD Stormwater Plan Review** ☛ water.phila.gov/development/stormwater-plan-review/manual/introduction/#4 for assistance. For Stormwater Retrofits (**Section 2.3.4** ☛ p. 42), the applicant should contact **Stormwater Billing and Incentives** ☛ water.phila.gov/development/stormwater-plan-review/manual/introduction/#6.

2.1.2 Determining project Review Path

The path to obtaining a PWD Stormwater Plan Review approval varies depending on project characteristics. Determining whether an approval is required, and, if so, which of the four Review Paths is applicable, represents a critical step for every project and must be completed by the applicant prior to submission of an ERSA Application.

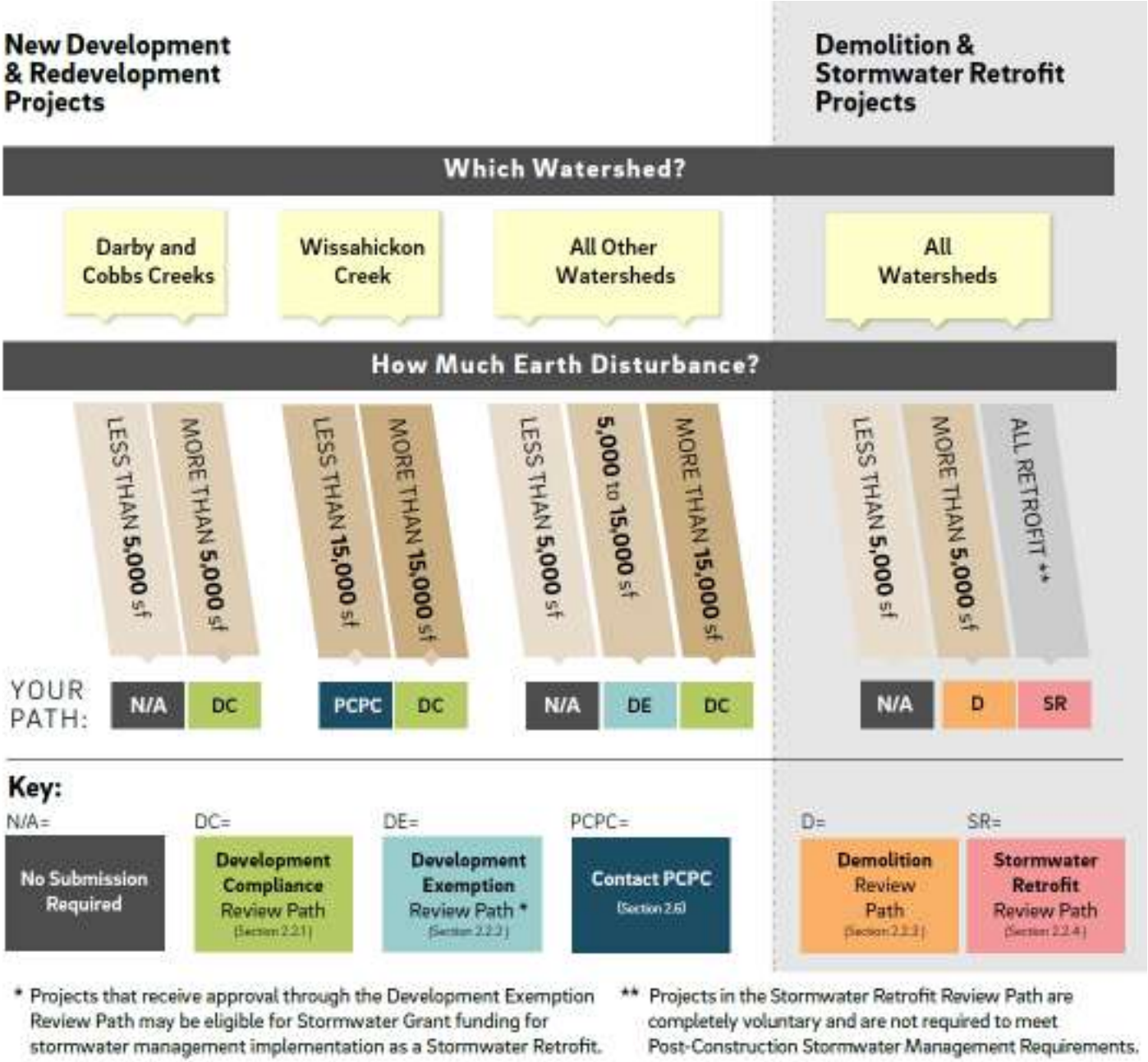
The applicant must identify the following three project characteristics to determine the appropriate review and submission requirements. These characteristics, used along with Figure 2.1-2 below, allow the applicant to determine the Review Path for their project. The applicant must input these characteristics when filling out the online ERSA Worksheet as part of the ERSA Application.

1. **Development type –** Projects fall into one of four development types: New Development, Redevelopment, Demolition, or Stormwater Retrofit. The applicant is referred to **Section 1.1.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1/1-1-applicability-factors#1.1.1 for the complete definition of each development type. If an applicant is uncertain which development type best defines a project, they can contact **PWD Stormwater Plan Review** ☛ water.phila.gov/development/stormwater-plan-review/manual/introduction/#4 for additional guidance. If the applicant incorporates voluntary stormwater management into their project, Stormwater Billing and Incentives can also provide additional guidance.
2. **Watershed –** Seven major watersheds exist in Philadelphia: Darby and Cobbs Creeks Watershed, Delaware Direct Watershed, Lower Schuylkill River Watershed, Pennypack Creek Watershed, Poquessing Creek Watershed, Tookany/Tacony-Frankford Watershed, and Wissahickon Creek Watershed. The applicant is referred to **Section 1.1.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1/1-1-applicability-factors#1.1.2 for more information on watersheds and to **Appendix D** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/d-watershed-and-phs-release-rate-maps for Watershed Maps.
3. **Earth disturbance –** PWD must review any project whose earth disturbance exceeds 5,000 square feet to ensure that an Erosion and Sediment Control (E&S) Plan has been prepared in accordance with Pennsylvania Department of Environmental Protection guidelines (**Section 2.3** ☛ p. 16). In addition, PWD must ensure that the limit of disturbance is correctly delineated and that the project is not part of a larger phased development that will trigger additional Stormwater Regulations.

   There are some earth disturbance activities that do not require post-construction stormwater management and/or should not be counted toward the regulatory threshold for triggering the Stormwater Regulations. The applicant is referred to **Section 1.1.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1/1-1-applicability-factors#1.1.3 for more information on earth disturbance.

After answering these questions, the applicant can use Figure 2.1-2 to determine a project's Review Path. Review Paths are color-coded throughout Chapter 2.

Figure 2.1-2: Project Review Path determination flow chart



After determining a Review Path, the applicant can proceed to **Section 2.2** ☛ p. 10 and **Section 2.3** ☛ p. 16 to learn more about the requirements and Review Phases of their project's Review Path. The applicant should review these sections before final submission of their ERSA Application, as the ERSA Application submission will occur concurrently with the Conceptual Review Phase Submission (except for Stormwater Grant-funded Stormwater Retrofits).

If unable to determine the appropriate Review Path, the applicant should contact **PWD Stormwater Plan Review** ☛ water.phila.gov/development/stormwater-plan-review/manual/introduction/#4.

2.2 Review Paths

Section 2.2 describes each of the four Review Paths to demonstrate a project's compliance with, or exemption from, the Philadelphia Water Department (PWD) Stormwater Regulations (Stormwater Regulations), including the steps, or Review Phases, within each Review Path. Each Review Path has its own individual set of requirements and criteria for approvals.

Once a project's Review Path is identified, the applicant must follow the steps in this section that correspond with the color-coded Review Path. Because some of the steps between Review Paths are identical, there is some repetition in the descriptions below. The applicant need only refer to the set of steps corresponding to the project's determined Review Path.

Each project will follow one of the four following Review Paths:

Development Compliance – **Section 2.2.1** ☛ p. 11

Development Exemption – **Section 2.2.2** ☛ p. 12

Demolition – **Section 2.2.3** ☛ p. 13

Stormwater Retrofit – **Section 2.2.4** ☛ p. 14

If the proposed limit of earth disturbance for the project changes at any point in the development process, the applicant must refer back to **Section 2.1.2** ☛ p. 8 to confirm the project's Review Path.

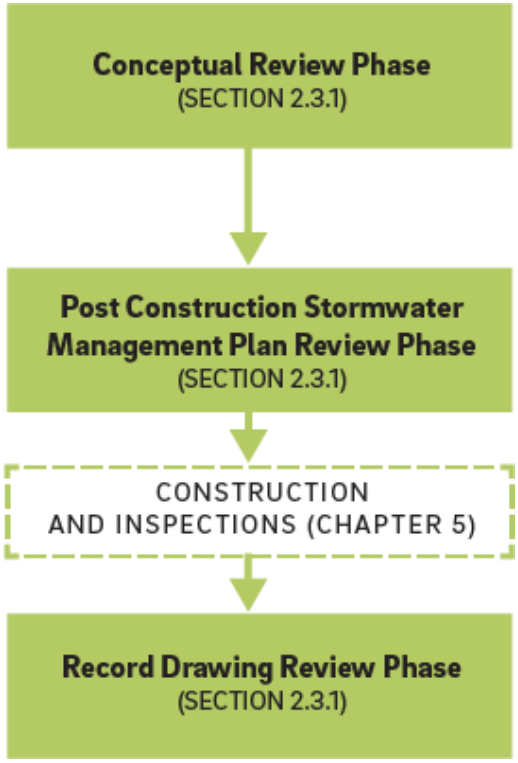
Projects may be subject to State or Federal permit requirements, or other PWD requirements aside from the Stormwater Regulations. It is the applicant's responsibility to determine whether their project must comply with other PWD, City, State, or Federal permit requirements. The applicant is referred to **Section 2.5** ☛ p. 63, **Section 2.6** ☛ p. 64, and **Section 2.7** ☛ p. 69 for more information. If uncertain about how to proceed, the applicant is encouraged to contact Stormwater Plan Review at any point during the submission and review process.

2.2.1 Development Compliance Review Path

The majority of development projects reviewed by Stormwater Plan Review fall into the Development Compliance Review Path and are subject to Post-Construction Stormwater Management (PCSM) Requirements (**Section 1.2.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1/1-2-stormwater-regulations#1.2.1). PCSM Requirements apply to most projects that propose 15,000 square feet or more of earth disturbance (5,000 square feet or more in the Darby and Cobbs Creek Watershed). Stormwater Retrofits may have earth disturbance above 15,000 square feet and not be required to meet Stormwater Regulations.

The Development Compliance Review Path includes three Review Phases, as detailed in Figure 2.2-1.

Figure 2.2-1: Development Compliance Review Path flow chart



Projects in the Development Compliance Review Path must obtain both Conceptual and Post-Construction Stormwater Management Plan (PCSMP) approvals from Stormwater Plan Review. **Section 2.3** ☛ p. 16 provides detailed submission requirements for projects in this Review Path.

For the Development Compliance Review Path, PWD offers incentives to developers proposing the use of disconnected impervious cover (DIC) and green stormwater practices, such as bioinfiltration/bioretention basins and green roofs, by providing Expedited PCSMP Reviews. To determine if a project qualifies for one of PWD's Expedited PCSMP Reviews, the applicant is referred to **Section 2.4** ☛ p. 57. The applicant must clearly state the intent to qualify for an Expedited PCSMP Review in the Conceptual Review Phase submission (**Section 2.3.1** ☛ p. 18).

If, during the course of construction, additional area is disturbed which changes the applicable requirements, the applicant must notify PWD and other appropriate agencies immediately. PWD often observes earth disturbances in the field that exceed initial estimates provided on plans. To avoid costly delays, change orders, and enforcement actions, PWD recommends that the applicant be conservative when estimating the disturbance area at each stage of the review process.

2.2.2 Development Exemption Review Path

The Development Exemption Review Path applies to most development projects with earth disturbances that are less than 15,000 square feet. Projects with earth disturbances of 5,000 square feet or more in the Darby and Cobbs Creeks Watershed should follow the Development Compliance Review Path (**Section 2.2.1** ☛ p. 11). Certain projects with earth disturbances greater than 15,000 square feet may still fall into the Development Exemption Review Path if the earth disturbance activities do not count toward the regulatory disturbance threshold (**Section 1.1.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1/1-1-applicability-factors/#1.1.3). The review and approval process for projects in the Development Exemption Review Path takes place in a single Review Phase. Specifically, the applicant will need to prepare a Conceptual Review Phase submission where PWD can review the proposed limits of disturbance (LOD) and verify that an Erosion and Sediment Control (E&S) Plan has been developed for the project. At the conclusion of the Conceptual Review Phase, all projects in the Development Exemption Review Path will be issued a Conceptual Approval Letter from Stormwater Plan Review. The Conceptual Approval Letter can be used as a Zoning Permit prerequisite. For most projects, the applicant can also use the Conceptual Approval Letter to satisfy their Building Permit prerequisite requirements, except for projects over one acre of earth disturbance, which may also require review from the Pennsylvania Department of Environmental Protection (PA DEP) (**Section 2.7** ☛ p. 69). Once the Development Exemption Review Path is complete, the applicant can proceed to construction upon receipt of their Building Permit.

If, during the course of construction, additional area is disturbed that changes the applicable requirements, the applicant must notify PWD and other appropriate agencies immediately. PWD often observes earth disturbances in the field that exceed initial estimates on plans. To avoid costly delays, change orders, and enforcement actions, PWD recommends that the applicant be conservative when estimating the disturbance area at each stage of the review process.

2.2.3 Demolition Review Path

Many development projects may have a demolition component; however, the Demolition Review Path applies only to projects that are limited to *the razing or destruction, whether entirely or in significant part, of a building, structure, site, or object (including the removal of a building, structure, site, or object from its site or the removal of destruction of the façade or surface)*, when no redevelopment is planned. If redevelopment is planned, the applicant may choose to submit an Existing Resources and Site Analysis (ERSA) Application (**Section 2.1** ☛ p. 4) limited to the demolition phase of work, allowing demolition to begin prior to completion of the Development Compliance or Development Exemption Review Paths. Applicants who wish to proceed with this option are advised to contact Stormwater Plan Review prior to making this additional ERSA Application submission.

In most cases, if the demolition activity will result in less than 15,000 square feet of earth disturbance (5,000 square feet in the Darby and Cobbs Creeks Watershed) the review and approval process takes place in a single Review Phase. Specifically, the applicant will need to prepare a Conceptual Review Phase submission where PWD can review the LOD and verify that an E&S Plan has been developed for the project. At the conclusion of this Conceptual Review Phase, PWD will issue a Conceptual Approval. The Conceptual Approval Letter can be used as a Zoning Permit prerequisite. For most projects, the applicant can also use the Conceptual Approval Letter to satisfy their Demolition Permit prerequisite requirements, except for projects over one acre of earth disturbance, which may also require review from PA DEP (**Section 2.7** ☛ p. 69). Once the Development Exemption Review Path is complete, the applicant can proceed to demolition upon receipt of their Demolition Permit.

If, during the course of demolition, additional area is disturbed that may change the project's Review Path or trigger additional stormwater management requirements, the applicant must contact PWD immediately to determine whether the current Review Path is still valid. PWD often observes earth disturbances in the field that exceed initial estimates on plans. To avoid costly delays, change orders, and enforcement actions, PWD recommends that the applicant be conservative when estimating the disturbance area at each stage of the review process.

If the project requires a full Building Permit, the applicant must contact Stormwater Plan Review to determine if a different Review Path is more appropriate for the project.

2.2.4 Stormwater Retrofit Review Path

The Stormwater Retrofit Review Path is administered by Stormwater Billing and Incentives to evaluate stormwater management designs proposed on private property for a purpose other than regulatory compliance (e.g., voluntary installations). An applicant who submits in the Stormwater Retrofit Review Path is typically looking to install stormwater management practices (SMPs) on their site to reduce their monthly stormwater bill, often with the assistance of **PWD Stormwater Grants** ☛ water.phila.gov/stormwater/incentives/grants. Other voluntary installations may be motivated by other City incentives, triple bottom line benefits, or completing Regulations-exempt development work. For additional guidance on Stormwater Retrofit projects, the applicant is referred to **Section 1.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1/1-3-stormwater-retrofits.

Quick tip

Stormwater Billing and Incentives can be reached at (215) 685-6070 or **pwd.stormwatercredits@phila.gov**

Stormwater Retrofit projects that are awarded Stormwater Grant funding should follow the Stormwater Retrofit Review Path flow chart for grant applicants (Figure 2.2-2). Other Stormwater Retrofit projects that are not awarded Stormwater Grant funding, as well as Stormwater Grant projects that vary considerably from their approved Stormwater Grant Application, should follow the Stormwater Retrofit Review Path flow chart, alternative (Figure 2.2-3), and its applicant should contact Stormwater Billing and Incentives as soon as possible. The applicant is referred to **Section 2.3.4** ☛ p. 42 for more information on the different Conceptual Review Phases for the Stormwater Retrofit Review Path.

Figure 2.2-2: Stormwater Retrofit Review Path flow chart for grant applicants

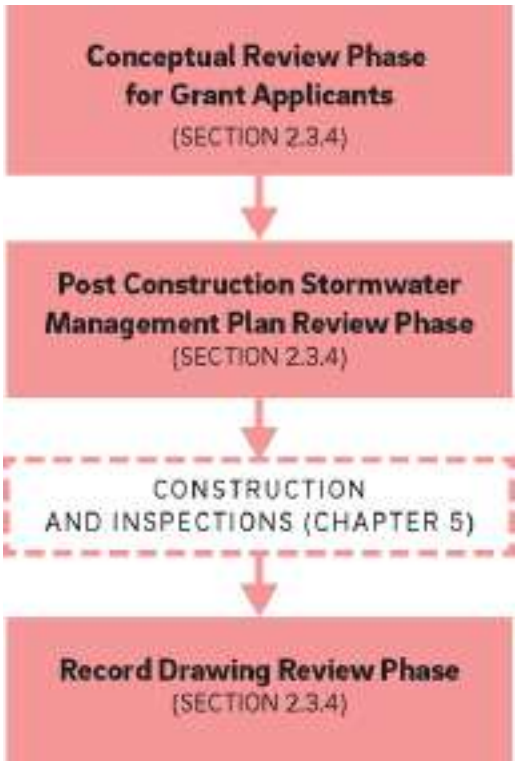
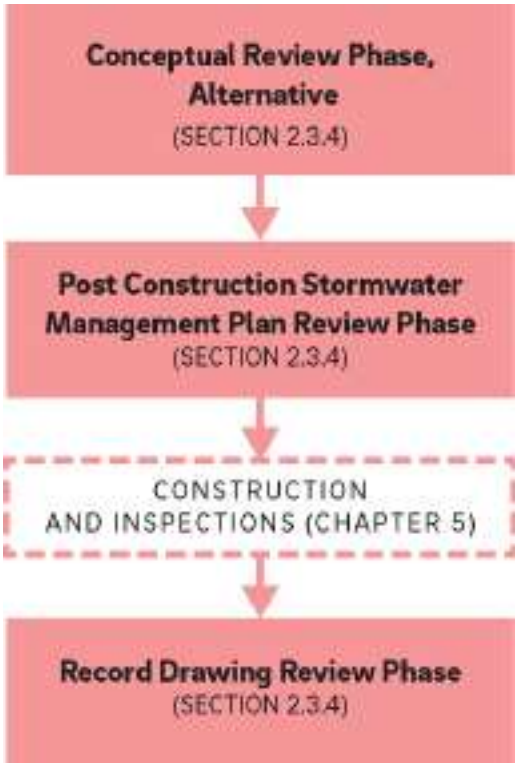


Figure 2.2-3: Stormwater Retrofit Review Path flow chart, alternative



If a project is for a purpose other than voluntary stormwater management, or if a project involves a development or demolition component, the applicant should contact Stormwater Billing and Incentives to confirm that they are proceeding through the correct Review Path.

The applicant is encouraged to meet with PWD early in the Stormwater Retrofit decision-making process to help determine eligibility for financial assistance through its **Stormwater Grant Program** ☛ water.phila.gov/stormwater/incentives/grants.

2.3 Review Phases

Section 2.3 describes the Review Phases associated with the Development Compliance, Development Exemption, Demolition, and Stormwater Retrofit Review Paths. The applicant should use this section after the applicable Review Path has been determined for their project (**Section 2.1.2** ☛ p. 8) and an understanding is achieved of which Review Phases and the Philadelphia Water Department (PWD) Stormwater Plan Review or Stormwater Billing and Incentives approvals are required for the project's Review Path (**Section 2.2** ☛ p. 10). The three possible Review Phases for a project include the Conceptual Review Phase, Post-Construction Stormwater Management Plan (PCSMP) Review Phase, and Record Drawing Review Phase.

Development Compliance Review Path (Section 2.3.1 ☛ p. 18)

- Conceptual Review Phase
- PCSMP Review Phase
- Record Drawing Review Phase

Development Exemption Review Path (Section 2.3.2 ☛ p. 35)

- Conceptual Review Phase

Demolition Review Path (Section 2.3.3 ☛ p. 38)

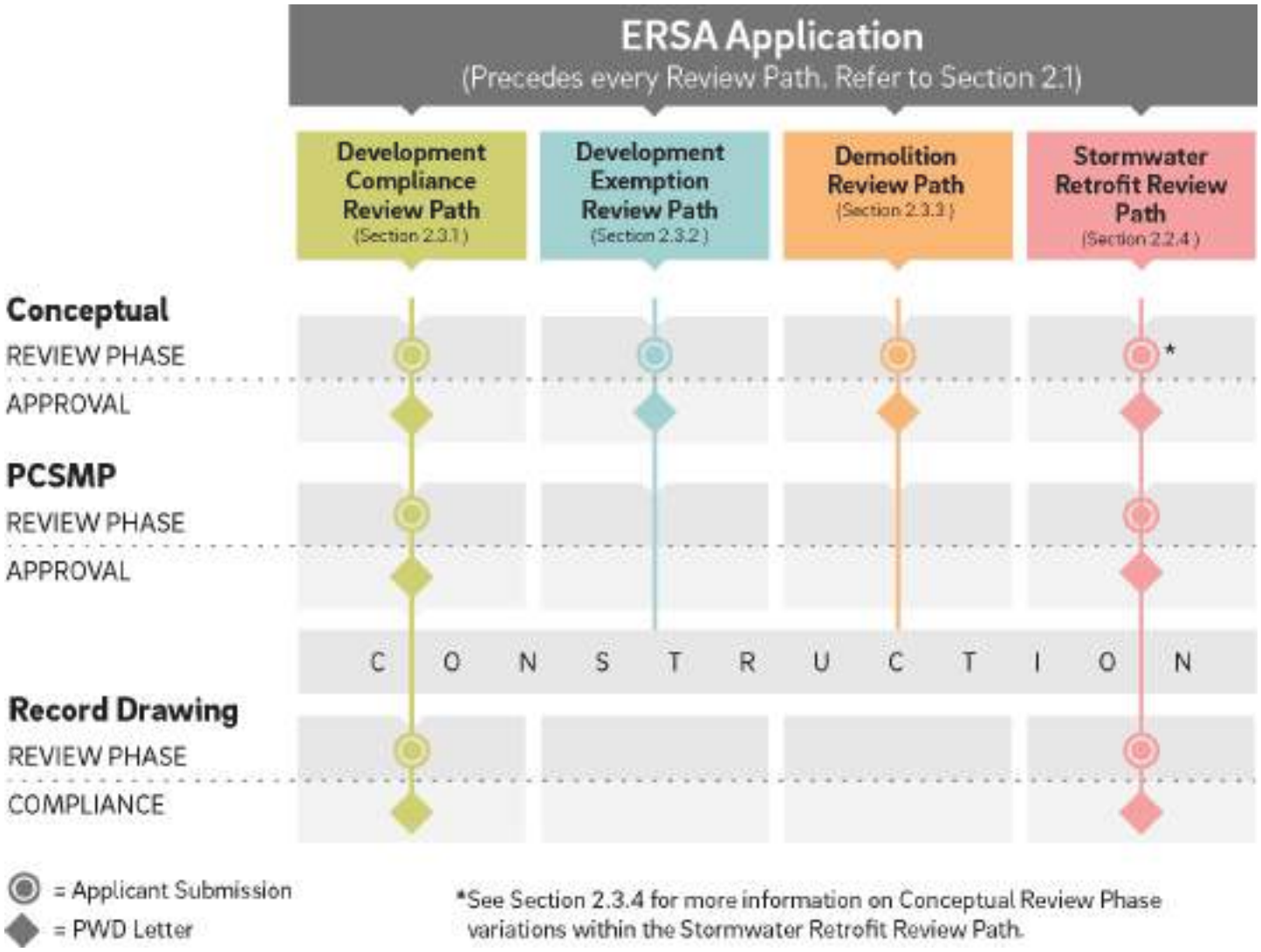
- Conceptual Review Phase

Stormwater Retrofit Review Path (Section 2.3.4 ☛ p. 42)

- Conceptual Review Phase
- PCSMP Review Phase
- Record Drawing Review Phase

Figure 2.3-1 summarizes the relevant Review Phases for the different Review Paths. For each Review Phase, this section describes Submission Package components, the submission and review process, and the project expiration policy.

Figure 2.3-1: Summary of Review Phases for each Review Path



☛ water.phila.gov/wp-content/uploads/images/swmg-figure-2-3-1-summary-path-review-phases.png

It is important for the applicant to note that while some Review Paths have similar Review Phases, specific Submission Package components, review processes, and approval documentation differ among Review Paths. These differences are described in detail within the following sections.

2.3.1 Development Compliance Review Path

Conceptual Review Phase

The Conceptual Review Phase is the first Review Phase of the Stormwater Plan Review process for the Development Compliance Review Path. A project is initiated with the submission of the Existing Resources and Site Analysis (ERSA) Application to PWD through the Project Dashboard on the **PWD Plan Review Portal** ☛ www.pwdplanreview.org, which includes a Conceptual Review Phase Submission Package.

Submission Package components

The Conceptual Review Phase Submission Package for the Development Compliance Review Path contains a Conceptual Stormwater Management Plan and Approval Fee. Projects on public land (local, State, and Federal) or projects sponsored by a government entity (unless PWD is the sole entity) must still pay review fees.

The process of developing a Conceptual Stormwater Management Plan will help the applicant develop a stormwater management strategy that minimizes impacts to existing critical features and responds to key site constraints and opportunities. PWD uses the Conceptual Stormwater Management Plan to gain a preliminary idea of what is proposed at the project site, to confirm the proposed project limits of disturbance (LOD), to assess the proposed stormwater management strategy, including evaluation of stormwater management practice (SMP) loading ratios and drainage areas (**Chapter 3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3), and to verify the project's applicability for an Expedited PCSMP Review (**Section 2.4** ☛ p. 57).

A complete Conceptual Review Phase Submission Package for the Development Compliance Review Path consists of the materials listed in Figure 2.3-2.

Figure 2.3-2: Development Compliance Review Path Conceptual Review Phase Submission Package checklist

DEVELOPMENT COMPLIANCE REVIEW PATH Conceptual Review Phase Submission Package checklist	
	Conceptual Stormwater Management Plan
	Conceptual Stormwater Management Plan Approval Fee

Conceptual Stormwater Management Plan

- The Conceptual Stormwater Management Plan must meet all requirements listed in **Appendix E, Table E-3: Conceptual Stormwater Management Plan Requirements** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/e-plan-and-report-checklists/table-e-3-conceptual-stormwater-management-plan-requirements as well as general plan sheet requirements listed in **Appendix E, Table E-1** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/e-plan-and-report-checklists/table-e-1-general-plan-sheet-requirements.
- In preparing the proposed stormwater management strategy for the project site, the applicant must use the stormwater management design process detailed in **Chapter 3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3.
- Construction details should not be submitted with the Conceptual Stormwater Management Plan.
- If Small Residential Development (SRD) is proposed, the applicant must clearly identify on the Conceptual Stormwater Management Plan the footprints of any buildings used exclusively as one- or two-family dwellings and the resultant total areas of SRD, which is exempt from PCSM Requirement applicability, and On-Site LOD, which is subject to PCSM Requirements if 15,000 square feet or more (5,000 square feet or more in the Darby and Cobbs Creeks Watershed). This site area information can be easily conveyed as a table; an example of which is provided below:

Total LOD	38,600 SF
Right-of-Way/Street Maintenance Activity	900 SF
Small Residential Development	5,100 SF
On-Site LOD	**32,600 SF**

If the entirety of the project is determined to be exempt from PCSM Requirement applicability, and, therefore, applicable to the Development Exemption Review Path (**Section 2.3.2** ☛ p. 35), the plan information regarding SRD described above must be included on the required E&S Plan.

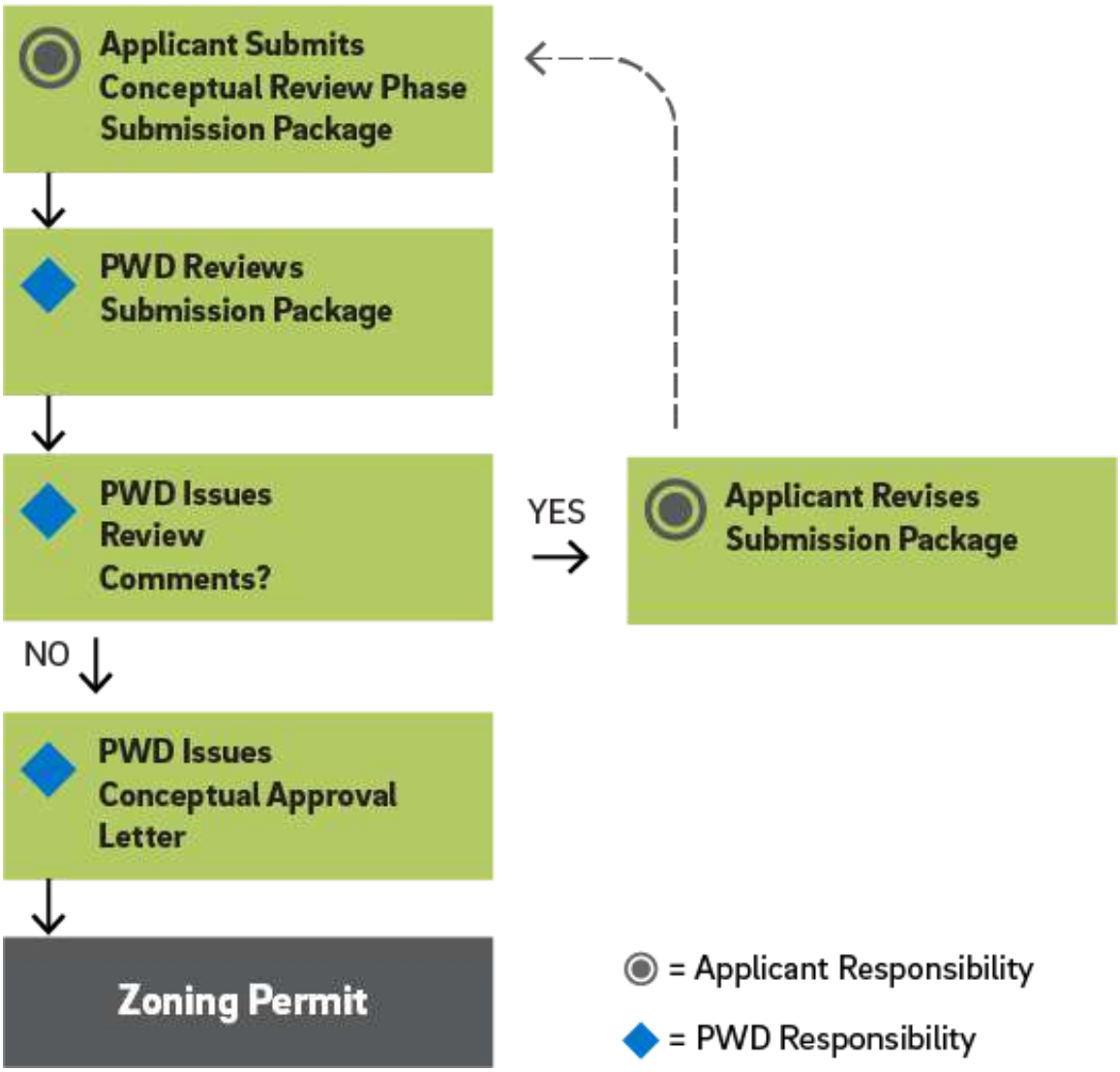
Conceptual Stormwater Management Plan Approval Fee

- For up-to-date fee information, the applicant is referred to the current **Rates and Charges** ☛ water.phila.gov/rates in the appendix of the PWD Regulations.
- PWD accepts payment in the form of a cashier's check, business check, or money order made payable to "City of Philadelphia." Personal checks will not be accepted, nor will installments.
- Because fees must be mailed or hand delivered, PWD will begin the Conceptual Review prior to receipt of the fee but cannot issue the Conceptual Approval Letter until the fee is received.
- The PWD project tracking number must be listed on the check and included in an accompanying transmittal letter.

Submission and review process

- The applicant submits the Conceptual Review Phase Submission Package as a component of a complete ERSA Application Submission Package (**Section 2.1.1** ☛ p. 5) through the Project Dashboard on the **PWD Plan Review Portal** ☛ www.pwdplanreview.org.
- The applicant will receive an automatic email confirmation that the submission has been received.
- PWD reviews the ERSA Application Submission Package, including the Conceptual Review Phase Submission Package, within five calendar days.
  - PWD reviews the submitted plans and documentation by analyzing the proposed development and its stormwater management strategy. At a conceptual level, preliminary determinations are made regarding compliance with the Stormwater Regulations, as well as eligibility for an Expedited PCSMP Review. Examples of specific review items evaluated by PWD include loading ratios for SMPs and management of 100% of post-development directly connected impervious area (DCIA). The applicant is referred to **Chapter 3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3 for stormwater management design guidance.
  - PWD performs an initial review of proposed water and sewer connections and possible conflicts with PWD infrastructure. However, this represents only a preliminary review, and more comprehensive reviews will take place with other PWD units (**Section 2.5** ☛ p. 63).
- If PWD has comments on the submission, comments will be issued to the applicant via email.
- The applicant resubmits to PWD, through the Project Dashboard on the **PWD Plan Review Portal** ☛ www.pwdplanreview.org, a revised Conceptual Review Phase Submission Package that addresses the comments. A response letter addressing each review comment and outlining any major plan or design changes must be included with each re-submission. This can be an iterative process, and PWD does not restrict the number of times an applicant can resubmit. At any time, the applicant or PWD may request a meeting to discuss review comments.
- If PWD has no comments, or if the comments have been addressed sufficiently by the applicant, PWD issues an email confirming Conceptual Approval of the project, including an electronic copy of a Conceptual Approval Letter.
- The applicant may use the Conceptual Approval Letter in filing for a Zoning Permit. Building Permits, however, cannot be obtained, nor can earth disturbance activities begin, until the PCSMP Review Phase is complete.

Figure 2.3-3: Development Compliance Review Path Conceptual Review Phase flow chart



Expiration policy

For the Conceptual Review Phase, the applicant has two years to resubmit in response to PWD comments. Longer extensions may be granted on a case-by-case basis. No extensions will be given for projects whose project tracking numbers begin with "20-".

Conceptual Approvals are valid for one year with an automatic one-year extension. This means an applicant has two years from the date of Conceptual Approval to apply for a Zoning Permit or submit the PCSMP Review Phase Submission Package to begin the PCSMP Review Phase. Past two years, a new Conceptual Approval must be obtained meeting current design standards and regulatory requirements. Applicants should contact their project's reviewer to determine if the Conceptual Stormwater Management Plan can be resubmitted under the existing project tracking number or if a new ERSA Application will be required. Projects whose project tracking numbers begin with "20-'" must submit a new ERSA Application.

PCSMP Review Phase

The PCSMP Review Phase is the second Review Phase in the Stormwater Plan Review process for the Development Compliance Review Path. A project is eligible to submit for the PCSMP Review Phase after receiving a Conceptual Approval Letter from PWD.

The PCSMP Review Phase is PWD's final review before construction. At the end of this Review Phase, PWD will issue a PCSMP Approval Letter. PCSMP Approval is not a permit, but rather one of many prerequisites that must be obtained in order to receive sign-off on a Building Permit (**Section 2.5** ☛ p. 63 and **Section 2.6** ☛ p. 64). For projects that do not require a Building Permit, PCSMP Approval must be obtained before earth disturbance activities can begin.

The site layout and stormwater management design included with the PCSMP Review Phase Submission Package must be consistent with the design that was approved during the Conceptual Review Phase. If major changes are made to the project after PWD issues a Conceptual Approval Letter, the applicant must contact PWD to determine if a revised Conceptual Approval Letter is needed before proceeding to the PCSMP Review Phase. Examples of major changes that would require a new Conceptual Approval include, but are not limited to:

- Changes in proposed LOD;
- Changes in proposed impervious area (such as building footprint or location);
- Changes in stormwater routing; and
- Changes in the type, placement, sizing, and/or location of SMPs or changes to the stormwater management strategy.

If the stormwater management design changes during the PCSMP Review Phase, and the applicant would like to pursue an Expedited PCSMP Review, they must contact PWD before resubmitting to discuss specific design and submission requirements. The applicant is referred to **Section 2.4** ☛ p. 57 for more information on Expedited PCSMP Reviews.

Some projects may plan to complete their project construction in phases. Applicants must state in their PCSMP Review Phase Submission if they are proposing a phased project. Each phase of construction must be individually compliant with the Stormwater Regulations as they are constructed. Vegetated components must be established before each phase close-out, so the growing seasons must be considered when planning phased construction. The applicant is referred to Chapter 5 for more information on project closeout procedures for phased construction.

Submission Package components

A complete PCSMP Review Phase Submission Package for the Development Compliance Review Path consists of the materials listed in Figure 2.3-4.

Figure 2.3-4: Development Compliance Review Path PCSMP Review Phase Submission Package checklist

DEVELOPMENT COMPLIANCE REVIEW PATH Post-Construction Stormwater Management Plan Review Phase Submission Package checklist	
	Final Construction Drawings
	Post-Construction Stormwater Management Plan (PCSMP) Package
	Proof of Application for Applicable State and Federal Permits
	PCSMP Submittal Fee
	Transmittal Letter

Final Construction Drawings

- All plans must be signed and sealed by a Professional Engineer licensed in the Commonwealth of Pennsylvania. Each plan sheet of the plan set must have an electronic signature and seal.
- All plans must meet general plan sheet requirements listed in **Appendix E, Table E-1** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/e-plan-and-report-checklists/table-e-1-general-plan-sheet-requirements.
- The following items must be incorporated into the Final Construction Drawings:
  - Existing Conditions Plan that meets all requirements listed in **Section 2.1.1** ☛ p. 5,
  - Demolition Plan,
  - Site Plan,
  - Grading and utility information,
  - Landscaping information, and
  - Construction details.

Post-Construction Stormwater Management Plan Package

- Post-Construction Stormwater Management Plan
  - The PCSMP is a set of engineering drawings depicting the post-development conditions and post-construction stormwater management design of a project. The PCSMP drawings and Final Construction Drawings do not necessarily have to be separate plans; they may be combined into a singular plan set.
  - The PCSMP must be signed and sealed by a Professional Engineer licensed in the Commonwealth of Pennsylvania. Each plan sheet of the plan set must have an electronic signature and seal.
  - Drawings must contain appropriate sequences of construction for each SMP (**Chapter 4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4). Any proposed phasing must be documented in the PCSMP.
  - Grading and utility information, landscaping information, and SMP construction details, must be either incorporated into PCSMP drawings or provided as separate plan sheets.

- E&S Plan
  - The E&S Plan displays the post-construction condition along with other site characteristics related to the earth disturbance activities and proposed E&S measures for a project site.
  - The E&S Plan must include a LOD line type which is drawn around all proposed site features, E&S controls, and other areas that may be disturbed over the course of construction for activities such as construction staging, re-grading, demolition, etc. The applicant is advised to be conservative when estimating the LOD to avoid proceeding along the wrong Review Path, which could lead to costly delays, change orders, and enforcement action during construction. PWD typically observes LODs in the field to be larger than what is proposed on the plans. A numerical value for the LOD must be clearly displayed on the E&S Plan.
  - The E&S Plan must be prepared in accordance with the ***Pennsylvania Department of Environmental Protection (PA DEP) Erosion and Sediment Pollution Control Program Manual*** ☛ https://www.dep.pa.gov/Business/Water/CleanWater/StormwaterMgmt/Stormwater%20Construction/Pages/E-S%20Resources.aspx (2012 or latest), Chapter 1 – Required E&S Plan Content. E&S measures are referred to as E&S Best Management Practices (BMPs) in the PA DEP Manual.
  - The E&S Plan must also comply with the following requirements specific to PWD. Should E&S Plan requirements conflict between PA DEP and PWD, the applicant is to follow the specific PWD E&S Plan requirements presented in this Manual.
    - All requirements listed in **Appendix E, Table E-4: Erosion and Sediment Control Plan Requirements** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/e-plan-and-report-checklists/table-e-4-erosion-and-sediment-control-plan-requirements must be met.
    - All Standard E&S Notes listed in **Appendix E, Table E-5: Standard Erosion and Sediment Control Notes** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/e-plan-and-report-checklists/table-e-5-standard-erosion-and-sediment-control-notes must be included.
    - All Standard Sequence of Construction Notes listed in **Appendix E, Table E-6: Standard Sequence of Construction Notes** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/e-plan-and-report-checklists/table-e-6-standard-sequence-of-construction-notes must be included.
    - Standard construction details must be included from the ***PA DEP Erosion and Sediment Pollution Control Program Manual*** ☛ https://www.dep.pa.gov/Business/Water/CleanWater/StormwaterMgmt/Stormwater%20Construction/Pages/E-S%20Resources.aspx (2012 or latest) for the following E&S measures: inlet protection, silt fence and/or compost filter sock, rock filter outlet, rock construction entrance, concrete washout station, dust control, and pumped water filter bag. If any of these E&S measures do not apply to the project site, justification must be provided as a note on the E&S Plan.
- Post-Construction Stormwater Management Plan Report
  - The PCSMP Report contains a detailed discussion of the proposed development and its impacts to the volume, rate, and quality of stormwater runoff from the site. It also contains descriptions of the project site, stormwater management criteria, calculations, maps, and other supporting documentation. The applicant may refer to **Chapter 3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3 for information on stormwater management criteria and calculations.
  - The PCSMP Report must be electronically signed and sealed by a Professional Engineer licensed in the Commonwealth of Pennsylvania.
  - Specific requirements for the PCSMP Report are listed in **Appendix E, Table E-7** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/e-plan-and-report-checklists/table-e-7-post-construction-stormwater-management-plan-report-requirements.

- Operations and Maintenance Agreement Information
  - An O&M Agreement between the property owner and PWD is a component of PCSMP Approval and required of any project subject to the Stormwater Regulations. This Agreement requires the property owner at the time of development to construct SMPs on the listed parcel(s) in strict accordance with the Approved PCSMP and to maintain the SMPs such that they will adequately perform their designed functions. It also requires the property owner to maintain the site in accordance with the Approved PCSMP, prohibiting alterations including the conversion of pervious areas to impervious cover without authorization from PWD. It does not require the property owner to construct the SMPs if the development project associated with the SMPs does not commence or if no earth disturbance takes place. The Agreement is recorded against the property and runs with the land, if and when the property is sold or otherwise conveyed.
  - The "Operations and Maintenance Agreement Information" section of the Online Technical Worksheet must be filled out with current property(ies) and ownership information including the subject property's(ies') addresses(es), OPA Account Number(s), owner name(s), and name(s), business title(s), address(es), and email address(es) of the Agreement's proposed signatory(ies). The "Notes" text field, in addition to supplemental pages, may be used for the additional property and owner information required of projects involving multiple properties.
  - The following signatory business titles are acceptable. For all others, the business title must be listed, and a letter of authorization from the acceptable business title for the signatory confirming their ability to bind the owner organization in legal agreements must be submitted.
    - Corporations: President or Vice President
    - Limited Partnership (LP): General Partner
    - Limited Liability Corporation (LLC): Member or Manager
  - The most recent executed deed(s) demonstrating the current ownership of the property(ies) must be submitted.
  - The most recent legal description(s) of the property(ies) in an electronically editable (Word document) format must be submitted.
  - For further details regarding when and how this part of the process is completed, the applicant is referred to the Submission and Review Process section below.
- SMP Maintenance Guide
  - Prepared by the project's designer and submitted to PWD as part of the PCSMP Review Phase.
  - SMP Maintenance Guides are SMP- and site-specific and should be provided to and implemented by the property owner as a guide for long-term operations and maintenance of the SMPs on-site.
  - The SMP Maintenance Guide must include a Site Map and a separate Maintenance Schedule Form for each SMP to allow the property owner to track all maintenance activities for their site.
  - The SMP Maintenance Guide must be updated and resubmitted with all field changes.
  - The applicant is referred to **Appendix G** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/g-smp-maintenance-guide-documents for an SMP Maintenance Guide sample and associated template documents.

Proof of application for applicable State and Federal permits

Proof of issuance is required for PWD sign-off on a Building Permit; however, the applicant must only prove that they have applied for all applicable permits within the initial submission for PCSMP Review to proceed. To provide proof of application, the applicant must submit copies of permit applications, application receipts, or notification letters from relevant agencies.

- Applicable permits include various State and Federal permits that may be required for development on a given site.
- If the project will involve earth disturbance of more than one acre, the applicant may need to obtain a PA DEP General (PAG-02) National Pollutant Discharge Elimination System (NPDES) Permit or Individual NPDES Permit for Stormwater Discharges Associated with Construction Activities.
- For Pennsylvania Land Recycling Program (Act 2) sites, proof of notice to PA DEP for both an intent to remediate and notification of work to an existing Act 2 site is required.
  - The applicant can submit notification correspondence through **PA DEP's OnBase form upload system** ☛ https://www.dep.pa.gov/DataandTools/Pages/Application-Form-Upload.aspx.
  - The PA DEP Environmental Cleanup and Brownfields program's resource account email address is **RA-EP-SEROECB@pa.gov**.
- It is the applicant's responsibility to determine which permits are required by other regulatory agencies for a project. The applicant is referred to **Section 2.6** ☛ p. 64 for information on Zoning Code requirements and to **Section 2.7** ☛ p. 69 for information on NPDES Permit requirements.

Post-Construction Stormwater Management Plan submittal fee

- For up-to-date fee information, the applicant is referred to the current **Rates and Charges** ☛ water.phila.gov/rates of the appendix of the PWD Regulations.
- Payment must come in the form of a cashier's check, business check, or money order, made payable to "City of Philadelphia." Personal checks will not be accepted, nor will installments.
- The PWD project tracking number must be listed on the check and included in an accompanying transmittal letter.

Submission and review process

- The applicant submits a complete PCSMP Review Phase Submission Package to PWD through the Project Dashboard on the **PWD Plan Review Portal** ☛ www.pwdplanreview.org.
- PWD conducts an initial PCSMP administrative screening of the submitted materials to confirm that all necessary components are included. If any of the PCSMP Review Phase Submission Package components are found to be missing or incomplete, PWD will contact the applicant by email.
- Once PWD's PCSMP administrative screening is complete, and PWD has verified the inclusion of all components, PWD contacts the applicant via email and begins the 15-day review period (five-day period for Expedited PCSMP Reviews, **Section 2.4** ☛ p. 57). During the review, PWD examines the submittal to determine if all applicable Stormwater Regulations are met for the project. PWD verifies that all plans, documents, and calculations are legible, accurate, and consistent.

- If PWD has comments on the submission, PWD issues the comments to the applicant via email. PWD issues all comments in a PCSMP Review letter, which is sent as an attachment to the email. In this email, the reviewer provides their contact information, and the applicant is encouraged to contact the reviewer directly if they have any questions about a particular comment.
- The applicant resubmits to PWD a revised PCSMP Review Phase Submission Package that addresses the comments through the Project Dashboard on the **PWD Plan Review Portal** ☛ www.pwdplanreview.org.
  - Each re-submission initiates the 15-day review period (five-day period for Expedited PCSMP Reviews).
  - Revised submittals must include all required revisions and new material, as well as a response letter addressing each review comment and indicating where the new information can be found.
  - A response letter is required that describes any changes to the design that may not be included within the comment response letter.
  - This can be an iterative process, and PWD does not restrict the number of times an applicant can resubmit. At any time, the applicant or PWD may request a meeting to discuss review comments.

Quick tip

The applicant can reduce the length of a PCSMP Review by being responsive to PWD-issued review comments, addressing comments and resubmitting quickly, performing quality assurance / quality control on all submission materials, and using this Manual to ensure the applicable Stormwater Regulations are being met and compliance is clearly documented.

- As described in the introduction of **Chapter 2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2, Stormwater Plan Review is part of a larger development review process, and there may be circumstances where Stormwater Plan Review cannot issue PCSMP Approval until comments from another PWD unit, local, State, or Federal agency have been addressed. It is the applicant's responsibility to determine whether the project must comply with other PWD, local, State, or Federal requirements. The applicant is referred to **Section 2.5** ☛ p. 63, **Section 2.6** ☛ p. 64, and **Section 2.7** ☛ p. 69 for more information.
  - The standard O&M Agreement consists of:
    - Agreement with signature pages;
    - Signatory acknowledgement sections;
    - Exhibit A, legal description(s) of the property(ies);
    - Exhibit B, a list of SMPs to be installed on the listed parcel(s); and
    - Exhibit C, legal description of the SMP area

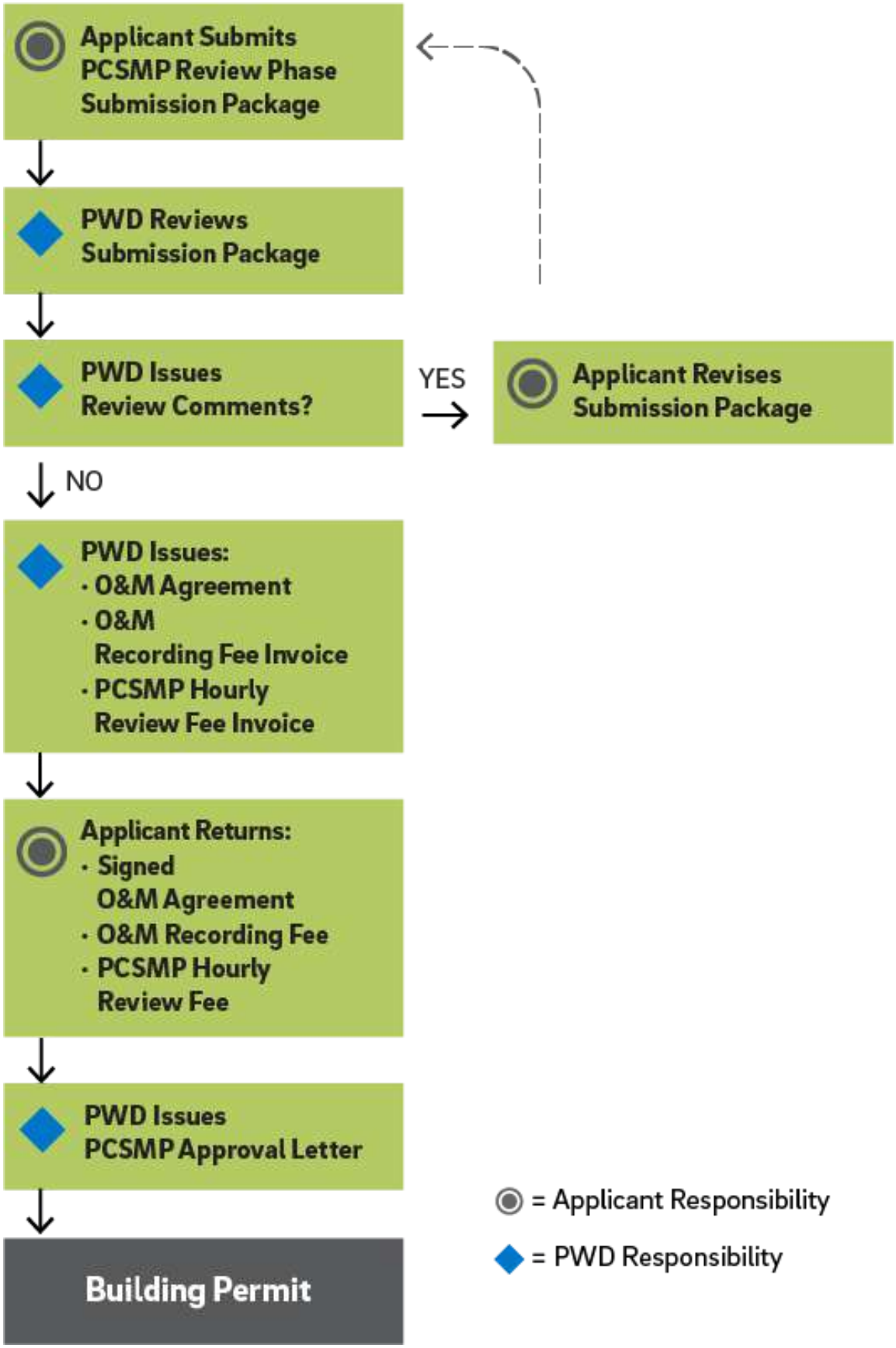
- PWD compiles the signatory sections, the signatory acknowledgement sections, and Exhibit A, based on the information provided by the applicant within the Online Technical Worksheet, which must be completed and submitted as part of the PCSMP Review Phase Submission Package. Incomplete and/or incorrect information within the Online Technical Worksheet will prevent the issuance of a PCSMP Approval Letter until all omissions and/or discrepancies are addressed. Signatory(ies) of the property owner(s) must be authorized to bind the property owner(s) to legal agreements. The signatory acknowledgement sections must be notarized and serve to verify the identities of all parties signing the agreement. Exhibit A contains metes-and-bounds descriptions for each parcel in its entirety, on which earth disturbance is proposed. Exhibit B lists all SMPs to be constructed on the listed parcel(s). Exhibit C can be either the property description listed in Exhibit A or a specific surveyed area of the property directly included in SMP design. Should amendments to the O&M Agreement become necessary after execution, the O&M Amendments will be sequentially numbered and will replace and supersede any and all of the project's previous O&M Agreements and Amendments.
- For up-to-date information on the PCSMP Hourly Review Fee and fee in lieu, the applicant is referred to the current **Rates and Charges** ☛ water.phila.gov/rates in the appendix of the PWD Regulations.
- The O&M Agreement Fee is determined by the **fee schedule** ☛ www.phila.gov/departments/department-of-records/document-recording-and-service-fees established with the City of Philadelphia Department of Records.
- The applicant submits fee payments in the form of a cashier's check, business check, or money order, made payable to "City of Philadelphia." Personal checks will not be accepted, nor will installments. The PWD project tracking number must be listed on all checks or included in an accompanying transmittal letter.

Quick tip

As described in the introduction of **Chapter 2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2, Stormwater Plan Review is part of a larger development review process, and there may be circumstances where Stormwater Plan Review cannot issue PCSMP Approval until comments from another PWD unit, local, State, or Federal agency have been addressed. It is the applicant's responsibility to determine whether the project must comply with other PWD, local, State, or Federal requirements. The applicant is referred to **Section 2.5** ☛ p. 63, **Section 2.6** ☛ p. 64, and **Section 2.7** ☛ p. 69 for more information.

- Upon receipt of fee check(s) and two original, signed, and notarized copies of each O&M Agreement, PWD issues a PCSMP Approval Letter via email.
- After issuance of the PCSMP Approval Letter, a representative of PWD will sign the O&M Agreement(s), and the O&M Agreement(s) are then recorded with the City of Philadelphia Department of Records on behalf of the property owner. A copy of the signed, fully executed O&M Agreement(s) will be mailed to the signatory at the conclusion of the recording process.
- The PCSMP Approval Letter can be used to obtain sign-off on the Building Permit.

Figure 2.3-5: Development Compliance Review Path PCSMP Review Phase flow chart



Field changes

PWD recognizes that design changes may be necessary after PWD issues the PCSMP Approval Letter. If construction must deviate from approved plans, the applicant must contact PWD immediately. Deviations include, but are not limited to:

- Location, size, and/or type of SMPs;
- Infiltration feasibility; and/or
- Other changes in the stormwater conveyance system.

Depending on the extent of the deviation, PWD may request that the applicant submit formally for field change approval. Field changes are given priority in the PCSMP Review queue and will be reviewed as soon as possible. The applicant must speak directly to the assigned reviewer to determine what must be included in the field change submittal. An additional hourly review fee may be applied to the review of all field changes.

Field changes should be submitted through the Project Dashboard on the **PWD Plan Review Portal** ☛ www.pwdplanreview.org. All field changes should include a short narrative describing the deviations from the originally approved PCSMP.

At the completion of construction, PWD's Inspections Coordinator must be contacted to schedule a final inspection (**Chapter 5** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-5). This will initiate the Record Drawings Review Phase.

Post-construction field change

PWD periodically inspects properties to check the functionality of the SMPs and associated drainage areas (**Section 6.2.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-6/6-2-post-construction-stormwater-management-maintenance-inspections-and-enforcement/#6.2.1). If the site is found to be non-compliant either because the SMP is not functioning as intended or has been modified without prior PWD approval, the project may be referred to Post-Construction Enforcement (**Section 6.2.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-6/6-2-post-construction-stormwater-management-maintenance-inspections-and-enforcement/#6.2.2) and directed to submit a field change to address the non-compliant site condition. The submission process and requirements for a post-construction field change may vary slightly. Property Owners should discuss the submission requirements with the Enforcement Case Coordinator before proceeding with a field change submission.

Expiration policy

For the PCSMP Review Phase, the applicant has two years to resubmit in response to PWD comments. Longer extensions may be granted on a case-by-case basis. No extensions will be given for projects whose project tracking numbers begin with "20-".

A PCSMP Approval is valid for two years from the date it is issued unless a valid Building or Site Permit is in place. Projects that did not require Building or Site Permits from L&I will remain active if the projects have advanced to active construction. Past two years, a new PCSMP Approval must obtained meeting current design standards and regulatory requirements. Applicants should contact their project's reviewer to determine if the PCSMP can be resubmitted under the existing project tracking number or if an

Record Drawing Review Phase

The Record Drawing Review Phase is the final Review Phase of the Stormwater Plan Review process for the Development Compliance Review Path. A project is eligible to submit for the Record Drawing Review Phase once construction activities are substantially complete.

PWD uses a project's Record Drawings to verify compliance of the constructed site with the Stormwater Regulations and to document and verify the quantity of stormwater managed on a site. As part of the Record Drawing Review Phase, an updated SMP Maintenance Guide may be required if the location of SMPs and associated structures differs from the Approved PCSMP. If compliance issues were observed during construction, PWD may request that L&I hold the Certificate of Occupancy until the Record Drawing Review Phase or final inspection is complete. It is critical that the Record Drawings reflect any changes from the Approved PCSMP design, approved field changes or otherwise, that may affect the performance of the SMPs. The Record Drawing Review Phase is complete when the applicant receives a letter confirming that the Record Drawing(s) are in general accordance with the Approved PCSMP.

Throughout construction, the contractor or engineer must document all SMP installations as described in the Construction Certification Package (CCP). The contractor must also keep the Approved PCSMP on-site at all times throughout the construction process and document all changes from the Approved PSCMP as they occur. PWD recommends marking up and tracking changes on an actual copy of the Approved PCSMP to simplify preparation of the Record Drawings. Using the Approved PCSMP as a base, the Record Drawings should highlight information confirmed to be in accordance with the Approved PCSMP in yellow and identify any deviations in red ink. The Record Drawings must be clear and legible.

Submission Package components

The Record Drawing Review Phase Submission Package consists of materials listed in Figure 2.3-6, which must be submitted to PWD for review after the final inspection has been completed. All submissions must be made through the Project Dashboard on the **PWD Plan Review Portal** ☛ www.pwdplanreview.org. All submissions should include the applicant's contact information if the submission is being made by a different engineering firm than that of the original ERSA Application.

Figure 2.3-6: Development Compliance Review Path Record Drawing Review Phase Submission Package checklist

DEVELOPMENT COMPLIANCE REVIEW PATH Record Drawing Review Phase Submission Package checklist	
	Record Drawings
	Construction Certification Package
	Transmittal Letter

Record Drawings

- The Record Drawings may be prepared by Professional Engineers, Registered Architects, Landscape Architects, Professional Land Surveyors, Professional Geologists, and Contractors licensed in the Commonwealth of Pennsylvania. The preparer of the plan must display prominently their signature and professional seal, or, in the case of Licensed Contractors, their signature and L&I Contractor License Number, on each Record Drawing plan sheet. (PA DEP may have different requirements concerning the types of professionals who may prepare Record Drawings. For projects that require a NPDES Permit, the applicant is strongly encouraged to refer to PA DEP's requirements for Record Drawings before selecting a professional to prepare Record Drawing(s) for PWD.)
- If the Record Drawings are determined to be in general accordance with the Approved PCSMP, PWD will issue a letter via email stating as such. Once the closeout process is complete, in accordance with **Appendix M** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/m-pcsmp-project-closeout, PWD will resolve the "Hold Permit Completion" on the "PWD Stormwater Mgmt. Review" for the associated L&I building permit(s) in **eCLIPSE** ☛ www.phila.gov/departments/department-of-licenses-and-inspections/eclipse-faqs.
- The Record Drawing(s) must meet all requirements listed in **Appendix E, Table E-8** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/e-plan-and-report-checklists/table-e-8-record-drawing-requirements.
- The applicant is referred to **Appendix K** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/k-record-drawing-sample for a sample Record Drawing.
- The applicant is referred to **Section 5.3.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-5/5-3-construction-documentation#5.3.2 for more information on Record Drawing construction documentation.

Construction Certification Package

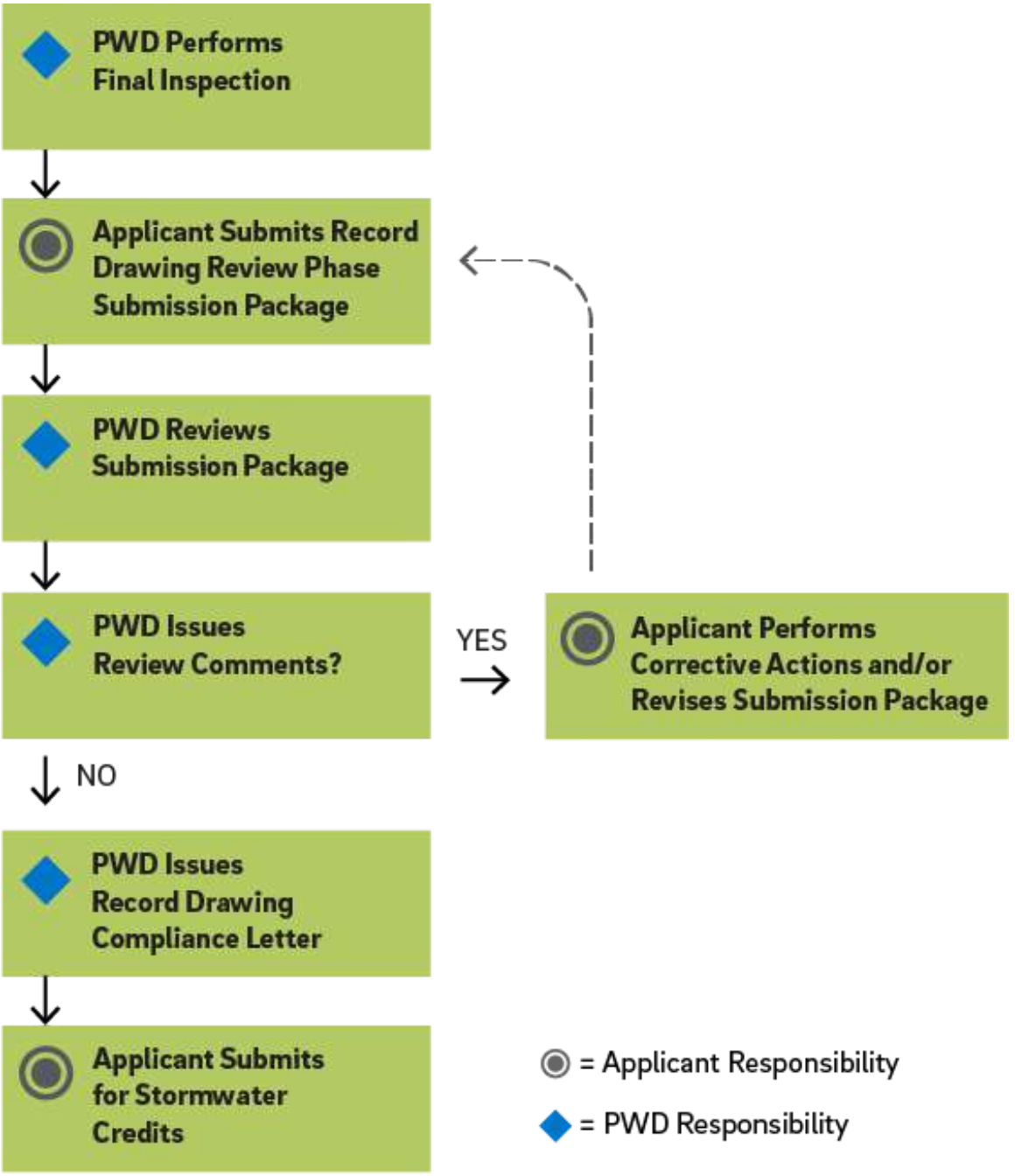
- The applicant is referred to **Appendix J** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/j-construction-certification-package for the CCP Template and instructions.
- The applicant can submit the CCP with the Record Drawing or as a separate submission using the "assorted files" option in the Project Dashboard on the **PWD Plan Review Portal** ☛ www.pwdplanreview.org.
- The applicant is referred to **Section 5.3.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-5/5-3-construction-documentation#5.3.1 for more information on CCP documentation during construction.

Submission and review process

- The applicant submits a complete Record Drawing Review Phase Submission Package to PWD through the Project Dashboard on the **PWD Plan Review Portal** ☛ www.pwdplanreview.org. The submission must also include a narrative identifying the PWD project tracking number and the applicant's contact information if the submission is being made by a different engineering firm than that of the original ERSA Application.
- PWD reviews the submitted Record Drawing(s) and CCP to ensure that the project has been constructed in accordance with the project's Approved PCSMP.
- Upon review, PWD will issue comments on the submission via email.
  - If the submitted Record Drawing Review Phase Submission Package is determined to be incomplete, the applicant must modify and/or add to the Record Drawings and/or CCP per the comments contained in the letter, and resubmit through the Project Dashboard on the **PWD Plan Review Portal** ☛ www.pwdplanreview.org. The applicant must include a response letter addressing each review comment.
  - If the submitted Record Drawings are determined to be complete, but constructed conditions differ from the Approved PCSMP, PWD may require the applicant to submit calculations prepared by a qualified design professional demonstrating compliance with Stormwater Regulations. Specifically, PWD may check the SMP storage volume, release rate, drainage areas, and other items that affect a site's compliance with the Stormwater Regulations (**Chapter 3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3). If the applicant cannot demonstrate compliance with the Stormwater Regulations, PWD will request that the applicant outline corrective actions to bring the project into compliance. Once corrective actions have been performed, the applicant must contact PWD to re-inspect. If necessary, the applicant must submit requested materials that address PWD's comments through the Project Dashboard on the **PWD Plan Review Portal** ☛ www.pwdplanreview.org.
  - If the Record Drawings are determined to be in general accordance with the Approved PCSMP, PWD will issue a letter via email stating as such. Once the closeout process is complete, in accordance with **Appendix M** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/m-pcsmp-project-closeout, PWD will resolve the "Hold Permit Completion" on the "PWD Stormwater Mgmt. Review" for the associated L&I building permit(s) in **eCLIPSE** ☛ www.phila.gov/departments/department-of-licenses-and-inspections/eclipse-faqs.

Most non-residential and condominium projects that comply with Stormwater Regulations per a Record Drawing review and final inspection may be eligible for stormwater credits. A **Stormwater Credits Application (Form B)** ☛ water.phila.gov/wp-content/uploads/files/form-b.pdf may be submitted to Stormwater Billing and Incentives for review. For additional information on stormwater credits, the applicant is referred to **Section 6.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-6/6-3-stormwater-credits.

Figure 2.3-7: Development Compliance Review Path Record Drawing Review Phase flow chart



2.3.2 Development Exemption Review Path

Conceptual Review Phase

The Conceptual Review Phase is the first Review Phase of the Stormwater Plan Review process for the Development Exemption Review Path. A project is initiated with the submission of the ERSA Application to PWD through the Project Dashboard on the **PWD Plan Review Portal** ☛ www.pwdplanreview.org, which includes a Conceptual Review Phase Submission Package.

Submission Package components

The Conceptual Review Phase Submission Package for the Development Exemption Review Path contains an E&S Plan which PWD will use to verify the proposed project LOD and to confirm the E&S Plan has been prepared in accordance with the E&S requirements of the PA DEP as specified in 25 Pa. Code §102.4.

A complete Conceptual Review Phase Submission Package for the Development Exemption Review Path consists of the materials listed in Figure 2.3-8.

Figure 2.3-8: Development Exemption Review Path Conceptual Review Phase Submission Package checklist

DEVELOPMENT EXEMPTION REVIEW PATH Conceptual Review Phase Submission Package checklist	
	Erosion and Sediment Control (E&S) Plan

Erosion and Sediment Control Plan

- The E&S Plan displays the post-construction condition along with other site characteristics related to the earth disturbance activities and proposed E&S measures for a project site.
- The E&S Plan must include a LOD line type which is drawn around all proposed site features, E&S controls, and other areas that may be disturbed over the course of construction for activities such as construction staging, re-grading, demolition, etc. The applicant is advised to be conservative when estimating the LOD to avoid proceeding along the wrong Review Path, which could lead to costly delays, change orders, and enforcement action during construction. PWD typically observes LODs in the field to be larger than what is proposed on the plans. A numerical value for the LOD must be clearly displayed on the E&S Plan.
- The E&S Plan must be prepared in accordance with the ***PA DEP Erosion and Sediment Pollution Control Program Manual*** ☛ https://www.dep.pa.gov/Business/Water/CleanWater/StormwaterMgmt/Stormwater%20Construction/Pages/E-S%20Resources.aspx (2012 or latest), Chapter 1 – Required E&S Plan Content. E&S measures are referred to as E&S BMPs in the PA DEP Manual.

- The E&S Plan must also comply with the following requirements specific to PWD. Should E&S Plan requirements conflict between PA DEP and PWD, the applicant is to follow the specific PWD E&S Plan requirements presented in this Manual.
  - All requirements listed in **Appendix E, Table E-4: Erosion and Sediment Control Plan Requirements** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/e-plan-and-report-checklists/table-e-4-erosion-and-sediment-control-plan-requirements must be met.
  - All Standard E&S Notes listed in **Appendix E, Table E-5: Standard Erosion and Sediment Control Notes** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/e-plan-and-report-checklists/table-e-5-standard-erosion-and-sediment-control-notes must be included.
  - All Standard Sequence of Construction Notes listed in **Appendix E, Table E-6: Standard Sequence of Construction Notes** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/e-plan-and-report-checklists/table-e-6-standard-sequence-of-construction-notes must be included.
  - Standard construction details must be included from the ***PA DEP Erosion and Sediment Pollution Control Program Manual*** ☛ https://www.dep.pa.gov/Business/Water/CleanWater/StormwaterMgmt/Stormwater%20Construction/Pages/E-S%20Resources.aspx (2012 or latest) for the following E&S measures: inlet protection, silt fence and/or compost filter sock, rock filter outlet, rock construction entrance, concrete washout station, dust control, and pumped water filter bag. If any of these E&S measures do not apply to the project site, justification must be provided as a note on the E&S Plan.
  - Electronic signature (for projects that propose more than 5,000 square feet of earth disturbance).
- If Small Residential Development (SRD) is proposed, the applicant must clearly identify on the E&S Plan the footprints of any buildings used exclusively as one- or two-family dwellings and the resultant total areas of SRD, which is exempt from PCSM Requirement applicability, and On-Site LOD, which is subject to PCSM Requirements if 15,000 square feet or more (5,000 square feet or more in the Darby and Cobbs Creeks Watershed). This site area information can be easily conveyed as a table; an example of which is provided below:

Total LOD	34,800 SF
Right-of-Way/Street Maintenance Activity	9,100 SF
Small Residential Development	12,200 SF
On-Site LOD	**13,500 SF**

If the project (all or any portion of it) is determined to be applicable to the Development Compliance Review Path (**Section 2.3.1** ☛ p. 18), the plan information regarding SRD described above must also be included on the required Conceptual Stormwater Management Plan.

Submission and review process

- The applicant submits the Conceptual Review Phase Submission Package as a component of a complete ERSA Application Submission Package (**Section 2.1.1** ☛ p. 5) through the Project Dashboard on the **PWD Plan Review Portal** ☛ www.pwdplanreview.org.
- The applicant will receive an automatic email confirmation that the submission has been received.
- PWD reviews the ERSA Application Submission Package, including the Conceptual Review Phase Submission Package, within five calendar days.
  - PWD reviews the submitted plans and documentation by analyzing the proposed development and LOD to confirm exemption from the Stormwater Regulations and by confirming the development of an E&S Plan. PWD performs an initial review of proposed water and sewer connections and possible conflicts with PWD infrastructure. However, this represents only a preliminary review, and the applicant will still need to obtain separate connection permits outside of this Conceptual Review Phase (**Section 2.5** ☛ p. 63).
- If PWD has comments on the submission, PWD issues the comments to the applicant via email.
- The applicant resubmits to PWD, through the Project Dashboard on the **PWD Plan Review Portal** ☛ www.pwdplanreview.org, a revised Conceptual Review Phase Submission Package that addresses the comments. A response letter addressing each review comment and outlining any major plan or design changes must be submitted with each resubmission. This can be an iterative process, and PWD does not restrict the number of times an applicant can resubmit. At any time, the applicant or PWD may request a meeting to discuss review comments.
- If PWD has no comments, or if the comments have been addressed sufficiently by the applicant, PWD issues an email confirming Conceptual Approval of the project, including an electronic copy of the Conceptual Approval Letter.
  - For projects whose earth disturbance will exceed one acre, PWD may defer the E&S review to PA DEP. If PWD does defer a review to PA DEP, this will be stated in the Conceptual Approval Letter. In this circumstance, earth disturbance activities cannot begin until PA DEP approves the E&S Plan and/or issues the NPDES Permit (if required). The applicant must also send an electronic copy of plans approved by PA DEP to PWD.
- The applicant may use the Conceptual Approval Letter when filing a Zoning Application or Building Permit.

Expiration policy

For the Conceptual Review Phase, the applicant has two years to resubmit in response to PWD comments. Longer extensions may be granted on a case-by-case basis.

For Development Exemption projects, a Conceptual Approval Letter is valid for two years from the date of issuance unless a valid Building or Site Permit is in place. Projects that did not require Building or Site Permits from L&I will remain active if the projects have advanced to active construction. Past two years, a new Conceptual Approval must be obtained meeting current design standards and regulatory requirements. Applicants should contact their project's reviewer to determine if the Conceptual Stormwater Management Plan can be resubmitted under the existing project tracking number or if a new ERSA Application will be required.

2.3.3 Demolition Review Path

Conceptual Review Phase

The Conceptual Review Phase is the first Review Phase of the Stormwater Plan Review process for the Demolition Review Path. A project is initiated with the submission of the ERSA Application to PWD through the Project Dashboard on the **PWD Plan Review Portal** ☛ www.pwdplanreview.org, which includes a Conceptual Review Phase Submission Package.

Submission Package components

The Conceptual Review Phase Submission Package for the Demolition Review Path contains a Demolition Plan and an E&S Plan. PWD uses these components to confirm the proposed project LOD, that the project is limited to just demolition, and to confirm that the E&S Plan has been prepared with the E&S requirements of the PA DEP as specified in 25 Pa. Code §102.4.

A complete Conceptual Review Phase Submission Package for the Demolition Review Path consists of the materials listed in Figure 2.3-9.

Figure 2.3-9: Demolition Review Path Conceptual Review Phase Submission Package checklist

DEMOLITION REVIEW PATH Conceptual Review Phase Submission Package checklist	
	Erosion and Sediment Control (E&S) Plan
	Demolition Plan

Erosion and Sediment Control Plan

- The E&S Plan is representative of the stabilized post demolition site condition and displays site characteristics related to the earth disturbance activities and proposed E&S measures. The E&S Plan must show that the site will be left in a stabilized condition that does not create a public health and safety concern. Further, site preparation for future development activities including foundation work associated with an L&I Foundation-Only Building Permit, is not permitted as part of the Demolition Review Path. In order for the project to complete the Demolition Review Path, all disturbed areas must be stabilized with pervious cover (e.g., grass, gravel, etc.).
- The E&S plan must include a LOD line type which is drawn around all proposed site features, structures to be removed, E&S controls, and other areas that may be disturbed over the course of demolition. The applicant is advised to be conservative when estimating the LOD so as to avoid continuing down the wrong Review Path, which could lead to costly delays, change orders, and enforcement action during construction. PWD typically observes LODs in the field to be larger than what is proposed on the plans. A numerical value for the LOD must be clearly displayed on the E&S Plan.
- The E&S Plan must be prepared in accordance with the ***PA DEP Erosion and Sediment Pollution Control Program Manual*** ☛ https://www.dep.pa.gov/Business/Water/CleanWater/StormwaterMgmt/Stormwater%20Construction/Pages/E-S%20Resources.aspx (2012 or latest), Chapter 1 – Required E&S Plan Content. E&S measures are referred to as E&S BMPs in the PA DEP Manual.

- The E&S Plan must also comply with the following requirements specific to PWD. Should E&S Plan requirements conflict between PA DEP and PWD, the applicant is to follow the specific PWD E&S Plan requirements presented in this Manual.
  - All requirements listed in **Appendix E, Table E-4: Erosion and Sediment Control Plan Requirements** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/e-plan-and-report-checklists/table-e-4-erosion-and-sediment-control-plan-requirements must be met.
  - All Standard E&S Notes listed in **Appendix E, Table E-5: Standard Erosion and Sediment Control Notes** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/e-plan-and-report-checklists/table-e-5-standard-erosion-and-sediment-control-notes must be included.
  - All Standard Sequence of Construction Notes listed in **Appendix E, Table E-6: Standard Sequence of Construction Notes** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/e-plan-and-report-checklists/table-e-6-standard-sequence-of-construction-notes must be included.
  - Standard construction details must be included from the ***PA DEP Erosion and Sediment Pollution Control Program Manual*** ☛ https://www.dep.pa.gov/Business/Water/CleanWater/StormwaterMgmt/Stormwater%20Construction/Pages/E-S%20Resources.aspx (2012 or latest) for the following E&S measures: inlet protection, silt fence and/or compost filter sock, rock filter outlet, rock construction entrance, concrete washout station, dust control, and pumped water filter bag. If any of these E&S measures do not apply to the project site, justification must be provided in the notes on the E&S Plan.

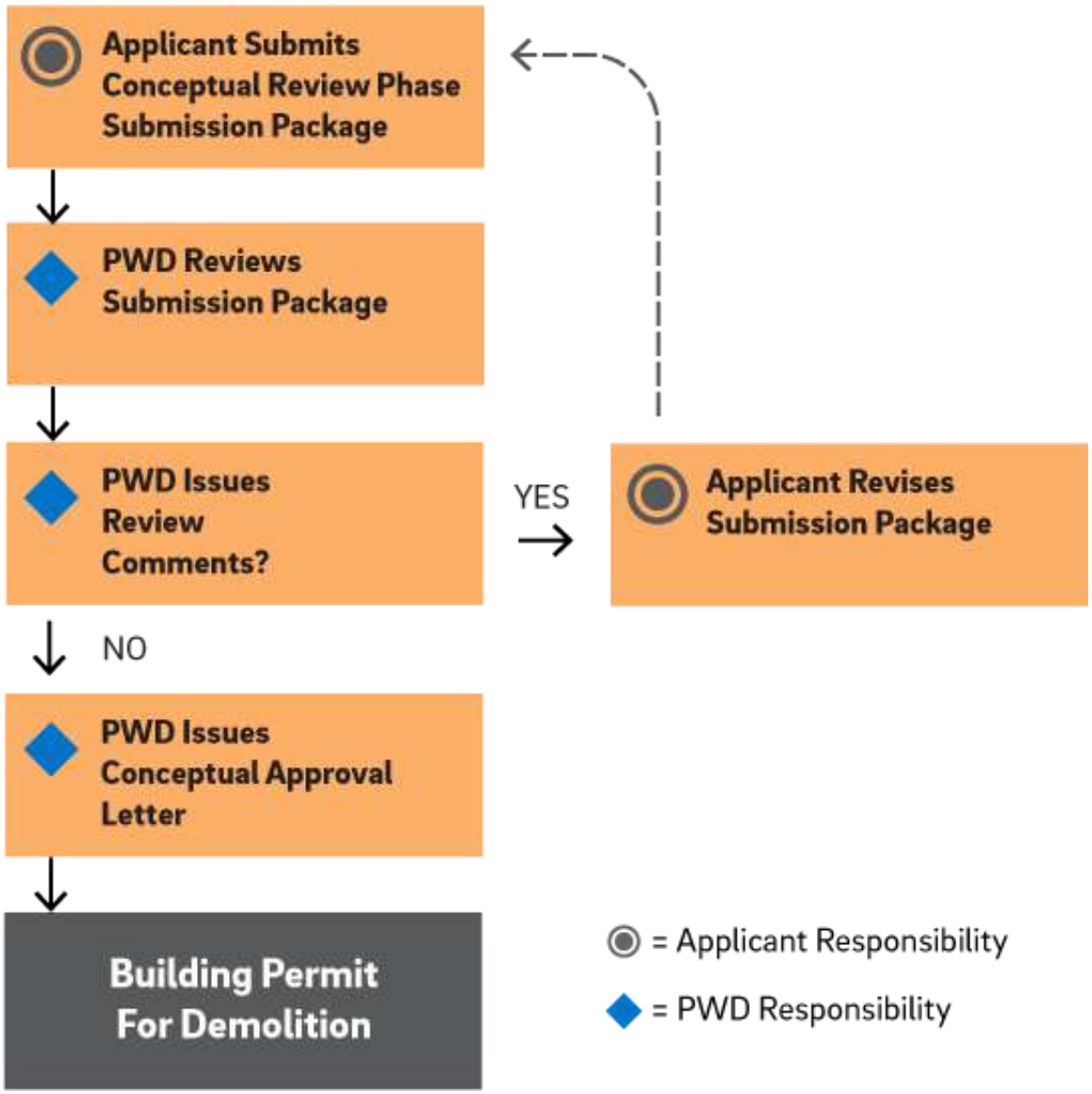
Demolition Plan

- The Demolition Plan is representative of existing conditions and identifies all site features to be removed during demolition
- The Demolition Plan identifies all utilities and lateral connections that will be abandoned including cut and plug locations.
- All requirements listed in **Appendix E, Table E-2: Existing Conditions Plan Requirements** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/e-plan-and-report-checklists/table-e-2-existing-conditions-plan-requirements must be met.

Submission and review process

- The applicant submits the Conceptual Review Phase Submission Package as a component of a complete ERSA Application Submission Package (**Section 2.1.1** ☛ p. 5) through the Project Dashboard on the **PWD Plan Review Portal** ☛ www.pwdplanreview.org.
- The applicant will receive an automatic email confirmation that the submission has been received.
- PWD reviews the ERSA Application Submission Package, including the Conceptual Review Phase Submission Package, within five calendar days.
  - PWD reviews the submitted plans and documentation by analyzing the proposed development and LOD to confirm exemption from the Stormwater Regulations and by confirming the development of an E&S Plan prepared by a Professional Engineer licensed in the Commonwealth of Pennsylvania.
- If PWD has comments on the submission, PWD issues the comments to the applicant via email.
- The applicant resubmits to PWD, a revised Conceptual Review Phase Submission Package that addresses the comments through the Project Dashboard on the **PWD Plan Review Portal** ☛ www.pwdplanreview.org. This can be an iterative process, and PWD does not restrict the number of times an applicant can resubmit. At any time, the applicant or PWD may request a meeting to discuss review comments.
- If PWD has no comments, or if the comments have been addressed sufficiently by the applicant, PWD issues an email confirming Conceptual Approval of the project, including an electronic copy of the Conceptual Approval Letter.
  - For projects whose earth disturbance will exceed one acre, PWD may defer the E&S review to PA DEP. If PWD does defer a review to PA DEP, this will be stated in the Conceptual Approval Letter. In this circumstance, demolition or earth disturbance activities cannot begin until PA DEP approves the E&S Plan and/or issues the NPDES Permit (if required). The applicant must also send an electronic copy of plans approved by PA DEP to PWD.
- The applicant may use the Conceptual Approval Letter in the process of obtaining Building Permit sign-off for Demolition from PWD. The applicant is referred to **Section 2.5** ☛ p. 63 for more information on other reviews for Building Permit sign-off.
  - If the project requires a Building Permit, the applicant must contact PWD to determine if a different Review Path is more appropriate for the project.
  - If the Demolition project involves the removal of impervious surfaces, the applicant may be eligible for stormwater credits. A **Stormwater Credits Application (Form B)** ☛ water.phila.gov/wp-content/uploads/files/form-b.pdf may be submitted to Stormwater Billing and Incentives for review. For additional information on stormwater credits, the applicant is referred to **Section 6.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-6/6-3-stormwater-credits.

Figure 2.3-10: Demolition Review Path Conceptual Review Phase flow chart



Expiration policy

For the Conceptual Review Phase, the applicant has two years to resubmit in response to PWD comments. Longer extensions may be granted on a case-by-case basis.

For Demolition Review Path projects, a Conceptual Approval Letter is valid for two years from the date of issuance unless a valid Demolition Permit is in place. Projects that did not require Demolition Permits from L&I will remain active if the projects have advanced to active demolition. Past two years, a new Conceptual Approval must be obtained meeting current design standards and regulatory requirements. Applicants should contact their project's reviewer to determine if the Conceptual Stormwater Management Plan can be resubmitted under the existing project tracking number or if a new ERSA Application will be required.

2.3.4 Stormwater Retrofit Review Path

Conceptual Review Phase

Stormwater Retrofits can follow one of two Conceptual Review Phase categories. The category selection depends on if the project is seeking a Stormwater Grant for design and construction funding. If the project is applying for grant funding, they will fall into the Application Review category.

Application Review (Stormwater Grant recipients only)

Most projects under the Stormwater Retrofit Review Path will be Stormwater Grant recipients. Stormwater Grant projects require a Conceptual Stormwater Management Plan as part of their applications for grant funding. The applicant is referred to the **Stormwater Grants Application Guide** ☛ water.phila.gov/wp-content/uploads/files/stormwater-grants-application-guide.pdf on the **Stormwater Grants** ☛ water.phila.gov/stormwater/incentives/grants page for a full review of requirements for application review and completion. Stormwater Billing and Incentives reviews Stormwater Grant Applications and provides technical assistance for determining Stormwater Grant award recipients.

Alternative Conceptual Review

Most projects that receive this type of review fall into the two following groups:

Stormwater Retrofit projects not funded by Stormwater Grants

Stormwater Retrofit projects that are not Stormwater Grant recipients should contact Stormwater Billing and Incentives as soon as possible. These projects will submit an ERSA Application (**Section 2.1** ☛ p. 4) and be reviewed by Stormwater Billing and Incentives.

Significant changes to approved application Conceptual Stormwater Management Plan

All Stormwater Grant recipients should design their project according to their Conceptual Stormwater Management Plan submitted with their Stormwater Grant Application. If significant changes are made from the awarded conceptual design, applicants should contact Stormwater Billing and Incentives as soon as possible. Projects are awarded based on the Conceptual Stormwater Management Plan provided in an application and are expected to match these plans as closely as technically possible. If the project must be altered significantly due to technical challenges or any other reason, Stormwater Billing and Incentives may re-evaluate the effectiveness and scope of the project.

Submission Package components

Projects applying for a Stormwater Grant should follow the procedures outlined in the **Stormwater Grants Application Guide** ☛ water.phila.gov/wp-content/uploads/files/stormwater-grants-application-guide.pdf.

No Conceptual Stormwater Management Plan Approval Fee is required for Stormwater Retrofits.

Below are requirements for projects under the Alternative Conceptual Review category.

Conceptual Stormwater Management Plan

- The Conceptual Stormwater Management Plan must meet all requirements listed in **Appendix E, Table E-3: Conceptual Stormwater Management Plan Requirements** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/e-plan-and-report-checklists/table-e-3-conceptual-stormwater-management-plan-requirements as well as general plan sheet requirements listed in **Appendix E, Table E-1** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/e-plan-and-report-checklists/table-e-1-general-plan-sheet-requirements.
- In preparing the proposed stormwater management strategy for the project site, the applicant must use the stormwater management design process detailed in **Chapter 3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3.
- Construction details should not be submitted with the Conceptual Stormwater Management Plan.

Submission and review process

- Projects applying for a Stormwater Grant should hold a pre-application meeting with Stormwater Billing and Incentives at least one month before the grant deadline. These meetings provide Stormwater Billing and Incentives with the opportunity to issue any comments on the draft Conceptual Stormwater Management Plan and application presented. Applicants can then modify their Conceptual Stormwater Management Plans and application accordingly and submit by the posted Stormwater Grant deadline. Stormwater Billing and Incentives will review the applications and present their findings to a PWD Review Board who will ultimately decide the Stormwater Grant recipients.
- Stormwater Retrofit projects that are not applying for a Stormwater Grant should submit their Conceptual Review Phase Submission as a component of a complete ERSA Application Submission Package (**Section 2.1.1** ☛ p. 5) through the Project Dashboard on the **PWD Plan Review Portal** ☛ www.pwdplanreview.org.
- The applicant will receive an automatic email confirmation that the submission has been received.

Figure 2.3-11: Stormwater Retrofit Review Path Conceptual Review Phase flow chart for grant applicants

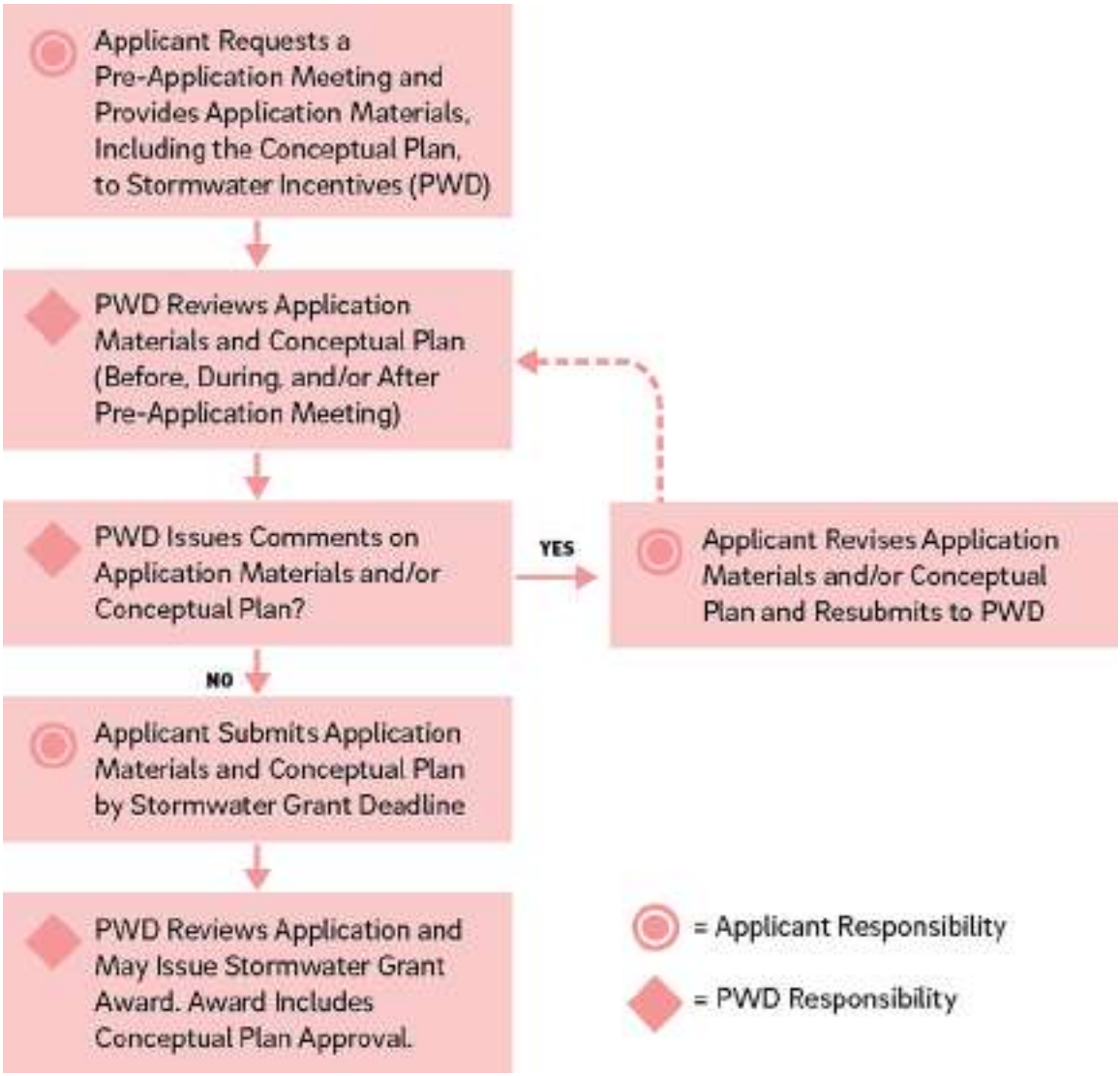
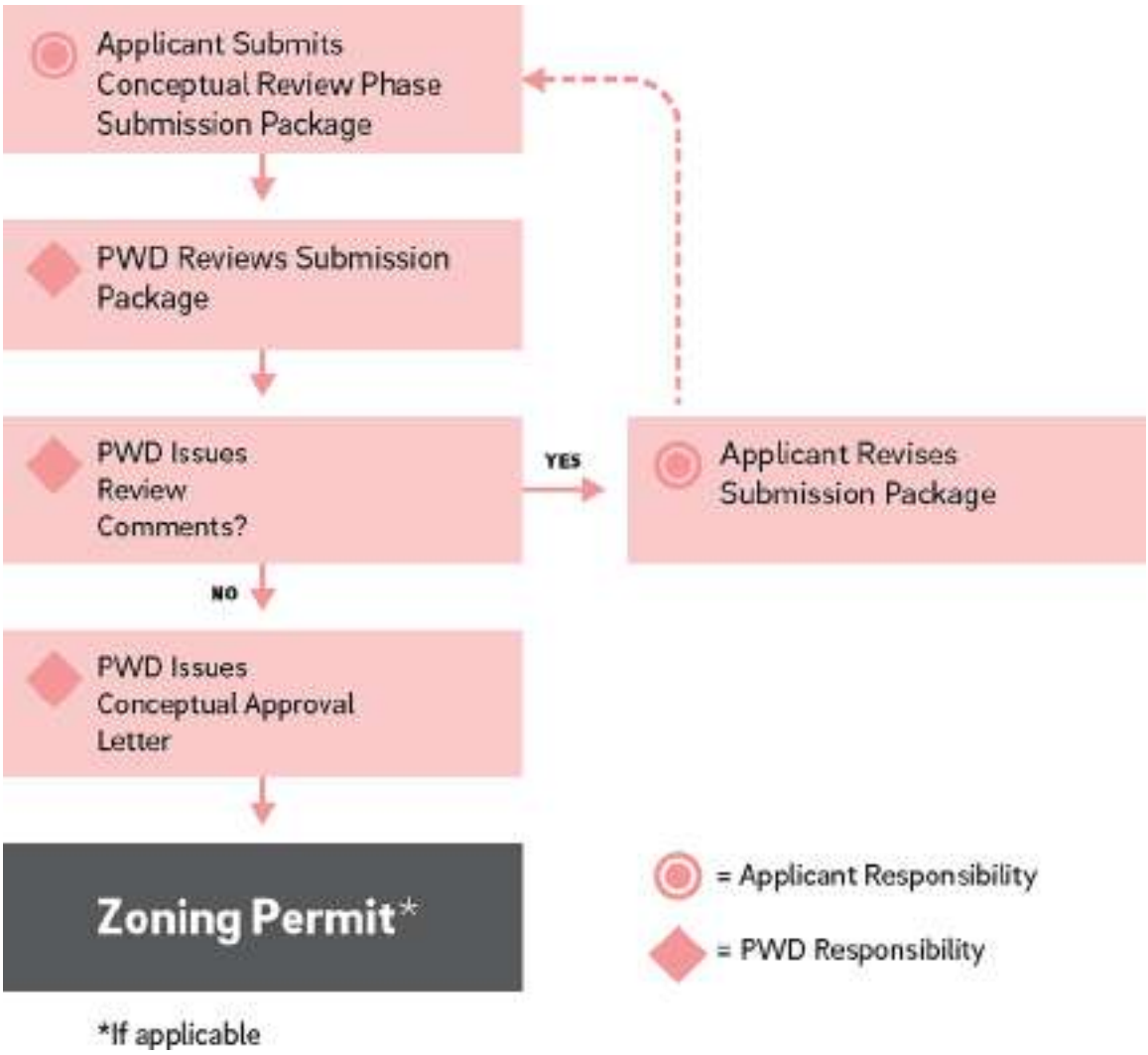


Figure 2.3-12: Stormwater Retrofit Review Path Conceptual Review Phase flow chart, alternative



Expiration policy

For Stormwater Grant-funded Stormwater Retrofits, a Conceptual Approval, which is automatic with notice of a Stormwater Grant award, is valid for six months after the grant manager signs the Subgrant Agreement. If a PCSMP Review Phase Submission Package cannot be submitted within six months of signing the Subgrant Agreement, the applicant must contact Stormwater Billing and Incentives as soon as possible. Applicants for Stormwater Retrofits that are not funded by Stormwater Grants should contact **Stormwater Billing and Incentives** ☛ water.phila.gov/development/stormwater-plan-review/manual/introduction#6 for more information on expiration policies.

PCSMP Review Phase

The PCSMP Review Phase follows approval of a Stormwater Retrofit Conceptual Stormwater Management Plan, either by notice of award of a Stormwater Grant or Conceptual Approval through the Alternative Concept Review Path. This is PWD's final review before construction. At the end of this Review Phase, PWD will issue a PCSMP Approval Letter. PCSMP Approval is not a permit, but rather one of many prerequisite materials that must be presented for obtaining permits, such as a required plumbing permit. PCSMP Approval must be obtained before earth disturbance activities can begin.

The site layout and stormwater management design included with the PCSMP Review Phase Submission Package must be consistent with the design that was approved during the Conceptual Review Phase. If major changes are made to the project after PWD issues a Conceptual Approval Letter, the applicant must contact PWD to determine if a revised Conceptual Approval Letter is needed before proceeding to the PCSMP Review Phase. Stormwater Billing and Incentives may re-evaluate Stormwater Grant funding awarded for projects with PCSMP Review Phase submissions that significantly vary from their awarded Conceptual Stormwater Management Plan in their Stormwater Grant Application. Examples of major changes that would require a new Conceptual Approval include, but are not limited to:

- Changes in proposed LOD;
- Changes in proposed impervious area (such as building footprint or location);
- Changes in stormwater routing; and
- Changes in the type, placement, sizing, and/or location of SMPs or changes to the stormwater management strategy.

There are no expedited reviews for Stormwater Retrofits. Reviews can be expected within two weeks from submission.

No PCSMP Submittal Fee is required for Stormwater Retrofits.

Quick tip

It is the applicant's responsibility to determine whether their project must comply with other PWD, City, State, or Federal permit requirements. At a minimum, Stormwater Retrofit Projects must apply for an L&I Plumbing permit. The applicant is referred to **Section 2.5** ☛ p. 63, **Section 2.6** ☛ p. 64, and **Section 2.7** ☛ p. 69 for more information. If uncertain about how to proceed, the applicant is encouraged to contact **Stormwater Billing and Incentives** ☛ water.phila.gov/development/stormwater-plan-review/manual/introduction#6 at any point in the submission and review process.

Submission Package components

Final Construction Drawings

- All plans must be signed and sealed by a Professional Engineer licensed in the Commonwealth of Pennsylvania. Each plan sheet of the plan set must have an electronic signature and seal.
- All plans must meet general plan sheet requirements listed in **Appendix E, Table E-1** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/e-plan-and-report-checklists/table-e-1-general-plan-sheet-requirements.
- The following items must be incorporated into the Final Construction Drawings:
  - Existing Conditions Plan that meets all requirements listed in **Section 2.1.1** ☛ p. 5,
  - Demolition Plan (if applicable),
  - Site Plan,
  - Grading and utility information,
  - Landscaping information, and
  - Construction details.

Post-Construction Stormwater Management Plan Package

- Post-Construction Stormwater Management Plan
  - The PCSMP is a set of engineering drawings depicting the post-development conditions and post-construction stormwater management design of a project. The PCSMP drawings and Final Construction Drawings do not necessarily have to be separate plans; they may be combined into a singular plan set.
  - The PCSMP must be signed and sealed by a Professional Engineer licensed in the Commonwealth of Pennsylvania. Each plan sheet of the plan set must have an electronic signature and seal.
  - Drawings must contain appropriate sequences of construction for each SMP (**Chapter 4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4).
  - Grading and utility information, landscaping information, and SMP construction details, must be either incorporated into PCSMP drawings or provided as separate plan sheets.
- E&S Plan
  - The E&S Plan displays the post-construction condition along with other site characteristics related to the earth disturbance activities and proposed E&S measures for a project site.
  - The E&S Plan must include a LOD line type which is drawn around all proposed site features, E&S controls, and other areas that may be disturbed over the course of construction for activities such as construction staging, re-grading, demolition, etc. The applicant is advised to be conservative when estimating the LOD to avoid proceeding along the wrong Review Path, which could lead to costly delays, change orders, and enforcement action during construction. PWD typically observes LODs in the field to be larger than what is proposed on the plans. A numerical value for the LOD must be clearly displayed on the E&S Plan.
  - The E&S Plan must be prepared in accordance with the ***PA DEP Erosion and Sediment Pollution Control Program Manual*** ☛ https://www.dep.pa.gov/Business/Water/CleanWater/StormwaterMgmt/Stormwater%20Construction/Pages/E-S%20Resources.aspx (2012 or latest), Chapter 1 – Required E&S Plan Content. E&S measures are referred to as E&S Best Management Practices (BMPs) in the PA DEP Manual.
  - The E&S Plan must also comply with the following requirements specific to PWD. Should E&S Plan requirements conflict between PA DEP and PWD, the applicant is to follow the specific PWD E&S Plan requirements presented in this Manual.
    - All requirements listed in **Appendix E, Table E-4: Erosion and Sediment Control Plan Requirements** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/e-plan-and-report-checklists/table-e-4-erosion-and-sediment-control-plan-requirements must be met.
    - All Standard E&S Notes listed in **Appendix E, Table E-5: Standard Erosion and Sediment Control Notes** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/e-plan-and-report-checklists/table-e-5-standard-erosion-and-sediment-control-notes must be included.
    - All Standard Sequence of Construction Notes listed in **Appendix E, Table E-6: Standard Sequence of Construction Notes** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/e-plan-and-report-checklists/table-e-6-standard-sequence-of-construction-notes must be included.

    - Standard construction details must be included from the ***PA DEP Erosion and Sediment Pollution Control Program Manual*** ☛ https://www.dep.pa.gov/Business/Water/CleanWater/StormwaterMgmt/Stormwater%20Construction/Pages/E-S%20Resources.aspx (2012 or latest) for the following E&S measures: inlet protection, silt fence and/or compost filter sock, rock filter outlet, rock construction entrance, concrete washout station, dust control, and pumped water filter bag. If any of these E&S measures do not apply to the project site, justification must be provided as a note on the E&S Plan.

- Post-Construction Stormwater Management Plan Report
  - The PCSMP Report contains a detailed discussion of the proposed Stormwater Retrofit and its impacts to the volume, rate, and quality of stormwater runoff from the site. It also contains descriptions of the project site, stormwater management criteria, calculations, maps, and other supporting documentation. The applicant may refer to **Chapter 3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3 for information on stormwater management criteria and calculations.
  - The PCSMP Report must be electronically signed and sealed by a Professional Engineer licensed in the Commonwealth of Pennsylvania.
  - Specific requirements for the PCSMP Report are listed in **Appendix E, Table E-7** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/e-plan-and-report-checklists/table-e-7-post-construction-stormwater-management-plan-report-requirements.
  - Stormwater Retrofit projects have more limited project scopes for the PCSMP Report than other development projects. If an applicant has any questions on the requirements, they are encouraged to contact **Stormwater Billing and Incentives** ☛ water.phila.gov/development/stormwater-plan-review/manual/introduction#6.
- Operations and Maintenance Agreement information
  - An O&M Agreement between the property owner and PWD is a component of PCSMP Approval and required of any project receiving Stormwater Grant funding to implement a Stormwater Retrofit. This Agreement requires the property owner at the time of development to construct SMPs on the listed parcel(s) in strict accordance with the Approved PCSMP and to maintain the SMPs such that they will adequately perform their designed functions. It also requires the property owner to maintain the site in accordance with the Approved PCSMP, prohibiting alterations including the conversion of pervious areas to impervious cover without authorization from PWD. It does not require the property owner to construct the SMPs if the development project associated with the SMPs does not commence or if no earth disturbance takes place. The Agreement is recorded against the property and runs with the land, if and when the property is sold or otherwise conveyed.
  - The “Operations and Maintenance Agreement Information” section of the Online Technical Worksheet must be filled out with current property(ies) and ownership information including the subject property’s(ies’) address(es), OPA Account Number(s), owner name(s), and the name(s), business title(s), address(es), and email address(es) of the Agreement’s proposed signatory(ies). The “Notes” text field, in addition to supplemental pages, may be used for the additional property and owner information required of projects involving multiple properties.
  - The following signatory business titles are acceptable. For all others, the business title must be listed, and a letter of authorization from the acceptable business title for the signatory confirming their ability to bind the owner organization in legal agreements must be submitted.
    - Corporations: President or Vice President
    - Limited Partnership (LP): General Partner
    - Limited Liability Corporation (LLC): Member or Manager

    - The most recent executed deed(s) demonstrating the current ownership of the property(ies) must be submitted.
    - The most recent legal description(s) of the property(ies) in an electronically editable (Word document) format must be submitted.
    - For further details regarding when and how this part of the process is completed, the applicant is referred to the Submission and Review Process section below.
- SMP Maintenance Guide
    - Prepared by the project's designer and submitted to PWD as part of the PCSMP Review Phase.
    - SMP Maintenance Guides are SMP- and site-specific and should be provided to and implemented by the property owner as a guide for long-term operations and maintenance of the SMPs on-site.
    - The SMP Maintenance Guide must include a Site Map and a separate Maintenance Schedule Form for each SMP to allow the property owner to track all maintenance activities for their site.
    - The SMP Maintenance Guide must be updated and resubmitted with all field changes.
    - The applicant is referred to **Appendix G** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/g-smp-maintenance-guide-documents for an SMP Maintenance Guide sample and associated template documents.

Proof of application for applicable State and Federal permits

The applicant must prove that they have applied for all applicable permits within the initial submission for PCSMP Review to proceed. To provide proof of application, the applicant must submit copies of permit applications, application receipts, or notification letters from relevant agencies.

- Applicable permits include various State and Federal permits that may be required for development on a given site.
- If the project will involve earth disturbance of more than one acre, the applicant may need to obtain a PA DEP General (PAG-02) National Pollutant Discharge Elimination System (NPDES) Permit or Individual NPDES Permit for Stormwater Discharges Associated with Construction Activities.
- For Pennsylvania Land Recycling Program (Act 2) sites, proof of notice to PA DEP for both an intent to remediate and notification of work to an existing Act 2 site is required.
    - The applicant can submit notification correspondence through **PA DEP's OnBase form upload system** ☛ https://www.dep.pa.gov/DataandTools/Pages/Application-Form-Upload.aspx.
    - The PA DEP Environmental Cleanup and Brownfields program's resource account email address is **RA-EP-SEROECB@pa.gov**.
- It is the applicant's responsibility to determine which permits are required by other regulatory agencies for a project. The applicant is referred to **Section 2.6** ☛ p. 64 for information on Zoning Code requirements and to **Section 2.7** ☛ p. 69 for information on NPDES Permit requirements.

Submission and review process

- The applicant submits a complete PCSMP Review Phase Submission Package to PWD through the Project Dashboard on the **PWD Plan Review Portal** ☛ www.pwdplanreview.org. The PCSMP Review Phase Submission Package will take the place of the Concept Review Phase Submission Package within the ERSA Application for grant-funded Stormwater Retrofit projects with pre-approved Conceptual Stormwater Management Plans.
- PWD conducts an initial PCSMP administrative screening of the submitted materials to confirm that all necessary components are included. If any of the PCSMP Review Phase Submission Package components are found to be missing or incomplete, PWD will contact the applicant by email.
- Once PWD's PCSMP administrative screening is complete, and PWD has verified the inclusion of all components, PWD contacts the applicant via email. During the review, PWD examines the submittal to determine if all applicable stormwater management design criteria are met for the project. PWD verifies all plans, documents, and calculations are legible, accurate, and consistent.
- If PWD has comments on the submission, PWD issues the comments to the applicant via email. PWD issues all comments in a PCSMP Review letter, which is sent as an attachment to the email. In this email, the reviewer provides their contact information, and the applicant is encouraged to contact the reviewer directly if they have any questions about a particular comment.
- In addition to submitting to Stormwater Billing and Incentives, applicants must submit a Utility Plan to Projects Control. Applicants can wait until Stormwater Billing and Incentives issues comments first to ensure accurate plans, but they must receive Utility Plan Review approval before the PCSMP Review Phase is completed. The applicant is referred to **Section 2.5** ☛ p. 63 for more information on Utility Plan Reviews.
- The applicant resubmits to PWD a revised PCSMP Review Phase Submission Package that addresses the comments through the Project Dashboard on the **PWD Plan Review Portal** ☛ www.pwdplanreview.org.
    - Revised submittals must include all required revisions and new material, as well as a response letter addressing each review comment and indicating where the new information can be found.
    - A response letter is required that describes any changes to the design that may not be included within the comment response letter.
    - This can be an iterative process, and PWD does not restrict the number of times an applicant can resubmit. At any time, the applicant or PWD may request a meeting to discuss review comments.
- Once all of the review comments have been addressed by the applicant, PWD will issue an O&M Agreement(s) for signature and notarization. There are no additional review fees for

Quick tip

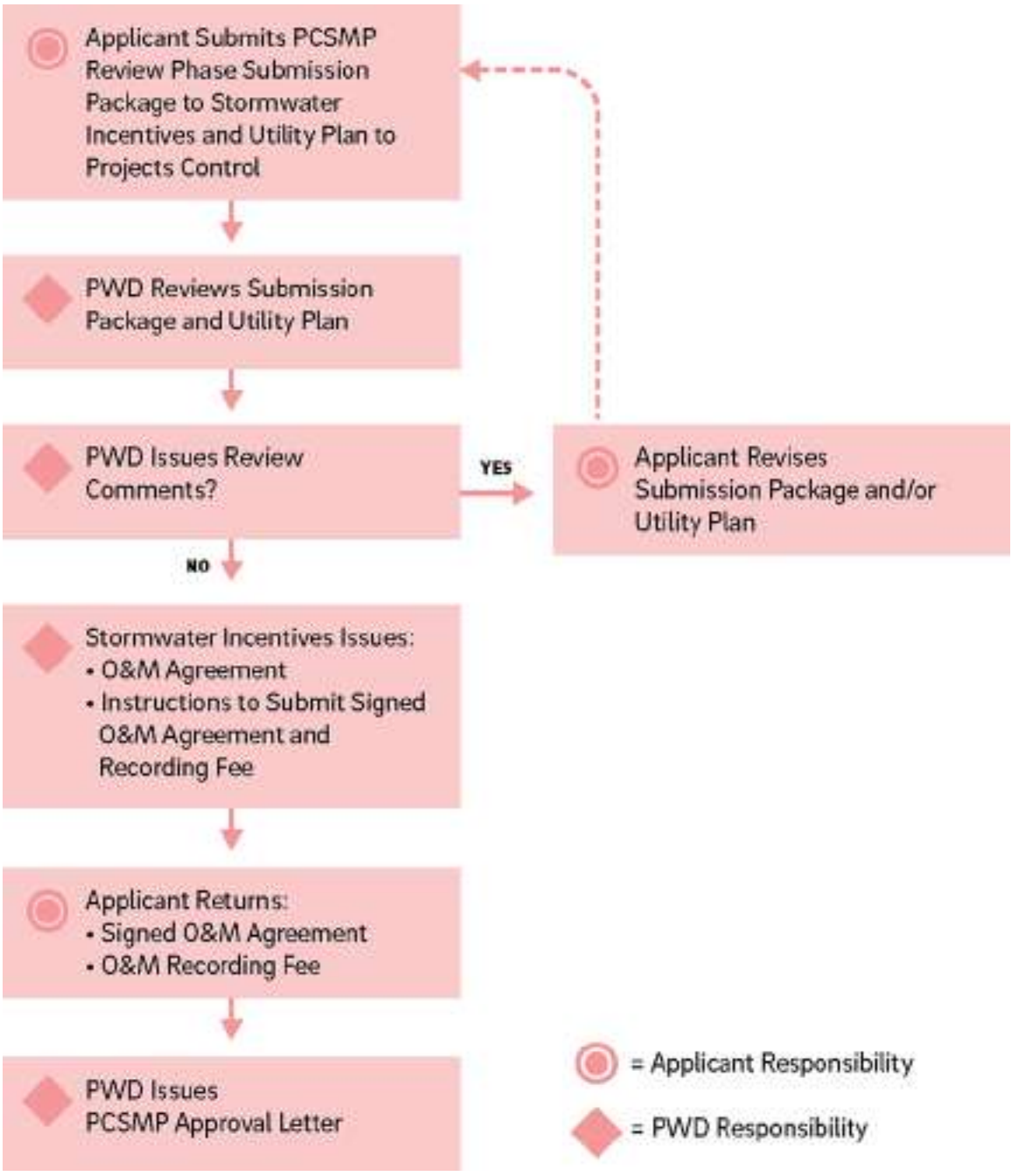
As described in the introduction of **Chapter 2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2, Stormwater Plan Review and Stormwater Billing and Incentives are part of a larger development review process, and there may be circumstances where Stormwater Plan Review cannot issue PCSMP Approval until comments from another PWD unit, local, State, or Federal agency have been addressed. It is the applicant's responsibility to determine whether the project must comply with other PWD, local, State, or Federal requirements. The applicant is referred to **Section 2.5** ☛ p. 63, **Section 2.6** ☛ p. 64, and **Section 2.7** ☛ p. 69 for more information.

Stormwater Retrofits, but there is an O&M Recording Fee for Stormwater Retrofit projects that must be paid prior to PCSMP Approval.

- The standard O&M Agreement consists of:
  - Agreement with signature pages;
  - Signatory acknowledgement sections;
  - Exhibit A, legal description(s) of the property(ies);
  - Exhibit B, a list of SMPs to be installed on the listed parcel(s); and
  - Exhibit C, legal description of the SMP area
- PWD compiles the signatory sections, the signatory acknowledgement sections, and Exhibit A, based on the information provided by the applicant within the Online Technical Worksheet, which must be completed and submitted as part of the PCSMP Review Phase Submission Package. Incomplete and/or incorrect information within the Online Technical Worksheet will prevent the issuance of a PCSMP Approval Letter until all omissions and/or discrepancies are addressed. Signatory(ies) of the property owner(s) must be authorized to bind the property owner(s) to legal agreements. The signatory acknowledgement sections must be notarized and serve to verify the identities of all parties signing the agreement. Exhibit A contains metes-and-bounds descriptions for each parcel in its entirety, on which earth disturbance is proposed. Exhibit B lists all SMPs to be constructed on the listed parcel(s). Exhibit C can be either the property description listed in Exhibit A or a specific surveyed area of the property directly included in SMP design. Should amendments to the O&M Agreement become necessary after execution, the O&M Amendments will be sequentially numbered and will replace and supersede any and all of the project's previous O&M Agreements and Amendments.
- The O&M Agreement Fee is determined by the **fee schedule** ☛ www.phila.gov/departments/department-of-records/document-recording-and-service-fees established with the City of Philadelphia Department of Records.
- The applicant submits fee payments in the form of a cashier's check, business check, or money order, made payable to "City of Philadelphia." Personal checks will not be accepted, nor will installments. The PWD project tracking number must be listed on all checks or included in an accompanying transmittal letter.

- Upon receipt of fee check(s) and two original, signed, and notarized copies of each O&M Agreement, PWD issues a PCSMP Approval Letter via email.
- After issuance of the PCSMP Approval Letter, a representative of PWD will sign the O&M Agreement(s), and the O&M Agreement(s) are then recorded with the City of Philadelphia Department of Records on behalf of the property owner. A copy of the signed, fully executed O&M Agreement(s) will be mailed to the signatory at the conclusion of the recording process.
- The PCSMP Approval Letter can be used to obtain sign-off on the Building Permit.

Figure 2.3-13: Stormwater Retrofit Review Path PCSMP Review Phase flow chart



Field changes

PWD recognizes that design changes may be necessary after PWD issues the PCSMP Approval Letter. If construction must deviate from approved plans, the applicant must contact PWD immediately. Deviations include, but are not limited to:

- Location, size, and/or type of SMPs;
- Infiltration feasibility; and/or
- Other changes in the stormwater conveyance system.

Depending on the extent of the deviation, PWD may request that the applicant submit formally for field change approval. Field changes are given priority in the PCSMP Review queue and will be reviewed as soon as possible. The applicant must speak directly to the assigned reviewer to determine what must be included in the field change submittal.

Field changes for Stormwater Retrofit projects can be submitted to the Stormwater Billing and Incentives reviewer. All Field changes should include a short narrative describing the deviations from the originally approved PCSMP.

At the completion of construction, PWD's Inspections Coordinator must be contacted to schedule a final inspection (**Chapter 5** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-5). This will initiate the Record Drawings Review Phase.

Post-construction field change

PWD periodically inspects properties to check the functionality of the SMPs and associated drainage areas (**Section 6.2.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-6/6-2-post-construction-stormwater-management-maintenance-inspections-and-enforcement/#6.2.1). If the site is found to be non-compliant either because the SMP is not functioning as intended or has been modified without prior PWD approval, the project may be referred to Post-Construction Enforcement (**Section 6.2.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-6/6-2-post-construction-stormwater-management-maintenance-inspections-and-enforcement/#6.2.2) and directed to submit a field change to address the non-complaint site condition. The submission process and requirements for a post-construction field change may vary slightly. Property Owners should reference the instructions received from their Enforcement Case Coordinator before proceeding with a field change submission.

Expiration Policy

For Stormwater Grant-funded Stormwater Retrofits, PCSMP Approval is valid for six months to start construction. If a grant-funded Stormwater Retrofit cannot start construction within six months of the date of PCSMP Approval, the applicant must contact Stormwater Billing and Incentives as soon as possible. Applicants for Stormwater Retrofits that are not funded by Stormwater Grants should contact **Stormwater Billing and Incentives** ☛ water.phila.gov/development/stormwater-plan-review/manual/introduction#6 for more information on expiration policies.

Record Drawing Review Phase

The Record Drawing Review Phase is the final Review Phase of the Stormwater Billing and Incentives process for the Stormwater Retrofit Review Path. A project is eligible to submit for the Record Drawing Review Phase once construction activities are substantially complete.

PWD uses a project's Record Drawings to verify compliance of the constructed site with stormwater management design criteria and to document and verify the quantity of stormwater managed on a site. It is critical that the Record Drawings reflect any changes from the Approved PCSMP design, approved field changes or otherwise, that may affect the performance of the SMPs. The Record Drawing Review Phase is complete when the applicant receives a letter confirming that the Record Drawing(s) are in general accordance with the Approved PCSMP.

Throughout construction, the contractor or engineer must document all SMP installations by measuring and taking photographs of key structure placements. The contractor must also keep the Approved PCSMP on-site at all times throughout the construction process and document all changes from the Approved PSCMP as they occur. PWD recommends marking up and tracking changes on an actual copy of the Approved PCSMP to simplify preparation of the Record Drawings. Using the Approved PCSMP as a base, the Record Drawings should highlight information confirmed to be in accordance with the Approved PCSMP in yellow and identify any deviations in red ink. The Record Drawings must be clear and legible.

Submission Package components

The Record Drawing Review Phase Submission Package consists of materials listed in **Figure 2.3-6** ☛ p. 31, which must be submitted to PWD for review after the final inspection has been completed. All submissions must be made through the Project Dashboard on the **PWD Plan Review Portal** ☛ www.pwdplanreview.org. All submissions should include the applicant's contact information if the submission is being made by a different engineering firm than that of the original ERSA Application.

Record Drawings

- The Record Drawings may be prepared by Professional Engineers, Registered Architects, Landscape Architects, Professional Land Surveyors, Professional Geologists, and Contractors licensed in the Commonwealth of Pennsylvania. The preparer of the plan must display prominently their signature and professional seal, or, in the case of Licensed Contractors, their signature and L&I Contractor License Number, on each Record Drawing plan sheet. (PA DEP may have different requirements concerning the types of professionals who may prepare Record Drawings. For projects that require a NPDES Permit, the applicant is strongly encouraged to refer to PA DEP's requirements for Record Drawings before selecting a professional to prepare Record Drawing(s) for PWD.)
- The Record Drawing(s) must meet all requirements listed in **Appendix E, Table E-8** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/e-plan-and-report-checklists/table-e-8-record-drawing-requirements.
- The applicant is referred to **Appendix K** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/k-record-drawing-sample for a sample Record Drawing.
- The applicant is referred to **Section 5.3.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-5/5-3-construction-documentation#5.3.2 for more information on Record Drawing construction documentation.

Construction photographs

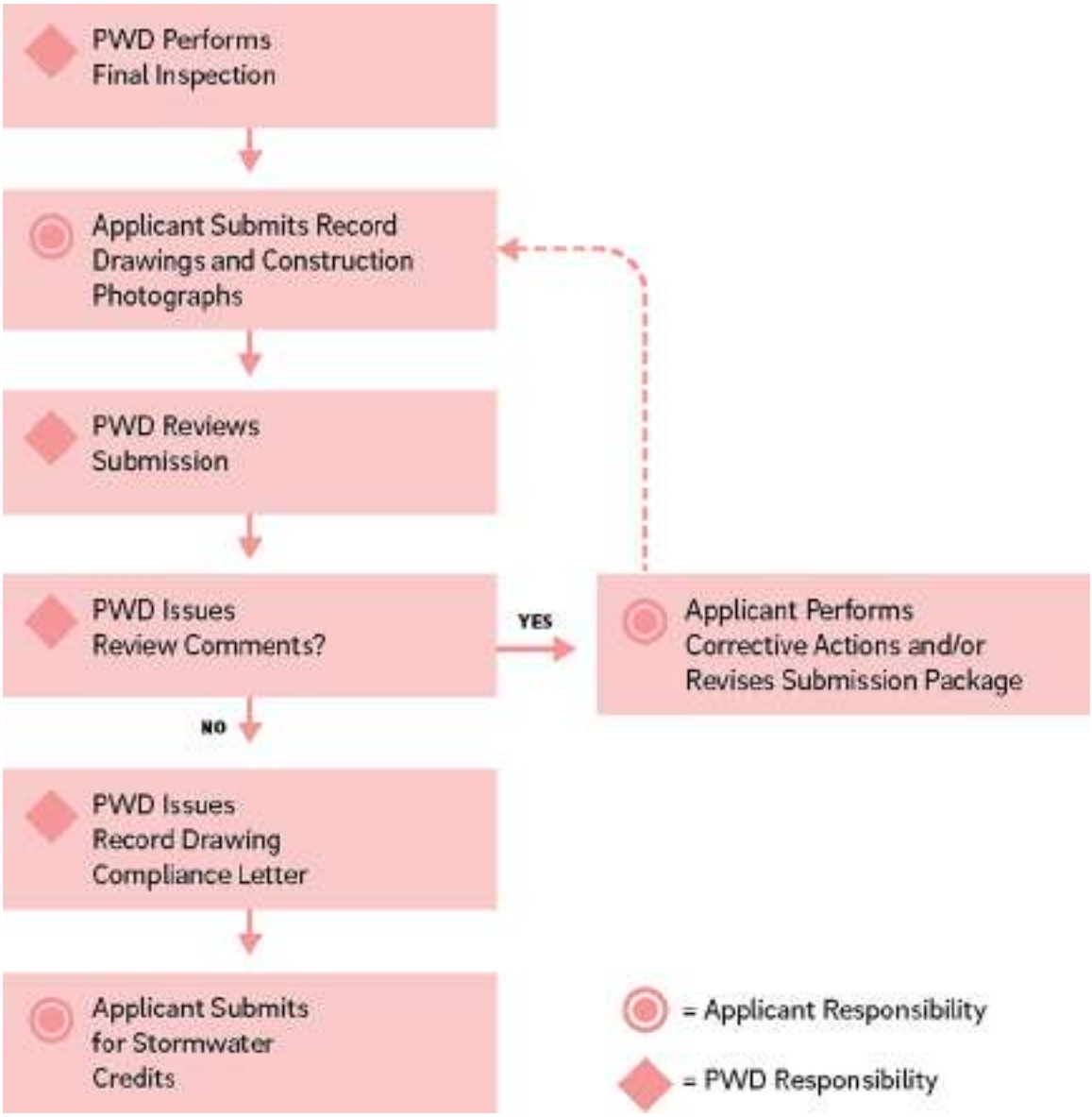
- Stormwater Retrofit projects generally require photographic documentation of key installations, but do not require material receipts.
- The applicant is referred to **Section 5.3.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-5/5-3-construction-documentation#5.3.1 for more information on documentation during construction but does not need to submit a full Construction Certification Package for Stormwater Retrofit projects.

Submission and review process

- The applicant submits the completed Record Drawings and construction photographs to PWD. If any changes occurred during construction that resulted in different drainage area delineations, new drainage area plans should be submitted, as well.
- PWD reviews the submitted Record Drawing(s) and construction photographs to ensure that the project has been constructed in accordance with the project's Approved PCSMP.
- Upon review, PWD will issue comments on the submission via email.
  - If the submitted Record Drawings are determined to be incomplete, the applicant must modify and/or add to the Record Drawings per the comments contained in the letter. Depending on the number and complexity of review comments, the applicant may choose to include a response letter addressing each review comment.
  - If the submitted Record Drawings are determined to be complete, but constructed conditions differ from the Approved PCSMP, PWD may require the applicant to submit calculations prepared by a qualified design professional demonstrating that the SMPs meet stormwater management design criteria. Specifically, PWD may check the SMP storage volume, release rate, drainage areas, and other items that affect an SMP's performance (**Chapter 3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3). If the applicant cannot demonstrate compliance with the applicable stormwater management design criteria, PWD will request that the applicant outline corrective actions to bring the project into compliance. Once corrective actions have been performed, the applicant must contact PWD to re-inspect. If necessary, the applicant must submit requested materials to the Stormwater Billing and Incentives reviewer.
  - If the Record Drawings are determined to be in general accordance with the Approved PCSMP, PWD will issue a letter via email stating as such. Once the closeout process is complete, in accordance with **Appendix M** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/m-pcsmp-project-closeout, PWD will resolve the "Hold Permit Completion" on the "PWD Stormwater Mgmt. Review" for the associated L&I building permit(s) in **eCLIPSE** ☛ www.phila.gov/departments/department-of-licenses-and-inspections/eclipse-faqs.

Most non-residential and condominium projects that comply with Stormwater Regulations per a Record Drawing review and final inspection may be eligible for stormwater credits. A **Stormwater Credits Application (Form B)** ☛ water.phila.gov/wp-content/uploads/files/form-b.pdf may be submitted to Stormwater Billing and Incentives for review once the previously outlined steps are completed. For additional information on stormwater credits, the applicant is referred to **Section 6.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-6/6-3-stormwater-credits.

Figure 2.3-14: Stormwater Retrofit Review Path Record Drawing Review Phase flow chart



2.4 Expedited Post-Construction Stormwater Management Plan Reviews

As an incentive for an applicant proposing green stormwater strategies for stormwater management, the Philadelphia Water Department (PWD) offers two Expedited Post-Construction Stormwater Management Plan (PCSMP) Reviews:

- Disconnection Green Review – **Section 2.4.1** ☛ p. 58
- Surface Green Review – **Section 2.4.2** ☛ p. 60

This section assists the applicant in determining whether a project qualifies for an Expedited PSCMP Review, elaborates on the modified submission requirements (**Section 2.4.3** ☛ p. 62), and provides a list of benefits included in the process.

Only projects in the Development Compliance Review Path can qualify for Expedited PCSMP Review. If eligible, the applicant must identify the project as a candidate for either the Disconnection Green Review or the Surface Green Review when submitting the Existing Resources and Site Analysis (ERSA) Application (**Section 2.1** ☛ p. 4).

Chapter 3 ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3 provides detailed guidance on stormwater management approaches, which the applicant can use as a guide to determine which strategies are appropriate for their site and whether the project may qualify for an Expedited PCSMP Review. Under an Expedited PCSMP Review, the PSCMP Review Phase differs from projects that take a more traditional approach to stormwater management. These differences are discussed in the following Sections.

2.4.1 Disconnection Green Review

Only Redevelopment projects that are exempt from the Channel Protection and Flood Control requirements as defined in **Section 1.2.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1/1-2-stormwater-regulations#1.2.1 are eligible for a Disconnection Green Review, and they must disconnect 95% or more of the post-construction impervious area within the project's limits of disturbance (LOD). Projects eligible for a Disconnection Green Review only use disconnected impervious cover (DIC) to comply with Post-Construction Stormwater Management (PCSM) Requirements (**Section 1.2.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1/1-2-stormwater-regulations#1.2.1). Examples of projects that are most likely to benefit from this approach include trail and park projects, as well as residential and industrial projects where significant green roofs, permeable pavers, and/or reinforced turf are proposed.

Disconnections eligible for use in Disconnection Green Reviews include:

- Green roofs (**Section 3.1.5** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-1-site-assessment-and-stormwater-management-strategies/#3.1.5 and **Section 4.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-3-green-roofs);
- Permeable pavers (**Section 3.1.5** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-1-site-assessment-and-stormwater-management-strategies/#3.1.5 and **Section 4.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-2-porous-surfaces);
- Reinforced turf (**Section 3.1.5** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-1-site-assessment-and-stormwater-management-strategies/#3.1.5 and **Section 4.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-2-porous-surfaces);
- Porous play safety surfaces (**Section 3.1.5** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-1-site-assessment-and-stormwater-management-strategies/#3.1.5 and **Section 4.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-2-porous-surfaces);
- DIC artificial turf athletic fields (**Section 3.5.5** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-5-integrated-stormwater-management-examples#3.5.5 details their important distinction from artificial turf athletic fields atop subsurface SMPs to manage directly connected impervious area (DCIA));
- Existing and proposed tree credits (**Section 3.1.5** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-1-site-assessment-and-stormwater-management-strategies/#3.1.5);
- Pavement disconnections (**Section 3.1.5** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-1-site-assessment-and-stormwater-management-strategies/#3.1.5); and
- Rooftop disconnections (**Section 3.1.5** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-1-site-assessment-and-stormwater-management-strategies/#3.1.5).

The applicant must identify the project's intent to qualify for a Disconnection Green Review when submitting the ERSA Application (**Section 2.1** ☛ p. 4) and will be notified by PWD of the project's eligibility.

Projects qualifying for the Disconnection Green Review benefit from the following:

- Shorter (five-day) review during the PCSMP Review Phase;
- Exemption from the infiltration testing requirements (**Section 3.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-3-infiltration-testing-and-soil-assessment-for-smp-design); and
- Use of **PWD Standard Details** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/l-standard-details for green roofs and porous surfaces.

If additional stormwater management practices (SMPs) are needed to comply with National Pollutant Discharge Elimination System (NPDES) Permit requirements from the Pennsylvania Department of Environmental Protection (PA DEP), contact PWD to discuss Disconnection Green Review eligibility.

2.4.2 Surface Green Review

New Development and Redevelopment projects that can demonstrate that 100% of post-construction impervious area within the project's LOD is managed by DIC and/or bioinfiltration/bioretention basins to comply with PCSM Requirements (**Section 1.2.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1/1-2-stormwater-regulations#1.2.1) are eligible for Surface Green Review.

Eligible SMPs and disconnections consist of:

- Bioinfiltration/bioretention basins (**Section 4.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-1-bioinfiltration-bioretention);
- Blue-green roofs (**Section 4.14** ☛ water.phila.gov/development/?page_id=5390&preview=true);
- Green roofs (**Section 3.1.5** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-1-site-assessment-and-stormwater-management-strategies/#3.1.5 and **Section 4.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-3-green-roofs);
- Permeable pavers (**Section 3.1.5** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-1-site-assessment-and-stormwater-management-strategies/#3.1.5 and **Section 4.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-2-porous-surfaces);
- Reinforced turf (**Section 3.1.5** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-1-site-assessment-and-stormwater-management-strategies/#3.1.5 and **Section 4.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-2-porous-surfaces);
- Porous play safety surfaces (**Section 3.1.5** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-1-site-assessment-and-stormwater-management-strategies/#3.1.5 and **Section 4.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-2-porous-surfaces);
- DIC artificial turf athletic fields (**Section 3.5.5** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-5-integrated-stormwater-management-examples#3.5.5 details their important distinction from artificial turf athletic fields atop subsurface SMPs to manage DCIA);
- Existing and proposed tree credits (**Section 3.1.5** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-1-site-assessment-and-stormwater-management-strategies/#3.1.5);
- Pavement disconnections (**Section 3.1.5** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-1-site-assessment-and-stormwater-management-strategies/#3.1.5); and
- Rooftop disconnections (**Section 3.1.5** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-1-site-assessment-and-stormwater-management-strategies/#3.1.5).

The applicant must identify the project's intent to qualify for a Surface Green Review when submitting the ERSA Application (**Section 2.1** ☛ p. 4) and will be notified by PWD of the project's eligibility.

Projects qualifying for a Surface Green Review benefit from the following:

- Shorter (five-day) review during the PCSMP Review Phase;
- An option to delay infiltration testing until construction to provide flexibility and potential cost savings. This only applies to projects using bioinfiltration/bioretention basins meeting the minimum requirements set forth in the Bioinfiltration/Bioretention Basin Standard Detail in conjunction with the Bioinfiltration/Bioretention Basin Sizing Table (**Table 4.1.4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-1-bioinfiltration-bioretention/#Table_4.1-4), both found in **Section 4.1.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-1-bioinfiltration-bioretention/#4.1.3; and
- Use of **PWD Standard Details** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/l-standard-details for bioinfiltration/bioretention basins, green roofs, and porous surfaces.

Projects that qualify for a Surface Green Review must still meet all applicable PCSM Requirements, which may include the Channel Protection, Flood Control, and Public Health and Safety Release Rate requirements. However, using DIC as a stormwater management strategy, an applicant may be able to qualify for exemptions from Channel Protection and Flood Control requirements by demonstrating a 20% reduction in impervious area from the predevelopment condition to the post-development condition (**Section 1.2.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1/1-2-stormwater-regulations#1.2.1). Use of Stormwater Management Trading as a compliance strategy (**Section 3.2.4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-2-stormwater-management-design#3.2.4) precludes a project from qualifying for a Surface Green Review. Applications that fall into this category are encouraged to contact PWD prior to ERSA Application submission to confirm Expedited PCSMP Review eligibility.

2.4.3 Expedited PCSMP Review process

An applicant who chooses to pursue either the Disconnection Green Review or Surface Green Review must declare this intent when submitting the ERSA Application (**Section 2.1.1** ☛ p. 5). By doing so, PWD can evaluate whether specific review requirements are being met in the Conceptual Review Phase (**Section 2.3** ☛ p. 16) and the applicant will know early on when, or if, infiltration testing will be required during the design process.

If the stormwater management approach changes during the plan review process and the applicant would like to consider pursuing an Expedited PCSMP Review, the applicant must contact PWD Stormwater Plan Review before resubmitting to discuss specific design and submission requirements.

The applicant is encouraged to use Stormwater Plan Review's Standard Details, including details for green roofs, porous surfaces, and bioinfiltration/bioretention basins, which are available in **Appendix L** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/l-standard-details of this Manual, when designing their project for Expedited PCSMP Review. Projects that are required to obtain a NPDES Permit from PA DEP should plan accordingly, as the shorter review times of PWD's Expedited PCSMP Reviews do not affect the NPDES Permit review process (**Section 2.7** ☛ p. 69).

2.5 PWD's Development Review Process

The Philadelphia Water Department (PWD) is organized into several different programs, each with various responsibilities and authority regarding land development. Many of the approvals needed from programs other than Stormwater Plan Review and Stormwater Billing and Incentives are related to water and sewer connections or instances in which PWD infrastructure is affected by a proposed development. Although the Development Services Unit will coordinate with other PWD programs throughout the review process, it is the applicant's responsibility to ensure obtainment of all required approvals from applicable PWD programs and other City and State agencies before beginning construction. For more information on other PWD programs involved in the development process, the applicant is encouraged to visit **PWD Development Services** ☛ water.phila.gov/development.

2.6 PWD's Role in Philadelphia's Development Process

Philadelphia Water Department (PWD) approvals are only one part of the full set of approvals required for development within Philadelphia. PWD approvals are often prerequisites for other approvals or permits. For example, the PWD Post-Construction Stormwater Management Plan (PCSMP) approval is required before the applicant may obtain a Building Permit from the City of Philadelphia **Department of Licenses and Inspections (L&I)** ☛ www.phila.gov/li. Less formally, PWD also coordinates reviews with other City agencies to promote continuity between department reviews and expedite the applicant through the City's development review process when feasible. This section provides a brief description of the City departments with which PWD interacts and overlaps as part of the City's development review process. It does not describe the full extent of each department's work, but rather a perspective of their work as it relates to PWD's review.

Licenses and Inspections

Permitting

PWD works closely with L&I to enforce the PWD Stormwater Regulations (Stormwater Regulations) and safe building practices through the issuance of various L&I permits, including Zoning, Plumbing, and Building Permits, and through active construction and maintenance inspections. PWD sign-off is a prerequisite approval for many types of permits issued by L&I.

Projects that apply for permits through the L&I Electronic Commercial Licensing, Inspection, and Permit Services Enterprise (eCLIPSE) system will require separate sign-offs from each applicable PWD unit. The applicant is referred to the **L&I eCLIPSE FAQs** ☛ www.phila.gov/departments/department-of-licenses-and-inspections/eclipse-faqs website for more guidance on eCLIPSE.

As part of the Zoning Permit review, the applicant will need to obtain PWD Conceptual Approval if the total earth disturbance associated with the project exceeds 5,000 square feet (**Section 2.3** ☛ p. 16). The primary purpose of the Conceptual Review Phase is to demonstrate compliance with the Stormwater Regulations. However, if the applicant is applying for a stormwater management-based height or density bonus, including the **Green Roof Density Bonus or Height Bonus** ☛ water.phila.gov/stormwater/incentives/development in the East Callowhill or Central Delaware Overlay Districts (Philadelphia Zoning Code § 14-702(14)), acknowledgement that the PWD requirements for the bonus have been met will be noted in the Conceptual Approval Letter. Therefore, it is important for the applicant to note in the ERSA Application (**Section 2.1.1** ☛ p. 5) if such a bonus is being sought. PWD does not review Conceptual Stormwater Management Plans for compliance with all aspects of the Zoning Code. It is the applicant's responsibility to make sure all plans submitted to PWD are code compliant.

A summary of required PWD approvals by L&I permit type is provided in Table 2.6-1.

Table 2.6-1: Summary of required PWD approval by L&I permit type

L&I Permit	Required PWD approval
Zoning Permit	• PWD Conceptual Approval is required for projects that propose more than 5,000 square feet of earth disturbance or applying for a stormwater management height or density bonus.
Building Permit – Demolition	• PWD Conceptual Approval is required for projects that propose more than 5,000 square feet of earth disturbance. • Projects that propose more than one acre also require a NPDES Permit from PA DEP (**Section 2.7** ☛ p. 69). • Discontinuance Permits are required to terminate existing water services prior to demolition.
Building Permit – Foundation Only, New Construction, and Site/Utility	• PWD Conceptual Approval is required for projects that propose more than 5,000 square feet of earth disturbance. • If more than 15,000 square feet of earth disturbance (5,000 square feet in the Darby and Cobbs Creeks Watershed) is proposed, PCSMP Approval will be required. • A NPDES Permit is required from PA DEP for projects that propose more than one acre of disturbance (**Section 2.7** ☛ p. 69). • Approvals are also required from Utility Plan Review and Sewage Facilities Planning (Act 537). • Private Cost Approval and approval from Green Stormwater Operations may be required if the project will impact PWD infrastructure.
Plumbing Permit	• Required PWD approvals for Plumbing Permits can be found at **Water and Sewer Connection Permits** ☛ water.phila.gov/development/connections/permits.

Enforcement

PWD Development Services staff coordinate with L&I staff in the enforcement of development projects that are not in compliance with Stormwater Regulations or the ***Pennsylvania Department of Environmental Protection (PA DEP) Erosion and Sediment Pollution Control Program Manual*** ☛ https://www.dep.pa.gov/Business/Water/CleanWater/StormwaterMgmt/Stormwater%20Construction/Pages/E-S%20Resources.aspx (2012 or latest). When deemed necessary, PWD will request L&I enforcement support on non-compliant properties.

The City of Philadelphia Plumbing Code

L&I administers the **City of Philadelphia Plumbing Code** ☛ www.phila.gov/departments/department-of-licenses-and-inspections/resources/applicable-codes (Plumbing Code). All requirements of the Plumbing Code must be met when designing a project to meet the Stormwater Regulations. This includes, but is not limited to, the design of all stormwater drainage piping as per the Plumbing Code. PWD will often refer the applicant to L&I for specific questions regarding sewer and water configurations as related to the Plumbing Code.

Floodplain Construction Approval

L&I requires **flood protection documents** ☛ www.phila.gov/services/permits-violations-licenses/apply-for-a-permit/building-and-repair/get-approval-for-construction-in-the-floodplain and **flood protection scoping meetings** ☛ https://form.jotform.com/83434300042139 for projects that are proposing construction, additions, renovations, and/or alterations in the floodplain over a project cost minimum. Floodplain scoping meetings should be held before zoning and/or Building Permit applications in order to receive a required Project Summary to submit with the application. PWD will refer the applicant to L&I for specific questions regarding applicability and requirements for work in the floodplain.

Streets Department

The **Streets Department** ☛ www.phila.gov/departments/department-of-streets is involved in the review of most development projects, particularly if a street opening or closing permit is required, there is bollard installation, new driveway or curb cuts are to be constructed, there are changes to ROWs or curb line widths, Americans with Disabilities Act (ADA) improvements are needed, or other ROW improvements are involved. As part of their plan review process, the Streets Department solicits comments from PWD Stormwater Plan Review and PWD Engineering Design Review to incorporate in their review letters. The comments provided by PWD will often direct the applicant to make a formal submission to the appropriate PWD unit for review.

If the applicant is proposing to make changes to PWD infrastructure located within the public ROW to accommodate a development, this work must be reviewed by the Streets Department. This includes minor improvements, such as relocation of an inlet, as well as major improvements, such as the complete striking of an existing drainage ROW. As part of their review, PWD Engineering Design Review will clarify for the applicant when and how the Streets Department should be notified.

Department of Planning and Development

The **Department of Planning and Development** ☛ www.phila.gov/departments/department-of-planning-and-development facilitates the **Division of Development Services** ☛ www.phila.gov/departments/division-of-development-services, which helps large real estate projects connect to key City departments through Developer Services Committee Meetings. The applicant can contact the Department of Planning and Development to convene a meeting of the committee. A representative from PWD Development Services will attend these meetings.

Philadelphia City Planning Commission

The **Philadelphia City Planning Commission** ☛ www.phila.gov/departments/philadelphia-city-planning-commission (PCPC) reviews development projects for various reasons, including the relocation of lot lines, location in Neighborhood Conservation Districts, Façade Control Districts, the construction of parking garages or surface parking lots, parking lot stripe modifications, and location within floodplains. As part of PCPC review, PWD's Conceptual Approval (**Section 2.3** ☛ p. 16) may be required. If the project involves relocation or striking of a public or drainage right-of-way (ROW), approval from PWD may be required. These prerequisite PWD approvals may also be requested by the **Civic Design Review Committee** ☛ www.phila.gov/services/zoning-planning-development/get-a-plan-review/philadelphia-city-planning-commission-plan-reviews/get-a-civic-design-review for projects that trigger this requirement.

While PWD and PCPC generally conduct their reviews independently, these agencies work directly with each other to administer §14-510 Wissahickon Watershed Overlay of the Philadelphia Code.

Wissahickon Watershed Overlay

To help reduce flooding, erosion, siltation, and channel enlargement resulting from development within the Wissahickon Creek Watershed, additional stormwater management requirements and impervious coverage limits may apply to projects within this watershed.

Projects located in the Wissahickon Creek Watershed are subject to the Philadelphia City Code §14-510 / Wissahickon Watershed Overlay (WWO) District. A map of the overlay is provided within the Code; however, the applicant can determine whether the project lies within the overlay by using the City's **Atlas map** ☛ https://atlas.phila.gov/ tool.

If the project is in the WWO, the applicant is advised to meet with **PCPC** ☛ www.phila.gov/departments/philadelphia-city-planning-commission prior to submitting the project's Existing Resources and Site Analysis (ERSA) Application. Depending on the project's location within the WWO, lot size, and net change in impervious area, PCPC may restrict new impervious cover, or impose additional stormwater management requirements (beyond PWD's Stormwater Regulations), which must be noted by the applicant in the project's ERSA Application (**Section 2.1.1** ☛ p. 5). Should the project be applicable to additional requirements as determined by PCPC, PWD Stormwater Plan Review will be responsible for review of the PCSMP.

PCPC does not use an earth disturbance threshold when determining whether stormwater management is required. Therefore, it is possible for development projects to trigger Post-Construction Stomwater Management Requirements under the WWO without triggering the Stormwater Regulations. Projects that fall under this category must follow the Development Compliance Review Path as defined in **Section 2.2.1** ☛ p. 11. These projects must also abide by all PWD design standards when designing systems to meet the WWO stormwater requirement.

Office of Property Assessment

For projects that trigger the Stormwater Regulations, PWD uses the **Office of Property Assessment** ☛ www.phila.gov/departments/office-of-property-assessment (OPA) address records to track projects and determine the appropriate address used in recording the Operations and Maintenance (O&M) Agreements (**Section 6.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-6/6-1-property-owner-inspections-and-maintenance). The applicant is encouraged to refer to the **OPA website** ☛ www.phila.gov/departments/office-of-property-assessment to confirm the legal address prior to submitting an ERSA Application to PWD. If an applicant disagrees with the address being used by PWD in the preparation of the O&M Agreement, the applicant should contact OPA for resolution.

PWD also uses OPA records to determine property classification (residential, non-residential, or condominium), which factor heavily into determining a monthly stormwater bill. If, over the course of a development, these features change, the applicant is advised to contact **PWD Stormwater Billing and Incentives** ☛ water.phila.gov/stormwater/billing so that the appropriate changes are reflected in subsequent stormwater bills.

Department of Records

O&M Agreements are recorded against the property for all projects that trigger the Stormwater Regulations or Stormwater Retrofit projects that receive Stormwater Grant funding. The owner is responsible for the recording of the O&M Agreement with the **Department of Records** ☛ www.phila.gov/departments/department-of-records (DOR); however, PWD may record this Agreement on the owner's behalf. The DOR charges a fee for all recordings and the DOR **fee schedule** ☛ www.phila.gov/documents/fee-schedules-department-of-records is used to determine O&M Agreement recording fees. To obtain a copy of the recorded O&M Agreement, the applicant must **contact DOR** ☛ www.phila.gov/departments/department-of-records. PWD also uses DOR deed records to determine parcel boundaries.

Historical Commission

Properties on the Philadelphia Register of Historic Places may need approval from the Philadelphia Historical Commission before starting any development or Stormwater Retrofit work. The applicant is referred to the **Philadelphia Historical Commission** ☛ www.phila.gov/departments/philadelphia-historical-commission website for more information on design reviews. **Stormwater Billing and Incentives** ☛ water.phila.gov/stormwater/billing can assist with coordination with this commission for Stormwater Retrofit projects.

2.7 PWD and Pennsylvania Department of Environmental Protection

This section outlines the circumstances in which the Philadelphia Water Department (PWD) and the Pennsylvania Department of Environmental Protection (PA DEP) jointly review projects, as well as other circumstances in which reviews are conducted entirely by PA DEP. PWD does not determine what State permits apply to a development project. This is the responsibility of the applicant, who should contact PA DEP directly with any questions.

Please note that projects that are exempt from PA DEP Permit Requirements (such as projects receiving ACOE 404 Permits for Wetlands Mitigation) are not necessarily exempt from the **PWD Stormwater Regulations** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/c-pwd-stormwater-regulations (Stormwater Regulations). The applicant may consult **Section 1.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1/1-1-applicability-factors for more information on Applicability Factors and contact PWD with any questions.

2.7.1 National Pollutant Discharge Elimination System Permits

Most projects proposing more than one acre of earth disturbance are subject to both the General (PAG-02) National Pollutant Discharge Elimination System (NPDES) Permit or Individual NPDES Permit for Stormwater Discharges Associated with Construction Activities and the Stormwater Regulations (or stormwater management design criteria for Stormwater Retrofits). NPDES Permits for land development in Philadelphia are issued by PA DEP, not PWD. The applicant must send NPDES Permit Applications to the PA DEP Southeast Regional Office in Norristown, PA. The applicant should contact PA DEP directly with questions concerning NPDES Permits. Municipal Notifications (such as those required under PA Acts 67, 68, and 127 of 2000) should be sent to the **Philadelphia City Planning Commission** ☛ www.phila.gov/departments/philadelphia-city-planning-commission (PCPC) with the PWD project tracking number listed on all notifications.

PWD recommends that NPDES Permit Applications are submitted concurrently to PA DEP with the Post-Construction Stormwater Management Plan (PCSMP) Review Phase Submission Package (**Section 2.3** ☛ p. 16) to PWD. Instructions for completing the NPDES Permit Applications should be obtained directly from PA DEP. However, the applicant may use the following general guidance when preparing and submitting a NPDES Permit Application:

- If the applicant is applying for a phased NPDES Permit, the phases listed under Section C.4 must match the order of phases submitted to PWD under individual project tracking numbers. The applicant is referred to **Section 2.1.1** ☛ p. 5 for information on PWD Stormwater Plan Review's project tracking numbers.
- The applicant must provide matching plans and reports to both PWD and PA DEP.
- If the applicant is requesting a waiver from PWD's infiltration requirement due to on-site contamination (**Section 3.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-3-infiltration-testing-and-soil-assessment-for-smp-design), the applicant must also submit this waiver request to PA DEP for review as part of the NPDES Permit Application.
- Stormwater Retrofits are subject to NPDES Permits if they propose more than one acre of earth disturbance. Most Stormwater Retrofit projects may be classified as "Site Restoration" projects by PA DEP.

In addition to comments received by PWD, comments the applicant receives from PA DEP must also be incorporated into the PCSMP and Erosion and Sediment Control (E&S) Plans for PWD Stormwater Plan Review and Stormwater Billing and Incentives to issue PCSMP Approval. PCSMP Approval is a prerequisite for receiving a NPDES Permit. However, PWD Stormwater Plan Review and Stormwater Billing and Incentives will not issue PCSMP Approval until receiving confirmation from PA DEP that there are no outstanding comments with the NPDES Permit review.

More information on PA DEP's NPDES Permit Application process and requirements can be found at the following resources:

- **PA DEP website** ☛ https://www.pa.gov/agencies/dep
- **Erosion and Sediment Control requirements (25 Pa. Code §102.4)** ☛ https://www.pacodeandbulletin.gov/Display/pacode?file=/secure/pacode/data/025/chapter102/s102.4.html
- **NPDES Permit Application Notice of Intent (NOI) Instructions and *Completeness Review Checklist*** ☛ https://www.dep.pa.gov/Business/Water/CleanWater/StormwaterMgmt/Stormwater/Pages/NOIApplication.aspx

2.7.2 Other PA DEP requirements

There are circumstances in addition to NPDES Permits for construction activities in which PA DEP review may be required for a project proposed in Philadelphia. These may include projects that are exempt from NPDES Permit Requirements but are still required to have an E&S Plan approved by PA DEP per 025 Pa. Code §102. This also includes projects that propose a new discharge to a water body or that propose activities within regulated waters of the Commonwealth as defined in 025 Pa. Code §105. The applicant is responsible for determining which State requirements apply to their project and is encouraged to contact PA DEP directly with any questions.

Land Recycling and Environmental Remediation Standards Act (Act 2)

Some development and Stormwater Retrofit projects may be affiliated with Act 2, which promotes voluntary remediation of contaminated sites for reuse and can preserve undeveloped land and reduce costs associated with building new infrastructure. Development and Stormwater Retrofit projects that are currently open under Act 2 will need to work with PA DEP directly regarding contamination cleanup requirements. Projects that have previously undergone remediation work under Act 2 will need to confirm that any proposed development or Stormwater Retrofit project work does not interfere with the remediation actions on the site. Contamination on site, identified during Act 2 remediation work, should be avoided when possible. The applicant is responsible for meeting any remediation requirements for work within contaminated areas.

3 Site Design and Stormwater Management Integration

Chapter 3 Site Design and Stormwater Management Integration

PHILADELPHIA WATER DEPARTMENT

3.0 Introduction

Chapter 3, Site Design and Stormwater Management Integration, guides the designer in successfully incorporating stormwater management into development site designs, while meeting the Philadelphia Water Department (PWD) Stormwater Regulations (Stormwater Regulations) and stormwater management design criteria for Stormwater Retrofits. The site design procedure is based on Pennsylvania Department of Environmental Protection recommendations, with minor modifications adapted to conditions in Philadelphia.

3.0.1 How to use this chapter

Before using this chapter, the designer should first review the Stormwater Regulations outlined in **Chapter 1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1. Having determined the applicable Stormwater Regulations, the designer should follow the guidance in Chapter 3 from beginning to end. The Chapter 3 sections are as follows:

Section 3.1 ☛ p. 7 – Site Assessment and Stormwater Management Strategies

Section 3.2 ☛ p. 41 – Stormwater Management Design

Section 3.3 ☛ p. 67 – Infiltration Testing and Soil Assessment for SMP Design

Section 3.4 ☛ p. 85 – How to Show Compliance

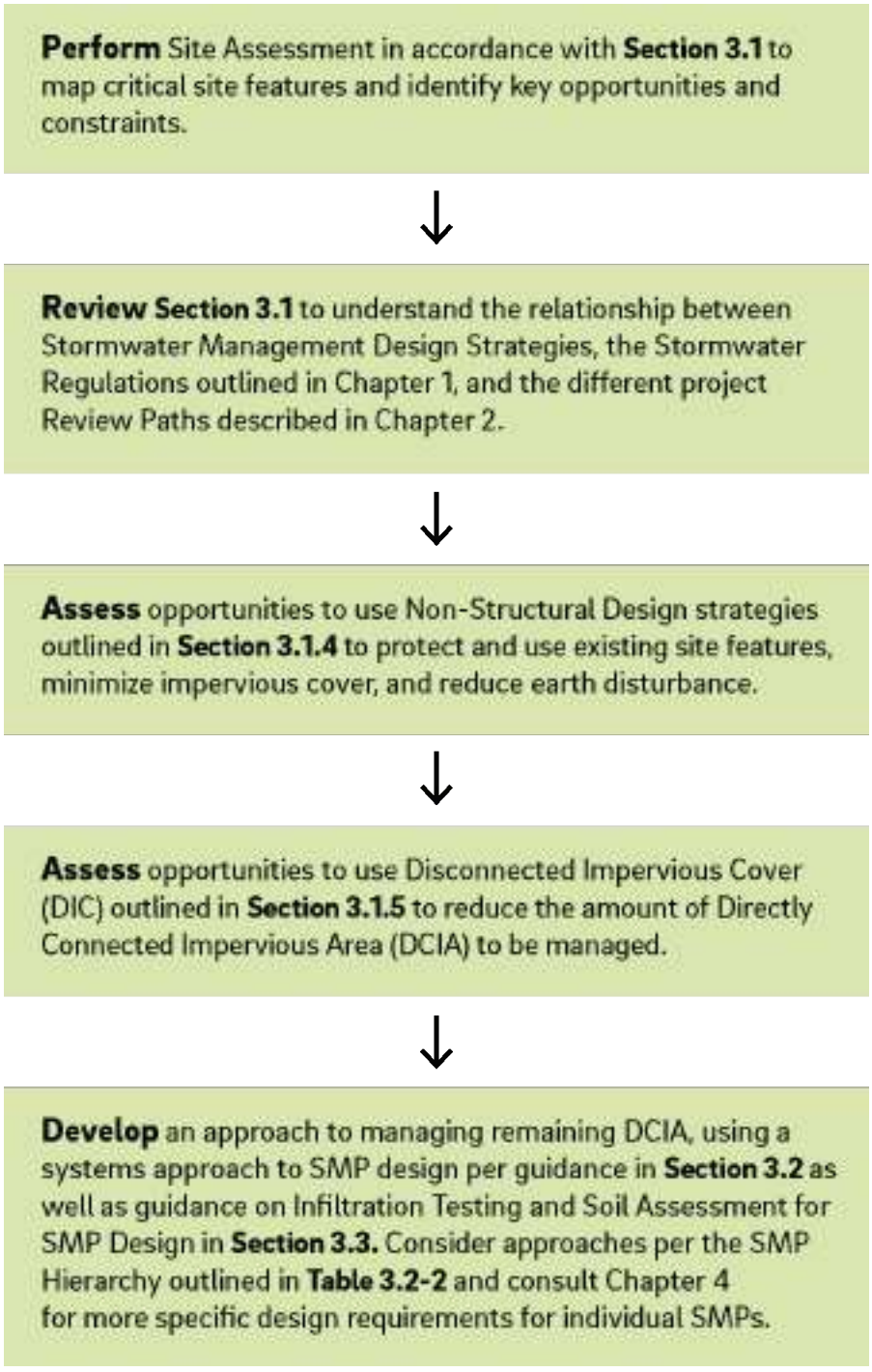
Section 3.5 ☛ p. 107 – Integrated Stormwater Management Examples

This chapter does not provide detailed design requirements for specific stormwater management practices (SMPs). For detailed SMP design requirements, the designer is referred to **Chapter 4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4.

3.0.2 Integrated site and stormwater management assessment and design process overview

This chapter outlines a step-by-step process for integrating robust and cost-effective stormwater management into site designs in ways that achieve PWD's key stormwater management goals of minimizing the harmful effects of flooding and maintaining the health of Philadelphia's streams and rivers. Figure 3.0-1 provides an overview of this process and the following sections represent underlying goals for the designer to keep in mind as they move through the process.

Figure 3.0-1: Chapter 3 process flow chart



Making stormwater a "before-thought"

The most important aspect of PWD's process for stormwater design is to start early, before the development plan and site layout are finalized. By considering green stormwater management approaches in the initial stages of the site design planning process, a comprehensive strategy can be integrated more efficiently, effectively, and creatively. Starting early allows designers to find smart ways to incorporate green stormwater management approaches including PWD's highest-preference SMPs (**Section 3.2.2** ☛ p. 43) and other approaches such as disconnected impervious cover (DIC) (**Section 3.1.5** ☛ p. 22) and non-structural design (**Section 3.1.4** ☛ p. 17), into the design process. Waiting until the site layout is finalized before considering stormwater management leaves the designer with options that are less appealing, have limited environmental benefit, and are often more expensive to build and maintain.

Considering the power of green

An increasing body of research shows that incorporating green features into an urban environment can have economic benefits for developments, including increased property values, reduced crime, positive changes in consumer behavior, and higher resale values. Sites with green features are often regarded as more welcoming and inviting places. Green stormwater management is becoming a powerful tool in the marketplace as it can provide development sites with a range of benefits not offered by more conventional stormwater management approaches. As discussed in the **Introduction** ☛ water.phila.gov/development/stormwater-plan-review/manual/introduction, the City of Philadelphia is committed to a balanced "land-water-infrastructure" approach in achieving its watershed management goals of fishable, swimmable waters. Every land development project plays a critical role in this city-wide effort to realize a collective future as a vibrant, sustainable, and modern city.

Dedicating space for green stormwater management approaches can be challenging (particularly on small or highly constrained lots), but before excluding "green," the designer should consider all outcomes and base decisions on full life cycle costs. Incorporating green stormwater management is PWD's strongly preferred approach for stormwater management and can help streamline the approval process through Expedited Post-Construction Stormwater Management Plan (PCSMP) Reviews (**Section 2.4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-4-expedited-pcsmp-reviews). Preserving open space or using SMPs, such as bioinfiltration/bioretention basins or green roofs, to manage stormwater can add value to a development, while meeting the Stormwater Regulations.

Quick tip

PWD acknowledges that infrastructure-based approaches (such as detention facilities) are not the entire solution. Implementing a range of land-based stormwater management techniques and restoration of aquatic habitats achieves a more balanced "land-water-infrastructure" approach that can help restore stream habitats lost to urbanization, as well as comply with the Stormwater Regulations in a cost-effective manner.

Green approaches toward stormwater management can also be used to achieve compliance with landscaping requirements within the Philadelphia Zoning Code; contribute towards requirements of third-party project certifications such as the United States Green Building Council (USGBC) Leadership in Energy and Environmental Design (LEED) certification program; and help achieve other project-specific goals such as improving aesthetics, providing shade, creating habitat, protecting and enhancing viewsheds, and maintaining safety. Furthermore, green stormwater management approaches have been shown to increase a city's climate resilience through reductions in urban heat impacts and flooding as well as prove local air and water quality benefits. If additional information is desired regarding green stormwater infrastructure's role in climate resiliency, the designer is referred to the Green Infrastructure Leadership Exchange's Climate Resilient Resources Guide.

This chapter provides guidance on PWD's highest-preference SMPs (**Section 3.2.2** ☛ p. 43) and other environmentally friendly approaches to stormwater management such as non-structural design and DIC. The designer is encouraged to use the guidance in this chapter to find creative ways of greening a project site while meeting the Stormwater Regulations. The designer is encouraged to contact PWD Stormwater Plan Review for assistance with incorporating green approaches to stormwater management.

Viewing stormwater as a resource

Stormwater is not wastewater – it's a resource! Stormwater can be collected, stored, and reused on sites for many purposes, including reclaimed water for toilet flushing and source-water for industrial use. These approaches are good for the environment, but can also make economic sense in reducing the need to purchase potable water, and can be incorporated effectively into an overall strategy for Stormwater Regulation compliance. The designer should consider potential reuse applications early in the design process in a collaborative discussion among the building and site design teams. The designer is referred to **Section 4.5** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-5-cisterns, Cisterns, for more information on rainwater harvesting.

Taking a site-wide approach

In order to help the designer take a site-wide approach to stormwater management, PWD offers enhanced tools such as new guidance on placing SMPs in series and Stormwater Management Banking and Trading. Understanding these options is critical when evaluating where and how much stormwater will need to be managed, addressing applicable Stormwater Regulations across multiple SMPs, and reserving various portions of a site for stormwater management. A designer unfamiliar with placing SMPs in series or Stormwater Management Banking and Trading is referred to Sections **3.2.3** ☛ p. 50 and **3.2.4** ☛ p. 55, respectively, for suggestions on getting started.

3.0.3 Interactions between design strategies, Stormwater Regulations, and Review Paths

In using Chapter 3, the designer should understand that some design decisions regarding specific stormwater management strategies can also impact the applicability of the Stormwater Regulations and the appropriate Review Path of a project. As a result, the designer may need to revisit **Chapter 1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1 and **Chapter 2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2 to make sure these initial determinations remain valid.

There is not a "one-to-one" relationship between the review process outlined in **Chapter 2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2 and the site assessment and design process outlined in Chapter 3. Guidance throughout Chapter 3 assists the designer with preparing Conceptual Review Phase and PCSMP Review Phase Submission Packages to PWD. The designer preparing a Conceptual Review Submission Package is referred to guidance throughout Chapter 3 in conducting site assessments and developing an initial stormwater management strategy and Conceptual Stormwater Management Plan. The designer preparing PCSMP Review Submission Packages will find **Section 3.2** ☛ p. 41, **Section 3.3** ☛ p. 67, and **Section 3.4** ☛ p. 85 particularly helpful in understanding the technical requirements associated with specific stormwater management strategies.

Applicable Stormwater Regulations and Review Path vary depending on site characteristics, such as site location and amount of earth disturbance. The designer should pay specific attention to changes in the proposed earth disturbance and directly connected impervious area (DCIA) throughout the design process, as well as the potential applicability of Expedited PCSMP Reviews.

Earth disturbance

The amount of earth disturbance associated with a development project, in part, determines the applicable Stormwater Regulations (**Chapter 1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1), as well as the appropriate Review Path (**Chapter 2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2). In this chapter, the designer will find guidance in using non-structural design techniques that could result in a reduction in earth disturbance. If the level of earth disturbance associated with a project significantly changes as the result of working through the guidance in this chapter, the designer should revisit Chapters 1 and 2 to assess potential changes in applicability.

Directly connected impervious area

Adjustments in a DCIA associated with a development project can impact the applicable Stormwater Regulations. If a project's DCIA significantly changes as the result of working through the guidance in this chapter, the designer should revisit **Chapter 1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1 and **Chapter 2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2 to assess whether the changes in DCIA alter either the applicable Stormwater Regulations or Review Path for the project.

Expedited PCSMP Reviews

A project that proposes a combination of non-structural design, DIC, and/or bioinfiltration/bioretention basins for Stormwater Regulation compliance may be eligible for an Expedited PCSMP Review. As the designer works through Chapter 3, opportunities for modifications in the initial site layout or stormwater management strategy may allow the project to qualify for an Expedited PCSMP Review. The designer is directed to **Section 2.4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-4-expedited-pcsmp-reviews for more guidance on the types of, and requirements for, Expedited PCSMP Reviews.

3.1 Site Assessment and Stormwater Management Strategies

This section will guide the designer in performing a site assessment—the necessary first step in designing a project that complies with the Philadelphia Water Department (PWD) Stormwater Regulations (Stormwater Regulations), or a grant-funded Stormwater Retrofit project. The designer must know the site location and general development plan before beginning the site assessment process.

The assessment consists of two components: the investigation of background site factors, and an analysis of how these factors will shape the development and stormwater management plan for a proposed site. Site assessment must be completed in the early stages of project design, and information gained from the assessment will be requested as part of the Existing Resources and Site Analysis (ERSA) Application Submission Package (**Section 2.1.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-1-existing-resources-and-site-analysis#2.1.1) to PWD. Stormwater Grant-funded Stormwater Retrofits should include site assessment details within the Stormwater Grant Application materials and submitted Conceptual Stormwater Management Plan.

A properly completed site assessment helps the designer understand a site's existing condition and natural systems. The assessment aids the designer in determining the most appropriate site layout and crafting a stormwater management approach and design for a site.

3.1.1 Background site factors and site factors inventory

Macro site factors consist of watershed-scale project site characteristics. These factors include a project's watershed and sewershed, and factors that influence flooding.

Micro site factors are smaller, site-scale features including property/land use boundaries and physical features that may affect the site layout or stormwater compliance strategy, for example, the presence of previously installed stormwater management practices (SMPs) on the project property and adjacent properties. If this is a concern, the designer should refer to PWD's *Big Green Map*, which inventories both public and private stormwater management infrastructure. Both macro and micro factors will play a significant role in determining not only the applicable Stormwater Regulations but also the best strategies for complying.

Project watershed

A watershed is an area of land that contains a common set of drainage pathways, streams, and rivers that all discharge to a single, larger body of water, such as a large river, lake, or ocean. There are seven major watersheds in Philadelphia. Watershed Maps in **Appendix D** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/d-watershed-and-phs-release-rate-maps are available to assist the designer in determining a site's watershed.

While Water Quality requirements are generally consistent across all of Philadelphia's watersheds, they do differ in terms of rate control requirements: specifically, Flood Control and Channel Protection. This is because the frequency and magnitude of flooding in headwater streams is affected to a far greater degree by unmanaged stormwater than in larger receiving bodies of water such as the Schuylkill or Delaware Rivers. There are some watersheds which are especially impaired in terms of water quality, localized flooding, and stream bank erosion that necessitate the compliance of small earth disturbance projects with some or all aspects of the Stormwater Regulations (**Section 1.2.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1/1-2-stormwater-regulations/#1.2.1).

Project sewershed

A sewershed is a defined area of land, or catchment, which drains via storm drain infrastructure to a common outlet point. As opposed to natural watersheds, the boundaries of which are defined by natural ridges, sewershed boundaries are determined by stormwater infrastructure such as curbs, storm drains, pipes, and stream outfalls. Sewershed boundaries may differ from watershed boundaries because stormwater infrastructure may cross watershed boundaries that predate urbanization.

Runoff may leave a site through a combined sewer system, separate sewer system (PWD-owned or private outfall), or via surface runoff. Some project sites may span multiple sewersheds, and runoff may leave different portions of the site via different methods. Discharge to different sewersheds will not only affect the stormwater management strategy, but also the requirements associated with the Water Quality requirement for the site, as these are different in combined sewer areas than other sewersheds. In addition, projects that discharge to a combined sewer system may be subject to a Public Health and Safety (PHS) Release Rate requirement because of specific capacity limitations in the combined sewer system. The designer is referred to **Appendix D** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/d-watershed-and-phs-release-rate-maps for a map of PHS Release Rate areas and their associated rates. Rates can also be found in the **Reg Finder** ☛ www.pwdplanreview.org/reg_finder.

Projects that can discharge stormwater runoff without the use of PWD infrastructure may qualify for exemption from some rate control requirements (**Section 1.2.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1/1-2-stormwater-regulations/#1.2.1); however, they may have additional permitting requirements from the Pennsylvania Department of Environmental Protection (PA DEP) (**Section 2.7** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-7-pwd-and-pennsylvania-department-of-environmental-protection) and may require the creation of easements if stormwater runoff will be directed to neighboring property via piped or diffused discharge.

Appendix D ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/d-watershed-and-phs-release-rate-maps contains Collection System Maps for use in determining the project sewershed. However, applicants with projects that are located near a sewershed boundary may want to contact PWD to confirm.

Flooding

An evaluation of existing flooding issues on a project site, or on adjacent properties, must be performed. For example, it is important to know whether floodwaters flow via an overland flow path on the site, and whether runoff from off-site properties is a component of these flows. It is also crucial to understand how flooding impacts the conveyance capacity of storm sewer infrastructure if the design proposes overflow connections from SMPs. This is especially important for private or semi-private systems. For example, there may be a high tailwater condition at the outfall or connection point during a relatively small rainfall event. The designer must account for these conditions during SMP design.

Although Federal Emergency Management Agency (FEMA) flood maps and related studies show flood-prone areas along the City's streams and rivers, these resources do not adequately address this issue at site scale. Prior property owners, neighbors, and other local sources may be able to indicate anecdotally the extent to which on-site or downstream flooding is already a problem. A review of historic maps may also provide an indication of possible flooding issues, specifically if the site is located in the vicinity of a historic stream or creek that was infilled or bricked up as a combined sewer.

Published FEMA Flood Maps are available at the Philadelphia City Planning Commission, which can be reached by phone at (215) 683-4615, or online at **FEMA's Flood Map Service Center** ☛ https://msc.fema.gov/portal/home.

Property/land use boundaries

Property/land use boundaries refer to the parcel's non-physical boundaries, such as zoning classification and/or overlays, setbacks, and any existing easements. Suitable locations for SMPs must be identified by mapping existing property/land use features. These features often leave large spaces of undevelopable land available for non-structural design opportunities and/or structural SMPs. Boundaries must be depicted on the Existing Conditions Plan submitted during the Conceptual Review Phase. The designer is referred to **Section 2.1.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-1-existing-resources-and-site-analysis#2.1.1 and **Appendix E, Table E-2** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/e-plan-and-report-checklists/table-e-2-existing-conditions-plan-requirements for specific Existing Conditions Plan requirements.

Physical features

It is necessary to assess important physical features within the project site to minimize impacts to these features and to identify opportunities to use existing natural areas and drainage patterns for stormwater management. Table 3.1-1 lists critical physical features that are required to be inventoried and understood, the methods and data sources for assessing these features, and whether each feature is required for an Existing Conditions Plan. Care must be taken to conserve and protect, or avoid, these areas, as appropriate.

Table 3.1-1: Physical site features required in Existing Conditions Plan

Physical Feature	Action	Source
Vegetation	Determine the location and extent of woodlands, riparian areas, or other special habitat areas (e.g., meadows) as defined by the *Pennsylvania Stormwater Best Management Practices (BMP) Manual* (2006 or latest version).	Topographic survey, aerial photography, Geographic Information Systems (GIS) mapping, local and regional natural resources inventories, Pennsylvania Natural Diversity Inventory (PNDI) surveys
Soils and geology	Determine existing soil conditions, expected permeability, hydrologic soil groups, depths to high seasonal groundwater table/bedrock, and presence of hydric soils or special geologic formations (e.g., carbonate). Document whether the site has native soils or if past development has led to fill conditions.	United States Department of Agriculture (USDA) Soil Surveys, hydrologic soil maps, existing geotechnical reports, existing soil investigation or infiltration reports, United States Geological Survey (USGS) Quadrangle Maps, USGS historic fill maps, historical aerial photography, local or regional groundwater studies or well data (Note: Usefulness of soil survey data for soils in urban settings may be limited)
Wetlands, waterways, floodplains, and drainageways	Note location and type of on-site waterbodies, waterways, and floodplains. Determine existing drainage pathways and patterns, both on-site and for site runoff to off-site receiving waters.	Topographic survey, FEMA Flood Maps, aerial photography, GIS mapping
Existing structures and paved areas	Determine on-site location of buildings, sheds, loading docks, parking lots, driveways, sidewalks, trails, etc.	Topographic survey, aerial photography
Existing stormwater infrastructure	Determine on-site locations of stormwater pipes, manholes, inlets, catch basins, outfalls, etc.	Topographic survey, utility records
Existing utilities, sewer, and water lines (within 25 feet of property lines)	Determine on-site locations of sewer pipes, manholes, force mains, water lines, water manholes, valve box covers, gas service lines, gas transmission mains, electric lines, and telephone/ cable/ fiber optic lines.	Topographic survey, utility records, utility locator services (PA One Call, private contractors)
Steep slopes	Determine location of slopes of 15% or greater. Determine whether site is located in Steep Slope Protection Area, as per **Philadelphia Code §14-704(2)** ☛ https://codelibrary.amlegal.com/codes/philadelphia/.	Topographic survey, GIS topographic data, Philadelphia Code

Hotspot investigation and historic fill assessment

Understanding the presence, extent, and location of potential soil, groundwater, or surface water contamination and potentially unstable fill is an important component of characterizing existing site conditions. Infiltration of stormwater through contaminated soils has the potential to negatively impact groundwater and downstream surface water bodies. Additionally, concentrated infiltration of stormwater in areas of unstable fill can increase the potential for soil stability issues such as differential settlement and sinkhole formation. The presence of both contamination and unstable fill can present significant risks to public health and public safety and can damage public and private property.

During this phase of the site assessment, the designer collects important information on both of these factors that may ultimately inform the placement of SMPs as described in **Section 3.2** ☛ p. 41 and whether SMPs can be designed as infiltrating facilities or must instead be designed as slow-release facilities. If a project can comply with the Stormwater Regulations solely through non-structural design techniques and/or disconnected impervious cover (DIC) (Sections **3.1.4** ☛ p. 17 and **3.1.5** ☛ p. 22, respectively), a hotspot and historic fill assessment may not be needed for stormwater management purposes.

The designer should use the following hotspot investigation and historic fill assessment procedure to identify soil contamination and unstable fill risks and to evaluate the potential for implementing infiltration SMPs if these conditions are present.

Step 1

Determine the prior land use at the site where development is proposed, and review all available data on soil and groundwater quality.

This can be done through a formal Phase I site assessment or informally by conducting a title search; a review of aerial photographs, soil surveys, topographic maps, City and State regulatory databases; and a review of local and State records. Historic maps, records of previous construction, local knowledge, or test pit data can also be used to determine whether contamination is present on-site, if the site has a history of hotspots, or the presence of unstable fill.

Step 2

Determine the potential for groundwater or surface water contamination through infiltrating SMPs based on available data and prior land use (determined in Step 1), history of hotspots, and suspected/known presence of unstable fill.

The following land uses are considered to have a potential for contaminated soil, which may adversely affect the quality of groundwater discharging to surface water. These uses may qualify a project site, or portions of it, as a hotspot.

- Sites designated as Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites, also known as Superfund Sites,
- Sites registered under PA DEP's Land Recycling Program, or Act 2 sites (**Section 2.7.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-7-pwd-and-pennsylvania-department-of-environmental-protection#2.7.2),
- Auto recycling facilities and junkyards,
- Commercial laundry and dry-cleaning facilities,
- Commercial nurseries,
- Vehicle fueling stations, service and maintenance areas,
- Toxic chemical manufacturing and storage facilities,
- Petroleum storage and refining facilities,
- Public works storage areas,
- Airports and deicing facilities,
- Railroads and rail yards,
- Marinas and ports,
- Heavy manufacturing and power generation facilities,
- Landfills and hazardous waste material disposal facilities, and
- Sites located on subsurface material such as fly ash known to contain mobile heavy metals and toxins.

Infiltration is required on all sites unless the designer can show that it is not feasible. A common factor in the preclusion of infiltration is the potential for contaminant migration (Step 3). Hotspot usage and historic fill sites could contain fill material, such as fly ash, which may contain mobile metals and toxins, as well as being a potentially unstable soil. When concentrated infiltration is present within regions with known hotspot usage or fly ash fill, infiltration can lead to extensive erosion and subsidence of infill containing very fine material. The designer is responsible for investigating the presence of contaminated or unstable soils.

If Steps 1 and 2 reveal that the presence of hotspots or unstable fill is known or anticipated, the designer must proceed to the detailed testing procedures in Step 3. Before starting Step 3, the designer is encouraged to identify initial areas that could be used for stormwater management so that testing can be focused on potential SMP areas.

Step 3 (if necessary)

Conduct field investigations to further evaluate contamination and/or historic fill.

For project sites that qualify as hotspots, due diligence must be performed to determine whether any contamination is present on-site. It is insufficient to rule out infiltration based on historical site uses alone. Testing must be performed to determine whether the site is contaminated and, if so, the areas where contamination is concentrated. Even if a site is contaminated, there may be some areas where infiltration is still feasible. Contamination must be evaluated per PA DEP guidelines, including, but not limited to, comparing testing results to PA DEP Direct Contact Medium Specific Concentration (MSC) thresholds and Soil-to-Groundwater MSC thresholds, evaluating contaminant solubility, and conducting Synthetic Precipitation Leachate Procedure (SPLP, EPA Method SW-846-1312) testing.

For project sites that anticipate the presence of unstable fill, the designer must work with a geotechnical professional to create an action to identify if unstable fill exists and whether the fill is suitable for infiltration. Field testing may include, though is not limited to, soil sampling, the use of ground penetrating radar (GPR), and electromagnetic induction (EMI) scanning.

Many sites in Philadelphia are constructed on fill; however, the presence of fill alone does not preclude a site from installing infiltrating practices. A waiver from the infiltration requirement can be requested if sufficient proof of soil instability or soil contamination is provided based on soil sampling results (**Section 3.3.6** ☛ p. 81). To request a waiver from infiltration due to contamination, the designer or applicant must submit environmental reports for any testing completed, as well as a justification letter from the geotechnical engineer or environmental professional clearly stating why infiltration is not recommended. If appropriate justification and documentation is provided to demonstrate that contamination or soil stability precludes the site from infiltrating, an impervious liner may be necessary for SMPs where stormwater is concentrated.

3.1.2 Site factors analysis

The final step in the site assessment is to review the information obtained from the background and site factors inventories and perform a stormwater management opportunities and constraints analysis. This analysis will identify areas where stormwater management may or may not be appropriate and assist the designer in making preliminary determinations regarding the size and layout of any development features.

Stormwater management opportunities

The designer must identify site characteristics that are favorable to stormwater management, such as soils with desirable permeability or locations for proposed discharge points (e.g., connections to existing storm sewers). Likewise, site development should be focused as much as possible in areas that provide poor opportunities for stormwater management, maximizing the areas conducive to stormwater. Certain types of critical natural areas can present both constraints to land development and significant opportunities for stormwater management. For example, riparian areas, which are not prime development areas, can sometimes be used to disconnect impervious cover (**Section 3.1.5** ☛ p. 22). However, the environmental impacts of implementing stormwater management in natural areas must be carefully considered.

Recognizing opportunities during site assessment to reduce the proposed directly connected impervious area (DCIA) to manage—while also protecting and using existing site features—can lower the costs associated with projects meeting the Stormwater Regulations or pursuing Stormwater Retrofits. Additionally, proposed site features that are conducive to stormwater management should be identified. For instance, areas such as parking lot islands can be used for surface management of stormwater. The designer is referred to **Section 3.2** ☛ p. 41 for additional guidance on stormwater management design strategies and to **Section 3.5** ☛ p. 107 for examples of integrated stormwater management strategies for different project types.

Stormwater management constraints

Stormwater management constraints are areas on the project site where stormwater management may be difficult, infeasible, or inadvisable. These can include constraints such as contamination, existing utilities, wetlands, riparian buffers, steep slopes, and soils with high permeability. The designer is referred to **Section 3.2** ☛ p. 41 for a discussion of constraints related to specific design strategies and to **Chapter 4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4 for constraints related to different SMP types.

For those development projects where all impervious areas within the limit of disturbance cannot be disconnected, and with constraints that prohibit stormwater management of the remaining DCIA on-site, the applicant should investigate opportunities to provide off-site management as described in **Section 3.2.4** ☛ p. 55 (Stormwater Management Banking and Trading). If no such opportunities exist, the applicant may consider making a one-time fee-in-lieu payment for the unmanaged DCIA. All requests for fee-in-lieu payment must be approved by PWD. More information on the criteria for fee-in-lieu is provided in **Section 3.4.1** ☛ p. 86.

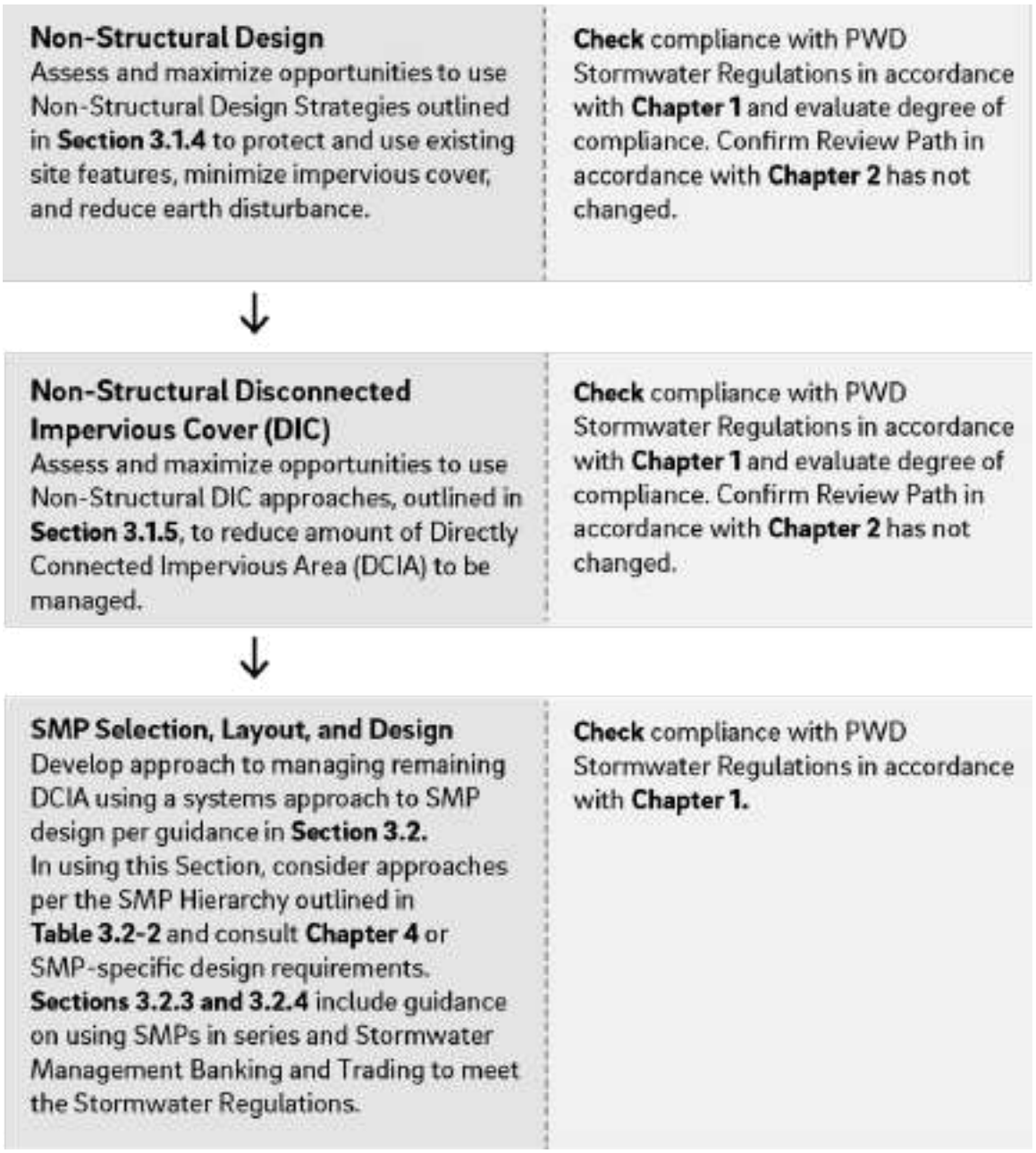
3.1.3 Integrated design approach

PWD has created an integrated design approach through which developers can meet the Stormwater Regulations for proposed development projects. The intent of the approach is to promote the use of stormwater management solutions that protect receiving waters in a cost-effective manner. The integrated design approach presented here is based on recommendations found within the *PA DEP Pennsylvania Stormwater Best Management Practice (BMP) Manual*, with minor modifications for adaptation to Philadelphia's urban conditions. For example, non-structural design, one of three major design strategies discussed in this section, may be challenging to implement in cases where higher densities/intensities are proposed on small sites in densely developed areas. However, non-structural DIC opportunities may be more cost-effective in the highly dense areas of Philadelphia because of energy savings, retail value, and other factors. Additional informational resources on the economic benefits of incorporating green features into an urban environment can be found on the PWD **Stormwater** ☛ water.phila.gov/stormwater webpage.

The process of integrating site development and stormwater management design begins with a comprehensive understanding of existing site conditions facilitated by a site assessment, as described in **Section 3.1.1** ☛ p. 8 and **Section 3.1.2** ☛ p. 14. The site assessment process allows the designer to identify key site and stormwater management design opportunities and constraints. For example, the designer may desire to locate a proposed building to preserve an existing large and mature tree or an area of existing native vegetation in good condition in order to obtain credits for preserving existing trees under **Philadelphia Code §14-705(g)** ☛ https://codelibrary.amlegal.com/codes/philadelphia/latest/philadelphia_pa/0-0-0-307367#rid-0-0-0-293524. In addition, low-lying areas on a site can be used for SMPs in order to minimize conveyance costs.

With an integrated design approach, the designer uses a combination of three primary strategies to meet the Stormwater Regulations, as applicable: non-structural design, non-structural DIC (rooftop, pavement, and/or tree disconnections), and structural SMPs (e.g. bioinfiltration/bioretention basins, porous surfaces, and green roofs). These strategies are implemented initially in sequence, then in an iterative approach, leading to formulation of a comprehensive site and stormwater management design as illustrated in Figure 3.1-1.

Figure 3.1-1: PWD's integrated design approach



3.1.4 Non-structural design

PWD places a premium on protecting sensitive and special value resources and preserving the natural systems and hydrologic functions that may be present on a site. Non-structural strategies, a primary characteristic of low-impact development, promote the treatment, infiltration, evaporation, and transpiration of precipitation close to where it falls, and are the primary means by which the designer works to preserve and protect high-value natural features. PWD recommends that the designer use non-structural design practices early in the site planning process to reduce the size and cost of stormwater management facilities. Implementing these practices involve the careful consideration of the project site's predevelopment condition, topography, natural drainage systems, and landscaping to arrange site development features in ways that minimize the use of impervious cover and the disruption of existing natural features, while promoting the use of construction staging strategies that limit disturbance and soil compaction.

When used in combination, non-structural strategies can result in a variety of environmental and financial benefits. In the designer's interest, the use of non-structural design practices can reduce land clearing and grading costs, reduce the size and cost of stormwater management facilities, reduce the cost and scope of operations and maintenance, and increase property values. In some cases, these strategies can result in the preservation of open space and working lands; the protection of natural systems; and the incorporation of existing site features, such as wetlands and stream corridors, which provide natural hydrologic and water quality functions in addition to fish and wildlife habitat.

Non-structural strategies

While most development sites within Philadelphia do not generally possess extensive natural systems, more modest natural systems and features may possess sufficient value to warrant preservation and integration within the development plan. These features may include mature trees or flowering shrubs, natural topography or rock outcroppings, or plant communities that protect slopes from erosion or act as buffers for streams or drainage ways. The designer must complete a site assessment, as described in **Section 3.1.1** ☛ p. 8 and **Section 3.1.2** ☛ p. 14, to better understand the property's existing physical features before exploring non-structural design strategies.

Following the completion of the site assessment, the first step in the stormwater design process is to thoroughly consider the use of non-structural strategies, finding creative ways of incorporating built features around existing natural areas. Recommended non-structural strategies fall within three categories: protecting sensitive and special value resources, clustering and concentrating, and minimizing disturbance and maintenance.

Protect sensitive and special value resources

To minimize stormwater impacts, land development activities should avoid encroaching on areas that provide important natural stormwater functions, such as floodplains, wetlands, and riparian areas, and on areas that are especially sensitive to stormwater impacts, like steep slopes. These features may not be widespread in the urban environment, but where they do exist, they must be identified and protected. By protecting sensitive and special value resources, the designer can make existing natural features an important and integral part of a development site, enhancing the development's role in the landscape and resilience of the community and providing attractive amenities for future tenants or owners. Protecting these features can also reduce the amount of stormwater runoff discharged from the site. For development

in the floodplain, in addition to the requirements from the City of Philadelphia **Department of Licenses and Inspections** ☛ www.phila.gov/li (L&I), special consideration should be given to SMP placement and design to minimize impacts from current and future floodwater inundation.

Within Philadelphia, most development sites do not have extensive sensitive and special value resources due to the density and history of development in the region. Many of the features that provided hydrologic functions within the landscape have been removed, covered, or buried, and most native soils have been removed, compacted, contaminated, or replaced with low-value fill material and debris. For these reasons, it may be difficult to identify substantial resources or features for protection. This relative scarcity of existing resources, however, prompts PWD to recognize the value and function of less extensive natural areas, even to the extent of valuing an individual tree. PWD urges the designer to consider the preservation and enhancement of natural features present at any scale, as well as enhancements that may help to protect natural features adjacent to the site, such as creating buffer zones or stabilizing steep slopes.

When development sites are adjacent to streams or rivers, riparian buffer systems can protect and enhance streams by limiting erosion, filtering and sequestering pollutants, and providing habitat for wildlife. Riparian buffer systems also aid in the prevention of localized flooding and thereby can protect surrounding property from damage by naturally absorbing flood waters, an important process that will be crucial as extreme storms increase with climate change. Buffers can be especially important along steep banks that are vulnerable to erosion and serve to separate waterbodies from decorative landscape areas where fertilizers are applied, and runoff carries nutrients to the open water. Streambeds—the disturbance of which is regulated by State and Federal regulations—support a variety of life and must be protected from trampling or other abuse. In urban areas where riparian habitat is limited, protecting and enhancing remaining streamside corridors is critical to avoiding further impacts to water quality and ecological health.

Special value features

Trees and shrubs are highly effective at retaining precipitation through interception, and all plants further reduce runoff through evapotranspiration. Well-developed root systems help keep soil ecosystems healthy, enhance infiltration, and limit erosion. Naturally-occurring bioretention areas—small, sometimes saturated areas that sustain plant communities such as pocket wetlands and vernal pools—are effective filters that sequester contaminants and support microbes that decompose organic pollutants. These existing vegetated features should be strongly prioritized for preservation. On larger sites, existing drainage pathways, such as natural draws or swales, should be identified and used whenever possible to convey stormwater in the post-development condition. By identifying these features and integrating their preservation within the development plan, sites can benefit from improved quality and reduced volume of off-site stormwater discharges, while simultaneously providing the many benefits of natural vegetation including wildlife habitat, improved air quality, and reductions in the urban heat island effect.

Riparian areas

When development sites are adjacent to streams or rivers, riparian buffer systems can protect and enhance streams by limiting erosion, filtering and sequestering pollutants, and providing habitat for wildlife. Buffers can be especially important along steep banks that are vulnerable to erosion and serve to separate waterbodies from decorative landscape areas where fertilizers are applied, and runoff carries nutrients to the open water. Streambeds—the disturbance of which is regulated by State and Federal regulations—support a variety of life and must be protected from trampling or other abuse. In urban areas where riparian

habitat is limited, protecting and enhancing remaining streamside corridors is critical to avoiding further impacts to water quality and ecological health.

Natural flow pathways

Where natural flow pathways or depressions exist, the designer should consider using these systems to help manage site runoff. Planting or protecting existing, deep-rooted plant cover within these existing features can limit erosion. Most larger sites, unless highly disturbed, will possess natural drainage features that, when conditions allow, will sustain and support a diverse plant community while also slowing and filtering runoff before it reaches larger bodies of water. These flow pathways can be attractively integrated within the site's landscaping, reducing irrigation demands and providing valuable site amenities that require minimal maintenance. Plant choices should be selected from native species that are adapted to the hydrologic conditions expected within the channel. The designer should assess whether existing drainage features are regulated by State or Federal statutes prior to conducting planting within these areas.

Cluster and concentrate

When assessing the programming needs of the development, the designer should attempt to cluster and concentrate structures in order to build on the smallest area possible and minimize extensive DCIA, reserving as much area as possible for "green" cover. By limiting the footprints of buildings, parking areas, and other DCIA, either through stacking or clustering structures on the site, the designer can leave larger areas open for green space programming without reducing gross density. This practice not only improves the ability of the site to manage stormwater but also increases the opportunity for green amenities and enhances long-term property values. Multi-story buildings also have lower energy consumption per square foot of floor space, fetch higher rent compared with low-rise buildings, and retain the urban character of the city.

This practice is not highly applicable to small or single parcel developments but is more conducive to larger master planning for neighborhoods, campuses for hospitals or educational institutions, or redevelopment of large brownfield sites. In these environments, designation of open spaces can provide enhanced access to shared amenities and promote community cohesion. Concentrating buildings can also reduce per unit construction costs and the cost of providing infrastructure and site circulation.

Minimize disturbance and maintenance

Builders and contractors must minimize unnecessary land disturbance in order to limit the movement and compaction of in situ soils and preserve existing vegetation. When planning and staging construction, the designer should work with contractors to avoid trampling or stockpiling where unnecessary, and to stay clear of special value and environmentally sensitive areas. Disturbed or compacted soils are less effective in supporting plant growth and promoting infiltration. Heavy equipment paths must be well marked to avoid unnecessary compaction of in situ soils in areas specified for open spaces, especially areas where infiltration is intended, and tree guards must be erected to prevent damage from construction vehicles. Site planners should also seek to conform to the existing topography to the greatest extent possible, limiting the cost of grading and planting, reducing soil compaction, and assuring that healthy topsoil remains on the surface. These practices will provide for more robust plant growth, speed the recovery of green spaces following construction, and require less maintenance in the long term.

Disturbed areas must be restored with native and recommended adapted non-invasive plants that do not require chemical maintenance and are selected for the appropriate hydrologic regime. In some cases, it will

be necessary to protect re-vegetated areas during the establishment period by erecting fences and limiting access.



An example of infiltration area marking to avoid compaction during construction in Philadelphia

How to use non-structural strategies to help comply with the Stormwater Regulations

The designer can use non-structural strategies to help comply with the Stormwater Regulations described in **Chapter 1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1 in the following ways:

Water Quality and Channel Protection

Non-structural practices encourage minimizing DCIA, thus reducing the volume of stormwater required to be managed. Additionally, Redevelopment projects that reduce impervious area within the limits of earth disturbance (excluding public right-of-way) by at least 20%—based on a comparison of predevelopment impervious area to post-development DCIA—are exempt from the Channel Protection requirement.

Flood Control

The use of non-structural practices will generally increase on-site stormwater retention and time of concentration, thus reducing the amount and peak flow rate of stormwater required to be managed. Additionally, Redevelopment projects that reduce impervious area within the limits of earth disturbance (excluding public right-of-way) by at least 20%—based on a comparison of predevelopment impervious area to post-development DCIA—are exempt from the Flood Control requirement.

How non-structural design strategies influence the PWD review and approval process

As described in **Chapter 2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2, characteristics of a project will determine the Review Path required for stormwater management compliance. The amount of earth disturbance associated with a proposed project is an important characteristic that can be influenced by non-structural design. By minimizing the amount of earth disturbance, the designer can potentially change Review Paths. For example, a project that is outside of the Darby and Cobbs Creeks or Wissahickon Creek Watersheds and that is able to reduce the amount of earth disturbance to less than 15,000 square feet will be eligible for a Development Exemption Review. After using all possible non-structural strategies to minimize earth disturbance, the designer should refer back to **Chapter 2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2 to confirm the Review Path for the project.

3.1.5 Disconnected impervious cover

This section includes guidance for discharging stormwater runoff from impervious surface and discusses techniques for reducing DCIA through disconnection. Depending on the configuration, all or a portion of disconnected impervious cover (DIC) may be deducted from the post-development impervious cover on a site, leading to an elimination of, or reduction in, total site DCIA. Further, by incorporating DIC into the design of a Redevelopment project, developers may be eligible for an Expedited Post-Construction Stormwater Management Plan (PCSMP) Review. **Section 2.4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-4-expedited-pcsmp-reviews details the criteria for Expedited PCSMP Review eligibility. The Online Technical Worksheet (**Section 3.4.3** ☛ p. 105) guides the designer through this stage of the design process and assists in analysis of post-development impervious area, DIC, and ultimate calculation of total site DCIA. All proposed DIC must be documented in the PCSMP Submission Package (**Section 2.3.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-3-review-phases#2.3.1).

Disconnection strategies

PWD distinguishes between impervious cover from which runoff is directed toward pervious areas for management within the landscape (DIC) and impervious cover from which runoff is directed toward SMPs with discharge/overflow connections to the sewer (DCIA). Disconnection opportunities depend on incorporating sufficient pervious areas into a site layout. Completing a site assessment (**Section 3.1** ☛ p. 7) will help to characterize the nature and extent of existing pervious areas on a site that can be used for impervious area disconnections. Disconnection strategies are described in the following sections.

Rooftop disconnection

A reduction in DCIA is permitted when a roof downspout is directed to a vegetated area that allows for infiltration, filtration, and increased time of concentration. PCSMP Approval issued by PWD Stormwater Plan Review may support the designer in their request to obtain relevant and necessary **City of Philadelphia Plumbing Code** ☛ www.phila.gov/departments/department-of-licenses-and-inspections/resources/applicable-codes variances for approved rooftop disconnections. The designer is advised to contact **L&I** ☛ www.phila.gov/li to confirm the Plumbing Code requirements associated with the disconnection of roof leaders. Under certain circumstances, drainage to an approved point of disposal, SMP, or open space is allowed under the Plumbing Code.

A rooftop is considered to be completely, or partially, disconnected if it meets all of the following requirements:

- The contributing area of rooftop to each disconnected discharge is 500 square feet or less.
- The soil of the pervious area is not designated as a hydrologic soil group “D” or equivalent.
- The overland flow path of the pervious area has a slope of 5% or less.

For designs that meet these requirements, the portion of the roof that may be considered disconnected depends on the length of the overland path as designated in Table 3.2-1.

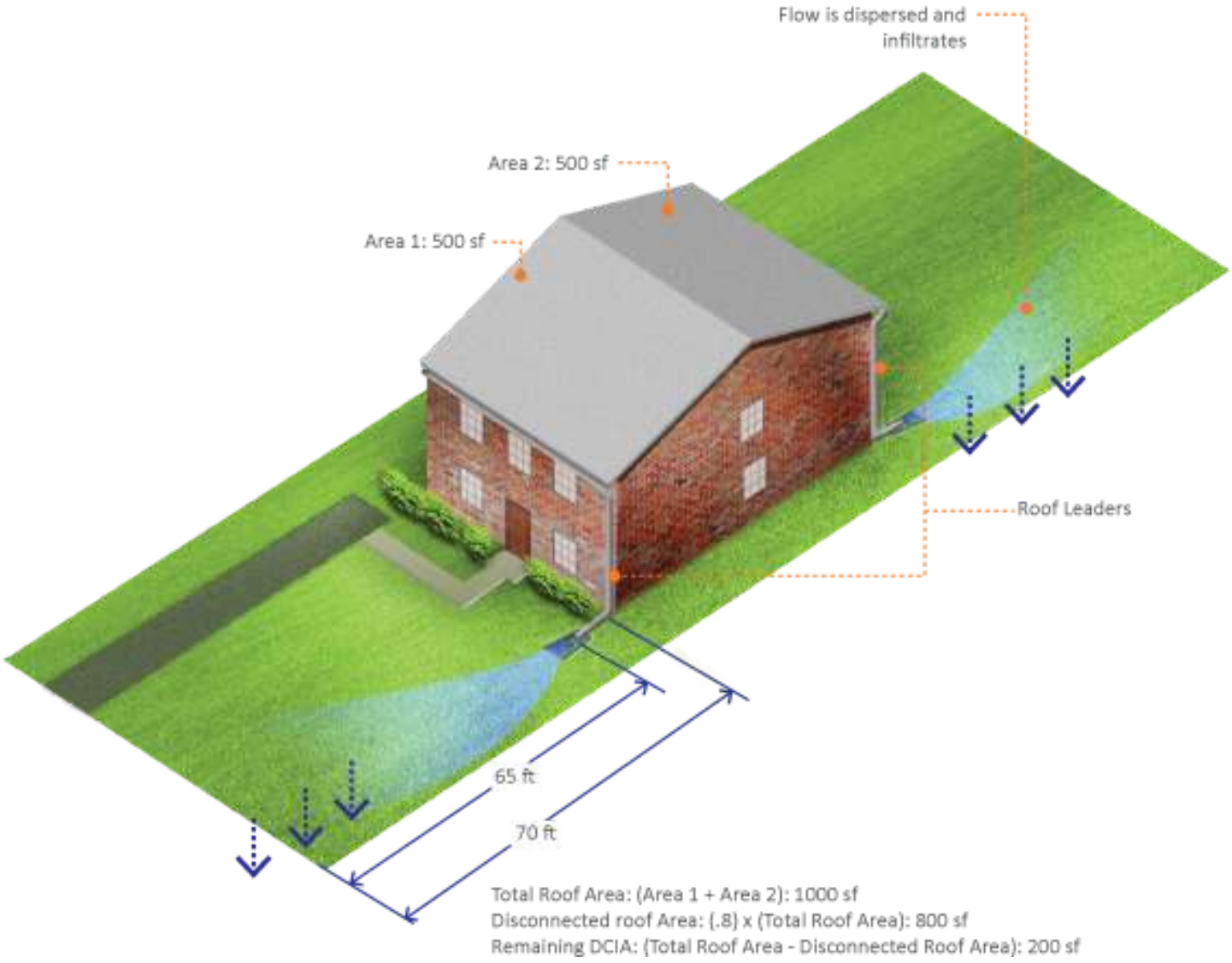
Table 3.1-2: Partial rooftop disconnection

Length of pervious flow path* (feet)	Roof area treated as disconnected (% of contributing roof area)
0–14	0
15–29	20
30–44	40
45–59	60
60–64	80
75 or more	100

*Flow path cannot include DCIA, must be at least 15 feet from any ground-level impervious surfaces, and must be continuous starting from the point of roof leader discharge. Two roof leaders cannot discharge to the same flow path for disconnection credit.

For example, consider a 1,000-square foot roof with two roof leaders, each draining an area of 500 square feet (Figure 3.1-2). Both roof leaders discharge to a lawn. The lawn has type B soils and a slope of 3%. The distance from the downspout discharge point to the street is 65 feet. Therefore, based on Table 3.1-2, 80% of the roof area may be considered disconnected and treated as pervious cover when calculating stormwater management requirements. Disconnecting the roof leaders will significantly reduce the size and cost of stormwater management facilities at this site.

Figure 3.1-2: Rooftop disconnection example



Roof leader disconnection can be incorporated into Stormwater Retrofit designs and is eligible for stormwater credit. The designer is referred to the ***Stormwater Management Service Charge Credits and Appeals Manual*** ☛ water.phila.gov/wp-content/uploads/files/stormwater-credits-appeals-manual.pdf (*Credits and Appeals Manual*) for eligibility requirements.

Pavement disconnection

A reduction in DCIA is permitted when pavement runoff is directed to a vegetated area that allows for infiltration, filtration, and an increased time of concentration. This method is generally applicable to small or narrow pavement structures such as driveways and narrow pathways through otherwise pervious areas (e.g., a trail through a park).



An example of a pavement disconnection in Philadelphia

Pavement is considered to be completely, or partially, disconnected if it meets all of the following requirements:

- The contributing flow path over impervious pavement is no more than 75 feet.
- The length and width of overland flow over pervious areas is greater than, or equal to, the length and width of the contributing flow path over impervious pavement.
- The overland flow is non-concentrated sheet flow over a vegetated area (flow through a swale is not eligible for pavement disconnection credit).
- The soil of the pervious area is not designated as a hydrologic soil group “D” or equivalent.
- The contributing impervious area has a slope of 5% or less.
- The overland flow path of the pervious area has a slope of 5% or less.
- If discharge is concentrated at one or more discrete points, no more than 1,000 square feet may discharge to any one point. In addition, an erosion control measure, such as a gravel strip, is required for concentrated discharges. Erosion control measures are not required for non-concentrated discharges along the entire edge of pavement; however, there must be provision for the establishment of vegetation along the pavement edge and temporary stabilization of the area until vegetation becomes established.

When choosing pavement disconnections, the designer should consider the impact of directing runoff from adjacent impervious areas on the pervious area. Disconnecting larger areas of pavement along stream banks and other potentially erosive or sensitive areas may necessitate additional measures to be taken beyond meeting the minimum requirements.

Pavement disconnection can be incorporated into Stormwater Retrofit designs and is eligible for stormwater credit. The designer is referred to the ***Credits and Appeals Manual*** ☛ water.phila.gov/wp-content/uploads/files/stormwater-credits-appeals-manual.pdf for eligibility requirements.

Tree disconnection credit

A reduction in DCIA is permitted when existing or newly proposed tree canopy (with trees selected from an approved species list) extends over, or is in close proximity to, an impervious area. Trees planted in vegetated practices, such as bioinfiltration/bioretention areas, and that meet the requirements set forth in this section can be used toward tree disconnection credit.



An example of new tree disconnection credit in Philadelphia

Existing tree disconnection credit may be applied for a reduction in DCIA if it meets the following requirements:

- The existing tree species is not an invasive species. The designer is referred to **Appendix I** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists for more information.
- The existing tree is at least a four-inch caliper.
- Existing tree canopies have been field measured, and tree location, size, and species are indicated on submitted plans. Alternatively, an annotated aerial photo clearly showing the existing tree canopy limits has been submitted.
- Only impervious area located directly under the tree canopy area is considered disconnected.
- Overlapping existing tree canopy area is not counted twice toward disconnection credit.
- Existing trees are located outside of the public right-of-way.

New tree disconnection credit may be applied for a reduction in DCIA if it meets the following requirements:

- The proposed tree species are chosen from **Table I-1** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists/#Table_I.1, the recommended and native non-invasive plant list, in **Appendix I** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists.
- New trees are planted within ten feet of ground-level impervious area, within the limits of earth disturbance, and outside of the public right-of-way.
- New deciduous trees are at least two-inch caliper.
- New evergreen trees are at least six feet tall.
- A 100-square foot DCIA reduction is permitted for each new tree. This credit may only be applied to the impervious area adjacent to the tree.
- Overlapping 100-square foot DCIA reduction areas corresponding to adjacent new trees cannot be counted twice toward disconnection credit.

The maximum reduction permitted for both new and existing trees is 25% of ground-level impervious area within the limits of earth disturbance, unless the width of the impervious area is less than ten feet. Up to 100% of narrow impervious areas (e.g., sidewalks and trails) may be disconnected through the application of tree credits.

Tree disconnection credit, as listed above, cannot be incorporated into Stormwater Retrofit designs, but a mature tree with canopy cover over unmanaged impervious area is eligible for Stormwater Credit. The designer is referred to the ***Credits and Appeals Manual*** ☛ water.phila.gov/wp-content/uploads/files/stormwater-credits-appeals-manual.pdf for eligibility requirements.

Green roof

A reduction in DCIA is permitted when a green roof is installed on a proposed building and when the design, construction, and maintenance plans meet the minimum requirements specified in **Section 4.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-3-green-roofs. To encourage the use of this technology, the entire extent of the green roof area may be considered DIC. However, since a green roof is not a zero-discharge system, the remaining site design must safely convey roof runoff from larger storm events to an approved point of discharge. When performing calculations for Flood Control and Public Health and Safety (PHS) Release Rate requirements, green roof discharge (i.e., overflows) must be modeled using appropriate Natural Resources Conservation Service (NRCS) runoff Curve Number (CN) values for green roof areas as described in **Section 3.4.3** ☛ p. 98. The designer is referred to **Section 4.3** ☛ water.phila.gov /development/stormwater-plan-review/manual/chapter-4/4-3-green-roofs for more information on green roofs.

Green roofs may be considered differently for Stormwater Retrofit projects. Designers wishing to incorporate green roofs into Stormwater Retrofit projects should contact **Stormwater Billing and Incentives** ☛ water.phila.gov/development/stormwater-plan-review/manual/introduction/#6 for additional information.



To encourage the use of green roofs, the Philadelphia Water Department considers the entire extent of the green roof as DIC.

Porous surfaces

PWD recognizes two types of porous surface systems that can be used to achieve compliance with the Stormwater Regulations: porous surface DIC areas receiving direct rainfall only; and porous surface over a structural SMP, which is designed to manage direct rainfall and concentrated runoff from adjacent DCIA.

Porous surfaces can be considered DIC when they do not create any areas of concentrated infiltration and do not receive runoff from any adjacent impervious areas.

Porous surfaces over structural SMPs are not considered DIC and therefore must be designed pursuant to the requirements of either a subsurface infiltration (**Section 4.4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-4-subsurface-infiltration) or subsurface detention (**Section 4.8** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-8-subsurface-detention) SMP, depending upon the feasibility of infiltration.

For disconnection credit, the design, construction, and maintenance plan must meet the minimum requirements or porous surfaces DIC, as specified in **Section 4.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-2-porous-surfaces. When performing calculations for Flood Control and PHS Release Rate requirements, appropriate CN values must be used for porous surfaces, as described in **Section 3.4.3** ☛ p. 98.

Porous surfaces may be considered differently for Stormwater Retrofit projects. Designers wishing to incorporate porous surfaces into Stormwater Retrofit projects should contact **Stormwater Billing and Incentives** ☛ water.phila.gov/development/stormwater-plan-review/manual/introduction/#6 for additional information.



The Philadelphia Water Department includes certain types of porous surfaces, such as artificial turf, as DIC.

DIC Applications

There is a broad range of additional applications, including proprietary products, which may be suitable for receipt of disconnection credits. Many of these products will require the use of an appropriate sub-base to allow for storage and infiltration and must generally be installed above non-compacted soil. In most cases, underdrain systems are not required for DIC. The designer must consult with PWD Stormwater Plan Review for specific performance or installation parameters. Potential applications include, but are not limited to, the following:

- Trails (**Section 3.5.4** ☛ p. 116);
- Artificial, or synthetic, turf surfaces for athletic fields (**Section 3.5.5** ☛ p. 118);
- Porous safety surfaces as found in play lots;
- Geogrid systems or other similar reinforced turfs;
- Pervious decking installed over a porous surface; and/or
- Permeable paver tiles with porous grout or gaps.

How to use disconnection strategies to help comply with the Stormwater Regulations

The designer can use DIC to help comply with the Stormwater Regulations described in **Chapter 1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1 in the following ways:

Water Quality and Channel Protection

For the strategies described above, impervious area meeting disconnection criteria is considered DIC; therefore, these projects are not subject to Stormwater Regulations concerning Water Quality and Channel Protection requirements for treatment of on-site DCIA. Implementing DIC can be an excellent strategy for managing small areas of DCIA for which routing the runoff to the proposed SMP is not feasible, such as porches, steps, concrete pads, walkways, or impervious cover atop utility trenching, etc. Additionally, Redevelopment projects that reduce impervious area within the limits of earth disturbance (excluding public right-of-way) by at least 20%—based on a comparison of predevelopment impervious area to post-development DCIA—are exempt from the Channel Protection requirement.

Flood Control

The use of some disconnection strategies such as green roofs and porous surfaces will generally increase on-site stormwater retention, thus reducing the amount and peak flow rate of stormwater required to be managed. Additionally, the use of disconnection strategies reduces DCIA. Redevelopment projects that reduce impervious area within the limits of earth disturbance (excluding public right-of-way) by at least 20% —based on a comparison of predevelopment impervious area to post-development DCIA—are exempt from the Flood Control requirement.

How disconnection design strategies influence the PWD review and approval process

Reducing DCIA through the implementation of DIC can influence the project Review Path, as described in **Chapter 2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2. By incorporating DIC into the design of a Redevelopment project, developers may be eligible for an Expedited PCSMP Review (**Section 2.4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-4-expedited-pcsmp-reviews) to obtain PCSMP Approval faster and meet tighter construction schedules. Disconnection Green Review projects (**Section 2.4.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-4-expedited-pcsmp-reviews#2.4.1) incorporate at least 95% DIC in the stormwater management design in order to meet the Stormwater Regulations, while Surface Green Review projects (**Section 2.4.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-4-expedited-pcsmp-reviews#2.4.2) use a combination of bioinfiltration/bioretention SMPs and DIC to meet the Stormwater Regulations. Disconnection Green Reviews benefit from a shorter (five-day) PCSMP Review Phase and exemption from the infiltration testing requirement. Surface Green Review projects also benefit from a shorter (five-day) PCSMP Review Phase and the option to delay infiltration testing until construction to provide flexibility and potential cost savings.

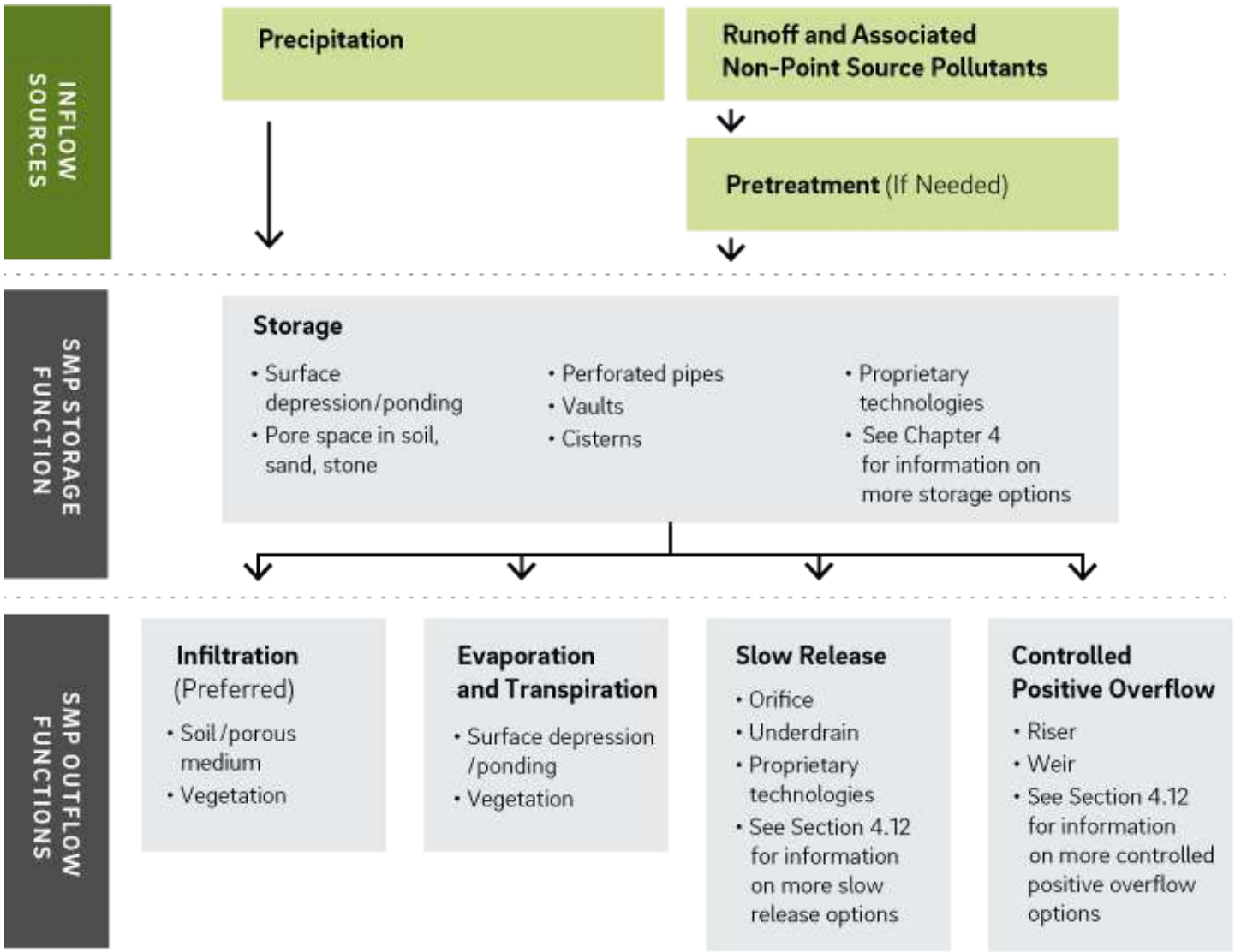
3.1.6 SMP functions

The designer will often need to use SMPs to meet the Stormwater Regulations. PWD expects that the designer will first consider maximizing the use of non-structural design and DIC strategies outlined earlier in this chapter but also recognizes that, for many sites, stormwater management compliance will rely strongly on the use of SMPs.

SMPs are systems that use physical, chemical, and biological processes to provide a certain level of stormwater control and treatment. This level of control typically includes a required storage volume, a volume to be infiltrated, and an acceptable release rate. These requirements are met through five principal hydraulic functions of SMPs, described below.

Figure 3.1-3 illustrates a variety of design elements available to provide these hydraulic functions. Depending on the configuration, physical, chemical, and biological processes lead to the removal of pollutants during these processes. By combining design components in a variety of ways, the designer can identify alternative systems that achieve a given function. The SMP functions are not mutually exclusive and certain SMPs may perform multiple functions.

Figure 3.1-3: Overview of SMP functions



1. Storage

Storage can be provided through surface ponding, enclosed surface storage, or subsurface storage. Subsurface stone storage beds provide storage in stone pore spaces, or voids. Some SMPs, such as bioinfiltration/bioretention basins, can provide a combination of both surface and subsurface storage.

A rough estimate of *surface storage* can be obtained by averaging the surface area and bottom area of a basin and multiplying by the average depth. For irregular shapes, volume can be estimated by finding the area inside each contour, multiplying each area by the contour interval, and adding the results.

Storage in *stone pores* is equal to the volume of the crushed stone bed multiplied by the porosity. A design porosity of 40% can be assumed for the stone if specifications for the crushed stone meet those provided in Chapter 4.

Storage available in *porous media* is equal to the initial moisture deficit, the portion of total porosity that is not already occupied by moisture. This portion varies at the beginning of every storm; acceptable design values are 30% for *sand* and 20% for *growing soil*.

Not all physical space in a given SMP is active. The maximum elevation that is considered active storage is the overflow elevation. In tanks draining by gravity whose bottoms do not infiltrate, any volume below the invert of the orifice or control structure cannot be considered *active storage*.

2. Infiltration

Infiltration of stored water into the underlying soil is desired in order to help restore natural hydrology and reduce the volume of stormwater runoff that enters the City's drainage system. Managing and infiltrating stormwater at its source reduces the risk of localized flooding and combined sewer overflows during heavy rainfall events, which are projected to occur more frequently with climate change. Moreover, the filtration process naturally aids in the removal of pollutants from stormwater runoff and improves the water quality of runoff entering our city's waterways. Surface vegetation helps prolong design life because the growth of plant roots helps to keep the soil pore structure open over time. This effect is greatest with vegetation that has a deeper root structure (e.g., trees, shrubs, and native herbaceous species rather than turf grass). Using such attractive landscaping practices improves the quality of life in the urban landscape.

3. Evaporation and transpiration

Evaporation and transpiration are minor SMP functions when measured over the course of one storm, but they are significant when measured over time. Surface SMPs will provide the greatest evaporation and transpiration benefit, particularly if they are vegetated. Some water that infiltrates the surface will evaporate. For this reason, vegetated systems provide both water quality treatment and volume reduction.

4. Slow release

When stored water cannot be infiltrated or evaporated, it must be released at a slow rate to a sewer or receiving water body. This allows the runoff to slowly drain into the City's system, preventing environmental issues stemming from large amounts of water entering the sewer system or receiving water all at once. For volumes greater than the SMP's infiltrated static storage, and for non-infiltrating SMPs, the SMP may release the volume slowly through an outlet control device. The outlet control structure may require design and maintenance measures to avoid clogging.

5. Controlled positive overflow

All designs must have a mechanism for water to overflow, or bypass, the system unimpeded during events larger than the design event. A riser or other overflow structure can be incorporated into the design to achieve this, or the flow capacity of some SMPs themselves can act as a bypass mechanism.

3.1.7 Pollutant-reducing practices and roof runoff isolation

Pollutant-reducing practices

While infiltration is always preferred, Table 3.1-3 presents a list of acceptable pollutant-reducing practices to be used for projects where infiltration is found to be infeasible. The designer is referred to the **Chapter 4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4 section referenced in the table for detailed design information concerning each SMP type. Additional information on SMP types is provided later in this section within the SMP Selection and Conceptual Design Section. If a particular practice is listed as "not acceptable" within separate sewer or direct discharge areas, it does not imply that this practice cannot be used; it simply means that that particular practice does not qualify as pollutant-reducing when used in those areas.

Table 3.1-3: Acceptable non-infiltrating pollutant-reducing practices

	Section	Combined sewer area	Separate sewer area or direct discharge
Bioretention	**4.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-1-bioinfiltration-bioretention	Yes	Yes
Porous surfaces DIC	**4.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-2-porous-surfaces	Yes	Yes
Green roofs	**4.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-3-green-roofs	Yes	Yes
Blue-green roofs	**4.14** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-14-blue-green-roofs	Yes	Yes
Cisterns	**4.5** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-5-cisterns	Yes	Yes
Blue roofs	**4.6** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-6-blue-roofs	Yes	No

Vegetated media filters	**4.9** ☛ water.phila.gov /development/stormwater -plan-review/manual /chapter-4/4-9-media-filters	Yes	Yes
Media filters	**4.9** ☛ water.phila.gov /development/stormwater -plan-review/manual /chapter-4/4-9-media-filters	Yes	Yes
Subsurface detention maintenance rows	**4.8** ☛ water.phila.gov /development/stormwater -plan-review/manual /chapter-4/4-8-subsurface -detention, **4.9** ☛ water.phila.gov /development/stormwater -plan-review/manual /chapter-4/4-9-media-filters	Yes	Yes
Roof runoff isolation*	**3.1.7** ☛ p. 35	Yes	No

**Roof runoff isolation* is the routing of runoff from non-vehicular roof area that is not commingled with untreated runoff.

Roof runoff isolation

Recognizing that runoff from some areas is cleaner than others, PWD has identified roof runoff isolation as an acceptable non-infiltrating pollutant-reducing practice for use only on projects that are within combined sewer areas and required to comply with Stormwater Regulations. Roof runoff isolation is the practice of segregating roof runoff from runoff exposed to any vehicular activity (e.g., roof-level parking deck) and from untreated surface ground-level runoff, prior to discharging to the sewer.



This Philadelphia parking garage with rooftop vehicular access does not qualify for roof runoff isolation.

The designer can incorporate roof runoff isolation into site layout and design by providing dedicated stormwater conveyance piping from roof areas to SMPs designed to meet the combined sewer area Water Quality slow-release rate requirement. A blue roof (Section 4.6) can also be used as streamlined approach for both achieving roof runoff isolation as well as controlling the roof runoff to meet the Water Quality slow-release requirement. Runoff from isolated roofs must not commingle with roof runoff exposed to vehicular activity or other untreated runoff until a point in the system after which such runoff has been treated by another pollutant-reducing practice. An example of an application of roof runoff isolation is illustrated in Figure 3.1-4.

Figure 3.1-4: Roof runoff isolation example



3.1.8 How to use SMPs to comply with the Regulations

A well-designed SMP will use combinations of the five principal hydraulic functions described above to achieve compliance with Stormwater Regulations. As noted previously, SMPs are one tool available to the designer to meet the Stormwater Regulations. PWD encourages the designer to first consider non-structural design and DIC to meet the Stormwater Regulations prior to considering SMPs (**Section 3.1.4** ☛ p. 17 and **Section 3.1.5** ☛ p. 22). Specific suggestions for using SMPs for compliance are discussed below. The designer should also consult the guidance on designing SMPs in series and Stormwater Management Banking and Trading in Sections **3.2.3** ☛ p. 50 and **3.2.4** ☛ p. 55, respectively, for additional options in using SMPs to help comply with the Stormwater Regulations.

Water Quality

Where infiltration is feasible, each SMP must provide adequate static storage for its entire Water Quality Volume (WQv) below its lowest outlet. Exceptions to this requirement include SMPs in series (for which the series as a whole must comply with this requirement) and dynamically designed bioinfiltration SMPs (for which static storage of only one inch of the WQv must be provided if the designer demonstrates, through dynamic routing, that the full 1.5-inch WQv is managed throughout the design storm, without overflow). Additionally, the designer must ensure a drain down time of no more than 72 hours. Drain down time compliance is typically achieved by varying the storage area dimensions.

Where infiltration is not feasible in a combined sewer area, the WQv must be treated and released at a controlled release rate and routed through an acceptable pollutant-reducing practice. The designer is referred to **Section 3.4.1** ☛ p. 86 for detailed information on how to comply with the Water Quality requirement.

For gravity systems, the target-controlled release rate is a function of head on the outlet structure orifice/weir and the orifice/weir characteristics. Compliance is typically achieved by varying storage area dimensions and outlet structure configuration to meet the target slow-release rate.

Channel Protection (if applicable)

Compliance with the Channel Protection requirement is typically achieved by varying storage area dimensions and outlet structure configuration to reduce the peak outflow rate during the one-year storm. Additionally, the designer must ensure a drain down time of no more than 72 hours. Controlled positive overflow must be provided, typically in the form of a riser or other overflow structure, to safely pass events larger than the one-year design storm. The designer is referred to **Section 3.4.1** ☛ p. 86 for detailed information on how to comply with the Channel Protection requirement.

Flood Control (if applicable)

Compliance with the Flood Control requirement is also typically achieved by varying storage area dimensions and outlet structure configuration to reduce the peak outflow rates for the post-development condition. Peak runoff in the proposed condition must be no greater than the peak runoff in the predevelopment condition for design storms specific to a project's given Flood Management District and discharge point. Controlled positive overflow must be provided, typically in the form of a riser or other overflow structure, to safely pass large storms. The designer is referred to **Section 3.4.1** ☛ p. 86 for detailed information on how to comply with the Flood Control requirement.

3.2 Stormwater Management Design

Section 3.2 contains a significant amount of design guidance that the designer should use to integrate robust and cost-effective stormwater management into site designs in ways that achieve the Philadelphia Water Department's (PWD's) key stormwater management goals of minimizing the harmful effects of flooding and maintaining the health of Philadelphia's streams and rivers. Additionally, this section contains general requirements and standards of which the designer must be aware.

3.2.1 Major SMP types

Infiltrating SMPs

Infiltrating stormwater management practices (SMPs), such as porous surfaces, subsurface infiltration, bioinfiltration practices, and drainage wells manage stormwater by infiltrating it into the ground. The designer is required to use infiltrating practices to meet the Water Quality requirement unless infiltration is found to be infeasible. All infiltrating practices are considered pollutant-reducing.

Slow release SMPs

Slow release SMPs detain and slowly release stormwater over time. Some slow-release practices are inherently pollutant-reducing practices (if stormwater is passed through a soil/vegetation/media complex), while others may need to be designed in series with an additional pollutant-reducing SMP.

Pollutant-reducing SMPs

On sites where infiltration is not feasible, directly connected impervious area (DCIA) must be routed to an acceptable pollutant-reducing practice. **Table 3.1-3** ☛ p. 35 in **Section 3.1.7** ☛ p. 35 presents the non-infiltrating SMPs that PWD currently accepts as pollutant-reducing practices. For detailed information and design guidelines for individual SMPs, the designer is referred to **Chapter 4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4. Alternative pollutant-reducing practices may be proposed and will be reviewed on a case-by-case basis. Pollutant-reducing practices include all infiltrating practices and some slow-release practices.

Vegetated SMPs

Vegetated practices feature vegetation as a significant or dominant component within the storage area and include bioinfiltration/bioretention basins, ponds and wet basins, green roofs, blue-green roofs, and vegetated media filters.

Non-vegetated SMPs

Non-vegetated practices include all subsurface practices, blue roofs, porous surfaces, media filters, and cisterns and do not have significant vegetative components.

3.2.2 SMP Hierarchy and selection process

Download a summary of the SMP Hierarchy guidance, with quick reference information for clients and developers:

- **SMP Hierarchy One-Sheet** ☛ water.phila.gov/wp-content/uploads/files/smp-hierarchy-one-sheet.pdf

The process of selecting the appropriate SMPs for a site is complex and can be challenging, particularly for constrained sites. PWD accepts many different SMPs and offers approaches such as SMPs in series and Stormwater Management Banking and Trading that provide the designer flexibility in fitting SMPs into challenging project sites. During the SMP selection and conceptual design process, the designer will select and propose an initial layout of SMPs that incorporates site assessment data and demonstrates an understanding of remaining stormwater management requirements (after accounting for non-structural design and disconnected impervious cover (DIC) strategies), PWD's SMP preferences, and other factors such as aesthetics, cost, and maintenance requirements. The initial SMP selection and layout process should be performed before finalizing the development site layout, such that the site layout can be revised, if needed, based on SMP requirements. Typically, the designer will complete an initial SMP selection and conceptual design before submitting the Conceptual Review Phase Submission Package (**Section 2.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-3-review-phases) or a Stormwater Grant Application for Stormwater Retrofit projects pursuing **Stormwater Grant** ☛ water.phila.gov/stormwater/incentives/grants funding.

PWD requires that infiltrating SMPs be used to meet the Water Quality requirement unless the designer demonstrates that infiltration is not feasible. Infiltration testing and soil characterization procedures are outlined in **Section 3.3** ☛ p. 67. In many cases, infiltration testing will not be conducted until the initial layout of SMPs has been completed. While it is generally prudent to perform this testing as soon as SMP footprints and depths have been estimated, infiltration testing is not required during conceptual design. By performing both a site assessment and a stormwater management opportunities and constraints analysis in accordance with **Section 3.1** ☛ p. 7, the designer can reduce the likelihood that a properly conducted infiltration and soil characterization plan (**Section 3.3.1** ☛ p. 70) will uncover non-infiltrating subsurface conditions at the proposed SMPs' footprints laid out during SMP selection and conceptual design. A site assessment and opportunities/constraints analysis achieves this by screening out locations that may preclude infiltration—like areas with documented high seasonal groundwater, shallow bedrock, clay, or other limiting soil layers—and steering the conceptual SMP layout toward areas more likely to support infiltration.

PWD recommends the following three-step process for selecting and advancing SMP design through the conceptual design phase.

Step 1 – Understanding the options: The SMP Hierarchy

SMPs can differ greatly from each other in terms of cost, function, and applicability to different types of sites. The designer is encouraged to thoroughly review the SMP-specific guidance provided in **Chapter 4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4 when selecting SMPs. The SMP One-Sheets at the beginning of each SMP chapter should help in understanding the potential for using each SMP type to meet the various Stormwater Regulations.

The SMP Hierarchy is a tool designed to help educate and communicate the Department's order of SMP preference to the development community. This tool has allowed PWD to formulate incentive-based policies that promote the use of high-performance and cost-effective stormwater management approaches that more effectively achieve the goals of the ***Green City, Clean Waters*** ☛ water.phila.gov/green-city program. Similarly, the Hierarchy provides a clear reference point for private developers to understand those SMPs that are most preferred by PWD. Specifically, the Hierarchy seeks to promote practices that:

- Reduce stormwater and pollutants entering and leaving the PWD collection system;
- Are likely to be maintained and have indicated longevity in previous installations; and
- Provide vegetation to create a greener city.

Ranking criteria

The criteria used to rank SMPs reflect a wide range of characteristics, such as water quality and quantity performance, space requirements, construction and maintenance costs, likeliness of failure, and triple bottom line performance. As a result, the Hierarchy promotes preferences based on stormwater management performance, constructability, and longevity. Table 3.2-1 below outlines the main criteria considered when ranking SMPs in order of their relative weight. The SMP One-Sheet at the beginning of each SMP section in **Chapter 4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4 displays relative performance levels for each attribute.

Table 3.2-1: SMP Hierarchy ranking criteria

SMP Hierarchy ranking criteria	
Infiltration and volume reduction	The SMP's ability to infiltrate or reduce the Water Quality volume (WQv)
Effluent pollutant load	The typical annual mass of total suspended solids (TSS) in the SMP's effluent runoff (total annual mass of TSS, accumulated at a point of analysis downstream of the SMP). Annual TSS mass is computed by considering the SMP to be managing one acre of DCIA with effluent event mean concentrations of TSS based on data from the International Stormwater BMP Database.
Likeliness of failure	The relative likelihood that the SMP will fail to operate and will fail to be repaired so that it functions as designed over a unit period of time based on observations at a program level.
Construction costs	The marginal redevelopment implementation costs associated with the construction of the SMP per acre of DCIA treated. As defined in the Long-Term Control Plan Update (LTCPU), marginal redevelopment cost is considered the cost beyond traditional measures to implement an SMP approach, assuming that redevelopment is already proceeding. SMP costs were derived from the construction cost analysis and reference cost assessment prepared for the LTCPU, with updated unit costs.
Evapotranspiration	The SMP's ability to manage stormwater runoff via evapotranspiration (ET). Each SMP is evaluated based on the characteristics of the surface area available for ET and any enhancement factors (vegetation). These vary by typical vegetation cover type and density, as well as any non-vegetative evaporation pathways (i.e., surface water and void spaces).
Triple Bottom Line	The SMP's ability to provide social, environmental, and economic benefits (land value, energy efficiency, etc.).
Water quality rate control	The ability of an SMP to reduce the release rate of the WQv to not exceed the maximum release rate.
Large storm rate control	The ability of an SMP sized for Water Quality compliance to reduce the discharge rate of large runoff events and to be resized to manage large storm events, which is helpful in complying with the Flood Control and PHS Release Rate requirements.
Operations and Maintenance (O&M) costs	The annual costs associated with O&M activities for the SMP. They were derived from the maintenance cost analysis prepared for the LTCPU.
Building footprint encroachment	Encroachment onto site area that could otherwise be used for building footprint.
Ground-level encroachment	Encroachment onto potential usable, open space on the ground-level surface of the site.

The SMP Hierarchy is shown below in Table 3.2-2. All SMPs are classified as one of three preference levels: Highest, Medium, and Lowest.

Highest-preference SMPs

The highest-ranking SMPs include bioinfiltration, bioretention, porous surfaces, green roofs, and blue-green roofs. Bioinfiltration is ranked highest for its ability to infiltrate stormwater and provide triple bottom line benefits while demonstrating cost effectiveness and longevity. Similarly, bioretention ranks highly, an acknowledgement of its ability to settle suspended solids and cycle nutrients via plant uptake. As bioinfiltration and bioretention basins are both vegetated, each have the potential to mitigate the urban heat island effect and to reduce pollutant loads within Philadelphia's waterways—both important contributors towards helping limit the predicted impacts on the City due to a warming climate.

The designer is encouraged to incorporate SMPs from this Hierarchy tier into their stormwater management design. As discussed in **Section 2.4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-4-expedited-pcsmp-reviews, projects that manage stormwater with SMPs exclusively from this category are eligible for a *Surface Green Review*. The advantages of a Surface Green Review include a shorter (five-day) Post-Construction Stormwater Management Plan (PCSMP) Review Phase and the option to postpone infiltration testing until construction.

Medium-preference SMPs

SMPs ranked medium preference (subsurface infiltration, drainage wells, cisterns, blue roofs, and ponds and wet basins) tend to efficiently manage stormwater via infiltration, volume reduction, or detention. These SMPs often provide fewer triple bottom line benefits and may not last as long as the more highly preferred SMPs.

Lowest-preference SMPs

The least-preferred SMPs in the Hierarchy (subsurface detention with vegetated media filters, subsurface detention with roof runoff isolation, subsurface detention with media filters, vegetated media filters, and media filters) are non-infiltrating and generally provide little to no triple bottom line benefits. Additionally, the SMPs in this tier tend to have relatively high operations and maintenance (O&M) costs and may malfunction more frequently than other SMPs.

Table 3.2-2: SMP Hierarchy

SMP / SMPs in Series	Section
HIGHEST PREFERENCE	
Bioinfiltration	4.1
Bioretention	4.1
Porous Surfaces	4.2
Green Roofs	4.3
Blue-Green Roofs	4.14
MEDIUM PREFERENCE	
Subsurface Infiltration	4.4
Drainage Wells	4.15
Cisterns	4.5
Blue Roofs	4.6
Ponds and Wet Basins	4.7
LOWEST PREFERENCE	
Subsurface Detention with Vegetated Media Filters	4.8 / 4.9
Subsurface Detention with Roof Runoff Isolation	4.8 / 3.1.7
Subsurface Detention with Media Filters	4.8 / 4.9
Vegetated Media Filters	4.9
Media Filters	4.9

Step 2 – Determining residual management requirements

The designer may be able to satisfy some or all Stormwater Regulations using non-structural design or DIC strategies. Prior to considering the selection of SMPs, the designer must develop a quantitative understanding of the remaining stormwater management needs with respect to each of the Post-Construction Stormwater Management Criteria: Water Quality, Channel Protection, Flood Control, and Public Health and Safety Release Rate. Following an evaluation of non-structural and disconnection options, the designer must determine the following prior to proceeding to the SMP design stage:

- Total remaining DCIA to be treated and associated Water Quality volume (WQv)
- Peak flow attenuation required for all site DCIA, for the Channel Protection requirement, if applicable; and
- Total peak flow comparison from predevelopment to post-development conditions for each point of interest, for the Flood Control requirement, if applicable.

Step 3 – SMP placement and layout

Some sites will offer numerous options for locating SMPs (on rooftops, on the ground's surface, or underground), while others, particularly "full build-out" sites (where ground-level open space is not available in the proposed site layout), will have limited options for SMP placement. PWD encourages the designer to incorporate ground-level vegetated SMPs on sites wherever possible, resorting to subsurface SMPs only when other options have been exhausted. The designer should initiate the SMP placement and layout process only after becoming thoroughly familiar with the characteristics, advantages, limitations, and appropriate uses of acceptable SMPs. The designer should choose SMPs per the SMP Hierarchy presented above, exhausting opportunities for the most-preferred practices prior to considering lower priority practices. The following guidelines and suggestions are provided to assist the designer with selecting and arranging SMPs.

- **Assessing space constraints** – SMPs rely on storage volume to achieve performance. The availability of space for SMPs will often dictate the location and type of SMPs that can work on a site. Considering SMP placement early in the design process is critical to ensuring that sufficient space exists for incorporating SMPs, particularly ground-level SMPs. The designer should calculate approximate design requirements (e.g., total required storage volume) to allocate space for stormwater management within the site layout. If insufficient space is available for incorporating surface-vegetated practices, the designer may need to explore alternatives like porous surfaces, or other SMPs, proceeding down the SMP Hierarchy. The use of SMPs in series, Stormwater Management Banking and Trading, and/or adding subsurface storage to a bioretention system can help the designer maximize the use of surface-vegetated SMPs, even on constrained sites.
- **Creating on-site amenities** – SMPs such as green roofs, blue-green roofs, and bioinfiltration/bioretention basins can provide on-site greening, as vegetated features can act as an aesthetic amenity, particularly for residential and commercial retail sites. Bioinfiltration/bioretention SMPs should be designed in conjunction with other desired and required landscaping.
- **Choosing areas with infiltration potential** – Although the exact infiltration rate at a particular location within a site is not generally known during the Conceptual Review Phase, the designer should use existing information to locate SMPs in areas that have a strong potential for infiltration. Much of this information—such as United States Department of Agriculture (USDA) Hydrologic Soil Maps, existing geotechnical reports, existing soil investigation reports, drainage feature mapping, topographic mapping, information on existing site drainage issues, and data on high seasonal groundwater—will have been compiled during initial site assessment activities as described in **Section 3.1.1** ☛ p. 8 and **Section 3.1.2** ☛ p. 14, and must be used for this purpose.
- **Prioritizing low-lying areas** – Surface-level SMPs should be located on the site's lower elevations, where stormwater can be gravity-fed from DCIA to the SMPs without making the SMPs excessively deep. These low-lying areas should be prioritized for stormwater management early in the site design process.
- **Providing downstream points of relief** – SMPs need to provide gravity drainage for both overflow structures and underdrains. SMP elevations must not be too low to preclude tying in underdrains and overflow structures to a downstream point of relief (e.g., sewer or receiving water).
- **Minimizing Conveyance Requirements** – SMPs are less costly and easier to maintain if the designer reduces the amount of collection and distribution piping. Opportunities to sheet flow stormwater from DCIA to SMPs, or to use surface conveyance systems like swales to bring stormwater into SMPs, should be pursued. In some cases, the designer may be able to use natural drainage features to convey stormwater with little additional cost.

- **Avoiding utilities** – Careful mapping of surface and subsurface utilities on-site is necessary to reduce conflicts and the potential for relocating of existing utilities. A designer can view PWD utility records by contacting PA One Call and PWD Water Transport Records Unit.
- **Avoiding sensitive features** – SMPs should be placed in locations that avoid sensitive features, such as mature tree stands, wetlands, steep slopes, and floodplains, as well as constraints, such as shallow bedrock and groundwater. These areas will have been mapped during the site assessment process in Section 3.1.1 ☛ p. 8 and Section 3.1.2 ☛ p. 14. Many of these areas are regulated by State and Federal agencies and/or City ordinances.
- **Providing maintenance access** – Locating SMPs in areas where they can be easily accessed for maintenance is an important design consideration. Vehicular access routes, if needed for sediment removal, should be considered.
- **Avoiding hotspots and contamination** – Locating SMPs away from hotspots and areas of known contamination is always a good idea, as the inclusion of infiltrating SMPs within contaminated areas is not permitted. The designer is referred to the hotspot investigation procedures in Section 3.1.1 ☛ p. 8 for more information. During this phase, a preliminary investigation of likely hotspots is suggested. During detailed design, more exhaustive characterization of soil contamination issues may be required for individual SMP sites to determine infiltration feasibility.
- **Avoiding unstable fill** – Many areas of Philadelphia are undergirded by historic fill, which can be loose or unstable. The designer is advised to identify areas of unstable fill through geophysical methods, exploratory geotechnical testing, or historic mapping to avoid these areas where possible.
- **Maintaining sight lines** – Clear lines of sight are critical for pedestrian and vehicular safety. SMPs should be placed so as to not impair sight lines, and the designer must consider full grow-out conditions for vegetation when assessing visibility issues.
- **Ensuring safety** – Many SMPs contain features like ponded water that could be unsafe, particularly for vulnerable populations, such as young children. The designer should consider locating SMPs with ponded water away from play-yards, playgrounds, or other areas where children recreate or installing fencing or other features to limit interaction with the system.
- **Considering appropriate conditions for vegetated SMPs** – Some variables to consider include amount of sunlight received and solar orientation, wind speed and direction, temperature gain, and surface character. For example, northeast-facing sites receive morning sun and tend to be cooler and wetter than those facing southwest, and runoff from asphalt will be hotter than that from concrete. Combinations of these variables create different micro-climates and should be accounted for when placing the SMP and selecting plants.

3.2.3 Placing SMPs in series

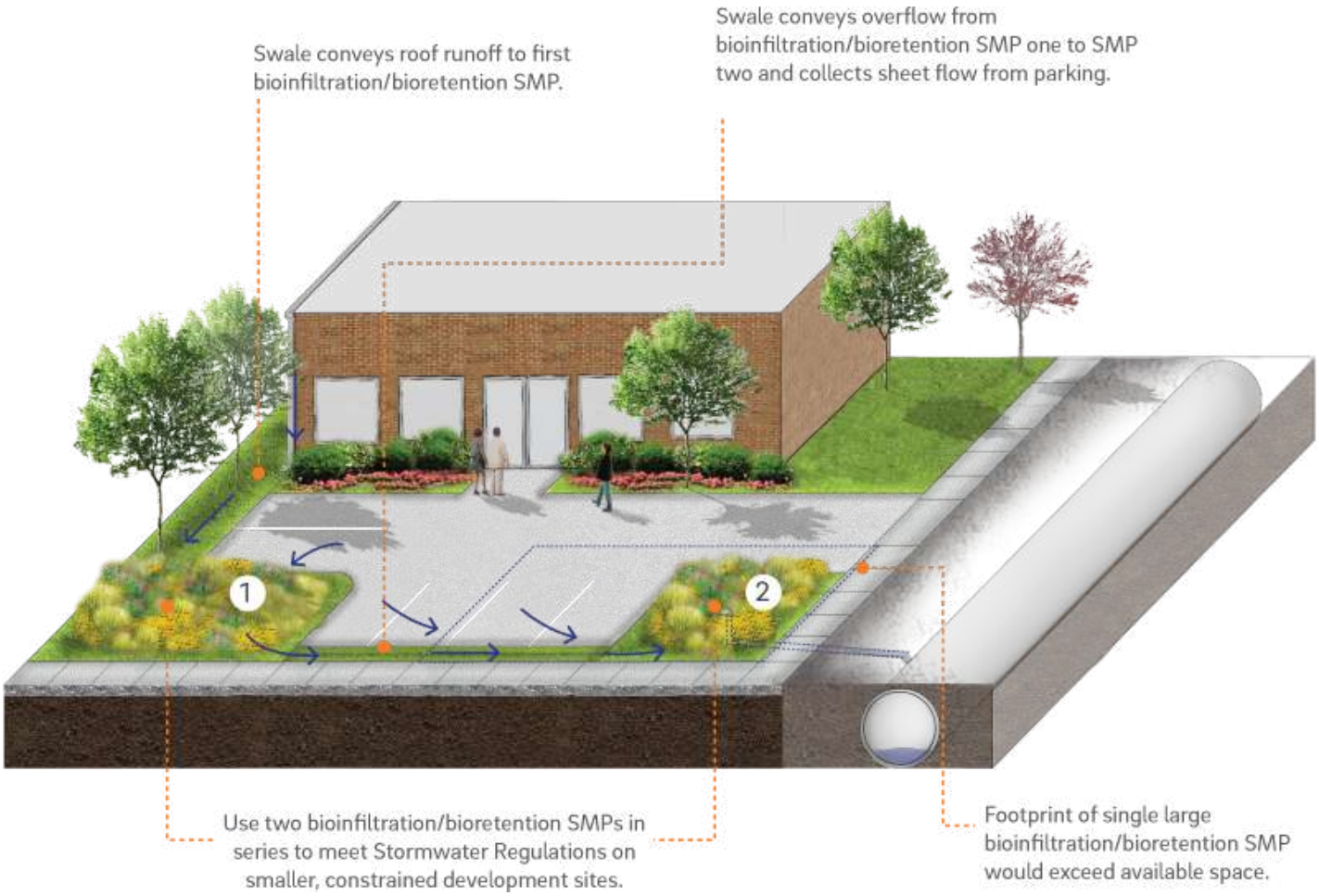
Many of the SMPs discussed in this Manual provide both Water Quality treatment and rate control, though some provide only rate control. The designer must keep in mind that some SMPs cannot fully meet all applicable Stormwater Regulations on their own; however, a network of SMPs can be used to meet the Stormwater Regulations for a given site. For example, peak rate control for Flood Control compliance could be progressively achieved through flow attenuation in a series of smaller, linked SMPs. Many of these SMPs could also be used to meet the Water Quality requirement by providing cumulative static storage equal to the contributing WQv. In addition, non-pollutant-reducing practices, such as subsurface detention systems, can be used to meet the requirements for Water Quality slow-release rate, Channel Protection, and Flood Control, but they cannot be used to meet the Water Quality pollutant-reduction requirement. In other cases, space constraints may preclude the ability to comply with the Stormwater Regulations using only one SMP.

While it is generally more cost effective, efficient, and easier to meet the Stormwater Regulations using as few SMPs as possible, to provide more flexibility, PWD allows the designer to use approaches that achieve compliance through the use of multiple SMPs connected in series. Placing SMPs in series allows the designer to minimize the disrupted space, limit the construction or maintenance costs of a system, or meet the Stormwater Regulations on a crowded or complex site. Approaches will vary by site, of course; the designer is encouraged to use creativity to combine SMPs in ways that achieve site-wide compliance. Some examples of these approaches are discussed below.

Multiple small bioinfiltration/bioretention SMPs

A series of smaller bioinfiltration/bioretention SMPs can be placed within small, landscaped areas in lieu of a single large bioinfiltration/bioretention SMP. This approach can be effective for promoting vegetated surface SMPs within constrained sites. Figure 3.2-1 illustrates this approach.

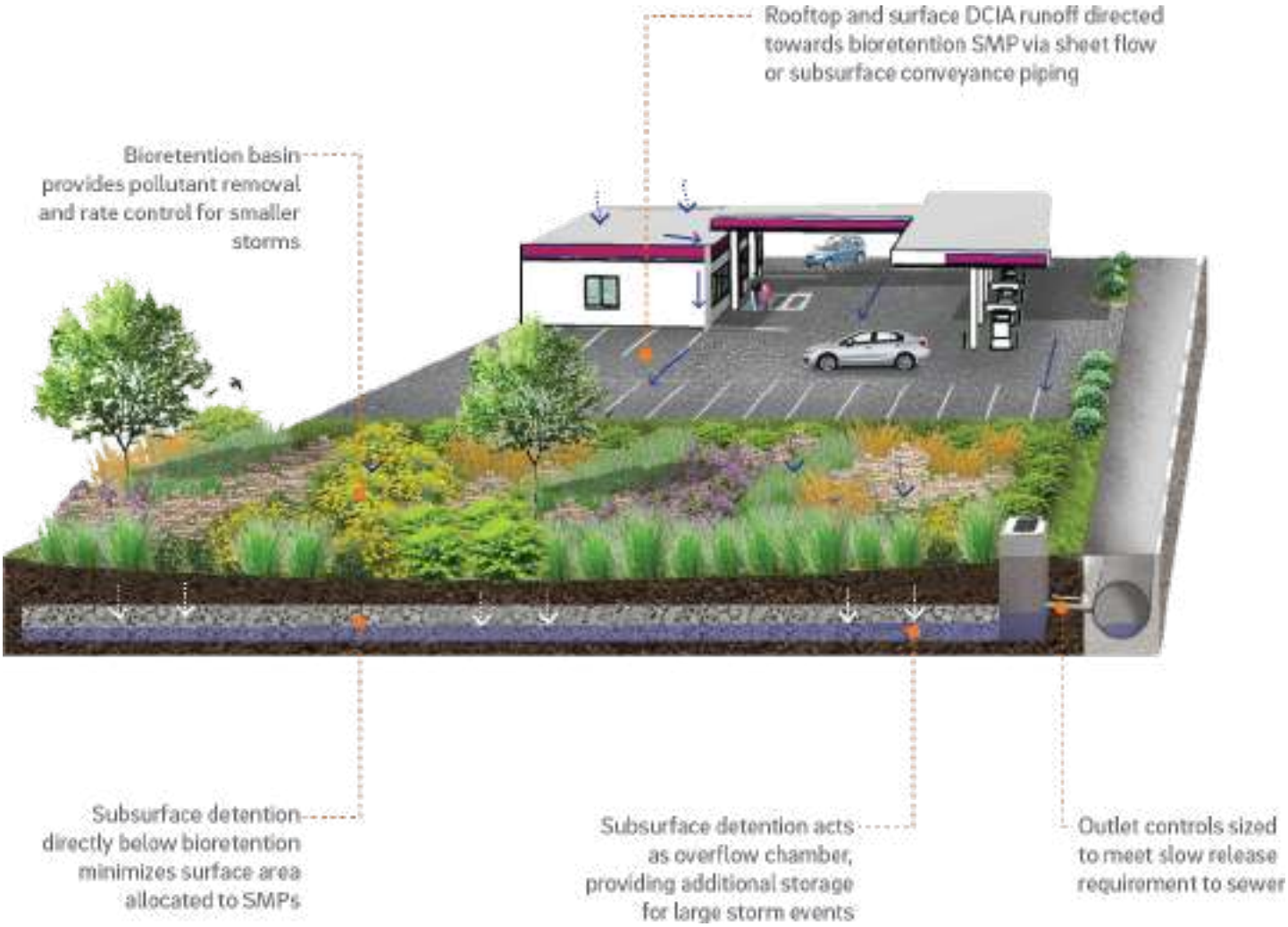
Figure 3.2-1: SMPs in series example #1 – Multiple small bioinfiltration/bioretention SMPs



Bioretention with subsurface detention

Bioretention systems are particularly effective for managing the WQv. They provide treatment and rate control but may not provide enough storage to meet the Flood Control or PHS Release Rate requirements, if applicable. A bioretention basin installed directly over a subsurface detention basin provides several benefits. The bioretention basin is relatively easy to maintain and is a pollutant-reducing practice. The subsurface detention basin provides effective rate control for small and large storms. This combination allows the subsurface detention basin to act as an overflow chamber for large runoff volumes generated by large storms. Designing the bioretention and subsurface detention basin in series can reduce the amount of usable surface area disrupted while meeting the Stormwater Regulations. Figure 3.2-2 illustrates this approach.

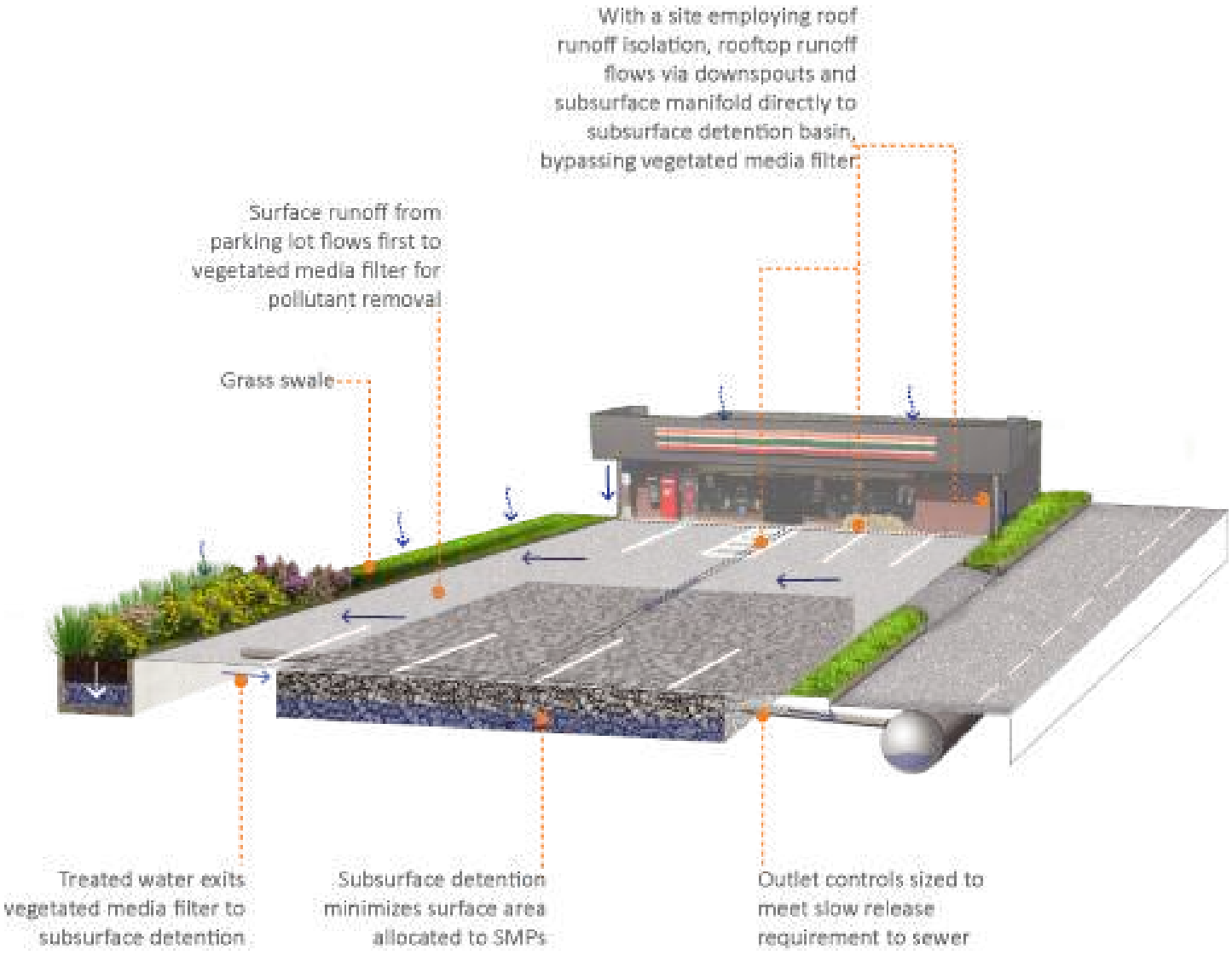
Figure 3.2-2: SMPs in series example #2 – Bioretention with subsurface detention



Vegetated media filter with subsurface detention

A subsurface detention basin with an upstream vegetated media filter is a combination of SMPs that can be used to meet the Water Quality slow-release and pollutant-reduction requirements on sites that cannot infiltrate in the combined sewer area. The subsurface detention basin is a compact SMP that can be installed below a parking lot to limit the amount of usable surface that is disrupted. With a site employing the pollutant-reducing practice of roof runoff isolation, runoff from rooftop DCIA can be sent directly to the subsurface detention basin without any filtering treatment. A vegetated media filter can then be installed on-site to capture the WQv from surface-level DCIA and treat the runoff before discharging the treated volume to the subsurface detention basin. Figure 3.2-3 illustrates this approach.

Figure 3.2-3: SMPs in series example #3 – Vegetated media filter with subsurface detention



The following requirements apply to SMPs placed in series:

- SMPs can be placed in series to achieve rate control for the Stormwater Regulations. The designer does not have to demonstrate compliance with rate control requirements at the discharge point of each SMP, as long as rate control can be provided at the downstream-most point of the SMP series, prior to discharge to the PWD sewer or receiving water.
- When complying with the Water Quality requirement, cumulative static storage volume may be provided within a connected series of SMPs, rather than any single SMP.
- Individual SMPs within a series must be designed in full accordance with design requirements provided in **Chapter 4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4. For example, each bioretention system in a series must individually meet loading ratio and drain down time requirements.
- When using SMP in series, upstream flow splitters may be used to direct larger events around Water Quality SMPs, such as bioretention systems, to larger Flood Control SMPs.

3.2.4 Stormwater Management Banking and Trading

Downloadable summaries of Stormwater Management Banking and Trading guidance, with quick reference information for clients and developers:

- **Stormwater Management Banking and Trading One-Sheet** ☛ water.phila.gov/wp-content/uploads/files/stormwater-management-banking-and-trading.pdf
- **Stormwater Management Banking and Trading: Same Parcel Trading One-Sheet** ☛ water.phila.gov/wp-content/uploads/files/stormwater-management-banking-and-trading-same-parcel-trading.pdf

PWD generally requires full compliance with the Stormwater Regulations for each point at which stormwater leaving the site is discharged to either a receiving water or PWD sewer. SMPs must be provided as appropriate to achieve compliance at each of these locations. If site constraints or existing conditions will prevent a development project from complying fully with the Stormwater Regulations, or if placement of an SMP could induce a potential environmental or safety hazard, the designer may consider *Stormwater Management Banking and Trading*. Stormwater Management Banking and Trading allows a project flexibility in the placement of required SMPs. Proposals to use banking and trading methods are considered by PWD on a case-by-case basis, and a pre-application meeting is highly recommended.

Stormwater Management Banking refers to the oversizing of SMPs to be used toward regulatory compliance for future development improvements. To qualify for Stormwater Management Banking, the SMPs must be constructed prior to the associated development project. When Stormwater Management Banking is proposed, each phase of work will be held to the Stormwater Regulations in place at the time of the Existing Resources and Site Analysis (ERSA) Application. Furthermore, the specific performance of the SMP is banked, not the area managed. Future projects must meet the regulations that apply at that time, which may reduce the amount of area for which the banked performance can be traded.

Stormwater Management Trading refers to the siting of SMPs to manage impervious area not associated with the proposed development improvement, whereas the DCIA associated with the development project is traded for an equivalent managed area. The SMPs can be located on the same parcel as the development project but must manage area outside of the development project's limit of disturbance. Area proposed for trade must be unmanaged in the predevelopment condition unless the area has been previously identified as part of a Stormwater Management Banking agreement.

Stormwater Management Banking and Trading is only relevant to projects required to comply with Stormwater Regulations. Stormwater Retrofits have differing management strategies, as discussed in **Section 1.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1/1-3-stormwater-retrofits.

Banking and Trading SMP standards

- SMP(s) must achieve the same regulatory standard (Water Quality and Channel Protection) as if it were directly managing stormwater from the proposed development project.
- Banking and trading methods are not permitted to be used to comply with Flood Control.
- SMP(s) located within the same sewershed are preferred.
- Applicants who wish to engage in large-scale Stormwater Management Banking and Trading that involves multiple parcels and/or property owners over a large area must provide a formal agreement that includes all parties and is approved by PWD. The parcel(s) containing the regulated improvement and the SMP(s) will be subject to Post-Construction Stormwater Management (PCSM) Requirements, including an O&M Agreement to be recorded to the property deed(s).

- Applicants must provide sufficient written justification in their PCSMP Report for proposing a banking or trading management solution, including reasons why management of the regulated area(s) is not feasible and why PWD may benefit from the proposal. A short explanation should also be included in the ERSA Application.
- SMP(s) must manage an area equal to or greater than the unmanaged area and produce an equivalent pollutant load. For example, PWD will not approve a trade of unmanaged impervious parking lot with existing roof area because the total pollutant load from the trade surfaces is not equivalent.

Submission Package components for Stormwater Management Banking and Trading are no different from typical submissions. The designer, however, must clearly identify the banking or trading strategy on all plans and reports in the Submission Package. This information can be easily conveyed as a table; an example of which is provided below:

Total LOD	18,000 SF
On-site LOD	17,000 SF
Impervious Area Within On-site LOD	16,500 SF
Managed DCIA (i.e. DCIA routed to SMP) Within On-site LOD	12,400 SF
DIC Area Within On-site LOD	600 SF
Remaining Unmanaged DCIA Within On-site LOD (e.g. parking lot runoff)	3,500 SF
Acceptable Trade Area (i.e. managed impervious area) outside of LOD	**≥ 3,500 SF of surface-level cover**

Additionally, if the designer believes that Stormwater Management Banking or Trading will be necessary to meet the Stormwater Regulations, they are encouraged to discuss this during the Conceptual Review Phase.

Understanding the limit of disturbance is key to proposing a trade approach for regulatory compliance. The existing impervious area to be managed for trade must remain outside the LOD throughout construction. For example, de-paving or otherwise converting an existing impervious surface to pervious cover (like converting a parking lot to porous surface) cannot be used as a trade because this activity increases the LOD, and the LOD boundary determines the area subject to the Stormwater Regulations. While this approach may help achieve an exemption from the Flood Control requirement (**Section 1.2.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1/1-2-stormwater-regulations/#1.2.1), it cannot be used for trade. Instead, the applicant should investigate low impact options that will minimize the amount of existing impervious area to be disturbed, thus maximizing potential trade area.

The next section presents examples of how this may be achieved. The most common stormwater trade scenario is Same Parcel Trading, whereby SMPs are sited on a parcel that will manage DCIA not associated with the proposed improvement (outside the project's LOD). The first scenario below presents an example of how Same Parcel Trading can be applied to, and benefit, a Redevelopment project.

Stormwater Management Trading examples

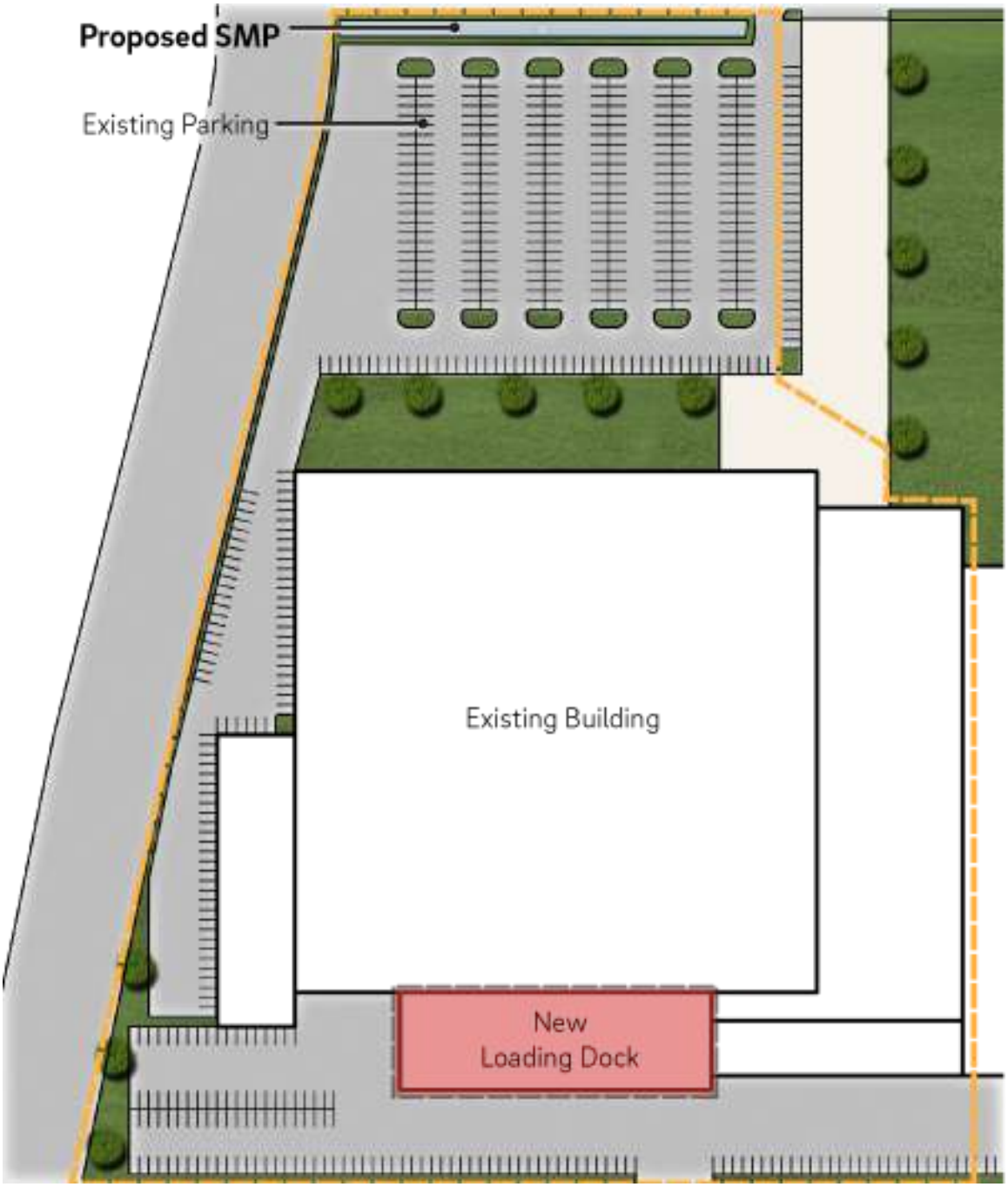
Example of Same Parcel Trading – Food distribution facility

A property owner sought approval from the City to construct a new loading dock (Figure 3.2-4, in red) at an existing food distribution facility. The only on-site area large enough on which to place an SMP was adjacent to the food warehouse, and the property owner had concerns about food contamination from wildlife attracted to a surface SMP. Therefore, the property owner considered subsurface SMPs that could be

installed adjacent to the new loading dock; however, the disadvantages and constraints of subsurface SMPs in this application included the following:

- Relatively high cost to construct and maintain;
- Large space requirements to achieve controlled release standards, since soils near the loading dock were significantly compacted, precluding infiltration; and
- The need for the subsurface SMP design to accommodate heavy truck traffic, balancing SMP access points with heavy load-bearing surfaces.

Figure 3.2-4: Same Parcel Trading example



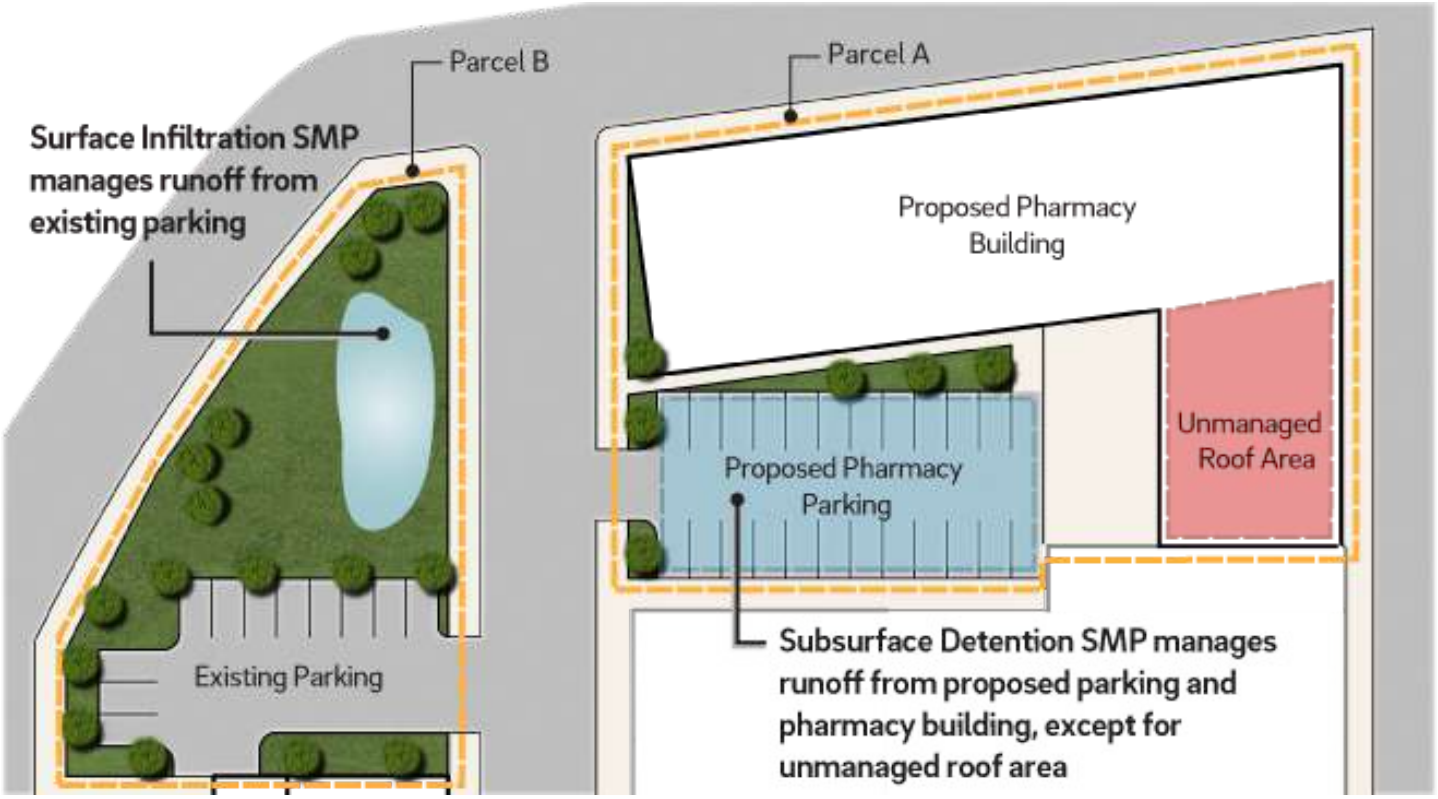
The property owner instead proposed an SMP (shown in blue) elsewhere on-site to manage existing undisturbed impervious area in the same sewershed. The benefits from this trade included the following:

- Less expensive SMP installation cost;
- Less disruption to distribution center's operations during construction;
- Smaller SMP footprint located in better-infiltrating soils; and
- An above-ground SMP that can be more easily inspected and maintained.

Example of Same Owner Trading – Pharmacy and parking lot

A single party owned two parcels separated by the public right-of-way (ROW). The developer proposed construction of a pharmacy and a parking lot on one undeveloped parcel. The same developer owns an already developed parking lot across the street (presented post-development in Figure 3.2-5).

Figure 3.2-5: Same Owner Trading example



The site designer was able to manage all new impervious area proposed for Parcel A with a subsurface detention facility (shown in blue), except for a portion of the pharmacy roof area (shown in red). To meet Stormwater Regulations on Parcel A, the designer proposed to manage the existing parking lot on Parcel B with a surface infiltration SMP (shown in blue). The unmanaged pharmacy roof area discharges directly to the sewer system. The benefits from this trade included the following:

- Increased ability to fully use Parcel A;
- Less expensive SMP installation cost;
- An above-ground SMP that can be more easily inspected and maintained; and
- Limited reliance on underground SMPs.

Example of Same Owner Banking – Shopping mall

A shopping mall owner proposed a series of improvements, with construction planned in phases. These included expansions to existing mall buildings, new standalone restaurants, and additional parking areas and driveways. Instead of designing and constructing SMPs for each individual improvement, the designer proposed a stormwater management banking scenario to construct a single SMP to serve all improvements.

Figure 3.2-6: Same Owner Banking example



The designer first proposed an existing building expansion and additional parking areas and driveways under Phase 1 (shown in yellow on Figure 3.2-6). Upon approval of this first phase, as well as a conceptual design of future standalone restaurant buildings under Phase 2 (shown in orange), PWD permitted the owner to install an oversized SMP (shown in blue) to manage these impervious surfaces. The owner then installed the remainder of the proposed improvements in Phase 2. The site designer directed all runoff to the single SMP that was constructed in Phase 1.

A benefit of this scenario was that the owner was able to obtain approvals quickly for the second phase of construction as the SMP was sized to meet the Stormwater Regulations for the entire project.

When Same Owner Banking is proposed, PWD will acknowledge the bank amount in terms of additional cubic feet capacity remaining in the SMP. This type of banking approach works best for projects where phases are planned in rapid succession, as each phase is held to the Stormwater Regulations in place at the time of its ERSA submission. Applicants with an interest in long-term site master planning (which may occur over several years or decades, or between multiple parcels and property owners) are encouraged to discuss with PWD prior to implementation.

3.2.5 SMP design guidance and general requirements

Once the initial selection of SMPs is complete, and PWD has approved the conceptual design, a detailed design of SMP systems can begin. A detailed design of SMPs and associated documentation will be submitted as part of the designer's PCSMP Review Phase Submission Package to PWD. The designer is referred to **Chapter 2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2 for details on preparing this Submission Package.

This section provides guidance in the design of SMPs, outlining general requirements that apply to all SMPs. The designer is also referred to **Chapter 4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4, which provides detailed guidance and requirements for specific SMPs.

Infiltration testing and waiver requirements

A designer using SMPs to comply with the Water Quality requirement must use infiltration unless they demonstrate that infiltration is infeasible. The designer must exhaust all possibilities for implementing infiltrating practices on proposed sites, including the exploration of alternative locations for infiltration facilities, if initial locations are judged unsuitable for infiltration or over-excavating poorly infiltrating soils. The designer is referred to **Section 3.3** ☛ p. 67 for detailed information on performing infiltration tests, assessing infiltration feasibility, and preparing requests for infiltration waivers. If appropriate justification that contamination will preclude the site from infiltration is provided, an impervious liner must be incorporated into the SMP design.

Pretreatment requirements

Pretreatment is critical for extending the design life and maximizing the performance of SMPs. The designer must provide adequate pretreatments for all SMPs. Appropriate pretreatment is based on several factors including SMP type, loading ratios, and drainage area characteristics. The designer is referred to **Chapter 4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4 for more information on the design of pretreatment systems for specific SMPs and general pretreatment options.

Conveyance and inlet and outlet control requirements

Conveyance systems—including piping that conveys stormwater to and from an SMP, and inlet and outlet control systems, which regulate the flow into and out of an SMP—are important aspects of SMP design. All storm sewer pipes must be designed to have adequate capacity to safely convey the ten-year storm without surcharging the crown of the pipe. **Section 3.4.2** ☛ p. 95 contains detailed guidance on storm sewer design and pipe capacity calculations, while **Section 4.11** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-11-inlet-controls and **Section 4.12** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-12-outlet-controls provide guidance on the design of inlet and outlet controls, respectively.

Sizing requirements

Appropriate sizing is critical for SMP performance. The designer must incorporate several factors, including SMP type, function, maximum loading ratio requirements, release rate requirements, ponding depth, static storage requirements, media characteristics, freeboard requirements, and space limitations in determining appropriate SMP sizing. The designer is referred to the loading ratio requirements later in this section and the SMP-specific sizing requirements in **Chapter 4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4 to aid in determining appropriate SMP sizing.

Safe overflow requirements

Safe overflow must be provided for all SMPs. Runoff that overflows from an SMP (runoff that is not infiltrated or slow released) must be conveyed to receiving waters or sewers in a controlled manner that does not cause flooding, endanger public safety, or produce erosive conditions. Positive overflow must be provided for large storm events, up to and including the 100-year, 24-hour storm event or, if the project is exempt from Flood Control, the ten-year, 24-hour storm.

Release rate requirements

For non-infiltrating practices in combined sewer areas, the designer must meet slow-release rate requirements prior to discharge into PWD sewers or receiving waters. Typically, release rates for slow-release systems are met using small orifices or other rate control devices. The designer is referred to **Chapter 4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4 for specific information on designing outlet control systems.

3.2.6 Loading ratio requirements

Download a summary of the loading ratio requirements, with quick reference information for clients and developers:

- Loading Ratio Requirements One-Sheet ☛ water.phila.gov/wp-content/uploads/files/loading-ratio-requirements.pdf

Loading ratio is defined as the area of contributing DCIA divided by the bottom surface footprint of vegetated surface SMPs and the bottom footprint of infiltrating subsurface SMPs. The loading ratio is a tool that is used for sizing an SMP with consideration of acceptable sediment loading. It is a balancing point between maintenance requirements, performance requirements, and safety considerations. PWD's loading ratios are used as maximum acceptable SMP sizes for stabilized sites that are appropriately maintained; they are not necessarily the recommended loading ratios. The maximum loading ratio for vegetated surface SMPs is 16:1. The maximum loading ratio for infiltrating subsurface SMPs is 10:1. Runoff that has been filtered through a soil profile should not be counted toward the subsurface loading ratio for SMPs in series.

Loading ratios	
Maximum loading ratios	Surface vegetated SMPs: 16:1 Subsurface infiltrating SMPs: 10:1
Maintenance	Long-term maintenance is a fundamentally important piece of an SMP's design. PWD's loading ratios were selected with the assumption that the final site will be stabilized, and the SMP will be maintained at regular intervals. Surface SMPs with a 16:1 loading ratio will require frequent maintenance, including the removal and replacement of the top layer of soil along the bottom footprint of the SMP.
Safety	The larger the loading ratio, the deeper the SMP must become to store the required volume of water. A surface basin with a 16:1 loading ratio will have a maximum Water Quality storage depth of two feet, which limits the total water depth and the risks to public safety.
Performance	The loading ratio greatly affects the performance of infiltrating SMPs by determining the footprint available for infiltration. PWD requires that all SMPs drain down in no more than 72 hours; however, owners may want their SMPs to drain more quickly, thus the loading ratio may need to be reduced to meet the performance goals for the system. For example, an SMP with a loading ratio of 16:1 and an infiltration rate of 0.4 inches/hour drains down in 60 hours; however, the site owner may not want ponded water on-site for 60 hours.
Limitations	The larger the loading ratio, the less redundancy there is in an SMP. The SMP designer should consider the causes of potential failure for their SMP and attempt to minimize their likelihood and their effects. For example, a small SMP with a large impervious drainage area has the potential to receive a significant volume of water and sediment in larger storm events, which could overwhelm and/or clog the small SMP. In this case, a larger basin footprint may be warranted to safely convey the extra volume. Subsurface SMPs are inherently more difficult to maintain because they are buried. If construction sediment or some other sediment source discharges to the subsurface basin it can become clogged. Repairing the basin could require a complete removal and replacement of the system. This is one reason why PWD requires lower loading ratios for subsurface SMPs. When considering SMPs that receive runoff from a likely sediment source, the designer must factor into their design the likelihood of clogging, and therefore the need for increased maintenance frequency; the cost of maintenance/replacement; and the likelihood of this occurring when determining the appropriate sizing of the system.

3.2.7 Planting and vegetation guidance

Vegetated SMPs are among the most preferred SMP types, as indicated in the SMP Hierarchy. They can often be integrated within planned landscape areas, with minor modifications to conventional landscape design. It is essential that impervious surfaces be graded toward the vegetated areas that are used as SMPs and that these SMPs are depressed to allow for flow and/or surface ponding.

Landscaping is a critical element to improve both the function and appearance of vegetated SMPs. Integrated stormwater landscapes can provide many benefits, such as construction cost savings, reduced maintenance, aesthetic enhancement, and improved long-term functionality. A well-designed and established landscape will also prevent post-construction soil erosion. Additionally, these approaches can help mitigate urban heat island effects, improve air quality, and reduce atmospheric carbon levels. Since these design approaches are still relatively new to many construction contractors, it is advisable to clearly show planting details in cross-sectional and plan view drawings.

The designer is referred to **Chapter 4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4 for detailed planting requirements and guidance for specific SMPs and **Section 4.13** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-13-landscaping for landscaping guidance.

Vegetated SMPs advance City goals

The tree and vegetation components of green stormwater infrastructure (GSI) are integral to advancing multiple City sustainability, climate resilience, and community equity goals. By designing stormwater management systems to include vegetated landscapes, designers can directly contribute to these goals. **Greenworks** ☛ www.phila.gov/media/20161101174249/2016-Greenworks-Vision_Office-of-Sustainability.pdf, the City's sustainability plan, includes GSI as part of two visions for all Philadelphians: (1) to benefit from parks, trees, stormwater management, and healthy waterways, including implementing PWD's **Green City, Clean Waters** ☛ water.phila.gov/green-city program, and (2) to be prepared for climate change and reduce carbon pollution. **Philadelphia's Climate Action Playbook** ☛ www.phila.gov/media/20210113125627/Philadelphia-Climate-Action-Playbook.pdf also outlines "utilizing nature as a solution to climate pollution" as one of its three climate action areas, and highlights "increasing and preserving green space" through integrated landscapes that incorporate tree planting, vegetation, and stormwater management.

Planting trees as part of vegetated SMPs and site landscaping, as well as protecting mature trees, can help address both stormwater regulation requirements and the **Philly Tree Plan** ☛ www.phila.gov/media/20230223005617/Philly-Tree-Plan.pdf goals. The Philly Tree Plan identifies long-term strategies for growing and protecting every part of Philadelphia's urban forest, aiming for a 30% increase of citywide tree canopy cover over a 10-year period. The plan's stakeholders represent many sectors—including city government, non-profit partners, Philadelphia's communities, designers, and developers—all collaborating to manage stormwater and protect our waterways through land-based solutions, including vegetated SMPs (or green stormwater infrastructure).

Pollution prevention

Stormwater pollution prevention practices related to landscaping can be categorized into two broad categories: Toxic Substance Use Reduction and Pollutant Source Reduction

- Toxic Substance Use Reduction – Projects should be designed to minimize the need for toxic or potentially polluting materials such as herbicides, pesticides, fertilizers, or petroleum-based fuels within the SMP area before, during, and after construction. Use of these materials creates the risk of spills, misuse, and future draining or leaching of pollutants into facilities or the surrounding area.
- Pollutant Source Reduction – Materials that could leach pollutants or pose a hazard to people and wildlife must not be used as components of a SMP. Some examples of these materials are chemically treated railroad ties and lumber and galvanized metals. Many alternatives to these materials are available.

3.2.8 Operations and Maintenance

An O&M Agreement, discussed in detail in **Section 6.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-6/6-1-property-owner-inspections-and-maintenance, is a required project component for both Stormwater Regulations and Stormwater Grant-funded Stormwater Retrofits. Decisions made in the design phase can affect operations and maintenance and can extend the design life of stormwater facilities. Key factors to consider are ownership, access, maintenance tasks, and frequency.

Designing to minimize maintenance

- Use of pretreatment systems should be maximized, particularly for infiltration systems. Reducing the velocities and pollutant loads entering SMPs will extend their design lives. The designer is referred to **Section 4.10** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-10-pretreatment for guidance on appropriate pretreatment design.
- For infiltration, surface-vegetated SMPs with deeper-rooted vegetation (e.g., trees, shrubs, and native herbaceous species) should be used whenever possible. Root growth helps to keep the soil's pore structure open and maximizes the life of infiltration SMPs. Routine landscaping tasks are the primary maintenance required.
- On smaller sites, SMPs that do not require slow-release control structures should be chosen. These structures can clog and require periodic inspection and maintenance.
- Access
  - Vehicle access from a public right-of-way can help to minimize the difficulty of maintenance.
  - A 15-foot-wide vehicle access path leading from a public right-of-way to all stormwater controls is strongly recommended.
- Post-construction ownership
  - The owner of the land where the SMP is located is responsible for performing long-term maintenance.
  - In the case of a single property owner, that owner is responsible for maintenance. In cases of common ownership, a homeowners' or condominium association may assume responsibility for maintenance.
  - Considering the type of ownership and owner preference can help the designer choose between smaller, distributed SMPs and a single, centralized SMP.
    - The owner of the land where the SMP is located is responsible for performing long-term maintenance.
    - In the case of a single property owner, that owner is responsible for maintenance. In cases of common ownership, a homeowners' or condominium association may assume responsibility for maintenance.
    - Considering the type of ownership and owner preference can help the designer choose between smaller, distributed SMPs and a single, centralized SMP.

3.3 Infiltration Testing and Soil Assessment for SMP Design

After exhausting options for using non-structural design and disconnected impervious cover (DIC), the designer is required to evaluate and document infiltration feasibility when using stormwater management practices (SMPs) as a strategy to comply with the Philadelphia Water Department (PWD) **Stormwater Regulations** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/c-pwd-stormwater-regulations (Stormwater Regulations) or applicable stormwater management design standards. If infiltration is deemed feasible, the designer must use infiltration SMPs, such as bioinfiltration basins, to comply with the Water Quality requirement. If infiltration is not feasible, the designer must document justification for this condition (**Section 3.3.6** ☛ p. 81) via the Online Technical Worksheet (**Section 3.4.3** ☛ p. 105) and use acceptable pollutant-reducing SMPs to comply with the Water Quality requirement (**Section 1.2.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1/1-2-stormwater-regulations/#1.2.1), if applicable. A slow-release rate requirement associated with the Water Quality requirement applies only to non-infiltrating areas in combined sewersheds, for both Development and Stormwater Retrofit project types. Efforts to maximize development potential should not preclude the use of infiltration SMPs.

This section details the infiltration testing and soil assessment procedures required for the selection and detailed design of SMPs. If conceptual SMP locations and footprint areas have not yet been determined, the designer should return to Sections **3.1** ☛ p. 7 and **3.2** ☛ p. 41 for guidance on conceptual SMP design. PWD recommends that preliminary soil analyses and infiltration testing be completed during the conceptual SMP design phase. This is strongly recommended because the results can be used as a planning tool for identifying areas most favorable for the construction of infiltration SMPs, and for more thorough investigations. If pursuing Stormwater Grant funding for a Stormwater Retrofit project, the designer should review the **Stormwater Grants Application Guide** ☛ water.phila.gov/wp-content/uploads/files/stormwater-grants-application-guide.pdf for guidance on the minimum testing required for a Stormwater Grant Application Conceptual Stormwater Management Plan. The designer should use the guidance below to further inform their Post-Construction Stormwater Management Plan (PCSMP) design.

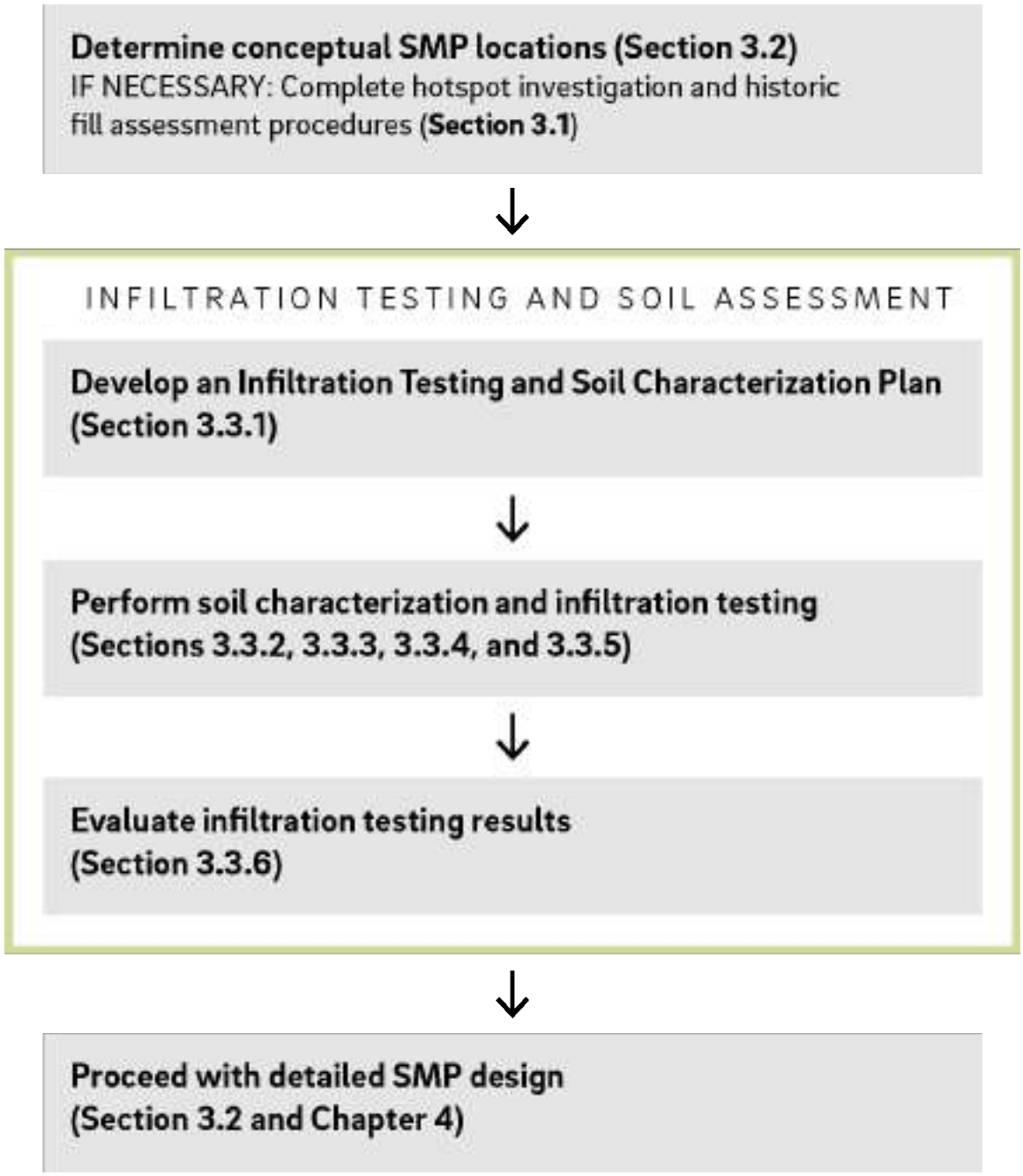
As a reminder, locating conceptual infiltration SMP footprint areas should be avoided in the following locations identified during the site assessment process (**Section 3.1.1** ☛ p. 8 and **Section 3.1.2** ☛ p. 14). A number of these scenarios will require further investigation before determining infiltration feasibility and SMP layout.

- Areas with previously documented high seasonal groundwater or located in the floodplain;
- Areas with previously documented shallow bedrock, clay, hydrologic soil group "D" soils, or other limiting soil layers;
- Areas within existing rights-of-way and easements;
- Areas that do not achieve the minimum required ten-foot setback from all existing and proposed buildings and neighboring properties; and
- Documented hotspots.

For projects where infiltration is not feasible due to full build-out designs (where ground-level space is not available in the proposed site layout), infiltration testing may not be required. For these scenarios, the applicant must request a waiver from the infiltration requirement (**Section 3.3.6** ☛ p. 81) via the Online Technical Worksheet (**Section 3.4.3** ☛ p. 105). The applicant is encouraged to contact **PWD Stormwater Plan Review** ☛ water.phila.gov/development/stormwater-plan-review/manual/introduction#4 prior to initial plan submission to confirm the full build-out design is eligible for a waiver from infiltration.

After conceptual SMP locations have been determined for the project site, the designer must complete the infiltration testing and soil assessment process illustrated in Figure 3.3-1. Each step of this process is described within the following sections.

Figure 3.3-1: Infiltration testing and soil assessment process for SMP design



If required, infiltration testing and soil characterization must be completed before the PCSMP Review Phase, unless the project is deemed eligible for an Expedited PCSMP Review. The designer is referred to **Section 2.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-3-review-phases and **Section 2.4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-4-expedited-pcsmp-reviews for descriptions and requirements related to Review Phases and Expedited PCSMP Reviews, respectively.

3.3.1 Infiltration Testing and Soil Characterization Plan development

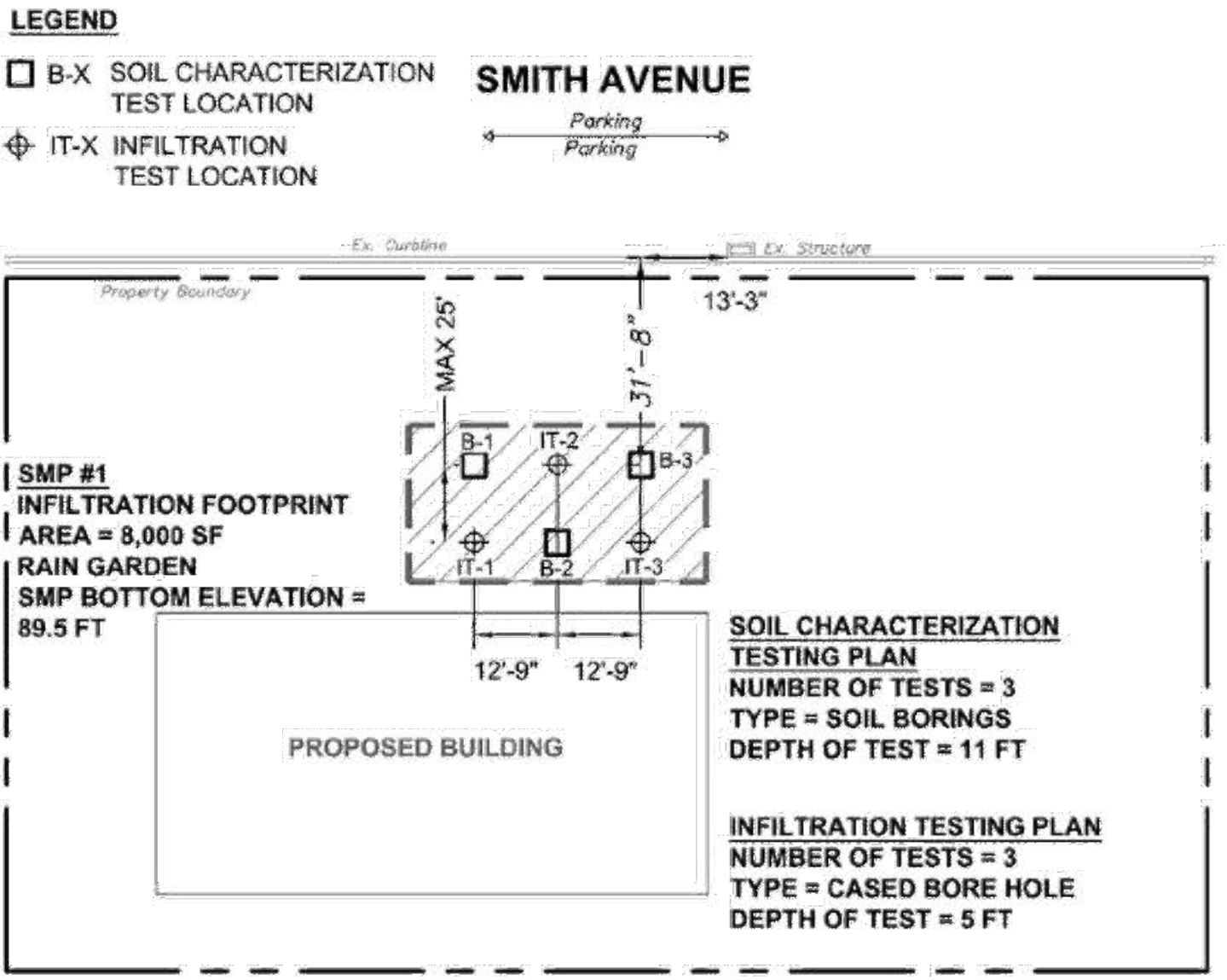
Prior to conducting infiltration testing and soil characterization at the project site, the designer must prepare an Infiltration Testing and Soil Characterization Plan (Testing Plan). This Testing Plan is a required element of the Geotechnical Report (**Section 3.3.6** ☛ p. 81). The Testing Plan must reflect the most up-to-date proposed SMP footprints at the time of testing.

The Testing Plan must be developed to meet the requirements within this chapter and, at a minimum, must indicate the following information:

- Location and SMP identifier of all proposed SMPs, each labeled with the following information:
  - Proposed infiltration footprint area,
  - Type of SMP proposed, and
  - Proposed infiltration interface (SMP bottom) elevation.
- Location of all proposed test pits, soil borings, and infiltration tests, each labeled with the following information:
  - Number of tests proposed based on the requirements provided within this section;
  - Type of test(s) proposed (test pit, soil boring, double-ring infiltrometer, cased borehole infiltration test);
  - Depth of testing for each test, relative to existing ground surface elevations, based on the requirements provided within this section; and
  - Dimensions from parcel boundaries and/or existing structures.

An example Testing Plan is included as Figure 3.3-2. This figure is generic and does not represent the required density or spacing of tests as documented within this section but demonstrates how to illustrate the minimum Testing Plan requirements described above. The hatched rectangle delineating the proposed SMP location and proposed test locations are dimensioned from a fixed object (e.g., an existing inlet within the public right-of-way).

Figure 3.3-2: Example Infiltration Testing and Soil Characterization Plan



The designer must adhere to the soil characterization requirements in **Section 3.3.2** ☛ p. 72 and the infiltration testing requirements in **Section 3.3.3** ☛ p. 74 when creating the Testing Plan. Prior to conducting geotechnical testing, the appropriate density, type, and spacing for each test must be determined using the requirements provided.

3.3.2 Soil characterization requirements

Soil characterization and limiting layer identification provides a visual assessment of the soil profile and serves as a supplement to the infiltration testing results. Understanding the characteristics of soils in which infiltration testing is conducted gives the designer added insight into the testing results, as well as the installation feasibility of an infiltrating SMP at the project site.

The presence of limiting layers such as groundwater, bedrock, or impermeable soils within two vertical feet of the infiltration footprint of an SMP is prohibited. The presence of bedrock or impermeable soils in relatively close proximity to the infiltration interface may result in lateral, as opposed to vertical, infiltration if the rock is not sufficiently jointed and/or fissured to infiltrate. This can result in water migrating to, and emerging within, topographically low areas. The presence of groundwater near the infiltration interface could increase the potential for groundwater mounding. Further characterization of subsurface soils can provide information on the underlying site conditions or evidence of limiting layers below the infiltration interface. Therefore, PWD requires that soil excavations be performed beyond the proposed infiltration interface (SMP bottom) elevation. As testing progresses, the testing professional must document the presence of any limiting layers, groundwater presence, and in situ observations of soil characteristics. PWD also requires soil sampling for laboratory soil classification to further supplement infiltration testing results.

Acceptable soil characterization testing methods are as follows:

- Exploratory Test Pits, and
- Hollow-Stem Auger Boreholes (Soil Borings).

These soil characterization methods must be conducted in conjunction with the required soil sampling.

An exploratory test pit allows visual observation of the soil horizons and overall soil conditions both horizontally and vertically in that portion of the site. Test pit observations can be made across a site at relatively low cost and in a short period of time. Unlike test pits, when soil borings are performed, the soil horizons cannot be observed in situ but must be observed from the extracted borings. As a result, visual observation is limited in a soil boring. As such, test pits are strongly recommended over soil borings unless conditions are present that render the excavation of test pits impractical (e.g., existing structures, utilities, space constraints, depth of test, etc.).

Key requirements for the two acceptable soil characterization methodologies and accompanying soil sampling are summarized below.

Test pits

- For projects with 15,000 square feet or more of earth disturbance, a minimum of two test pits must be completed for each SMP footprint. For projects with less than 15,000 square feet of earth disturbance, a minimum of one test pit must be completed for each SMP footprint.
- Test pits are required in order to conduct double-ring infiltrometer testing.
- At least one test pit for each SMP must be excavated to a minimum depth of four feet below the proposed infiltration interface of the SMP, which is the lowest elevation where infiltration is proposed (the SMP bottom elevation), or until bedrock or fully saturated conditions are encountered. When conditions prevent the over-excavation of test pits to the minimum required depth, soil borings, in addition to the under-excavated test pits, should be used in conjunction with double-ring infiltrometer testing to provide soil classification down to the required depths.

- Where test pits are greater than five feet deep, appropriate sloping and benching must be provided for access and infiltration testing, as necessary, in accordance with *Occupational Safety and Health Administration (**OSHA** ☛ https://www.osha.gov/) Regulations (Part 1926, Subpart P – Excavations, Standard Number 1926.652 Requirements for Protective Systems)*.

Soil borings

- A hollow-stem auger borehole should be used for soil classification when site constraints do not allow for a test pit (e.g., the proposed SMP footprint is located in an area with existing structures or utilities present, or the depth to the infiltration interface does not allow for a benched excavation with site constraints).
- A minimum of one soil boring must be conducted for each cased borehole infiltration test.
- All soil borings must be advanced to a depth of ten feet below the SMP bottom elevation, or until auger refusal, with continuous split spoon sampling.
- Hollow-stem auger borehole soil characterization studies must not be completed within the same hole as the infiltration testing, but the boreholes must be located no less than five feet, and no more than ten feet, away from the infiltration test locations.
- Drilling and sampling procedures must be in accordance with the Hollow-Stem Auger Method (American Society of Testing and Materials (ASTM) standard D6151-08), with a minimum four-inch inner tube diameter.
- Standard Penetration Tests (SPTs) must be in accordance with ASTM D1586 (Standard Test Method for SPT and Split-Barrel Sampling of Soils). Blow count data must be collected from the soil samples.

Soil sampling

- PWD requires that three soil samples be taken per acre of SMP footprint area, with a minimum of one soil sample per SMP.
- At least one soil sample must be taken as close to the infiltrating interface (SMP bottom elevation) as possible, within one vertical foot.
- The designer is also required to obtain a soil sample from the location of an infiltration test and conduct a sieve analysis of the sample.
- Soil samples must be obtained during the soil characterization field analysis and classified according to ASTM D2487 (Standard Practice for Classification of Soils for Engineering Purposes [Unified Soil Classification System]) and ASTM D2488 (Standard Practice for Description and Identification of Soils [Visual-Manual Procedure]).
- Soil samples must undergo laboratory particle size analysis according to ASTM D422-63 (Standard Test Method for Particle-Size Analysis of Soils) down to the No. 200 sieve.
- Split spoon sampling must be completed in accordance with ASTM D1586 (Standard Test Method for SPT and Split-Barrel Sampling of Soils). Blow count data must be collected from the soil samples.

3.3.3 Infiltration testing requirements

Note: If a designer is considering proposing a drainage well for stormwater management, there are specific infiltration testing requirements for this SMP. The designer should refer to those requirements in **Section 4.15.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-15-drainage-wells/#4.15.3.

All tests must be performed within 25 horizontal feet of each infiltration area. At least one infiltration test must be conducted, as closely as possible, within one vertical foot of the proposed infiltration interface (SMP bottom elevation). Additional tests may be warranted if the results of the first three tests vary significantly. Testing locations should, ideally, be evenly distributed. Infiltration tests may be used for the design of multiple SMPs as long as the minimum requirements are met for each SMP. Follow-up testing may be required if the location or elevation of any SMPs change in such a way that infiltration testing previously performed in the area of a planned SMP no longer meets PWD's proximity, elevation, and density requirements. It is the designer's responsibility to contact **PWD Stormwater Plan Review** ☛ water.phila.gov/development/stormwater-plan-review/manual/introduction#4 or **Stormwater Billing and Incentives** ☛ water.phila.gov/development/stormwater-plan-review/manual/introduction#6 concerning the need for follow-up testing for a project. Each test must be accompanied by either a test pit or soil boring.

Acceptable infiltration testing methodologies consist of:

- Double-ring infiltrometer tests with test pits, and
- Cased borehole tests with soil borings.

The main difference between the two methods is that a double-ring infiltrometer test estimates the vertical movement of water through the bottom of the test area using a larger surface area than a cased borehole infiltration test. The double-ring infiltrometer testing apparatus consists of two concentric metal rings that are driven into the ground and filled with water. The outer ring helps to reduce lateral movement of water in the soil (typically 12 to 24 inches in diameter) while the inner ring is used to calculate an infiltration rate (typically six to 12 inches in diameter). The cased borehole test uses an outer casing (typically four inches in inner diameter) to prevent lateral movement of water through soil. The procedures of these test methods are provided in **Section 3.3.5** ☛ p. 78.

While both testing methods are allowed, PWD strongly prefers the use of double-ring infiltrometer testing where space permits. Because test pits are required to perform double-ring infiltrometer tests, the applicant must first determine whether test pits are feasible (**Section 3.3.2** ☛ p. 72). If test pits are feasible, the designer should develop the Testing Plan to meet the minimum requirements for double-ring infiltrometer tests and test pits. If conditions render the excavation of test pits impractical due to existing structures, utilities, space constraints, depth of test, etc., the designer should document the condition(s) and then develop the Testing Plan to meet the requirements of cased borehole tests and soil borings. Soil borings may be used in lieu of over-excavating test pits where space constraints exist.

Key requirements for the two acceptable infiltration testing methodologies are summarized below.

Double-ring infiltrometer test

- Five infiltration tests must be performed per acre of SMP footprint, or one test per 8,712 square feet, with a minimum of three tests performed.
- The diameter of the inner ring must be no less than six inches.
- Test pits are required in order to conduct double-ring infiltrometer tests. A maximum of two double-ring infiltration tests can be conducted within the same test pit.
- Test holes must be presoaked for one hour immediately prior to testing. The presoaking procedure is intended to simulate saturated conditions in the environment and to minimize the influence of unsaturated flow.
- Testing must be conducted for a minimum of eight readings or until a stabilized infiltration rate is measured. A stabilized rate of drop means a difference of 0.25 inch or less of drop between the highest and lowest readings of four consecutive readings.
- The designer is referred to the infiltration testing procedure information provided in **Section 3.3.5** ☛ p. 78 for further double-ring infiltrometer testing guidance.

Cased borehole test

- Infiltration tests must not be completed within the same borehole as the hollow-stem auger borehole soil characterization studies, but must be completed no less than five feet, and no more than ten feet, away from the soil characterization borehole locations.
- Eight infiltration tests must be performed per acre of SMP footprint, or one test per 5,445 square feet, with a minimum of three tests performed.
- The casing installation must be completed using ASTM D6151-08 – Hollow-Stem Auger Method, with the inner diameter of the pipe being no less than four inches.
- Only one infiltration test is acceptable for each borehole, regardless of whether tests are proposed to be completed at different depths.
- Test holes must be presoaked for one hour immediately prior to testing. The presoaking procedure is intended to simulate saturated conditions in the environment and to minimize the influence of unsaturated flow.
- Testing must be conducted for a minimum of eight readings or until a stabilized infiltration rate is measured. A stabilized rate of drop means a difference of 0.25 inch or less of drop between the highest and lowest readings of four consecutive readings.
- The designer is referred to the infiltration testing procedure information provided in **Section 3.3.5** ☛ p. 78 for further cased borehole testing guidance.

3.3.4 Soil characterization procedures

Soil characterization and limiting layer identification provides a visual assessment of the soil profile, which can supplement infiltration testing results. PWD allows the use of exploratory test pits or soil borings to assess soil for infiltration feasibility; however, PWD strongly prefers the use of test pits where space allows. With both methods, soil sampling and characterization are required. Requirements for each soil characterization and soil sampling method are described in **Section 3.3.2** ☛ p. 72, while procedures are described below.

Exploratory test pit procedure

A test pit consists of a backhoe-excavated trench, of an appropriate width, with the goal of exposing a soil profile. As the excavation progresses, the testing professional must document the presence of any limiting layers, groundwater presence, and in situ observations of soil characteristics. When test pits are the chosen soil characterization methodology, the double-ring infiltrometer method must be used for the infiltration testing. The designer is referred to **Appendix H** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/h-infiltration-testing-log for a blank Infiltration Testing Log, which is required to be completed and submitted as part of the Geotechnical Report and includes guidance for documenting soil characteristics. Soil classifications must be conducted in accordance with ASTM D2488. The designer is referred to **Section 3.3.5** ☛ p. 78 for the double-ring infiltrometer testing procedure.

Hollow-stem auger borehole procedure

A hollow-stem auger borehole soil characterization can be performed where space constraints prevent the excavation of test pits. The test is completed using a four-inch inner diameter or larger hollow-stem auger. The designer is referred to **Appendix H** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/h-infiltration-testing-log for a blank Infiltration Testing Log, which is required to be completed and submitted as part of the Geotechnical Report and includes guidance for documenting soil characteristics. Soil classifications must be conducted in accordance with ASTM D2488. Blow counts, if the designer and geotechnical professional elect to perform SPTs, must be performed in accordance with ASTM D1586. As the test progresses, the testing professional must document the presence of any limiting layers, groundwater presence, and in situ observations of soil characteristics (Soil Sampling Requirements and Procedure sections are listed below). The ASTM standard D6151-08,Hollow-Stem Auger Method, should be referenced for specific direction, but the general testing procedure is as follows:

1. Advance a borehole to the proposed testing depth using the Hollow-Stem Auger Method (ASTM D6151-08). The auger hole diameter must be at least two inches larger than the outer diameter of the inner casing. The inner casing will consist of a PVC pipe with a minimum inner diameter of four inches and a smooth, square bottom.
2. Push the inner casing within the auger hollow stem to the infiltration interface and firmly set it into the bottom of the borehole. Use a borehole plane to scarify the soil surface at the bottom of the casing and remove any remaining loose soil. Measure the depth from the top of casing to the bottom of the hole to the nearest 0.01 feet.
3. Collect soil samples per soil sampling requirements and procedure.
4. Remove the augers.

5. Upon completion of the test, remove the hollow-stem auger tubes and backfill the borehole with cuttings. If testing is conducted in vegetated areas, return the surface to its previous state. If testing is completed in paved areas, plug the hole with a bentonite plug and seal the surface with concrete or asphalt.
6. If a cased borehole infiltration test is to be completed, backfill the borehole before conducting the infiltration test. Refer to **Section 3.3.3** ☛ p. 74 and **Section 3.3.5** ☛ p. 78 for guidance on borehole infiltration testing.

Soil sampling procedure

- Soil samples must be obtained during the soil characterization field analysis.
- Field soil sample classification must be performed according to ASTM D2488, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).
- Split spoon sampling must be completed in accordance with ASTM D1586 (Standard Test Method for SPT and Split-Barrel Sampling of Soils). Blow count data must be collected from the soil samples.
- Laboratory analysis of collected soil samples must include, at a minimum:
  - ASTM D422-63 – Standard Test Method for Particle-Size Analysis of Soils, down to the No. 200 sieve, and
  - ASTM D2487 – Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).
- Additional laboratory testing can be completed at the geotechnical professional and designer's discretion.

3.3.5 Infiltration testing procedures

PWD allows the use of double-ring infiltrometers or cased boreholes for infiltration testing; however, PWD strongly prefers the use of double-ring infiltrometer testing where space allows. The designer is referred to **Section 3.3.3** ☛ p. 74 for Infiltration Testing Requirements. Each test must be accompanied by a test pit or soil boring and a soil characterization study.

Double-ring infiltrometer

A double-ring infiltrometer test estimates the vertical movement of water through the bottom of the test area using a larger surface area than a cased borehole infiltration test. A double-ring infiltrometer test must be completed if a test pit is the chosen methodology for obtaining the soil characterization and soil samples.

The designer is referred to **Appendix H** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/h-infiltration-testing-log for a blank Infiltration Testing Log, which is required to be completed and submitted as part of the Geotechnical Report. The general testing procedure outlined below is based on a slightly modified ASTM standard D3385-09.

1. Determine a location and depth for the test based on the information obtained from the in situ soil classification analysis.
2. Dig a test pit to the desired depth where the infiltration interface is proposed using the benched methodology recommended in the test pit procedure.
3. Establish a level surface for the testing apparatus to be placed.
4. Drive outer ring into the soil to a minimum depth of six inches or at a minimum two inches more than the inner ring. A drive cap is recommended to ensure consistent and uniform installation and to avoid fracturing the soil surface.
5. Center the inner ring within the outer ring and drive to a depth of approximately two to four inches below grade using the same technique as described for the outer ring placement.
6. If soil along the inner ring is excessively disturbed, reset the ring. If the soil along the inside of either ring is slightly disturbed, tamp the soil with minimal force until soil is as firm as prior to disturbance.
7. A constant head must be maintained within the inner ring and annular space between the two rings. Manually controlling the flow of liquid is sufficient; however, the testing professional can consult the ASTM standard for additional methods. If manually controlling the liquid level, depth gauges must be installed such that the reference head is between one and six inches. Place the depth gauges towards the center of the inner ring and midway between the two rings.
8. Install anti-scouring measures such as a one-inch layer of coarse sand or washed, fine gravel and splash guards (pieces of burlap or rubber sheet) to avoid scour when water is applied.
9. Fill both rings with water to the same depth in each ring. Remove splash guards, and do not record this initial volume of liquid.
10. The test area must be presoaked immediately prior to testing. Fill both rings with water-to-water level indicator mark or rim at 30-minute intervals for one hour. The minimum water depth must be four inches. The drop in the water level during the last 30 minutes of the presoaking period must be applied to the following standard to determine the time interval between readings:
    a. If water level drop is two inches or more, use ten-minute measurement intervals.
    b. If water level drop is fewer than two inches, use 30-minute measurement intervals.

11. Obtain a reading of the drop in water level in the center ring at appropriate time intervals. After each reading, refill both rings to the water level indicator mark or rim. Measurement to the water level in the center ring must be made from a fixed reference point and must continue at the interval determined until a minimum of eight readings are completed or until a stabilized rate of drop is obtained, whichever occurs first. A stabilized rate of drop means a difference of 0.25 inch or less of drop between the highest and lowest readings of four consecutive readings.
12. The drop that occurs in the center ring during the final period or the average stabilized rate, expressed as inches per hour, represents the infiltration rate for that test location.
13. Backfill the excavation and restore the surface to its original condition once all testing is completed.

Cased borehole

A cased borehole infiltration test is only recommended when site characteristics do not allow for a test pit and double-ring infiltration test. If a borehole infiltration test is performed, it must not be completed within the same hole as the hollow-stem auger soil characterization study.

The borehole infiltration method is based on a slightly modified ASTM D6391-11 standard. The casing installation method required by PWD is a modified procedure that avoids the use of a bentonite paste at the tip of the casing and a bentonite seal within the annular space between the casing and the surrounding soils. The use of bentonite can absorb moisture from the surrounding soils before swelling and hardening. As a result, the test results may not be accurate.

The designer is referred to **Appendix H** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/h-infiltration-testing-log for a blank Infiltration Testing Log, which is required to be completed and submitted as part of the Geotechnical Report. The modified borehole infiltration testing procedure required is outlined below.

1. Advance a borehole to the depth of the proposed infiltration interface depth using the Hollow-Stem Auger Method (ASTM D6151-08). The auger hole diameter must be at least two inches larger than the outer diameter of the inner casing. The inner casing will consist of a PVC pipe with minimum inner diameter of four inches and a smooth, square bottom.
2. Push the inner casing within the auger hollow stem to the infiltration interface and firmly set into the bottom of the borehole. Use a borehole plane to scarify the soil surface at the bottom of the casing and remove any remaining loose soil. Measure the depth from the top of casing to the bottom of the hole to the nearest 0.01 feet.
3. Remove the augers.
4. Place two inches of washed, fine gravel or clean, coarse sand in the bottom of the borehole to prevent scour during filling of the casing. Be sure to place gravel or sand uniformly to obtain an even depth within the hole. Re-measure the depth from the top of casing to the gravel or sand surface to the nearest 0.01 feet.
5. Presoak test holes immediately prior to testing to simulate saturated conditions. Fill casing with water at a very low rate so as not to disturb the bottom sediments. Place water to a depth of at least six inches above the bottom and readjust every 30 minutes for one hour. A constant head can be applied and maintained at the top of the casing as an alternate method. The drop in the water level during the last 30 minutes of the presoaking period must be applied to the following standard to determine the time interval between readings:
    a. If water level drop is two inches or more, use ten-minute measurement intervals.
    b. If water level drop is fewer than two inches, use 30-minute measurement intervals.

6. After the presoaking, the water level is measured, using an approved method per the ASTM standard, where the water level remains between 12 and 18 inches above the bottom of the hole. All water added must be recorded as a volume along with the time of addition.
7. Measurements of water level must be made from the top of casing and must continue at the interval determined until a minimum of eight readings are completed or until a stabilized rate of drop is obtained, whichever occurs first. A stabilized rate of drop means a difference of 0.25 inch or less of drop between the highest and lowest readings of four consecutive readings.
8. Upon completion, remove casing and backfill hole with cuttings. If testing is conducted in vegetated areas, return the surface to its previous state. If testing is completed in paved areas, plug the hole with a bentonite plug and seal the surface with concrete or asphalt.
9. Use the field-observed stabilized infiltration rate as the test infiltration rate.

3.3.6 Evaluation of infiltration testing results

Upon completion of soil characterization and infiltration testing, the designer must first determine SMP design infiltration rates based on the tested infiltration rates. Once the design infiltration rate is calculated, tentative SMP locations must be assessed for suitable underlying soils that would support an infiltrating practice. The designer must locate SMPs within areas where infiltration is feasible based on the allowable and acceptable infiltration rates. The following steps will assist the designer in determining the final SMP footprint locations.

Step 1: Determine the geometric mean of the tested infiltration rates.

Starting with the tested infiltration rates, the geometric mean must be used to determine the *mean tested infiltration rate* following multiple tests for each SMP. As the rates are log-normally distributed, the geometric mean, not the arithmetic averages, of multiple test results must be reported and used. The field data and/or any statistically derived result of field measurements must pass a rigid quality control procedure. In some situations, a measured rate of zero may be obtained. A measured rate of zero is generally related to inherent flaws in the testing methodology. In these cases, a default value should be used based on one decimal digit less than the smallest detectable reading for that particular test method/equipment. For example, if the smallest detectable reading using an infiltrometer test is a 0.125-inch drop, then 0.124 inches should be substituted for the zero value which represents one decimal digit smaller than 0.125 inches. This substitution method is necessary to ensure that the test calculations do not yield a zero value for hydraulic conductivity since a zero value cannot be used in the calculation of a geometric mean.

The highest tested infiltration rate from the test results must be discarded when more than three are employed for design purposes. The geometric mean of the remaining readings must be calculated for each SMP.

The geometric mean of a data set is the n^{th} root of the product of "n" numbers:

$$\{a_1, a_2, \ldots, a_n\} = \sqrt[n]{a_1 * a_2 * \cdots a_n}$$

Step 2: Compare the geometric mean to the allowable and acceptable infiltration rates.

Prior to determining whether the SMP footprint and location are suitable for installation of an infiltrating SMP, the designer must check that the geometric mean of the tested infiltration rates falls within the allowable and acceptable range defined by PWD. Soils underlying infiltration practices must have a mean tested infiltration rate between 0.4 and ten inches per hour. Infiltration is to be considered infeasible in soils with mean tested infiltration rates of less than 0.4 inches per hour. If the designer wishes to design an SMP to infiltrate with a mean tested infiltration rate of less than 0.4 inches per hour, calculations must be provided demonstrating an SMP drain down time of no more than 72 hours with its proposed loading ratio. PWD will review this scenario on a project-by-project basis.

Soils with mean tested infiltration rates in excess of ten inches per hour will require soil amendments. Upon achieving final subgrade elevations, a two-foot-thick layer of amended soil must be placed across the entire cross-section of the infiltrating SMP, below the bottom elevation of the SMP. A conservative infiltration rate must be used in the stormwater routing calculations during the design of the SMP, and a soil amendment sequence of construction must be provided on the plans. A minimum of three infiltration tests must be performed within the amended soil layer during construction to verify rates. The double-ring infiltrometer test procedure must be used, and soil sampling and characterization are also required; all must comply with the procedures detailed in these sections. The engineer must provide a signed and sealed Geotechnical Report. All information must be submitted to PWD for review and approval before proceeding with construction. If soil amendments are installed and the mean tested infiltration rate is determined to be outside of PWD's allowable range of 0.4 to ten inches per hour, or varies significantly from the design infiltration rate, additional soil amendments and/or a system redesign will be required.

For soil amendments, verify that the following sequence of construction is clearly noted on the plans.

1. Excavate two feet below the proposed infiltration bed invert elevation.
2. Manually grade and scarify the existing soil surface. The bottom of the infiltration bed shall be at a level grade. The existing subgrade shall not be compacted or subject to excessive construction equipment.
3. Place geotextile filter fabric immediately after approval of subgrade preparation, in accordance with manufacturer's standards and recommendations.
4. Amend in-situ soil. [Provide instructions for amending the in-situ soil. Soil amendment media can include compost, mulch, manures, sand, and manufactured microbial solutions.] The project geotechnical engineer should be on-site to observe installation of soil amendments.
5. Place two feet of amended soil across the entire cross-section of the infiltration bed. Lightly compact each layer with light equipment, keeping equipment movement over storage bed subgrades to a minimum.
6. Perform infiltration testing of the amended soil layer. A minimum of three infiltration tests must be performed within the amended soil layer. The procedure used must be the double-ring infiltrometer test, soil sampling and characterization are also required, and all must be in compliance with the current Philadelphia Stormwater Management Guidance Manual. Prior to infiltration testing, PWD must be called (office: (215) 685-6387) to schedule an observation. The engineer must provide a signed and sealed Geotechnical Report. All information must be submitted to PWD for review and approval before proceeding with construction. If soil amendments are installed, and the tested infiltration rate is determined to be outside of the PWD allowable range of 0.4 to ten inches per hour, or varies significantly from the design infiltration rate, additional soil amendments and/or a system redesign will be required. Once the infiltration test results are reviewed and determined by PWD to be acceptable, proceed with installation of the infiltration practice.
7. Soil amendments shall not be compacted or subject to excessive construction prior to the placement of geotextile and stone bed.
8. Place geotextile and infiltration bed aggregate immediately after approval of soil amendment preparation to prevent accumulation of debris and sediment. Prevent runoff and sediment from entering the storage bed during the placement of the geotextile and aggregate bed.
9. Place geotextile in accordance with manufacturer's standards and recommendations. Adjacent strips of filter fabric shall overlap a minimum of 16 inches. Fabric shall be secured at least four feet outside of bed.

10. Install aggregate course in lifts of six to eight inches. Lightly compact each layer with light equipment, keeping equipment movement over storage bed subgrades to a minimum. If proposed, install storage structures (e.g., pipes, arches, crates, etc.) during stone bed placement. Install aggregate to grades indicated on the drawings.
11. Complete surface grading above subsurface infiltration system, using suitable equipment to avoid excess compaction.

Step 3: Evaluate the proposed SMP locations (if necessary).

If infiltration rates are found to be below the minimum allowable rate at proposed SMP locations, and there are other areas of the project site where infiltration may be feasible, the designer must consider alternative SMP locations. Alternatively, the designer may explore the possibility of over-excavating poorly infiltrating soils, if the removal and replacement of these soils would allow for SMPs to infiltrate into more porous material that may exist below poorly infiltrating soils.

Additionally, SMPs must not be located within two feet of any limiting layers. A two-foot separation between the infiltration interface (SMP bottom elevation) and the regularly occurring seasonally high-water table must be maintained. This reduces the likelihood that temporary groundwater mounding will affect the system and allows sufficient distance of water movement through the soil to permit adequate pollutant removal. Also, a minimum separation of two feet must be maintained between bedrock and the SMP bottom elevation to ensure adequate pollutant removal.

Step 4: Document infiltration feasibility.

All projects require documentation for infiltration feasibility. If infiltration is determined to be feasible on-site, the designer must provide a Geotechnical Report meeting the requirements provided in **Appendix E** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/e-plan-and-report-checklists and may then proceed to detailed design (Step 5). Where infiltration is found to be infeasible, a waiver from the infiltration requirement must be requested.

Infiltration waiver request

The two scenarios for which PWD will generally grant a waiver from the infiltration requirement are: (1) full build-out and (2) projects with unacceptable infiltration rates, or where contamination is present. If applicable, a request for a waiver from the infiltration requirement must be accompanied by supporting documentation.

1. For projects confirmed to be full build-out (where ground-level open space is not sufficient to accommodate required SMP loading ratios and setbacks), a site layout must be provided that verifies this scenario. Where a full build-out is confirmed, the designer must prepare and submit a Conceptual Stormwater Management Plan and request a waiver from the infiltration requirement via completion and submittal of the Existing Resources and Site Analysis (ERSA) Worksheet (**Section 2.1.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-1-existing-resources-and-site-analysis#2.1.1). A full build-out does not require a Geotechnical Report.
2. Where infiltration has been found to be infeasible due to unacceptable infiltration rates or contamination, a waiver from the infiltration requirement must be requested via the Online Technical Worksheet (**Section 3.4.3** ☛ p. 105). If a waiver from the infiltration requirement is requested due to unacceptable infiltration rates, it must be accompanied by a Geotechnical Report—both of which are required as part of the PCSMP Review Phase Submission Package. The Geotechnical Report must be

Appendix E ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/e-plan-and-report-checklists. If a waiver from the infiltration requirement is requested due to contamination, electronic copies of environmental reports for any testing completed must be submitted, as well as a justification letter from the geotechnical engineer or environmental professional.

Geotechnical Report

The designer must provide a signed and sealed Geotechnical Report with a testing location plan and summary of results. All information must be submitted to PWD for review and approval before start of construction.

Infiltration testing results are required as part of the PCSMP Review Phase Submission Package (**Section 2.3.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-3-review-phases#2.3.1); however, the designer is encouraged to submit infiltration testing results as early as possible in the review process. If available, infiltration testing results will be accepted and reviewed as part of the Conceptual Review Phase Submission Package or Stormwater Grant Application for Stormwater Grant-funded Stormwater Retrofit projects. PWD may not be able to complete its review of the infiltration testing during the Conceptual Review Phase if all pertinent design information is not provided, such as SMP bottom elevation, and will defer final determination of infiltration feasibility to the PCSMP Review Phase.

Infiltration testing results must be submitted in a signed and sealed (by a professional engineer licensed in the Commonwealth of Pennsylvania) Geotechnical Report containing the engineer's analysis and summary of all results including soil classification (in accordance with ASTM D2488) and site evaluation, along with the engineer's affirmative or negative recommendation on feasibility of infiltration, with justification. The designer is referred to **Appendix E** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/e-plan-and-report-checklists for a complete listing of all required Geotechnical Report components.

Step 5: Proceed with detailed SMP design.

If infiltration has been documented as feasible for the proposed SMP locations, the designer may proceed with detailed design of infiltration SMPs, using guidance provided in **Section 3.2** ☛ p. 41 and **Chapter 4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4. The designer must apply a factor of safety of two to the geometric mean of the tested infiltration rates, as documented in **Section 3.4.1** ☛ p. 86. This rate will be the SMP-specific *design infiltration rate* to be used for all further design and calculations.

For project sites where infiltration is deemed infeasible, and this condition is confirmed by PWD, the designer must use acceptable pollutant-reducing SMPs to comply with the Water Quality requirement. Water Quality release rate requirements also apply to non-infiltrating areas in combined sewersheds. Acceptable pollutant-reducing SMPs are listed in **Section 3.1.7** ☛ p. 35. Additional detailed design guidance for pollutant-reducing SMPs is provided in **Chapter 4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4.

3.4 How to Show Compliance

Section 3.4 provides detail on how to ensure and demonstrate that stormwater management design strategies are implemented in accordance with the Philadelphia Water Department's (PWD's) Stormwater Regulations (Stormwater Regulations). This section provides resources that can be used in conjunction with the design requirements detailed in **Section 3.2** ☛ p. 41 and **Chapter 4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4.

Section 3.4.1 ☛ p. 86 gives specific guidance and requirements for compliance with the following:

- Water Quality requirement,
- Channel Protection requirement,
- Flood Control requirement, and
- Public Health and Safety Release Rate requirement.

Compliance with some Stormwater Regulations may not be required for all projects; therefore, the applicant is referred to **Chapter 1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1 to assess and/or confirm applicability of specific requirements.

Section 3.4.2 ☛ p. 95 provides guidance and requirements for the design of storm sewer systems.

Section 3.4.3 ☛ p. 98 contains calculation methods and design tools to assist in stormwater management design.

3.4.1 Regulatory compliance documentation requirements

After determining which Stormwater Regulations are applicable to the project site using **Chapter 1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1, the applicant can use this section as a guide to document regulatory compliance within the Post-Construction Stormwater Management Plan (PCSMP) Review Phase. For each requirement, a step-by-step guide to documenting compliance is provided. While some steps are either identical or similar between requirements, this redundancy is provided for projects where not all requirements are applicable. The applicant is referred to **Section 2.3.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-3-review-phases#2.3.1 for complete PCSMP Review Phase submission requirements.

Quick tip

As part of an integrated design approach (**Section 3.1.3** ☛ p. 15), the designer may choose to meet multiple Stormwater Regulations with a single SMP or multiple SMPs. Additionally, the designer may choose an approach that uses SMPs in series (**Section 3.2.3** ☛ p. 50)

Water Quality

The designer must use the following steps to document compliance with the Water Quality requirement. This requirement, with key differences noted below and in **Section 1.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1/1-3-stormwater-retrofits, contains the design standards for Stormwater Retrofit projects. No other Post-Construction Stormwater Management Requirement is applicable to voluntary stormwater management.

Step 1:

Delineate all post-development impervious area within the project limit of disturbance (LOD) and differentiate between disconnected impervious cover (DIC) and directly connected impervious area (DCIA). For projects located in combined sewer areas, also differentiate between DCIA that meets roof runoff isolation requirements (**Section 3.1.7** ☛ p. 35) and all other DCIA. For Stormwater Retrofit projects, delineate the impervious area draining to any proposed stormwater management practices (SMPs). The roof runoff isolation pollutant-reducing practice does not apply for Stormwater Retrofit projects.

Step 2:

For all DIC within the project LOD, identify the proposed DIC strategy (i.e., rooftop disconnection, pavement disconnection, tree disconnection credit, green roof, or porous surface).

DIC strategies must meet applicable requirements in **Section 3.1.5** ☛ p. 22. For Stormwater Retrofit projects, different policies on DIC strategies apply. Refer to **Section 1.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1/1-3-stormwater-retrofits for more information on incorporating DIC into Stormwater Retrofit projects.

Step 4:

Calculate the Water Quality Volume (WQv) for each proposed SMP (or series of SMPs, if applicable) using the following equation:

$$WQv = (DCIA)\ x\ (\frac{R}{12})$$

Where:

WQv = Water Quality Volume [cubic feet]
DCIA = Directly Connected Impervious Area [square feet]
R = 1.5 inches runoff depth

Step 5:

Determine the sewershed of the discharge point of each proposed SMP.

Design the SMP(s) to provide management of the WQv and to meet all SMP design requirements by SMP type in **Chapter 4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4. WQv management requirements differ by infiltration feasibility and sewershed, as detailed in **Chapter 1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1; after determining these factors, proceed to Step 5a, Step 5b, or Step 5c.

Step 5a:

Where infiltration is feasible:

- Design the SMP(s) to infiltrate 100% of WQv.
- Size the SMP(s) to provide static storage of the WQv below the lowest outlet elevation.
- Bioinfiltration SMPs can be designed for an adjusted WQv= (DCIA) [sf] x (1-inch runoff depth/12) if the designer demonstrates through modeling that the full WQv can be routed dynamically through the system. See **Section 4.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-1-bioinfiltration-bioretention for more information.
- Design the SMP(s) to ensure drain down time is no more than 72 hours based on the tested infiltration rate, with an applied factor of safety of two to the geometric mean of the tested infiltration rates (design infiltration rate) and the SMP horizontal surface area (footprint).

Step 5b:

Where infiltration is not feasible, and the project is located in a combined sewer area:

- Design the SMP(s) to route 100% of the WQv that is not infiltrated through an acceptable pollutant-reducing practice (**Table 3.1-3** ☛ p. 35). This is not a requirement for Stormwater Retrofit projects.
- Design the SMP(s) to ensure a slow-release rate on-site that does not exceed 0.05 cubic feet per second (cfs) per acre of DCIA when routing a 1.7-inch PWD Design Storm.
  See **Section 3.4.3** ☛ p. 98 for calculation methods and **Table 3.4-4** ☛ p. 101 for dimensionless rainfall distribution for the PWD Design Storm. A curve number of 98 must be used for all DCIA when performing routing calculations for the Water Quality requirement.
- Design the SMP(s) to ensure drain down time is no more than 72 hours after the storm event for a 1.7-inch PWD Design Storm. The drain down time is the time required for evacuation of the instantaneous storage of the WQv in the SMP.

Step 5c:

Where infiltration is not feasible, and the project is located in a separate sewer area or is a direct discharge project:

- Design SMP(s) to route 100% of the WQv that is not infiltrated through an acceptable pollutant-reducing practice (**Table 3.1-3** ☛ p. 35).
- Design SMP(s) to ensure drain down time is no more than 72 hours after the 24-hour storm event. The drain down time is the time required for evacuation of the instantaneous storage of the WQv in the SMP.

Step 6:

For Development Projects only, when meeting the Water Quality requirement via stormwater management is not possible for all or a portion of the DCIA within the LOD, the applicant may propose payment of a one-time fee-in-lieu. The amount of the fee-in-lieu charge is set forth in Section 8.2 of PWD's **Rates and Charges** ☛ water.phila.gov/rates. The following must be documented for a fee-in-lieu request to be considered by PWD:

- In the PCSMP Report, outline all stormwater management strategies that have been considered to comply with the Water Quality requirement, including off-site management as discussed in **Section 3.2.4** ☛ p. 55, and why they are not feasible or advisable. PWD may advise that stormwater runoff be directed to a nearby City-owned SMP, if such an SMP exists and has the capacity to handle the additional runoff.
- Investigate and confirm that the Development Project proposal to pay fee-in-lieu will not adversely affect flooding, stream protection, neighboring properties, or be inconsistent with NPDES Permit requirements or any other applicable local, State, or Federal law.
- On the PCSMP, identify the square footage, type, and location of DCIA that will bypass stormwater management for Water Quality requirement compliance. This value will be used to calculate the onetime fee-in-lieu payment.

All design information developed to document compliance with the Water Quality requirement must be included in the PCSMP Review Phase Submission Package. This includes, but is not limited to:

- PDF printout of completed Online Technical Worksheet;
- Post-development drainage area plans;
- Static storage calculations; and
- Flow routing calculations and model inputs and results for slow-release or bioinfiltration dynamic design, if applicable.

Complete PCSMP Review Phase submission requirements are provided in **Section 2.3.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-3-review-phases#2.3.1.

Channel Protection

The applicant must use the following steps to document compliance with the Channel Protection requirement, if applicable. The applicant is referred to **Section 1.2.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1/1-2-stormwater-regulations#1.2.1 for details on Channel Protection exemptions.

Step 1:

Determine a point of analysis (POA) for the post-development condition. A POA is a common point of discharge from the project site or drainage area. A POA may serve one or several drainage areas and/or SMPs. PWD recommends using as few POAs as possible for compliance calculations. If there are multiple points of discharge from a property, it may still be possible to use a single POA if all discharge points lead to the same waterbody or outfall. Should a project fall into this category, contact PWD for more information as to how many POAs should be identified.

Step 2

Delineate drainage areas for each POA and all DCIA within each drainage area. All area within the project LOD must be accounted for in a POA, including areas that bypass SMPs.

Step 3

Design stormwater outlet controls (within or external to SMPs) to ensure the release rate at each POA does not exceed 0.24 cfs per acre of DCIA (draining to the POA) when routing a one-year National Resources Conservation Service (NRCS) Type II 24-hour design storm. The design precipitation depth of a one-year, 24-hour storm is 2.83 inches. See **Section 3.4.3** ☛ p. 98 for calculation methods, **Table 3.4-3** ☛ p. 100 for design storm depths, and **Table 3.4-5** ☛ p. 102 for dimensionless rainfall distribution for the NRCS Type II 24-hour design storm. Outlet controls and SMPs must also meet all design requirements of **Chapter 4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4.

Where runoff is routed through an SMP prior to reaching a POA, design the SMP(s) to ensure drain down time is no more than 72 hours after the storm event for a one-year NRCS Type II 24-hour design storm. The drain down time is the time required for evacuation of the instantaneous storage of the Channel Protection volume in the SMP.

All design information developed to document compliance with the Channel Protection requirement must be included in the PCSMP Review Phase Submission Package. This includes, but is not limited to:

- PDF printout of completed Online Technical Worksheet;
- Post-development drainage area plans; and
- Flow routing calculations and model inputs and results for the one-year design storm.

Complete PCSMP Review Phase submission requirements are provided in **Section 2.3.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-3-review-phases#2.3.1.

Flood Control

The applicant must use the following steps to document compliance with the Flood Control requirement, if applicable. The applicant is referred to **Section 1.2.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1/1-2-stormwater-regulations#1.2.1 for details on Flood Control exemptions.

Step 1:

Determine a POA for comparison of the predevelopment and post-development conditions. A POA is a common point of discharge from the project site or drainage area. A POA may serve one or several drainage areas and/or SMPs. PWD recommends using as few POAs as possible for compliance calculations. If there are multiple points of discharge from a property, it may still be possible to use a single POA if all discharge points lead to the same waterbody or outfall. Should a project fall into this category, contact PWD for more information as to how many POAs should be identified.

Step 2:

Determine the predevelopment and post-development drainage area(s) and drainage area conditions for each POA. The predevelopment condition is determined by the dominant land use for the ten years preceding the date of the project's Existing Resources and Site Analysis (ERSA) Application submission. All area within the project LOD must be accounted for within a POA, including areas that bypass SMPs.

The applicant is referred to **Table 3.4-2** ☛ p. 99 for acceptable curve numbers and must use the following guidance for determining land use designations for Flood Control:

- Pervious area is considered to be area covered by a pervious surface that allows water to drain through it rather than running off of the site.
- All non-forested pervious areas must be considered meadow in good condition for predevelopment runoff calculations.
- Non-forested pervious area consists of the following cover types: meadow, grass/lawn, brush, gravel, dirt, porous surfaces, and any combination of these cover types.
- Dirt and gravel are generally considered pervious cover; however, if the applicant believes an impervious classification is more suitable, they can submit documentation, such as photographic evidence and testing results, to support this claim.
- DIC should be represented as the appropriate cover type, as this management strategy does not apply to the Flood Control requirement; thus, impervious area must be represented as impervious, green roof area as green roof, porous surface area as porous surface, and permeable paver area as permeable paver.
- For redevelopment projects, in addition to any other pervious area, 20% of the existing impervious cover, when present, must be considered meadow (good condition) for the predevelopment runoff calculations.

Step 3:

Confirm or determine, if not done previously, the level of flood control required based on the project's Flood Management District (**Appendix D** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/d-watershed-and-phs-release-rate-maps) and peak runoff rate requirements by Flood Management District, per Table 3.4-1 below.

If a project is located near or across a Flood Management District border, the applicant is responsible for contacting PWD to confirm the District requirements that apply to the project. In most cases, a project that is located in multiple Districts will be required to meet the requirements of the District within which each POA is located, resulting in discrete rate reductions for each POA.

Table 3.4-1: Peak runoff rates for Management Districts

District	Column A NRCS Type II 24-hour Design Storm applied to proposed condition	Column B NRCS Type II 24-hour Design Storm applied to predevelopment condition
A	2 – year	1 – year
A	5 – year	5 – year
A	10 – year	10 – year
A	25 – year	25 – year
A	50 – year	50 – year
A	100 – year	100 – year
B	2 – year	1 – year
B	5 – year	2 – year
B	10 – year	5 – year
B	25 – year	10 – year
B	50 – year	25 – year
B	100 – year	50 – year
B-1	2 – year	1 – year
B-1	5 – year	2 – year
B-1	10 – year	5 – year
B-1	25 – year	10 – year
B-1	50 – year	25 – year
B-1	100 – year	100 – year
B-2	2 – year	1 – year
B-2	5 – year	2 – year
B-2	25 – year	5 – year
B-2	50 – year	10 – year
B-2	100 – year	100 – year
C*	Conditional Direct Discharge District	
C-1**	Conditional Direct Discharge District	

SMPs shall be designed such that peak rates from Column A are less than or equal to Peak Rates from Column B.
** In District C, a Development Site that can discharge directly without use of City infrastructure may do so without control of proposed conditions peak rate of runoff.*
*** In District C-1, a Development site that can discharge directly to the Tookany/Tacony-Frankford main channel or major tributaries without the use of City infrastructure may do so without the control of proposed conditions peak rate of runoff greater than the 5-year storm.*
Redevelopment located in the Delaware Direct Watershed or that discharges to the Lower Schuylkill River, Manayunk Canal, or Mingo Creek, but situated outside of District C, that can discharge directly to the Delaware Direct or Lower Schuylkill main channels without the use of City infrastructure, may do so without the control of proposed conditions peak rate of runoff according to the procedures found in the Manual.
For Conditional Direct Discharge Districts, the proposed conditions peak rate of runoff for a Development site that discharges to City infrastructure must be controlled to the Predevelopment Conditions peak rate as required in District A provisions or the specified Design Storms. The Predevelopment Condition shall be defined according to the procedures found in the Manual.

Step 4:

Design stormwater outlet controls (within, or external to, SMPs) to ensure the peak runoff rate in the proposed condition (left column of Table 3.4-1) does not exceed the peak runoff rate in the predevelopment condition (right column of Table 3.4-1) at each POA for the stated design storms. For a given Flood Management District, all storms' rate reductions must be met concurrently. Peak rate reduction provided by SMPs that meet the Water Quality and Channel Protection requirements may be considered in sizing calculations for peak rate controls. See **Section 3.4.3** ☛ p. 98 for calculation methods, **Table 3.4-3** ☛ p. 100 for design storm depths, and **Table 3.4-5** ☛ p. 102 for dimensionless rainfall distribution for the NRCS Type II 24-hour design storm. Outlet controls and SMPs must also meet all design requirements of **Chapter 4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4.

All design information developed to document compliance with the Flood Control requirement must be included in the PCSMP Review Phase Submission Package. This includes but is not limited to:

- PDF printout of completed Online Technical Worksheet;
- Predevelopment and post-development drainage area plans;
- Predevelopment time of concentration (Tc) calculations;
- Post-development Tc calculations (if demonstration of a Tc greater than an assumed six minutes is desired); and
- Flow routing calculations and model inputs and results for predevelopment and post-development conditions during all design storms applicable to the Flood Management District's required rate reductions.

Complete PCSMP Review Phase submission requirements are provided in **Section 2.3.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-3-review-phases#2.3.1.

Public Health and Safety Release Rate

The applicant must use the following steps to document compliance with a Public Health and Safety (PHS) Release Rate requirement, if applicable. The designer is referred to **Section 1.2.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1/1-2-stormwater-regulations/#1.2.1 for more information on the PHS Release Rate requirement.

Step 1:

Confirm the project-specific PHS Release Rate requirement in **Appendix D** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/d-watershed-and-phs-release-rate-maps or with the **Reg Finder** ☛ www.pwdplanreview.org/reg_finder. A PHS Release Rate requirement is stated as a peak runoff release rate in cfs per acre of earth disturbance, pervious and impervious alike.

Step 2:

Determine a POA for the post-development condition. A POA is a common point of discharge from the project site or drainage area. A POA may serve one or several drainage areas and/or SMPs. Multiple POAs must be identified for project sites with multiple points of discharge.

Step 3:

Delineate drainage areas for each POA, the extent of earth disturbance within each drainage area, and the post-development condition within the LOD. All area within the project LOD must be accounted for within a POA, including areas that bypass SMPs.

Step 4:

Design stormwater outlet controls (within, or external to, SMPs) to ensure the peak runoff release rate at each POA does not exceed the project-specific PHS Release Rate requirement (cfs per acre LOD within the POA) when routing the one-year through ten-year NRCS Type II 24-hour design storms. See **Section 3.4.3** ☛ p. 98 for calculation methods, **Table 3.4-3** ☛ p. 100 for design storm depths, and **Table 3.4-5** ☛ p. 102 for dimensionless rainfall distribution for the NRCS Type II 24-hour design storm. Outlet controls and SMPs must also meet all design requirements of **Chapter 4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4.

All design information developed to document compliance with the PHS Release Rate requirement must be included in the PCSMP Review Phase Submission Package. This includes but is not limited to:

- PDF printout of completed Online Technical Worksheet;
- Post-development drainage area plans;
- Post-development Tc calculations (if demonstration of a Tc greater than an assumed six minutes is desired); and
- Flow routing calculations and model inputs and results for the one-year through ten-year design storms.

Complete PCSMP Review Phase submission requirements are provided in **Section 2.3.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-3-review-phases#2.3.1.

3.4.2 Storm sewer design requirements

All storm sewer pipes must be designed to have adequate capacity to safely convey the ten-year storm without surcharging the crown of the pipe. Pipe capacity calculations are required for all stormwater conveyance that is not connected to the roof drainage system. The designer is referred to the **City of Philadelphia Plumbing Code** ☛ www.phila.gov/departments/department-of-licenses-and-inspections/resources/applicable-codes (Plumbing Code) for guidance on sizing roof drainage systems.

If Flood Control is required, runoff from larger storms must be safely conveyed off the site, either through overland flow or a storm sewer. Runoff may not be conveyed to a neighboring property.

The Rational Method may be used when designing storm sewers. The Rational Method is a simple method for determining peak runoff discharge from both pervious and impervious cover. This method uses Rational Method runoff coefficients (C-values) based on land use, soil type, and watershed slope, to estimate peak runoff rates during different rainfall conditions. The Rational Method is primarily used to estimate runoff rates and not runoff volume.

The Rational Method may not be used for SMP design, outlet control design, or detention routing. It may be used for storm sewer capacity design, including open channel collection and conveyance systems analyses.

Required assumptions to obtain conservative results using the Rational Method include the following:

- A runoff coefficient value of 0.35 must be used for pervious areas.
- A runoff coefficient value of 0.95 must be used for impervious areas.
- A precipitation intensity of 6.96 inches per hour must be used, which is the five-minute inlet concentration time in the ten-year storm event. The designer is referred to the *Pennsylvania Department of Transportation (PennDOT) Drainage Manual*, Chapter 7, Appendix A, Field Manual For Pennsylvania Design Rainfall Intensity Charts From the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 Version 3 Data (2010 or latest) for the Intensity Duration Frequency (IDF) for Region 5 for more information.
- For use with Manning's Equation for calculating full channel flow, a Manning's n value of 0.013 must be used for RCP, VCP, and CIP, and a value of 0.011 must be used for PVC and HDPE.

When designing a site's storm sewer system, the designer must be mindful of the following requirements:

- Length, material, size, and slope of all piping associated with stormwater conveyance and roof drainage systems must be clearly labeled on the submitted PCSMP and should be consistent with associated profiles, if provided.
- Piping conflicts must be avoided.
- Inlets may not be connected in series. Similarly, roof drainage systems may not tie directly into an inlet. Wye connections, or similar, may be used to ensure that inlets are offline.
- A minimum of 12 inches of vertical clearance is required when a sanitary sewer line crosses above a storm sewer line. The sanitary sewer must be encased in concrete if the clearance is less than 12 inches.
- Any manholes between outlet structures and sewer connections in combined sewer areas must have sanitary (non-vented) covers.
- A cleanout must be provided, at minimum, every 100 feet, at the end of all pipes, and for all 90-degree bends.

- If curb cuts or non-standard inlets are used to capture runoff, especially from driveways or roadways where the inlets are not in a sump condition, verification that the one-year storm will be captured by the inlet must be provided.
- The invert elevation(s) for the proposed connection(s) to the existing City sewer and a pipe connection detail must both be provided on the submitted PSCMP.
- The outlet culvert(s) must be right-sized to minimize impacts on PWD infrastructure.
- All stormwater conveyance pipe material must be in compliance with the **Plumbing Code** ☛ www.phila.gov/departments/department-of-licenses-and-inspections/resources/applicable-codes.
- A minimum cover of 36 inches must be provided over all private storm sewer pipes, in accordance with the **Plumbing Code** ☛ www.phila.gov/departments/department-of-licenses-and-inspections/resources/applicable-codes.
- Stormwater conveyance pipes must be designed with a minimum velocity of two feet per second. Designs should attempt to maintain velocity without sacrificing SMP depth.
- All proposed connections to the City sewer must be right-sized to convey the necessary flow while minimizing the pipe diameter.
- All proposed connections to the City sewer must be inspected by PWD Water Transport Records. More information on this process can be found in the **Sewer Connection and Repair Manual** ☛ water.phila.gov/wp-content/uploads/files/sewer-connection-manual.pdf.
- As City sewers are regularly at full capacity, two feet of clearance between the bottom of the SMP and the crown of the City sewer pipe and/or a backflow prevention device must be provided to alleviate potential flooding. If a backflow prevention device is proposed, please take into consideration the on-site point of relief during larger storms.
- Stormwater conveyance piping and SMPs cannot receive runoff from fueling station pads for gas stations. The drainage area under a pad's canopy must be treated by an oil/water separator then discharge directly to the sanitary sewer system.
- Stormwater conveyance piping and SMPs that encroach onto an adjacent property require a drainage easement.

Proper hydraulic isolation of proposed SMPs is critical to promoting infiltration, when feasible, while also preventing inflow and infiltration to nearby infrastructure, which could undermine SMP performance and lead to sinkholes and damage to infrastructure. To that end, the designer must be mindful of the following requirements:

- Any abandoned length of sewer within 20 feet of the boundaries of a proposed SMP must be either removed or filled with controlled density fill (flowable fill) and bulkheaded.
  - Class F Fly Ash Slurry Backfill with a maximum compressive strength of 75 psi should be used for flowable fill, in accordance with the *PennDOT Specification Publication 408, 2001*, or latest revision, for flowable backfill, non-structural.
  - The open ends of sewers to be abandoned must be sealed with a bulkhead, consisting of nine-inch-thick brick masonry with non-shrink grout.
  - When an existing storm sewer is rerouted for connection to a proposed SMP (inflow) or a proposed SMP is connecting to an existing sewer (outflow), an anti-seep collar (either a prefabricated anti-seep collar or bentonite clay trench dam) must be provided along the proposed storm sewer pipe.
- Any abandoned sewer inlet connection must be cut and capped at least five feet from the exterior of the inlet.
  - A foam debris plug must be installed six to 12 inches into the exposed end of the abandoned storm sewer lateral.
  - The abandoned lateral must be filled with concrete behind the plug, to form a concrete bulkhead.
- The minimum allowable distance between any active length of building sewer, private sewer, or public sewer and the boundaries of a proposed SMP is 20 feet from the outside of the pipe, unless vertical clearance is provided between the bottom of the sewer and the top of the SMP. It is acceptable for SMPs to be located directly adjacent to the public right-of-way (ROW).
- The minimum allowable distance between any active inlets or laterals—whether publicly or privately owned—and the boundaries of a proposed SMP is ten feet from the outside of the structure or pipe, unless the inlets or laterals drain to the SMP. It is acceptable for SMPs to be located directly adjacent to the public ROW.
- For all pipes entering or exiting the proposed SMP storage media, an anti-seep collar (either a prefabricated anti-seep collar or bentonite clay trench dam) must be provided. The collar must be sufficiently sized and distanced from the edge of the storage media, where space allows, to prevent water from traveling along the outside of the pipes.

3.4.3 Calculation methods and design tools

The designer will need to use various calculation methods and design tools in order to prepare an integrated stormwater management design and to demonstrate compliance with the Stormwater Regulations. The calculation methods and design tools described in this section are used for a variety of purposes relating to integrated design including computing the amount of runoff from DCIA and other surfaces, modeling peak flow rates and drain down times, determining SMP sizing, and developing inlet/outlet control and conveyance system designs. Calculations, model inputs/outputs, and completed Online Technical Worksheet are used in the preparation of PCSMP Review Phase Submission Package, which is detailed in **Section 2.3.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-3-review-phases#2.3.1.

Calculation methods

Runoff estimation

The NRCS Curve Number Method is used to estimate site stormwater runoff from a given storm. While it is PWD's preferred runoff estimation method, additional methods may be used at the designer's discretion with approval from PWD.

The NRCS Curve Number Method is widely used to produce estimates of runoff volume for both pervious and impervious cover. It empirically accounts for the initial abstraction and infiltration of rainfall events based on ground cover type characteristics. For a detailed description of the Curve Number Method, the designer is referred to Urban Hydrology for Small Watersheds (NRCS Technical Release 55).

Care must be taken to select appropriate curve number values since this calculation method is very sensitive to changes in these values. In order to obtain conservative results, separate calculations for pervious and impervious area runoff must be used. Weighted curve number values between pervious and impervious areas are not acceptable. The resulting flows can be routed, if necessary, and then summed.

Table 3.4-2 below provides acceptable curve number values for each Hydrologic Soil Group.

Table 3.4-2: Acceptable Curve Number values

Cover description		Curve Number for Hydrologic Soil Group				
COVER TYPE	HYDROLOGIC CONDITION	A	B	C	D	Ub*
Lawns, parks, golf courses, etc.						
	Poor (grass cover <50%	68	79	86	89	79
	Fair (grass cover 50–75%)	49	69	79	84	69
	Good (grass cover > 75%)	39	61	74	80	61
Brush (brush-weed-grass mixture with brush the major element)						
	Poor	57	73	82	86	73
	Fair	43	65	76	82	65
	Good	32	58	72	79	58
Wood-grass combination (orchard or tree farm)						
	Poor	57	73	82	86	73
	Fair	43	65	76	82	65
	Good	32	58	72	79	58
Woods						
	Poor	45	66	77	83	66
	Fair	36	60	73	79	60
	Good	30	55	70	77	55
Paved parking lots, roofs, driveways, streets, etc.		98	98	98	98	98
Gravel/crushed stone		76	85	89	91	89
Dirt streets and roads		72	82	87	89	87
Green roof**		86	86	86	86	86
Blue-green roof		98	98	98	98	98
Athletic field		68	79	86	89	79
Permeable pavers		70	70	79	84	70
Pour-in-place rubber		70	70	74	80	70
Porous turf		70	70	79	84	69
Meadow		30	58	71	78	58

* Ub refers to "Urban Land" and generally conforms to a hydrological soil group classification of B. A Ub curve number must be used on Redevelopment projects unless the engineer provides soil mapping indicative of another, more appropriate soil classification.

** Existing rainfall runoff models are limited in their ability to predict runoff from green roofs since this process is dominated by percolations through a thin veneer of soil and is not surface runoff. Green roof research studies have back-calculated a range of curve number values for various storms and roof media types/thicknesses. Alternative curve number values may be applied when supported by submitted analysis and relevant references, which will be reviewed on a case-by-case basis.

Design storms

Sizing requirements for compliance with the Stormwater Regulations have been developed using long-term computer simulations. These requirements have been translated to single event design conditions that yield roughly equivalent results.

The rainfall depths of design storms shown in Table 3.4-3 are taken from the *PennDOT Drainage Manual*, Chapter 7, Appendix A, Field Manual For Pennsylvania Design Rainfall Intensity Charts From NOAA Atlas 14 Version 3 Data (2010 or latest). These totals indicate the largest depth that can be expected over the specified interval in the specified return period. These design precipitation depths are similar to those found in other standard references such as **NOAA Technical Paper No. 40** ☛ https://www.weather.gov/media/owp/oh/hdsc/docs/TechnicalPaper_No40.pdf or the **NOAA Atlas 14** ☛ http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=pa; however, the designer must use the values provided in Table 3.4-3 for their design calculations.

Table 3.4-3: Design precipitation depths (in)

	Return period						
DURATION	1 yr	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
5 min	0.37	0.45	0.52	0.58	0.59	0.65	0.71
10 min	0.58	0.69	0.81	0.90	1.04	1.15	1.26
15 min	0.71	0.85	1.00	1.11	1.29	1.42	1.56
30 min	0.94	1.14	1.37	1.56	1.82	2.04	2.27
1 hr	1.17	1.42	1.76	2.03	2.39	2.69	3.04
2 hrs	1.39	1.69	2.12	2.46	2.93	3.34	3.90
3 hrs	1.53	1.86	2.33	2.71	3.25	3.75	4.34
6 hrs	1.91	2.31	2.91	3.40	4.12	4.70	5.34
12 hrs	2.37	2.86	3.56	4.20	5.15	5.96	6.86
24 hrs	**2.83**	**3.40**	**4.22**	**4.95**	**6.10**	**7.16**	**8.43**

PWD Design Storm rainfall distribution

The Water Quality requirement is required to be demonstrated with the PWD Design Storm rainfall distribution, found in Table 3.4-4 below.

This distribution is only to be used for complying with the Water Quality requirement. It is not intended to replace any assessments of Flood Control requirement compliance, Channel Protection requirement compliance, pipe sizing, or conveyance capacity for large events that are necessary for other design requirements. The NRCS Type II 24-hour storm should still be used for those purposes.

Table 3.4-4: PWD Design Storm rainfall distribution

Time elapsed, minutes	Cumulative % of total event volume	Time elapsed, minutes	Cumulative % of total event volume
0	0.000	285	0.389
15	0.000	300	0.413
30	0.002	315	0.437
45	0.012	330	0.464
60	0.037	345	0.492
75	0.058	360	0.518
90	0.079	375	0.543
105	0.102	390	0.677
120	0.121	405	0.808
135	0.141	420	0.828
150	0.166	435	0.853
165	0.186	450	0.877
180	0.207	465	0.892
195	0.234	480	0.912
210	0.258	495	0.933
225	0.283	510	0.953
240	0.310	525	0.980
255	0.338	540	1.000
270	0.364		

NRCS Type II 24-Hour Design Storm rainfall distribution

The Channel Protection, Flood Control, and PHS Release Rate requirements all require calculations using design rainfall depths distributed in a NRCS Type II 24-hour dimensionless rainfall distribution. The Type II distribution was selected not because it represents a typical event, but because it includes periods of low-intensity and high-intensity rainfall; design that uses this distribution results in SMPs that can manage a variety of event types, particularly high intensity storms.

Table 3.4-5: Tabulated NRCS Type II 24-hour rainfall distribution

Time	Dimensionless rainfall	
(hr)	CUMULATIVE	INCREMENTAL
0.00	0.000	0.000
2.00	0.022	0.022
4.00	0.048	0.026
6.00	0.080	0.032
7.00	0.098	0.018
8.00	0.120	0.022
8.50	0.133	0.013
9.00	0.147	0.014
9.50	0.163	0.016
9.75	0.172	0.009
10.00	0.181	0.009
10.50	0.204	0.023
11.00	0.235	0.031
11.50	0.283	0.048
11.75	0.357	0.074
12.00	0.663	0.306
12.50	0.735	0.072
13.00	0.772	0.037
13.50	0.799	0.027
14.00	0.820	0.021
16.00	0.880	0.060
20.00	0.952	0.072
24.00	1.000	0.048

Storm return periods for large events and flow bypass

At a minimum, safe conveyance of the ten-year, 24-hour design storm must be provided to and from all SMPs. Additionally, the flow that is leaving the system must meet the requirements of the Stormwater Regulations. For SMPs designed to manage smaller storms, the designer may choose to allow runoff from larger storms to bypass or quickly pass through a storage element. This is permitted as long as all applicable Stormwater Regulations, along with all SMP design requirements (**Chapter 4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4), are met.

Flow routing

Sheet flow and shallow concentrated flow

Sheet flow consists of shallow flow spread out over a plane. Eventually, this flow will generally concentrate into a deeper, narrower stream. While the prevalence of sheet flow in the natural environment is debated among design professionals, it does provide a reasonable mathematical basis for predicting travel time over short distances.

Urban Hydrology for Small Watersheds (TR-55) provides a sheet flow equation based on Manning's kinematic solution. Tables of roughness values for sheet flow are available in Urban Hydrology for Small Watersheds and in Table 3.4-6 shown below.

PWD will only accept sheet flow for the first 100 feet. After sheet flow, overland flow is considered shallow concentrated flow. Shallow concentrated flow will be considered as flowing over paved or unpaved surface for the purpose of estimating velocity.

Another method for routing overland flow is the kinematic wave solution, which can be obtained by coupling the momentum and continuity equations with simplifying assumptions and it may be solved in a computer program using numerical methods.

Table 3.4-6: Roughness coefficients (Manning's n) for sheet flow

Surface descrption	n[1]
Rooftops	0.011
Concrete	0.013
Asphalt	0.015
Bare Soil	0.018
Sparse vegetation[2]	0.100
Grass: Short grass prairie, lawn	0.150
Grass: Dense grasses[3]**, meadow** (good condition)	0.240
Range (natural)	0.130
Woods[4]**: Light underbrush**	0.400
Woods[4]**: Dense underbrush**	0.800

1 The n values are a composite of information compiled by Engman (1986) and Akan (1985)

2 Areas where vegetation is spotty and consists of less than 50% vegetative cover.

3 Species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.

4 Consider cover to a height of 0.1 ft. This is part of the plant cover that will obstruct sheet flow.

Channel flow

Channel flow equations may be used to estimate flows in free-flowing gutters and swales. Manning's equation is sufficient for these estimates on many sites. Tables of roughness values are available in *Civil Engineering Reference Manual (CERM) Appendix 19.A*. For channels with significant backwater, culverts which may flow under pressure, or other complex features, the St. Venant equations may be needed. These equations represent the complete solution of the momentum and continuity equations in one dimension. These may require a computer application to solve.

Time of concentration paths must be shown from the most hydraulically distant point of each drainage area to a point of interest within the drainage area, and the path must be perpendicular to each area's contours. For reference, the post-development Tc will be less than or equal to the predevelopment Tc values, unless the site is specifically altered to increase this path. Total post-development Tc for any path must be no less than six minutes.

Storage routing

For small storage elements where travel time within the element is insignificant, simple mass balance routing may be performed in a spreadsheet. At each time step, the change in storage volume is the difference between inflows and outflows. Inflows and outflows are a function of design and soil properties.

For larger or more complex structures, where the shape and size of the element have a significant effect on outflows, the Modified Puls (also called storage-indication) method provides more accurate routing.

Table 3.4-7: Summary of recommended methods for flow routing

Type	Mathematical mode	Appropriate for...	Hand/spreadsheet calculations	Example computer applications
Overland flow	Simplified Manning kinematic solution	Sheet flow path up to 100 feet	Yes	TR-55, TR-20
	Shallow concentrated/ NRCS empirical curve	Overland flow longer than 100 feet	Yes	TR-55, TR-20
	Kinematic wave	Larger or more complex sites	No	EPA SWMM, HEC-HMS
Channel flow	Manning equation	Uniform flow without backwater	Yes	TR-55, TR-20, EPA SWMM, HEC-HMS
	St. Venant equations	Channels with storage, backwater	No	EPA SWMM, HEC-RAS
Storage routing	Simple mass balance	Small storage elements	Yes	USACE STORM
	Modified Puls/storage-indication	Large or irregularly shaped elements	Yes	TR-55, TR-20, HEC-HMS

Design tools

Hydrologic computer software applications

The empirical methods discussed above are most commonly applied using hydraulic and hydrologic software applications. Both public domain and proprietary applications are available. The designer is strongly encouraged to consider the assumptions and mathematical models underlying each computer application when choosing an appropriate tool to aid in design. PWD requires any stormwater model to use the minimum time step allowable by the implemented hydrologic software or a maximum of 0.01 hours.

Examples of computer programs available in the public domain are listed in Table 3.4-8**.**

Table 3.4-8: Acceptable calculation methods for runoff estimation

Type	Mathematical method	Impervious cover	Experience modeling soil properties	Hand/spreadsheet calculations	Example computer applications
Empirical methods	NRCS Curve Number Method	Any	Moderate to high	Yes (smaller sites)	NRCS, TR-55, TR-20, HEC-HMS
Infiltration loss models	Constant Loss	Any	Moderate to high	Yes (smaller sites)	HEC-HMS
	Green-Ampt	Any	High	No	EPA SWMM, HEC-HMS
	Horton	Any	High	No	EPA SWMM

PWD Stormwater Plan Review Online Technical Worksheet

The PWD Stormwater Plan Review Online Technical Worksheet is designed to standardize and summarize the results of design calculations. The worksheet is generated via the **PWD Plan Review Portal** ☛ www.pwdplanreview.org's Project Dashboard and can then be accessed at any time. The Project Dashboard is accessed by logging into the website.

The completed worksheet is a required part of each PCSMP Review Phase Submission Package. In addition to the worksheet, the designer must also submit relevant data, field testing results, assumptions, hand calculations, and computer application results.

The **PWD Plan Review Portal** ☛ www.pwdplanreview.org also contains additional resources for the designer to use as the design and Submission Packages are prepared.

PWD Stormwater Plan Review Design Guidance Checklists

The PWD Stormwater Plan Review Design Guidance Checklists are a supplemental list of guidelines for regulatory compliance, plan creation, hydrologic modeling and calculations, and the design of specific SMPs. They are provided to assist in the formation of both sound, compliant stormwater management designs and complete PCSMP submissions.

The designer should use the checklists as guidance during the design and calculation stages or as useful quality assurance/quality control checks prior to PCSMP Review Phase submission. They can be found in **Appendix F** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/f-design-guidance-checklist.

Standard Details

Typical construction details for several SMPs, including all of PWD's highest-preference SMPs, such as bioinfiltration/bioretention basins, porous surfaces, and green roofs, and for SMP-related structures, such as cleanouts, observations wells, and outlet control structures, are available for download in AutoCAD (*.dwg) format in **Appendix L** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/l-standard-details of this Manual. These Standard Details incorporate design specifications pursuant to each SMP's respective design and material requirements. The designer is encouraged, though not required, to use them for PCSMP creation wherever possible.

For bioinfiltration/bioretention basins, the minimum requirements set forth in the Standard Detail must be used—along with the Bioinfiltration/Bioretention Basin Sizing Table—to ensure that bioinfiltration/bioretention SMPs can be fully designed and approved for Water Quality compliance without knowledge of infiltration feasibility under a Surface Green Review. This allows for postponement of infiltration testing until construction of the development project. The designer is referred to **Section 4.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-1-bioinfiltration-bioretention for more information on bioinfiltration/bioretention SMPs and to **Section 2.4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-4-expedited-pcsmp-reviews for more information on Expedited PCSMP Reviews.

3.5 Integrated Stormwater Management Examples

The following hypothetical examples illustrate the various components of an integrated site design and stormwater management planning process and how this process can be implemented for different types of land development projects.

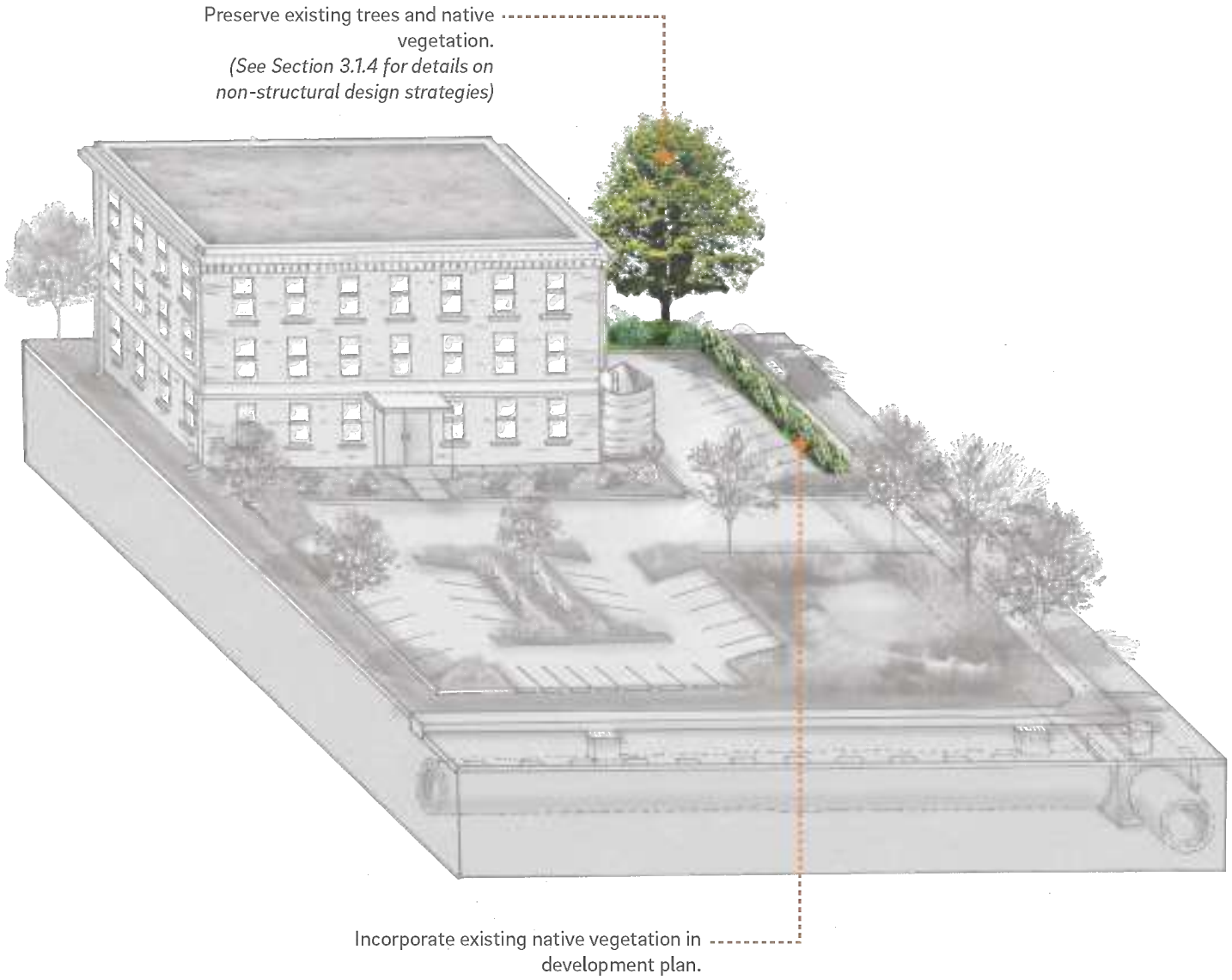
3.5.1 Commercial office building development

This example includes the following three-step process:

Step 1

Preserve existing mature trees and native vegetation as illustrated in Figure 3.5-1. Incorporate existing trees and native vegetation into the development plan.

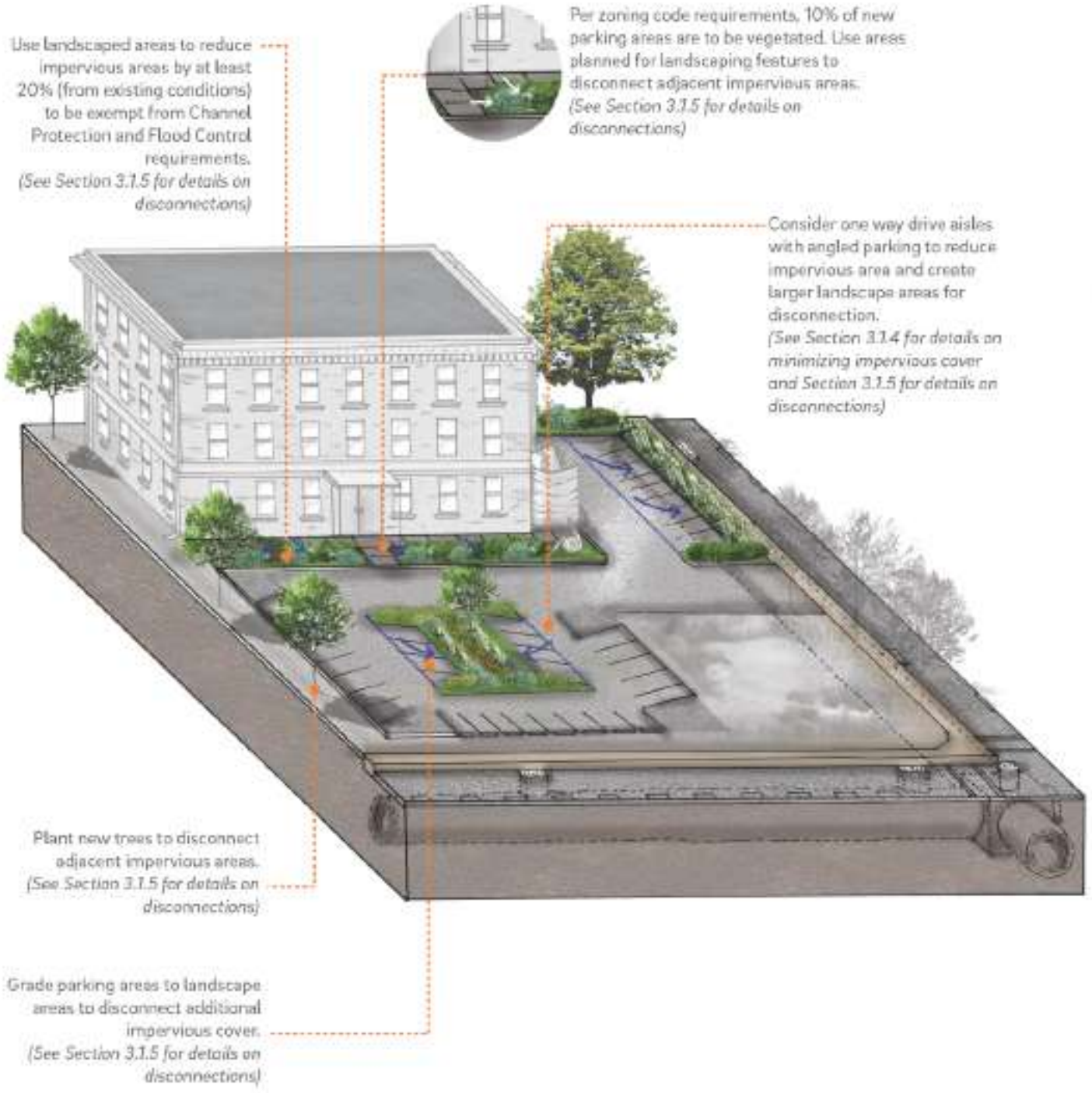
Figure 3.5-1: Commercial office building development example, Step 1



Step 2

Minimize impervious areas and investigate opportunities to disconnect impervious areas as illustrated in Figure 3.5-2.

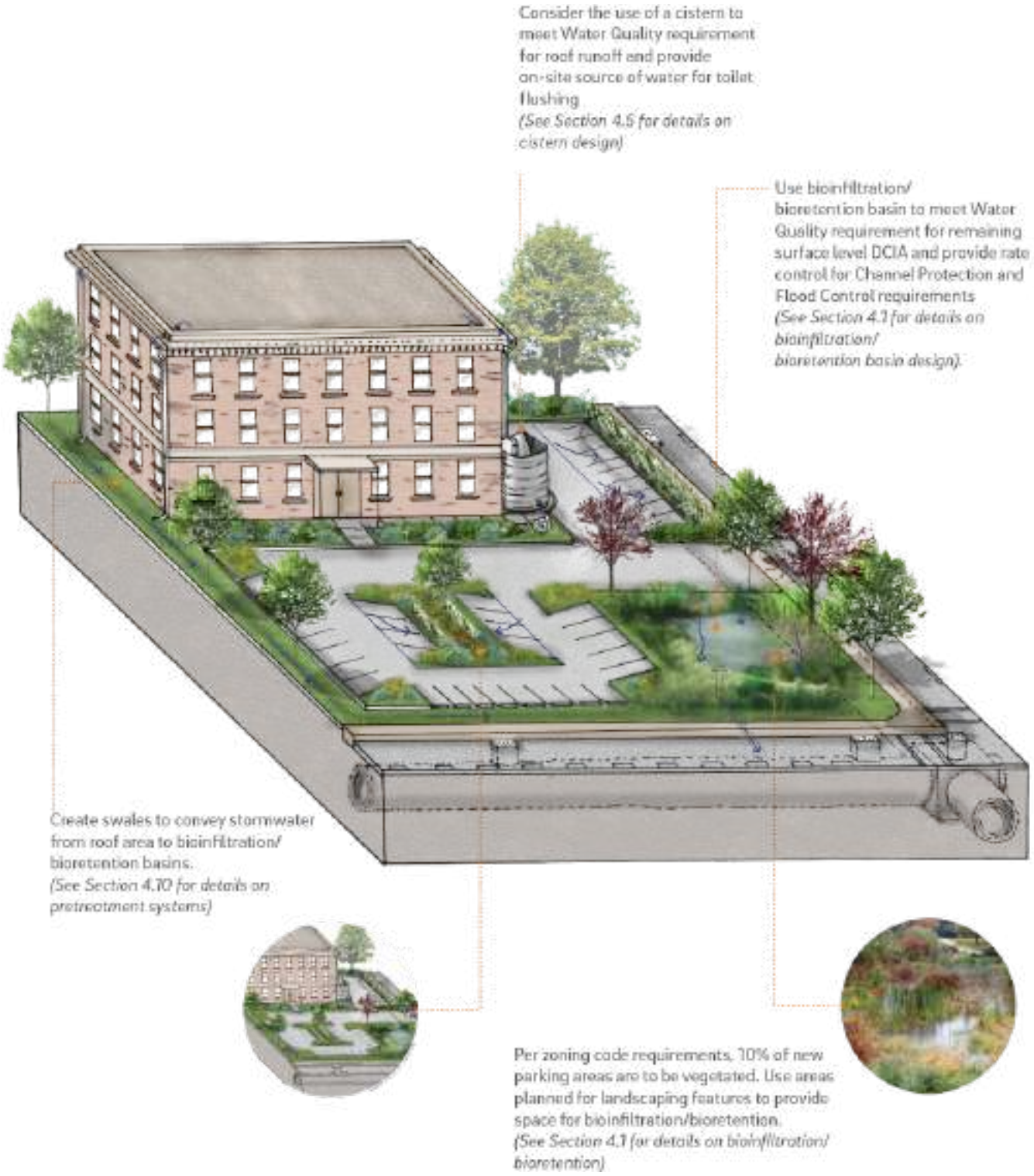
Figure 3.5-2: Commercial office building development example, Step 2



Step 3

Use surface-vegetated stormwater management practices (SMPs) to manage runoff from a directly connected impervious area (DCIA) in order to meet the Philadelphia Water Department (PWD) Stormwater Regulations (**Chapter 1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1), as illustrated in Figure 3.5-3.

Figure 3.5-3: Commercial office building development example, Step 3



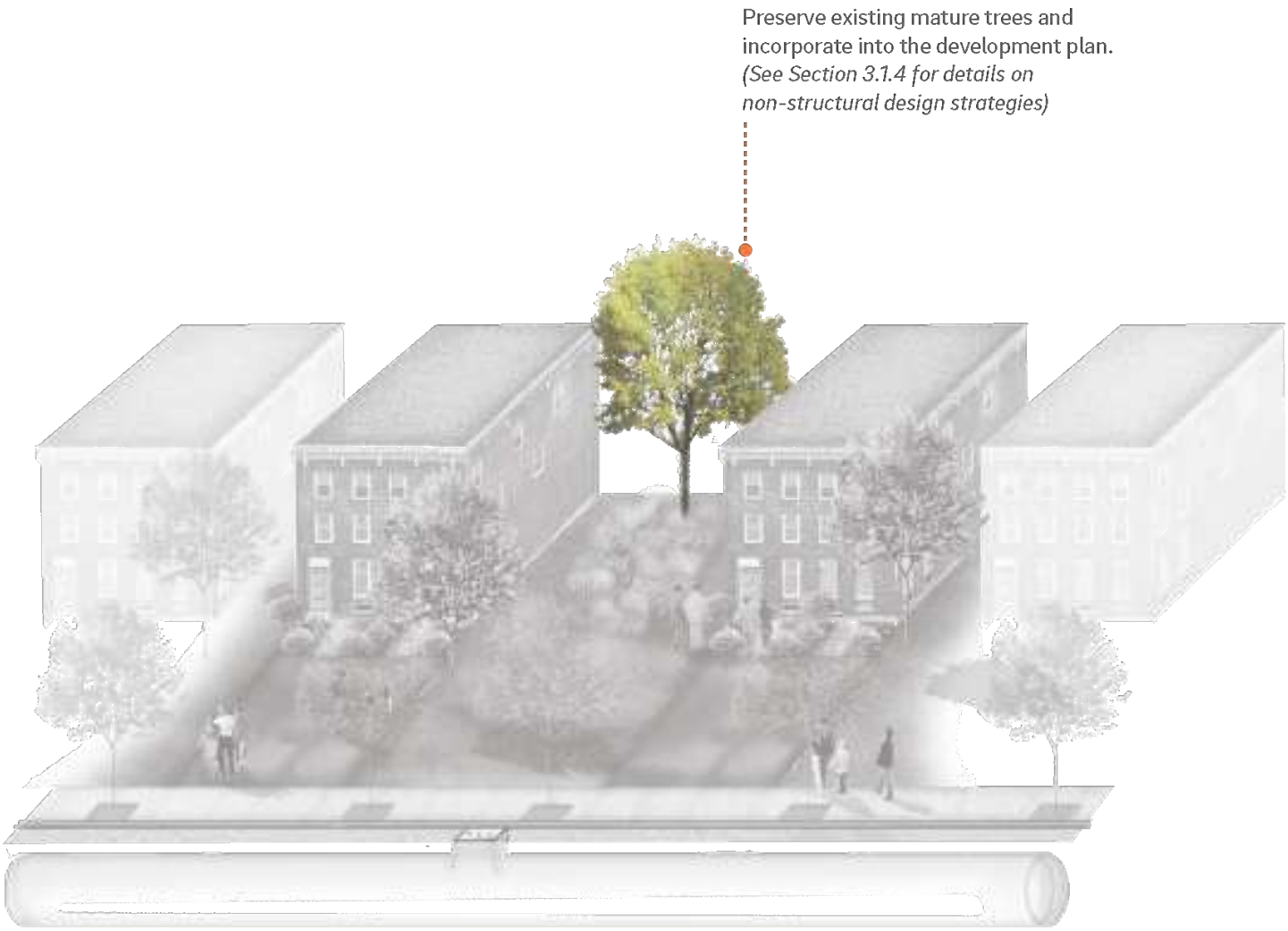
3.5.2 Residential multi-family development

This example includes the same three-step process as described in the commercial office building development example and is illustrated in Figures 3.5-4, 3.5-5, and 3.5-6.

Step 1

Preserve existing mature trees and native vegetation as illustrated in Figure 3.5-4. Incorporate existing trees and native vegetation into the development plan.

Figure 3.5-4: Residential multi-family development example, Step 1



Step 2

Minimize impervious areas and investigate opportunities to disconnect impervious areas as illustrated in Figure 3.5-5.

Figure 3.5-5: Residential multi-family development example, Step 2



Step 3

Use surface-vegetated SMPs to manage runoff from impervious areas in order to meet the Stormwater Regulations (**Chapter 1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1), as illustrated in Figure 3.5-6.

Figure 3.5-6: Residential multi-family development example, Step 3



3.5.3 Full build-out

Non-structural options are limited for a full build-out scenario as the building footprint will cover the entire lot. For a full build-out project, the designer is encouraged to select green roof and cistern SMPs, as illustrated in Figure 3.5-7, before considering subsurface practices, or to select a green roof/blue roof combination as illustrated in Figure 3.5-8. If the project is a redevelopment project, by making a percentage of the roof area a green roof, the applicant may be able to demonstrate a 20% reduction in impervious area and be eligible for an exemption from Flood Control and Channel Protection requirements. A blue roof on the remainder of the same roof can be used to meet the Water Quality requirement peak release rate.

Figure 3.5-7: Full build-out example, green roof

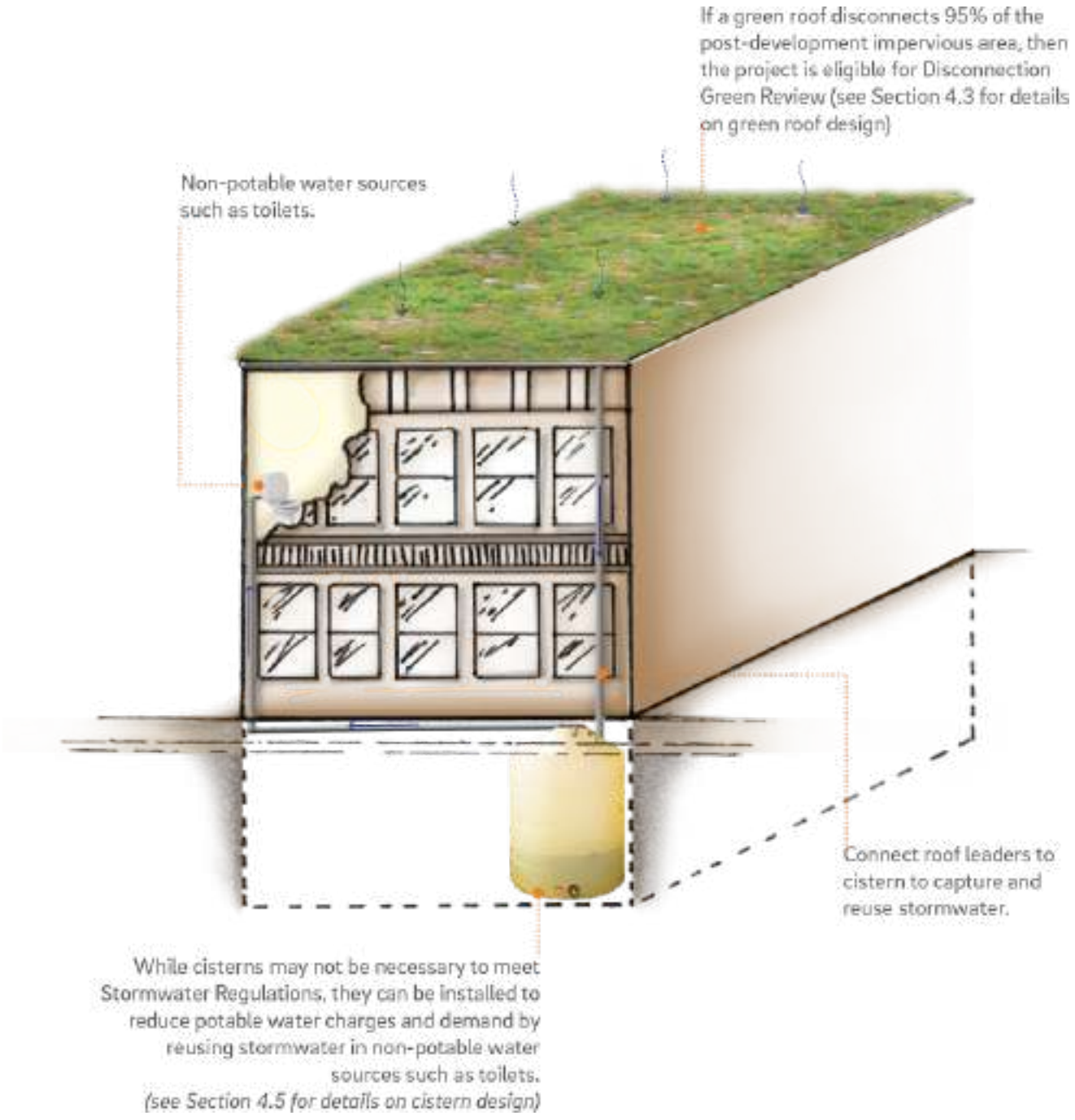
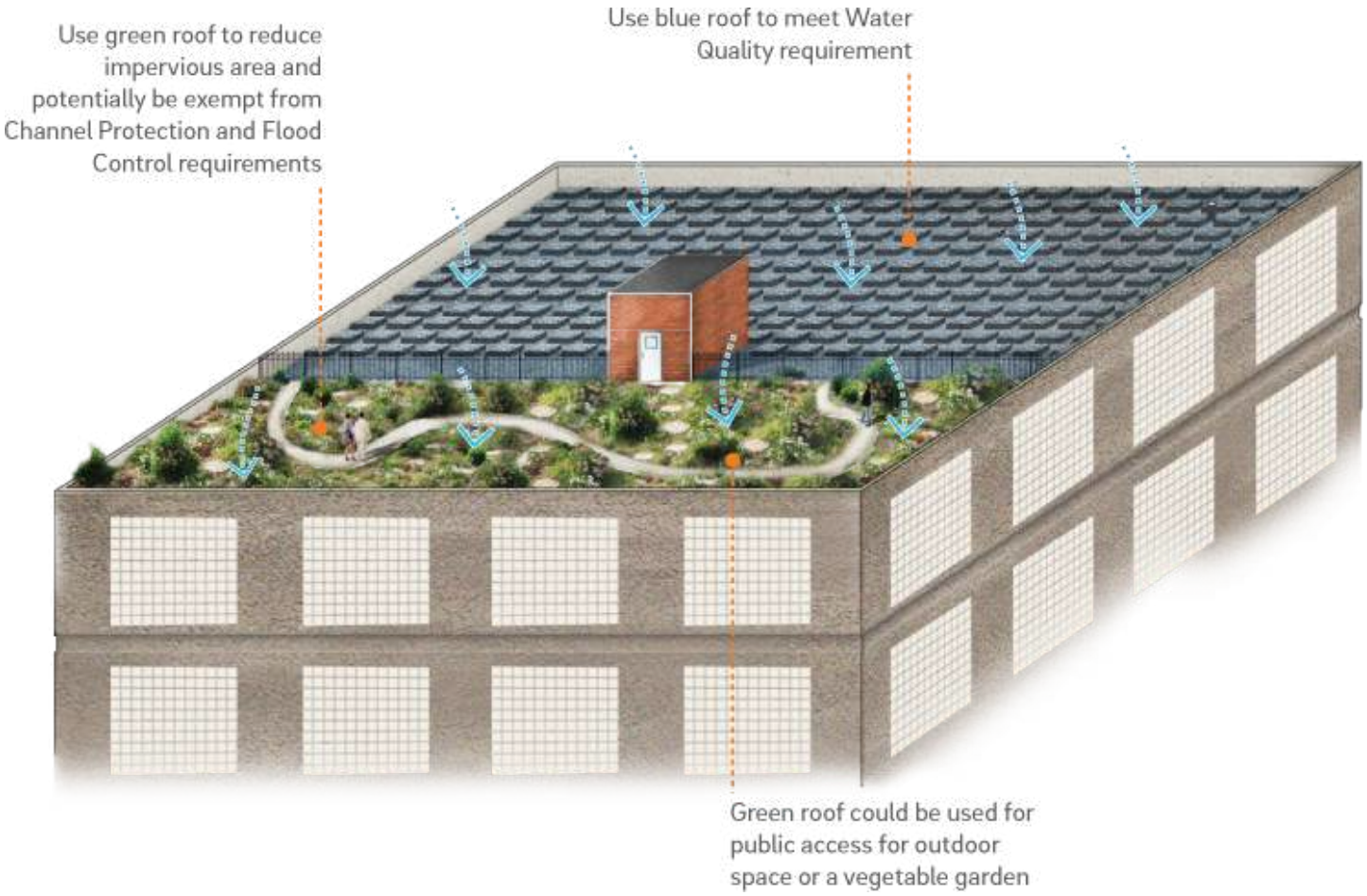


Figure 3.5-8: Full build-out example, green roof / blue roof



3.5.4 Trails

A trail is defined as a relatively narrow pathway (not a road) used for pedestrian, bicycle, or small vehicle travel on public or private property. For the purposes of complying with the Stormwater Regulations, PWD will determine whether a proposed project may be considered a trail.

Figure 3.5-9: Trail example



Trails may be paved or unpaved, as illustrated in Figure 3.5-9. Pavements used to construct trails may be pervious or impervious. Examples of paved trails include off-road paths, greenway bike trails, and sidewalks. The trail designer is encouraged to first consider specifying pervious materials such as porous surfaces, gravel, or mulch for proposed trail projects. If pervious materials are not feasible or desired, the designer should consider a disconnected impervious cover (DIC) design approach, using porous surfaces, pavement disconnections, or tree disconnections. The designer is referred to **Section 3.1.5** ☛ p. 22 for more information on DIC options. As a last resort, the designer should consider using SMPs to manage stormwater runoff from proposed trail projects in order to meet the Stormwater Regulations.

By their nature, it may be difficult for trail projects to meet applicable Channel Protection and Flood Control requirements, so the use of DIC should be pursued before considering any SMP implementation.

3.5.5 Athletic fields

Athletic fields are typically made of pervious natural turf or porous artificial/synthetic turf but may or may not include run-on from adjacent DCIA. The replacement of existing athletic fields with natural turf often does not require an SMP for management of stormwater. For fields that include impervious surfaces, like new bleacher areas or team dugouts, the designer should first explore ways to disconnect these surfaces rather than proposing an SMP. Redevelopment projects that propose natural turf athletic fields are often eligible for an Expedited Post-Construction Stormwater Management Plan (PCSMP) Review (**Section 2.4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-4-expedited-pcsmp-reviews). The designer should select natural turf options for field design when appropriate, as artificial turf fields will typically require structural and maintenance-intensive management strategies.

When artificial turf fields require maintenance, the turf surface or drainage components may need to be replaced. Replacement of the artificial turf surface, or repairs to the drainage system that do not expose the subbase, will not be considered earth disturbance. Modifications to the drainage system may affect the turf system's ability to qualify as DIC.

An example of a natural turf athletic field DIC is illustrated in Figure 3.5-10. In this scenario, the designer should grade adjacent DCIA so that it can be disconnected to the vegetated areas. If this is not feasible, the designer should consider designing the athletic field to include a subsurface storage component to demonstrate compliance with the Stormwater Regulations, which is illustrated in Figure 3.5-11.

Figure 3.5-10: Natural turf athletic field example, DIC



Figure 3.5-11: Artificial turf athletic field example, subsurface SMP to manage DCIA



There are three main approaches for designing artificial, or synthetic, turf fields to meet the Stormwater Regulations: (1) designing the field to function as DIC; (2) designing the field, or a portion of the field, to function as an SMP; or (3) designing the field to convey stormwater to a separate SMP for treatment. The guidance below focuses on options (1) and (2), the two methods that are aimed at managing stormwater within the field itself and describe PWD's design requirements that apply to each of these approaches. Although there are fundamental differences between the primary use, design, and construction of artificial turf fields and porous surface systems—like permeable pavers or reinforced turf—due to similarities in stormwater management function, PWD considers artificial turf fields to be classified as porous surfaces. As such, PWD's requirements for artificial turf fields as stormwater management systems are similar to the requirements for porous surface systems.

1. PWD will allow artificial turf fields to be considered DIC if design of the field is in accordance with the design requirements of porous surface DIC, as described in **Section 4.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-2-porous-surfaces. If compaction of the subgrade is preferred for structural design purposes, infiltration testing must be performed during construction, after compaction of the subgrade, in accordance with **Section 3.3** ☛ p. 67. If infiltration is determined to not be feasible, the field area must be considered DCIA, treated as such when determining compliance with the Water Quality requirement, and modeled with a curve number of 98 in all required stormwater routing calculations. If an underdrain is proposed, the artificial turf field will only be considered DIC if the first 1.5 inches of runoff can be stored below the lowest invert of the underdrain.
2. Any portion of an artificial turf field that receives stormwater runoff from impervious areas or is determined infeasible for infiltration must be considered DCIA rather than DIC. In this scenario, if any portion of the field system is designed to function as an SMP (as opposed to a conveyance system), that portion of the field must meet PWD's requirements for subsurface basins. Infiltration testing is required in this case. After considering infiltration feasibility, the designer must adhere to the design requirements of either a subsurface infiltration system or subsurface detention system—detailed in **Section 4.4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-4-subsurface-infiltration and **Section 4.8** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-8-subsurface-detention, respectively.
3. Stormwater runoff from the field may be directed to a separate SMP for management. The designer is referred to **Chapter 4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4 for guidance and requirements for the design and implementation of a suite of acceptable SMPs.

3.5.6 Streets

When new streets are proposed as part of a development project, whether publicly or privately designated, the impervious area must be managed to meet the Water Quality requirement. To meet Water Quality, the runoff from the street must be directed to an on-site SMP. It is acceptable for the on-site SMP to manage runoff from both the street and the development site. On-site SMPs will be owned and maintained by the property owner (**Chapter 6** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-6).

Private streets

New private streets can be managed in a similar manner to other private developments. Inlets, manholes, and conveyance piping will be owned and maintained by the property owner or their designee. In addition to the Water Quality requirement, the Channel Protection, Flood Control, and Public Health and Safety Release Rate requirements may also apply to the private street (**Section 1.2.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1/1-2-stormwater-regulations/#1.2.1). The designer should refer to **Section 3.4.2** ☛ p. 95 and **Section 4.11** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-11-inlet-controls of this Manual for guidance on designing conveyance infrastructure.

Public streets

New public streets must be managed by the private SMP on the development site. As such, new public streets are typically designed with two different stormwater conveyance systems. A green system is used to manage the Water Quality storm from all the impervious surfaces, and a traditional grey sewer system serves as an overflow for larger storm events. A green stormwater system typically consists of Green Inlets, which are placed in the street to convey runoff to a junction box or manhole located at the property line that connects to the private SMP on the development site. A grey sewer system may be a single combined sewer or a separate stormwater-only sewer, depending on the connecting sewer network.

The on-site SMP should be sized to account for 1.5 inches of runoff over the proposed street drainage area, while any street conveyance systems should be sized to covey a 2.5 inches per hour precipitation intensity (the average peak 15-minute intensity from the 24-hour rain gauge network in Philadelphia). This intensity translates to a 2.04-inch 24-hour storm event.

For conveyance of public street runoff, it is recommended that Green Inlets be located five feet upstream of an existing PWD inlet. For additional guidance on Green Inlet design, the designer is referred to Section 3.3.6, Inlets, of the **PWD Green Stormwater Infrastructure Planning and Design Manual** ☛ water.phila.gov/wp-content/uploads/files/gsi-planning-and-design-manual.pdf.

In most cases, the Green Inlet, inlet lateral, junction box, and the grey sewer system will be designed to PWD standards and located in a right-of-way., Upon completion, PWD will own and maintain these systems.

PWD's Design Branch (**Section 2.5** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-5-pwds-development-review-process) will be responsible for the review and approval of all infrastructure to be owned by PWD, facilitated concurrently with the PCSMP Review. PWD's Construction Unit will inspect the proposed PWD infrastructure during construction to ensure installation meets PWD standards. The designer should contact PWD for the standard details and plan requirements for these conveyance features.

4 Stormwater Management Practice Guidance

Chapter 4 Stormwater Management Practice Guidance

4.0 Introduction

Chapter 4, Stormwater Management Practice Guidance, provides detailed guidance to the designer regarding stormwater management practices (SMPs) as well as pretreatment, inlet and outlet control systems, and landscaping that support SMP functions.

4.0.1 How to use this chapter

Before using this chapter, the designer should first review the Philadelphia Water Department (PWD) Stormwater Regulations (Stormwater Regulations) outlined in **Chapter 1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1 to assess what level of stormwater management a project will need to achieve compliance. It is also important for the designer to have made a preliminary determination of an appropriate Review Path for their project, which is covered in **Chapter 2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2. Chapter 4 is only applicable for projects that fall under the Development Compliance Review Path (**Section 2.2.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-2-review-paths#2.2.1) and Stormwater Retrofit Review Path (**Section 2.2.4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-2-review-paths#2.2.4).

For a project meeting Stormwater Regulations, the designer should have arrived at Chapter 4 after confirming, through a review of **Chapter 3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3, that the project cannot show compliance with the Stormwater Regulations solely through use of non-structural design strategies (**Section 3.1.4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-1-site-assessment-and-stormwater-management-strategies/#3.1.4) and disconnected impervious cover (DIC; **Section 3.1.5** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-1-site-assessment-and-stormwater-management-strategies/#3.1.5) and that SMPs are required. Before designing SMPs using the detailed guidance in Chapter 4, the designer should follow the SMP selection, layout, and design guidance in **Section 3.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-2-stormwater-management-design and review the requirements for infiltration testing and soil assessment for SMP design in **Section 3.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-3-infiltration-testing-and-soil-assessment-for-smp-design. The designer is also referred to **Section 3.4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-4-how-to-show-compliance for detailed guidance on how to show compliance with the Stormwater Regulations or applicable design criteria, and to **Section 3.5** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-5-integrated-stormwater-management-examples for examples of stormwater management strategies that include SMPs. After the designer has selected the type(s) of SMP(s) needed on the project site, the designer can then refer to individual sections within Chapter 4 as needed to develop detailed designs of SMP(s) that comply with PWD requirements and standards.

4.0.2 Chapter organization

The SMPs in this chapter are presented in order of PWD preference according to the SMP Hierarchy (**Section 3.2.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-2-stormwater-management-design#3.2.2). Several SMPs in this chapter are on PWD's list of acceptable non-infiltrating pollutant-reducing practices (**Section 3.1.7** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-1-site-assessment-and-stormwater-management-strategies/#3.1.7).

This chapter consists of guidance and requirements for the following SMPs:

- **Section 4.1** ☛ p. 4 – Bioinfiltration/Bioretention
- **Section 4.2** ☛ p. 29 – Porous Surfaces
- **Section 4.3** ☛ p. 45 – Green Roofs
- **Section 4.4** ☛ p. 64 – Subsurface Infiltration
- **Section 4.5** ☛ p. 80 – Cisterns
- **Section 4.6** ☛ p. 97 – Blue Roofs
- **Section 4.7** ☛ p. 106 – Ponds and Wet Basins
- **Section 4.8** ☛ p. 118 – Subsurface Detention
- **Section 4.9** ☛ p. 134 – Media Filters
- **Section 4.14** ☛ p. 239 – Blue-Green Roofs
- **Section 4.15** ☛ p. 256 – Drainage Wells

Additionally, this chapter contains guidance and requirements for the following types of systems that support SMP function:

- **Section 4.10** ☛ p. 148 – Pretreatment
- **Section 4.11** ☛ p. 166 – Inlet Controls
- **Section 4.12** ☛ p. 182 – Outlet Controls
- **Section 4.13** ☛ p. 218 – Landscaping

Each SMP section in this chapter is organized into subsections that contain the following information:

- *Introduction* – Introduces the SMP; gives examples of when the SMP can be used; and describes key advantages, limitations, and design considerations.
- *Components* – Describes the typical SMP pretreatment, inlet control, storage area, outlet control, and inspection and maintenance access components, as applicable.
- *Design standards* – Lists all SMP design requirements, denoted by easy-to-reference numerals.
- *Material standards* – List all SMP material specifications and requirements, denoted by easy-to-reference numerals.
- *Construction guidanc*e – Provides guidance related to SMP construction.
- *Maintenance guidance* – Provides guidance on SMP maintenance activities and frequencies, including a recommended SMP maintenance schedule.

4.0.3 Design innovation

SMPs contained in this chapter are by no means exclusive. PWD encourages the development of innovative practices that meet the intent of the Stormwater Regulations. PWD recognizes that new stormwater management systems and products are being developed continuously and is in support of innovative approaches to management. The designer is encouraged to request a pre-application meeting with PWD Stormwater Plan Review early in the approval process to discuss PWD's standard SMP design requirements or if the designer wishes to use new or non-standardized technologies to meet the Stormwater Regulations.

4.1 Bioinfiltration/Bioretention

Download summaries of this SMP and its maintenance guidance, with quick reference information for clients and developers:

- **Bioinfiltration/Bioretention SMP One-Sheet** ☛ water.phila.gov/wp-content/uploads/files/bioinfiltration-bioretention-smp-one-sheet.pdf
- **Bioinfiltration/Bioretention Maintenance Guidance One-Sheet** ☛ water.phila.gov/wp-content/uploads/files/bioinfiltration-bioretention-maintenance-guidance.pdf

4.1.1 Bioinfiltration/bioretention introduction

Bioinfiltration and bioretention stormwater management practices (SMPs), often referred to as rain gardens, are vegetated depressions or basins that use surface storage, vegetation, planting soil, outlet controls, and other components to treat, detain, and retain stormwater runoff. Bioinfiltration and bioretention SMPs represent the highest level of preference in the Philadelphia Water Department's (PWD's) SMP Hierarchy by providing high-performance and cost-effective stormwater management, green space, and triple bottom line benefits. Both types of SMPs reduce stormwater volume and pollution by filtering runoff through a vegetated soil medium that promotes evapotranspiration. Bioinfiltration SMPs remove stormwater via infiltration into the surrounding soils while bioretention SMPs attenuate runoff with flow-regulating underdrains.

Bioinfiltration/bioretention SMPs can be found in a variety of configurations, from relatively large and open vegetated basins to small-scale SMPs contained within flow-through planter boxes. These SMPs can be combined with other SMPs in series to meet the PWD Stormwater Regulations (Stormwater Regulations). The designer is referred to **Section 3.2.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-2-stormwater-management-design#3.2.3 for information on using SMPs in series.

Quick tip

Required bioinfiltration/bioretention design and material standards are denoted in this section by easy-to-reference numerals.

Because bioinfiltration and bioretention SMPs are ranked highest in the SMP Hierarchy (**Section 3.2.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-2-stormwater-management-design#3.2.2), special design guidance is provided in this section to promote their use. This design guidance provides flexibility for designers to either dynamically model bioinfiltration or to follow a prescribed design based on the drainage area without performing infiltration testing. The dynamic routing allows designers to account for the volume of water infiltrated into the ground in real time, which allows the bioinfiltration SMP to have less storage and be shallower. The prescribed design makes use of the minimum requirements set forth in the Standard Detail (**Figure 4.1-4** ☛ p. 20) and the Bioinfiltration/bioretention basin sizing table (**Table 4.1-4** ☛ p. 16), ensuring that bioinfiltration/bioretention SMPs can be fully designed and approved for Water Quality compliance without knowledge of infiltration feasibility. Therefore, postponement of infiltration testing until construction of the evelopment project is permitted; the results of the infiltration testing will dictate whether an underdrain cap should be equipped with an orifice. Additionally, development projects incorporating only disconnected

-review/manual/chapter-2/2-4-expedited-pcsmp-reviews for details on the Expedited Post-Construction Stormwater Management Plan (PCSMP) Review submission process.



An example of a typical bioretention basin in Philadelphia

When can bioinfiltration/bioretention be used?

Bioinfiltration SMPs must have underlying soils that, when tested pursuant to the infiltration testing procedure described in **Section 3.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-3-infiltration-testing-and-soil-assessment-for-smp-design, are determined to be infiltration-feasible. Where infiltration is not feasible, bioretention SMPs can be used by converting capped underdrains to flow-regulating underdrains to comply with the Water Quality requirement. The designer is referred to **Section 3.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-3-infiltration-testing-and-soil-assessment-for-smp-design for guidance on infiltration testing.

Bioinfiltration/bioretention SMPs can be used to manage stormwater on small and large sites. For example, bioinfiltration/bioretention may be integrated into smaller sites using flow-through planter boxes or integrated into larger sites by using multiple bioinfiltration/bioretention basins throughout the project area.

Bioinfiltration/bioretention SMPs are also suitable for many types and sizes of development, from multi-family residential to high-density commercial projects, and are viewed as an integral part of a development's landscape design during site layout, doubling as both a landscape amenity and stormwater management feature.

At commercial, industrial, and institutional sites, areas for stormwater management and green space are often limited. At these sites, bioinfiltration/bioretention SMPs serve multiple purposes of stormwater management and landscaping by managing runoff from impervious site areas such as parking lots, sidewalks, and rooftops. Bioinfiltration SMPs can also be dynamically sized to save space or reduce the depth of the SMP.

A parking lot is an ideal location for bioinfiltration/bioretention SMPs. These SMPs can be incorporated as an island, median, or along the perimeter of the parking area. Bioinfiltration/bioretention SMPs can enhance the aesthetics of a parking lot while managing stormwater from the site.

Key advantages of bioinfiltration/bioretention

- Flexible layout and easy to incorporate in landscaped areas
- Very effective at removing pollutants and reducing runoff volumes
- Generally, one of the more cost-effective stormwater management options
- Relatively low maintenance activities costs
- Can contribute to better air quality and help reduce urban heat island impacts
- Can improve property values and site aesthetics through attractive landscaping
- Can provide educational benefits, especially when used at public and/or highly visible sites such as schools, recreation centers, libraries, etc.
- Eligible for inclusion in an Expedited PCSMP Review project
- Above benefits may be maximized with the inclusion of trees
- Bioinfiltration SMPs are eligible for dynamic sizing

Key limitations of bioinfiltration/bioretention

- May need to be combined with other SMPs to meet the Flood Control requirement
- May have limited opportunities for implementation based on the amount of open space available at the site

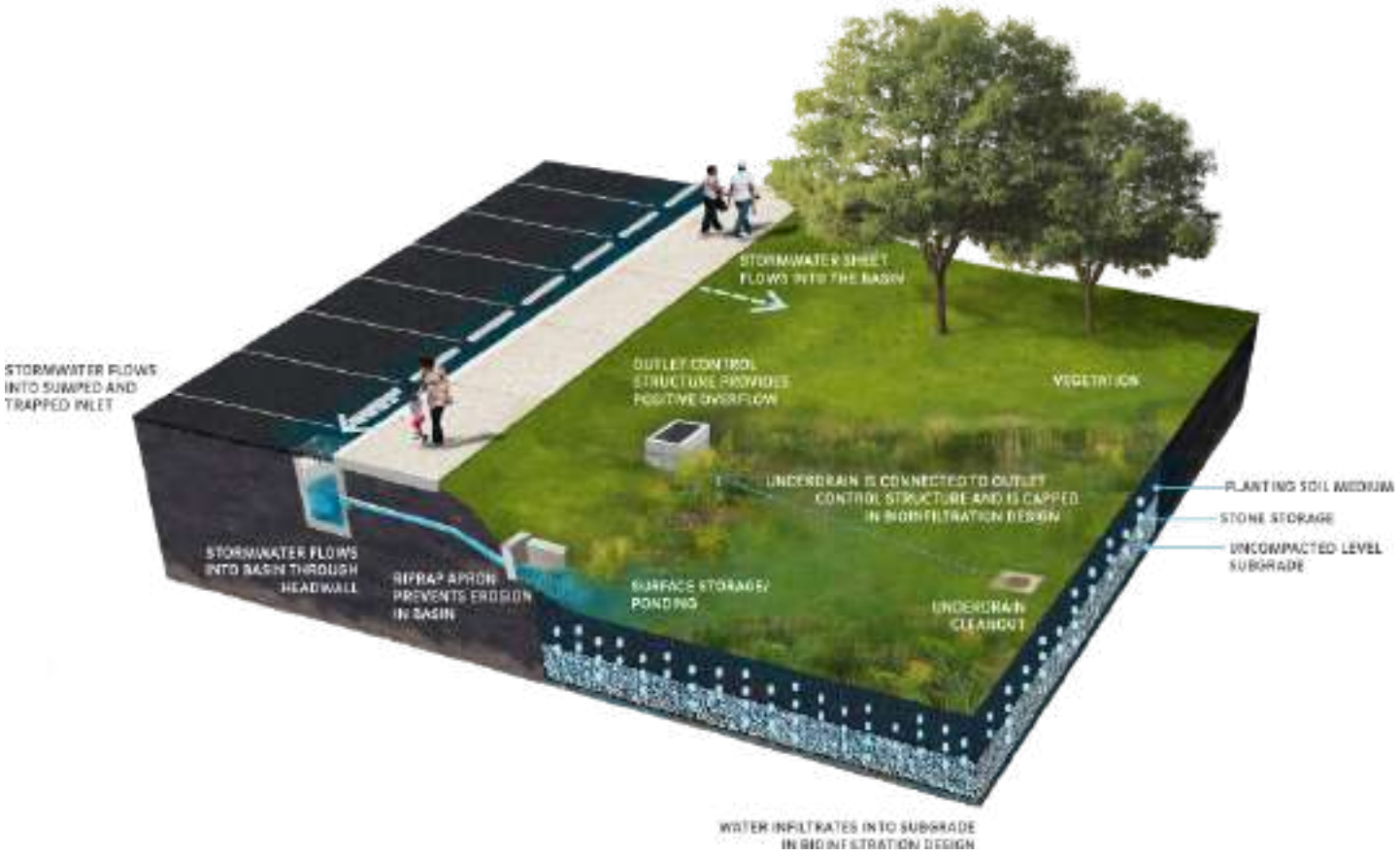
Key design considerations for bioinfiltration/bioretention

- Bioinfiltration/bioretention SMPs should be considered as an alternative before designing subsurface infiltration and detention SMPs. Bioinfiltration/bioretention SMPs are preferred for several reasons, including installation and maintenance cost, ease of maintenance, habitat creation, nutrient cycling, and aesthetics.
- Bioinfiltration SMPs can be dynamically designed, which may save space or reduce the depth of the SMP. These SMPs must statically store one inch of runoff and be shown, via dynamic routing, to manage 1.5 inches of runoff throughout the design storm, without overflow.
- The pretreatment approach should be matched to site characteristics. Bioinfiltration/bioretention SMPs rely on flow through soil media to provide Water Quality treatment. Media layers can become clogged, particularly when runoff has high quantities of sediment. To avoid this, SMPs managing runoff from surfaces that generate high sediment loads should have adequate pretreatment to remove dirt and grit before they reach the bioinfiltration/bioretention SMP.
- The SMPs should be viewed as landscape features. Viewing bioinfiltration/bioretention SMPs as an integral part of a site's landscape design can help identify key implementation locations. Bioinfiltration/bioretention SMPs can double as landscape features on many sites, providing landscape amenities and stormwater management in the same location.
- Non-basin designs can be used for small spaces. Integrating bioinfiltration/bioretention into flow-through planter boxes or tree pits can be an effective way of incorporating bioinfiltration/bioretention functions into spatially constrained sites.
- Safety issues relating to ponding depth should be carefully considered, particularly for sites where small children will be proximate to the installation.
- Balancing cut and fill can reduce costs. A berm placed on the downslope side of a mild slope can help retain stormwater and increase capacity without additional excavation.
- For constrained sites, using additional subsurface stone to meet storage volume needs should be considered. Bioinfiltration SMPs can also be dynamically designed to save space.
- Areas of soil contamination should be avoided; however, in some cases, an impervious liner may be appropriate for separating bioinfiltration/bioretention SMPs from these underlying conditions.
- Whenever possible, the designer should preserve existing trees and develop tree protection plans. A plan should be developed for the removal of invasive species both in and around the project area.
- A diverse planting palette should be used. A diverse community of native plants is recommended to minimize susceptibility to insect and disease infestation and reduce long-term maintenance requirements. A mixture of herbaceous plants, grasses, shrubs, and trees is generally recommended to create a microclimate that can ameliorate urban stresses, discourage weed growth, and reduce maintenance needs.

- Smart plant selection for the site should be a focus. It is critical that plant materials are appropriate for soil, hydrologic, light, and other site conditions. The designer is referred to the list of native and recommended non-invasive species in **Appendix I** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists. Ponding depth, drainage time, sunlight, salt tolerance, and other conditions should be taken into consideration when selecting plants. Turf grass is generally not recommended but may be acceptable provided the designer can demonstrate that it meets all applicable requirements. The designer is referred to **Section 4.13** ☛ p. 218, Landscaping, for additional guidance.
- The designer should choose low maintenance plants that minimize the need for mowing, pruning, and irrigation.
- The characteristics of the soil for the bioinfiltration/bioretention SMP are perhaps as important as the facility location, size, and treatment volume. The soil must be permeable enough to allow runoff to filter through the media, while having characteristics suitable to promote and sustain a robust vegetative cover crop. In addition, much of the nutrient pollutant uptake (nitrogen and phosphorus) is accomplished through adsorption and microbial activity within the soil profile. Therefore, the soils must balance soil chemistry and physical properties to support biotic communities above and below ground.
- Flow-through planter box planting requires that plants be supplied with nutrients that they would otherwise receive from being part of an ecosystem. Since they are cut off from these processes, they must be cared for accordingly.
- Generally, six-inch to twelve-inch centers with triangular spacings for plugs are recommended.
- Mulch for a bioinfiltration/bioretention SMP should have a minimum depth of two inches.
- For any bioinfiltration/bioretention SMP that discharges onto an adjacent property, a drainage easement may be required and is recommended.

4.1.2 Bioinfiltration/bioretention components

Figure 4.1-1: Bioinfiltration/bioretention basin with typical features



Pretreatment component

Pretreatment systems capture trash, sediment, and/or other pollutants from stormwater runoff before delivery to the storage or infiltration area. Pretreatment needs will vary significantly depending on the contributing drainage area composition and use. Pretreatment can include structures such as sumped and trapped inlets, sediment/grit chambers or separators, media filters, inlet inserts, or other appropriate prefabricated or proprietary designs to remove sediment, floatables, and/or hydrocarbons from stormwater runoff prior to being conveyed to a bioinfiltration/bioretention SMP. While inlet hoods are preferred, permanent filter bags may be accepted for Stormwater Retrofit projects where existing inlets do not have hoods and inlet reconstruction is not feasible. In addition to sumped and trapped inlets, permanent filter bag inserts are required for sites that generate pollutants such as loading docks, material storage facilities, junk yards, and waste collection and disposal sites. Permanent filter bags will require frequent cleanings.

Pretreatment can also consist of filter strips, forebays, and swales. The designer is referred to **Section 4.10** ☛ p. 148, Pretreatment, for more information.

Inlet control component

Inlet control systems convey and control the flow of stormwater from the contributing catchment area to a bioinfiltration/bioretention SMP. Inlet control needs will vary depending on the design of stormwater conveyance systems and the site layout. The designer is referred to **Section 3.4.2** ☛ water.phila.gov /development/stormwater-plan-review/manual/chapter-3/3-4-how-to-show-compliance#3.4.2 for guidance on stormwater conveyance system design.

Inlet controls may include flow splitters, curbless design/curb openings, energy dissipaters, and inlets. The designer is referred to **Section 4.11** ☛ p. 166, Inlet Controls, for more information.

Storage area component

Storage areas within bioinfiltration/bioretention SMPs temporarily hold stormwater runoff until it can either infiltrate into native soils, evaporate, be used by plants through transpiration, or be released downstream at a controlled rate, depending on the SMP design. Bioinfiltration/bioretention SMPs can include both surface and subsurface storage areas.

Surface storage is typically provided by excavating an area to create a depression. Surface storage for bioinfiltration/bioretention SMPs can also be created using curbing or concrete structures such as flow-through planter boxes. It provides temporary storage of stormwater runoff before infiltration, evaporation, and uptake can occur within the bioinfiltration/bioretention SMP. Ponding time provides Water Quality benefits by allowing larger debris and sediment to settle out of the water. Maximum surface ponding depth requirements are provided in order to reduce hydraulic loading on underlying soils, ensure adequate drain down time, and prevent standing water.

Figure 4.1-2: Flow-through planter box with typical features



Beneath surface storage areas, prepared planting soil medium provides *subsurface storage* capacity. This storage capacity is a function of the soil depth, surface area, and void space. The planting soil medium serves as the primary Water Quality treatment mechanism of a bioinfiltration/bioretention SMP, filtering runoff before it reaches the native soil (for bioinfiltration SMPs) or before it reaches the downstream discharge point (for bioretention SMPs).

The characteristics of the soil for the bioinfiltration/bioretention SMP are perhaps as important as the facility location, size, and treatment volume. The soil must be permeable enough to allow runoff to filter through the media, while having characteristics suitable to promote and sustain a robust vegetative cover crop. In addition, much of the nutrient pollutant uptake (nitrogen and phosphorus) is accomplished through adsorption and microbial activity within the soil profile. Therefore, the soils must balance soil chemistry and physical properties to support biotic communities above and below ground.

Many bioinfiltration/bioretention SMPs include an additional subsurface storage component, typically constructed of a stone-filled, level-bottomed bed or trench. The void spaces between the stones store stormwater until it can infiltrate into the surrounding soils or be released downstream.

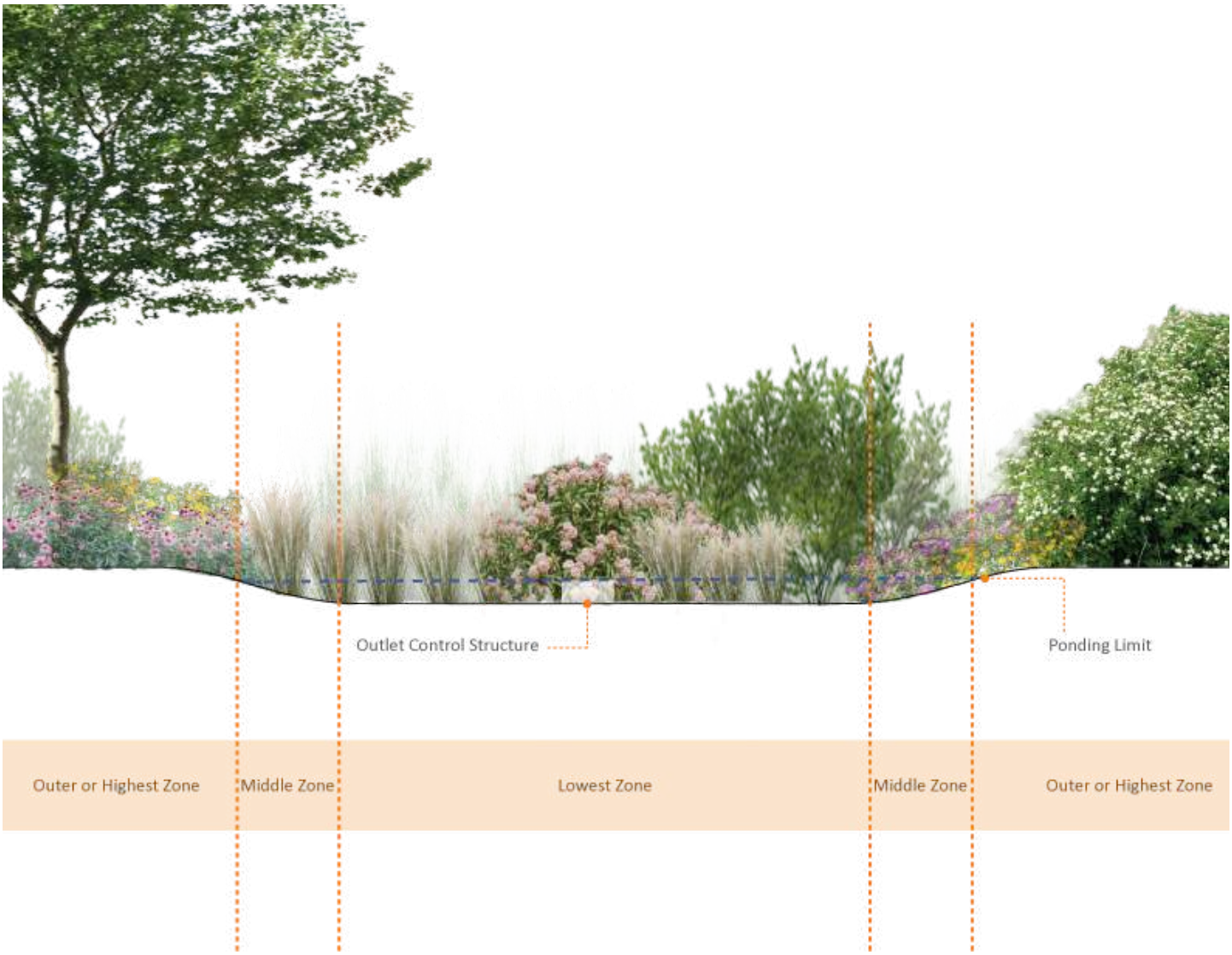
A mulch or organic layer, atop the planting soil medium, provides a medium for biological growth, decomposition of organic material, and adsorption of pollutants such as heavy metals. The mulch layer can also absorb some water during storms and help the planting soil retain water for plant growth during dry periods.

Vegetation component

Plant material in a bioinfiltration/bioretention SMP removes nutrients and stormwater pollutants through vegetative uptake and microbial community support, removes water through evapotranspiration, creates pathways for infiltration (in bioinfiltration SMPs) through root development and plant growth, improves aesthetics, provides habitat, and helps to stabilize soil.

The proper selection and installation of plant materials is critical to a successful bioinfiltration/bioretention SMP. There are essentially six zones within a bioinfiltration/bioretention SMP (**Figure 4.1-3** ☛ p. 13). The lowest elevation supports plant species adapted to standing and fluctuating water levels. The middle elevation supports a slightly drier group of plants, but still tolerates fluctuating water levels. The outer edge is the highest elevation and generally supports plants adapted to drier conditions. However, plants in all zones should be drought tolerant.

Figure 4.1-3: Hydrologic zones of a bioinfiltration/bioretention basin



The *lowest zone (hydrologic zones 2–4)* contains plant species adapted to standing and fluctuating water levels and frequent inundation. Frequently used native plants include the following species. The designer is referred to **Table I-1** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists/#Table_I.1 in **Appendix I** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists for a complete listing.

Table 4.1-1: Frequently used native plants for hydrologic zones 2–4

Frequently used native plants for hydrologic zones 2–4	
asters (*Aster spp.*)	winterberry (*Ilex verticillata*)
goldenrods (*Solidago spp.*)	arrowwood (*Viburnum dentatum*)
bergamot (*Monarda fistulosa*)	sweet pepperbush (*Clethra alnifolia*)
blue-flag iris (*Iris versicolor*)	bayberry (*Myrica pensylvanica*)
sedges (*Carex spp.*)	buttonbush (*Cephalanthus occidentalis*)
ironweed (*Vernonia noveboracensis*)	swamp azalea (*Rhododendron viscosum*)
blue vervain (*Verbena hastata*)	elderberry (*Sambucus canadensis*)
joe-pye weed (*Eupatorium spp.*)	red maple (*Acer rubrum*)
swamp milkweed (*Asclepias incarnata*)	river birch (*Betula nigra*)
switchgrass (*Panicum virgatum*)	sweetgum (*Liquidambar styraciflua*)
shrub dogwoods (*Cornus spp.*)	northern white cedar (*Juniperus virginiana*)

The *middle zone (hydrologic zones 4–5)* is slightly drier than the lowest zone, but plants should still tolerate fluctuating water levels. Frequently used native plants include the following species. The designer is referred to **Table I-1** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists/#Table_I.1 in **Appendix I** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists for a complete listing.

Table 4.1-2: Frequently used native plants for hydrologic zones 4–5

Frequently used native plants for hydrologic zones 4–5	
black snakeroot (*Cimicifuga racemosa*)	spicebush (*Lindera benzoin*)
switchgrass (*Panicum virgatum*)	hackberry (*Celtis occidentalis*)
spotted joe-pye weed (*Eupatorium maculatum*)	willow oak (*Quercus phellos*)
cutleaf coneflower (*Rudabeckia lacinata*)	winterberry (*Ilex verticillata*)
frosted hawthorn (*Crataegus pruinosa*)	slippery elm (*Ulmus rubra*)
marginal wood fern (*Dryopteris marginalis*)	viburnums (*Viburnum spp.*)
ironwood (*Carpinus caroliniana*)	witch-hazel (*Hamamelis virginiana*)
serviceberry (*Amelanchier canadensis*)	steeplebush (*Spiraea tomentosa*)
obedient plant (*Physostegia virginiana*)	blueberry (*Vaccinium spp.*)

The *outer zone (hydrologic zones 5–6)* generally supports plants adapted to drier conditions. Frequently used native plants include the following species. The designer is referred to **Table I-1** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists/#Table_I.1 in **Appendix I** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists for a complete listing.

Table 4.1-3: Frequently used native plants for hydrologic zones 5–6

Frequently used native plants for hydrologic zones 5–6	
basswood (*Tilia americana*)	sweet-fern (*Comptonia peregrina*)
white oak (*Quercus alba*)	eastern red cedar (*Juniperus virginiana*)
scarlet oak (*Quercus coccinea*)	smooth serviceberry (*Amelanchier laevis*)
black oak (*Quercus velutina*)	American holly (*Ilex opaca*)
american beech (*Fagus grandifolia*)	sassafras (*Sassafras albidum*)
black chokeberry (*Aronia melanocarpa*)	white pine (*Pinus strobus*)

Outlet control component

Outlet controls within a bioinfiltration/bioretention SMP can provide a range of functions, including the following:

- Controlling how much water is stored for infiltration (for bioinfiltration SMPs);
- Meeting drain down time requirements;
- Controlling the rate of discharge from the SMP and limiting water surface elevations during various storm events; and
- Bypassing of flows from large storm events.

Outlet controls may include orifices, weirs, risers, or underdrains. The designer is referred to **Section 4.12** ☛ p. 182, Outlet Controls, for more information.

Inspection and maintenance access component

Safe and easy inspection and maintenance access to all major components within a bioinfiltration/bioretention SMP is critical to ensuring long-term performance. Cleanouts provide a means to maintain any installed underdrains. Mildly sloping, stabilized, and graded areas also provide access to surface storage areas for heavy equipment, which may be needed for sediment removal.

4.1.3 Bioinfiltration/bioretention design standards

The designer is encouraged to design bioinfiltration/bioretention SMPs meeting the minimum requirements set forth in the Bioinfiltration/bioretention basin Standard Detail (**Figure 4.1-4** ☛ p. 20) in conjunction with the Bioinfiltration/bioretention basin sizing table (**Table 4.1-4** ☛ p. 16). Basins sized as such provide Water Quality compliance in all sewersheds and regardless of infiltration feasibility, with only minor modification necessary to the capped underdrain during construction. As a result, bioinfiltration/bioretention SMPs can be designed without knowledge of infiltration feasibility.

If infiltration is deemed feasible, the designer may elect to dynamically design the bioinfiltration SMP. The dynamically designed SMP must still meet all applicable requirements, but it may be designed to statically store one inch of runoff, rather than the full 1.5-inch Water Quality Volume (WQv). If this strategy is chosen, the designer must show, via dynamic routing, that the full 1.5-inch WQv is managed throughout the design storm, without overflow.

Assuming a directly disconnected impervious area (DCIA) to SMP footprint loading ratio less than or equal to 16:1, the Bioinfiltration/bioretention basin sizing table (**Table 4.1-4** ☛ p. 16) provides an orifice diameter based on the DCIA drainage area being treated by the basin. The designer may use this table to determine the orifice diameter required for Water Quality compliance where infiltration is infeasible, for DCIA drainage areas less than one acre.

Table 4.1-4: Bioinfiltration/bioretention sizing table

Tier	DCIA drainage area range (square feet)	Orifice diameter (inches)
A	0 – 17,000	½
B	17,000 – 24,000	⅝
C	24,000 – 33,000	¾
D	33,000 – 43,560	⅞

1. DCIA to SMP footprint loading ratio must not exceed 16:1.

2. For DCIA drainage areas greater than 1 acre, the designer must design the SMP to meet all applicable PWD Stormwater Regulations.

Basins designed to meet the minimum requirements of the Standard Detail (**Figure 4.1-4** ☛ p. 20) and the Bioinfiltration/bioretention basin sizing table (**Table 4.1-4** ☛ p. 16) inherently meet key design requirements: static storage of the WQv (when infiltration is feasible), Water Quality release rate requirements (when infiltration is infeasible in the combined sewer area), appropriate maximum ponding depths, and drain down within 72 hours. Accordingly, calculations confirming these design requirements have been met do not need to be submitted when designing bioinfiltration/bioretention SMPs for Water Quality compliance per these recommendations. Design modifications may be necessary when the Flood Control, Channel Protection, and/or Public Health and Safety requirements apply.

General design standards

1. The maximum allowable drain down time is 72 hours after the 24-hour storm event.
2. The maximum allowable DCIA to SMP footprint loading ratio is 16:1.
3. Positive overflow must be provided for large storm events, up to and including the 100-year, 24-hour storm event, or, if the project is exempt from Flood Control, the ten-year, 24-hour storm. Overflow structures and pipes must be designed to convey at least the ten-year, 24-hour storm.
4. The minimum allowable distance between the contour of a bioinfiltration/bioretention basin's Water Quality Volume elevation and any adjacent private property line is ten feet. This includes fully or partially lined basins. Exceptions can be made for water-tight planter boxes with their own structural integrity. It is acceptable for SMPs to be located directly adjacent to the public right-of-way (ROW).
5. The minimum allowable distance between the contour of a bioinfiltration/bioretention basin's Water Quality Volume elevation and any building or retaining wall is ten feet. This includes fully or partially lined basins. The following requirements and exceptions apply:
    a. For existing and proposed buildings with basements, the setback is measured from the basement wall and may be waived if the basin is a water-tight planter box with its own structural integrity.
    b. For existing buildings without basements and existing retaining walls, the setback is measured from the foundation and may be waived if a signed and sealed geotechnical analysis is submitted that evaluates the impacts of infiltration and excavation on the existing foundation and determines it to be feasible.
    c. For proposed buildings without basements and proposed retaining walls, the setback is measured from the foundation and may be waived if the foundation is proposed to be designed with the basin's proximity in mind.
6. Infiltration Requirements:
    a. The designer is referred to **Section 3.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-3-infiltration-testing-and-soil-assessment-for-smp-design for information on infiltration testing requirements.
    b. The SMP must be located at least two feet above any poorly infiltrating soils, seasonal high groundwater table, bedrock, or any other limiting zone.
    c. For hydrologic modeling, infiltration must be applied to the horizontal surface area (SMP footprint), not the wetted area. If necessary, for the purpose of meeting the Water Quality requirement, infiltration can be assumed through the horizontal projection of the wetted area up to the WQv water surface elevation.
    d. Soils underlying infiltration practices must, when tested pursuant to the infiltration testing procedure described in **Section 3.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-3-infiltration-testing-and-soil-assessment-for-smp-design, be determined to be infiltration feasible.
    e. Soils with rates in excess of ten inches per hour require soil amendments. During construction, upon achieving final subgrade elevations, a two-foot-thick layer of amended soil must be placed across the entire cross-section of the infiltrating SMP, below the bottom elevation of the SMP, and a minimum of three infiltration tests must be performed within the amended soil layer. If soil amendments are installed and the tested infiltration rate is determined to be outside of the PWD-allowable range or varies significantly from the design infiltration rate, additional soil amendments and/or an SMP redesign will be required. The designer is referred to **Section 3.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-3-infiltration-testing-and-soil-assessment-for-smp-design for additional detail.

f. If the infiltration SMP is used as a temporary sediment basin during construction, the invert elevation of the infiltration SMP must be a minimum of three feet below the bottom elevation of the pre-basin-conversion sediment basin.

g. An infiltrating SMP within the zone of influence of any nearby sewers or sewer laterals must be installed with an impervious liner. The zone of influence is defined by the area within a 1:1 (H:V) slope line from the outer edge of a sewer or sewer lateral.

Pretreatment design standards

7. Acceptable form(s) of pretreatment must be incorporated into design. Pretreatment of runoff from all inlets is required. At a minimum, this can be achieved through the use of sumps and traps for inlets, sump boxes with traps downstream of trench drains, and filter strips for overland flow.
8. The designer is referred to **Section 4.10** ☛ p. 148, Pretreatment, for more information on design standards for pretreatment systems.

Inlet control design standards

9. To prevent erosion, energy dissipaters, such as riprap stone, must be placed at all locations of concentrated inflow. Riprap aprons must be designed, and stone sizing must be determined, in accordance with the riprap apron design procedures in the latest edition of the *Pennsylvania Department of Environmental Protection (PA DEP) Erosion and Sediment Pollution Control Program Manual*.
10. The designer is referred to **Section 4.11** ☛ p. 166, Inlet Controls, for more information on design standards for inlet control systems.

Storage area design standards

11. The storage area for a bioinfiltration SMP must provide static storage for the WQv between the bottom elevation of the SMP and the elevation of the lowest outlet, including the planting soil medium and stone storage void space. The minimum allowable ponding depth below the lowest outlet device is three inches. Bioinfiltration basins may also be sized per the Bioinfiltration/bioretention basin sizing Table (**Table 4.1-4** ☛ p. 16) to ensure that storage requirements are achieved. For dynamically designed bioinfiltration SMPs, static storage of only one inch of the WQv must be provided if the designer demonstrates, through dynamic routing, that the full 1.5-inch WQv is managed throughout the design storm, without overflow.
12. The storage area for a bioretention SMP must provide adequate storage to control release rates to meet all applicable Stormwater Regulations. All permanent pool areas must be excluded from the SMP's storage volume estimation. Void space in the soil and/or stone layers beneath the bioretention area surface may be considered part of the available volume of the SMP. Bioretention basins may also be sized per the Bioinfiltration/bioretention basin sizing table (**Table 4.1-4** ☛ p. 16) to ensure that storage and Water Quality release rate requirements are achieved.
13. The maximum allowable static storage volume without supporting documentation (defined below) is the runoff volume from the one-year, 24-hour storm.

14. The maximum allowable static storage volume with supporting documentation is the runoff volume from the ten-year, 24-hour storm. Requirements for supporting documentation include a letter, signed and sealed by both the geotechnical and design engineer, indicating that the proposed design is recommended, with the following components acknowledged and considered. The designer is encouraged to contact PWD for further guidance when pursuing this design.
    a. A summary of the long-term impacts to the neighboring properties, including, but not limited to, subsidence, change in basement moisture/water, and structural damage;
    b. The location of the groundwater table;
    c. References to other projects that have successfully infiltrated more than the one-year, 24-hour storm event; and
    d. Rigorous pretreatment to promote longevity of the infiltration SMP.
15. When SMPs are used in series, the storage areas for all SMPs must provide cumulative static storage for the WQv, but there is no minimum storage requirement for each individual SMP used in series.
16. Bioinfiltration/bioretention SMPs can be designed with additional storage beyond the WQv and with outlet controls that allow all remaining applicable Stormwater Regulations to be met.
17. Maximum side slopes for surface storage areas are as follows:
    a. All – 2(H):1(V) (The recommended side slope is 3(H):1(V))
    b. Mowed – 4(H):1(V) to avoid "scalping" by mower blades
18. Porosity values for storage volume calculations are as follows:
    a. Soil media: 0.20
    b. Sand: 0.30
    c. Stone: 0.40
19. Stone must be separated from soil media by a geotextile or a pea gravel filter to prevent sand, silt, and sediment from entering the SMP.
20. Stone storage systems for bioinfiltration SMPs must have a level bottom or use a terraced system if installed along a slope.
21. The planting soil medium must have a minimum depth of two feet.

Vegetation design standards

22. Care must be taken to ensure that the ponding area depth is appropriate for the size and species of the plants selected.
23. Plants that are appropriate for, and compatible with, the site conditions must be chosen. The designer is referred to **Section 4.13** ☛ p. 218, Landscaping, for additional landscaping guidance and **Appendix I** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists for plant lists.

Outlet control design standards

24. Impervious liners should be avoided, but they may be necessary in areas where the threats of spills and/or groundwater contamination are likely. They must not be interrupted by structures within the basin footprint. Impervious liners must be continuous and extend completely up the sides of any structures that are located within the lined basin footprint to the ground surface. If additional liner material must be added to extend up the structures, the additional liner sections must be joined to the rest of the liner with an impervious seam per the manufacturers' recommendation.

25. Underdrains must be provided for all bioinfiltration/bioretention SMPs and must meet the following requirements:
    a. Underdrains must be surrounded by a sand or stone layer to filter sediment and facilitate drainage.
    b. The minimum allowable depth of a sand or stone filter layer above and beneath the underdrain is six inches, which must extend across the entire basin bottom.
    c. Underdrains must be surrounded by a geotextile fabric, if sand is used.
    d. Underdrains for bioinfiltration basins must remain capped to facilitate infiltration into native soils.
    e. For bioretention SMPs located in the combined sewer area where infiltration is infeasible, underdrains must be capped with an appropriately sized orifice to control release rates to meet all applicable Stormwater Regulations. Orifice diameter for flow-regulating underdrains may be determined based on the Bioinfiltration/bioretention basin sizing table (**Table 4.1-4** ☛ p. 16) for basins meeting the minimum requirements of the Standard Detail (**Figure 4.1-4** ☛ p. 20).
    f. For bioretention SMPs located in the separate sewer area, where infiltration is infeasible, flow through the underdrain may be modeled as exfiltration at a rate of two inches per hour over the basin footprint. This exfiltration flow must be routed through the primary outlet of the bioretention area, not discarded from the stormwater model.
    g. The outlet pipe of an outlet control structure must have an invert at or below the invert of the underdrain. Setting the outlet pipe invert at a minimum of 7.5 inches below that of the underdrain is recommended.
26. The designer is referred to **Section 4.12** ☛ p. 182, Outlet Controls, for information on design standards for outlet control systems.

Inspection and maintenance access design standards

27. Cleanouts, manholes, access panels and other access features must be provided to allow unobstructed and safe access to SMPs for routine maintenance and inspection of inflow, outflow, underdrains, and storage systems.

Figure 4.1-4: Bioinfiltration/bioretention basin standard detail

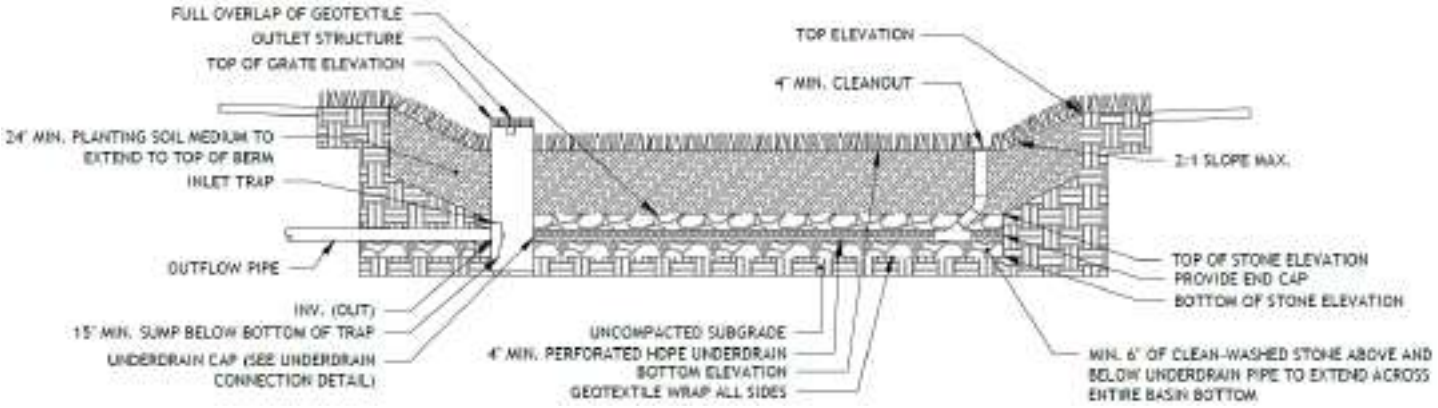
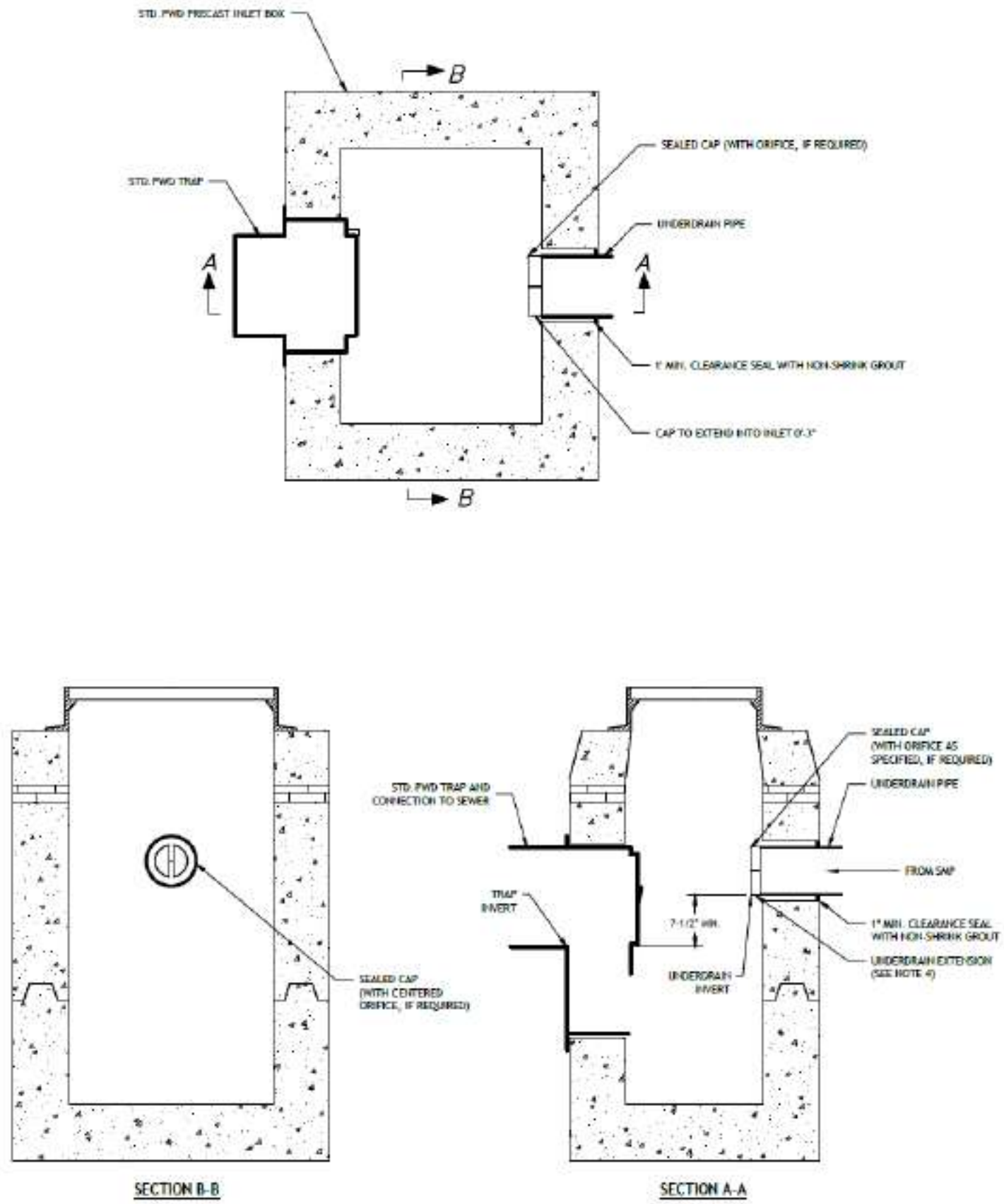


Figure 4.1-5: Underdrain connection standard detail



(The designer is referred to **Appendix L** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/l-standard-details to download Standard Detail CAD files.)

4.1.4 Bioinfiltration/bioretention material standards

Pretreatment material standards

1. The designer is referred to **Section 4.10** ☛ p. 148, Pretreatment, for information on materials standards for pretreatment systems.

Inlet control material standards

2. The designer is referred to **Section 4.11** ☛ p. 166, Inlet Controls, for information on material standards for inlet control systems.

Storage area material standards

3. Stone designed for stormwater storage must be uniformly graded, crushed, clean-washed stone. PWD defines "clean-washed" as having less than 0.5% wash loss, by mass, when tested per American Association of State Highway and Transportation Officials (AASHTO) T-11 wash loss test. AASHTO No. 3 and No. 57 stone can meet this specification.
4. Sand, if used, must be AASHTO M-6 or American Society of Testing and Materials (ASTM) C-33 sand and must have a grain size of 0.02 to 0.04 inches.
5. Planting Soil Medium
    a. Planting soil should meet all the specifications listed below and should be a fertile, natural soil, free from large stones, roots, sticks, clods, plants, peat, sod, pockets of coarse sand, pavement and building debris, glass, noxious weeds including invasive species, infestations of undesirable organisms and disease-causing pathogens, and other extraneous materials harmful to plant growth.
    b. The texture of planting soil should conform to the classification within the United States Department of Agriculture triangle for Sandy Loam or Loamy Sand. Planting soil should be a mixture of sand, silt, and clay particles as required to meet the classification. Ranges of particle size distribution, as determined by pipette method in compliance with ASTM F-1632, are as follows:
        i. Sand (0.05 to 2.0 mm): 50 – 85%
        ii. Silt (0.002 to 0.05mm): 40% maximum
        iii. Clay (less than 0.002mm): 10% maximum
        iv. Gravel (2.0 to 12.7 mm): 15% maximum
    c. Planting soil should be screened and free of stones larger than a half-inch (12.7 millimeters) in any dimension. No more than 10% of the soil volume should be composed of soil peds greater than one inch.
    d. Clods, or natural clumps of soils, greater than three inches in any dimension should be absent from the planting soil. Small clods ranging from one to three inches and peds, natural soil clumps under one inch in any dimension, may be present but should not make up more than 10% of the soil by volume.
    e. The pH of the planting soil should have a range of 5.8 to 7.1.
    f. Soluble salts should be less than 2.0 mmhos/cm (dS/m), typically as measured by 1:2 soil-water ratio basic soil salinity testing. Sodic soils (Exchangeable Sodium Percentage greater than 15 and/or Sodium Adsorption Ratio greater than 13) are not acceptable for use regardless of amendment.
    g. Organic content of planting soil should have a range of 3% to 15% by weight, as determined by loss on ignition (ASTM D2974). To adjust organic content, planting soil may be amended, prior to placing and final grading, with the addition of organic compost.

6. Mulch, if used, must be free of weeds and must consist of aged, double-shredded hardwood bark mulch or leaf mulch that has been shredded sufficiently to limit risk of matting, which can limit surface infiltration rates. For hydroseeding, paper mulch may be used. Approved mulching materials include organic materials such as compost, bark mulch, leaves, as well as small river gravel, pumice, or other inert materials. Grass clippings should not be used as mulch.
7. Geotextile must consist of polypropylene fibers and meet the following specifications (AASHTO Class 1 or Class 2 geotextile is recommended):
    a. Grab Tensile Strength (ASTM-D4632): ≥ 205 lbs
    b. CBR Puncture Strength (ASTM-D6241): ≥ 500 lbs
    c. Flow Rate (ASTM-D4491): ≥ 95 gal/min/ft2
    d. UV Resistance after 500 hours (ASTM-D4355): ≥ 70%
    e. Tear Resistance (ASTM-D4533): ≥ 80 lbs
    f. Heat-set or heat-calendared fabrics are not permitted.

Vegetation material standards

8. Trees and shrubs must be freshly dug and grown in accordance with good nursery practice.
9. Perennials and herbaceous plants must be healthy, well-rooted specimens.
10. A native grass/wildflower seed mix can be used as an alternative to groundcover planting. Seed mix must be free of weed seeds.
11. Use of invasive plants is not permitted. All plants and trees must be appropriate and compatible with soil, hydrologic, light, and other site conditions. The designer is referred to **Appendix I** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists for plant lists.

Outlet control material standards

12. Underdrains must be made of continuously perforated high-density polyethylene (HDPE) plastic piping with a smooth interior and a minimum inner diameter of four inches. HDPE pipe must meet the specifications of AASHTO M252, Type S or AASHTO M294, Type S.
13. The designer is referred to Section 4.12, Outlet Controls, for more information on material standards for outlet control systems.

Inspection and maintenance access material standards

14. Cleanouts must be made of material with a smooth interior having a minimum inner diameter of six inches. If the connecting pipe is eight inches in diameter or larger, then the cleanout must be eight inches in diameter.

4.1.5 Bioinfiltration/bioretention construction guidance

Careful consideration of issues like soil compaction, infiltration performance, and sediment control are critical to ensure proper bioinfiltration/bioretention functionality and reduce long-term maintenance needs. Poor oversight of construction activities could result in the need for substantial reconstruction to address performance problems.

1. Provide erosion and sedimentation control protection on the site such that construction runoff is directed away from the proposed bioinfiltration/bioretention location. The designer is referred to the latest edition of the *PA DEP Erosion and Sediment Pollution Control Program Manual* for information on design standards for erosion and sedimentation control practices.
2. Bioinfiltration areas must be physically marked prior to any land-disturbing activities to avoid soil disturbance and compaction during construction. Install construction fencing around bioinfiltration areas.
3. Proposed bioretention areas may be used as sediment traps during construction. Bioinfiltration areas may not be used as sediment traps during construction, unless at least three feet of soil are left in place while the area is serving as a sediment trap and subsequently removed during construction after the contributing drainage areas have been stabilized.
4. Complete site elevation grading and stabilize the soil disturbed within the limits of disturbance. Do not finalize bioinfiltration/bioretention excavation and construction until the drainage area is fully stabilized.
5. Excavate bioinfiltration/bioretention area to proposed invert depth and manually scarify the *in situ* soils at the base of the excavation. Do not compact in situ soils. Heavy equipment must not be used within the bioinfiltration area. All equipment must be kept out of the excavated area to the maximum extent possible. The use of machinery to load any proposed stone from outside of the basin footprint is recommended. Rock construction entrances must not be located on top of areas proposed for infiltration practices. Heavy equipment exclusion zones must be established to avoid compaction of the infiltration area during construction. Excavate bioinfiltration/bioretention area to proposed invert depth and manually scarify the *in situ* soils at the base of the excavation. Do not compact in situ soils. Heavy equipment must not be used within the bioinfiltration area. All equipment must be kept out of the excavated area to the maximum extent possible. The use of machinery to load any proposed stone from outside of the basin footprint is recommended. Rock construction entrances must not be located on top of areas proposed for infiltration practices. Heavy equipment exclusion zones must be established to avoid compaction of the infiltration area during construction.
6. Perform infiltration testing (if testing was deferred until construction). The designer is referred to **Section 3.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-3-infiltration-testing-and-soil-assessment-for-smp-design for guidance on infiltration testing procedures.
7. For bioinfiltration SMPs, where infiltration is feasible, ensure underdrains are equipped with a water-tight end cap within the outlet control structure.
8. For bioretention basins, where infiltration is infeasible, convert the underdrain to a flow-regulating underdrain by drilling an appropriately-sized orifice in the center of a water-tight underdrain cap center within the outlet control structure.

9. Place impervious liner, if needed within a bioretention basin, ensuring continuous contact with subgrade. Extreme care should be taken during installation of a geomembrane liner so that no damage is done to any part of the material. Construction equipment, gasoline driven generators, or cans of gas or solvent must not be placed on the geomembrane material. The geomembrane material must not be used as a work area to prepare patches or to store tools and supplies. Temporary wind anchorage by means of sandbags or tires must be provided during geomembrane installation. Nails, rebar, wire ties, or other metal materials shall not be used to hold geomembrane in position. Geomembrane seaming must be performed in accordance with ASTM D7408 (PVC) and ASTM D8580 (LLDPE, PP). Non-destructive and destructive testing of geomembrane seaming must be performed in accordance with ASTM D7700. Mechanical attachment of geomembrane to pipe penetrations or structures must be installed in accordance with ASTM D6497/D6497M-02. Placement of overlying material must be performed in a manner that will not damage the geomembrane. Excessive wrinkling of the geomembrane must be prevented prior to or while covering the geomembrane, ensuring no permanent folds or wrinkles in the liner. Any damage to the geosynthetic material must be repaired immediately.
10. Any stone within the infiltration SMP must remain free of sediment and meet the washed stone specification found above. If sediment enters the stone, the contractor may be required to remove the sediment and replace with clean washed stone.
11. Place filter fabric or pea gravel filter, then place the stone, and set the underdrain according to the plans.
12. Backfill the excavated area as soon as the subgrade preparation is complete to avoid accumulation of debris. Place bioinfiltration/bioretention soil in 12- to 18-inch lifts and tamp lightly by hand or compact by watering each lift. Ensure backfill process does not disrupt pipe placement and configuration. Slight overfilling might be necessary to account for settlement. Pre-soak the soil at least one day prior to final grading and landscaping to allow for settlement.
13. After allowing for settlement, complete final grading within about two inches of the proposed design elevations, leaving space for top dressing of mulch or mulch/compost blend.
14. Seed and plant vegetation as indicated on the plans and specifications.
15. Place mulch and hand grade to final elevations.
16. Install energy dissipaters as specified on the plans, if applicable.
17. Water vegetation at the end of each day for two weeks after planting is completed.
18. Water vegetation regularly during first year to ensure successful establishment.



An example of a bioinfiltration basin installation in Philadelphia

4.1.6 Bioinfiltration/bioretention maintenance guidance

Bioinfiltration/bioretention maintenance activities focus largely on maintaining infiltration capacity and the health of vegetation. During periods of extended drought, bioinfiltration/bioretention SMPs may require watering approximately every ten days.

General recommended maintenance activities for bioinfiltration/bioretention SMPs are summarized in Table 4.1-5 below

Table 4.1-5: Bioinfiltration/bioretention maintenance guidelines

Early maintenance activity	Frequency
Water vegetation at the end of each day for two weeks after planting is completed.	Daily for two weeks after installation
Water vegetation regularly to ensure successful establishment after planting.	Every four days during periods of four or more days without rain, June through August for the first year after installation
Inspect vegetation for signs of disease or distress.	Biweekly for the first year after installation
Inspect inlet controls, outlet structures, and storage areas for trash and sediment accumulation.	Monthly for the first year after installation to determine ongoing maintenance frequency

Ongoing maintenance activity	Frequency
Remulch void areas.	As needed
Treat diseased trees and shrubs.	As needed
Keep overflow free and clear of leaves.	As needed
Remove any invasive vegetation by hand.	As needed
Thin any overgrown areas of vegetation.	As needed
Inspect soil and repair eroded areas.	Monthly
Remove litter and debris.	Monthly
Clear leaves and debris from overflow.	Monthly
Empty filter bags for pretreatment devices. Ensure filter bag is installed properly.	Monthly
Inspect trees and shrubs to evaluate health, replacing if necessary.	Quarterly
Inspect underdrain cleanouts.	Quarterly
Ensure river rock layout is sufficient to dissipate flow and check for downstream erosion. Replace river rock as necessary and repair erosion issues.	Quarterly
Add additional mulch.	Quarterly
Inspect for sediment build-up, erosion, and vegetative conditions. Remove sediment buildup, stabilize eroded areas and add vegetation if necessary.	Quarterly
Evaluate the drain down time of the SMP after a storm of at least one inch in no more than 24-hours to ensure an SMP drain down time of less than 72 hours.	Ongoing
Maintain records of all inspections and maintenance activity.	Ongoing

The designer is referred to **Section 4.10** ☛ p. 148, Pretreatment, **Section 4.11** ☛ p. 166, Inlet Controls, **Section 4.12** ☛ p. 182, Outlet Controls, and **Section 4.13** ☛ p. 218, Landscaping, for information on maintenance guidance for pretreatment, inlet controls, outlet controls, and landscaping.

4.2 Porous Surfaces

Download summaries of this SMP and its maintenance guidance, with quick reference information for clients and developers:

- **Porous Surfaces SMP One-Sheet** ☛ water.phila.gov/wp-content/uploads/files/porous-surfaces-smp-one-sheet.pdf
- **Porous Surface Maintenance Guidance One-Sheet** ☛ water.phila.gov/wp-content/uploads/files/porous-surfaces-maintenance-guidance.pdf

4.2.1 Porous surface introduction

Porous surfaces can provide *surface-level* structural support while allowing stormwater to drain directly through the surface into an underlying stone bed and the soil below, thereby reducing surface stormwater runoff. Permitted porous surfaces include, but are not limited to, permeable pavers, reinforced turf, artificial, or synthetic, turf, and porous safety surfaces. (Porous asphalt, porous concrete, and resin-bound aggregate are strictly prohibited.) Interlocking pavers have openings filled with stone to create a porous surface. For all these types, stormwater flows through the porous surface during a rain event, then drains into the subbase, where it is stored until it infiltrates into the soil.

Porous surfaces can be combined with other SMPs in series to meet the Stormwater Regulations. The designer is referred to **Section 3.2.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-2-stormwater-management-design#3.2.3 for information on using SMPs in series.

Design of porous surfaces is not limited to the examples shown within this text. Successful stormwater management plans will combine appropriate materials and designs specific to each site.

Porous surface design may be considered differently for Stormwater Retrofits. Designers looking to incorporate porous surface in Stormwater Retrofit projects should contact **Stormwater Billing and Incentives** ☛ water.phila.gov/development/stormwater-plan-review/manual/introduction#6 for additional information.

Quick tip

Required porous surface design and material standards are denoted in this section by easy-to-reference numerals.



An example of permeable pavers in Philadelphia

When can porous surfaces be used?

Porous surface is only suitable for select types of development. Porous surfaces can be particularly well-suited for walkways, sidewalks, athletic surfaces, and playgrounds. Its footprint can be adapted to fit into spaces of almost any size and can be integrated into many different site layouts.

Porous surface can be designed to meet the traffic loading requirements for most parking lots and travel surfaces, but the maintenance costs are significantly increased in areas that receive high traffic volume. For example, commercial parking lots will require more frequent vacuuming to prevent the surface from clogging.

Key advantages of porous surfaces

- Can be used in place of traditional paved surfaces
- Can fit into spaces of almost any size and be integrated into many different site layouts
- Can be used as DIC to reduce DCIA as an alternative to traditional hardscape surfaces
- Reduces ponding and icing that can be associated with traditional hardscape surfaces
- Provides ancillary benefits such as better conditions for trees and reduced heat island effect
- Permeable pavers, reinforced turf, artificial turf, and porous safety surfaces are eligible for inclusion in an Expedited Post-Construction Stormwater Management Plan (PCSMP) Review project

Key limitations of porous surfaces

- Not recommended for high traffic loading areas or on heavy industrial sites where vehicles or equipment may contribute heavy sediment or gross pollutant loads to porous surfaces
- Typically, not suitable for steep slope applications
- Requires frequent maintenance with specialized equipment to maintain performance
- May degrade more rapidly if located in areas with frequent vehicular turning

Key design considerations for porous surfaces

- Design of paving sections must consider system stability based on anticipated structural loading.
- Porous surfaces should not be placed downstream of large impervious or pervious areas.
- Runoff from adjacent impervious and pervious areas must be conveyed directly to the subsurface storage to prevent clogging of porous surfaces.
- Porous surfaces should not be used in areas where gasoline or other hazardous materials may be dispensed or handled.
- For any porous surface structural SMP that discharges onto an adjacent property, a drainage easement may be required and is recommended.

Porous surface types

Porous surface systems can be distinguished by their intended stormwater management objective.

Porous surface DIC systems are designed to receive and infiltrate direct (1:1) rainfall only and are considered as DIC. Infiltration testing is not required for porous surface DIC; however, it is recommended to ensure timely drainage of the stone base. In some cases, where a small amount of run-on cannot be avoided, it may still be possible to consider the porous surface disconnected. Such allowances will be considered on a case-by-case basis by PWD.

Porous surface over a structural SMP is considered an SMP in series, where the porous surface is designed to manage its direct (1:1) rainfall, and the structural SMP beneath it is designed to store and manage DCIA runoff from other areas on-site in addition to direct (1:1) rainfall onto the porous surface atop the SMP. The porous surface cannot receive the additional runoff; The additional runoff must be conveyed directly to the underlying SMP. Porous surface that receives direct overland flow is extremely prone to clogging. Porous surface over a structural SMP is essentially a subsurface infiltration or detention system (based on infiltration feasibility) with a porous surface at-grade. The porous surface over the structural SMP footprint is considered DCIA. The structural SMP requires infiltration testing. The designer is referred to **Section 3.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-3-infiltration-testing-and-soil-assessment-for-smp-design for information on infiltration testing.

Porous surface systems can also be distinguished by the type of porous paving surface. There are many different types of structural surfaces that allow water to flow through void spaces in the surface. Any of these alternatives serve as a form of conveyance and filtration for the storage bed below. Several of the most commonly used porous structural surfaces are described below, but this does not represent an exhaustive list of the porous surfaces appropriate for stormwater management applications.

Permeable pavers are typically interlocking units (often concrete) with openings that can be filled with a pervious material such as gravel. These units are often implemented for aesthetic reasons and are especially well suited to plazas, patios, residential driveways, and small parking areas. There are also plastic grids that can be filled with gravel to create a fully gravel surface that is not as susceptible to rutting and compaction as are traditional gravel lots. Gravel used in interlocking concrete pavers or plastic grid systems must be well-graded to ensure permeability.

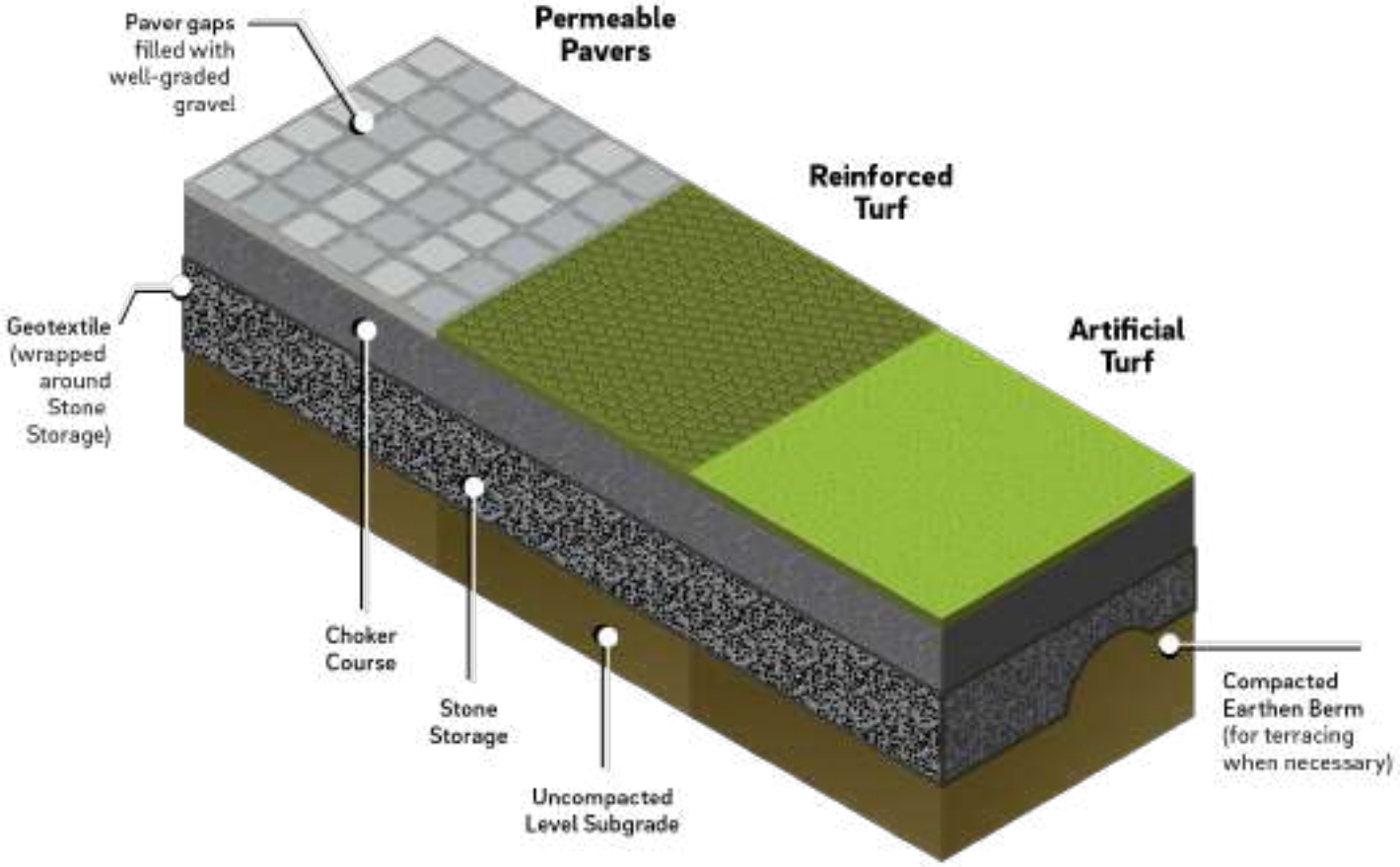
Reinforced turf consists of interlocking structural units with openings that can be filled with soil for the growth of turf grass and are suitable for traffic loads and parking. They are often used in overflow or event parking. Reinforced turf grids can be made of concrete or plastic and are underlain by a stone and/or a sand drainage system for stormwater management. While both plastic and concrete units perform well for stormwater management and traffic needs, plastic units may provide better turf establishment and longevity, largely because the plastic will not absorb water and diminish soil moisture conditions.

Artificial, or ***synthetic***, ***turf*** is a water permeable surface of synthetic fibers that emulates the aesthetic of natural grass. First gaining popularity in the 1960s, artificial turf has undergone a number of changes to its standard composition, with the most widely-used systems today featuring infills that are mixtures of sand and recycled (“crumb”) rubber. The designer is referred to **Section 3.5.5** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-5-integrated-stormwater-management-examples#3.5.5 for more information on athletic turf fields.

Porous asphalt, ***porous concrete***, and ***resin-bound aggregate*** are strictly prohibited. Property owners with existing systems comprised of any of these surface types are referred to **Section 4.2.6** ☛ p. 43 for Maintenance Guidance.

4.2.2 Porous surface components

Figure 4.2-1: Porous surfaces with typical features



Pretreatment component

Porous surface does not typically have pretreatment systems due to its (1:1) loading ratio. Run-on from pervious or impervious areas is not permitted, so pretreatment is not necessary. However, any SMP installed beneath a porous surface does require pretreatment of the runoff conveyed directly to it via piping.

Pretreatment systems capture trash, sediment, and/or pollutants from stormwater runoff before delivery to the storage or infiltration area. Pretreatment needs will vary significantly depending on the contributing drainage area composition and use. Pretreatment can include structures such as sumped and trapped inlets, sediment/grit chambers or separators, media filters, inlet inserts, or other appropriate prefabricated or proprietary designs to remove sediment, floatables, and/or hydrocarbons from stormwater runoff prior to being conveyed to a porous surface structural SMP. While inlet hoods are preferred, permanent filter bags may be accepted for Stormwater Retrofit projects where existing inlets do not have hoods and inlet reconstruction is not feasible. In addition to sumped and trapped inlets, permanent filter bag inserts are required for sites that generate pollutants such as loading docks, material storage facilities, junk yards, and waste collection and disposal sites. Permanent filter bags will require frequent cleanings.

Pretreatment can also consist of filter strips, forebays, and swales. The designer is referred to **Section 4.10** ☛ p. 148 for more information on pretreatment systems.

Inlet control component

Porous surface DIC systems, which receive direct (1:1) rainfall only, do not have inlet controls. For porous surface over structural SMPs, inlet control systems convey and control the flow of stormwater from the contributing catchment area directly to the structural SMP.

Inlet control needs will vary depending on the design of stormwater conveyance systems and the site layout. The designer is referred to **Section 3.4.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-4-how-to-show-compliance#3.4.2 for guidance on stormwater conveyance system design.

Inlet controls may include flow splitters, curbless design/curb openings, energy dissipaters, and inlets. The designer is referred to **Section 4.11** ☛ p. 166 for more information on inlet controls.

Storage area component

Storage areas within porous surface DIC systems temporarily hold stormwater runoff as it infiltrates into native soils.

The subsurface storage component of a porous surface structural SMP is typically constructed of a stone-filled, level-bottomed bed or trench, which may or may not incorporate pipes, arches, concrete vaults, crates, plastic grids, or other proprietary structures. The void spaces between the stones and/or structures store stormwater until it can infiltrate into the surrounding soils or be released downstream at a controlled rate.

Outlet control component

Outlet controls within a porous surface structural SMP can provide a range of functions, including the following:

- Controlling how much water is stored for infiltration, if infiltration is feasible;
- Meeting drain down time requirements;
- Controlling the rate of discharge from the system and limiting water surface elevations during various storm events; and/or
- Bypassing of flows from large storm events.

Positive overflow must be provided for porous surfaces. Positive overflow conveys runoff from larger storms out of the system and prevents flooding. In most cases, specifically for porous surface DIC, appropriate grading of the porous surface is sufficient for providing positive flow away from porous surface should it become clogged or ineffective. For larger porous surface systems or porous surface over a structural SMP, inlets are the most common overflow. A perforated pipe system can convey water from the storage bed, but static storage for the Water Quality Volume (WQv) is required below the perforated pipes.

Outlet controls may include orifices, weirs, or underdrains. The designer is referred to **Section 4.12** ☛ p. 182 for more information on outlet controls.

Inspection and maintenance access component

Safe and easy inspection and maintenance access to all major components within porous surface is critical to ensuring long-term performance. Inspection and maintenance access structures provide a portal to any structural SMP beneath the porous surface. Access points provide access to subsurface systems, both for inspections and routine maintenance, and for pumping water out of subsurface systems in cases of failure or severe damage. Manholes provide access for maintenance personnel and equipment to perform maintenance and inspections. Cleanouts provide access for hoses and vacuum equipment, as well as for any installed underdrains. Observation wells provide access to the bottom of subsurface systems for performance inspections and monitoring. Access structures may also serve additional functions, such as joining subsurface pipes.

4.2.3 Porous surface design standards

General design standards

1. For porous surface DIC systems:
    a. A reduction in DCIA is permitted when a porous surface system is installed on-site such that it does not create any areas of concentrated infiltration or discharge.
    b. The surface slope in any direction across porous surface cannot exceed 5% to be eligible for disconnection credit.
    c. The choker course depth must be a minimum of two inches.
    d. If an underdrain is proposed, the porous surface will only be considered DIC if the first 1.5 inches of runoff can be stored below the lowest invert of the underdrain.
    e. Appropriate Curve Number (CN) values must be used when performing Flood Control calculations.
2. For porous surfaces over structural SMPs, if infiltration is feasible, the designer is referred to **Section 4.4** ☛ p. 64 for subsurface infiltration general design requirements.
3. For porous surfaces over structural SMPs, if infiltration is infeasible, the designer is referred to **Section 4.8** ☛ p. 118 for subsurface detention general design requirements.

Pretreatment design standards

4. Acceptable form(s) of pretreatment must be incorporated into design. Pretreatment of runoff from all inlets is required. At a minimum, this can be achieved through the use of sumps and traps for inlets, and sump boxes with traps downstream of trench drains. The designer is referred to **Section 4.10** ☛ p. 148 for more information on design standards for pretreatment systems.

Inlet control design standards

5. The designer is referred to **Section 4.11** ☛ p. 166 for information on design standards for inlet control systems.

Storage area design standards

6. For porous surface DIC systems:
    a. Stone storage bed depth must be a minimum of eight inches, except when located beneath walkways or play surfaces, for which a depth of four inches is allowable.
    b. Stone must be separated from soil media by a separation barrier, such as a geotextile or a pea gravel filter, to prevent sand, silt, and sediment from entering the system.
    c. Stone storage systems must have a level bottom. Terraced systems may be used to maintain a level infiltration interface with native soil while accommodating significant grade changes.
7. For porous surfaces over structural SMPs, if infiltration is feasible, the designer is referred to **Section 4.4** ☛ p. 64 for subsurface infiltration storage area requirements.
8. For porous surfaces over structural SMPs, if infiltration is infeasible, the designer is referred to **Section 4.8** ☛ p. 118 for subsurface detention storage area requirements.
9. When SMPs are used in series, the storage areas for all SMPs must provide cumulative static storage for the WQv, but there is no minimum storage requirement for each individual SMP used in series.

Outlet control design standards

10. Impervious liners beneath porous surfaces should be avoided, but they may be necessary in areas over tunnels or subsurface structures. The lined area should be a minimal portion of the total porous area. If a significant area needs to be lined, a porous surface may not be an appropriate management strategy.
11. Underdrains, if proposed for porous surface DIC systems, must meet the following requirements:
    a. Underdrains must be surrounded by a sand or stone layer to filter sediment and facilitate drainage.
    b. The minimum allowable thickness of a sand or stone filter layer is six inches both above and beneath the underdrain.
    c. To prevent clogging, underdrain pipes must be surrounded by a geotextile fabric if a sand layer is used.
12. Inlets or area drains must be provided for all porous surface areas in excess of 5,000 square feet, in order to provide positive overflow.
13. The designer is referred to **Section 4.12** ☛ p. 182 for information on design standards for outlet control systems.

Inspection and maintenance design standards for porous surfaces over a structural SMP

14. Cleanouts, manholes, access panels and other access features must be provided to allow unobstructed and safe access to SMPs for routine maintenance and inspection of inflow, outflow, underdrains, and storage systems.
15. Observation wells must be provided for SMPs that include stone storage and must meet the following requirements:
    a. The observation well must be placed at the invert of the stone bed.
    b. The observation well must be located near the center of the stone bed system to monitor the level and duration of water stored within the SMP (drain down time). A minimum of six inches of clearance must be provided between the edge of the observation well's concrete ring or frame and any nearby site features (curbing, tree pits, sidewalk edge, etc.). Plan view dimensioning for the proposed location of the observation well, relative to the boundaries of the SMP it lies within, must be provided on the plans.
    c. Adequate inspection and maintenance access to the observation well must be provided.
    d. An observation well located in a paved area must be outfitted with a cover and frame. The cover plate must be installed flush with the surrounding surface at finished grade, and grading should drain away from the observation well wherever possible. The solid section of the observation well must extend into the cover frame enough such that a bentonite/cement seal can be placed around the well within the frame, and a solid slip-on cap can be fitted onto the pipe end.
    e. An observation well located in an unpaved area must have a concrete ring or frame poured for support, with three lengths of rebar evenly spaced around the ring and three inches from its outer edge. The observation well should be located outside of the ponding area of any surface SMPs. If, due to space limitations, an observation well must be placed in the ponding area of a surface SMP, the concrete ring and well cover must extend three inches above the SMP's maximum ponding depth.
    f. The observation well must include a slotted section within the storage layer of the SMP. The top of the slotted well section must extend to a minimum of six inches below the top of the SMP storage layer, and the slotted section must extend down the entire depth of the SMP.

16. Access features for underground storage systems
    a. Access features must be provided for all underground storage systems that are not stone storage beds.
    b. A sufficient number of access points in the system must be provided to efficiently inspect and maintain the storage area.
    c. For cast-in-place vault systems, access features must consist of manholes or grated access panels or doors. Grated access panels are preferred to maintain airflow.
    d. For grid storage or other manufactured systems, follow the manufacturer's recommendations.
    e. Ladder access is required for vaults greater than four feet in height.
    f. Header pipes, at minimum 36-inch diameter, connected to manholes at each corner of the subsurface system must be provided. Alternatively, smaller header pipes may be used if cleanouts are provided on the manifold/header pipe junction for each distribution pipe. The cleanouts must be on alternating sides of the SMP.

Figure 4.2-2: Porous surfaces standard detail

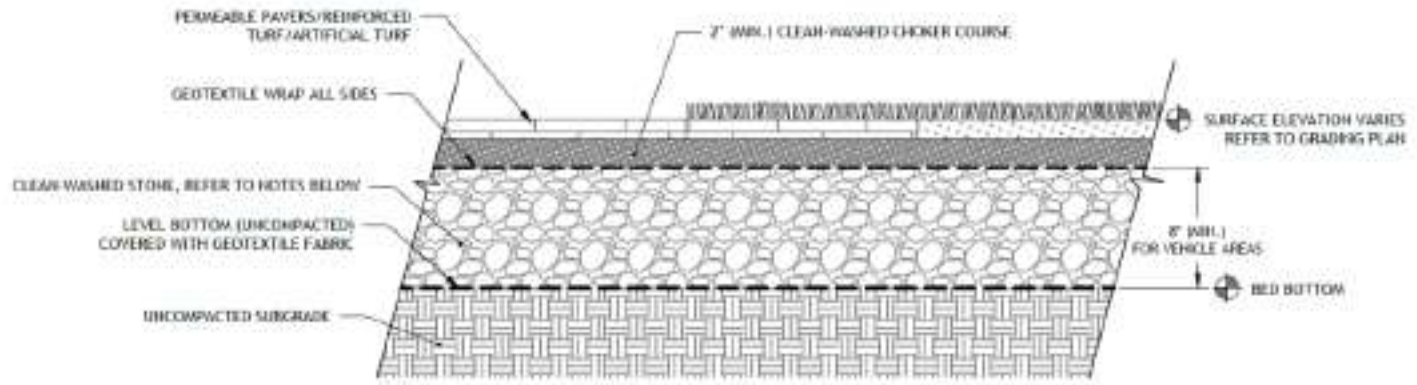
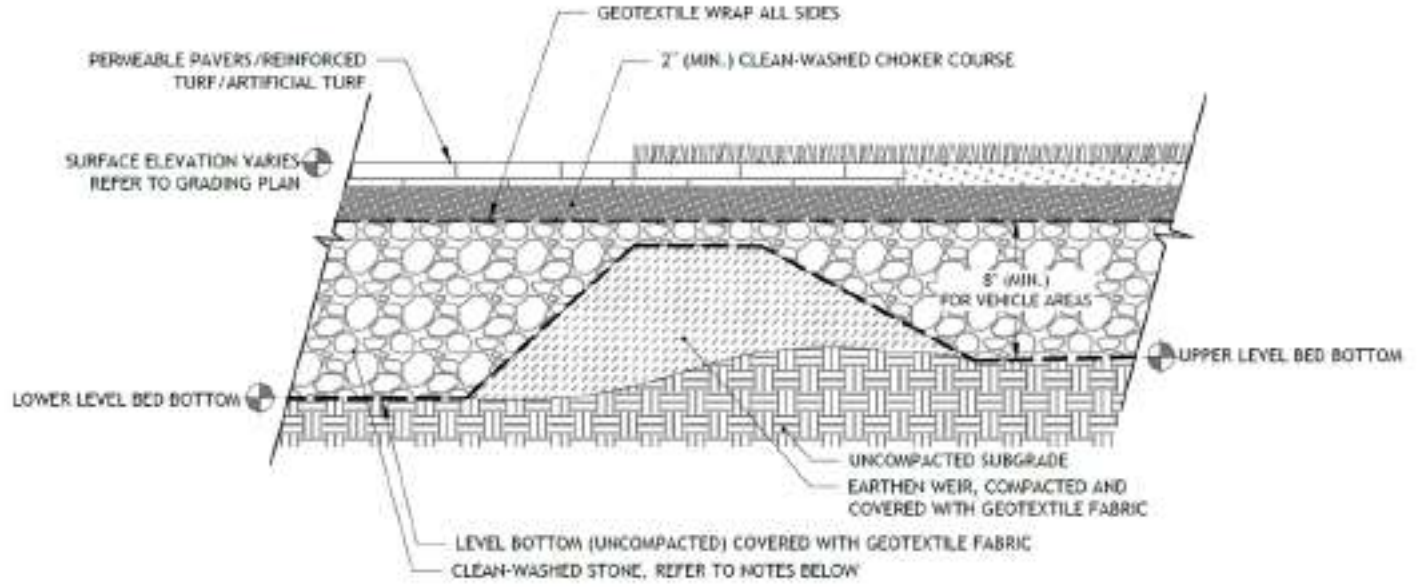


Figure 4.2-3: Terraced porous surfaces standard detail



(The designer is referred to **Appendix L** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/l-standard-details to download CAD files or PDF file versions.)

4.2.4 Porous surface material standards

Pretreatment material standards

1. The designer is referred to **Section 4.10** ☛ p. 148 for information on materials standards for pretreatment systems.

Inlet control material standards

2. Permeable Pavers and Reinforced Turf Grid Systems
   a. Permeable paver and grid systems must conform to manufacturer specifications.
   b. The systems must have a minimum flow through rate of five inches per hour and a void percentage of no less than 10%.
   c. Gravel used in interlocking concrete pavers or plastic grid systems must be well-graded and washed to ensure permeability.
3. The designer is referred to **Section 4.11** ☛ p. 166 for information on material standards for inlet control systems.

Storage area material standards

4. Stone
   a. Stone designed for stormwater storage must be uniformly graded, crushed, clean-washed stone. PWD defines "clean-washed" as having less than 0.5% wash loss, by mass, when tested per AASHTO T-11 wash loss test. AASHTO No. 3 and No. 57 stone can meet this specification.
   b. All aggregates used within a porous surface system must meet the following requirements:
      i. Maximum wash loss: 0.5% per AASHTO T-11
      ii. Minimum durability index: 35 per ASTM D3744
      iii. Maximum abrasion: 10% for 100 revolutions and 50% for 500 revolutions per ASTM C131
   c. All choker course aggregate must meet the specifications of AASHTO No. 57 and must meet the following gradation:

Table 4.2-1: Required choker course gradation

U.S. standard sieve size	Percent passing by weight
1 ½" (37.5 mm)	100%
1" (25 mm)	95–100%
½" (19 mm)	25–60%
#4 (4.75 mm)	0–10%
#8 (2.36 mm)	0–5%

5. Sand, if used, must be AASHTO M-6 or ASTM C-33 sand and must have a grain size of 0.02 to 0.04 inches.
6. Storage Chambers (For Porous Surface Structural SMPs)
    a. Pipe used within a subsurface infiltration SMP must be continuously perforated and have a smooth interior with a minimum inside diameter of four inches.
    b. High-density polyethylene (HDPE) pipe must meet the specifications of AASHTO M252, Type S or AASHTO M294, Type S.
    c. Any pipe materials outside the SMP are to meet City Plumbing Code Standards.
7. Geotextile must consist of polypropylene fibers and meet the following specifications (AASHTO Class 1 or Class 2 geotextile is recommended):
    a. Grab Tensile Strength (ASTM-D4632): ≥ 205 lbs
    b. CBR Puncture Strength (ASTM-D6241): ≥ 500 lbs
    c. Flow Rate (ASTM-D4491): ≥ 95 gal/min/ft^2
    d. UV Resistance after 500 hours (ASTM-D4355): ≥ 70%
    e. Tear Resistance (ASTM-D4533): ≥ 80 lbs
    f. Heat-set or heat-calendared fabrics are not permitted.

Outlet control material standards

8. Underdrains, if proposed, must be made of continuously perforated HDPE plastic piping with a smooth interior and a minimum inner diameter of four inches. HDPE pipe must meet the specifications of AASHTO M252, Type S or AASHTO M294, Type S.
9. The designer is referred to **Section 4.12** ☛ p. 182 for information on material standards for outlet control systems.

Inspection and maintenance access material standards

10. Observation wells
    a. The observation well must consist of slotted plastic pipe with minimum inner diameter of four inches and a solid cap at the surface. The slotted section of the well must consist of PVC slotted well screen with 0.01-inch slot size and an attached perforated PVC cap at the bottom.
    b. The observation well's cover must be ductile iron in a gray iron frame.
    c. For an observation well located in an unpaved area, the well's concrete ring must be a minimum of six inches wider in any dimension than the cover frame, of equal depth as the cover frame itself, and poured atop a minimum of six inches of AASHTO #57 stone bedding. A frame conforming to these minimum dimensions may be circular or square.
11. Cleanouts must be made of material with a smooth interior having a minimum inner diameter of six inches. If the connecting pipe is eight inches in diameter or larger, then the cleanout must be eight inches in diameter.

4.2.5 Porous surface construction guidance

The construction guidelines herein apply to all porous surface systems. Proper construction and careful consideration of soil compaction, infiltration performance, and sedimentation control of subsurface infiltration systems are essential to ensure long-term functionality and reduce long-term maintenance needs. Since subsurface infiltration systems are, by definition, buried, construction oversight is critical. At a minimum, verification of volumes, grades, and elevations must be confirmed prior to backfill.



An example of a porous safety surface installation in Philadelphia

1. Areas for porous surface systems must be clearly marked before any site work begins to avoid soil disturbance and compaction during construction.
2. Excavate subsurface area to proposed depth. Excavation should take place after contributing upstream disturbed areas have been permanently stabilized. If this is impractical, install PWD-approved erosion and sedimentation control Best Management Practices (BMPs) to prevent runoff and sediment from entering the excavated bed. Where erosion of subgrade has caused accumulation of fine materials and/or surface ponding, this material must be removed with light equipment and the underlying soils scarified to a minimum depth of six inches with a York rake or equivalent and light tractor.

3. Existing subgrade must not be compacted, and construction equipment traffic must be minimized prior to placement of the geotextile and stone bed. The use of machinery to load stone from outside of the basin footprint is recommended. If it is essential that equipment be used in the excavated area, all equipment must be approved by the engineer. Equipment with narrow tracks or tires, rubber tires with large lugs, or high-pressure tires will cause excessive compaction and must not be used. Should the subgrade be compacted during construction, additional testing of soil infiltration rates and system redesign may be required. Rock construction entrances must not be located on top of areas proposed for infiltration practices.
4. Bring subgrade of stone infiltration bed to line, grade, and elevations indicated in the drawings, while avoiding compaction. The bottom of the infiltration bed must be at a level grade.
5. Place geotextile and recharge bed aggregate immediately after approval of subgrade preparation to prevent accumulation of debris or sediment. Aggregate installation should take place after contributing upstream disturbed areas have been permanently stabilized. Install PWD-approved erosion and sedimentation control BMPs to prevent runoff and sediment from entering the storage bed during the placement of the geotextile and aggregate bed.
6. Place geotextile in accordance with manufacturer's standards and recommendations. Adjacent strips of filter fabric must overlap a minimum of 16 inches. Fabric must be secured at least four feet outside of bed. This edge strip should remain in place until all bare soils contiguous to beds are stabilized and vegetated. As the site is fully stabilized, excess geotextile can be cut back to the edge of the bed.
7. Install aggregate course in lifts of six to eight inches. Compact each layer with equipment, keeping equipment movement over storage bed subgrades to a minimum. Install aggregate to grades indicated on the drawings.

4.2.6 Porous surface maintenance guidance

Maintenance of porous surfaces focuses on the periodic removal of sediment and debris from the system. While porous asphalt, porous concrete, and resin-bound aggregate are no longer permitted, maintenance guidance for existing systems can be found below. General recommended maintenance activities for porous surfaces are summarized in Table 4.2-2.

Table 4.2-2: Porous surface maintenance guidelines

Early maintenance activity	Frequency
Inspect erosion control and flow spreading devices until soil settlement and vegetative establishment of contributing areas has occurred.	Biweekly

Ongoing maintenance activity	Frequency
Inspect erosion control and flow spreading devices until soil settlement and vegetative establishment of contributing areas has occurred.	Biweekly
Mow grass in permeable paver or reinforced turf grid systems that have been planted with grass.	As needed
Replace filter bags for pretreatment devices. Please ensure filter bags are installed properly.	Quarterly
Vacuum porous asphalt or concrete surfaces on grandfathered projects with regenerative air sweeper or commercial vacuum sweeper (traditional street sweepers are not appropriate).	Semiannually
Vacuum inlet structures within or draining to the structural SMP beneath the porous surface.	Semiannually
Inspect underdrain cleanouts, if any.	Semiannually
Maintain records of all inspections and maintenance activity.	Ongoing

Sediment control

Superficial soil does not necessarily clog the voids in porous surfaces. However, soil that is ground in repeatedly by tires can lead to clogging. Therefore, trucks or other heavy vehicles should be prevented from tracking or spilling soil onto the porous surface. Furthermore, all construction or hazardous materials carriers should be prohibited from entering a porous surface lot. Areas with heavy vehicular traffic will require more frequent vacuuming.

Winter maintenance

Winter maintenance for a porous surface may be necessary but is usually less intensive than that required for a standard pavement lot. By its very nature, a porous surface system with subsurface aggregate bed may have better snow and ice melting characteristics than standard pavement. Once snow and ice melt, they flow through the porous surface rather than refreezing. Therefore, ice and light snow accumulation are generally not as problematic. However, snow will accumulate during heavier storms. Abrasives such as sand or cinders must not be applied on or adjacent to the porous surface. Snow plowing is acceptable, provided it is done carefully (i.e., by setting the blade about 0.5 inches higher than usual and using a rubberized blade or blade tip). Salt is acceptable for use as a deicer on the porous surface, though non-toxic, organic deicers, applied either as blended, magnesium chloride-based liquid products or as pretreated salt, are preferable. Any deicing materials should be used in moderation.

Repairs

Potholes are not common; though settling might occur if a soft spot in the subgrade is not removed during construction. Damaged areas that are smaller than 50 square feet and comprising less than 10% of the total porous area can be patched, depending on the location within the porous area. In many cases the loss of porous surface will be insignificant. If an area greater than 50 square feet or 10% of the total is in need of repair, approval of patch type must be sought from either the engineer or owner. Porous surfaces must never be seal coated under any circumstances. Any required repair of drainage structures should be done promptly to ensure continued proper functioning of the system.

Outlet controls

The designer is referred to **Section 4.12** ☛ p. 182 for information on maintenance guidance for outlet controls.

4.3 Green Roofs

Download summaries of this SMP and its maintenance guidance, with quick reference information for clients and developers:

- **Green Roofs SMP One-Sheet** ☛ water.phila.gov/wp-content/uploads/files/green-roof-smp-one-sheet.pdf
- **Green Roof Maintenance Guidance One-Sheet** ☛ water.phila.gov/wp-content/uploads/files/green-roof-maintenance-guidance.pdf

4.3.1 Green roof introduction

Green roofs, also referred to as vegetated roofs, eco-roofs, and roof gardens, consist of a layer of vegetation that covers an otherwise conventional flat or moderately pitched roof. A green roof is composed of multiple layers that may include a moisture interception layer/geotextile, drainage layer, engineered growing medium, and vegetation above the roofing system and its waterproofing membrane. Through the appropriate selection of materials, green roofs can provide runoff volume reduction and runoff peak rate attenuation.

Green roofs can be combined with other stormwater management practices (SMPs) in series to meet the Philadelphia Water Department (PWD) Stormwater Regulations (Stormwater Regulations). The designer is referred to **Section 3.2.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-2-stormwater-management-design#3.2.3, for information on using SMPs in series.

Quick tip

Required green roof design and material standards are denoted in this section by easy-to-reference numerals.

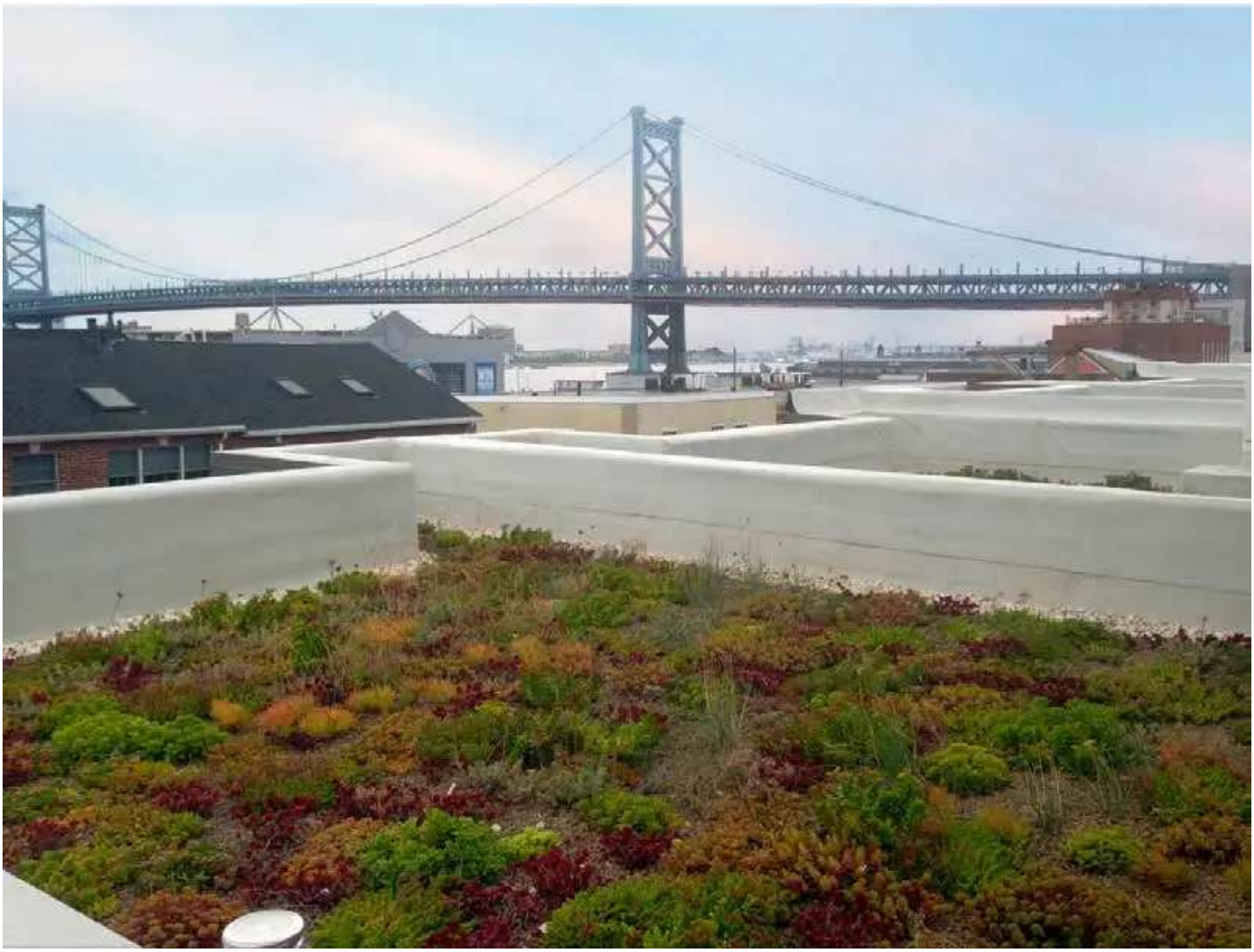
Green roofs may be partially paved, where property owners wish to include occupiable space within the green roof. The designer is referred to **Section 4.3.3** ☛ p. 53, for information on green roofs with paving, or decks where runoff is tributary to and managed by the adjacent vegetated roof.

The design of green roofs is not limited to the examples shown within this text. Successful stormwater management plans will combine appropriate materials and designs specific to each site.

Green roof design may be considered differently for Stormwater Retrofits. Designers looking to incorporate green roofs in Stormwater Retrofit projects should contact Stormwater Billing and Incentives for additional information.

A green roof is an excellent stormwater management option on a fully built-out or highly-constrained site. They can be installed on many types of roofs, including terraces, high-rise building roofs, and low-podium or at-grade on-structure installations. Roofs with pitches up to 2:12 (16.7%) can, in most instances, accommodate green roofs without special slope stabilization provisions.

Green roofs can also be installed as a Stormwater Retrofit on existing buildings with flat, mildly sloped, or terraced roofs after confirmation of adequate structural loading capacity, waterproofing, and protection of rooftop utilities.



An example of a green roof in Philadelphia

Where can green roofs be used?

A green roof is an excellent stormwater management option on a fully built-out or highly constrained site. They can be installed on many types of roofs, including terraces, high-rise building roofs, and low-podium or at-grade on-structure installations. Roofs with pitches up to 2:12 (16.7%) can, in most instances, accommodate green roofs without special slope stabilization provisions.

Green roofs can also be installed as a Stormwater Retrofit on existing buildings with flat, mildly sloped, or terraced roofs after confirmation of adequate structural loading capacity, waterproofing, and protection of rooftop utilities.

Key advantages of green roofs

- Manage stormwater runoff without occupying surface-level space
- Well-suited for sites at which roofs make up a large fraction of the total impervious area and for sites with ground-level space constraints
- Typically require no additional sewer connections besides those already provided for the building
- Promote the retention, slow release, and evapotranspiration of precipitation
- Enhance building aesthetics and market value
- Help regulate building temperature in both the summer and winter, thus reducing cooling and heating costs
- Reduce urban heat island effect by providing evaporative cooling
- Can improve air quality by filtering particulate matter
- Extend the service life of the roof by protecting the underlying roof membrane from mechanical damage, shielding it from UV radiation, and buffering temperature extremes
- Require no excavation
- Can be designed to provide spaces for recreation, supplement bird habitat, developing educational resources, and creating new opportunities for urban food production
- Provide educational benefits, especially when used at public and/or highly visible sites such as schools, recreation centers, libraries, etc.
- Assume less risk for projects within the floodplain
- Eligible for inclusion in an **Expedited Post-Construction Stormwater Management Plan (PCSMP) Review project** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-4-expedited-pcsmp-reviews

Tax Credit

Installation of a green roof may also qualify a project for a Business Income and Receipts Tax (BIRT) Credit!

Learn more about this Credit ☛ www.phila.gov/services/payments-assistance-taxes/taxes/tax-credits/business-tax-credits/green-roof-tax-credit

Key limitations of green roofs

- May need to be combined with other SMPs to meet the Flood Control requirement
- More expensive to install than most conventional roofs
- May have limited Stormwater Retrofit feasibility for existing buildings and structures due to structural capacity issues

Key design considerations for green roofs

- Coordination of green roof design with the design of building heating, ventilation, and air conditioning (HVAC) systems can help to maximize operational cost savings. For example, some research suggests that green roofs can improve building energy efficiency by lowering the temperature of air at the intakes for climate control systems.
- Stormwater management effectiveness can be improved by introducing measures to enhance evapotranspiration. Typical expedient measures include:
  - Introducing low-transmissivity drainage layers;
  - Lengthening seepage pathways to drains;
  - Introducing rainfall interception layers;
  - Selecting plants with dense root habits; and
  - Selecting growing medium with high water-holding capacity.
- For extensive green roofs (green roofs six inches thick or less), a large proportion of the initial planting should be varieties of sedums. Sedums may be interplanted or installed as a ground cover in coordination with other species. To ensure diversity and viability, at least six different species or cultivars of sedum should be used, including two genera (i.e., both *Sedum* and *Phedimus* species). The remainder of plants may be herbs, meadow grasses, or meadow flowers, depending on the desired appearance.
- Plant diversity and coverage are more significant for stormwater performance than specific species type (note that species selections remain important from a habitat and ecosystems perspective). Long-term species selection is flexible provided the plant cover is continuous, the root masses are persistent, and:
  - Plant species are not invasive;
  - Plant cover is perennial (i.e., present in winter); and
  - Plant species are biodiverse. For more information, the designer is referred to Sections **4.3.3** ☛ p. 53 and **4.3.4** ☛ p. 57 for vegetation design and material standards, respectively, below.
- Green roof plant management should emphasize continuous plant cover to maximize effectiveness of rainfall interception and minimize the potential for wind erosion, particularly in the winter months. Plant combinations that include meadow-type native grasses and wildflowers may reduce weed pressures when mature. Species must not be invasive.
- For stormwater management purposes, artificial, or synthetic, turf surfaces are not considered green roofs and must be combined with other SMPs.
- For any green roof that discharges onto an adjacent property, a drainage easement may be required and is recommended.

Green roof types

There are two types of green roofs. An *extensive green roof* is a thin (usually less than six inches), lightweight system that is typically predominantly planted with succulents, drought-tolerant perennials, and drought-tolerant grass. An *intensive green roof* is a deeper (typically greater six inches or greater), heavier system designed to sustain complex landscapes. Intensive green roofs offer a wider range of stormwater design options, including blue-green roofs (**Section 4.14** ☛ p. 239) and similar designs with roof drain restrictors that retain water in the base of the profile for subsequent plant transpiration.

4.3.2 Green roof components

Figure 4.3-1: Green roof with typical features

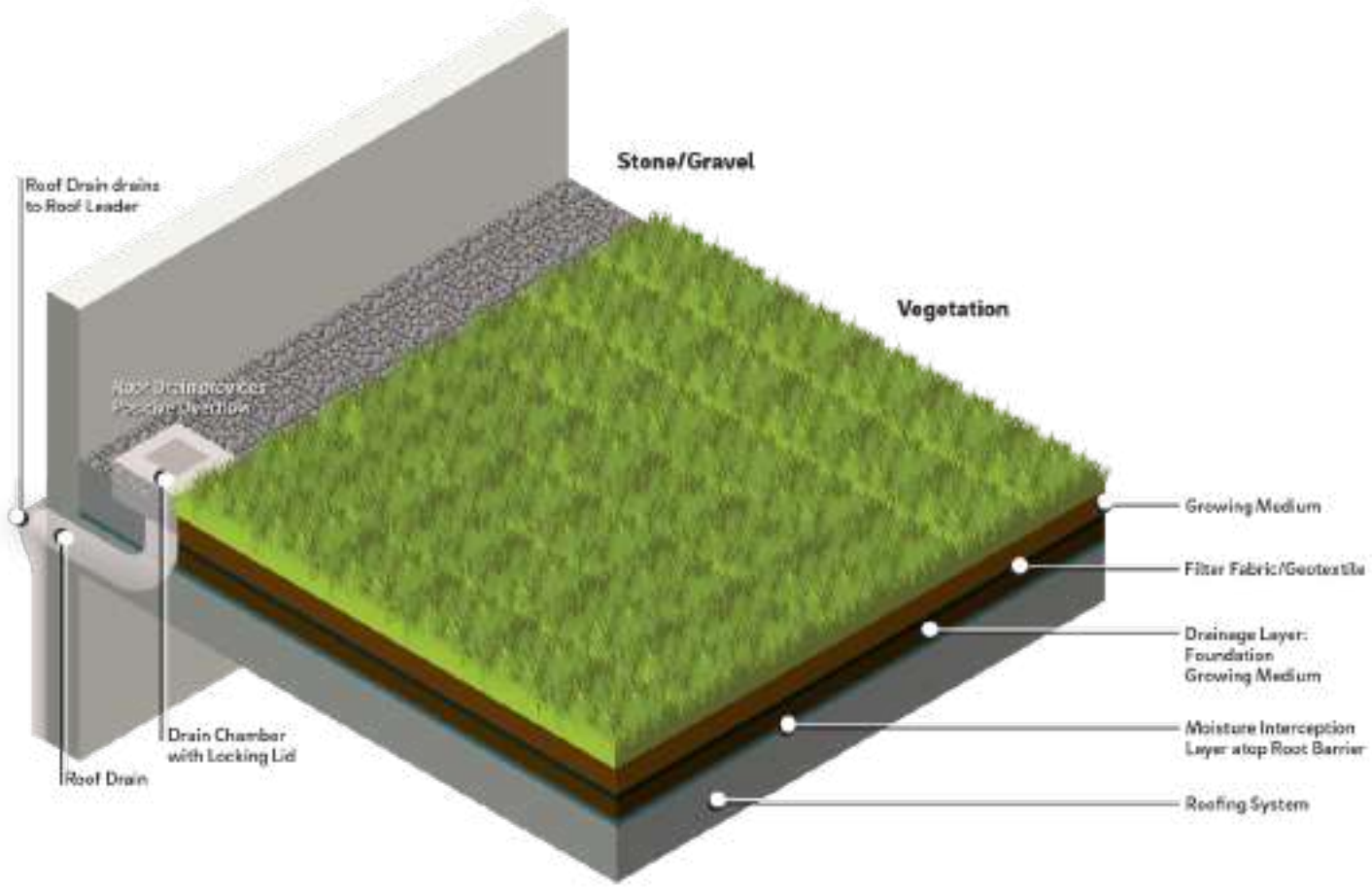
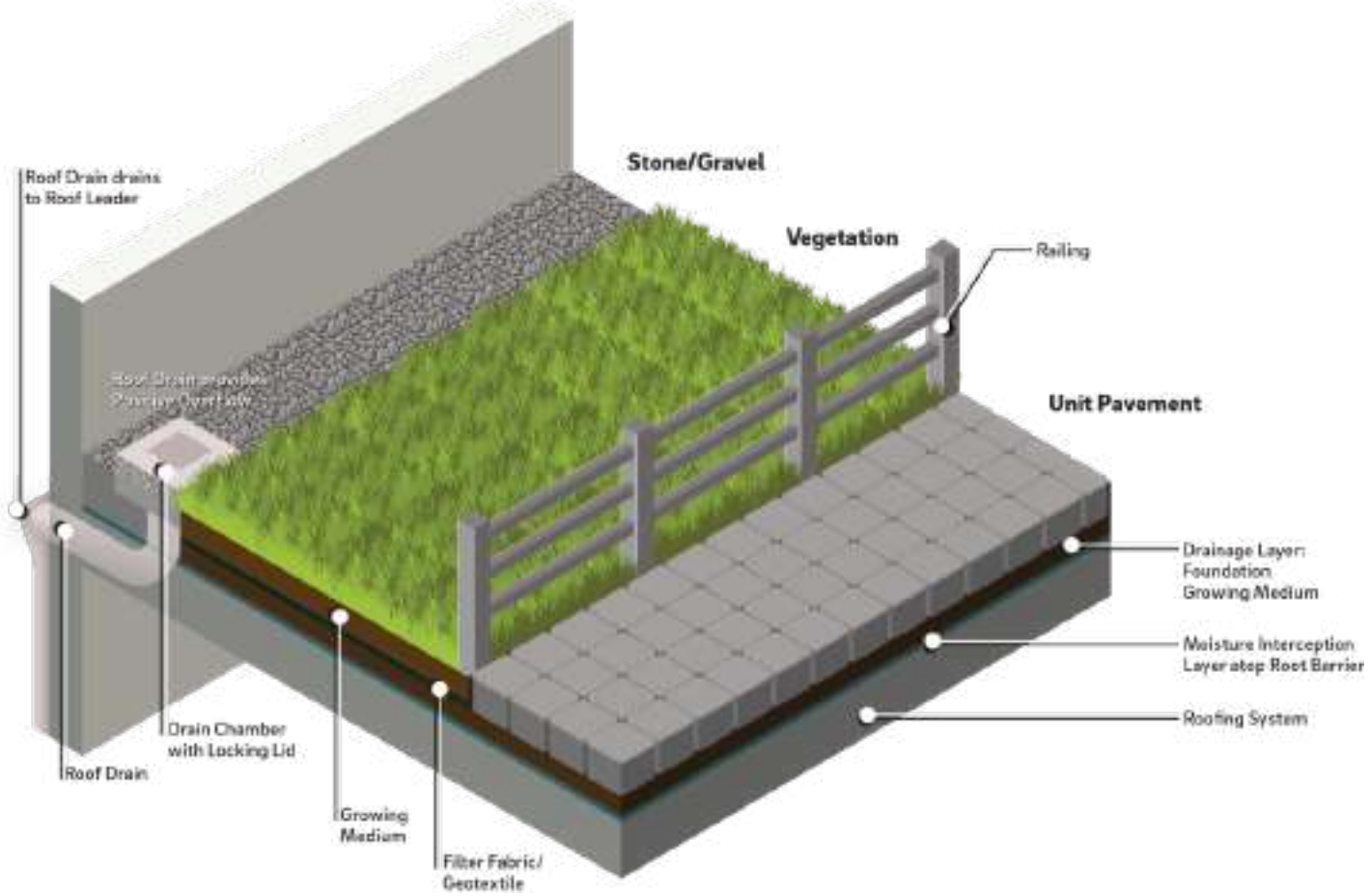


Figure 4.3-2: Partially paved green roof with typical features



Inlet control component

Green roofs that only receive direct (1:1) rainfall do not have inlet controls. For green roofs that receive runoff from roof directly connected impervious area (DCIA), distribution piping may be provided to evenly disperse run-on water from the contributing catchment area throughout the green roof. The designer is referred to **Section 4.11** ☛ p. 166, Inlet Controls, for more information.

Storage area component

Green roof storage areas temporarily hold stormwater before it can either be used by plants through evapotranspiration or be released downstream. Storage areas for green roofs typically are composed of the following components:

The ***growing medium*** supports plant growth and provides for storage of stormwater within voids. The storage capacity is a function of medium depth, surface area, and available void space (i.e., moisture holding capacity, or a field capacity). The total growing medium depth includes, as applicable, the primary growing medium, root-friendly moisture retention products, and root-friendly drainage aggregates such as ***foundation growing medium*** (lightweight drainage aggregate) as a base.

Filter fabric, also called ***separation fabric***, or ***geotextile***, prevents migration of soil into the underlying drainage layer of the green roof.

A ***drainage layer*** may incorporate measures to intercept and retain percolated rainfall as it moves through the green roof storage area. Examples include synthetic sheets with waffle-type cups to hold water and specialized fabrics or mats with high capillary indices. Drainage products that have low horizontal flow rates and allow deep growth of plant roots are required for green roofs managing runoff from adjacent tributary surfaces. Root-friendly drainage products include foundation growing medium (lightweight drainage aggregates) and waffled reservoir sheets where the cups are filled with lightweight aggregate.

Moisture interception layers are thick geotextiles or other porous materials that retain water and help protect the underlying roof deck. Moisture interception layers can help increase moisture availability to plants between rain events.

Root barriers are impermeable liners or membranes that protect the underlying roof deck from moisture and plant root intrusion. Some waterproofing membrane materials are inherently root resistant, whereas others require an additional root barrier.

Underlying ***roofing systems*** typically consist of a structural deck, its supporting structures, and a traditional overlying waterproofing system.

Vegetation component

Green roof plant material is designed to take up much of the water that falls on the roof during a storm event. Plant cover is instrumental in controlling wind erosion of the underlying green roof materials. It mitigates soil moisture loss and water erosion, transpires captured moisture back into the atmosphere, and provides evaporative cooling. Plant material also collects dust and creates oxygen. Some green roofs may also have irrigation systems to support plant growth during dry periods.

Outlet control component

Outlet controls may include risers, edge drains, scuppers, gutters, or impervious liners. The designer is referred to **Section 4.12** ☛ p. 182, Outlet Controls, for more information.

Paving component

Paved walkways, stepping stones, patios, and paver or stone perimeter strips are common elements of green roof designs. Non-vegetated surfaces that discharge runoff into the vegetated area of the green roof must count toward the impervious runoff loading ratio.

Inspection and maintenance access component

Safe and easy inspection and maintenance access to all major components within a green roof is critical to ensuring long-term performance. Dependent on roof height and slope, green roof inspection and maintenance access components may consist of permanent or temporary safety monitoring systems, guardrail and safety net systems, warning line systems, and/or personal fall arrest systems. Inspection and maintenance access systems for green roofs may also include long-term leak detection systems for locating and managing leaks.

In the case of accessible roof terraces for residential settings, the provision of a railing with a maintenance gate that separates the vegetated green roof from accessible areas is required. The railing can be metal, wood, or glass. Bird-friendly glass with a Threat Factor Rating of 1–25 is highly recommended. Pet access to green roofs that are certified as SMPs should be restricted, as urine, pet digging, and habitual foot traffic can all damage plants and growing medium, leading to potential erosion and diminished stormwater management performance.

4.3.3 Green roof design standards

General design standards

1. Runoff from impervious roof area onto a green roof must be dispersed evenly across the green roof surface and pass through the growing medium either by sheet flow or a level spreading device. The designer is referred to **Section 4.12** ☛ p. 182, Outlet Controls, for design standards for level spreaders.
2. The flow path of runoff across the green roof surface must be greater than or equal to the contributing DCIA length.
3. Structural requirements:
    a. Structural loading must be considered for all green roof designs, and green roof design must be coordinated with a licensed structural engineer for both new building construction and retrofits to existing structures.
    b. A structural engineer must verify that the building will support the weight of the green roof.
    c. Design calculations must consider the wet weight of the green roof. Extensive green roofs typically weigh between 20 and 45 pounds per square foot and are typically compatible with many wood or steel decks, as well as reinforced concrete or concrete fill roof systems. Intensive green roofs typically weigh more than 45 pounds per square foot and are most common in new construction where the roofing design can accommodate these loads.
    d. Potential maximum loads must be based on American Society of Testing and Materials (ASTM) E2397.
4. The green roof area can be considered pervious open space when determining post-development flow rates to meet the Flood Control requirement. Default values for runoff parameters for extensive green roofs must be as follows; however, alternative runoff parameters may be applied when supported by submitted analysis and relevant references, which will be reviewed on a case-by-case basis:
    a. Natural Resources Conservation Service (NRCS) runoff curve number (CN): 86
    b. Composite runoff coefficient (CR): 0.40
    c. Time of concentration (T_C): Six minutes
5. The total amount of impervious surfaces within the designated boundary of a green roof footprint must not exceed one-third of the combined area.
6. The following are exempt from being counted as tributary impervious area when installed on a green roof:
    a. Pervious pavers containing planted openings; and
    b. Drain chambers, including an adjacent stone margin with an offset distance from the chamber edge of 12 inches or less. All other stone/gravel margins or perimeters must be considered roof DCIA, unless they are graded to allow flow over or through vegetated green roof area, in which case, they may be counted as tributary impervious area to the green roof.
7. Root barrier layers must conform to the requirements of the waterproofing provider for each project.

Inlet control design standards

8. If runoff is conveyed via piping, a distribution piping manifold must be embedded in a gravel strip to dissipate energy and promote uniform flow. The designer is referred to **Section 3.4.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-4-how-to-show-compliance/#3.4.2, for information on design standards for distribution piping.

9. The designer is referred to **Section 4.11** ☛ p. 166, Inlet Controls, for information on design standards for inlet control systems.

Storage area design standards

10. For green roofs that receive direct (1:1) rainfall only:
    a. The minimum allowable thickness of the green roof growing medium is four inches. This can include both an upper course of growing medium and a base layer of foundation growing medium (lightweight drainage aggregate), together comprising a dual media system. The foundation growing medium must be a low-transmissivity drainage layer, defined as a layer with a transmissivity of 0.005 m^2/s or less (ASTM D4716) that is available to plant roots. For this dual media green roof, the minimum allowable thicknesses of the planting layer and foundation growing medium drainage layer are three inches and one inch, respectively.
    b. Green roofs that meet minimum growing medium thickness requirements are permitted a DCIA reduction equal to the entire area of the green roof.
11. For green roofs that receive runoff from contributing impervious roof catchments:
    a. Impervious roof areas that direct runoff onto the green roof cannot exceed 50% of the green roof area, which is equivalent to a maximum hydraulic impervious runoff loading ratio of 0.5:1.
    b. The minimum thickness of the green roof growing medium must be calculated as follows, where the "impervious roof area to green roof area" ratio is less than or equal to 0.50. A minimum depth of four inches is required.
    *Minimum thickness (in inches) of green roof growing medium = 4 inches + [3 * (Impervious roof area / Green roof area)]*
    c. Green roofs that meet minimum growing medium thickness requirements are permitted a DCIA reduction equal to the entire area of the green roof. Impervious roof areas that drain to these green roofs can be also considered as disconnected impervious cover, and, thus, included in the green roof's DCIA reduction.
    d. In areas that will receive tributary discharge, the green roof must not include a high-transmissivity drainage layer, defined as a layer with a transmissivity of greater than 0.005 m^2/s (ASTM D4716), where such products limit plant root access to tributary runoff. In general, this will exclude most synthetic sheet drains, including peg-style or egg-carton-style drains. High-transmissivity drainage layers will allow runoff to effectively flow under the green roof, minimizing contact with growing medium and plant roots. Typical foundation growing medium (also called granular aggregate or coarse granular green roof medium), with a grain-size distribution complying with ASTM gradation No.7 will satisfy the requirement, as will also a variety of mats and composite drainage layer assemblies.
    e. Any deck built atop a green roof that does not allow for sheet flow runoff must be slotted, and the minimum thickness of growing medium required for the green roof must be maintained under the entire extent of the deck.
12. Saturated permeability of the growing medium, in its compacted state [ASTM E2399], must not be less than six inches per hour.
13. Filter or separation fabric must allow root penetration but prevent the growing medium from passing through into the drainage layer.
14. A drainage layer is required to promote aerated conditions in the growing medium and to convey excess runoff during large rainfall events.

Vegetation design standards

15. When fully established, the selected plantings must thoroughly cover the growing medium. Mature plant cover must be a minimum of 80% on established green roofs, with a contiguous non-vegetated areas no larger than three square feet (i.e., a 24-inch diameter circle).
16. Plant coverage must persist year-round. While individual plants may exhibit seasonal dormancy, vegetation coverage in winter months must be maintained. Mulch should be limited to 0.25 inches of compost if used as a temporary component in an establishment planting. Mulching can jeopardize green roof performance by clogging the geotextiles with the system and increasing system weights. Mulching also inhibits the reseeding of plants, which is necessary process for long term species persistence.
17. Plants that are appropriate for, and compatible with, the site conditions must be chosen. The designer is referred to **Section 4.13** ☛ p. 218, Landscaping, for additional landscaping guidance and **Appendix I** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists for plant lists.

Outlet control design standards

18. The contributing area of impervious rooftop to each disconnected discharge point must be equal to, or less than 500 square feet.
19. Internal drainage, including provisions to cover and protect drains or scuppers, must anticipate the need to manage large rainfall events without inundating the cover.
20. All drains and scuppers must be covered and protected by an enclosure, typically a square or round chamber with a locking lid. These chambers are designed to prevent clogging of the drains by debris.
21. Although green roofs are not considered DCIA, they are not zero discharge systems. The roof drainage system and the remainder of the site drainage system must safely convey roof runoff to the storm sewer, combined sewer, or receiving water.
22. The designer is referred to **Section 4.12** ☛ p. 182, Outlet Controls, for additional information on design standards for outlet control systems.

Inspection and maintenance access design standards

23. Green roofs must be designed to allow for safe access and working conditions for green roof inspection and maintenance personnel. This access must be a permanent feature of the building, such as a pilot house, roof hatch, or exterior stairs to the green roof. Retractable, unsecured ladders should not be required for routine maintenance and inspections due to safety concerns. The design may include other permanent, personal safety measures. For green roofs, designers must specifically assess applicability to Occupational Safety and Health Administration (OSHA) Fall Protection Safety Standards and the American National Standards Institute (ANSI) and American Society of Safety Engineers (ASSE) consensus-based fall protection standards.
24. For accessible residential roof terraces, a railing with a maintenance gate that separates the vegetated green roof from accessible areas must be provided. The railing can be metal, wood, or glass. Bird-friendly glass with a Threat Factor Rating of 1–25 is highly recommended.

Figure 4.3-3: Green roof (single media) standard detail

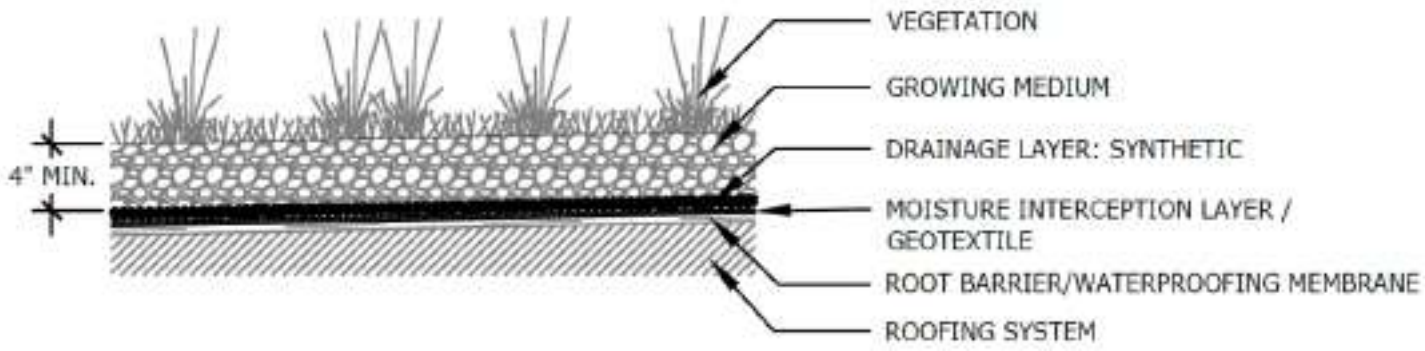


Figure 4.3-4: Green roof (dual media) standard detail

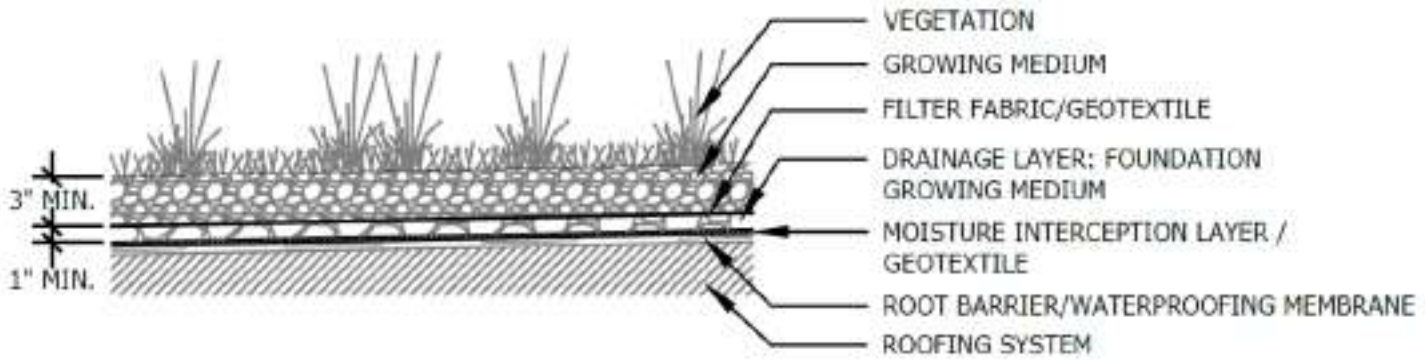
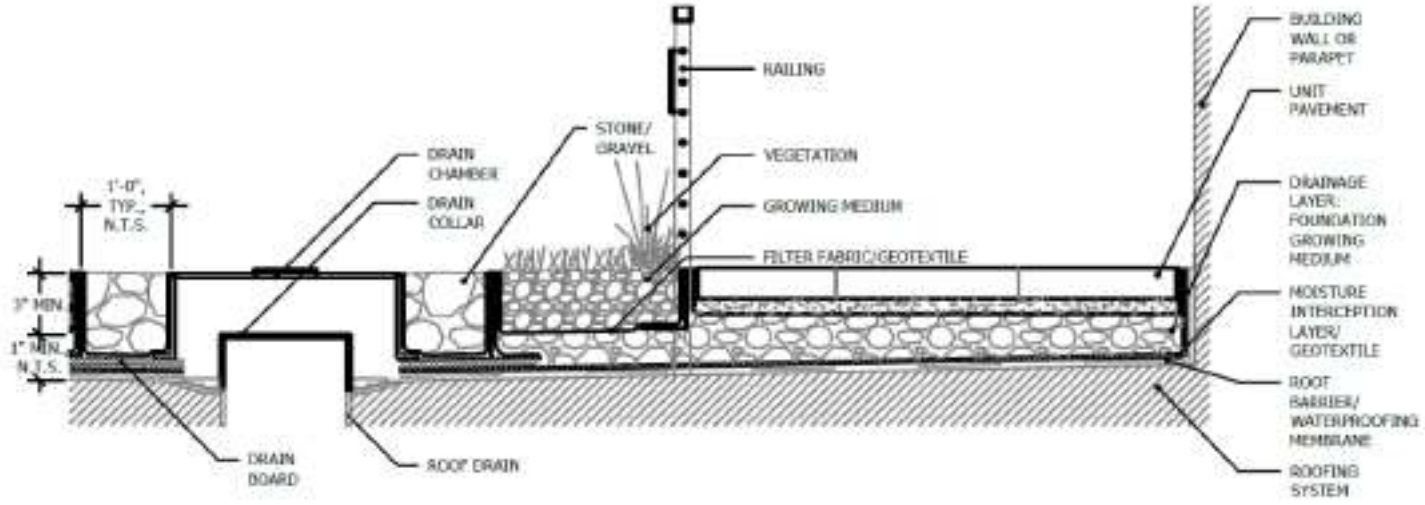


Figure 4.3-5: Partially paved green roof with typical features standard detail



(The designer is referred to **Appendix L** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/l-standard-details to download Standard Detail CAD files.)

4.3.4 Green roof material standards

Inlet control material standards

1. The designer is referred to **Section 4.11** ☛ p. 166, Inlet Controls, for information on material standards for inlet control systems.

Storage area material standards

2. Green roof growing medium must be a lightweight mineral material with added organic material that meets the following specifications:
   a. Moisture content at maximum water holding capacity (ASTM E2399 or FLL): 40% to 60% (vol)
   b. Porosity at maximum water holding capacity (ASTM E2399 or FLL): 10% to 15%
   c. Density at maximum water holding capacity (ASTM E2399 or FLL): ≤ 85 lbs/ft^3
   d. Total organic matter (MSA): 6% to 10% (dry weight)
   e. pH (MSA): 6.5 to 7.8
   f. Soluble salts (DPTA saturated media extraction): ≤ 2 mmhos/cm
   g. Water permeability (ASTM E2399 or FLL): 0.25 in/min to 1.25 in/min
   h. Grain-size distribution consisting of ≤ 4.5% passing for clay (0.002 mm) and 5% to 15% passing for silt (0.05 mm)
   i. The nutrients must be initially incorporated in the formulation of a suitable mix for the support of the specified plant materials.
   j. The medium must withstand freeze/thaw cycles.
3. Foundation growth media (lightweight drainage aggregate) must be composed of a blended medium that meets the following specifications:
   a. Density at maximum water capacity (ASTM E2399-05): ≤ 65 lbs/ft^3
   b. Maximum water holding capacity: 15% to 25%
   c. Water permeability (ASTM E2396-05): ≥ 25 in/min
   d. Total organic matter by loss on ignition (ASTM F1647): ≤ 1%
   e. Porosity (ASTM C29): 20% to 65%
   f. Grain-size distribution (ASTM C136) consisting of the following gradations:
      i. Pct. Passing US#18 sieve (1.0 mm): ≤ 5%
      ii. Pct. Passing ¼-inch sieve: ≤ 30%
      iii. Pct. Passing 3/8-inch sieve (9.5 mm): ≥ 75%
      iv. Pct. Passing ½-inch sieve (12 mm): 100%
4. Geotextile must consist of polypropylene fibers and meet the following specifications:
   a. Grab Tensile Strength (ASTM-D4632): 70 lbs to 120 lbs
   b. CBR Puncture Strength (ASTM-D6241): 120 lbs to 340 lbs
   c. Flow Rate (ASTM-D4491): 130 gal/min/ft2 to 200 gal/min/ft2
   d. UV Resistance after 500 hrs (ASTM-D4355): 70%
   e. Tear Resistance (ASTM-D4533): 30 lbs to 50 lbs
   f. Heat-set or heat-calendared fabrics are not permitted.

5. Drainage layer
    a. For vegetated roof cover assemblies with thicknesses of less than five inches, synthetic drainage layers may be used in lieu of granular drainage layers.
    b. For vegetated cover assemblies with an overall thickness of five inches, or greater, the drainage layer must meet the following specifications:
        i. Abrasion resistance (ASTM-C131-96): ≤ 25% loss
        ii. Soundness (ASTM-C88): ≤ 5% loss
        iii. Porosity (ASTM-C29): ≥ 25%
        iv. Percent of particles passing 1/2-inch sieve (ASTM-C136): ≥ 75%
        v. The minimum thickness of the granular layer must be two inches. The granular layer may be installed in conjunction with a synthetic reservoir sheet.
6. Root barrier/waterproofing membrane
    a. PVC, EPDM, and thermal polyolefin (TPO) are permitted and inherently root resistant.
    b. All waterproof membranes must meet appropriate ASTM specifications. PVC membranes must meet ASTM D4434 requirements, EPDM membranes must meet ASTM D4637 requirements, and TPO membranes must meet ASTM D6878 requirements.
    c. Waterproofing membrane must be fully waterproof with properly sealed seams, corners, and protrusions to prevent any intrusion of standing water above the membrane.
    d. Roofing membranes must meet all building code requirements and guidelines of the City of Philadelphia.

Vegetation material standards

7. Invasive species are not permitted in green roof planting. All plants must be appropriate and compatible with soil, hydrologic, light, and other site conditions. The designer is referred to **Appendix I** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists, Plant Lists.
8. Plant species must be biodiverse. Species diversity for green roofs is defined as follows:
    a. Sedum: Include at least two genera (i.e., both *Sedum* and *Phedimus*) and six different species or cultivars in planting plans.
    b. Native or adaptive grasses: Provide at least two genera and three different species, if grasses are included in the design
    c. Native or adaptive perennials: Provide at least three genera and four different species, if perennials are included in the design
9. Plant establishment:
    a. Plant establishment may be achieved through plugs, mats, container plants, and / or seed.
    b. The inclusion of seed as a supplement to live plants is required. The designer is referred to **Section 4.13.3** ☛ p. 226, Landscape Design Considerations, for a list of species appropriate for overseeding on green roofs.
    c. Temporary erosion control measures must be provided appropriate to the planting method during the plant establishment period.
10. Perennials, grasses, grass-like plants, and groundcover plants must be healthy, well-rooted specimens.

11. Green roof plantings must be able to withstand heat, cold, and high winds. After establishment, the plants must be self-sustaining and tolerant of drought conditions, with little to no need for fertilizers or pesticides.
12. The only sedum known to be invasive, and which must be avoided is *Sedum sarmentosum*, also known as star sedum, gold moss, stringy stonecrop, or graveyard moss.

Outlet control material standards

13. The designer is referred to **Section 4.12** ☛ p. 182, Outlet Controls, for information on material standards for outlet control systems.

Inspection and maintenance access material standards

14. Personal protection systems must comply with OSHA Fall Protection Safety Standards and the ANSI and ASSE consensus-based fall protection standards.

4.3.5 Green roof construction guidance

1. Inspect waterproof membrane for any irregularities that will interfere with drainage or may cause leaks. Do not continue until roofer has addressed defects.
2. Install root barrier layer, if required.
3. Install moisture-management layer or geotextile, as appropriate to the design.
4. Install drainage layer.
5. Install filter fabric, as appropriate to the design.
6. Install growing medium, as specified.
7. Install irrigation system with the growing medium, if included in design.
8. Test the irrigation system, if included in design.
9. Finish installing and grading growing medium
10. Install wind protection, if included in the design. A wind scour blanket or hydromulch may be required to prevent erosion during the establishment period. It generally takes about two growing seasons for full establishment. High wind environments may necessitate permanent wind blankets.
11. Establish vegetation.
    a. Green roofs can be effectively established by broadcasting fresh sedum cuttings during the spring and fall months. Depending on seasonal conditions, irrigation may be required after planting.
    b. Many perennial plants can be installed as plugs or container plants between April and November. Depending on the time of planting, temporary irrigation may be required.
    c. Perennials can be established from seed, except during the months of June, July, and August.



An example of a green roof installation in Philadelphia

4.3.6 Green roof maintenance guidance

Green roof maintenance activities largely focus on maintaining drainage capacity and the health of vegetation. Inspect all facility components, including vegetation, growing medium, filter fabric, drainage layer, and visible portions of the waterproof membrane to maximize the lifespan of the green roof.

Regardless of plant density and coverage, control of weed species is encouraged as part of long-term maintenance. The designer is referred to the ***Landscape Design Guidebook*** ☛ water.phila.gov/wp-content/uploads/files/gsi-landscape-design-guidebook.pdf for more detail.

General recommended maintenance activities for green roofs are summarized in Table 4.3-1 below.

Table 4.3-1: Green roof maintenance guidelines

Early maintenance activity	Frequency
Water vegetation in the early morning.	Daily for two weeks after installation
	Every four days for the first year after planting, during periods of four or more days without rain during June through August
Hand-weed non-target / invasive plants.	Every three months for the first two years after planting
Inspect vegetation for signs of disease or distress. Treat or replace as necessary.	Every two weeks for the first year after planting

Ongoing maintenance activity	Frequency
Clear roof drains when growing medium, vegetation, debris, or other material clogs the drain inlet. Under normal operating conditions, all roof discharge must be filtered and growing medium must not migrate toward the drains. Identify and correct sources of sediment and debris.	As needed
Maintain plant material to provide a minimum of 80% foliage cover during warm months. If coverage rate is declining, determine the reason (e.g. soil nutrition, soil moisture conditions) and implement remedial measures.	As needed
Remove weeds manually and use herbicide only in extreme instances of weed infestations that compromise the plant cover integrity and when herbicides are permitted on a project site (e.g., certain sustainability rating systems do not allow chemical herbicides on site). Remove weeds entirely.	As needed
Thin any overgrown areas of vegetation	Monthly
Remove debris and sediment from impervious areas adjacent to green roof vegetation.	Monthly
Inspect root development. If root zone is not well developed, determine the reason (e.g., soil nutrition or soil moisture conditions) and implement remedial measures.	Quarterly
Inspect permanent irrigation system and adjust irrigation dosing rates as needed to optimize plant performance and water-use efficiency.	Quarterly
Inspect growing medium for evidence of erosion from wind or water. If erosion channels are evident, a problem with the drainage system or with the growing medium is present. Surface ponding or runoff must not occur except during very large rainfall events. Correct the problem then refresh the affected areas with additional growing medium and provide temporary soil stabilization. Consult with the Green Roof Manufacture for guidance on making repairs to green roof.	Quarterly
In early spring, manually cut dormant, herbaceous vegetation from the previous growing season to four to six inches above the ground.	Annually
Inspect drain inlet pipe and containment system.	Annually
Test growing medium for soluble nitrogen content. Fertilize as needed.	Annually

During the plant establishment period, conduct at least three to four maintenance visits per year to perform basic weeding, fertilization, and in-fill planting. Thereafter, conduct at least two annual visits for inspection and light weeding. Irrigated assemblies will require more frequent maintenance.

Use of herbicides must be minimized to prevent root penetration of waterproofing.

Apply organic or chemical fertilizer according to soil-testing results to maintain soluble nitrogen (nitrate and ammonium ion) levels between one and four ppm. The best source of nutrients for fertilization is mature compost.

Exercise spill-prevention measures from mechanical systems located on roofs when handling substances that can contaminate stormwater.

The designer is referred to **Section 4.12** ☛ p. 182, Outlet Controls, and **Section 4.13** ☛ p. 218, Landscaping, for information on maintenance guidance.

4.4 Subsurface Infiltration

Download summaries of this SMP and its maintenance guidance, with quick reference information for clients and developers:

- **Subsurface Infiltration SMP One-Sheet** ☛ water.phila.gov/wp-content/uploads/files/subsurface-infiltration-smp-one-sheet.pdf
- **Subsurface Infiltration Maintenance Guidance One-Sheet** ☛ water.phila.gov/wp-content/uploads/files/subsurface-infiltration-maintenance-guidance.pdf

4.4.1 Subsurface infiltration introduction

Subsurface infiltration stormwater management practices (SMPs) are typically stone beds, or basins, with storage pipes beneath landscaped or paved surfaces. Stormwater flows into the subsurface infiltration SMP where it collects within the aggregate void space and infiltrates into the surrounding soil. Dry wells, infiltration trenches, and infiltration beds are a few examples of this SMP type.

Subsurface infiltration SMPs can be combined with other SMPs in series to meet the Philadelphia Water Department (PWD) Stormwater Regulations (Stormwater Regulations). The designer is referred to **Section 3.2.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-2-stormwater-management-design#3.2.3 for information on using SMPs in series.

Quick tip

Required subsurface infiltration design and material standards are denoted in this section by easy-to-reference numerals.

Design of subsurface infiltration SMPs is not limited to the examples shown within this text. Successful stormwater management plans will combine appropriate materials and designs specific to each site.



An example of a subsurface infiltration basin in Philadelphia

When can subsurface infiltration be used?

Subsurface infiltration SMPs should be considered only if surface bioinfiltration/bioretention SMPs are not feasible on-site.

Subsurface infiltration SMPs must have underlying soils that, when tested pursuant to the infiltration testing procedure described in **Section 3.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-3-infiltration-testing-and-soil-assessment-for-smp-design, are determined to be infiltration-feasible. They can be used to manage stormwater on both small and large sites. For large sites, multiple subsurface infiltration SMPs can be integrated throughout to manage larger areas.

Subsurface infiltration SMPs are versatile SMPs suitable for many types of development, from multi-family residential to high-density commercial projects. Provided that overburden loads and utility conflicts are evaluated, they can be sited beneath lawns and recreational areas, as well as parking lots and other hardscape surfaces.

Key advantages of subsurface infiltration

- Manages stormwater runoff without occupying surface or rooftop space
- Can be sited, through flexible design options, beneath lawns and recreational areas, as well as parking lots and other impervious areas when space constraints exist
- Can be a good option to meet the Flood Control requirement for constrained sites

Key limitations of subsurface infiltration

- Can be more costly and difficult to install and maintain than surface practices like bioinfiltration SMPs
- Not appropriate for runoff with high sediment loads without aggressive pretreatment
- Require strict adherence to regularly scheduled inspections because the maintenance needs are not easily visible
- Typically results in additional maintenance costs due to access limitations and Occupational Safety and Health Administration (OSHA) requirements
- Does not improve natural aesthetics or provide the ancillary environmental benefits associated with vegetated SMPs, such as habitat creation and improved air quality

Key design considerations for subsurface infiltration

- Appropriate pretreatment should be provided to remove sediment and debris before discharging to a subsurface infiltration system. A pretreatment approach should be developed based on the expected level of sediment loading and difficulty of sediment removal.
- Subsurface chambers, crates, pipes, or arches can be used to increase void space and reduce SMP footprint; however, proper analysis must be completed to ensure that loading ratio requirements are not exceeded.
- Long-term maintenance must also be carefully considered when evaluating such systems.
- The system and maintenance access should be located in an area where maintenance and potential repairs can be conducted with minimal disturbance to surrounding uses
- Structural suitability for overburden support and traffic loading should be considered, where applicable.
- Areas of soil contamination or unstable soils may need to be remediated or stabilized prior to subsurface infiltration SMP installation
- For any subsurface infiltration SMP that discharges onto an adjacent property, a drainage easement may be required and is recommended.

Subsurface infiltration types

Subsurface infiltration SMPs come in a variety of shapes and sizes, but commonly fit into the following three categories:

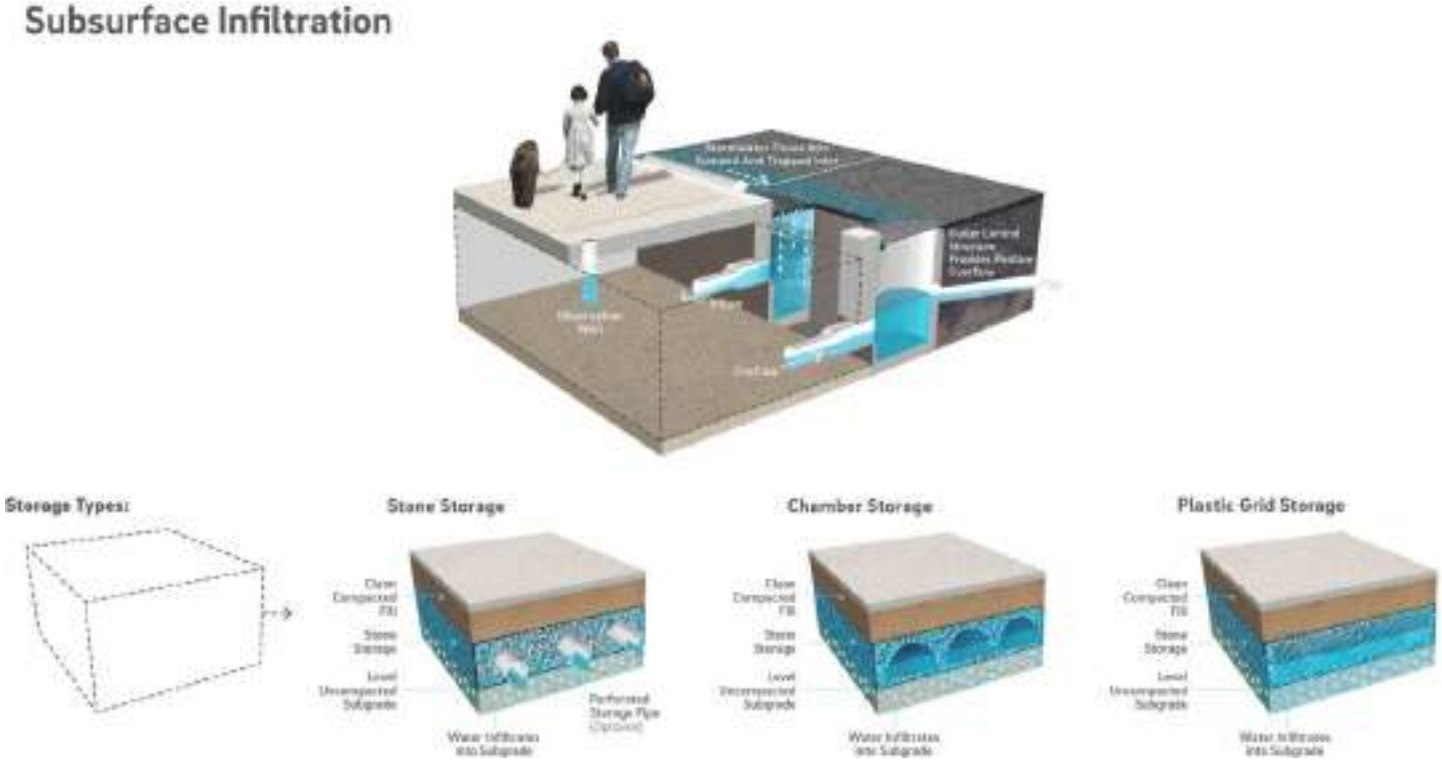
Underground stone storage consists of buried stone beds wrapped in geotextile that promote infiltration into subsoils. Stone storage beds provide the least amount of storage volume per unit area among the subsurface infiltration types. Removing sediment from underground stone storage is difficult, which necessitates effective pretreatment.

Underground pipe and chamber storage comprises perforated plastic or metal pipes, or pipe-like linear chambers, that are placed in a stone bed to provide more storage per unit volume and promote infiltration into subsoils. Various pipe dimensions and shapes can be used to optimize the storage volume to meet the specific site requirements. The designer is referred to **Section 4.15** ☛ p. 256 for information on drainage wells, a subsurface infiltration system that falls into this category.

Underground plastic grid storage consists of buried plastic structures that can be stacked and interconnected to form various shapes and sizes. Grid systems can provide as much as 95% void space for storage of stormwater.

4.4.2 Subsurface infiltration components

Figure 4.4-1: Subsurface infiltration with typical features



☛ water.phila.gov/wp-content/uploads/images/swmg-figure-4-4-1-subsurface-infiltration-typical-features.jpg

Pretreatment component

Pretreatment systems capture trash, sediment, and/or pollutants from stormwater runoff before delivery to the infiltration area. Pretreatment needs will vary significantly depending on the contributing drainage area composition and use. Pretreatment can include structures such as sumped and trapped inlets, sediment/grit chambers or separators, media filters, inlet inserts, or other appropriate prefabricated or proprietary designs to remove sediment, floatables, and/or hydrocarbons from stormwater runoff prior to being conveyed to a subsurface infiltration SMP. While inlet hoods are preferred, permanent filter bags may be accepted for Stormwater Retrofit projects where existing inlets do not have hoods and inlet reconstruction is not feasible. In addition to sumped and trapped inlets, permanent filter bag inserts are required for sites that generate pollutants such as loading docks, material storage facilities, junk yards, and waste collection and disposal sites. Permanent filter bags will require frequent cleanings.

Pretreatment can also consist of maintenance rows, filter strips, forebays, and swales. The designer is referred to **Section 4.10** ☛ p. 148, Pretreatment, for more information on pretreatment systems.

Inlet control component

Inlet control systems convey and control the flow of stormwater from the contributing catchment area to a subsurface infiltration SMP. Inlet control needs will vary depending on the design of stormwater conveyance systems and the site layout. The designer is referred to **Section 3.4.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-4-how-to-show-compliance#3.4.2 for guidance on stormwater conveyance system design.

Inlet controls may include flow splitters, curbless design/curb openings, energy dissipaters, and inlets. The designer is referred to **Section 4.11** ☛ p. 166, Inlet Controls, for more information on inlet controls.

Storage area component

Storage areas within subsurface infiltration SMPs temporarily hold stormwater runoff as it infiltrates into native soils. The storage component of a subsurface infiltration SMP is typically constructed of a stone-filled, level-bottomed bed or trench, which may or may not incorporate pipes, arches, concrete vaults, crates, plastic grids, or other proprietary structures. The void spaces between the stones and/or structures store stormwater until it can infiltrate into the surrounding soils.

Outlet control component

Outlet controls within a subsurface infiltration SMP can provide a range of functions, including the following:

- Controlling how much water is stored for infiltration;
- Meeting drain down time requirements;
- Controlling the rate of discharge from the SMP and limiting water surface elevations during various storm events; and/or
- Bypassing of flows from large storm events.

Outlet controls may include orifices, weirs, or level spreaders. The designer is referred to **Section 4.12** ☛ p. 182, Outlet Controls, for more information on outlet controls.

Inspection and maintenance access component

Safe and easy inspection and maintenance access to all major components within a subsurface infiltration SMP is critical to ensuring long-term performance. Access points provide access to subsurface systems, both for inspections and routine maintenance, and for pumping water out of subsurface SMPs in cases of failure or severe damage. Manholes provide access for maintenance personnel and equipment to perform maintenance and inspections. Cleanouts provide access for hoses and vacuum equipment. Observation wells provide access to the bottom of subsurface systems for performance inspections and monitoring. Access structures may also serve additional functions, such as joining subsurface pipes.

4.4.3 Subsurface infiltration design standards

General design standards

1. The maximum allowable drain down time is 72 hours after the 24-hour storm event.
2. The maximum allowable directly connected impervious area (DCIA) to SMP footprint loading ratio is 10:1.
3. Positive overflow must be provided for large storm events, up to and including the 100-year, 24-hour storm, or, if the project is exempt from Flood Control, the ten-year, 24-hour storm. Overflow structures and pipes must be designed to convey at least the ten-year, 24-hour storm.
4. The minimum allowable distance between subsurface infiltration basins and any adjacent private property line is ten feet. This includes partially lined basins. It is acceptable for SMPs to be located directly adjacent to the public right-of-way (ROW).
5. The minimum allowable distance between subsurface infiltration basins and any building or retaining wall is ten feet. This includes partially lined basins. The following requirements and exceptions apply:
    a. For existing and proposed buildings with basements, the setback is measured from the basement wall.
    b. For existing buildings without basements and existing retaining walls, the setback is measured from the foundation and may be waived if a signed and sealed geotechnical analysis is submitted that evaluates the impacts of infiltration and excavation on the existing foundation and determines it to be feasible.
    c. For proposed buildings without basements and proposed retaining walls, the setback is measured from the foundation and may be waived if the foundation is proposed to be designed with the basin's proximity in mind.
6. Infiltration requirements:
    a. The designer is referred to **Section 3.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-3-infiltration-testing-and-soil-assessment-for-smp-design for information on infiltration testing requirements.
    b. The SMP must be located at least two feet above any poorly infiltrating soils, seasonal high groundwater table, bedrock, or any other limiting zone.
    c. For hydrologic modeling, infiltration must be applied to the horizontal surface area (SMP footprint), not the wetted area.
    d. Soils underlying infiltration practices must, when tested pursuant to the infiltration testing procedure described in **Section 3.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-3-infiltration-testing-and-soil-assessment-for-smp-design, be determined to be infiltration feasible. If infiltration feasibility is unknown and determination is deferred until construction, the applicant must submit two complete designs (e.g. plans, calculations, Online Technical Worksheet, etc.) for both infiltrating and non-infiltrating scenarios to be fully reviewed. A PCSMP Conditional Approval will be issued, and the approval letter will feature both plan sets. Following infiltration testing, only the applicable design's plan set will be included on the PCSMP Approval Letter.

e. Soils with rates in excess of ten inches per hour require soil amendments. During construction, upon achieving final subgrade elevations, a two-foot-thick layer of amended soil must be placed across the entire cross-section of the infiltrating SMP, below the bottom elevation of the SMP, and a minimum of three infiltration tests must be performed within the amended soil layer. If soil amendments are installed and the tested infiltration rate is determined to be outside of the PWD-allowable range or varies significantly from the design infiltration rate, additional soil amendments and/or a SMP redesign will be required. The designer is referred to **Section 3.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-3-infiltration-testing-and-soil-assessment-for-smp-design for additional detail.

f. If the infiltration SMP is used as a temporary sediment basin during construction, the invert elevation of the infiltration SMP must be a minimum of three feet below the bottom elevation of the pre-basin-conversion sediment basin.

g. An infiltrating SMP within the zone of influence of any nearby sewers or sewer laterals must be installed with an impervious liner. The zone of influence is defined by the area within a 1:1 (H:V) slope line from the outer edge of a sewer or sewer lateral.

7. Structural suitability for overburden support and traffic loading must be considered, where applicable.

Pretreatment design standards

8. Acceptable form(s) of pretreatment must be incorporated into design. Pretreatment of runoff from all inlets is required. At a minimum, this can be achieved through the use of sumps and traps for inlets, sump boxes with traps downstream of trench drains, and filter strips for overland flow.
9. The designer is referred to **Section 4.10** ☛ p. 148, Pretreatment, for more information on design standards for pretreatment systems.

Inlet control design standards

10. The designer is referred to **Section 4.11** ☛ p. 166, Inlet Controls, for information on design standards for inlet control systems.

Storage area design standards

11. The storage area must provide static storage for the Water Quality Volume (WQv) between the bottom elevation of the SMP and the elevation of the lowest outlet, including storage voids. Storage or distribution pipes alone are not sufficient in providing static storage. A minimum of at least three inches of forced storage via an outlet control device is recommended in order to give the statically stored volume time to infiltrate.
12. The maximum allowable static storage volume without supporting documentation (defined below) is the runoff volume from the one-year, 24-hour storm.

13. The maximum allowable static storage volume with supporting documentation is the runoff volume from the ten-year, 24-hour storm. Requirements for supporting documentation include a letter, signed and sealed by both the geotechnical and design engineer, indicating that the proposed design is recommended, with the following components acknowledged and considered. The designer is encouraged to contact PWD for further guidance when pursuing this design.
    a. A summary of the long-term impacts to the neighboring properties, including, but not limited to subsidence, change in basement moisture/ water, and structural damage;
    b. The location of the groundwater table;
    c. References to other projects that have successfully infiltrated more than the one-year, 24-hour storm event; and
    d. Rigorous pretreatment to promote longevity of the infiltration SMP.
14. When SMPs are used in series, the storage areas for all SMPs must provide cumulative static storage for the WQv, but there is no minimum storage requirement for each individual SMP used in series.
15. Subsurface infiltration SMPs can be designed with additional storage beyond the WQv and with outlet controls that allow all remaining applicable Stormwater Regulations to be met.
16. Void space provided by linear chamber systems, plastic grids, or other related structures must be as specified by the manufacturer and noted in supporting documentation.
17. Bedding and foundations:
    a. Pipe, vault, grid, and chamber storage areas must be adequately bedded with stone to prevent settling or subsidence.
    b. Bedding thickness must vary according to system requirements but must not be less than six inches.
    c. Over-excavation and replacement of loose or unstable subsurface material may be required if such conditions are encountered. A geotechnical engineer or other appropriate design professional should be consulted for additional guidance.
    d. Foundations/footers must be provided as warranted by system loading, geotechnical conditions, and manufacturer's recommendations. Foundation designs must be performed by an appropriate design professional.
18. The storage design must account for potential loading from vehicles, as appropriate, based on expected maximum active loading, including consideration for emergency vehicles.
19. Porosity values for storage volume calculations are as follows:
    a. Soil media: 0.20
    b. Sand: 0.30
    c. Stone: 0.40
20. Stone must be separated from soil media by a geotextile or a pea gravel filter to prevent sand, silt, and sediment from entering the system.
21. Stone storage systems must have a level bottom or use a terraced system if installed along a slope.

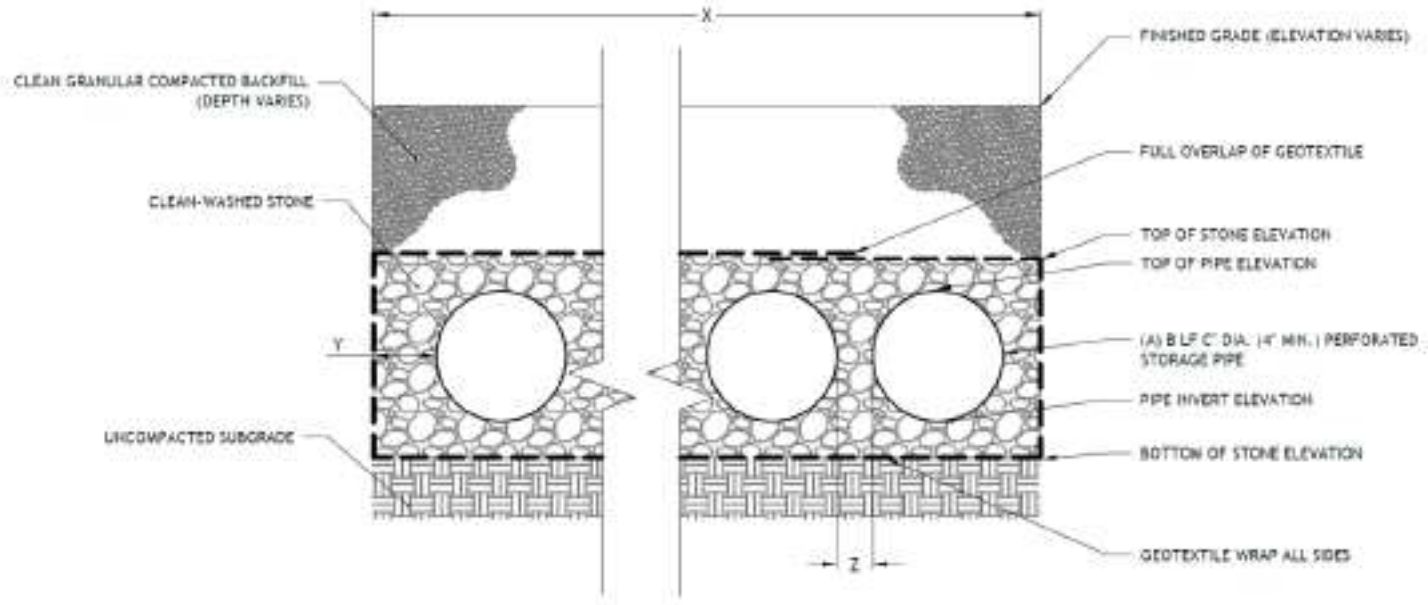
Outlet control design standards

22. The designer is referred to **Section 4.12** ☛ p. 182, Outlet Controls, for information on design standards for outlet control systems.

Inspection and maintenance access design standards

23. Cleanouts, manholes, access panels and other access features must be provided to allow unobstructed and safe access to SMPs for routine maintenance and inspection of inflow, outflow, underdrains, and storage systems.
24. Observation wells must be provided for SMPs that include stone storage and must meet the following requirements:
    a. The observation well must be placed at the invert of the stone bed.
    b. The observation well must be located near the center of the stone bed system to monitor the level and duration of water stored within the SMP (drain down time). A minimum of six inches of clearance must be provided between the edge of the observation well's concrete ring or frame and any nearby site features (curbing, tree pits, sidewalk edge, etc.). Plan view dimensioning for the proposed location of the observation well, relative to the boundaries of the SMP it lies within, must be provided on the plans.
    c. Adequate inspection and maintenance access to the observation well must be provided.
    d. An observation well located in a paved area must be outfitted with a cover and frame. The cover plate must be installed flush with the surrounding surface at finished grade, and grading should drain away from the observation well wherever possible. The solid section of the observation well must extend into the cover frame enough such that a bentonite/cement seal can be placed around the well within the frame, and a solid slip-on cap can be fitted onto the pipe end.
    e. An observation well located in an unpaved area must have a concrete ring or frame poured for support, with three lengths of rebar evenly spaced around the ring and three inches from its outer edge. The observation well should be located outside of the ponding area of any surface SMPs. If, due to space limitations, an observation well must be placed in the ponding area of a surface SMP, the concrete ring and well cover must extend three inches above the SMP's maximum ponding depth.
    f. The observation well must include a slotted section within the storage layer of the SMP. The top of the slotted well section must extend to a minimum of six inches below the top of the SMP storage layer, and the slotted section must extend down the entire depth of the SMP.
25. Access features for subsurface infiltration SMPs:
    a. Access features must be provided for all underground storage SMPs that are not stone storage beds.
    b. A sufficient number of access points in the SMP must be provided to efficiently inspect and maintain the infiltration area.
    c. For cast-in-place vault systems, access features must consist of manholes or grated access panels or doors. Grated access panels are preferred to maintain airflow.
    d. For grid storage or other manufactured systems, the manufacturer's recommendations must be followed.
    e. Ladder access is required for vaults greater than four feet in height.
    f. Header pipes, at minimum 36-inch diameter, connected to manholes at each corner of the subsurface infiltration SMP must be provided. Alternatively, smaller header pipes may be used if cleanouts are provided on the manifold/header pipe junction for each distribution pipe. The cleanouts must be on alternating sides of the SMP.

Figure 4.4-2: Subsurface infiltration basin (pipe in stone) standard detail



(The designer is referred to **Appendix L** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/l-standard-details to download Standard Detail CAD files.)

4.4.4 Subsurface infiltration material standards

Pretreatment material standards

1. The designer is referred to **Section 4.10** ☛ p. 148, Pretreatment, for information on materials standards for pretreatment systems.

Inlet control material standards

2. The designer is referred to **Section 4.11** ☛ p. 166, Inlet Controls, for information on material standards for inlet control systems.

Storage area material standards

3. Stone designed for stormwater storage must be uniformly graded, crushed, clean-washed stone. PWD defines “clean-washed” as having less than 0.5% wash loss, by mass, when tested per American Association of State Highway and Transportation Officials (AASHTO) T-11 wash loss test. AASHTO No. 3 and No. 57 stone can meet this specification.
4. Sand, if used, must be AASHTO M-6 or ASTM C-33 sand and must have a grain size of 0.02 inches to 0.04 inches.
5. Storage pipes:
   a. Pipe used within the subsurface infiltration SMP must be continuously perforated and have a smooth interior with a minimum inner diameter of four inches.
   b. High-density polyethylene (HDPE) pipe must meet the specifications of AASHTO M252, Type S or AASHTO M294, Type S.
   c. Any pipe materials outside the SMP are to meet City Plumbing Code Standards.
6. Geotextile must consist of polypropylene fibers and meet the following specifications (AASHTO Class 1 or Class 2 geotextile is recommended):
   a. Grab Tensile Strength (ASTM-D4632): ≥ 205 lbs
   b. CBR Puncture Strength (ASTM-D6241): ≥ 500 lbs
   c. Flow Rate (ASTM-D4491): ≥ 95 gal/min/ft2
   d. UV Resistance after 500 hours (ASTM-D4355): ≥ 70%
   e. Tear Resistance (ASTM-D4533): ≥ 80 lbs
   f. Heat-set or heat-calendared fabrics are not permitted.

Outlet control material standards

7. The designer is referred to **Section 4.12** ☛ p. 182, Outlet Controls, for information on material standards for outlet control systems.

Inspection and maintenance access material standards

8. Observation wells:
    a. The observation well must consist of slotted plastic pipe with a minimum inner diameter of four inches and a solid cap at the surface. The slotted section of the well must consist of PVC slotted well screen with 0.01-inch slot size and an attached perforated PVC cap at the bottom.
    b. The observation well's cover must be ductile iron in a gray iron frame.
    c. For an observation well located in an unpaved area, the well's concrete ring must be a minimum of six inches wider in any dimension than the cover frame, of equal depth as the cover frame itself, and poured atop a minimum of six inches of AASHTO #57 stone bedding. A frame conforming to these minimum dimensions may be circular or square.
9. Cleanouts must be made of material with a smooth interior having a minimum inner diameter of six inches. If the connecting pipe is eight inches in diameter or larger, then the cleanout must be eight inches in diameter.

4.4.5 Subsurface infiltration construction guidance

Proper construction and careful consideration of soil compaction, infiltration performance, and sedimentation control of subsurface infiltration SMPs are essential to ensure long-term functionality and reduce long-term maintenance needs and costs. Since subsurface infiltration SMPs are, by definition, buried, construction oversight is critical. At a minimum, verification of volumes, grades, and elevations must be performed prior to backfill.



An example of a subsurface infiltration basin installation in Philadelphia

1. Areas for proposed subsurface infiltration SMPs must be physically marked as heavy equipment exclusion zones prior to any land-disturbing activities to avoid soil disturbance and compaction during construction. Install construction fencing around subsurface infiltration areas. If areas are compacted during construction, additional infiltration testing and potential redesign efforts may be required.
2. Provide erosion and sedimentation control protection on the site such that construction runoff is directed away from the proposed subsurface infiltration SMP. Sediment deposited in a subsurface infiltration SMP during construction, particularly a stone bed, can significantly reduce SMP performance. The designer is referred to the latest edition of the *Pennsylvania Department of Environmental Protection (PA DEP) Erosion and Sediment Pollution Control Program Manual* for information on design standards for erosion and sedimentation control practices.

3. Infiltration areas may not be used as sediment traps during construction, unless at least three feet of soil are left in place while the area is serving as a sediment trap and subsequently removed during construction after the contributing drainage areas have been stabilized.
4. Complete site elevation grading and stabilize all disturbed soil. Stabilization of disturbed areas must be implemented before finalizing the subsurface infiltration SMP's excavation and construction.
5. Excavate subsurface infiltration area to proposed depth and manually grade and scarify the existing soil surface. The bottom of the infiltration bed must be at a level grade.
6. Existing subgrade must NOT be compacted or subject to excessive construction equipment prior to placement of geotextile and stone bed. The use of machinery to load stone from outside of the infiltration bed footprint is recommended. Stone should be carefully placed, not dumped, in the infiltration bed. If it is essential that equipment be used in the excavated area, all equipment must be low ground pressure equipment and approved by PWD. Use of equipment with narrow tracks or tires, rubber tires with large lugs, or high-pressure tires will cause excessive compaction and must not be used. Should the subgrade be compacted during construction, additional testing of soil infiltration rates and SMP redesign may be required. Rock construction entrances must not be located on top of areas proposed for infiltration practices.
7. Place geotextile and stone aggregate immediately after approval of subgrade preparation to prevent accumulation of debris or sediment. Prevent runoff and sediment from entering the infiltration bed during the placement of the geotextile and aggregate bed.
8. Place geotextile in accordance with manufacturer's standards and recommendations. Secure geotextile at least four feet outside of bed. Adjacent strips of filter fabric must overlap a minimum of 16 inches
9. Install aggregate course in lifts of six to eight inches. Lightly compact each layer with equipment, keeping equipment movement over storage bed subgrades to a minimum. Install aggregate to grades indicated on the drawings.
10. All stone that makes up the infiltration SMP must remain free of sediment. If sediment enters the stone, the contractor may be required to remove the sediment and replace with clean washed stone.
11. Confirm and document invert elevations and dimensions for all structures such as chambers and pipes prior to backfill.
12. Backfill to finished grade. Ensure backfill is properly compacted in accordance with specifications. Ensure backfill process does not disrupt pipe placement and configuration.
13. Structures such as inlet boxes, reinforced concrete boxes, inlet controls, and outlet controls must be constructed according to manufacturer's guidelines or design professional's guidance.
14. Complete surface grading above subsurface infiltration SMP, using suitable equipment to avoid excess compaction.
15. Once the site is permanently stabilized with vegetation, remove temporary erosion and sediment control measures.

4.4.6 Subsurface infiltration maintenance guidance

Maintenance of subsurface infiltration SMPs focuses on the periodic removal of sediment and debris from pretreatment and storage areas. Sediment removal from vaults, chambers, and pipes is typically conducted using vacuum or flushing systems. Guidance on the use and operation of vacuum or flushing sediment removal equipment is beyond the scope of this Manual; a maintenance professional should be contacted for additional details. As applicable, subsurface SMP maintenance procedures must meet OSHA confined space entry requirements.

General recommended maintenance activities for subsurface infiltration SMPs are summarized in Table 4.4-1.

Table 4.4-1: Subsurface infiltration maintenance guidelines

Early maintenance activity	Frequency
Inspect erosion control and flow spreading devices until soil settlement and vegetative establishment of contributing areas has occurred.	Biweekly
Inspect inlet controls, outlet structures, and storage areas for trash and sediment accumulation.	Monthly for the first year after installation to determine ongoing maintenance frequency

Ongoing maintenance activity	Frequency
Regularly clean out gutters and catch basins to reduce sediment load to infiltration SMP. Clean intermediate sump boxes, replace filters, and otherwise clean pretreatment areas in directly connected systems.	As needed
Remove sediment and debris from subsurface infiltration SMP sedimentation chamber, as applicable, when the sediment zone is 3/4 full. Sediment and debris build-up may need to be removed by a professional. Consult with a professional as necessary.	As needed
Remove sediment and debris from pipe/vault systems. Sediment depth is not to reach a maximum depth of four inches below the SMP's outlet invert elevation. Removal of sediment from grid systems must be per manufacturer's recommendations or as per the site-specific maintenance plan.	As needed
Replace filter bags for pretreatment devices. Ensure filter bag is installed properly.	Quarterly
Inspect subsurface infiltration facility and control structures.	Quarterly
Remove floating debris and accumulated petroleum products from system and all components.	Quarterly
Evaluate the drain down time of the SMP after a storm of at least one inch to ensure a SMP drain down time of less than 72 hours.	Ongoing
Maintain records of all inspections and maintenance activity.	Ongoing

The designer is referred to **Section 4.10** ☛ p. 148, Pretreatment, **Section 4.11** ☛ p. 166, Inlet Controls, and **Section 4.12** ☛ p. 182, Outlet Controls, for information on maintenance guidance for pretreatment, inlet controls, and outlet controls.

4.5 Cisterns

Download summaries of this SMP and its maintenance guidance, with quick reference information for clients and developers:

- **Cisterns SMP One-Sheet** ☛ water.phila.gov/wp-content/uploads/files/cisterns-smp-one-sheet.pdf
- **Cistern Maintenance Guidance One-Sheet** ☛ water.phila.gov/wp-content/uploads/files/cistern-maintenance-guidance.pdf

4.5.1 Cistern introduction

Cisterns are storage tanks, located either above or below ground, that hold rainwater for beneficial reuse. Cisterns are multi-function systems that help to meet the Philadelphia Water Department (PWD) Stormwater Regulations (Stormwater Regulations) and collect water for reuse. Rainwater may be collected from rooftops or other impervious surfaces and conveyed to cisterns for storage. Stored water may drain by gravity or be pumped to its ultimate end use. This process, often referred to as rainwater harvesting, may include the use of captured water as permitted by local plumbing and building codes for:

- Exterior washing (e.g., car washes, building facades, sidewalks);
- Make-up water for mechanical systems (e.g., cooling towers, condensate make-up);
- Ornamental water fountains;
- Toilet and urinal flushing;
- Laundry; and/or
- Other uses, as approved.

Irrigation as a use for runoff stored in a cistern is not an acceptable strategy for meeting the Stormwater Regulations.

Sizing considerations for cisterns include both the frequency and volume of water usage demand, if applicable, and the frequency and volume of supply. Cisterns may also be sized to provide detention/flow control along with water conservation as a hybrid system.

Quick tip

Required cistern design and material standards are denoted in this section by easy-to-reference numerals.

Cisterns only provide an effective flow control function if the stored water is partially or fully used (or emptied) between storms. This function restores available storage volume within the cistern in advance of the next storm. For example, unless it is oversized, a fire storage system provides no meaningful stormwater benefit if it is fed by rainwater because fire storage systems must always be full, in case there is a fire.

Cisterns can be combined with other stormwater management practices (SMPs) in series to meet the Stormwater Regulations. The designer is referred to **Section 3.2.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-2-stormwater-management-design#3.2.3 for information on using SMPs in series.

The design recommendations within this section are to serve as guidance only. Site-specific parameters, such as anticipated water demand, will dictate alternative designs and calculations which will be reviewed accordingly.



An example of a surface cistern in Philadelphia



An example of a subsurface cistern in Philadelphia

When can cisterns be used?

Cisterns can be used as part of a comprehensive stormwater compliance and reuse strategy for residential, commercial, and industrial areas. They are typically located within or adjacent to buildings. In addition to above-ground cisterns, rainwater harvesting systems can be sited beneath lawns, recreational areas, parking lots, and other hardscape surfaces, provided that overburden loads and utility conflicts are evaluated.

Key advantages of cisterns

- Can be used to provide rate control within small/constrained spaces
- Decrease demand on the municipal water supply and water costs for the end user, when used as part of a rainwater harvesting system in accordance with City, State, and Federal code restrictions
- Can be sited, through flexible design options, beneath lawns, recreational areas, parking lots, other impervious areas, or within buildings when space constraints exist
- Provide educational benefits, especially at public and/or highly visible sites

Key limitations of cisterns

- May not be able to fully meet the Water Quality requirement
- Limited to circumstances where there is a year-round water demand that can replenish storage capacity between storms
- May be subject to additional City, State, and Federal code restrictions
- Require draining before a freeze when located on the surface, to prevent structural damage
- Require strict adherence to regularly scheduled inspections because the maintenance needs are not easily visible
- Does not improve aesthetics or provide the ancillary environmental benefits associated with vegetated SMPs, such as habitat creation and improved air quality

Key design considerations for cisterns

- The specific end use of harvested rainwater can influence other design considerations, including cistern location, type of treatment, and delivery and distribution, among others.
- If a cistern is used for rainwater harvesting, a distribution system is needed to deliver stored water to its ultimate end use. It is often best to locate a cistern close to the building or drainage area to limit the amount of pipe needed for delivery or distribution of water. Pumps can be used to convey stored rainwater to the end use. When the water is being routed from the cistern to the inside of a building for non-potable use, pumps can be used to feed a much smaller pressure tank inside the building, which then serves the internal water demands. Cisterns can also use gravity flow to accommodate indoor residential uses (e.g., laundry) that do not require high water pressure.
- Depending on the intended use for the captured water, the level of treatment can vary. For some non-potable uses, filtration can be limited to sediment removal. Other uses may require treatment to remove microorganisms via physical filtration and disinfection.
- Cisterns can be placed underground, indoors, adjacent to buildings, and on rooftops that are structurally designed to support the added weight. The designer can work with architects and landscape architects to strategically site the cisterns. If cisterns are sited near the ultimate end use, costly distribution systems can be minimized.
- Rainwater harvesting is most effective when the volume and frequency of rainfall and the size of the contributing drainage area can generate sufficient water for the ultimate end use. Rooftops are most often targeted for rainwater harvesting systems. Rainwater can also be harvested from other impervious surfaces, such as parking lots; however, this typically requires more extensive treatment prior to use. Water Quality compliance is largely a function of the type of material covering the drainage area.
- For any cistern that discharges onto an adjacent property, a drainage easement may be required and is recommended.

Cistern types

Cisterns can be distinguished by their location and by the type of water use they support. With respect to location, cisterns can be categorized in two ways.

Surface tank systems can be sited on rooftops or integrated into commercial sites. They may drain by gravity or be pumped.

Subsurface tank systems are typically pumped. Because the cisterns are below the surface, they do not interfere with the landscape.

With respect to use of stored water, rainwater harvesting systems can be categorized in three ways.

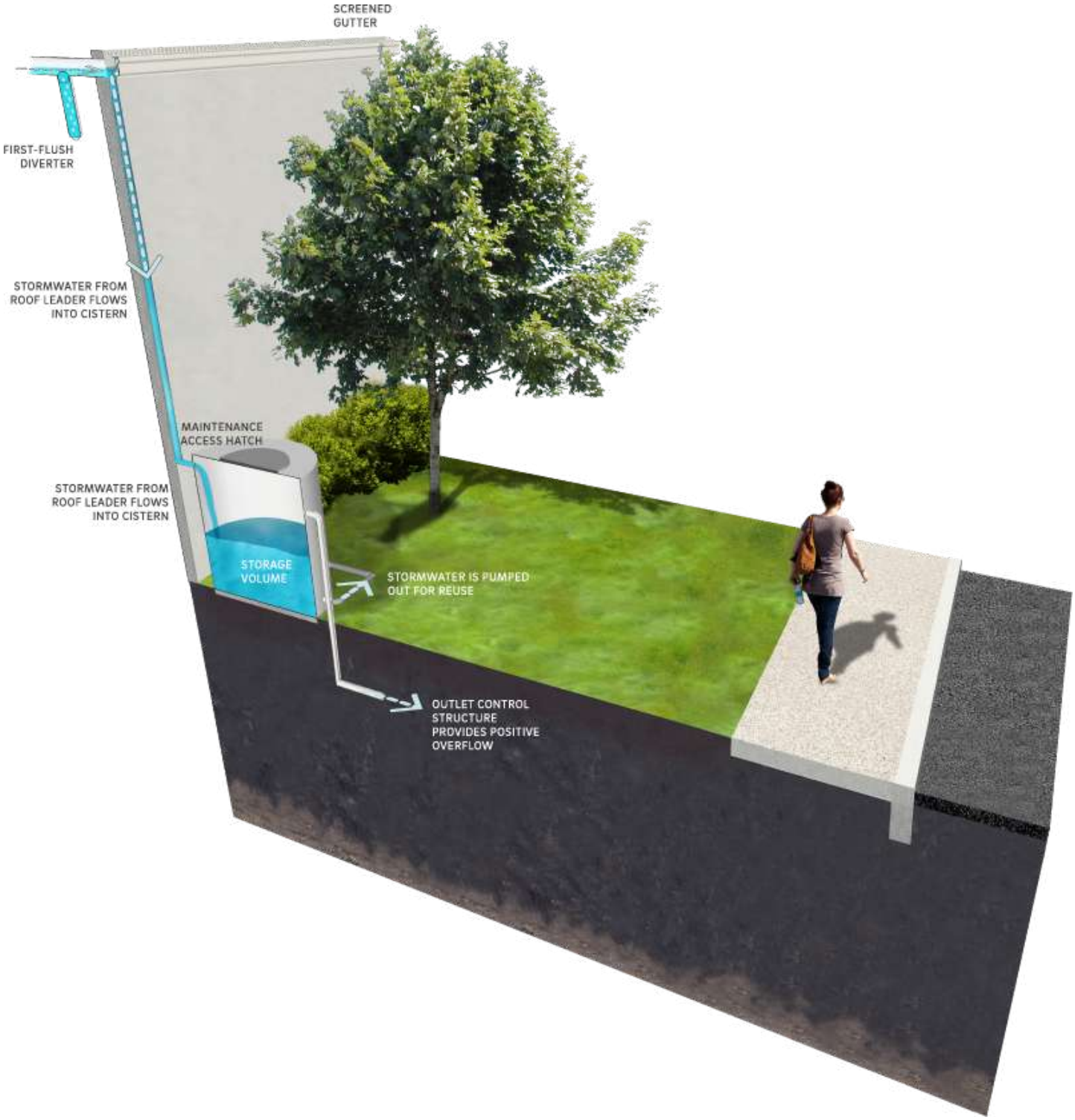
Runoff can be captured and stored for *outdoor use*, including exterior washing and architectural water features. Irrigation as a use for runoff stored in a cistern is not an acceptable strategy for meeting the Stormwater Regulations.

Runoff can be captured and stored for *indoor use* if properly treated and managed. A non-potable rainwater harvesting system cannot be directly connected to the potable plumbing of a building. The non-potable plumbing needs to be kept separate and properly labeled. With more extensive treatment, rainwater may be used for drinking purposes. The designer should seek professional guidance on the rules governing non-public potable water.

When a specific use for harvested rainwater cannot be identified or when the supply of harvested rainwater significantly exceeds demand, then a *hybrid system* using both water conservation and a delayed discharge to a down-gradient pervious area or another SMP can be considered.

4.5.2 Cistern components

Figure 4.5-1: Surface cistern with typical features



Pretreatment component

Pretreatment systems capture trash, sediment, and/or other pollutants from stormwater runoff before delivery to the storage area. Pretreatment needs will vary significantly depending on the contributing drainage area composition and use. Pretreatment can include structures such as sumped and trapped inlets, sediment/grit chambers, media filters, inlet inserts, or other appropriate prefabricated or proprietary designs to remove sediment, floatables, and/or hydrocarbons from stormwater runoff prior to being conveyed to a cistern. While inlet hoods are preferred, permanent filter bags may be accepted for Stormwater Retrofit projects where existing inlets do not have hoods and inlet reconstruction is not feasible. In addition to sumped and trapped inlets, permanent filter bag inserts are required for sites that generate pollutants such as loading docks, material storage facilities, junk yards, and waste collection and disposal sites. Permanent filter bags will require frequent cleanings.

The designer is referred to **Section 4.10** ☛ p. 148, Pretreatment, for more information.

The following pretreatment options are often used with cisterns that manage roof runoff:

Gutter screening – All larger debris (e.g., leaves and twigs) must be screened at the gutter, roof, or at the edge of the impervious surface.

Prefiltration devices – Prefiltration devices prevent smaller particles from entering the cistern. The choice of the proper type of prefiltration device depends on cistern configuration and rainfall patterns.

- ***First flush diverters*** route the first flow, or flush, of water from the catchment surface away from the cistern prior to entry into the tank. While gutter screens are effective at removing larger debris such as leaves and twigs, first flush diverters can be used to remove smaller contaminants such as dust, pollen, bacteria from insect and animal droppings, and other harmful contaminants. Options for first flush can include a standpipe with slow drainage and a floating ball that seals off the top of the diverter pipe, among others.
- ***Roof washers*** are placed just ahead of cisterns and are used to filter small debris from harvested rainwater. Roof washers use a small tank, usually between 25 and 50 gallons in size, with leaf strainers and a filter with openings as small as 30 microns. The filter functions to remove very small particulate matter from harvested rainwater. All roof washers must be cleaned on a regular basis.
- ***Rainwater pre-filters*** screen rainwater before it enters the cistern on a continuous flow basis. These screens are preferable to first flush diverters and roof washers because they have significantly higher collection efficiencies.

The designer is referred to **Section 4.10** ☛ p. 148, Pretreatment, for more information.

Inlet control component

Inlet control systems convey and control the flow of stormwater from the contributing catchment area to a cistern. Inlet control needs will vary depending on the design of stormwater conveyance systems and the site layout. The designer is referred to **Section 3.4.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-4-how-to-show-compliance#3.4.2 for guidance on stormwater conveyance system design.

The designer is referred to **Section 4.11** ☛ p. 166, Inlet Controls, for more information.

Storage area component

The storage component is the cistern, or tank, itself, which temporarily holds stormwater runoff before it can either be reused or be released downstream at a controlled rate, depending on the system design. Cistern capacities generally range from 50 to 50,000 gallons, but they can be as large as 100,000 gallons or more for larger projects. Multiple cisterns can be connected in series to balance water levels and to tailor to the storage volume needed.

Outlet control component

Outlet controls within a cistern control the amount of water that is stored for reuse and the rate at which the excess water is discharged from the cistern. These structures can provide a range of functions, including the following:

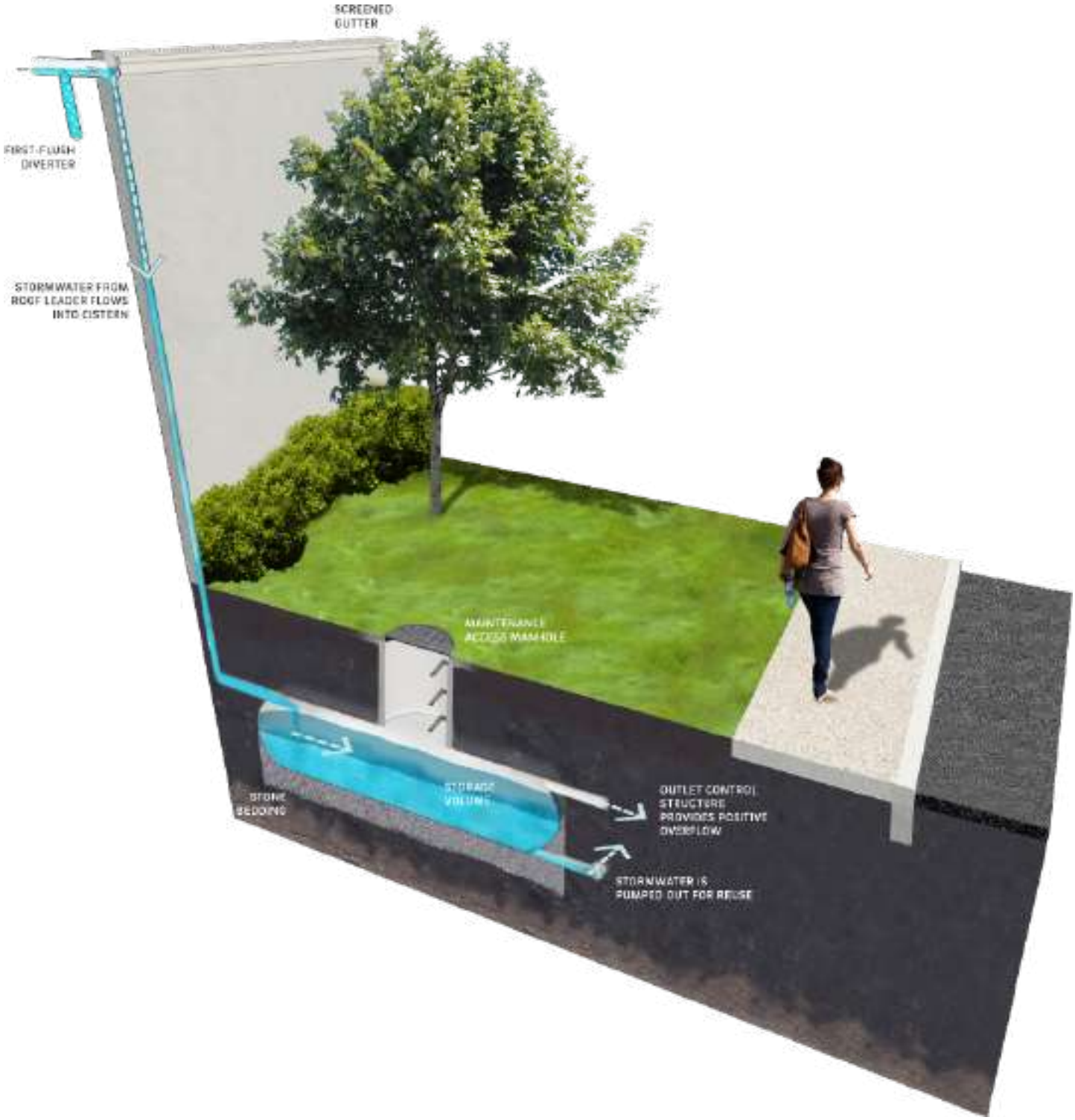
- Controlling how much water is stored for reuse;
- Meeting drain down time requirements;
- Controlling the rate of discharge from the SMP and limiting water surface elevations during various storm events; and/or
- Bypassing of flows from large storm events.

Outlet controls may include orifices and weirs. The designer is referred to **Section 4.12** ☛ p. 182, Outlet Controls, for more information.

Inspection and maintenance access component

Safe and easy inspection and maintenance access to all major components within a cistern is critical to ensuring long-term performance. Inspection and maintenance access structures provide a portal to subsurface structures within a cistern. They most commonly consist of a panel, port, or manhole. Access points provide access to subsurface cisterns, both for inspections and routine maintenance, and for pumping water out of subsurface cisterns in cases of failure or severe damage. Manholes provide access for maintenance personnel and equipment to perform maintenance and inspections. Cleanouts provide access for hoses and vacuum equipment. Observation wells provide access to the bottom of subsurface cisterns for performance inspections and monitoring. Access structures may also serve additional functions, such as joining subsurface pipes. The design of water distribution systems, internal plumbing systems, and water treatment systems required for rainwater harvesting end uses is beyond the scope of this Manual.

Figure 4.5-2: Subsurface cistern with typical features



4.5.3 Cistern design standards

General design standards

1. The maximum allowable drain down/withdrawal time for any portion of storage intended to meet the Water Quality requirement is 72 hours after the 24-hour storm event.
2. Positive overflow must be provided for large storm events, up to and including the 100-year, 24-hour storm, or, if the project is exempt from Flood Control, the ten-year, 24-hour storm. Overflow structures and pipes must be designed to convey at least the ten-year, 24-hour storm.
3. The minimum allowable freeboard above maximum ponding depth is four inches or the diameter of the outlet pipe, whichever is greater.
4. The soil bearing capacity or foundation upon which the cistern will be placed must be considered, as full cisterns can be very heavy. This is particularly important for above-ground cisterns, as significant settling could cause the cistern to lean or be damaged.
5. Designers must consult the City's Building and Plumbing Codes (administered by the **City of Philadelphia Department of Licenses and Inspections** ☛ www.phila.gov/li (L&I)) to determine the allowable indoor uses and pipe labeling and routing (i.e., separate stud bays), and State and Federal codes for required treatment and management of harvested rainwater.
6. In cases where a municipal backup supply is used, rainwater harvesting systems must have backflow preventers or air gaps to keep non-potable harvested water separate from the potable water supply. Distribution and waste pipes, internal to the building, must be designated as such per the City's Building and Plumbing Codes (administered by L&I).

Pretreatment design standards

7. Pretreatment of runoff from all inlets is required to keep sediment, leaves, contaminants, and other debris from the system. The purpose of pretreatment is to maintain functionality and cleanliness of pumps and to significantly cut down on maintenance by preventing organic buildup in the cistern, thereby decreasing microbial food sources.
8. Acceptable form(s) of pretreatment include, at a minimum, sumps and traps for inlets, sump boxes with traps downstream of trench drains, and filter strips for overland flow. The designer is referred to **Section 4.10** ☛ p. 148, Pretreatment, for more information on design standards for pretreatment systems.
9. Screening:
    a. Gutters and downspouts must be fitted with leaf/debris screens along the entire length of the gutter leading to the cistern tank. Leaf/debris screens must be made from a corrosion-resistant material with screen openings in the range of 0.25 inches to 0.50 inches. Leaf screens must be inspected on a regular basis to prevent accumulated leaves and debris from clogging the gutter openings.
    b. All inlets and vents to a cistern must be protected by 1/6-inch stainless steel mesh screens, which keep insects, vermin, leaves and other debris from entering the cistern.

10. First-flush diverter:
    a. Approximately one to two gallons of water per 100 square feet of roof collection surface must be diverted to the first-flush chamber instead of the cistern tank.
    b. Once the first-flush chamber is full, the remainder of the stormwater is directed to the cistern tank. A slow-release control valve or drip system is typically included in the design to empty the first-flush chamber automatically in between storm events.
    c. The first-flush diverter system must include an accessible cleanout.

Inlet control design standards

11. The designer is referred to **Section 4.11** ☛ p. 166, Inlet Controls, for information on design standards for inlet control systems.

Storage area design standards

12. The storage area must provide adequate storage for the Water Quality Volume (WQv) between the overflow elevation and the controlling low flow orifice elevation. If the water reuse demand is less than the WQv, and only a portion of the WQv drains down or is withdrawn in 72 hours, only that portion of volume will be considered for compliance, and the remainder of the WQv must be managed by an additional SMP in series. The designer is referred to **Section 3.2.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-2-stormwater-management-design#3.2.3 for information on using SMPs in series. Any portion of the storage that will not drain down or be withdrawn within 72 hours must be excluded from the system's storage volume estimation.
13. When SMPs are used in series, the storage areas for all SMPs must provide cumulative static storage for the WQv, but there is no minimum storage requirement for each individual SMP used in series.
14. Cisterns can be designed with additional storage beyond the WQv and with outlet controls that allow all remaining applicable Stormwater Regulations to be met.
15. Opportunities and areas where water can be reused to meet indoor use needs must be identified. The rate at which water can be reused must be estimated. If the process of reuse is proposed to meet the Water Quality requirement, the WQv must be used in the first 72 hours after the storm event. Detailed calculations to demonstrate the anticipated daily, 72-hour, and monthly water use must be provided. For toilet use, volume must be calculated based on the number of flushes per day multiplied by gallons per flush.
16. When cisterns are used to support on-site reuse, additional volume may be required (in addition to that required for Water Quality). A rough estimate may be obtained by performing a weekly water balance of rainfall and water reuse. Table 4.5-1 below lists average monthly rainfall amounts at the Philadelphia International Airport. The difference on a weekly basis between rainfall depth and water depth needed must be estimated. This deficit must be multiplied by the roof drainage area to obtain an estimate of the cistern volume needed. The designer may choose to do more rigorous analysis using a long-term daily or hourly rainfall record, or a drier than average year.

Table 4.5-1: Average monthly rainfall at the Philadelphia International Airport table

Month	Average precipitation (inches)	Average temperature (°F) high	Average temperature (°F) low	Potential evaporation (inches per month)
January	3.3	39.2	24.4	2.1
February	2.9	42.1	26.1	2.1
March	3.6	50.9	33.1	2.1
April	3.4	63	42.6	4.5
May	3.5	73.2	52.9	5.4
June	3.6	81.9	61.7	6.3
July	4.1	86.4	67.5	6.6
August	4.3	84.6	66.2	5.7
September	3.4	77.4	58.6	4.2
October	2.8	66.6	46.9	2.7
November	3.0	55	37.6	2.1
December	3.3	43.5	28.6	2.1

17. Cisterns must be watertight and must be sealed using a water-safe, non-toxic substance.
18. Bedding and foundations:
    a. Cistern storage areas must be adequately bedded with stone to prevent settling or subsidence.
    b. Bedding thickness must vary according to system requirements but must not be less than six inches.
    c. Over-excavation and replacement of loose or unstable subsurface material may be required if these conditions are encountered. A geotechnical engineer or other appropriate design professional must be consulted for additional guidance.
    d. Foundations/footers must be provided as warranted by system loading, geotechnical conditions, and manufacturer's recommendations. Foundation designs must be performed by an appropriate design professional.
19. The storage design must account for the potential loading from vehicles, as appropriate, based on expected maximum active loading, including consideration for emergency vehicles.

Outlet control design standards

20. Cisterns must provide for overflow or bypass of large storm events. The overflow from cisterns can occur through a hose, weir, pipe, or other mechanism. Overflow conveyance must have a capacity equal to or greater than the inflow pipe(s) and have a diameter and slope sufficient to drain the cistern while maintaining an adequate freeboard height. The overflow conveyance must be screened to prevent access to the cistern by small mammals and birds. The discharge from the overflow must be directed to an acceptable flow path that will not cause erosion. The outlet of the cistern to the pump is typically provided by a floating screened suction device on a hose.
21. The designer is referred to **Section 4.12** ☛ p. 182, Outlet Controls, for additional information on design standards for outlet control systems.

Inspection and maintenance access design standards

22. Cleanouts, manholes, access panels and other access features must be provided to allow unobstructed and safe access to SMPs for routine maintenance and inspection of inflow, outflow, underdrains, and storage systems.
23. Access features for subsurface cisterns:
    a. Access features must be provided for all subsurface cisterns.
    b. A sufficient number of access points in the system must be provided to efficiently inspect and maintain the storage area.
    c. For cast-in-place vault systems, access features must consist of manholes or grated access panels or doors. Grated access panels are preferred to maintain airflow.
    d. For manufactured systems, the manufacturer's recommendations must be followed.
    e. Ladder access is required for vaults greater than four feet in height.
    f. The access opening must be installed in such a way as to prevent surface or groundwater from entering through the top of any fittings, and it must be secured/locked to prevent unwanted entry.

4.5.4 Cistern material standards

Pretreatment material standards

1. The designer is referred to **Section 4.10** ☛ p. 148, Pretreatment, for information on materials standards for pretreatment systems.

Inlet control material standards

2. The designer is referred to **Section 4.11** ☛ p. 166, Inlet Controls, for information on material standards for inlet control systems.

Storage area material standards

3. Cisterns may be constructed of fiberglass, concrete, plastic, brick, or other materials. Subsurface cisterns may be poured concrete or prefabricated plastic tanks like septic tanks. Pre-manufactured tanks should have a watertight rating as issued by the tank manufacturer. Non-galvanized steel, wood, or other products prone to environmental corrosion/decay are not approved for use. Other material types may be approved for use on a case-by-case basis.
4. Proprietary products that store water in a variety of structures are also available. Some of these are designed to bear the weight of vehicles. With the addition of an impervious liner, many of the designs discussed in **Section 4.4** ☛ p. 64, Subsurface Infiltration, and **Section 4.8** ☛ p. 118, Subsurface Detention, can be modified to serve as reuse systems.
5. Cisterns must be opaque or otherwise shielded to prevent the growth of algae.

Outlet control material standards

6. The designer is referred to **Section 4.12** ☛ p. 182, Outlet Controls, for information on material standards for outlet control systems.

Inspection and maintenance access material standards

7. Cleanouts must be made of material with a smooth interior having a minimum inner diameter of six inches. If the connecting pipe is eight inches in diameter or larger, then the cleanout must be eight inches in diameter.
8. The first-flush diverter system must include an accessible cleanout.
9. Serviceways must consist of manhole openings with lockable manhole covers. Depending on the size of the cistern, multiple serviceway openings are recommended to support inspection, repair, and cleaning.

4.5.5 Cistern construction guidance

Proper construction of cisterns is essential to ensure long-term functionality and reduce long-term maintenance needs. A standard construction sequence for proper cistern system installation is provided below. This can be modified to reflect different cistern system applications or expected site conditions.

1. Install temporary flow diversion.
2. Install cistern as per manufacturer's guidelines or design professional's specifications. For subsurface cisterns, the designer is referred to Construction Guidance in **Section 4.8** ☛ p. 118, Subsurface Detention.
3. Install downstream SMPs, if applicable.
4. Install outlet control systems as per manufacturer's guidelines or design professional's specifications. The designer is referred to **Section 4.12** ☛ p. 182 for Outlet Controls construction guidance.
5. Install pretreatment systems and inlet controls as per manufacturer's guidelines or design professional's specifications. Use temporary flow diversion or inlet protection to restrict runoff from unstabilized areas to reach the cistern. The designer is referred to **Section 4.11** ☛ p. 166 for Inlet Controls construction guidance.
6. Once site is permanently stabilized, remove temporary flow diversion and/or erosion and sediment control measures to allow stormwater flow to the cistern.



An example of a subsurface cistern installation in Philadelphia

4.5.6 Cistern maintenance guidance

Maintenance of cisterns focuses on the periodic removal of sediment and debris from pretreatment and storage areas. Sediment removal from tanks and pipes is typically conducted using vacuum or flushing systems. Guidance on the use and operation of vacuum or flushing sediment removal equipment is beyond the scope of this Manual; a maintenance professional should be contacted for additional details. As applicable, cistern maintenance procedures must meet Occupational Safety and Health Administration confined space entry requirements.

General recommended maintenance activities for cisterns are summarized in Table 4.5-2.

Table 4.5-2: Cistern maintenance guidelines

Early maintenance activity	Frequency
Inspect inlet structures, outlet structures, and storage areas for trash and sediment accumulation.	Monthly for the first year after installation to determine ongoing maintenance frequency

Ongoing maintenance activity	Frequency
Regularly clean out gutters, gutter screening, first-flush chamber, and catch basins to reduce sediment load to the cistern. Clean intermediate sump boxes, replace filters, and otherwise clean pretreatment areas in directly connected systems.	As needed
Remove sediment and debris from cisterns according to the manufacturer's recommendations or the site-specific maintenance plan.	As needed
Test sediment for toxicants in compliance with current disposal requirements if land uses in the catchment include commercial or industrial zones, or if indications of pollution are present.	As needed
Brush the inside surfaces and thoroughly disinfect.	Annually
Prior to freezing weather, to avoid structural damage perform winterization of cisterns as per manufacturer's requirements or design professional's specifications.	Annually
Inspect cistern and control structures.	Quarterly
Remove floating debris and accumulated petroleum products from system and all components.	Quarterly
Maintain records of inspections and maintenance activity.	Ongoing

Periodic inspections and maintenance of cisterns must be conducted by a qualified professional. Maintenance requirements for cisterns that are part of rainwater harvesting systems vary according to reuse. Detailed maintenance guidance for rainwater harvesting systems is beyond the scope of this Manual.

The designer is referred to **Section 4.10** ☛ p. 148, Pretreatment, **Section 4.11** ☛ p. 166, Inlet Controls, and **Section 4.12** ☛ p. 182, Outlet Controls, for information on maintenance guidance for pretreatment, inlet controls, and outlet controls.

4.6 Blue Roofs

Download summaries of this SMP and its maintenance guidance, with quick reference information for clients and developers:

- **Blue Roofs SMP One-Sheet** ☛ water.phila.gov/wp-content/uploads/files/blue-roofs-smp-one-sheet.pdf
- **Blue Roof Maintenance Guidance One-Sheet** ☛ water.phila.gov/wp-content/uploads/files/blue-roof-maintenance-guidance.pdf

4.6.1 Blue roof introduction

Blue roofs, also known as controlled flow roof drain systems, are detention stormwater management practices (SMPs) that provide temporary storage and slow release of rainwater on a rooftop. Blue roof systems are an effective practice for controlling runoff from buildings with flat or mildly sloped roof surfaces. On blue roofs, water is temporarily detained on the roof surface using rooftop check dams or roof drain restrictors. In all cases, outflow is controlled using orifices prior to discharge, which is typically directed to the building's storm drains, scuppers, or downspouts.

Quick tip

Required blue roof design and material standards are denoted in this section by easy-to-reference numerals.

Since blue roofs function through detention and slow release alone, they neither add nor remove contaminants from stormwater; however, in a combined sewer area, they are acceptable pollutant-reducing practices for non-infiltrating Water Quality compliance. Blue roofs may also enable compliance with all remaining applicable Philadelphia Water Department (PWD) Stormwater Regulations (Stormwater Regulations), depending on outlet control sizing and structural and feasibility constraints. The designer is referred to **Section 3.2.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-2-stormwater-management-design#3.2.3 for information on using SMPs in series.

The design of blue roofs is not limited to the examples shown within this text. Successful stormwater management plans will combine appropriate materials and designs specific to each site.



An example of a blue roof in Philadelphia

When can blue roofs be used?

In combined sewer areas where infiltration is not feasible, blue roofs can be used to meet Water Quality release rate and pollutant-reducing requirements.

A blue roof can be considered for installation on a fully built-out or highly-constrained site. They can be installed on many types of roofs, including terraces, high-rise building roofs, and low podium or at-grade on-structure installations.

Blue roofs can also be installed as a Stormwater Retrofit on existing buildings with flat, mildly sloped, or terraced roofs after confirmation of adequate structural loading capacity, waterproofing, and protection of rooftop utilities.

Key advantages of blue roofs

- Manage stormwater runoff without occupying surface-level space
- Well-suited for sites at which roofs make up a large fraction of the total impervious area and for sites with ground-level space constraints
- Typically require no additional sewer connections besides the ones already provided for the building
- Easy to install if structural and waterproofing requirements are met
- Readily coupled with other SMPs, such as green roofs
- Can cost less than other SMPs
- Require no excavation
- Can provide educational benefits, especially when used at public and/or highly visible sites such as schools, recreation centers, libraries, etc.

- Assume less risk for projects within the floodplain

Key limitations of blue roofs

- Require regular inspection and maintenance of roof surface and roof drains, especially following high winds, as algae and debris can develop around roof drains and limit the rate of discharge
- Require strict adherence to regularly scheduled inspections because the maintenance needs are not easily visible
- May have limited storage capacity with slopes greater than 2%, likely necessitating installation of roof check dams and/or terraces to meet release rate requirements
- May result in increased cost or limited Stormwater Retrofit opportunities for existing buildings and structures due to additional loading associated with ponded water on roof
- Offer limited benefit on sites where roof area makes up only a small fraction of the total impervious area
- Do not improve aesthetics or provide the ancillary environmental benefits associated with vegetated SMPs, such as habitat creation and improved air quality

Key design considerations for blue roofs

- Blue roof systems utilizing controlled flow roof drains generally require flat or nearly flat roofs (e.g., less than 2% slope). It may be feasible to use check dams when slopes are higher than 2%.
- All building mechanical systems, roof furniture, and other appurtenances installed on the roof should not be compromised by roof ponding during rain events and should not cause damage to the roof membrane.
- Blue roof drains should be located away from overhead trees, if possible, to prevent leaf litter that would result in the clogging of the drains and additional or prolonged ponding on the rooftop.
- In order to prevent damage to the waterproofing membrane, access to the roof should be limited to maintenance needs only. Pedestal pavers can be used to separate the blue roof from the walking surface.
- It is recommended that an easily accessible vantage point be created to facilitate visual inspection of the blue roof system after rain events. If the storage volume has not drained within the intended drain down time, a more thorough inspection of the roof surface and/or outlet controls should be performed.
- For any blue roof that discharges onto an adjacent property, a drainage easement may be required and is recommended.

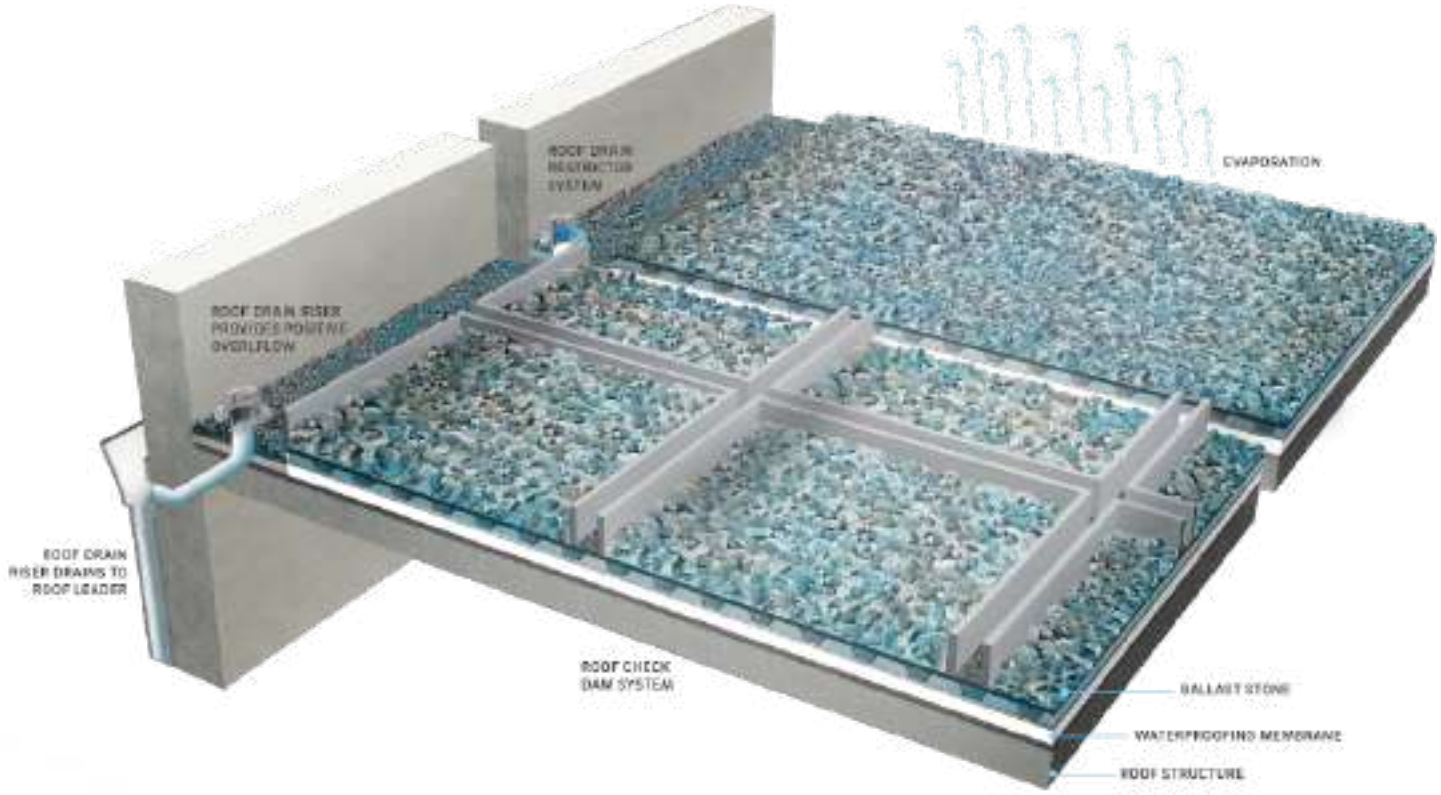
Blue roof types

On roofs with a parapet, ***roof drain restrictor systems*** detain water on the roof, with eventual discharge to the existing roof drain.

Roof check dam systems detain rainwater on rooftops or sections of rooftops without a parapet to increase storage volumes over roof areas with greater than 2% slope. These dams create temporary ponding areas during rain events before slowly discharging to the roof drain.

4.6.2 Blue roof components

Figure 4.6-1: Blue roof with typical features



Inlet control component

Blue roofs that receive direct (1:1) rainfall only do not have inlet controls. For blue roofs that receive runoff from adjacent roof directly connected impervious area (DCIA), including additional roof levels, inlet control systems convey and control the flow of stormwater from the contributing catchment area to the SMP. The designer is referred to **Section 4.11** ☛ p. 166, Inlet Controls, for more information on inlet controls.

Storage area component

Blue roof storage areas temporarily hold stormwater until it can either evaporate or be released downstream at a controlled rate. The area dedicated to storage is dependent on the chosen blue roof system type.

Storage in *roof drain restrictor systems* is determined by the roof slope and geometry relative to the height of both the restrictors and parapets. The bulk volume occupied by all building mechanical systems, roof furniture, and appurtenances must also be factored into the storage volume calculations.

Storage in *roof check dam systems* is determined by the roof slope and associated area dedicated to ponding behind the dams. The bulk volume occupied by all building mechanical systems, roof furniture, and appurtenances must also be factored into the storage volume calculations

Blue roof storage areas are underlain by a waterproofing membrane. Numerous waterproofing membrane systems exist, including modified bitumen roofing (MBR), waterproof types of single-ply roofing, metal roof panels, spray polyurethane foam roofing, synthetic rubber membranes, thermoplastic membranes, and liquid-applied (including polyurethane-based and polymer-modified bituminous products) roofing. While high quality MBR systems (multiple MBR sheets tiled to reduce seam susceptibility) are suitable for blue roof usage, lower quality MBR systems (multiple layers of asphaltic sheets) are not recommended due to their seams that allow water to penetrate.

The durability and lack of seams achievable with a hot fluid applied, rubberized asphalt, fabric reinforced roofing system is well-suited for blue roofs. Cold liquid-applied systems are equally effective due to strict regulations on the use of the propane-fired devices for hot fluid systems.

Outlet control component

Outlet controls within a blue roof system can provide a range of functions, including the following:

- Meeting drain down time requirements;
- Controlling the rate of discharge from the SMP and limiting water surface elevations during various storm events; and/or
- Bypassing of flows from large storm events.

Outlet controls may include orifices, weirs, roof restrictors, risers, or impervious liners. The designer is referred to **Section 4.12** ☛ p. 182, Outlet Controls, for more information on outlet controls.

Roof drain restrictor blue roofs use a roof drain restrictor that is placed over the roof drain. These devices restrict flow through an orifice within the drain assembly, causing temporary ponding on the roof. They are typically purchased commercially through a manufacturer. Alternatively, a manufacturer can customize an orifice size for a specific development. The number and sizing of weirs and orifices are based on a predetermined relationship between the water depth approaching the drain and the flow rate entering the drain. The overflow mechanism of the device determines the maximum ponding depth.

For roof check dam systems, perforated aluminum T-section dams have been used to retain and slow-release rainwater. These inverted T-sections are weather sealed and secured to the roof structure, creating ponding areas behind the dam. Perforations in the dam allow for slow release. If not commercially available, these dams can be easily fabricated.

Inspection and maintenance access component

Safe and easy inspection and maintenance access to all major components within a blue roof system is critical to ensuring long-term performance. Dependent on roof height and slope, blue roof inspection and maintenance access components may consist of permanent or temporary safety monitoring systems, guardrail and safety net systems, warning line systems, and/or personal fall arrest systems. Inspection and maintenance access systems for blue roofs may also include long-term leak detection systems for locating and managing leaks.

4.6.3 Blue roof design standards

General design standards

1. Structural loading must be considered for all blue roof designs, and blue roof design must be coordinated with a licensed structural engineer for both new building construction and retrofits to existing structures.
2. The maximum allowable surface ponding depth is four to six inches. This will depend on loading capacity of the roof; six inches represents roughly 32 pounds per square foot of dead load.
3. The maximum allowable drain down time is 72 hours after the 24-hour storm event.
4. Positive overflow must be provided for large storm events, up to and including the 100-year, 24-hour storm event, or, if the project is exempt from Flood Control, the ten-year, 24-hour storm. Overflow structures and pipes must be designed to convey at least the ten-year, 24-hour storm.
5. Blue roof storage areas must be underlain by a waterproofing membrane.

Inlet control design standards

6. The designer is referred to **Section 4.11** ☛ p. 166, Inlet Controls, for information on design standards for inlet control systems.

Storage area design standards

7. The storage system must provide adequate storage to control release rates to meet all applicable Stormwater Regulations. The designer is referred to **Section 3.2.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-2-stormwater-management-design#3.2.3 for information on using SMPs in series.
8. Designed storage capacity for blue roofs must account for structural and feasibility constraints. Connection to other SMPs can provide additional storage, if necessary.
9. A porosity of 0.40 must be used for ballast stone.
10. On roofs without ballast, designers must ensure that enough weight is provided to secure the waterproofing membrane. On roofs with ballast, designers must consider the depth and porosity of the ballast when calculating the potential storage volume.

Outlet control design standards

11. Roof drain restrictors must be sized according to the desired release rate and ponding depth.
12. The designer is referred to **Section 4.12** ☛ p. 182, Outlet Controls, for information on design standards for outlet control systems.

Inspection and maintenance access design standards

13. Safe access to blue roofs must be provided for periodic cleaning, inspection, and maintenance by trained building personnel. Easy access must be provided to each of the outlet controls, low-flow discharge points, and overflow connections to permit removal of debris under saturated conditions.
14. Seams, corners, penetrations, mounts or platforms for mechanical utilities, and any other areas of the roofing membrane where risk of leakage is highest, must be inspected for damage or failure and repaired in a manner consistent with the membrane material.

4.6.4 Blue roof material standards

Inlet control material standards

1. The designer is referred to **Section 4.11** ☛ p. 166, Inlet Controls, for information on material standards for inlet control systems.

Storage area material standards

2. Stone:
    a. Stone or gravel used for ballast within the stormwater storage area must be uniformly graded, clean-washed stone, either crushed or smooth. PWD defines “clean-washed” as having less than 0.5% wash loss, by mass, when tested per the Association of State Highway and Transportation Officials (AASHTO) T-11 wash loss test. AASHTO No. 3 and No. 57 stone can meet this specification.
    b. Stone size must exceed the mesh size of the outlet control screen or slots. Ballast stone typically falls within the size range of 3/8 inch to 2 inches.
    c. Ballast must meet all American Society of Testing and Materials (ASTM) D1863 requirements for mineral aggregate used on built-up roofs.
    d. Other materials may be allowable pending PWD approval.
3. Waterproof membrane:
    a. PVC, EPDM, and thermal polyolefin (TPO) are permitted.
    b. All waterproof membranes must meet appropriate ASTM specifications. PVC membranes must meet ASTM D4434 requirements, EPDM membranes must meet ASTM D4637 requirements, and TPO membranes must meet ASTM D6878 requirements.
    c. Waterproofing membrane must be fully waterproof with properly sealed seams, corners, and protrusions to prevent any intrusion of standing water above the membrane.
    d. Roofing membranes must meet all building code requirements and guidelines of the City of Philadelphia.

Outlet control material standards

4. The designer is referred to **Section 4.12** ☛ p. 182, Outlet Controls, for information on material standards for outlet control systems.

4.6.5 Blue roof construction guidance

Proper construction of blue roofs is essential to ensure long-term functionality and reduce long-term maintenance needs. Blue roof systems are best installed by experienced roofing contractors with expertise in installing flat roof membranes over new or existing roof structures. A standard construction sequence for proper blue roof system installation is provided below. This can be modified to reflect different blue roof system applications or expected site conditions.

1. Install waterproof membrane along the roof and parapet wall to a height at least six inches above the peak ponding elevation as per the SMP designs.
2. Inspect for any irregularities that will interfere with drainage.
3. Seal all edges, seams, corners, protrusions, and other anomalies in a watertight manner consistent with the installation specifications of the membrane manufacturer.
4. Install outlet controls in a manner consistent with the City's Building and Plumbing Codes and guidelines. The designer is referred to **Section 4.12** ☛ p. 182 for information on sizing and installation of outlet control systems. Outlet systems must include a bypass/overflow mechanism to permit rapid discharge when the storage volume of the blue roof system is exceeded.

4.6.6 Blue roof maintenance guidance

Maintenance of blue roof systems focuses on the periodic removal of sediment and debris from outlet and storage areas in order to prevent clogging and limit deterioration of the roof membrane. Maintenance activities can generally be performed by individual building owners or site maintenance staff as needed. The contractor responsible for the installation of the rooftop system should be contacted immediately if it is not performing as designed.

Maintenance of roof assembly and waterproofing membrane will be dependent on the assembly type, age, and quality of roof components. As with any roof system, periodic inspections should be performed to assure that repair or replacement is not necessary.

Blue roof components are relatively easy to maintain due to their simplicity and ease of access. In both the roof check dam and roof drain restrictor systems, maintenance activities are readily conducted at the roof surface. All restrictors and ponded areas must be accessible for periodic inspection and cleaning.

Problems with a blue roof system generally fall into two categories: (1) the system drains too slowly, resulting in buildup of excess water on the roof for extended periods of time, bypasses of the controlled flow roof drains, or bypasses/overflows during small rainfall events; or (2) the system drains too quickly, due to leaking or other issues, exceeding the design drain down rate. If problems persist, a licensed professional should be consulted.

General recommended maintenance activities for blue roof systems are summarized in Table 4.6-1.

Table 4.6-1: Blue roof maintenance guidelines

Early maintenance activity	Frequency
Inspect outlet structures, and storage areas for trash and sediment accumulation.	Monthly for the first year after installation to determine ongoing maintenance frequency

Ongoing maintenance activity	Frequency
Remove debris from drainage outlets and outlet screens to prevent clogging.	During inspections or as needed to ensure performance
Remove debris from secondary drainage/overflows.	During inspections or as needed to ensure performance
Remove excessive buildup of sediment around the outlet controls or within the storage cells.	During inspections or as needed to ensure performance
Inspect for leaks.	During inspections or as needed to ensure performance
Break up ice formation around outlets and overflows.	As needed during winter months
Maintain records of all inspections and maintenance activity.	Ongoing

The designer is referred to **Section 4.12** ☛ p. 182, Outlet Controls, for information on maintenance guidance for outlet controls.

4.7 Ponds and Wet Basins

Download summaries of this SMP and its maintenance guidance, with quick reference information for clients and developers:

- **Ponds and Wet Basins SMP One-Sheet** ☛ water.phila.gov/wp-content/uploads/files/ponds-wet-basins-smp-one-sheet.pdf
- **Pond and Wet Basin Maintenance Guidance One-Sheet** ☛ water.phila.gov/wp-content/uploads/files/pond-wet-basin-maintenance-guidance.pdf

4.7.1 Pond and wet basin introduction

Ponds and wet basins are earthen depressions constructed with a substantial permanent water pool to provide both temporary and long-term storage of stormwater runoff, and they can be used to attenuate peak flows and provide Water Quality treatment through both pollutant removal and slow release. These stormwater management practices (SMPs) attenuate peak flows through the use of an outlet control structure and provide storage capacity above the permanent pool, while water held within the system, including the permanent pool, is treated through a variety of physical, chemical, and biological processes. Wet basins can also achieve minimal volume reduction through evapotranspiration.

Wet basins are relatively effective at removing many common stormwater pollutants including suspended solids, heavy metals, total phosphorus, total nitrogen, and pathogens. The pollutant removal effectiveness varies by season and may be affected by the age of the wet basin. Detention basins are similar in function to ponds and wet basins with the exception that they lack these water quality benefits and are primarily used for peak rate control and extended detention.

Quick tip

Required pond and wet basin design and material standards are denoted in this section by easy-to-reference numerals.

Design of ponds and wet basins is not limited to the examples shown within this text. Successful stormwater management plans will combine appropriate materials and designs specific to each site.



An example of a wet basin in Philadelphia

When can ponds and wet basins be used?

Ponds and wet basins are capable of managing runoff in a variety of different settings, provided there is adequate space available for the SMP. They require a connection with shallow groundwater or a sufficient source of inflow to maintain the permanent pool.

Key advantages of ponds and wet basins

- Can be effective at providing Water Quality requirement treatment and flow attenuation while also providing aesthetic amenities and wildlife habitat
- Can easily be converted from a dry detention basin
- Can contribute to better air quality and help reduce urban heat island impacts
- Can provide educational benefits, especially when used at public and/or highly visible sites such as schools, recreation centers, libraries, etc.

Key limitations of ponds and wet basins

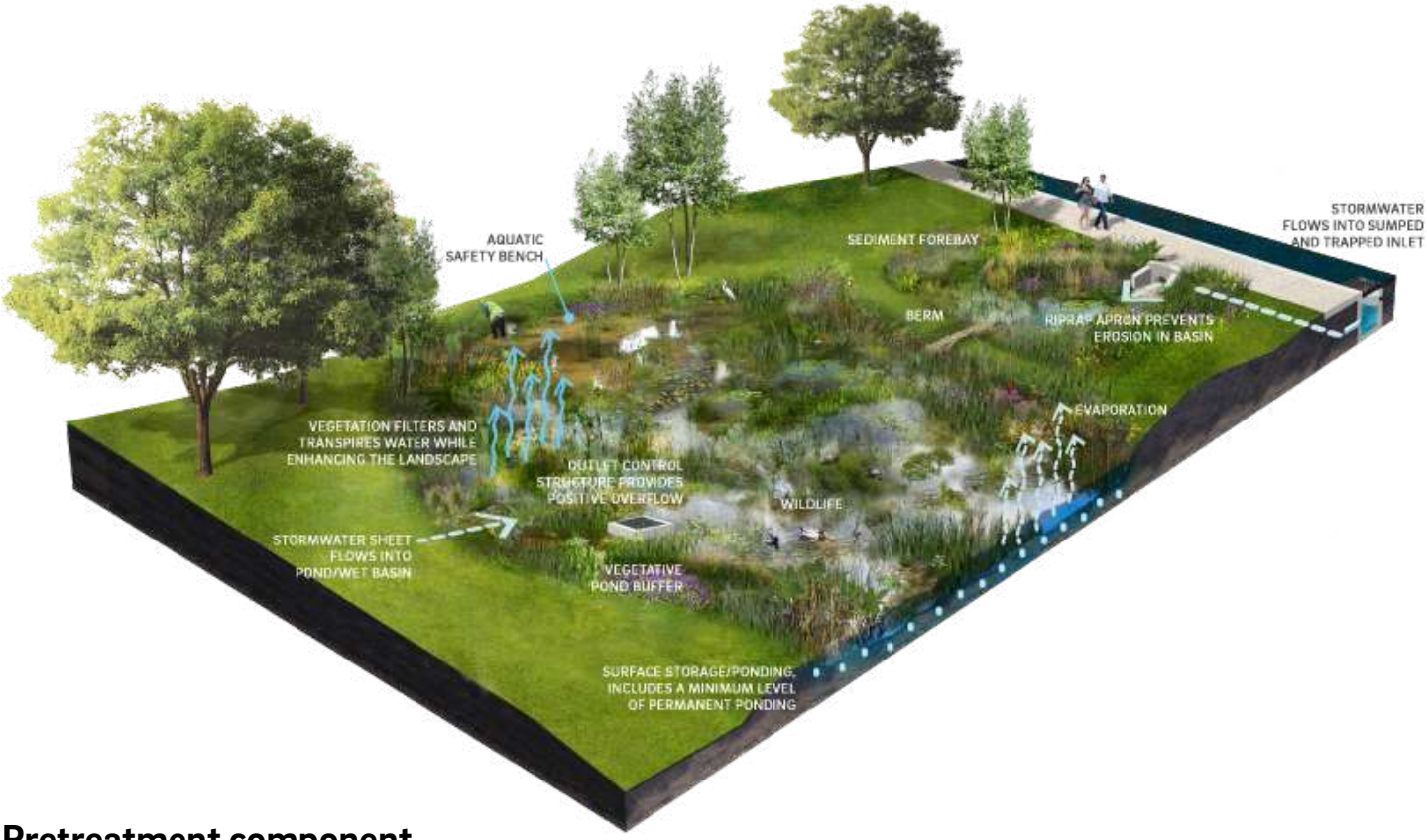
- Require a dedicated, large ground surface area
- May contain deep water, which can pose a safety hazard and may require fencing to restrict access
- Can sometimes attract geese and other wildlife that may conflict with the intended site use of surrounding areas
- Can provide a mosquito breeding habitat along shallow edges if not designed appropriately

Key design considerations for ponds and wet basins

- A berm placed on the downslope side of a mild slope can function as a forebay, helping retain stormwater and increasing capacity without additional excavation. The designer is referred to **Section 4.10** ☛ p. 148, Pretreatment, for more information on forebays.
- Secondary benefits, such as wildlife viewing areas and walking paths, can be incorporated into wet basin designs to enhance their value.
- Robust and diverse vegetation should be used along the perimeter of the pond to provide a buffer from surrounding areas.
- Smart plant selection for the site should be a focus. It is critical that plant materials are appropriate for soil, hydrologic, light, and other site conditions. The designer is referred to the list of native species in **Appendix I** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists. Ponding depth, drain down time, sunlight, salt tolerance, and other conditions should be taken into consideration when selecting plants. Turf grass is generally not recommended but may be acceptable provided the designer can demonstrate that it meets all applicable requirements. The designer is referred to **Section 4.13** ☛ p. 218, Landscaping, for additional landscaping guidance.
- For any pond or wet basin that discharges onto an adjacent property, a drainage easement may be required and is recommended.

4.7.2 Pond and wet basin components

Figure 4.7-1: Ponds and wet basins with typical features



Pretreatment component

Pretreatment systems capture trash, sediment, and/or other pollutants from stormwater runoff before delivery to the storage area. Pretreatment needs will vary significantly depending on the contributing drainage area composition and use. Pretreatment can include structures such as sumped and trapped inlets, sediment/grit chambers or separators, media filters, inlet inserts, or other appropriate prefabricated or proprietary designs to remove sediment, floatables, and/or hydrocarbons from stormwater runoff prior to introduction to a pond or wet basin. While inlet hoods are preferred, permanent filter bags may be accepted for Stormwater Retrofit projects where existing inlets do not have hoods and inlet reconstruction is not feasible. In addition to sumped and trapped inlets, permanent filter bag inserts are required for sites that generate pollutants such as loading docks, material storage facilities, junk yards, and waste collection and disposal sites. Permanent filter bags will require frequent cleanings.

Pretreatment can also consist of filter strips, forebays, and swales. The designer is referred to **Section 4.10** ☛ p. 148, Pretreatment, for more information on pretreatment systems.

Inlet control component

Inlet control systems convey and control the flow of stormwater from the contributing catchment area to a pond or wet basin. Inlet control needs will vary depending on the design of stormwater conveyance systems and the site layout. The designer is referred to **Section 3.4.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-4-how-to-show-compliance#3.4.2 for guidance on stormwater conveyance system design.

Inlet controls may include flow splitters, curbless design/curb openings, energy dissipaters, and inlets. The designer is referred to **Section 4.11** ☛ p. 166, Inlet Controls, for more information on inlet controls.

Storage area component

Storage areas within ponds and wet basins temporarily hold stormwater runoff until it can either evaporate, be used by plants through evapotranspiration, or be released downstream at a controlled rate, depending on the system design. The storage component of a pond or wet basin is provided typically by either excavating an area to create a depression, or by constructing berms around a low-lying area to create an impoundment. Ponding time provides water quality benefits by allowing larger debris and sediment to settle out of the water.

Storage areas within ponds and wet basins are designed with aquatic/safety benches. An aquatic/safety bench is a shallow, graded area that extends inward from the perimeter of the permanent pool boundary. This bench provides valuable wildlife habitat area and helps to minimize safety risks associated with the permanent pool by providing a shallow perimeter zone.

A pond buffer should extend outward from the permanent pool boundary in order to enhance habitat potential, improve aesthetics, reduce water temperatures, and improve overall pond health.

Vegetation component

Plant material in a pond or wet basin removes nutrients and stormwater pollutants through vegetative uptake and microbial community support, removes water through evapotranspiration, improves aesthetics, provides wildlife habitat, and helps to stabilize soil. Vegetation in and around a pond or wet basin also provides algal control and cooler water temperatures. The designer is referred to **Section 4.13** ☛ p. 218, Landscaping, for more information on landscaping.

Outlet control component

Outlet controls within a pond or wet basin can provide a range of functions, including the following:

- Meeting drain down time requirements;
- Controlling the rate of discharge from the SMP and limiting water surface elevations during various storm events; and/or
- Bypassing of flows from large storm events.

Outlet controls may include orifices, weirs, risers, level spreaders, or impervious liners. The designer is referred to **Section 4.12** ☛ p. 182, Outlet Controls, for more information on outlet controls.

Inspection and maintenance access component

Safe and easy inspection and maintenance access to all major components within a pond or wet basin is critical to ensuring long-term performance. Mildly sloping, stabilized, graded areas can provide access to surface storage areas for heavy equipment, which may be needed for sediment removal.

4.7.3 Pond and wet basin design standards

General design standards

1. The maximum allowable drain down time is 72 hours after the 24-hour storm event.
2. Positive overflow must be provided for large storm events, up to and including the 100-year, 24-hour storm event, or, if the project is exempt from Flood Control, the ten-year, 24-hour storm. Overflow structures and pipes must be designed to convey at least the ten-year, 24-hour storm.
3. The minimum allowable freeboard between the peak storage elevation during the 100-year, 24-hour storm event and the emergency spillway invert elevation is one foot.
4. The minimum allowable distance between the emergency spillway crest elevation and the top-of-berm elevation is one foot.
5. The minimum allowable basin length-to-width ratio is 2:1.
6. The minimum allowable basin width is ten feet.
7. The minimum allowable sediment forebay length is ten feet.
8. The distance between the basin inflow and outflow points must be maximized.
9. A Natural Resources Conservation Service curve number of 98 must be used for the area below the water surface elevation, where required for hydrologic calculations.
10. All areas deeper than four feet must have two aquatic safety benches extending a combined total of 15 feet, at minimum, inward from the perimeter of the basin. One bench must be above the normal water surface elevation and extend up to the pond side slopes at a maximum slope of 10%. The other bench must be below the water surface extending into the pond at a 10% slope to a maximum depth of 18 inches.
11. A dewatering mechanism must be provided for facilities that are not in connection with groundwater.

Pretreatment design standards

12. Acceptable form(s) of pretreatment must be incorporated into design. Pretreatment of runoff from all inlets is required. At a minimum, this can be achieved through the use of sumps and traps for inlets, sump boxes with traps downstream of trench drains, and filter strips for overland flow.
13. The designer is referred to **Section 4.10** ☛ p. 148, Pretreatment, for more information on design standards for pretreatment systems.

Inlet control design standards

14. To prevent erosion, energy dissipaters, such as riprap stone, must be placed at all locations of concentrated inflow. Riprap aprons must be designed, and stone sizing must be determined, in accordance with the riprap apron design procedures in the latest edition of the *Pennsylvania Department of Environmental Protection (PA DEP) Erosion and Sediment Pollution Control Program Manual*.
15. The designer is referred to **Section 4.11** ☛ p. 166, Inlet Controls, for more information on design standards for inlet control systems.

Storage area design standards

16. The storage area must provide static storage for the Water Quality Volume (WQv) between the overflow elevation and the basin's water surface. All permanent pool areas must be excluded from the SMP's storage volume estimation. The minimum allowable ponding depth below the lowest outlet device is three inches.
17. Ponds and wet basins can be designed with additional storage beyond the WQv and with outlet controls that allow all remaining applicable Philadelphia Water Department (PWD) Stormwater Regulations (Stormwater Regulations) to be met.
18. Maximum side slopes for open storage areas as follows:
    a. All – 2(H):1(V) (The recommended side slope is 3(H):1(V))
    b. Mowed- 4(H):1(V) to avoid "scalping" by mower blades
19. A minimum planting soil medium depth of 18 inches must be provided (under emergent planting zones only). The planting soil medium may be composed of on-site soils.

Vegetation design standards

20. Plantings must be designed to minimize the need for mowing, pruning, and irrigation.
21. Plants and trees that are appropriate for, and compatible with, the site conditions must be chosen. The designer is referred to **Section 4.13** ☛ p. 218, Landscaping, for more information on landscaping and **Appendix I** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists for plant lists.
22. Care must be taken to ensure that the ponding area depth is appropriate for the size and species of the plants selected.
23. The planting design must provide for at least 85% cover of the emergent vegetation zone (the area of the pond that is less than 18 inches deep) and buffer area.
24. A vegetated pond buffer must extend outward 25 feet from the permanent pool.
25. Ponds and wet basins must be planted with species tolerant of a range of inundation depths and periods. A wetland ecologist or other appropriate design professional should be consulted for guidance.

Outlet control design standards

26. Energy dissipaters, such as riprap stone, must be placed at the end of the primary outlet to prevent erosion. Riprap aprons must be designed, and stone sizing must be determined, in accordance with the riprap apron design procedures in the latest edition of the *PA DEP Erosion and Sediment Pollution Control Program Manual*.
27. The primary and low-flow outlets must be protected from clogging by an external trash rack.
28. The emergency spillway must not direct flow toward neighboring properties.
29. The designer is referred to **Section 4.12** ☛ p. 182, Outlet Controls, for information on design standards for outlet control systems.

Inspection and maintenance access design standards

30. Stabilized vehicular access must be provided for sediment removal. Areas must be at least nine feet wide, have a maximum slope of 15%, and be stabilized as needed to provide load support for vehicles.

4.7.4 Pond and wet basin material standards

Pretreatment material standards

1. The designer is referred to **Section 4.10** ☛ p. 148, Pretreatment, for information on materials standards for pretreatment systems.

Inlet control material standards

2. The designer is referred to **Section 4.11** ☛ p. 166, Inlet Controls, for more information on material standards for inlet control systems.

Storage area material standards

3. Planting soil medium:
    a. Hydrologic soil groups “C” and “D” are suitable, without modification, for underlying soils.
    b. If natural topsoil from the site is to be used, it must have at least 8% organic carbon content by weight in the A-horizon for sandy soils and 12% for other soil types.
    c. If planting soil is imported, it must be made up of equivalent proportions of organic and mineral materials.

Vegetation material standards

4. Trees and shrubs must be freshly dug and grown in accordance with good nursery practice.
5. Perennials, grass-like plants, and groundcover plants must be healthy, well-rooted specimens.
6. A native grass/wildflower seed mix can be used as an alternative to groundcover planting. Seed mix must be free of weed seeds.
7. Use of invasive plants is not permitted. All plants and trees must be appropriate and compatible with soil, hydrologic, light, and other site conditions. The designer is referred to **Appendix I** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists for plant lists.

Outlet control material standards

8. The designer is referred to **Section 4.12** ☛ p. 182, Outlet Controls, for information on material standards for outlet control systems.

4.7.5 Pond and wet basin construction guidance

Construction of ponds and wet basins often encompasses substantial excavation and grading activities that require careful oversight to ensure appropriate SMP function. Some general construction guidelines are as follows:

1. Pond excavation depths should account for any impervious liners, plant matter, and/or planting soil required.
2. The subsoil must be free of hard clods, stiff clay, hardpan, ashes, slag, construction debris, petroleum hydrocarbons, and other undesirable materials and must not be frozen or in a muddy state.
3. Place impervious liner, if needed, ensuring continuous contact with subgrade. Extreme care should be taken during installation of a geomembrane liner so that no damage is done to any part of the material. Construction equipment, gasoline driven generators, or cans of gas or solvent must not be placed on the geomembrane material. The geomembrane material must not be used as a work area to prepare patches or to store tools and supplies. Temporary wind anchorage by means of sandbags or tires must be provided during geomembrane installation. Nails, rebar, wire ties, or other metal materials shall not be used to hold geomembrane in position. Geomembrane seaming must be performed in accordance with ASTM D7408 (PVC) and ASTM D8580 (LLDPE, PP). Non-destructive and destructive testing of geomembrane seaming must be performed in accordance with ASTM D7700. Mechanical attachment of geomembrane to pipe penetrations or structures must be installed in accordance with ASTM D6497/D6497M-02. Placement of overlying material must be performed in a manner that will not damage the geomembrane. Excessive wrinkling of the geomembrane must be prevented prior to or while covering the geomembrane, ensuring no permanent folds or wrinkles in the liner. Any damage to the geosynthetic material must be repaired immediately.
4. During all phases of work, including transport and on-site handling, the plant materials must be carefully handled and packed to prevent injury and/or desiccation of the plants. Plant material should be kept from freezing and kept moist, cool, and covered so as to protect the plants from any precipitation, wind, and/or sun. Plants must be watered to maintain moist soil and/or plant conditions until accepted.



An example of a wet basin installation in Philadelphia

4.7.6 Pond and wet basin maintenance guidance

Maintenance of ponds and wet basins focuses on the periodic removal of sediment and debris from pretreatment and storage areas and prevention of outlet control clogging.

General recommended maintenance activities for ponds and wet basins are summarized in Table 4.7-1.

Table 4.7-1: Ponds and wet basins maintenance guidelines

Early maintenance activity	Frequency
Water vegetation at the beginning of each day for eight weeks after planting is completed.	Daily for eight weeks after installation
Water vegetation regularly to ensure successful establishment.	Every four days during periods of four or more days without rain, June through August for the 24 months after installation
Inspect vegetation for signs of disease or distress. Treat or replace, as necessary.	Biweekly for the first year after installation
Inspect inlet controls, outlet structures, and storage areas for trash and sediment accumulation. Remove debris and sediment, as necessary.	Monthly for the first year after installation to determine ongoing maintenance frequency

Ongoing maintenance activity	Frequency
Remove trash and debris from forebay, pond, and outlet structure.	As needed
Remove non-target/invasive vegetation.	As needed
Grassed areas require periodic prudent fertilizing, dethatching and soil conditioning.	As needed
Trees, shrubs, and other vegetative cover will require periodic maintenance such as fertilizing, pruning and pest control.	As needed
Mow/trim detention basin vegetation, excluding aquatic bench and buffer.	As needed
Treat basin for mosquito larvae if stagnant water remains for longer than 72 hours.	As needed
Dredge large volumes of sediment and organic debris from basin and forebay areas. Accumulated sediment must never occupy greater than 50% of the forebay volume.	As needed (At least once every five to ten years*)
Inspect outlet control structure for clogging.	Quarterly and after every storm greater than one inch
Replace filter bags for pretreatment devices. Ensure filter bag is installed properly.	Quarterly
Inspect SMP for potential problems, including subsidence, erosion, cracking, or tree growth on the embankment; damage to the emergency spillway; sediment accumulation around the outlet; inadequacy of the inlet/outlet channel erosion control measures; changes in the condition of the pilot channel; and erosion within the SMP and its banks.	Semiannually
Maintain records of all inspections and maintenance activity.	Ongoing
**The frequency of sediment removal depends on site conditions such as soil type and maintenance of site stabilization which influence the sediment load on the SMP.*	

The designer is referred to **Section 4.10** ☛ p. 148, Pretreatment, **Section 4.11** ☛ p. 166, Inlet Controls, **Section 4.12** ☛ p. 182, Outlet Controls, and **Section 4.13** ☛ p. 218, Landscaping, for information on maintenance guidance for pretreatment, inlet controls, outlet controls, and landscaping.

4.8 Subsurface Detention

Download summaries of this SMP and its maintenance guidance, with quick reference information for clients and developers:

- **Subsurface Detention SMP One-Sheet** ☛ water.phila.gov/wp-content/uploads/files/subsurface-detention-smp-one-sheet.pdf
- **Subsurface Detention Maintenance Guidance One-Sheet** ☛ water.phila.gov/wp-content/uploads/files/subsurface-detention-maintenance-guidance.pdf

4.8.1 Subsurface detention introduction

Subsurface detention stormwater management practices (SMPs) are underground structures that are used to temporarily detain and release stormwater. They can include vaults, stone storage, pipe storage, and plastic grid storage.

Subsurface detention SMPs can be combined with other SMPs in series to meet the Philadelphia Water Department (PWD) Stormwater Regulations (Stormwater Regulations). The designer is referred to **Section 3.2.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-2-stormwater-management-design#3.2.3 for information on using SMPs in series.

Quick tip

Required subsurface detention design and material standards are denoted in this section by easy-to-reference numerals.

Design of subsurface detention SMPs is not limited to the examples shown within this text. Successful stormwater management plans will combine appropriate materials and designs specific to each site.



An example of a subsurface detention basin in Philadelphia

When can subsurface detention be used?

Subsurface detention SMPs are suitable on sites where infiltration has been deemed infeasible and space constraints prevent the use of surface-level or rooftop SMPs. Provided that overburden loads and utility conflicts are evaluated, subsurface detention SMPs can be sited beneath lawns, recreational areas, parking lots, and other hardscape surfaces.

Key advantages of subsurface detention

- Manages stormwater runoff without occupying surface or rooftop space
- Can be sited, through flexible design options, beneath lawns, recreational areas, parking lots, buildings, or other impervious areas when space constraints exist
- Allows for easily adaptable footprints that can fit into almost any size space and be integrated into many different site layouts

Key limitations of subsurface detention

- May need to be combined with other SMPs to meet the Water Quality requirement
- Can be more costly and difficult to install and maintain than surface practices like bioretention SMPs
- Require strict adherence to regularly scheduled inspections because the maintenance needs are not easily visible
- Require additional maintenance costs due to access limitations and Occupational Safety and Health Administration (OSHA) requirements
- Does not improve aesthetics or provide the ancillary environmental benefits associated with vegetated SMPs, such as habitat creation and improved air quality

Key design considerations for subsurface detention

- Appropriate pretreatment of runoff should be provided to remove sediment and debris before discharging to a subsurface detention SMP. A pretreatment approach should be developed based on the SMP's expected level of sediment loading and anticipated difficulty of sediment removal.
- Before using subsurface detention to comply with Water Quality release rate requirements, it must be adequately demonstrated that infiltration is not feasible on-site. The designer is referred to **Section 3.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-3-infiltration-testing-and-soil-assessment-for-smp-design for information on infiltration testing requirements.
- Subsurface chambers, crates, or arches can be used to increase void space and reduce SMP footprint; however, long-term maintenance should also be carefully considered when evaluating such systems. Subsurface vaults can be periodically cleaned using vacuum cleaning, whereas it is much more difficult to remove accumulated sediment from stone storage and grid storage systems.
- The SMP and maintenance access should be located in an area where maintenance and potential repairs can be conducted with minimal disturbance to surrounding uses.
- Areas of soil contamination or unstable soils should be avoided; however, in some cases, an impervious liner may be appropriate.
- For any subsurface detention SMP that discharges onto an adjacent property, a drainage easement may be required and is recommended.

Subsurface detention types

Subsurface detention SMPs can be designed in a variety of different ways, but commonly fit into the following four categories:

Underground storage vaults are buried concrete, fiberglass, or polyethylene chambers that temporarily store and release stormwater. The designer is referred to **Section 4.5** ☛ p. 80, Cisterns, for more information on the use of underground storage SMPs for rainwater harvesting.

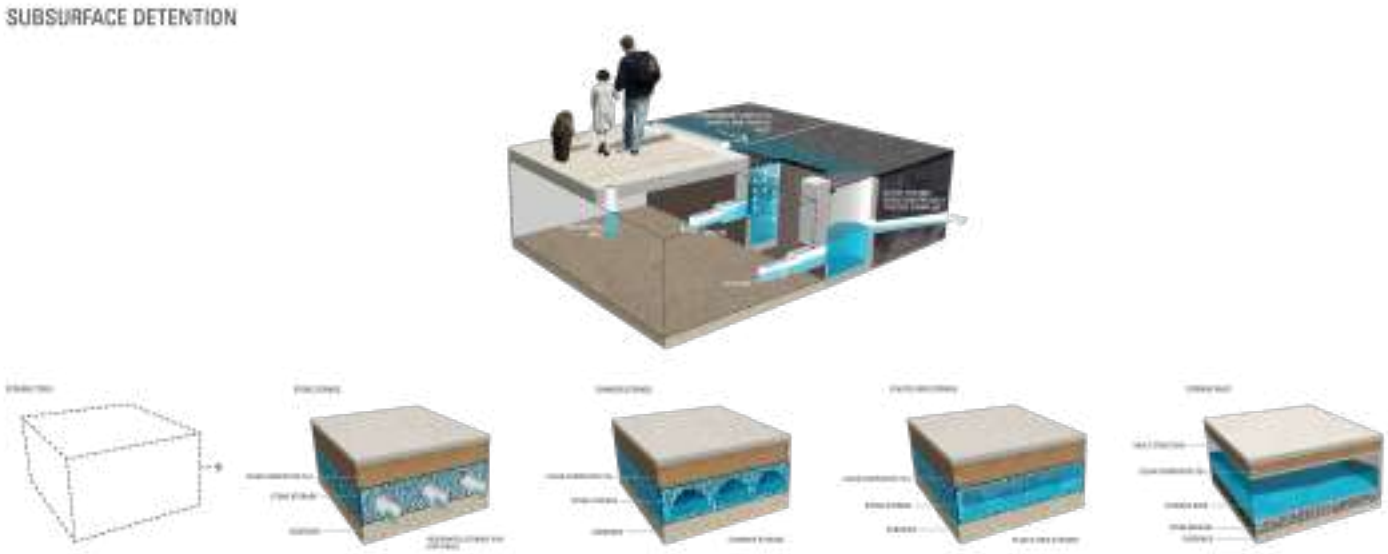
Underground stone storage consists of buried stone beds wrapped in geotextile that temporarily store and release stormwater. Stone storage beds provide the least amount of storage volume per unit area among the subsurface detention types. Removing sediment from underground stone storage is difficult, which necessitates effective pretreatment.

Underground pipe and chamber storage consists of perforated plastic or metal pipes, or pipe-like linear chambers, that are placed in a stone bed to provide more storage per unit volume and temporarily store and release stormwater. Various pipe dimensions and shapes can be used to optimize the storage volume to meet the specific site requirements.

Underground plastic grid storage consists of buried plastic structures that can be stacked and inter-connected to form various shapes and sizes. Grid systems can provide as much as 95% void space for storage of stormwater.

4.8.2 Subsurface detention components

Figure 4.8-1: Subsurface detention with typical features



Pretreatment component

Pretreatment systems capture trash, sediment, and/or other pollutants from stormwater runoff before delivery to the storage area. Pretreatment needs will vary significantly depending on the contributing drainage area composition and use. Pretreatment can include structures such as sumped and trapped inlets, sediment/grit chambers or separators, media filters, inlet inserts, or other appropriate prefabricated or proprietary designs to remove sediment, floatables, and/or hydrocarbons from stormwater runoff prior to being conveyed to a subsurface detention SMP. While inlet hoods are preferred, permanent filter bags may be accepted for Stormwater Retrofit projects where existing inlets do not have hoods and inlet reconstruction is not feasible. In addition to sumped and trapped inlets, permanent filter bag inserts are required for sites that generate pollutants such as loading docks, material storage facilities, junk yards, and waste collection and disposal sites. Permanent filter bags will require frequent cleanings.

Some storage manufacturers have maintenance rows that qualify as pollutant-reducing practices. The designer is referred to this **list of acceptable filter products** ☛ water.phila.gov/development/resources/#media-filter and to **Section 3.1.7** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-1-site-assessment-and-stormwater-management-strategies/#3.1.7 for more information on maintenance rows and pollutant-reducing practices, respectively.

Pretreatment can also consist of filter strips, forebays, and swales. The designer is referred to **Section 4.10** ☛ p. 148 for more information on pretreatment systems.

Inlet controls may include flow splitters, curbless design/curb openings, energy dissipaters, and inlets. The designer is referred to **Section 4.11** ☛ p. 166 for more information on inlet controls.

Storage area component

The storage component of a subsurface detention SMP is typically constructed of a stone-filled bed or trench, which may or may not incorporate pipes, arches, concrete vaults, crates, plastic grids, or other proprietary structures. The void spaces between the stones and/or structures store stormwater until it can be released downstream at a controlled rate.

A permanent pool of water may be incorporated to dissipate energy and improve the settling of particulate pollutants, in which case, the design may be referred to as a "wet underground detention SMP."

Outlet control component

Outlet controls within a subsurface detention SMP can provide a range of functions, including the following:

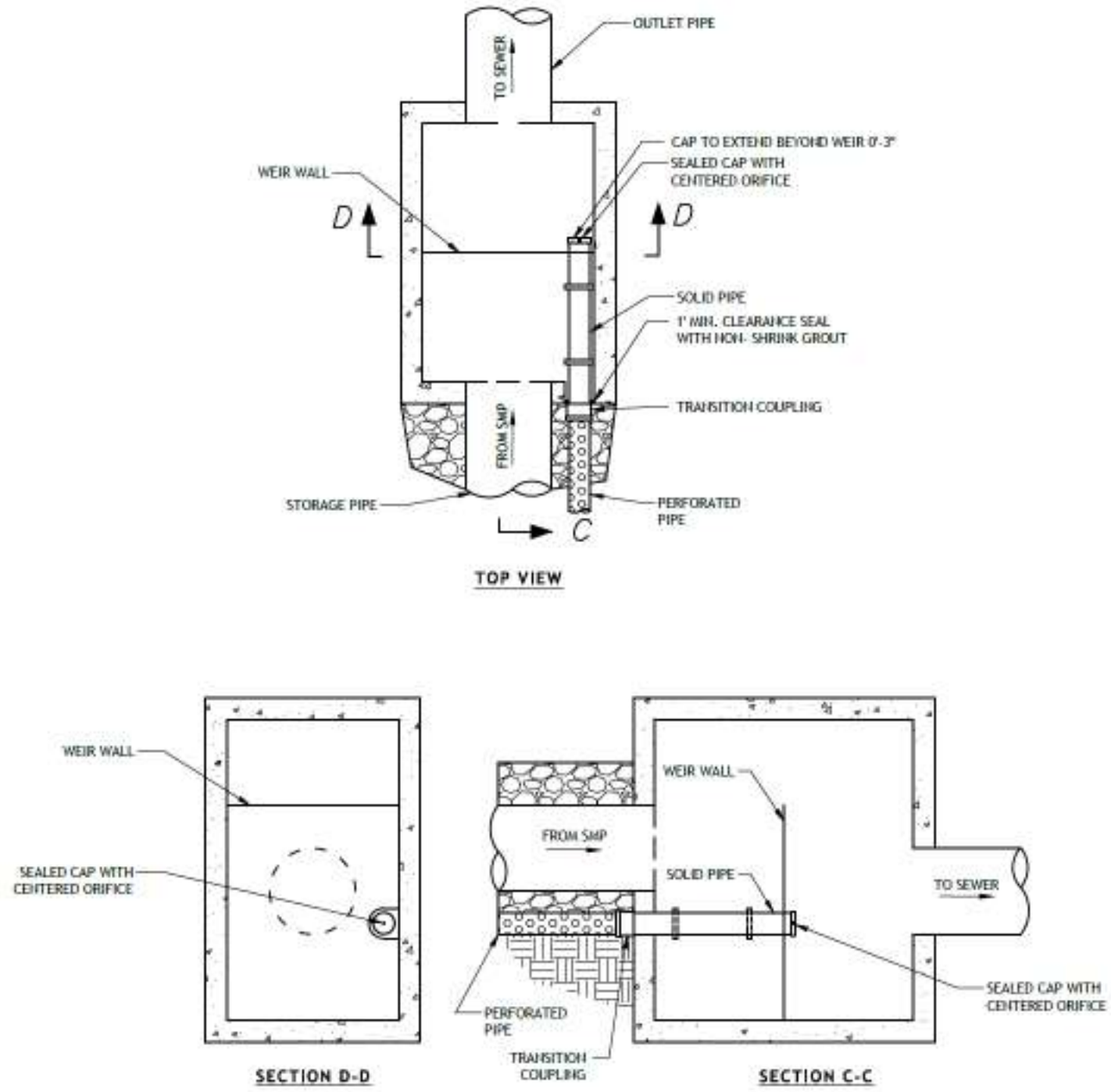
- Meeting drain down time requirements;
- Controlling the rate of discharge from the SMP and limiting water surface elevations during various storm events; and
- Bypassing of flows from large storm events.

Outlet controls may include orifices, weirs, level spreaders, or low flow devices.

When coupled with the implementation of an acceptable pollutant-reducing practice, a subsurface detention SMP can be used to achieve a slow-release rate in order to fully comply with the Water Quality requirement on sites that cannot infiltrate in the combined sewer area. This ability to slowly release the discharge into PWD sewers or receiving waters can also be used to meet Channel Protection, Flood Control, and Public Health and Safety Release Rate requirements, if applicable.

Typically, release rates for slow-release systems are met using small orifices or other rate control devices. Additionally, the outlet control structure may require design and maintenance measures to avoid clogging. To accommodate these design mandates, PWD offers a design option in the form of an Underdrain Orifice Standard Detail (Figure 4.8-2).

Figure 4.8-2: Underdrain orifice standard detail



(The designer is referred to **Appendix L** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/l-standard-details to download Standard Detail CAD files.)

Inspection and maintenance access component

Safe and easy inspection and maintenance access to all major components within a subsurface detention SMP is critical to ensuring long-term performance. Inspection and maintenance access structures provide a portal to subsurface structures within a subsurface detention SMP. They most commonly consist of a panel, port, or manhole. Access points provide access to subsurface systems, both for inspections and routine maintenance, and for pumping water out of subsurface SMPs in cases of failure or severe damage. Manholes provide access for maintenance personnel and equipment to perform maintenance and inspections. Cleanouts provide access for hoses and vacuum equipment. Observation wells provide access to the bottom of subsurface systems for performance inspections and monitoring. Access structures may also serve additional functions, such as joining subsurface pipes.

4.8.3 Subsurface detention design standards

General design standards

1. The maximum allowable drain down time is 72 hours after the 24-hour storm event.
2. Positive overflow must be provided for large storm events, up to and including the 100-year, 24-hour storm event, or, if the project is exempt from Flood Control, the ten-year, 24-hour storm. Overflow structures and pipes must be designed to convey at least the ten-year, 24-hour storm.
3. Structural suitability for overburden support and traffic loading must be considered, where applicable.
4. The minimum allowable distance between subsurface detention basins and any adjacent private property line is ten feet. This includes lined basins. Exceptions can be made for water-tight vaults with their own structural integrity, such as concrete or fiberglass vaults. It is acceptable for SMPs to be located directly adjacent to the public right-of-way (ROW).
5. The minimum allowable distance between subsurface detention basins and any building or retaining wall is ten feet. This includes lined basins. The following requirements and exceptions apply:
    a. For existing and proposed buildings with basements, the setback is measured from the basement wall and may be waived if the basin is a water-tight vault with its own structural integrity, such as a concrete or fiberglass vault.
    b. For existing buildings without basements and existing retaining walls, the setback is measured from the foundation and may be waived if a signed and sealed geotechnical analysis is submitted that evaluates the impacts of residual infiltration and excavation on the existing foundation and determines it to be feasible.
    c. For proposed buildings without basements and proposed retaining walls, the setback is measured from the foundation and may be waived if the foundation is proposed to be designed with the basin's proximity in mind.

Pretreatment design standards

6. Acceptable form(s) of pretreatment must be incorporated into design. Pretreatment of runoff from all inlets is required. At a minimum, this can be achieved through the use of sumps and traps for inlets, sump boxes with traps downstream of trench drains, and filter strips for overland flow.
7. The designer is referred to **Section 4.10** ☛ p. 148 for more information on design standards for pretreatment systems.

Inlet control design standards

8. The designer is referred to **Section 4.11** ☛ p. 166 for information on design standards for inlet control systems.

Storage area design standards

9. The storage area must provide adequate storage to control release rates to meet all applicable Stormwater Regulations. All permanent pool areas must be excluded from the SMP's storage volume estimation.
10. Bedding and foundations:
    a. Pipe, vault, grid and chamber storage areas must be adequately bedded with stone to prevent settling or subsidence.
    b. Bedding thickness must vary according to SMP requirements but must not be less than six inches.
    c. Over-excavation and replacement of loose or unstable subsurface material may be required if such conditions are encountered. A geotechnical engineer or other appropriate design professional should be consulted for additional guidance.
    d. Foundations/footers must be provided as warranted by system loading, geotechnical conditions, and manufacturer's recommendations. Foundation designs must be performed by an appropriate design professional.
11. The storage design must account for potential loading from vehicles, as appropriate, based on expected maximum active loading, including consideration for emergency vehicles.
12. Subsurface detention SMPs must be designed with outlet controls that allow all applicable Stormwater Regulations to be met.
13. Porosity values for storage volume calculations are as follows:
    a. Soil media: 0.20
    b. Sand: 0.30
    c. Stone: 0.40
    d. Void space provided by linear chamber systems, plastic grids, or other related structures must be as specified by the manufacturer and noted in supporting documentation.
14. Stone must be separated from soil media by a geotextile or a pea gravel filter to prevent sand, silt, and sediment from entering the system.

Outlet control design standards

15. The designer is referred to **Section 4.12** ☛ p. 182 for information on design standards for outlet control systems.
16. Impervious liners should be avoided, but they may be necessary in areas where the threats of spills and/or groundwater contamination are likely. They must not be interrupted by structures within the basin footprint. Impervious liners must be continuous and extend completely up the sides of any structures that are located within the lined basin footprint to the ground surface. If additional liner material must be added to extend up the structures, the additional liner sections must be joined to the rest of the liner with an impervious seam per the manufacturers' recommendation.

Inspection and maintenance access design standards

17. Cleanouts, manholes, access panels, and other access features must be provided to allow unobstructed and safe access to SMPs for routine maintenance and inspection of inflow, outflow, underdrains, and storage systems.
18. Observation wells must be provided for SMPs that include stone storage and must meet the following requirements:
    a. The observation well must be placed at the invert of the stone bed.
    b. The observation well must be located near the center of the stone bed system to monitor the level and duration of water stored within the SMP (drain down time). A minimum of six inches of clearance must be provided between the edge of the observation well's concrete ring or frame and any nearby site features (curbing, tree pits, sidewalk edge, etc.). Plan view dimensioning for the proposed location of the observation well, relative to the boundaries of the SMP it lies within, must be provided on the plans.
    c. Adequate inspection and maintenance access to the observation well must be provided.
    d. An observation well located in a paved area must be outfitted with a cover and frame. The cover plate must be installed flush with the surrounding surface at finished grade, and grading should drain away from the observation well wherever possible. The solid section of the observation well must extend into the cover frame enough such that a bentonite/cement seal can be placed around the well within the frame, and a solid slip-on cap can be fitted onto the pipe end.
    e. An observation well located in an unpaved area must have a concrete ring or frame poured for support, with three lengths of rebar evenly spaced around the ring and three inches from its outer edge. The observation well should be located outside of the ponding area of any surface SMPs. If, due to space limitations, an observation well must be placed in the ponding area of a surface SMP, the concrete ring and well cover must extend three inches above the SMP's maximum ponding depth.
    f. The observation well must include a slotted section within the storage layer of the SMP. The top of the slotted well section must extend to a minimum of six inches below the top of the SMP storage layer, and the slotted section must extend down the entire depth of the SMP.
19. Access features for subsurface detention SMPs:
    a. Access features must be provided for all underground storage SMPs that are not stone storage beds.
    b. A sufficient number of access points in the system must be provided to efficiently inspect and maintain the storage area.
    c. For cast-in-place vault systems, access features must consist of manholes or grated access panels or doors. Grated access panels are preferred to maintain airflow. A minimum of 50 square feet of grate area is recommended for permanent pool designs.
    d. For grid storage or other manufactured systems, the manufacturer's recommendations must be followed.
    e. Ladder access is required for vaults greater than four feet in height.
    f. Header pipes, at minimum 36-inch diameter, connected to manholes at each corner of the subsurface detention SMP must be provided. Alternatively, smaller header pipes may be used if cleanouts are provided on the manifold/header pipe junction for each distribution pipe. The cleanouts must be on alternating sides of the SMP.

4.8.4 Subsurface detention material standards

Pretreatment material standards

1. The designer is referred to **Section 4.10** ☛ p. 148 for information on materials standards for pretreatment systems.

Inlet control material standards

2. The designer is referred to **Section 4.11** ☛ p. 166 for information on material standards for inlet control systems.

Storage area material standards

3. Stone designed for stormwater storage must be uniformly graded, crushed, clean-washed stone. PWD defines “clean-washed” as having less than 0.5% wash loss, by mass, when tested per the American Association of State Highway and Transportation Officials (AASHTO) T-11 wash loss test. AASHTO No. 3 and No. 57 stone can meet this specification.
4. Sand, if used, must be AASHTO M-6 or American Society of Testing and Materials (ASTM) C-33 sand and must have a grain size of 0.02 inches to 0.04 inches.
5. Storage pipes:
   a. Pipe used within the subsurface detention SMP must have a minimum inner diameter of four inches.
   b. High-density polyethylene (HDPE) pipe must meet the specifications of AASHTO M252, Type S or AASHTO M294, Type S.
   c. Any pipe materials outside the SMP are to meet City Plumbing Code Standards.
6. Geotextile must consist of polypropylene fibers and meet the following specifications (AASHTO Class 1 or Class 2 geotextile is recommended):
   a. Grab Tensile Strength (ASTM-D4632): ≥ 205 lbs
   b. CBR Puncture Strength (ASTM-D6241): ≥ 500 lbs
   c. Flow Rate (ASTM-D4491): ≥ 95 gal/min/ft^2
   d. UV Resistance after 500 hrs. (ASTM-D4355): ≥ 70%
   e. Tear Resistance (ASTM-D4533): ≥ 80 lbs
   f. Heat-set or heat-calendared fabrics are not permitted.

Outlet control material standards

7. The designer is referred to **Section 4.12** ☛ p. 182 for additional information on material standards for outlet control systems.

Inspection and maintenance access material standards

8. Observation wells:
    a. The observation well must consist of slotted plastic pipe with a minimum inner diameter of four inches and a solid cap at the surface. The slotted section of the well must consist of PVC slotted well screen with 0.01-inch slot size and an attached perforated PVC cap at the bottom.
    b. The observation well's cover must be ductile iron in a gray iron frame.
    c. For an observation well located in an unpaved area, the well's concrete ring must be a minimum of six inches wider in any dimension than the cover frame, of equal depth as the cover frame itself, and poured atop a minimum of six inches of AASHTO #57 stone bedding. A frame conforming to these minimum dimensions may be circular or square.
9. Cleanouts must be made of material with a smooth interior having a minimum inner diameter of six inches. If the connecting pipe is eight inches in diameter or larger, then the cleanout must be eight inches in diameter.

4.8.5 Subsurface detention construction guidance

Proper construction of subsurface detention systems is essential to ensure long-term functionality and reduce long-term maintenance needs and costs. Subsurface detention SMPs are, by definition, buried; therefore, construction oversight is critical. At a minimum, verification of volumes, grades, and elevations must be performed prior to backfill.

1. Provide erosion and sedimentation control protection on the site such that construction runoff is directed away from the proposed subsurface detention SMP. Sediment deposited in a subsurface detention SMP during construction, particularly a stone bed system, can reduce system performance. The designer is referred to the latest edition of the *Pennsylvania Department of Environmental Protection (PA DEP) Erosion and Sediment Pollution Control Program Manual* for information on design standards for erosion and sedimentation control practices.
2. Excavate subsurface detention area to proposed depth, providing appropriate shoring and sheeting for deep excavations.
3. Place impervious liner, if needed, ensuring continuous contact with subgrade. Extreme care should be taken during installation of a geomembrane liner so that no damage is done to any part of the material. Construction equipment, gasoline driven generators, or cans of gas or solvent must not be placed on the geomembrane material. The geomembrane material must not be used as a work area to prepare patches or to store tools and supplies. Temporary wind anchorage by means of sandbags or tires must be provided during geomembrane installation. Nails, rebar, wire ties, or other metal materials shall not be used to hold geomembrane in position. Geomembrane seaming must be performed in accordance with ASTM D7408 (PVC) and ASTM D8580 (LLDPE, PP). Non-destructive and destructive testing of geomembrane seaming must be performed in accordance with ASTM D7700. Mechanical attachment of geomembrane to pipe penetrations or structures must be installed in accordance with ASTM D6497/D6497M-02. Placement of overlying material must be performed in a manner that will not damage the geomembrane. Excessive wrinkling of the geomembrane must be prevented prior to or while covering the geomembrane, ensuring no permanent folds or wrinkles in the liner. Any damage to the geosynthetic material must be repaired immediately.
4. If using a stone storage bed, place geotextile, ensuring adequate overlap of 16 inches, or pea gravel, and storage stone.
    a. Set the pipe or chamber storage, if proposed, during installation of the stone storage bed, according to the plans.
    b. Place geotextile in accordance with manufacturer's standards and recommendations.
    c. Secure geotextile at least four feet outside bed.
    d. Place stone in six- to eight-inch lifts and lightly compact.
    e. Confirm storage area dimensions and outlet control elevations prior to backfill.
5. If using a vault, pipe, or grid system, place geotextile or pea gravel, and stone base as described above.
    a. Place storage units. If using a manufactured system, install storage units in accordance with manufacturer's recommendations.
    b. If using a cast-in-place vault system, perform form work, reinforcement, and concrete work in conformance with project specifications.
    c. Confirm the storage volume prior to backfill.
6. Confirm and document invert elevations and dimensions for all structures such as vaults and pipes prior to backfill.

7. Backfill to finished grade. Ensure backfill is properly compacted in accordance with specifications. Ensure backfill process does not disrupt pipe placement and configuration.
8. Structures such as inlet boxes, reinforced concrete boxes, inlet controls, and outlet controls must be constructed according to manufacturer's guidelines or design professional's guidance.
9. Once the site is permanently stabilized with vegetation, remove temporary erosion and sediment control measures.



An example of a subsurface detention basin installation in Philadelphia

4.8.6 Subsurface detention maintenance guidance

Maintenance of subsurface detention SMPs requires the periodic removal of sediment and debris from pretreatment and storage areas and the prevention of outlet control clogging. Sediment removal from vaults, chambers, and pipes is typically conducted using vacuum or flushing systems. Guidance on the use and operation of vacuum or flushing sediment removal equipment is beyond the scope of this Manual; a maintenance professional should be contacted for additional details. As applicable, subsurface detention SMP maintenance procedures must meet OSHA confined space entry requirements.

General recommended maintenance activities for subsurface detention systems are summarized in Table 4.8-1.

Table 4.8-1: Subsurface detention maintenance guidelines

Early maintenance activity	Frequency
Inspect erosion control and flow spreading devices until soil settlement and vegetative establishment of contributing areas has occurred.	Biweekly
Inspect inlet controls, outlet structures, and storage areas for trash and sediment accumulation. Remove debris and sediment, as necessary.	Monthly for the first year after installation to determine ongoing maintenance frequency

Ongoing maintenance activity	Frequency
Regularly clean out gutters and catch basins to reduce sediment load to detention system. Clean intermediate sump boxes, replace filters, and otherwise clean pretreatment areas in directly connected systems.	As needed
Remove sediment and debris from subsurface detention SMP sedimentation chamber, as applicable, when the sediment zone is 3/4 full. Sediment and debris buildup may need to be removed by a professional. Consult with a professional, as necessary.	As needed
Remove sediment and debris from pipe/vault systems. Sediment depth is not to reach a maximum depth of four inches below the SMP's outlet invert elevation. Removal of sediment from grid systems must be per manufacturer's recommendations or as per the site-specific maintenance schedule.	As needed
Replace filter bags for pretreatment devices. Ensure filter bag is installed properly.	Quarterly
Inspect subsurface detention facility and control structures.	Quarterly
Remove floating debris and accumulated petroleum products from system and all components.	Quarterly
Maintain records of all inspections and maintenance activity.	Ongoing

The designer is referred to **Section 4.10** ☛ p. 148, Pretreatment, **Section 4.11** ☛ p. 166, Inlet Controls, and **Section 4.12** ☛ p. 182, Outlet Controls, for information on maintenance guidance for pretreatment, inlet controls, and outlet controls.

4.9 Media Filters

Download summaries of this SMP and its maintenance guidance, with quick reference information for clients and developers:

- **Media Filters SMP One-Sheet** ☛ water.phila.gov/wp-content/uploads/files/media-filters-smp-one-sheet.pdf
- **Media Filter Maintenance Guidance One-Sheet** ☛ water.phila.gov/wp-content/uploads/files/media-filter-maintenance-guidance.pdf

4.9.1 Media filter introduction

Media filters (also referred to as "filters" in this section) are structures or excavated areas containing a layer of sand, compost, organic material, peat, or other filter media. They reduce pollutant levels in stormwater runoff by filtering sediments, metals, hydrocarbons, and other pollutants. Filtered stormwater is then released to a sewer, receiving water, or downstream stormwater management practice (SMP). Media filters are designed to allow higher rates of stormwater flow than traditional filters. Sand and other rapid filter media enable smaller SMP footprints by allowing for faster filtration of stormwater.

Media filters can be combined with other SMPs in series to meet the Philadelphia Water Department (PWD) Stormwater Regulations (Stormwater Regulations). The designer is referred to **Section 3.2.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-2-stormwater-management-design#3.2.3 for information on using SMPs in series. Facilitating evapotranspiration, *vegetated media filters* are useful in meeting the Water Quality requirement when placed upstream of a non-infiltrating SMP. Non-vegetated *media filters* can assist in meeting the Water Quality requirement when placed upstream or downstream of a non-infiltrating SMP. For Stormwater Retrofits, media filters are needed for subsurface detention systems in the Municipal Separate Storm Sewer System (MS4).

The design of media filters is not limited to the examples provided within this text. Successful stormwater management plans will combine appropriate materials and designs specific to each site. Other types of prefabricated or proprietary filters such as water quality inserts fitted within inlets are available, but they are only to be used as pretreatment and are not considered SMPs.

Quick tip

Required media filter design and material standards are denoted in this section by easy-to-reference numerals.

Filters are evaluated on a project-specific basis since site conditions, such as sediment loading and/or drainage area size, can impact a product's ability to meet Stormwater Regulations. Third-party certification of all performance claims is strongly encouraged for all prefabricated and proprietary devices. Examples of third-party certification programs include the New Jersey Department of Environmental Protection (NJDEP) and the Washington State Department of Ecology. The NJDEP certification uses the New Jersey Center for Advanced Technology (NJCAT) verification as conducted according to the Technology Acceptance and Reciprocity Partnership (TARP) Protocol. Washington State Department of Ecology uses the Technology Assessment Protocol – Ecology (TAPE). In addition to all certifications and laboratory test data, all performance claims should be supported by field test data where possible. PWD does not endorse the use of specific third-party certification programs, and specific programs are mentioned as examples only. PWD has developed a list, accessible on the PWD Development Services Resource Directory, of **filter products** ☛ water.phila.gov/development/resources/#media-filter that may be used to comply with the Stormwater Regulations. PWD allows the use of monitoring programs in lieu of, or in addition to, third-party certification.

The designer should note that there may be situations where PWD's compliance requirements are more restrictive than a manufacturer's specifications for a particular product; in these scenarios, the designer must engineer a solution that satisfies PWD standards.



An example of a media filter in Philadelphia

When can media filters be used?

Media filters can be used on sites where vegetated SMPs are impractical due to limited surface area or other constraints. They can assist applicants in meeting the Water Quality requirement where infiltration is not feasible. Filters may be used alone in separate sewer areas, or upstream or downstream of detention practices as part of a series approach in combined sewer areas, to meet multiple Stormwater Regulations.

Key advantages of media filters

- Have highly flexible designs and configurations that can be useful in meeting the Water Quality requirement where space-constrained, highly developed, or otherwise challenging locations prevent the use of traditional surface-level or rooftop SMPs, and infiltration is not feasible
- Can be designed to be visible from the surface or completely subsurface, located beneath parking lots or other impervious areas

Key limitations of media filters

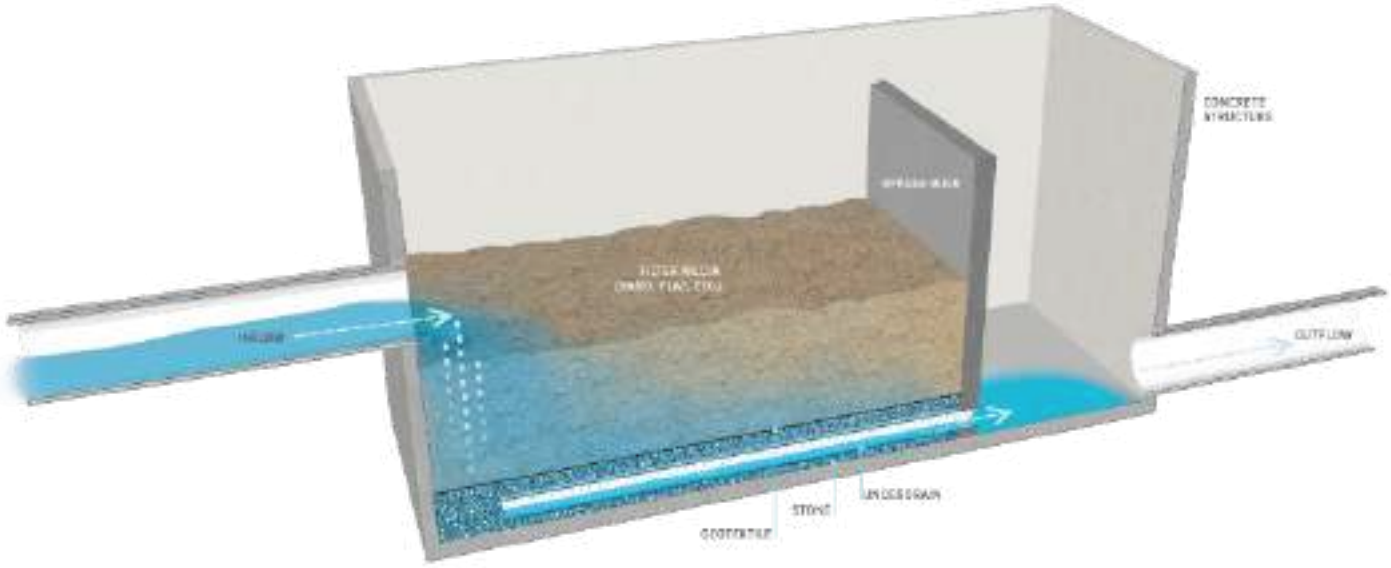
- Do not offer, when non-vegetated, many of the ancillary benefits associated with surface vegetated SMPs, including aesthetic value, improved air quality, and habitat creation
- Do not reduce the volume of stormwater runoff like bioretention basins and green roofs do
- May have sizing requirements that result in large footprints due to filtration rates for filter media such as sand

Key design considerations for media filters

- A primary design consideration for filters is site suitability. The use of a bioretention SMP should first be considered before selecting a media filter. Bioretention SMPs provide the same, or better, level of Water Quality treatment, provide a range of other economic and aesthetic benefits, and are typically easier to access and maintain.
- Philadelphia's low temperatures are below freezing for approximately four months every year, and surface filtration may not function as well in the winter. Design options that allow direct subsurface discharge into filter media during cold weather may help overcome this condition.
- Filter media should be selected and sized to match the required rate of stormwater flow for the SMP. The designer should carefully consider the filtration rate of the media and the available storage volume in order to size the SMP.
- The maintenance access that is required for the filter system must be considered. Filter systems require frequent maintenance and may require different maintenance equipment than other SMPs.
- Proprietary media filters may inherently comply with many of the following design and material standards, in which case, submission of appropriate supporting documentation is critical.
- For any media filter that discharges onto an adjacent property, a drainage easement may be required and is recommended.

4.9.2 Media filter components

Figure 4.9-1: Media filter with typical features



☛ water.phila.gov/wp-content/uploads/images/swmg-figure-4-9-1-media-filter-typical-features.png

Pretreatment component

Pretreatment systems capture trash, sediment, and/or other pollutants from stormwater runoff before delivery to the storage area. Pretreatment needs will vary significantly depending on the contributing drainage area composition and use. Pretreatment can include structures such as sumped and trapped inlets, sediment/grit chambers or separators, inlet inserts, or other appropriate prefabricated or proprietary designs to remove sediment, floatables, and/or hydrocarbons from stormwater runoff prior to being conveyed to a filter system.

Pretreatment can also consist of filter strips, forebays, and swales. The designer is referred to **Section 4.10** ☛ p. 148 for more information on pretreatment systems.

Inlet control component

Inlet control systems convey and control the flow of stormwater from the contributing catchment area to a filter SMP. Inlet control needs will vary depending on the design of stormwater conveyance systems and the site layout. The designer is referred to **Section 3.4.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-4-how-to-show-compliance/#3.4.2 for guidance on stormwater conveyance system design.

Inlet controls may consist of flow splitters, curbless design/curb openings, energy dissipaters, and inlets. The designer is referred to **Section 4.11** ☛ p. 166 for more information on these types of inlet controls.

Storage area component

Storage areas within filter systems temporarily hold stormwater runoff before it can either pass through the filter media or be released downstream, depending on the system design and the size of the storm event. Storage for media filter systems can be located either above or below the ground surface. Surface storage is typically constructed by either excavating an area to create a depression or by erecting berms around a low-lying area to create an impoundment. Subsurface storage areas are typically constructed by excavating a trench or chamber below grade, lining it with concrete or another impermeable material, and constructing a cover over the storage area. Filter media, most typically sand, is contained within storage areas.

Outlet control component

Outlet controls in a filter system control the high-water level in the SMP and regulate overflow, either into an existing drainage network or into another SMP. Outlet controls can provide a range of functions, including:

- Meeting drain down time requirements, and/or
- Bypassing of flows from large storm events.

Outlet controls may consist of orifices, weirs, underdrains, level spreaders, impervious liners, micro siphon drain belts, or low flow devices. The designer is referred to **Section 4.12** ☛ p. 182 for more information on these types of outlet controls.

Inspection and maintenance access component

Safe and easy inspection and maintenance access to all major components in a media filter system is critical to ensuring long-term performance. Inspection and maintenance access structures provide a portal to subsurface structures within a filter system. They most commonly consist of a panel or manhole. Manholes or panels provide access for maintenance personnel and equipment to perform maintenance and inspections. Filter structures may require lift access or special equipment to perform the required maintenance. Large openings may be necessary to properly maintain the filters.

4.9.3 Media filter design standards

General design standards

1. The following information must be submitted for each proposed media filter as part of the applicant's Post-Construction Stormwater Management Plan (PCSMP) Review Phase Submission Package. Preliminary consultations with PWD prior to submission are encouraged.
   a. Inflow and outflow event mean concentrations and percent removals for Total Suspended Solids (TSS) for sand/media filters (Designs must demonstrate a maximum effluent event mean concentration of 15 milligrams per liter for TSS at a point of analysis (POA) downstream of the SMP);
   b. Third-party certifications for proprietary media filters;
   c. Hydrologic and hydraulic model files, if applicable;
   d. Product specifications for proprietary media filters;
   e. Manufacturer's guidelines for installation for proprietary media filters;
   f. Construction sequence; and
   g. Maintenance requirements, including product life and replacement schedule, if applicable.

   PWD will review media filter performance documentation submissions during the PCSMP Review Phase and will provide the applicant with comments or requests for additional information. All comments and requests for information must be addressed before PWD may issue approval.
2. The maximum allowable drain down time is 72 hours after the 24-hour storm event.
3. The filter footprint must be sized pursuant to filter media flow-through rate.
4. Positive overflow must be provided for large storm events. All systems must include overflow structures and pipes designed to convey at least the ten-year, 24-hour storm event.
5. Filters without detention must be able to convey the ten-year, 24-hour storm event.
6. Filters with detention must be designed to safely store and/or convey the 100-year, 24-hour storm event, or, if the project is exempt from Flood Control, the ten-year, 24-hour storm.

Pretreatment design standards

7. For proprietary media filters, the manufacturer's design guidance must be followed when determining appropriate pretreatment.
8. Acceptable form(s) of pretreatment must be incorporated into design. Pretreatment of runoff from all inlets is required. At a minimum, this can be achieved through the use of sumps and traps. The designer is referred to **Section 4.10** ☛ p. 148, Pretreatment, for more information on design standards for pretreatment systems.

Inlet control design standards

9. For proprietary media filters, the manufacturer's design guidance must be followed when configuring the inlet controls.
10. The designer is referred to **Section 4.11** ☛ p. 166, Inlet Controls, for information on design standards for inlet control systems.

Storage area design standards

11. For proprietary media filters, the manufacturer's design guidance must be followed when sizing the filter.
12. The filter system must provide enough storage to allow the Water Quality storm to flow through the filter media. Upstream SMPs can be used to store this flow.
13. When SMPs are used in series, the storage areas for all SMPs must provide cumulative static storage for the Water Quality Volume (WQv), but there is no minimum storage requirement for each individual SMP used in series.
14. SMPs can be designed with additional storage beyond the WQv and with control structures that meet all remaining applicable Stormwater Regulations. Sand and peat media are acceptable for use in filters. The designer is referred to the material standards in this section for details on these approved mixtures. Other media mixtures may be approved on a case-by-case basis by PWD.
15. Porosity values for storage volume calculations are as follows:
    a. Soil media: 0.20
    b. Sand: 0.30
    c. Stone: 0.40
    d. Porosity values of any proprietary rapid media should be obtained from the appropriate manufacturer.
16. Surface Area
    a. Filters must have a minimum surface area as computed by the following equation:

$$A_f = \frac{(WQv \; x \; 0.8)}{k}$$

WHERE:

A_f = surface area of the filter (square feet);
WQv = Water Quality Volume, the 1.5-inch Water Quality Volume over directly connected impervious area (DCIA) (cubic feet); and
k = saturated hydraulic conductivity of the filter media (feet per day)

    b. When computing surface area, use a filtration rate of two inches per hour for sand and soil (accounting for the reduction in filtration rates for sand over time due to build-up of fine material)
    c. Determination of filtration rate for proprietary or mixed media must be obtained from manufacturers or from evaluation of similar applications. High filtration rates at installation associated with some media types may yield small required surface area values. The designer must, however, account for the potential for filter systems to clog over time and must therefore adjust the assumed filtration rate to account for this
17. The minimum allowable filter media depth is 18 inches (greater depths may be used but do not alter filter sizing requirements).
18. Stone cannot be used as filter media, but it can be used within filter systems to provide additional storage and must be provided as bedding for underdrains.

19. Bedding and foundations:
    a. Pipe, vault, grid and chamber storage areas must be adequately bedded with stone to prevent settling or subsidence.
    b. Bedding thickness must vary according to system requirements but must not be less than six inches.
    c. Over-excavation and replacement of loose or unstable subsurface material may be required if such conditions are encountered. A geotechnical engineer or other appropriate design professional should be consulted for additional guidance.
    d. Foundations/footers must be provided as warranted by system loading, geotechnical conditions, and manufacturer's recommendations. Foundation designs must be performed by an appropriate design professional.
20. The storage design must account for potential loading from vehicles, as appropriate, based on expected maximum active loading, including consideration for emergency vehicles.
21. The system must have a level bottom and use a terraced system, if installed along a slope.

Outlet control design standards

22. For proprietary media filters, the manufacturer's design guidance must be followed when configuring the outlet controls.
23. Impervious liners are required for all filter systems not contained in impermeable structures. They must not be interrupted by structures within the filter footprint. Impervious liners must be continuous and extend completely up the sides of any structures that are located within the lined filter footprint to the ground surface. If additional liner material must be added to extend up the structures, the additional liner sections must be joined to the rest of the liner with an impervious seam per the manufacturers' recommendation.
24. Underdrains must be provided for all non-infiltrating systems and must meet the following requirements:
    a. Underdrains must be surrounded by a sand layer or stone to filter sediment and facilitate drainage.
    b. The minimum allowable depth of a sand or stone filter layer above and beneath the underdrain is six inches.
    c. Underdrains must be surrounded by a geotextile fabric if sand is used.
    d. The outlet pipe of an outlet control structure must have an invert at or below the invert of the underdrain. Setting the outlet pipe invert at a minimum of 7.5 inches below that of the underdrain is recommended.
25. For filters located in the separate sewer area, where infiltration is infeasible, flow through the underdrain may be modeled as exfiltration at a rate of two inches per hour for sand media and at an appropriate rate for other filter media, then routed through the underdrain system. This exfiltration flow must be routed through the primary outlet of the filter, not discarded from the stormwater model. Determination of filtration rate for proprietary or mixed media must be obtained from the manufacturer or from evaluation of similar applications.
26. The designer is referred to **Section 4.12** ☛ p. 182, Outlet Controls, for information on design standards for outlet control systems.

Inspection and maintenance access design standards

27. For proprietary media filters, the manufacturer's design guidance must be followed for inspection and maintenance access.
28. Manholes, access panels and other access features must be provided to allow unobstructed and safe access to SMPs for routine maintenance and inspection of inflow, outflow, underdrains, and storage systems.
29. Access features for underground storage SMPs within which filters may be contained:
    a. Access features must be provided for all underground storage SMPs that are not stone storage beds.
    b. A sufficient number of access points in the SMP must be provided to efficiently inspect and maintain the storage area.
    c. For cast-in-place vault systems, access features must consist of manholes or grated access panels or doors. Grated access panels are preferred to maintain airflow.
    d. Lifts or other equipment may be necessary for maintaining the filter media.
    e. Large access points may be required for maintaining/replacing the filter media.
    f. Ladder access is required for vaults greater than four feet in height.

4.9.4 Media filter material standards

Pretreatment material standards

1. The designer is referred to **Section 4.10** ☛ p. 148, Pretreatment, for materials standards for pretreatment systems.

Inlet control material standards

2. The designer is referred to **Section 4.11** ☛ p. 166, Inlet Controls, for materials standards for inlet control systems.

Storage area material standards

3. Stone
    a. Stone designed for stormwater storage must be uniformly graded, crushed, clean-washed stone. PWD defines “clean-washed” as having less than 0.5% wash loss, by mass, when tested per the American Association of State Highway and Transportation Officials (AASHTO) T-11 wash loss test. AASHTO No. 3 and No. 57 stone can meet this specification.
    b. Stone must be separated from filter media by a geotextile or a pea gravel filter.
4. Sand
    a. Sand used as filter media must be clean, medium to fine sand and have organic material meeting the specifications of AASHTO M-6 (grain size of 0.02 to 0.04 inches) or American Society of Testing and Materials (ASTM) C-33.
    b. At a minimum, applicants must demonstrate that the sand filter is capable of generating a maximum effluent EMC of 15 milligrams per liter for TSS accumulated at a POA downstream of the SMP.
5. Other filter media
    a. Prior to use of any prefabricated, proprietary, or mixed filter media, the designer must carefully review design specifications and vendor information to assess performance, maintenance, longevity, and third-party verification.
    b. Peat must have an ash content of less than 15%, a pH range of 3.3 to 5.2, and a loose bulk density range of 0.12 g/cc to 0.14 g/cc.
    c. Filter media other than sand or peat may be used in certain cases, if approved for use by PWD. Approvals are granted on the basis of a case-by-case review by PWD based on information submitted by the applicant. At a minimum, applicants must demonstrate that the filter media is capable of generating a maximum effluent EMC of 15 milligrams per liter for TSS accumulated at a POA downstream of the SMP, meets all other filter design and water quality specifications set forth in this section, and has a demonstrated record of high performance within urban settings.
6. Geotextile must consist of polypropylene fibers and meet the following specifications (AASHTO Class 1 or Class 2 geotextile is recommended):
    a. Grab Tensile Strength (ASTM-D4632): ≥ 205 lbs
    b. CBR Puncture Strength (ASTM-D6241): ≥ 500 lbs
    c. Flow Rate (ASTM-D4491): ≥ 95 gal/min/ft2
    d. UV Resistance after 500 hours (ASTM-D4355): ≥ 70%
    e. Tear Resistance (ASTM-D4533): ≥ 80 lbs
    f. Heat-set or heat-calendared fabrics are not permitted.

Outlet control material standards

7. Underdrains must be made of continuously perforated high-density polyethylene (HDPE) plastic piping with a smooth interior and a minimum inner diameter of four inches. HDPE pipe must meet the specifications of AASHTO M252, Type S or AASHTO M294, Type S.
8. Stone used for filter underdrains must be uniformly graded, clean-washed stone, either crushed or smooth. PWD defines “clean-washed” as having less than 0.5% wash loss, by mass, when tested per the AASHTO T-11 wash loss test.
9. Sand, if used for filter underdrains, must be with AASHTO M-6 or American Society of Testing and Materials (ASTM) C-33 sand and must have a grain size of 0.02 inches to 0.04 inches.
10. The designer is referred to **Section 4.12** ☛ p. 182, Outlet Controls, for information on material standards for outlet control systems.

4.9.5 Media filter construction guidance

Proper construction of filter systems is essential to ensure long-term functionality and reduce long-term maintenance needs.

1. Provide erosion and sedimentation control protection on the site such that construction runoff is directed away from the proposed filter system. Sediment deposited in a filter system during construction, particularly a stone bed system, can reduce system performance. The designer is referred to the latest edition of the *Pennsylvania Department of Environmental Protection (PA DEP) Erosion and Sediment Pollution Control Program Manual* for information on design standards for erosion and sedimentation control practices.
2. Excavate filter area to proposed depth, providing appropriate shoring and sheeting for deep excavations.
3. For excavated systems, place impermeable liner ensuring continuous contact with subgrade. Extreme care should be taken during installation of a geomembrane liner so that no damage is done to any part of the material. Construction equipment, gasoline driven generators, or cans of gas or solvent must not be placed on the geomembrane material. The geomembrane material must not be used as a work area to prepare patches or to store tools and supplies. Temporary wind anchorage by means of sandbags or tires must be provided during geomembrane installation. Nails, rebar, wire ties, or other metal materials shall not be used to hold geomembrane in position. Geomembrane seaming must be performed in accordance with ASTM D7408 (PVC) and ASTM D8580 (LLDPE, PP). Non-destructive and destructive testing of geomembrane seaming must be performed in accordance with ASTM D7700. Mechanical attachment of geomembrane to pipe penetrations or structures must be installed in accordance with ASTM D6497/D6497M-02. Placement of overlying material must be performed in a manner that will not damage the geomembrane. Excessive wrinkling of the geomembrane must be prevented prior to or while covering the geomembrane, ensuring no permanent folds or wrinkles in the liner. Any damage to the geosynthetic material must be repaired immediately.
4. If using a stone storage bed in fill beneath the filter:
    a. Place geotextile, ensuring adequate overlap of 16 inches, or pea gravel, and storage stone.
        i. Set the underdrain during placement according to the plans.
        ii. Place geotextile in accordance with manufacturer's standards and recommendations.
        iii. Secure geotextile at least four feet outside bed.
        iv. Place stone in six-to-eight inch lifts and lightly compact.
    b. Confirm storage elevations prior to backfill.
5. If the filter is to be placed within a vault or concrete structure:
    a. Place stone base beneath vault.
    b. Place vault. If using a manufactured system, install vault in accordance with manufacturer's recommendations.
    c. Perform form work, reinforcement, and concrete work in conformance with project specifications.
    d. Place geotextile, ensuring adequate overlap of 16 inches, or pea gravel, and storage stone.
        i. Set the underdrain for the filter during placement according to the plans.
        ii. Place geotextile in accordance with manufacturer's standards and recommendations.
        iii. Secure geotextile at least four feet outside bed.
        iv. Place stone in six-to-eight inch lifts and lightly compact.

6. Place filter media in six-inch to eight-inch lifts within structure or excavated area, over the underdrain and storage stone and cover with debris screen, stone filter layer, or non-woven fabric.
7. Confirm and document invert elevations and dimensions for all structures such as vaults and pipes prior to backfill.
8. Backfill to finished grade. Ensure backfill is properly compacted in accordance with specifications. Ensure backfill process does not disrupt pipe placement and configuration.
9. Structures such as inlet boxes, reinforced concrete boxes, inlet controls, and outlet controls must be constructed according to manufacturer's guidelines or design professional's guidance.
10. Once site is permanently stabilized with vegetation, remove temporary erosion and sediment control measures.



An example of a media filter installation in Philadelphia

4.9.6 Media filter maintenance guidance

All areas of the filter should be inspected regularly and after significant storm events for ponding, sediment and/or debris accumulation, and damage. Corrective measures should be taken when ponding, sediment and/or debris accumulation, and/or damage occurs.

In areas where the potential exists for the discharge and accumulation of toxic pollutants (such as metals), filter media removed from filters must be handled and disposed of in accordance with all City, State, and Federal regulations.

General recommended maintenance activities and frequencies for media filters are summarized in Table 4.9-1 below.

Table 4.9-1: Media filter maintenance guidelines

Maintenance activity	Frequency
Rake filter media surface for the removal of trash and debris from control openings.	As needed
Repair leaks from the sedimentation chamber or deterioration of structural components.	As needed
Inspect filter for standing water (filter drainage is not optimal) and discoloration (organics or debris have clogged filter surface).	Quarterly
Remove the top few inches of filter media and cultivate the surface when filter bed is clogged.	Annually
Clean out accumulated sediment from filter bed chamber.	Annually
Clean out accumulated sediment from sedimentation chamber. Sediment and debris buildup may need to be removed by a professional. Consult with a professional, as necessary.	Annually
Maintain records of all inspections and maintenance activity.	Ongoing

If the SMP design proposes modifications to the approved saturated hydraulic conductivity of media filters, appropriate modifications should be made to the maintenance schedule (Table 4.9-1) for the proposed management practice. For example, utilizing an increased filtration rate for sand is appropriate if the maintenance schedule includes increased frequency of sediment removal and replacement of filter media.

The designer is referred to **Section 4.10** ☛ p. 148, Pretreatment, **Section 4.11** ☛ p. 166, Inlet Controls, **Section 4.12** ☛ p. 182, Outlet Controls, and **Section 4.13** ☛ p. 218, Landscaping, for information on maintenance guidance for pretreatment, inlet controls, outlet controls, and landscaping.

4.10 Pretreatment

4.10.1 Pretreatment introduction

Pretreatment is critical to the design of stormwater management practices (SMPs). Properly designed pretreatment systems help to sustain required stormwater management function, extend service life, and reduce maintenance costs of SMPs. The primary goal of most pretreatment systems is to capture sediment, trash, and debris. This can be done using a variety of methods but is most commonly achieved by decreasing peak stormwater velocities to allow sediment to settle or by filtering incoming stormwater through vegetation to remove sediment before it reaches a downstream SMP.

Pretreatment of runoff from all inlets is required. For all SMPs, the use of sumps and traps or hoods for inlets, and sump boxes with traps or hoods downstream of trench drains, is the minimum requirement. The designer is referred to **Section 4.11** ☛ p. 166, Inlet Controls, for guidance on inlets. Pretreatment beyond these minimum requirements is recommended for SMPs with catchment areas that generate high sediment loads, such as roadways and parking lots and may be required for sites that generate pollutants such as loading docks, material storage facilities, junk yards, and waste collection and disposal sites. The designer should reference the pretreatment sections within the individual SMP Sections of Chapter 4 for SMP-specific guidance regarding pretreatment.

In the following section, guidance is provided on three of the most commonly applied pretreatment practices. These consist of:

- Filter strips
- Forebays
- Swales

Quick tip

Required pretreatment design and material standards are denoted in this section by easy-to-reference numerals.

The design of an effective pretreatment system may incorporate any number of these or other types of pretreatment systems, and the designer should not be limited by the guidance provided in this Manual. Successful pretreatment systems will combine appropriate materials and designs specific to each site.

Table 4.10-1 below provides guidance on the typical applicability of the types of pretreatment systems covered in this section. Red indicates that the pretreatment type would typically be used with the SMP; yellow indicates that the pretreatment type may be used with the SMP in certain circumstances; and blue indicates that the pretreatment type would not typically be used with the associated SMP. Filter strips are typically applicable for diffuse stormwater flow, while forebays and swales are typically applicable for concentrated stormwater flow.

The pretreatment systems within this section are not typically applicable for green roofs, blue roofs, and cisterns treating roof runoff. The designer is referred to the pretreatment sections within **Section 4.5** ☛ p. 80, for cistern pretreatment guidance.

Table 4.10-1: Pretreatment applicability guidance

SMP	*Pretreatment for diffuse flow*	*Pretreatment for concentrated flow*	
	Filter strips	**Forebays**	**Swales**
Bioinfiltration/bioretention	Typical	Typical	Typical
Ponds and wet basins	Typical	Typical	Typical
Subsurface infiltration	Occasional	Occasional	Occasional
Drainage wells	Occasional	Occasional	Occasional
Subsurface detention	Occasional	Occasional	Occasional
Media filters	Occasional	Occasional	Occasional
Porous surfaces	Atypical	Atypical	Atypical
Green roofs	Atypical	Atypical	Atypical
Blue-green roofs	Atypical	Atypical	Atypical
Cisterns	Atypical	Atypical	Atypical
Blue roofs	Atypical	Atypical	Atypical

4.10.2 Filter strips

Filter strips consist of densely vegetated land or gravel covered areas, as seen in the photo below, that treats stormwater sheet flow from adjacent pervious and impervious areas. These systems function by reducing runoff velocity, trapping sediment and pollutants, and, in some cases, infiltrating a portion of the runoff into the ground. Filter strips are generally a sensible and cost-effective stormwater pretreatment option applicable to a variety of development sites, including roads and highways.

Design of filter strip SMPs is not limited to the examples shown within this text. Successful stormwater management plans will combine appropriate materials and designs specific to each site.



An example of filter strips in Philadelphia

When can filter strips be used?

Filter strips are a pretreatment option typically applicable to bioinfiltration/bioretention basins and ponds and wet basins. Depending on the site layout and stormwater conveyance design, they may be applicable to subsurface infiltration, subsurface detention, and media filters.

Filter strips are typically used for pretreatment of diffuse sheet flow. They are a pretreatment option for SMPs in residential, commercial, and light industrial developments, and for roads, highways, and parking lots.

Key advantages of filter strips

- Relatively simple structures that provide effective runoff pretreatment
- Effective at slowing runoff velocities, removing pollutant loads, and promoting infiltration of runoff produced by both impervious and pervious areas
- Extend the life of associated SMPs and decrease their hydraulic residence time
- Decrease the frequency of required maintenance of associated SMPs

Key limitations of filter strips

- Require preservation and minimization of impacts leading to compaction and/or erosion
- Often require medium-to-large vegetated areas, making them often impractical in an ultra-urban setting

Key design considerations for filter strips

- Filter strip effectiveness may be enhanced by installing berms and retentive grading perpendicular to the flow path. A pervious berm and/or retentive grading allows for a reduction in both runoff velocity and volume, thus improving pollutant removal capabilities by providing a temporary (very shallow) ponded area.
- The use of existing vegetated areas that have surface features that disperse runoff is encouraged, as the use of these areas will also reduce overall site disturbance and soil compaction.
- Trees and shrubs may be allowed in the flow path if the filter strip exceeds the minimum length and width requirements specified in Table 4.10-2 below.
- The vegetation for filter strips may be comprised of turf grasses, meadow grasses, shrubs, and native vegetation (**Appendix I** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists houses plant lists). Approved native grass mixes are preferable. Seed shall be applied at the rates specified by the supplier.
- Turf grass is generally not recommended but may be acceptable provided the designer can show it meets all requirements.
- A pea gravel diaphragm, which is a gravel-filled trench running along the top of the filter strip's slope, may be used as a pretreatment level spreader, maintaining sheet flow into the filter strip.
- Vegetation cover should be maintained at 85%. If vegetation is damaged, the damaged areas should be re-established in accordance with the original specifications or according to a new design approved by the Philadelphia Water Department (PWD). In all design cases where vegetation is to be established, the planting regime should be as dense as the soil conditions can sustain. This is especially true at the top portions of the filter strip where the highest sheet flow velocities are found. Soils that can sustain higher quantities and qualities of vegetation may need to be added to ensure the thick vegetative densities needed for sustainable filter strip performance. All vegetation deficiencies should be addressed without the use of fertilizers or pesticides, if possible.

Filter strip design and material standards

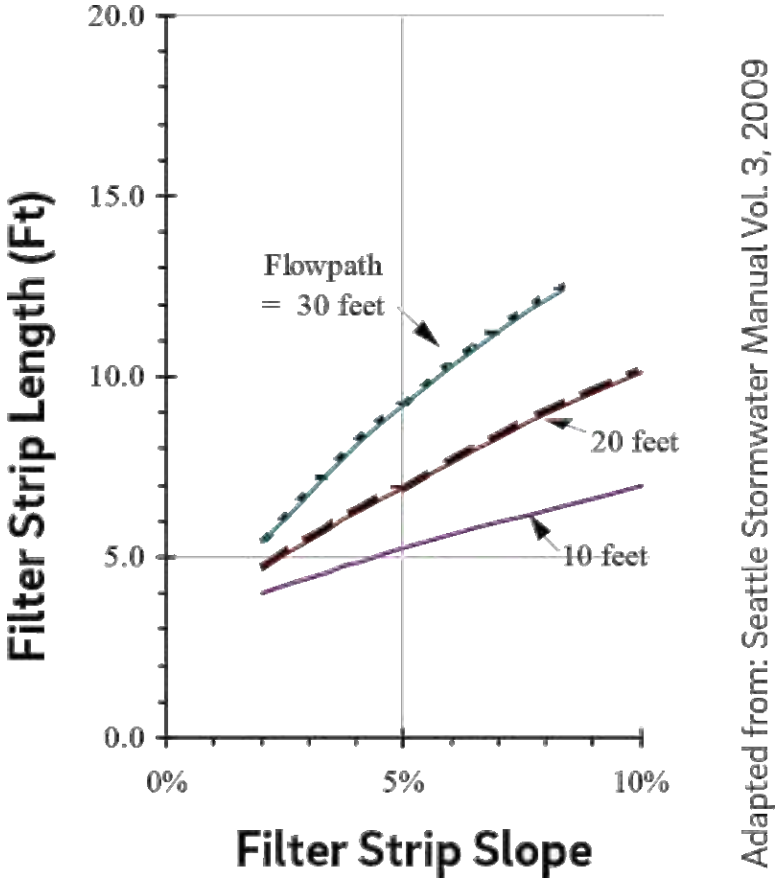
1. It is critical that plant materials are appropriate for soil, hydrologic, light, and other site conditions. The designer is referred to the list of native species in **Appendix I** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists for plant lists. Ponding depth, drain down time, sunlight, salt tolerance, soil infiltration capacities, pollution tolerances, root structure, and other conditions must be taken into consideration when selecting plants.
2. Concentrated flow can have an erosive effect that can damage the filter strip, rendering the strip ineffective. If discharge of concentrated flow to the filter strip is proposed, level spreading devices are required to provide uniform sheet flow. The designer is referred to **Section 4.12** ☛ p. 182, Outlet Controls, for guidance on level spreaders.
3. Filter strips may not be used in high-use areas unless precautions are taken to minimize disturbance of the filter strip, such as signage, fences, and placement of sidewalks or paths to minimize pedestrian or vehicular traffic.
4. The maximum allowable flow path to a filter strip, without the installation of energy dissipaters and/or flow spreaders, is 75 feet for impervious ground cover and 150 feet for pervious ground cover.
5. The maximum contributing drainage area must be less than five acres and must not exceed a drainage area to filter strip area ratio of 6:1.
6. The maximum contributing drainage area slope must be less than 5%, unless energy dissipation and/or flow spreaders are provided up-gradient of the filter strip.
7. The filter strip slope must not exceed 8%. Slopes less than 5% are generally preferred. Filter strips with slopes that exceed 5% should implement check dams to encourage ponding and prevent scour and erosion of the filter strip area. The designer is referred to **Section 4.10.4** ☛ p. 160, Swales, for additional guidance on check dam design.
8. The slope (parallel to the flow path) of the top of the filter strip, after a flow spreading device, must be very small (less than 1%) and gradually increase to the designed value to protect from erosion and undermining of the device.
9. Plants must be established at the time of filter strip completion (at least three months after seeding). No runoff must be allowed to flow across the filter strip until the vegetation is established.
10. Filter strip length must be in accordance with Table 4.10-2 below.

Table 4.10-2: Required starting design values for filter strip length

Required starting design values for filter strip length	
Strip length perpendicular to flow path	Largest feasible on-site
Strip length parallel to flow path	Four feet* to 150 feet
** The minimum pretreatment filter strip value is based on the length of the receiving flow path. Figure 4.10-1 below shows how the minimum length requirement changes as both flow path and filter strip slope change.*	

11. For contributing flow paths less than 30 feet in length, Figure 4.10-1 below must be used to determine the filter strip length. The filter strip length requirements reflected in Figure 4.10-1 are scaled from dimensions of a grassy vegetative swale for the same slope and flow conditions mentioned in Table 4.10-2.

Figure 4.10-1: Design specifications for narrow pretreatment filter strips with flow paths less than 30 feet in length



12. For contributing flow paths greater than 30 feet in length, the required flow characteristics for maximum velocity and depth listed in Table 4.10-3 below must be used.

Table 4.10-3: Maximum velocities and water depths for filter strip area

Maximum velocities and water depths for filter strip area	
Maximum velocity	1 ft/s max., less than 0.5 ft/s preferred
Maximum water depth	1 inch max., less than 0.5 inch preferred
The values for both maximum velocity and water depth were taken from *US DOT Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring* and the *Seattle BMP Manual*.	

Filter strip construction guidance

Guidance on typical construction sequencing to ensure proper installation and performance of filter strips is as follows:

1. Areas for filter strips must be clearly marked before any site work begins to avoid soil disturbance and compaction during construction.
2. In areas where soil is compacted, tilling to depths of 12 to 18 inches is necessary. A minimum of six inches of topsoil must be added into the tilled soil column, and small trees and shrubs with capabilities for deep root penetrations should be introduced to maximize the infiltrative capacity of the soil.
3. Provide erosion and sedimentation control protection on the site such that construction runoff is directed away from the proposed filter strip location.
4. Complete site elevation and retentive grading, if proposed. Stabilize the soil disturbed within the limit of earth disturbance.
5. Install energy dissipaters and flow spreaders if required. The designer is referred to **Section 4.12** ☛ p. 182, Outlet Controls, for more detailed construction information.
6. Construct filter strip as specified in the design.
7. Seed and plant vegetation (plants, shrubs, and trees) as indicated on the plans and specifications.
8. Once site vegetation is stabilized, remove erosion and sediment control protection.

Filter strip maintenance guidance

All areas of the filter strip should be inspected after significant storm events for ponding. Corrective measures should be taken when excessive ponding occurs.

General recommended maintenance activities for filter strips are summarized in Table 4.10-4.

Table 4.10-4: Filter strip maintenance guidelines

Early maintenance activity	Frequency
Inspect erosion control and flow spreading devices until soil settlement and vegetative establishment of contributing areas has occurred.	Biweekly
Water vegetation at the end of each day for two weeks after planting is completed.	Daily for two weeks after installation
Water vegetation regularly to ensure successful establishment after planting.	Every four days during periods of four or more days without rain, June through August for the 24 months after installation
Inspect vegetation for signs of disease or distress. Treat or replace, as necessary.	Biweekly for the first year after installation

Ongoing maintenance activity	Frequency
Mow and/or trim vegetation (not applicable to all filter strips). Filter strips that need mowing are to be cut to a height no less than four inches. Greater than five inches is preferred.	As needed
Inspect all vegetated strip components expected to receive and/or trap debris and sediment for clogging, excessive debris, and sediment accumulation; remove sediment during dry periods.	Quarterly
Inspect vegetated areas for erosion, scour, and unwanted growth. This should be removed with minimum disruption to the planting soil bed and remaining vegetation.	Semiannually
Inspect all level spreading devices for trapped sediment and flow spreading abilities. Remove sediment and correct grading and flow channels during dry periods.	Semiannually
Maintain records of all inspections and maintenance activity.	Ongoing

When correcting grading of a flow spreading device, proper erosion and sediment control precautions should be used in the concentrated area of disturbance to ensure protection of the remaining portion of the filter.

Disturbance to filter strips should be minimal during maintenance. At no time should any vehicle be driven on the filter strip. In addition, foot traffic should be kept to a minimum.

If the filter strip is of the type that needs mowing, such as turf grass and possibly other native grasses, push mowers, not riding mowers, should be used. The filter strip should be mowed perpendicular to the flow path (however not exactly the same path every mowing) to prevent any erosion and scour due to channeling of flow in the maintenance depressions.

Filter strips are often used as a convenient area for snow storage. Therefore, filter strip vegetation should be salt-tolerant, and the project's SMP Maintenance Schedule Forms should include removal of sand build-up at the toes of the filter strip slope. If the filter strip cannot provide pretreatment in the winter due to snow storage or vegetation choice, another pretreatment should be provided.

4.10.3 Forebays

A forebay is a small impoundment designed to dissipate the energy of incoming runoff and allow for initial settling of coarse sediments. They are typically used for pretreatment of runoff prior to discharge into an SMP. Storage created within forebay systems is primarily intended to promote gross pollutant removal prior to introducing flow into a downstream water quality SMP. The forebay is typically isolated from the downstream SMP facility by an earthen, stone, or concrete berm which creates the outer limitations of the forebay.

In some cases, forebays may be constructed as separate structures, but often they are integrated into the design of larger SMPs. Since forebays are typically designed as surface features, surface forebays are the primary focus of this section. Storm drain piping or other conveyance practices may be aligned upstream of a forebay to discharge into one, or several, forebays, as appropriate for the particular site.

Design of forebays is not limited to the examples shown within this text. Successful stormwater management plans will combine appropriate materials and designs specific to each site.



An example of a forebay in Philadelphia

When can forebays be used?

Forebays are a pretreatment option typically implemented with bioinfiltration/bioretention basins and ponds and wet basins. Depending on the site layout and stormwater conveyance design, they may be applicable to subsurface infiltration, subsurface detention, and media filters. Forebays are typically used for pretreatment at points of concentrated stormwater flow.

Key advantages of forebays

- Very effective at removing coarse sediment and debris from small frequent storm events
- Reduce the frequency of maintenance of the associated SMP
- Enhance pollutant removal capabilities of the associated SMP

Key limitations of forebays

- Take up space and expand the footprint of the associated SMP
- Generally ineffective at fine particulate removal
- Increase construction costs and required land area
- Require careful monitoring and removal of accumulated sediment, which can be visible and create aesthetic concerns

Key design considerations for forebays

- A berm placed on the downslope side of a mild slope can be used to create a forebay without additional excavation.
- As an alternative to an earthen basin, an underground structure may serve as a forebay; however, use of fully enclosed structures must allow accessibility for inspection and maintenance.
- Forebay systems can be vegetated or may be lined with hard materials such as rock or concrete. Vegetation within forebays can help to improve aesthetics and assist with pollutant removal; however, high velocities and high rates of sedimentation within forebays can make vegetation survival difficult.
- Forebays should be installed in locations that are accessible by maintenance equipment and should be designed for ease of maintenance. Those constructed with a bottom made of concrete or other solid materials make sediment removal easier and more accessible by heavy machinery.
- Forebay sizing should consider expected level of sediment loading. Drainage area size and characteristics have an impact on the nature and frequency of maintenance activities and corresponding long-term performance. For example, large parking lots deliver more sediment to an SMP than roof areas and therefore require additional maintenance than systems that receive only roof runoff.
- Exposed earthen slopes and the bottom of the forebay should be stabilized using seed mixes appropriate for soils, mowing practices, and exposure to inundation.
- If the forebay is separated from the downstream SMP by an impervious barrier such as a concrete wall or weir, an outlet control structure may be required to drain the forebay. A designed overflow spillway section may be constructed on the top of the berm separating the forebay from the SMP to allow overflow to exit the forebay and enter the downstream SMP at non-erosive velocities.

Forebay design and material standards

1. Forebays within large SMPs, such as ponds and wet basins, must contain 10% to 15% of the total permanent pool volume of the larger SMP.
2. For forebays within smaller SMPs such as bioinfiltration/bioretention basins, the storage volume should be sized to retain 0.25 inches of runoff of contributing directly connected impervious area (DCIA), with an absolute minimum of 0.1 inch of runoff.
3. A stone berm must physically separate the forebay from its associated SMP. The berm should span the entire width of the basin.
4. Inlet controls for forebays must include riprap aprons, stone placed in concrete, or some other type of energy dissipation device to rapidly reduce the inflow velocity for erosion/scour protection and to encourage settlement of suspended solids. The designer is referred to **Section 4.11** ☛ p. 166, Inlet Controls, for information on design requirements for inlet control systems.
5. Permanent vertical markers constructed of durable materials must be installed within the forebay area to indicate the sediment depth.
6. Inspection and maintenance access must be provided to allow for periodic sediment removal; this is most commonly provided via stabilized and mildly sloping graded areas that can be accessed by heavy equipment.
7. Exit velocities from the forebay must be non-erosive. The designer is referred to the latest edition of the *Pennsylvania Department of Environmental Protection (PA DEP) Erosion and Sediment Pollution Control Program Manual* for information on design standards for erosion and sedimentation control practices.

Forebay construction guidance

Guidance on typical construction sequencing to ensure proper installation and performance of forebays is as follows:

1. Install all temporary erosion and sedimentation controls. The area immediately adjacent to the forebay must be stabilized in accordance with the latest edition of the *PA DEP Erosion and Sediment Pollution Control Program Manual* prior to SMP construction.
2. Prepare site for excavation and/or embankment construction.
3. All existing vegetation should remain, if feasible, and must only be removed if necessary for construction.
4. If excavation is required, clear the area to be excavated of all vegetation. Remove all tree roots, rocks, and boulders only in excavation area.
5. Excavate bottom of forebay to desired elevation (if necessary).
6. Install surrounding embankments and inlet and outlet control structures.
7. Grade subsoil in bottom of forebay and compact surrounding embankment areas and around inlet and outlet structures.
8. Apply and grade planting soil.
9. Seed, plant, and mulch according to Planting Plan.

Forebay maintenance guidance

All areas of the forebay should be inspected after significant storm events. Corrective measures must be taken if erosion or excessive debris accumulation occurs. General recommended maintenance activities for forebays are summarized in Table 4.10-5.

Table 4.10-5: Forebay maintenance guidelines

Ongoing maintenance activity	Frequency
Remove trash and debris.	As needed
Weed by hand and remove invasive plants.	As needed
Grassed areas require periodic prudent fertilizing, de-thatching, and soil conditioning.	As needed
Trees, shrubs, and other vegetative cover will require periodic maintenance such as fertilizing, pruning, and pest control.	As needed
Mow/trim forebay vegetation.	As needed
Dredge sediment. Accumulated sediment must not occupy greater than 50% of the forebay volume.	As needed, but at least once every five years*
Inspect forebay for potential problems including subsidence, erosion, cracking, or tree growth on the stabilized overflow spillway embankment; damage to the spillway; sediment accumulation; changes in the condition of the inflow; and erosion within the forebay and banks.	Annually
Maintain records of all inspections and maintenance activity.	Ongoing
** The frequency of sediment removal depends on site conditions such as soil type and maintenance of site stabilization which influence the sediment load on the basin.*	

In most cases, no specific limitations have been placed on disposal of sediments removed from forebays. Studies to date indicate that sediments are likely to meet toxicity limits and can be safely landfilled. It is the owner's responsibility to ensure that the sediment is not contaminated. On-site sediment disposal is always preferable as long as the sediments are deposited away from the edge of the forebay to prevent their re-entry, and away from recreation areas where people could inhale resulting dust. Information regarding sediment disposal should be provided to the property owner by the design professional.

Sediments should be tested for toxicants in compliance with current disposal requirements if land uses in the drainage area are commercial or industrial, or if indications of pollution are seen or smelled.

4.10.4 Swales

A swale is an open channel vegetated with a combination of grasses and other herbaceous plants, shrubs, and/or trees that can reduce peak flow at the discharge point by increasing travel time and friction along the flow path. A traditional swale typically provides conveyance and pretreatment to another SMP, such as a bioinfiltration/bioretention basin, and provides some infiltration and water quality benefits. Check dams can increase these functions by providing ponding areas where settling and infiltration can occur. As the number of check dams increases, a swale may resemble a series of bioinfiltration/bioretention basins while still being designed to convey peak flows. Swales planted with turf grass provide some of these functions, but turf grass is not as effective as deeper-rooted vegetation at decreasing peak flow rates, allowing infiltration, and controlling erosion. A swale can be more aesthetically pleasing than a concrete or rock-lined drainage system and is generally less expensive to construct. Runoff can enter the swale through a curb opening, pipe, weir, or other design, and it may flow off of a curbless parking lot or road and down a swale slope in a diffuse manner.

When not used for conveyance and/or pretreatment, swales may be considered narrow bioinfiltration/bioretention basins, if designed as such. This section only covers the design of swales as pretreatment systems; the designer is referred to **Section 4.1** ☛ p. 4, Bioinfiltration/bioretention, for guidance on swales designed for Water Quality treatment.

Design of swales is not limited to the examples shown within this text. Successful stormwater management plans will combine appropriate materials and designs specific to each site.



An example of a swale in Philadelphia

When can swales be used?

Swales are pretreatment options typically applicable to bioinfiltration/bioretention basins and ponds and wet basins. Depending on the site layout and stormwater conveyance design, they may be applicable to subsurface infiltration, subsurface detention, and media filters.

Swales are typically used for pretreatment and/or conveyance of concentrated stormwater flow. They may be applicable in many urban settings, including parking lots, commercial and light industrial facilities, and roads and highways (via median strips and shoulders). Swales can also be used in residential developments and constructed, with approved property agreements, parallel to the sidewalks and streets. Alternatively, they can collect stormwater from multiple properties and convey it to a shared SMP.

Key advantages of swales

- Allow for flexible design for both stormwater treatment and conveyance
- Can often be used in lieu of more expensive subsurface conveyance or rock-lined/concrete channels
- Can effectively balance storage, treatment, and infiltration with peak flow conveyance needs
- Can be designed to fit into many types of landscapes in an aesthetically pleasing manner
- Can effectively balance needs for infiltration and treatment during small storms with needs for conveyance during large storms

Key limitations of swales

- Generally distributed across a larger area than other SMPs
- May have limited opportunities for implementation due to the amount of open space available at the site

Key design considerations for swales

- The first ponding area may be designed as a sediment forebay and function as a pretreatment practice for the remainder of the swale or downstream SMPs. Vegetated or stone filter strips are also options for pretreatment.
- The excavated channel itself provides the storage volume and conveyance capacity of the swale. An effective swale design will balance the need for infiltration and treatment during small storms with need for conveyance during large storms.
- The site's natural topography should be considered when siting the swale; if possible, the swale should be located along contours and natural drainage pathways with slopes of 2% to 3%.
- A bottom channel width of two to eight feet is recommended.
- The soil provides a growing medium for plants and allows for infiltration. The growing medium may consist of amended in situ soils or imported soil.
- A crushed stone layer may be added beneath the soil to increase storage and promote infiltration. Stone will perform this function most effectively when placed beneath ponded areas.
- In some cases, an underdrain and piping system may be designed to prevent prolonged ponding of stormwater or to collect and convey water to another facility such as an infiltration trench. Underdrain systems may be appropriate in locations where conditions are not ideal for infiltration. The designer is referred to **Section 3.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-3-infiltration-testing-and-soil-assessment-for-smp-design for detail on minimum infiltration rates and infiltration testing requirements.
- Vegetation or ground cover within a swale should be suitable for expected velocities. For the swale flow path, native grass mixes are preferable. Native wildflowers, grasses, and ground covers, which can be designed to require mowing only once or twice annually, are preferred to turf and lawn areas.

- It is recommended that swale SMP designs include check dams. Ponding behind check dams provides storage, increases infiltration, increases travel time, reduces peak flows, and helps prevent erosion by dissipating energy.
  - Check dams can be constructed from concrete, stone, boulders, earth, or other materials.
  - If a stone check dam is designed to be overtopped, appropriate selection of aggregate will ensure stability during flooding events. In general, one stone size for a dam is recommended for ease of construction. However, two or more stone sizes may be used, provided a larger stone (e.g., R-4) is placed on the downstream side, since flows are concentrated at the exit channel of the weir. Several feet of smaller stone (e.g., American Association of State Highway and Transportation Officials #57) can then be placed on the upstream side. Smaller stone may also be more appropriate at the base of the dam for constructability purposes.
  - Check dams should be evenly spaced and at least six inches high.

Swale design and material standards

1. If a swale is being designed as a primary SMP, it must meet the applicable design requirements for bioinfiltration/bioretention basins, as well as the applicable requirements in this section. The designer is referred to **Section 4.1** ☛ p. 4, Bioinfiltration/bioretention, for guidance and design requirements.
2. Swales must convey the ten-year, 24-hour storm with a minimum of six inches of freeboard and a maximum depth of 18 inches. Flow over check dams may be estimated using a weir equation.
3. Swales must be designed to resist erosion. It is recommended that the swale convey the two-year, 24-hour storm without erosion. The latest edition of the *PA DEP Erosion and Sediment Pollution Control Program Manual* is recommended as a reference for these calculations. Soil mix, vegetation, and temporary or permanent stabilization measures must be adjusted as needed.
4. Plants must be established at the time of swale completion (at least three months after seeding).
5. Energy dissipaters must be evaluated for use at points of concentrated inflow. The designer is referred to **Section 4.11** ☛ p. 166, Inlet Controls, for information on the design of energy dissipaters.
6. It is critical that plant materials are appropriate for soil, hydrologic, light, and other site conditions. The designer is referred to the list of native species in **Appendix I** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists for plant lists. Ponding depth, drain down time, sunlight, salt tolerance, and other conditions must be taken into consideration when selecting plants. Turf grass is generally not recommended but may be acceptable provided the designer can show it meets all requirements.
7. Maximum side slopes for parabolic channel swales are as follows:
   a. All – 2(H):1(V) (The recommended side slope is 3(H):1(V))
   b. Mowed – 4(H):1(V) to avoid “scalping” by mower blades
8. Check dams intended to provide ponding in swale SMP designs must not be porous (i.e. composed of stone gabions), as water should be ponded behind each check dam and forced to infiltrate. If the swales are only being used for conveyance or to increase time of concentration, check dams may be porous.

Swale construction guidance

Guidance on typical construction sequencing to ensure proper installation and performance of swales is as follows:

1. To promote infiltration through swales, rock construction entrances must not be located on top of areas of proposed swale bottoms.
2. Heavy equipment exclusion zones must be established to avoid compaction of the swale's bottom footprint during construction.
3. Begin vegetated swale construction only when the up-gradient site has been sufficiently stabilized and temporary erosion and sediment control measures are in place. Vegetated swales should be constructed and stabilized very early in the construction schedule, preferably before mass earthwork and paving increase the rate and volume of runoff. The designer is referred to the latest edition of the *PA DEP Erosion and Sediment Pollution Control Program Manual* for information on design standards for erosion and sedimentation control practices.
4. Rough grade the swale. Equipment must avoid excessive compaction and/or land disturbance. Excavating equipment should operate from the side of the swale and never on the bottom. If excavation leads to substantial compaction of the subgrade (where an infiltration trench is not proposed), 18 inches must be removed and replaced with a blend of topsoil and sand to promote infiltration and biological growth. At the very least, topsoil must be rototilled into the subgrade in order to penetrate the compacted zone and promote aeration and the formation of macropores. Following this, the area should be disked prior to final grading of topsoil.
5. Construct check dams, if required.
6. Fine grade the swale. Accurate grading is crucial for swales. Even the smallest non-conformities may compromise flow conditions.
7. Seed and vegetate according to final planting plans. Seeding with an annual turf grass is recommended to provide temporary stabilization. Plant the swale at a time of the year when successful establishment without irrigation is most likely. Provide temporary irrigation during any periods of little rain or drought. Vegetation should be established as soon as possible to prevent erosion and scour.
8. Concurrent with the previous step, stabilize freshly seeded swales with appropriate temporary or permanent soil stabilization methods, such as erosion control matting or blankets. If runoff velocities are high, consider sodding the swale or diverting runoff until vegetation is fully established. Erosion and sediment control methods must adhere to latest edition of the *PA DEP Erosion and Sediment Pollution Control Program Manual*.
9. Once the swale is sufficiently stabilized, remove temporary erosion and sediment controls. It is very important that the swale be stabilized before receiving stormwater flow. No runoff must be allowed to flow in the swale until grass is established.

Swale maintenance guidance

Swales should be inspected after significant storm events, and corrective measures should be taken if erosion or excessive debris accumulation occurs. General recommended maintenance activities for swales are summarized in Table 4.10-6.

Table 4.10-6: Swale maintenance guidelines

Ongoing activity	Frequency
Treat or replace diseased trees and shrubs.	As needed
Inspect soil and repair eroded areas.	Monthly
Remove litter and debris.	Monthly
Clear leaves and debris from overflow.	Monthly
Replace filter bags for pretreatment devices. Ensure filter bag is installed properly.	Quarterly
Inspect trees and shrubs to evaluate health.	Semiannually
Prune trees and shrubs.	Annually
Inspect for sediment build-up, erosion, vegetative conditions, etc.	Annually
Inspect outlet control devices after several storms to ensure that they are functioning properly and that there are no erosion problems developing.	Ongoing
Maintain records of all inspections and maintenance activity.	Ongoing

4.11 Inlet Controls

4.11.1 Inlet control introduction

Inlet controls are the structures or landscape features that manage the runoff flow into a stormwater management practice (SMP). Distribution piping, flow splitters, curbless design, curb openings, energy dissipaters, and inlets are all examples and elements of inlet controls. Inlet controls often serve an integral role in the pretreatment of stormwater entering an SMP by minimizing erosion potential or capturing sediment and gross solids. They restrict the volume and rate of flow introduced to an SMP while ensuring that flow is delivered to the SMP without causing erosion.

Design of inlet controls is not limited to the examples shown within this text. Successful stormwater management plans will combine appropriate materials and designs specific to each site.

Table 4.11-1 below is a guide to the inlet controls covered in this section, showing whether they are typically used in conjunction with various SMP practices. Red indicates that an inlet control would typically be used with an SMP; yellow indicates that the inlet control may be used with the associated SMP in certain circumstances; and blue indicates that the inlet control would not typically be used with the associated SMP. An appropriate inlet control must be matched to the contributing drainage area and receiving SMP.

Quick tip

Required inlet control design and material standards are denoted in this section by easy-to-reference numerals.

Table 4.11-1: Inlet controls applicability guidance

SMP	Flow splitters	Curbless design / curb openings	Energy dissipaters	Inlets
Bioinfiltration/ bioretention	Typical	Typical	Typical	Typical
Ponds and wet basins	Typical	Typical	Typical	Typical
Subsurface infiltration	Typical	Atypical	Atypical	Typical
Drainage wells	Typical	Atypical	Atypical	Typical
Cisterns	Typical	Atypical	Atypical	Occasional
Subsurface detention	Typical	Atypical	Atypical	Typical
Media filters	Occasional	Occasional	Occasional	Occasional
Porous surfaces	Atypical	Atypical	Atypical	Atypical
Green roofs	Atypical	Atypical	Atypical	Atypical
Blue-green roofs	Atypical	Atypical	Atypical	Atypical
Blue roofs	Atypical	Atypical	Atypical	Atypical

4.11.2 Flow splitters

Flow splitting devices are used to direct a fraction of runoff into an SMP while bypassing excess flows from larger events around the SMP into a bypass pipe or channel. The bypass typically connects to another SMP or to a receiving drainage system, depending on the design and management requirements. This type of inlet control can also serve as the positive overflow for the SMP.

Flow splitters can be constructed by installing bypass weirs in stormwater control structures such as inlets and manholes. On a larger scale, they can be constructed using concrete baffles in manholes.

When can flow splitters be used?

Flow splitters are inlet controls that are typically applicable to bioinfiltration/bioretention basins, subsurface infiltration and detention SMPs, ponds and wet basins, and cisterns. Depending on the site layout and stormwater conveyance design, they may be applicable to media filters.

Flow splitters are used to divert required Water Quality Volume (WQv) to appropriate SMPs while allowing excess stormwater to pass to another SMP, storm sewer, or receiving water body. They may also be used to divert first flush stormwater to lower-maintenance surface SMPs while allowing excess flows to discharge to subsurface SMPs.

Key advantages of flow splitters

- Divide runoff volume and divert it to different destinations to alleviate downstream flooding during a storm or to prevent a SMP from exceeding its designed capacity
- Reduce the cost of building an SMP by reducing the storage capacity needed to provide positive overflow
- Enhance SMP longevity by reducing the volume of runoff treatment and the amount of erosion, slope, and vegetation damage
- Separate the first flush volume, which contains most of the runoff pollutants, allowing it to be sent to more intensive treatment SMPs or be treated for a longer period without being diluted by additional runoff, which can be diverted downstream or to another SMP

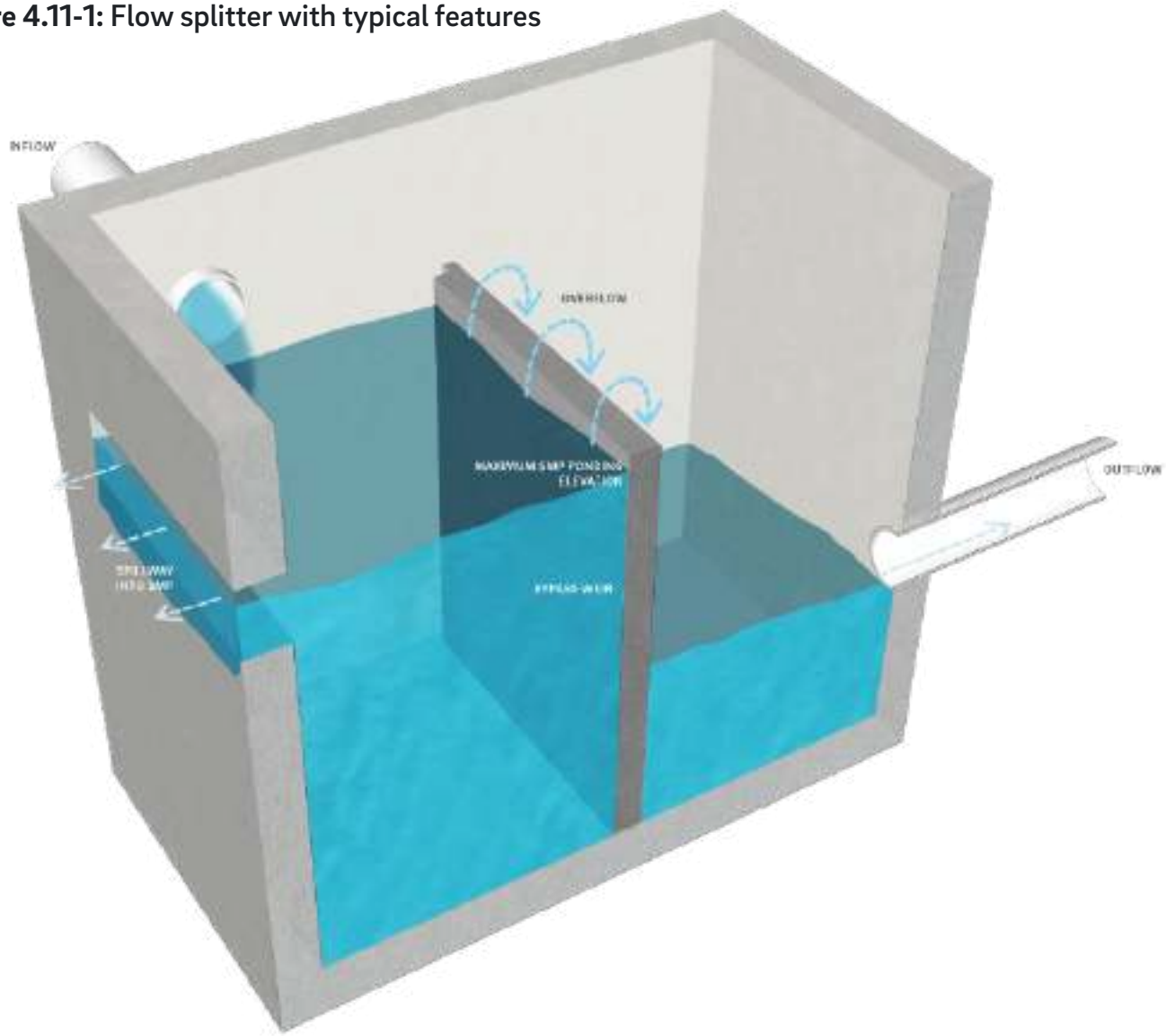
Key limitations of flow splitters

- Have the potential to cause flow reversal under certain circumstances (e.g., due to lack of backflow preventer or one-way valve) in which water will flow from an SMP back through the flow splitter

Key design considerations for flow splitters

- Flow splitters can be used as part of a connected system of SMPs to meet the Philadelphia Water Department (PWD) Stormwater Regulations (Stormwater Regulations). For example, a flow splitter can be used to divert portions of larger storm events from Water Quality requirement-meeting SMPs to SMPs better-suited to meet the Flood Control requirement.
- There are two basic considerations in the design of flow splitters: the elevation of the bypass weir and the capacity of the pipe to and from the SMP, which controls the maximum flow the SMP can receive and discharge.

Figure 4.11-1: Flow splitter with typical features



☛ water.phila.gov/wp-content/uploads/images/swmg-figure-4-11-1-flow-splitter-typical-features.png

Flow splitter design and material standards

1. The elevation of the bypass weir dictates the maximum elevation of the water in the SMP. The bypass elevation must be set at minimum, at the design storage elevation in the SMP. Flow will then only start to bypass the SMP once it exceeds the design storage elevation of the SMP. The design storage elevation is the water surface elevation at which the SMP storage area contains the runoff volume from a design storm event (for example, the WQv or the ten-year, 24-hour storm).
2. Positive overflow must be provided for large storm events, up to and including the 100-year, 24-hour storm, or, if the project is exempt from Flood Control, the ten-year, 24-hour storm. Overflow structures and pipes must be designed to convey at least the ten-year, 24-hour storm. The system should have enough capacity to transmit larger flows over the bypass weir without surcharging the structure.
3. Flow splitters must be designed with appropriate materials, taking flow velocities and exposure to the elements into consideration. Flow splitters are typically constructed from reinforced concrete, galvanized steel, or brick and mortar.
4. Flow splitters must be anchored to stormwater control structures using methods and materials appropriate to the structure's environment, such as corrosion-resistant hardware or epoxy mortar.

4.11.3 Curbless design/curb openings

Curbless designs allow stormwater to flow directly from the impervious source to the SMP. This type of design discourages the concentration of flow and reduces the energy of stormwater entering an SMP. Curbless designs are often used with bioretention basin islands or roadside swales.

Curb openings provide an alternative inlet control when a curbless design or the use of inlet structures is not possible. Bioinfiltration/bioretention and landscaped islands in curbed parking lots or roadways often use curb openings as inlet controls.



An example of curbless parking lot design in Philadelphia

When can curbless design/curb openings be used?

Curbless design/curb openings are inlet controls typically applicable to bioinfiltration/bioretention basins and ponds and wet basins. Depending on the site layout and stormwater conveyance design, they may be applicable to media filters.

Curbless design/curb openings can be implemented in a stormwater management design when standard inlet control and conveyance system structures are neither feasible, due to space or other constraints, nor desired.

Key advantages of curbless design/curb openings

- Can reduce SMP depths and associated excavation and materials costs when chosen in lieu of inlets
- Can be implemented as a strategy to reduce the concentration of stormwater flows into the SMP, thus reducing erosion potential

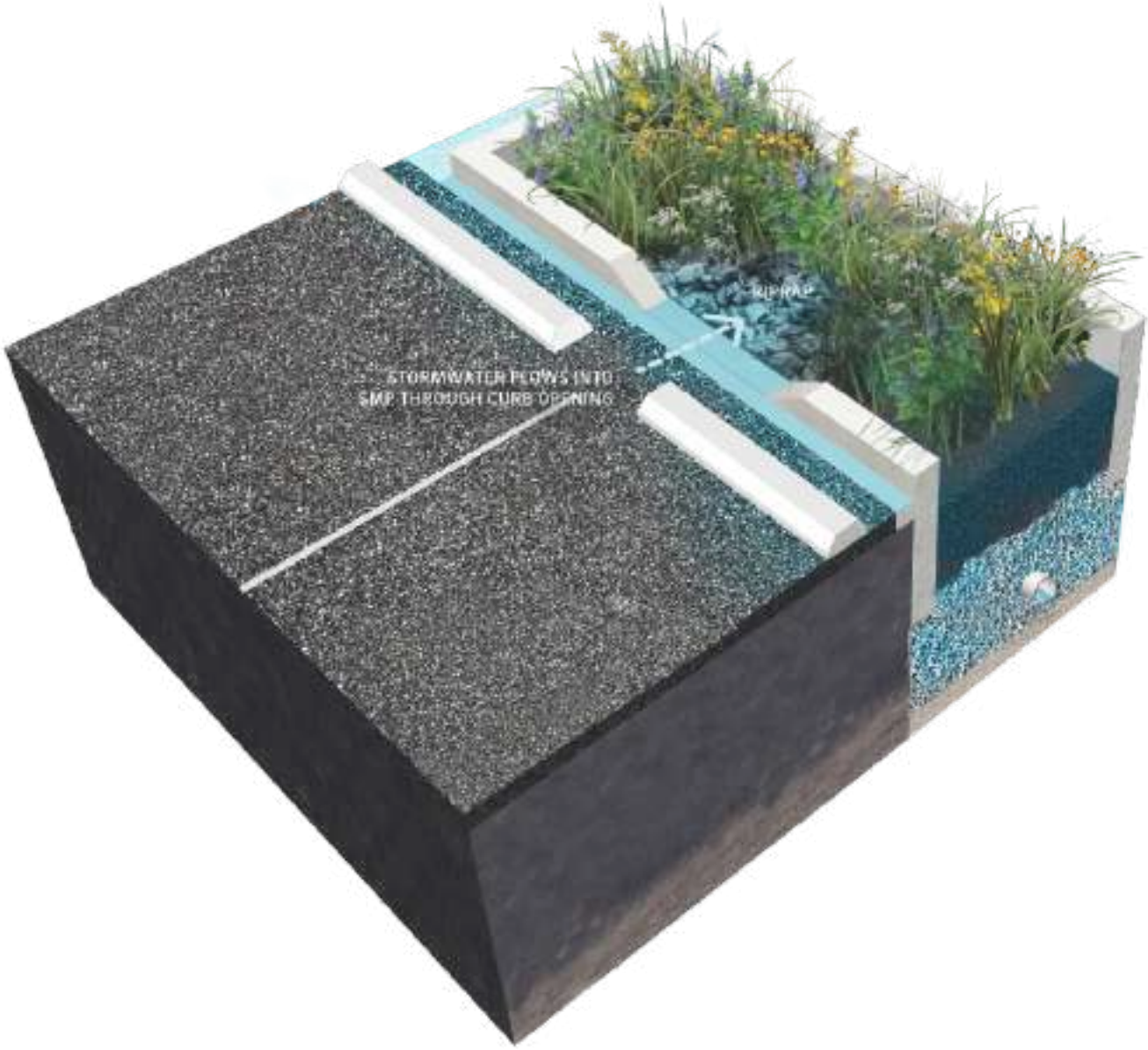
Key limitations of curbless design/curb openings

- Can result in limited control of bypass flows
- May not be appropriate for subsurface SMPs, large contributing drainage areas, contributing drainage areas with long flow paths over impervious areas, or along driveways or roadways where a sump condition is not feasible

Key design considerations for curbless design/curb openings

- A standard reference for designing traditional drainage systems is *U.S. Army Corps of Engineers, Hydraulic Engineering Center Circular 22 (HEC-22)*.
- Curb openings should be sized appropriately for sump or on-grade conditions. Further design guidance may be found in the *Federal Highway Administration Urban Drainage Design Manual* (FHWA-NHI-10-009), Section 4.4.4.2, Curb Opening Inlets.
- Curbless designs should be designed with appropriate non-erosive linings, such as biodegradable erosion control fabric, turf reinforcement mat, stone, or riprap, on all pervious downslope areas to the full width of the curb opening/curbless design. Riprap aprons or riprap basins placed downstream of a flow path are also acceptable, but are considered energy dissipaters, which are discussed in **Section 4.11.4** ☛ p. 174.
- Trench drains can be used to convey flow from curb openings across sidewalks.

Figure 4.11-2: Curb opening with typical features



☛ water.phila.gov/wp-content/uploads/images/swmg-figure-4-11-2-curb-opening-typical-features.png

Curbless design/curb opening design and material standards

1. If flow is to be introduced through curb openings, the pavement edge must be slightly higher than the elevation of the vegetated areas within the SMP.
2. Curbless design/curb openings must be designed to convey flow into an SMP without inducing erosive conditions. Integration of energy dissipaters is recommended where appropriate.
3. Curb openings must be designed to reduce bypass of gutter flow past the curb opening. This is a common problem with many curb openings that are oriented perpendicular to flow.
4. If curb openings are used to capture runoff, especially from driveways or roadways where the curb openings are not in a sump condition, verification that runoff from the one-year, 24-hour storm event will be captured by the curb opening must be provided.
5. Roadway materials and thicknesses must be able to withstand the appropriate loads at the edge and prevent undercutting.
6. Erosion control fabric must be designed in accordance with the channel design procedures in the latest edition of the *Pennsylvania Department of Environmental Protection (PA DEP) Erosion and Sediment Pollution Control Program Manual*, or per the manufacturer's specifications.
7. Curb openings are to be designed as gaps in otherwise continuous sections of concrete or granite curb conforming to the specifications of the *City of Philadelphia Department of Streets, Standard Construction Items (1997)*.
8. All subsurface portions of concrete or granite curb (i.e. below finished pavement grade) must be continuously installed within the extents of the curb opening.
9. Pedestrian fall safety must be considered where the curb openings direct flow adjacent to or beneath sidewalks. The need for edge protection, such as railings or wheel stops, must be evaluated.
10. Curb openings must be appropriately sized to convey the design discharge. Curb openings are typically 12 to 48 inches wide. Curb openings must be at least eight inches wide to prevent clogging and for ease of maintenance.

4.11.4 Energy dissipaters

Energy dissipaters are devices or practices designed to reduce the velocity, energy, and turbulence of flow. These structures can be employed when highly erosive velocities are encountered at the end of culverts or at the bottom of steep slopes where aesthetics are not a concern. Energy dissipaters include, but are not limited to, riprap aprons, riprap basins, and baffled outlets.

Riprap aprons are commonly used for energy dissipation due to their relatively low cost and ease of installation. A flat riprap apron can be used to prevent erosion at the transition from a pipe or box culvert outlet to a natural channel. Riprap aprons will provide adequate protection against erosive flows provided there is sufficient length and flare to dissipate energy by expanding the flow.

A ***riprap outlet basin*** is a pre-shaped scour hole lined with riprap that functions as an energy dissipater. Like a riprap apron, a riprap basin can be used to prevent erosion at the transition from a pipe or box culvert outlet to an earthen channel.

Baffled outlets are concrete or fiberglass boxes containing an alternating series of baffles and chambers. In addition to reducing flow velocity and energy, baffled outlets can effectively remove sediment, suspended particles, and associated pollutants from stormwater.



An example of a riprap apron in Philadelphia

When can energy dissipaters be used?

Energy dissipaters are inlet controls typically applicable to bioinfiltration/bioretention basins and ponds and wet basins. Depending on the site layout and stormwater conveyance design, they may be applicable to media filters. They can be used downstream of other inlet controls that concentrate stormwater flow, as well as on steeper slopes, to reduce erosion potential.

Key advantages of energy dissipaters

- Reduce velocities of concentrated stormwater runoff
- Reduce erosion potential and allow for more efficient sediment removal efforts, reducing overall maintenance costs and improving SMP performance
- Prevent scour that may undermine the structure discharging concentrated stormwater runoff
- Prevent downslope erosion that may create gullies and scour holes

Key limitations of energy dissipaters

- May increase erosion if not properly designed and installed
- May be difficult to install on some steeply sloping areas and in highly constrained sites

Key design considerations for energy dissipaters

- Select an appropriate energy dissipater type based on site characteristics such as slope, available area, and aesthetics.
- A key design issue is the interface between the end of the energy dissipater and the adjacent downstream area, which is typically vegetated. Vegetation should be well established at this interface. Turf reinforcement mat may be used at this interface to provide additional structure for vegetation.
- Vegetation/plantings can be used to obscure views of energy dissipation structures if aesthetics is a concern.

Figure 4.11-3: Riprap apron with typical features



☛ water.phila.gov/wp-content/uploads/images/swmg-figure-4-11-3-riprap-apron-typical-features.png

Energy dissipater design and material standards

1. Energy dissipaters must be used if flow is concentrated at the entrance to a surface SMP.
2. Riprap must be designed and sized in accordance with the riprap apron design procedures in the latest edition of the *PA DEP Erosion and Sediment Pollution Control Program Manual* or *U.S. Army Corps of Engineers, Hydraulic Engineering Center Circular 14 (HEC-14)*. The designer is referred to HEC-14 for the design of alternate types of energy dissipaters, such as drop structures and stilling basins.
3. Riprap stone must be angular, graded stone aggregate meeting the specifications of *PennDOT Publication 408, Section 703.2, Coarse Aggregate, Type A*.
4. For stream outfalls, the energy dissipation design tools HEC 11, HEC 14, and HEC 15 must be used for riprap, energy dissipaters, and flexible linings, respectively.

Energy dissipater maintenance guidance

All areas of the energy dissipater should be inspected after significant storm events for ponding. Corrective measures should be taken when excessive ponding occurs.

General recommended maintenance activities for energy dissipater are summarized in Table 4.11-2.

Table 4.11-2: Energy dissipater maintenance guidelines

Ongoing maintenance activity	Frequency
Inspect energy dissipaters after storms for displaced stones, slumping, and erosion at edges, particularly downstream or downslope. Repair or replace damaged riprap.	Monthly/concurrent with storm events
Inspect dissipater area for sediment and other debris accumulations. Remove sediment and other debris accumulations from dissipater area.	Quarterly
Inspect for woody vegetation build-up. Remove woody vegetation from the riprap.	Quarterly
Inspect stream for obstructions, such as debris, fallen trees, and sediment bars, if riprap is located on a channel bank. Remove obstructions.	Quarterly
Inspect any underlying fabric for damage. Repair or replace damaged fabric.	Quarterly

4.11.5 Inlets

Inlets, or catch basins, are structures within traditional stormwater collection systems where water is collected before it enters a pipe network. These structures can be designed with inlet pretreatment devices.

Inlet pretreatment devices are structural screens, hoods, traps, racks, bags, or suspended catch basin inserts inserted into the inlet to filter debris before it can enter the SMP's distribution piping system. They offer a range of screening capacity. Hoods and trash racks, for example, offer a coarse level of protection, typically screening only large debris and/or floatables. Filter screens or bags, available in a variety of proprietary designs, may filter large sediment particles, in addition to floatables and large debris. Stormwater Retrofit projects planning to utilize existing inlets without hoods and sites that generate pollutants such as loading docks, material storage facilities, junk yards, and waste collection and disposal sites require permanent filter bag inserts as inlet pretreatment devices.

The designer is referred to **Section 4.10** ☛ p. 148 for more information on Pretreatment.



An example of an inlet in Philadelphia

When can inlets be used?

Inlets are typically applicable to bioinfiltration/bioretention basins, subsurface infiltration and detention SMPs, and ponds and wet basins. Depending on the site layout and stormwater conveyance design, they may be applicable to cisterns and media filters.

Inlets may be used as an inflow device for any SMP where curb and gutter design is desired or required.

Key advantages of inlets

- Can provide a stable, relatively low-maintenance point for stormwater to enter an SMP
- Allow for pretreatment of stormwater runoff upstream of SMPs

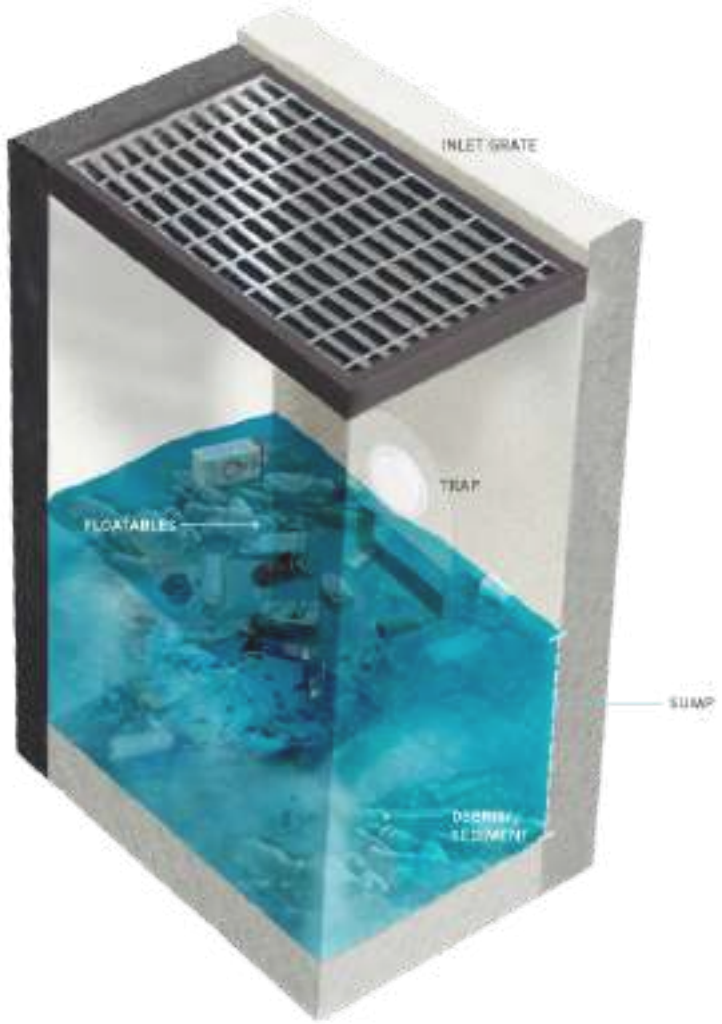
Key limitations of inlets

- Can often result in deeper SMPs than those with curbless design/curb openings due to outlet pipe inverts
- May store and release re-suspended captured sediment during subsequent flows unless frequently maintained
- Can become a source of pollutants through resuspension unless frequently maintained
- Cannot effectively remove soluble pollutants or fine particles

Key design considerations for inlets

- A standard reference for designing traditional drainage systems is *U.S. Army Corps of Engineers, Hydraulic Engineering Center Circular 22 (HEC-22)*.
- Clogging of an SMP's distribution piping system can be reduced by equipping upstream inlets with pretreatment devices such as structural screens, hoods, traps, racks, bags, or suspended catch basin inserts.

Figure 4.11-4: Inlet with typical features



☛ water.phila.gov/wp-content/uploads/images/swmg-figure-4-11-4-inlet-typical-features.png

Inlet design and material standards

1. Inlets must not be connected in series. Similarly, roof drainage systems must not be directly connected to inlets.
2. All inlets must include a sump and trap or sump and hood for pretreatment of stormwater runoff. The sump depth must be at least 15 inches below the bottom of the trap or at least 12 inches below the bottom of the hood.
3. If non-standard inlets are used to capture runoff, especially from driveways or roadways where the inlets are not in a sump condition, verification that runoff from the one-year storm event will be captured by the inlet must be provided.
4. Inlet spacing must be designed to prevent water from overtopping the curb and gutter or drainage ditch.
5. Inlets must be sized based on the size of the contributing drainage area, the amount of sediment expected from the discharging waters, the size and frequency of runoff events, and the amount of maintenance expected, recognizing that an undersized system will require more frequent maintenance. For large inlet drainage areas, area drains and yard drains 18 inches in diameter or smaller, or smaller than 2’ x 2’, should be upsized to at least 2’ x 2’ inlets.
6. All area drains and yard drains 18 inches in diameter or smaller, or smaller than 2’ x 2’, must include a permanent pretreatment device, such as a filter bag insert, for pretreatment of stormwater runoff.

7. The designer is referred to the *City of Philadelphia Standard Details and Standard Specifications for Sewers* booklet and the *Philadelphia Plumbing Code*, Section P-1001.7 for more design and material guidance.
8. All inlets on sites that generate pollutants, such as loading docks, material storage facilities, junk yards, and waste collection and disposal sites, must include a permanent filter bag insert.

Inlet maintenance guidance

Table 4.11-3 below is a schedule of recommended inspection and maintenance activities for inlets.

Table 4.11-3: Inlet maintenance guidelines

Ongoing activity	Frequency
Inspect inlets after several storms to ensure that they are functioning properly and that there are no erosion problems developing.	As needed
Identify and control source of sediment contamination when *in situ* soil is exposed or erosion channels are present.	As needed
Replace filter bags for pretreatment devices. Ensure filter bag is installed properly.	Quarterly
Inspect all pipe connections and parge ensuring a watertight seal.	Quarterly
Inspect for sediment and debris build-up. Remove sediment build=up exceeding two inches in depth or if it begins to constrict the flow path.	Semiannually
Clean out leaves, trash, and debris.	Semiannually
Maintain records of all inspections and maintenance activity.	Ongoing

4.12 Outlet Controls

4.12.1 Outlet control introduction

Outlet controls regulate the release of stormwater from a stormwater management practice (SMP). Proper design and construction practices are crucial to outlet control performance, which is closely interconnected with SMP performance. They must be appropriately selected and sized for the storage component of the SMP. Small differences in outlet control parameters, such as dimensions and invert elevations, can have drastic effects on SMP outflow characteristics. Examples of outlet controls include orifices, weirs, risers, underdrains, level spreaders, impervious liners, micro siphon drain belts, and low flow devices.

Outlet controls can provide a range of functions including:

- Meeting peak flow requirements;
- Controlling the rate of discharge from the SMP during various storm events;
- Controlling the amount of water stored for infiltration;
- Meeting drain down requirements;
- Providing adequate retention time for Water Quality requirement treatment;
- Bypassing of larger flows (positive overflow) to prevent re-suspension of sediment, hydraulic overload, or erosion of management practices; and/or
- Reducing downstream erosion potential.

Outlet control structures typically consist of concrete boxes that contain one or more outlet controls such as orifices or weirs.

A multi-stage outlet control structure can be designed with multiple orifices and weirs at different elevations to meet varying Philadelphia Water Department (PWD) Stormwater Regulations (Stormwater Regulations). A multi-stage outlet control structure may include several orifices for controlled flow and a positive overflow to quickly pass flow during extreme events.

Quick tip

Required outlet control design and material standards are denoted in this section by easy-to-reference numerals.



An example of an outlet control structure installation in Philadelphia

Design of outlet controls is not limited to the examples shown within this text. The designer must also consider the means and methods of the maintenance activities needed for the long-term operation of the structure and specific controls. Successful stormwater management plans will combine appropriate materials and designs specific to each site.

The following table is a guide to the outlet controls covered in this section showing whether they are typically used in conjunction with various SMP practices. Red indicates that an outlet control would typically be used with an SMP; yellow indicates that the outlet control may be used with the associated SMP in certain circumstances; and blue indicates that the outlet control would not typically be used with the associated SMP.

Table 4.12-1: Outlet controls applicability guidance

	SMP							
	Orifices	Weirs	Risers	Underdrains	Level spreaders	Impervious liners	Micro siphon drain belts	Low flow devices
Ponds and wet basins	Typical	Typical	Typical	Atypical	Typical	Typical	Occasional	Occasional
Bioretention	Typical	Typical	Typical	Typical	Typical	Occasional	Occasional	Occasional
Bioinfiltration	Typical	Typical	Typical	Typical	Typical	Atypical	Atypical	Atypical
Subsurface detention	Typical	Typical	Atypical	Occasional	Typical	Occasional	Occasional	Typical
Subsurface infiltration	Typical	Typical	Atypical	Occasional	Typical	Atypical	Atypical	Atypical
Blue-green roofs	Typical	Occasional	Occasional	Atypical	Atypical	Typical	Typical	Occasional
Blue roofs	Typical	Occasional	Occasional	Atypical	Atypical	Typical	Atypical	Occasional
Media filters	Occasional	Occasional	Atypical	Occasional	Occasional	Occasional	Occasional	Occasional
Cisterns	Occasional	Occasional	Atypical	Atypical	Atypical	Occasional	Atypical	Occasional
Drainage wells	Occasional	Atypical	Atypical	Atypical	Atypical	Atypical	Atypical	Atypical
Green roofs	Atypical	Atypical	Occasional	Atypical	Atypical	Typical	Occasional	Occasional
Porous surfaces	Atypical	Atypical	Atypical	Occasional	Atypical	Atypical	Atypical	Atypical

General design standards

(The designer is referred to **Appendix L** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/l-standard-details to download a CAD file of the Double Manhole Outlet Control Structure Standard Detail.)

1. Outlet controls must be provided as necessary to regulate flow in order to meet all applicable release rate, drain down time, ponding depth, positive overflow, and other requirements.
2. Outlet controls must provide positive overflow for their associated SMP, allowing stormwater to flow out of the SMP when the water level reaches a maximum design elevation in a subsurface feature or a maximum ponding depth in a surface feature without surcharging the SMP. Positive overflow from an SMP can either flow to another SMP or to an approved point of discharge. Outlet control structures must be sized to convey at least the ten-year, 24-hour storm event without surcharging the structure. The outlet controls must be designed to convey flows from the SMP up to the 100-year, 24-hour storm event, or, if the project is exempt from Flood Control, the ten-year, 24-hour storm, without surcharging the SMP. If flow reaches the SMP via a flow splitter, this structure can provide the positive overflow. The designer is referred to the SMP Sections within this chapter for SMP-specific design standards.
3. Outlet controls must be located so as to be easily and readily accessible for maintenance purposes.

4. Subsurface outlet control structures must remain free of any obstruction preventing manhole lids from being removed for accessibility and maintenance.
5. Outlet control structures must be sealed with a waterproof membrane, such as bituminous tar or similar.
6. A watertight seal for all pipe connections in the outlet control structure must be provided, such as rubberized boot collars, water stop grouting rings with non-shrink grout, or similar.
7. Precast structure sections must be interlocked using key joints. Key joints must be fitted with bituminous tar, gaskets, or similar, to prevent water intrusion.
8. A watertight seal must be provided between the precast structure and the impermeable weir.
9. An anti-seep collar (either a prefabricated anti-seep collar or a bentonite clay trench dam) must be provided on all outlet pipes and be sufficiently sized and distanced from the outlet structure to prevent water from traveling along the outside of the outlet pipe. Anti-seep collars must be constructed in accordance with the latest edition of the *PA DEP Erosion and Sediment Pollution Control Program Manual.*
10. All outlet control structures in combined sewer areas must include a sump and trap or sump and hood. The sump depth must be at least 15 inches below the bottom of the trap or at least 12 inches below the bottom of the hood, and the traps or hoods must be air-tight. The designer is referred to the City of Philadelphia Water Department Standards Details and Standard Specifications for Sewers and the Philadelphia Plumbing Code Section P-1001.7 for additional guidance.
11. Ladder bars must be included within any outlet control structure.
12. Any manholes between outlet structures and sewer connections in combined sewer areas must have sanitary, non-vented covers.
13. Outlet control structures must have solid, non-grated, tops.
14. The outlet pipe of an outlet control structure must have an invert at or below the invert of the inlet pipe(s). Setting the outlet pipe invert at a minimum of 7.5 inches below that of the inlet pipe(s) is recommended.
15. The outlet pipe of an outlet control structure directed to the City sewer may not be designed to be used as flow attenuation for its associated SMP. Upstream outlet control devices, such as an orifice or weir, must control the flow for all design storms up to, and including, the 100-year storm.
16. Proprietary and subscription-based active outlet controls must be designed with a passive default control that complies with applicable Stormwater Regulations in the case that the subscription is canceled or lapsed.

Outlet control construction guidance

Proper installation of outlet controls is essential to long-term function. Outlet controls must be installed per the following construction sequence:

1. Install all temporary erosion and sedimentation controls in the immediately adjacent work areas in accordance with the latest edition of the *Pennsylvania Department of Environmental Protection (PA DEP) Erosion and Sediment Pollution Control Program Manual* prior to construction.
2. If excavation is required, clear the areas to be excavated of all vegetation. Remove all tree roots, rocks, and boulders in excavation areas.
3. Excavate areas to desired elevation (if necessary).
4. If using an underdrain, place filter fabric or pea gravel filter, then place the rock and set the underdrain according to the plans. Otherwise, prepare subgrade for outlet structures.

5. Install outlet controls according to plans. Outlet controls must be constructed in accordance with manufacturer's guidelines or the design professional's guidance. Ensure outlet control structures are properly sealed and waterproofed to prevent leakage. Outlet controls must comply with all applicable American Society of Testing and Materials (ASTM) testing methods as required by PWD.
6. Confirm invert elevations and dimensions of outlet controls prior to final backfill and compaction of surrounding areas.
7. Backfill and compact areas around outlet controls. Ensure backfill is properly compacted in accordance with specifications.
8. Once site vegetation is stabilized, remove erosion and sediment control measures.

Outlet control maintenance guidance

General recommended maintenance activities for outlet controls are summarized in Table 4.12-2.

Table 4.12-2: Outlet controls maintenance guidelines

Ongoing activity	Frequency
Inspect outlet control structures after several storms to ensure that they are functioning properly and that there are no erosion problems developing.	As needed
Identify any sources of sediment contamination and control when in situ soil is exposed or erosion channels are present.	As needed
Maintain and cut back vegetation directly surrounding outlet control structures if impairing function of SMP.	As needed
Clean out leaves, trash, and debris, from all structures, such as grates and orifices (Note: consult with professional vacuum cleaning service if subsurface pipes, including underdrains, appear to be clogged).	As needed
Inspect all pipe connections and parging ensuring a watertight seal.	Quarterly
Remove all trash, sediment, and debris accumulation from the orifice.	Quarterly
Remove all trash, sediment, and debris build-up on the trash rack.	Quarterly
Inspect for sediment and debris build-up. Sediment build-up that begins to constrict the flow path must be removed.	Quarterly
Maintain records of all inspections and maintenance activity.	Ongoing

4.12.2 Orifices

An orifice is a circular or rectangular opening of a prescribed shape and size that allows a controlled rate of release for outflow from an SMP when the orifice is submerged.



An example of an underdrain orifice in Philadelphia

When can orifices be used?

An orifice is an outlet control that is typically applicable to bioinfiltration/bioretention basins, subsurface infiltration and detention SMPs, ponds and wet basins, and blue roofs. Depending on the site layout and stormwater conveyance design, they may be applicable to cisterns and media filters.

Orifices are suitable for SMPs of any size and can be used in conjunction with other outlet controls, such as weirs, to meet the Stormwater Regulations, if necessary.

Key advantages of orifices

- Are simple, passive structures that rely on gravity flow
- Can be variously sized to provide rate control for a wide variety of applications
- Multiple orifices may be located at the same or different elevations, if necessary, to meet performance requirements
- Allow for controlled drain down times

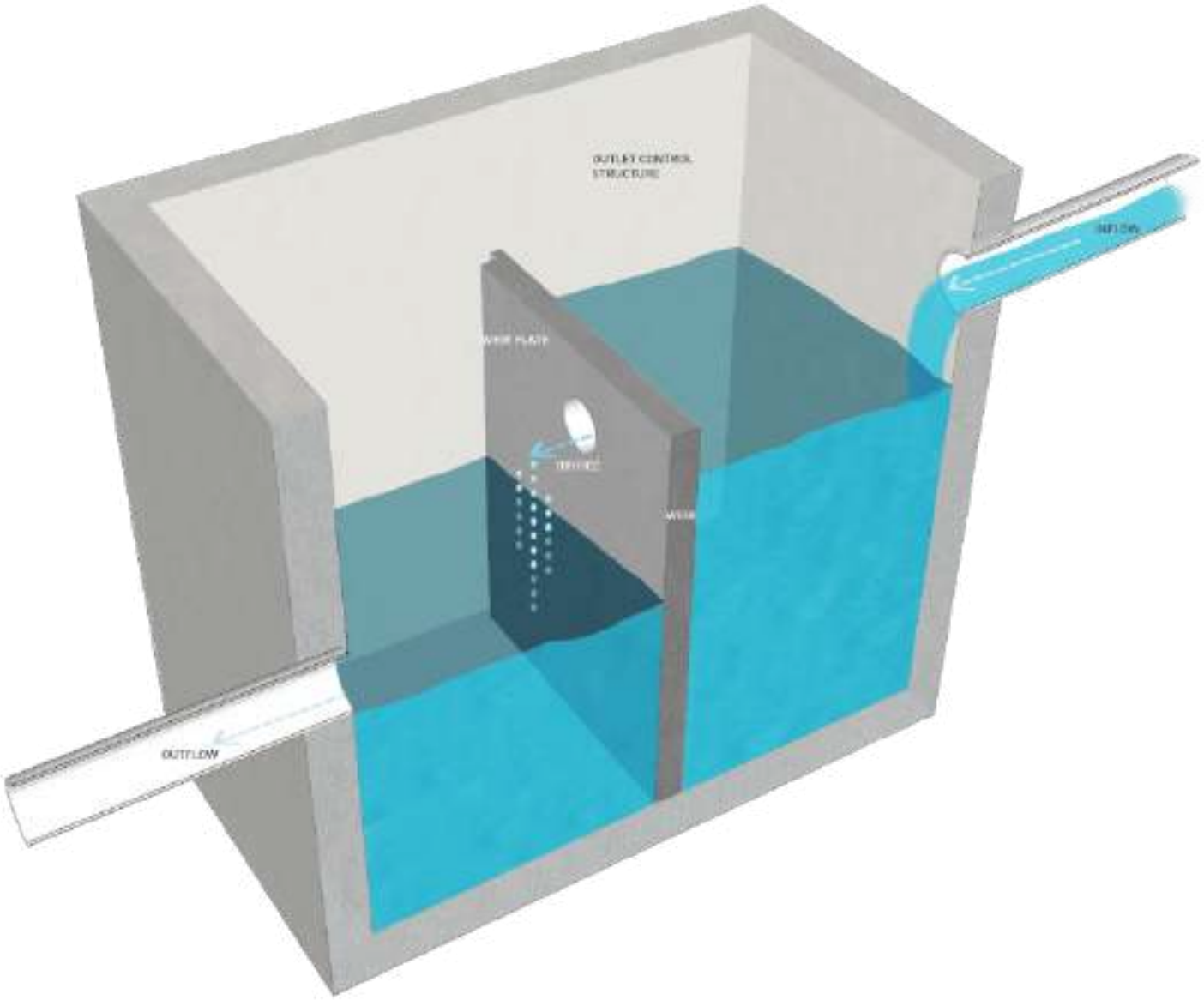
Key limitations of orifices

- May become clogged with sediment and debris, particularly traditional orifices with small diameters
- May be difficult to access for maintenance purposes when placed below grade
- Can concentrate flow and may cause erosive velocities

Key design considerations for orifices

- Multiple orifices may be necessary to meet the Stormwater Regulations.
- Sizing is dependent upon release rate requirements, maximum ponding depth, and drain down time requirements.
- The orifice size that is needed to meet a certain release rate can be increased by reducing the head over the orifice, which can be achieved by enlarging the SMP's footprint or adjusting overlying soil depths/cover for orifices below grade.
- Low flow devices can allow smaller release rates with larger orifices. The designer should explore all options before choosing a small orifice. The designer is referred to **Section 4.12.9** ☛ p. 215 for further information on low flow devices.

Figure 4.12-1: Orifice with typical features



☛ water.phila.gov/wp-content/uploads/images/swmg-figure-4-12-1-orifice-typical-features.png

Orifice design and material standards

1. No *underdrain orifice* (i.e., that which is located at the capped end of an underdrain) may be smaller than 0.5 inches in diameter. No *traditional orifice* (i.e., that which is not part of an underdrain) may be smaller than one inch in diameter. (The designer is referred to **Appendix L** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/l-standard-details to download a CAD file of the Underdrain Connection Standard Detail.)
2. Trash racks must be provided for all orifices draining surface basins.
3. To prevent clogging, screening must be provided over any traditional orifice three inches in diameter or smaller. The dimensions of the openings within the screening must be half the diameter of the orifice. The screening should be separated from the orifice, not placed directly over the orifice. A minimum 12-inch sump must be provided beneath the invert of the orifice to prevent the collection of debris.
4. One manhole access lid on each side of the orifice is required for maintenance access. The manholes must be located no farther than two horizontal feet from the orifice. Adequate space to perform maintenance on the orifice must be provided; it is recommended that at least four feet by three feet of space be provided on each side of the orifice.
5. Orifices must be designed and constructed of appropriate materials, taking flow velocities and exposure to the elements into consideration.
6. Suitable access must be provided to inspect and maintain all orifices.

4.12.3 Weirs

Weirs are engineered barriers/dams designed to control the release of stormwater from SMPs. Weirs can be located within surface SMPs or open channels or within outlet control structures. Typical weir shapes are rectangular, V-notch, and trapezoidal. Weir crests can be either sharp or broad.

Impermeable weirs controlling overland flow paths, such as swales, are typically called check dams. Impermeable check dams control upstream stormwater ponding depths and can be used to promote infiltration and/or sedimentation.

Check dams are permeable weirs that promote sedimentation by slowing flow velocities as water ponds behind the weir. Under low flow conditions, water ponds behind the check dam and slowly seeps through the openings between the permeable weir materials. Under high flow conditions, water flows both over and through the weir. Check dams also provide a means of spreading runoff as it is discharged, helping to decrease concentrated flow and reduce velocities as the water travels downstream. Stone check dams are typically located within overland flow paths, such as swales.

Spillways are weir outlet controls that are designed to provide safe, positive overflow from SMPs that store water on the surface, such as bioinfiltration/bioretention basins and ponds and wet basins. Spillways are typically trapezoidal, earthen, broad-crested weirs lined with riprap that allow for controlled flow of water over an SMP storage berm during extreme events.



An example of a weir in Philadelphia

When can weirs be used?

A weir is an outlet control that is typically applicable to bioinfiltration/bioretention basins, subsurface infiltration and detention SMPs, and ponds and wet basins. Depending on the site layout and stormwater conveyance design, they may be applicable to blue roofs, cisterns, and media filters.

Weirs are suitable for SMPs of any size and can be used in conjunction with other outlet controls, such as orifices, to meet the Stormwater Regulations, if necessary. Sizing of weirs is dependent upon release rate requirements, maximum ponding depth, and drain down time requirements.

Weirs can be used to do the following:

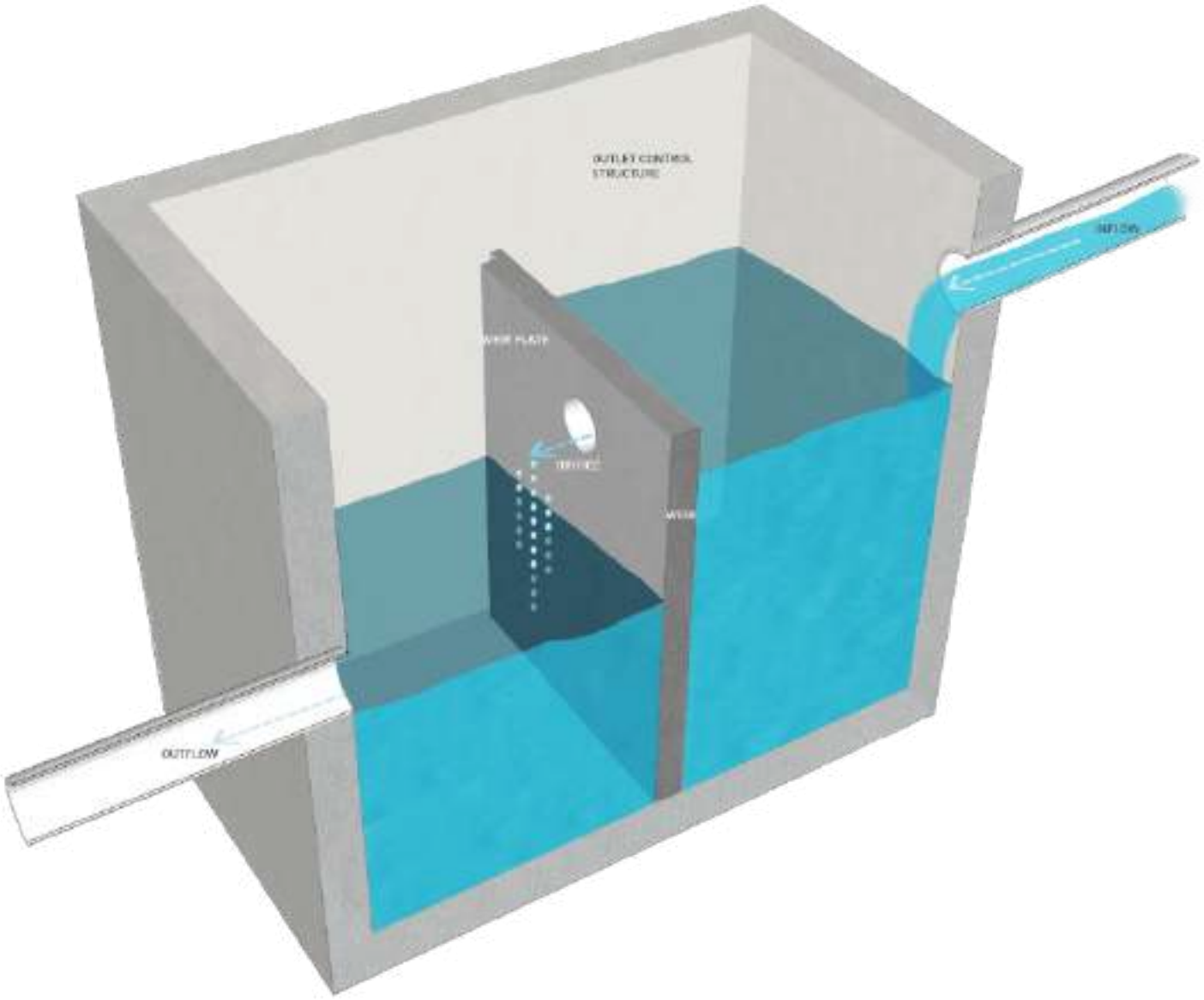
- Increase storage within surface depressions such as swales;
- Encourage ponding in areas where settling of solids and infiltration through vegetation and soil media can occur;
- Discharge overflow or bypass flow within an SMP to downstream conveyance systems; and/or
- Dissipate energy, reduce peak release rates, and control erosion.

A check dam is typically applicable to ponds and wet basins and swales. Depending on the site layout and stormwater conveyance design, check dams may also be applicable to bioinfiltration/bioretention basins.

Stone check dams, placed in a ditch or swale, allow for water to flow through the weir, as opposed to an impermeable weir. Check dams are most often used in large drainage areas within regional SMPs.

A spillway is typically applicable to bioinfiltration/bioretention basins and ponds and wet basins.

Figure 4.12-2: Weir with typical features



☛ water.phila.gov/wp-content/uploads/images/swmg-figure-4-12-2-weir-with-typical-features.png

Key advantages of weirs

- Are easily maintained
- May be surface-level structures that can usually be more easily accessed and maintained than closed systems

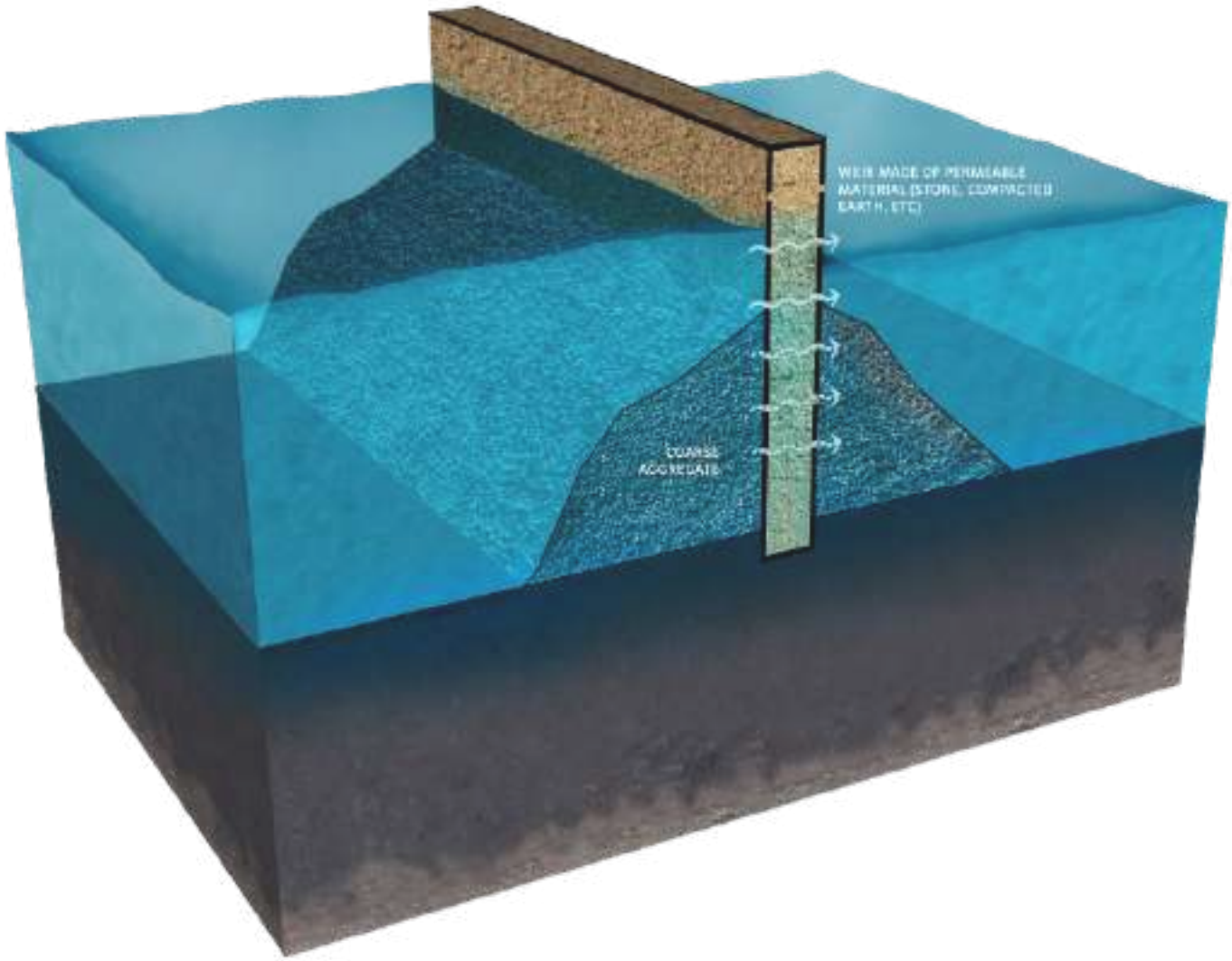
Key limitations of weirs

- Can concentrate flow and may cause erosive velocities
- Are not typically an effective technology for providing controlled discharge of stormwater
- Check dams may become clogged over time, and, once clogged, would likely require full replacement

Key design considerations for weirs

- Check dams can include decorative stone caps.
- One stone size for a stone check dam is recommended for ease of construction. However, if two or more stone sizes are used, a larger stone should be placed on the outer layer and downstream side, since flows are concentrated at the exit channel of the weir. Several feet of smaller stone can then be placed on the upstream side. Smaller stone may also be more appropriate at the base of the dam for constructability purposes.

Figure 4.12-3: Check dam with typical features

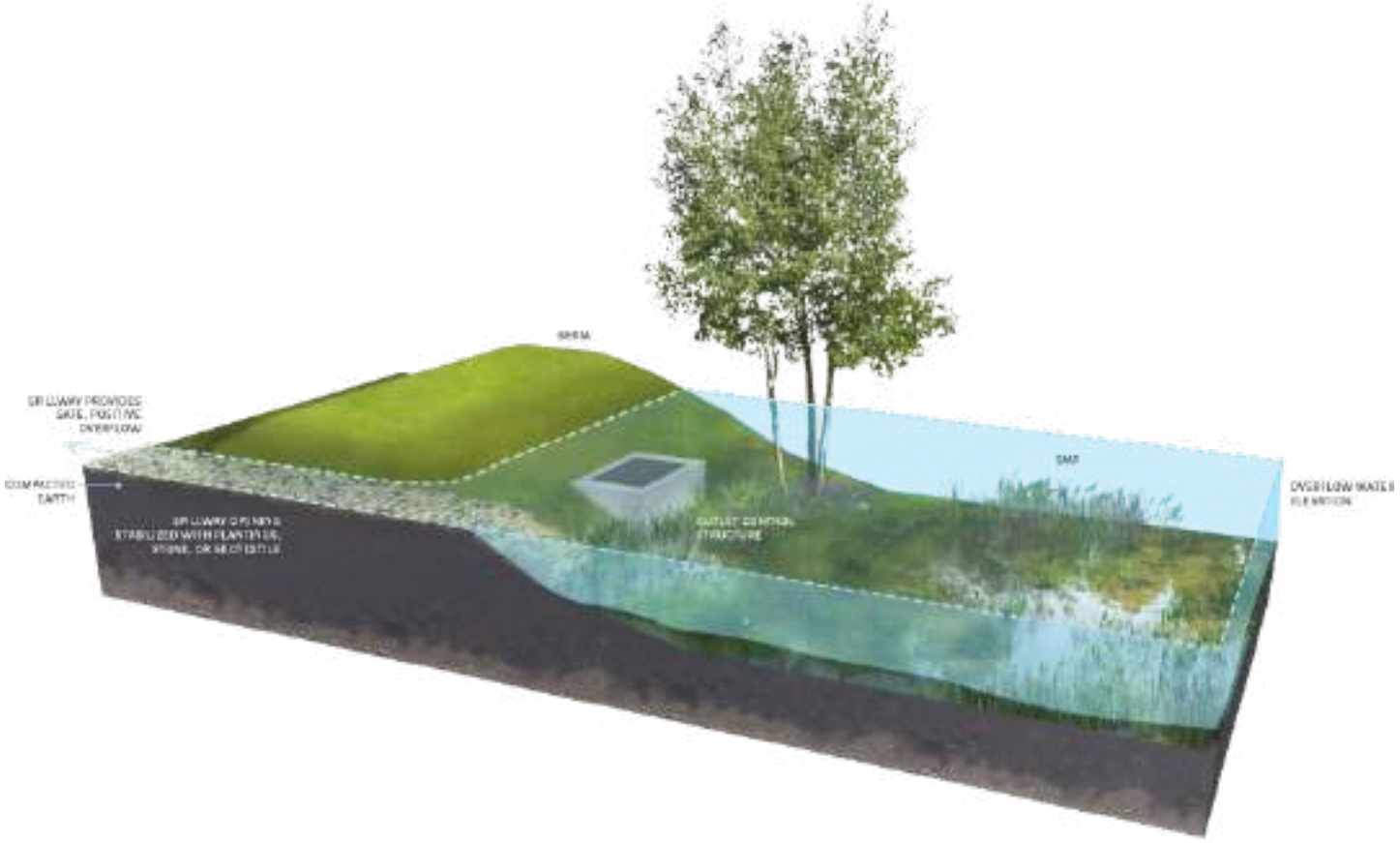


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Weir design and material standards

1. Design of weirs must consider structural stability during extreme conditions, including flow velocities and upstream hydrostatic pressure from ponded water. Structural supports must be designed by a structural engineer.
2. Weirs must be designed and constructed with appropriate materials taking flow velocities and their exposure to the elements into consideration.
3. Impermeable weirs in outlet control structures
    a. Weir walls must consist of concrete that is poured monolithically, and the sides and bottom of the weir must be tied into the outlet control structures using rebar reinforcement.
    b. Weir walls must have a minimum thickness of six inches.
    c. Weir walls must be entirely watertight, including the sides and bottom of the weir wall.
    d. A minimum of 18 inches of clearance must be provided above the top of the weir wall.
    e. One manhole access lid on each side of the weir wall is required for maintenance access. The manholes must be located no farther than two horizontal feet from the weir wall.
4. Check dams
    a. When placed within swales, check dams must be evenly spaced and no more than six to 12 inches high.
    b. Check dams that provide ponding in swales and are designed for infiltration must not be porous, as water should be ponded behind each check dam and forced to infiltrate.
5. Spillways
    a. A minimum of one foot of freeboard must be provided between the ponding elevation during the 100-year, 24-hour storm event, or, if the project is exempt from Flood Control, the ten-year, 24-hour storm, and the invert elevation of the emergency spillway.
    b. A minimum of one foot must be provided between the invert elevation of the emergency spillway and the top-of-berm elevation.
    c. All emergency spillways must be stabilized with stone, geotextile, or plant material that can withstand strong flows.
    d. Spillway flow must not be directed toward neighboring properties.

Figure 4.12-4: Spillway with typical features



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4.12.4 Risers

Risers are vertical structures with a grated top that can be designed to control the amount of water ponded within an SMP and to provide positive overflow. Riser pipes are vertical pipes topped with a dome-shaped grate. Riser boxes are modified concrete boxes (outlet control structures) outfitted with inlet grates. Orifices may also be placed on the upstream face and sides of a riser box to create a multi-stage riser.



An example of a domed riser pipe in Philadelphia

When can risers be used?

A riser is an outlet control that is typically applicable to bioinfiltration/bioretention basins, and ponds and wet basins. Depending on the site layout and stormwater conveyance design, they may be applicable to blue roofs and green roofs. Risers can be used to control ponding depths and release water at a reduced rate. Risers can be used in conjunction with orifices, weirs, or underdrains, as necessary, to meet the Stormwater Regulations.

Key advantages of risers

- Provide flexible outlet controls, when multi-staged, to meet varying Stormwater Regulations simultaneously

Key limitations of risers

- Can be aesthetically displeasing

Key design considerations for risers

- Concrete form liners and surrounding risers with vegetation can be used to improve aesthetics.
- Location of a riser is important to provide easy maintenance access, and risers should not be placed near inflow structures in order to avoid shortcutting of treatment.

Figure 4.12-5: Riser pipe with typical features



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Riser design and material standards

(The designer is referred to **Appendix L** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/l-standard-details to download a CAD file of the Riser Outlet Control Structure Standard Detail.)

1. Riser design must balance providing positive overflow with allowing for adequate static storage. Overflow must be provided at the maximum Water Quality storm ponding depth for all SMPs and, for bioinfiltration/bioretention basins, at the minimum height to provide sufficient static storage of the Water Quality Volume (WQv).
2. Riser pipes must be constructed of high-density polyethylene (HDPE) plastic, corrugated metal, concrete, or other weather resistant material.
3. Riser boxes must be constructed of precast or cast-in-place concrete with reinforcing as warranted. All concrete must be Class C, conforming to the specifications of the *City of Philadelphia Department of Streets, Standard Construction Items (1997)*.
4. Trash racks or screens are required and must be constructed of durable, weather-resistant materials resistant to photo-degradation, weathering, oxidation, or other corrosive impacts.

4.12.5 Underdrains

Underdrains are typically perforated pipes in stone layers or trenches that intercept, collect, and convey stormwater that has percolated through soil, a suitable aggregate, and/or geotextile, in order to drain the SMP after a storm event, allowing its storage volume to be available for subsequent storms. Underdrains can be connected to an outlet control structure that then controls the ponding elevation or release rate through weirs and/or orifices.

When can underdrains be used?

An underdrain is an outlet control that is typically applicable to bioinfiltration/bioretention basins. Depending on the site layout and stormwater conveyance design, they may be applicable to porous surfaces, subsurface infiltration and detention SMPs, and media filters.

Underdrains can be used to collect runoff from media storage beds for non-infiltrating SMPs. Underdrains can be used when sub-soils are not appropriate for infiltration (e.g., karst geology, massive structure, known contaminants, etc.).

Capped underdrains are required for all bioinfiltration/bioretention SMPs. The designer is referred to **Section 4.1** ☛ p. 4 for design guidance on flow-regulating underdrains for bioinfiltration/bioretention SMPs.

Key advantages of underdrains

- Can collect stormwater over a large surface area
- Allow for vegetative and media filtration prior to release of stormwater into downstream conveyance systems
- Allow for vegetated or filtering practices to be placed in areas where infiltration is infeasible

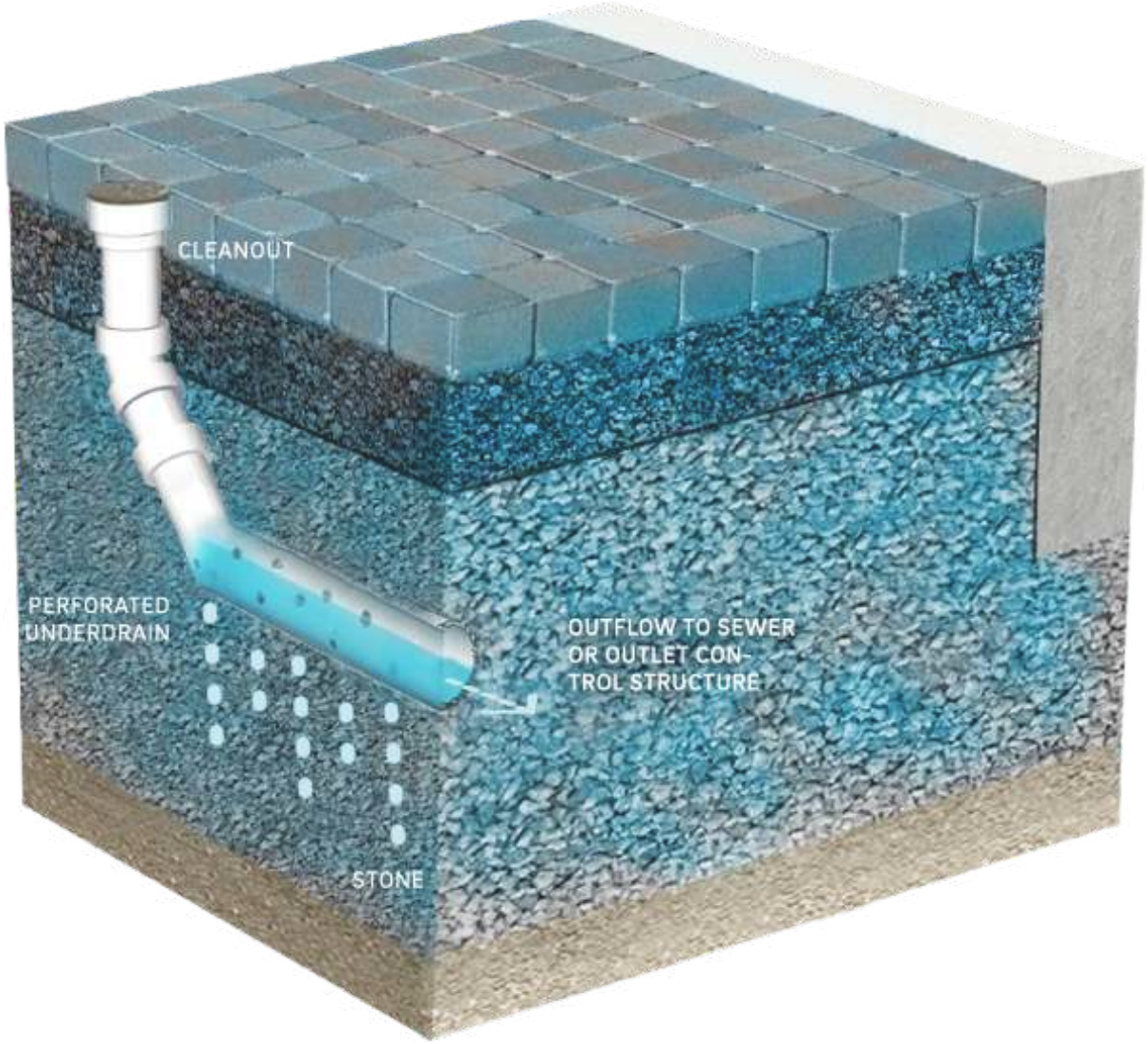
Key limitations of underdrains

- May require maintenance, inspection, and replacement that can be difficult since the systems are typically buried underneath stone and, sometimes, soil
- Can experience inhibited performance due to root intrusion, if not properly controlled

Key design considerations for underdrains

- To help prevent or minimize the potential for root intrusion, trees with aggressive root systems should be located away from underdrains.

Figure 4.12-6: Underdrain with typical features



☛ water.phila.gov/wp-content/uploads/images/swmg-figure-4-12-6-underdrain-typical-features.png

Underdrain design and material standards

(The designer is referred to **Appendix L** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/l-standard-details to download CAD files of the Underdrain Connection and Orifice Standard Details.)

1. Underdrains are required for all bioinfiltration/bioretention SMPs. For bioinfiltration SMPs, a solid cap must be provided at the end located within the outlet control structure to promote infiltration. For bioretention SMPs located in the combined sewer area, a cap must be provided at the end located within the outlet control structure, and it must be outfitted with an orifice, sized appropriately to meet all applicable release rate requirements.
2. Underdrains must be designed to be level (i.e., with no slope).
3. Underdrains must be made of continuously perforated HDPE plastic piping with a smooth interior and a minimum inner diameter of four inches. HDPE pipe must meet the specifications of AASHTO M252, Type S or AASHTO M294, Type S.
4. Underdrains must be surrounded by a sand or stone layer to filter sediment and facilitate drainage.

5. The minimum allowable thickness of a sand or stone filter layer is six inches both above and beneath the underdrain.
6. To prevent clogging, underdrain pipes must be surrounded by geotextile fabric if a sand layer is used.
7. Stone surrounding an underdrain must be uniformly graded, crushed, clean-washed stone. PWD defines "clean-washed" as having less than 0.5% wash loss, by mass, when tested per AASHTO T-11 wash loss test. AASHTO No. 3 and No. 57 stone can meet this specification.
8. Sand, if used, must be AASHTO M-6 or ASTM C-33 sand and must have a grain size of 0.02 inches to 0.04 inches.
9. Geotextile fabric must be placed between the stone layer and surrounding soil to prevent sediment contamination.
10. Geotextile must consist of polypropylene fibers and meet the following specifications (AASHTO Class 1 or Class 2 geotextile is recommended):
    a. Grab Tensile Strength (ASTM-D4632): ≥ 205 lbs
    b. CBR Puncture Strength (ASTM-D6241): ≥ 500 lbs
    c. Flow Rate (ASTM-D4491): ≥ 95 gal/min/ft2
    d. UV Resistance after 500 hrs. (ASTM-D4355): ≥ 70%
    e. Tear Resistance (ASTM-D4533): ≥ 80 lbs
    f. Heat-set or heat-calendared fabrics are not permitted.
11. Cleanouts or maintenance access structures must be provided at the end of all underdrain pipes.
12. Cleanouts must be provided for all 90-degree bends, located upstream of complicated bends, and evenly spaced during straight pipe runs.
13. All intermediate cleanouts and domed riser pipe connections must be located upstream of the connected outlet control structure to allow for cleaning equipment to flush in the direction of the structure.
14. An anti-seep collar must be installed around outlet pipes passing through embankments. Anti-seep collars must be constructed in accordance with the latest edition of the *PA DEP Erosion and Sediment Pollution Control Program Manual*.
15. Cleanouts must be made of material with a smooth interior having a minimum inner diameter of six inches. If the connecting pipe is eight inches in diameter or larger, then the cleanout must be eight inches in diameter.
16. The outlet pipe of an outlet control structure must have an invert at or below the invert of the underdrain. Setting the outlet pipe invert at a minimum of 7.5 inches below that of the underdrain is recommended.

4.12.6 Level spreaders

Level spreaders are outlet controls that are designed to uniformly distribute concentrated flow over a large area. Level spreaders help reduce concentrated flow, thereby reducing erosion and increasing the design life of many SMPs.

All level spreader designs follow the same principles:

- Concentrated flow enters the spreader at a single point such as a pipe, swale, or curb opening.
- The flow is slowed, and energy is dissipated.
- The flow is distributed throughout a long, linear, shallow trench or behind a low berm.
- Water then flows over the berm or edge of trench uniformly along the entire length.

There are many types of level spreaders that can be selected based on the peak rate of inflow, the duration of use, and the site conditions. Examples of level spreaders include subsurface discharge through level perforated pipes (bubble-up level spreader), concrete curbs, half-sections of pipe, troughs, and surface discharge to plunge pools.



An example of a level spreader in Philadelphia

When can level spreaders be used?

A level spreader is an outlet control that is typically applicable to bioinfiltration/bioretention basins, ponds and wet basins, and subsurface infiltration and detention SMPs. Depending on the site layout and stormwater conveyance design, they may be applicable to media filters. They are suitable as outlet controls for pretreatment structures such as forebays and at locations where SMPs cannot discharge to the City sewer and/or must outfall to open spaces. Plunge pools can be used in combination with concrete curbing and/or trough level spreaders.

Key advantages of level spreaders

- Reduce velocities, reducing the potential for erosive conditions
- Eliminate the need for larger outlets and/or conveyance systems in some instances

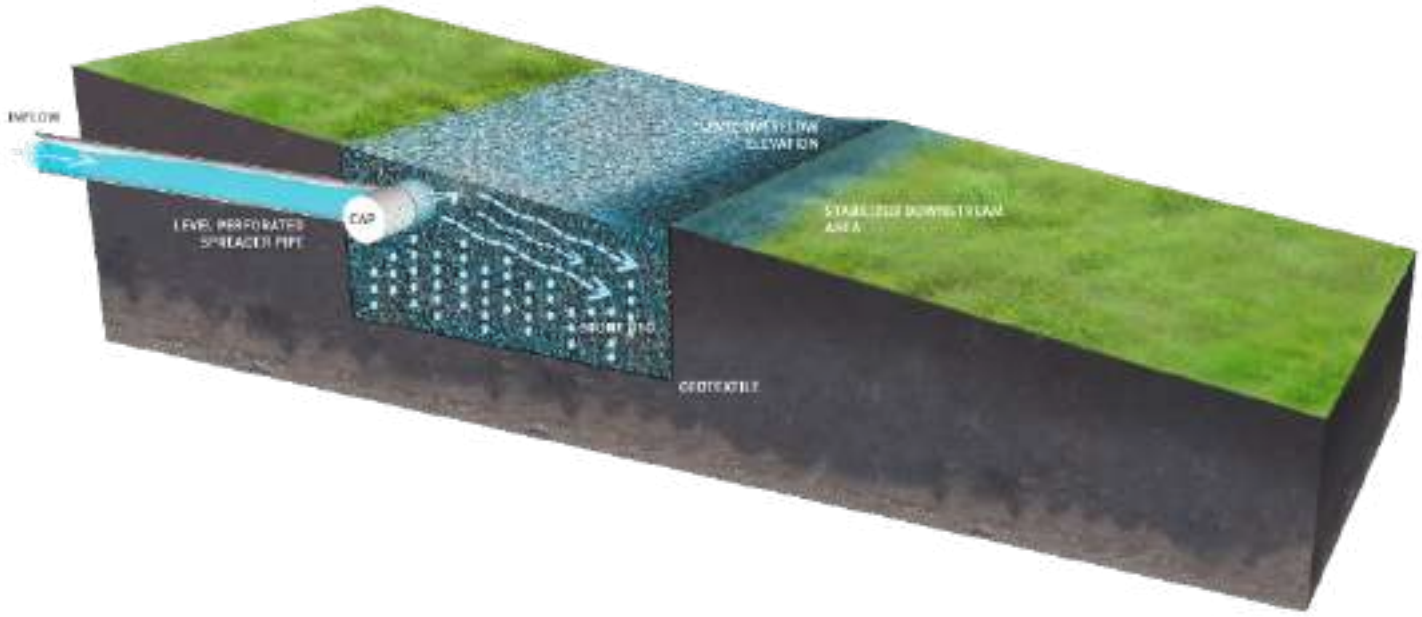
Key limitations of level spreaders

- Not effective for providing rate control
- Have strong failure potential if soils are not protected from compaction and settlement; performance is strongly influenced by relatively small changes in elevation
- Require a relatively flat grade and downslope pervious areas onto which the spread flow can be discharged
- Can require 100 feet in downstream length in certain scenarios
- May be rendered ineffective by high sediment load deposition on the surface

Key design considerations for level spreaders

- The depths of trough or pipe level spreaders will depend on the flow. If sediment or debris accumulates in the trough or pipe, it can be easily removed.
- Concrete troughs are generally a more expensive level spreader alternative; however, they are easy to maintain and typically have a longer design life.
- Long-term maintenance and replacement costs can be decreased with proper installation.

Figure 4.12-7: Level spreader with typical features



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Level spreader design and material standards

1. The following level spreader lengths are required by cover condition:
   a. Dense grass ground cover: 13 linear feet for every one cubic feet per second (cfs) of flow during the ten-year, 24-hour storm event
   b. Forested areas with no ground cover: 100 linear feet for every one cfs of flow during the ten-year, 24-hour storm event
2. Level spreaders must safely diffuse flows up to, and including, the 100-year, 24-hour storm event.
3. It is critical that the edge over which flow is distributed is exactly level. If there are small variations in height on the downstream lip, small rivulets will form. Experience suggests that variations of more than 0.25 inches can cause water to re-concentrate and potentially cause erosion downstream of the level spreader. The site selected for the installation of a level spreader must be a level grade (a constant horizontal elevation, to within +/- four inches).
4. The downslope side of the level spreader must be clear of debris. After construction, debris such as soil, wood, and other organic matter might accumulate immediately downstream of the level spreader. This effectively blocks water as it flows out of the level spreader, forcing it to re-concentrate.
5. The downstream side of the level spreader must be fully stabilized before the level spreader is installed. If a level spreader is installed above a disturbed area without sufficient vegetative cover or other ground cover such as mulch or construction matting, erosion rills will quickly form. Even sheet flow can cause significant downstream erosion on disturbed areas. The first three feet downslope of a level spreader must be stabilized with soil/turf reinforcement matting and grass or other approved vegetation.
6. Level spreaders cannot be constructed in newly deposited fill. Undisturbed earth is much more resistant to erosion than fill. Erosion is even likely to occur over a well-established young stand of grass planted fill.
7. For level spreaders that do not direct discharge to a receiving stream or sewer, the minimum distance between the level spreader and any downslope property boundary must be 15 feet. If this requirement cannot be met, a drainage easement may be required.

8. For level spreaders that direct discharge to a receiving stream or sewer via overland flow, the maximum distance between the level spreader and any receiving stream or sewer must be 100 feet. Distances greater than 100 feet but less than 150 feet may be considered on a case-by-case basis for very mild slopes (less than or equal to 1%) and heavily vegetated (grassy) areas.
9. The first ten feet downslope of the level spreader must not exceed a slope of 4%.
10. Earthen berms must not be used as level spreaders due to the difficulty of grading a level edge within acceptable tolerances.
11. Treated lumber must not be used as level spreaders due to issues with deformation and decomposition.
12. Geotextile-covered berms must not be used as level spreaders.
13. Concrete curbs, troughs, and half-pipes:
    a. Concrete curbs, troughs, and half-sections of pipe must be between four and 12 inches deep.
    b. Curbs and troughs must be constructed of Class C concrete or reinforced concrete, conforming to the specifications of the *City of Philadelphia Department of Streets, Standard Construction Items (1997)*.
    c. Half-pipes must be either Class C concrete or reinforced concrete, conforming to the specifications of the *City of Philadelphia Department of Streets, Standard Construction Items (1997)* or HDPE plastic meeting the specifications of AASHTO M252, Type S or AASHTO M294, Type S.
14. Subsurface discharge through level perforated pipes (bubble-up level spreaders)
    a. Perforated pipes must be between four and 12 inches in diameter. HDPE pipe must meet AASHTO M252, Type S or AASHTO M294, Type S standards.
    b. The pipes must be enveloped in uniformly graded, crushed, clean-washed stone. PWD defines "clean-washed" as having less than 0.5% wash loss, by mass, when tested per AASHTO T-11 wash loss test. AASHTO No. 3 and No. 57 stone can meet this specification.
    c. Geotextile must be placed between the stone aggregate and soil.
    d. Geotextile must consist of polypropylene fibers and meet the following specifications (AASHTO Class 1 or Class 2 geotextile is recommended):
        i. Grab Tensile Strength (ASTM-D4632): ≥ 205 lbs
        ii. CBR Puncture Strength (ASTM-D6241): ≥ 500 lbs
        iii. Flow Rate (ASTM-D4491): ≥ 95 gal/min/ft^2
        iv. UV Resistance after 500 hrs (ASTM-D4355): ≥ 70%
        v. Tear Resistance (ASTM-D4533): ≥ 80 lbs
        vi. Heat-set or heat-calendared fabrics are not permitted.
15. Perforated pipes must include end treatments consisting of cleanouts, inlets, or manholes for maintenance purposes.
16. Surface discharge to plunge pools
    a. Underlying soils within plunge pools must remain undisturbed, uncompacted, and protected from heavy equipment to preserve infiltration capacities.
    b. Riprap stone sizing must be determined in accordance with the riprap apron design procedures in the latest edition of the *PA DEP Erosion and Sediment Pollution Control Program Manual*.

Level spreaders maintenance guidance

General recommended maintenance activities for level spreaders are summarized in Table 4.12-3.

Table 4.12-3: Level spreader maintenance guidelines

Ongoing maintenance activity	Frequency
Inspect for debris and sediment accumulation in the forebay, along the stone, in the pipe, and along the downslope side of the level spreader. Remove all debris and sediment.	Quarterly
Inspect the downstream side of the level spreader for erosion.	Quarterly
Remove all vegetation from areas of stone.	Monthly during the growing season
Mow/trim vegetation on the downstream side of the level spreader.	Monthly during the growing season
Inspect level spreader after storms to ensure there is sufficient stone to diffuse flow and replace as needed	Concurrent with storm events
Inspect the edge over which flow is distributed for levelness. Eliminate variations in height on the downstream lip.	Quarterly
Inspect the level spreader site for levelness. Ensure a constant horizontal elevation.	Quarterly

4.12.7 Impervious liners

Impervious, or impermeable, liners prevent water from crossing a system boundary such as infiltrating through the subgrade beneath an SMP. Impervious liners include, but are not limited to, compacted till liners, clay liners, geomembrane liners, and concrete liners.



An example of an impervious liner installation in Philadelphia

When can impervious liners be used?

An impervious liner is an outlet control that is typically applicable to green roofs and blue roofs. Depending on the site layout and stormwater conveyance design, they may be applicable to bioretention basins, cisterns, ponds and wet basins, and subsurface detention SMPs. Impervious liners are only permitted in instances where placement is over in situ soils in which infiltration is restricted due to geotechnical concerns, such as over contaminated soils and brownfields, adjacent to subsurface structures, or adjacent to sewer infrastructure.

Key advantages of impervious liners

- Prevent infiltration in areas of contamination, adjacent to subsurface structures, or adjacent to sewer infrastructure in need of protection from potential flooding or seepage

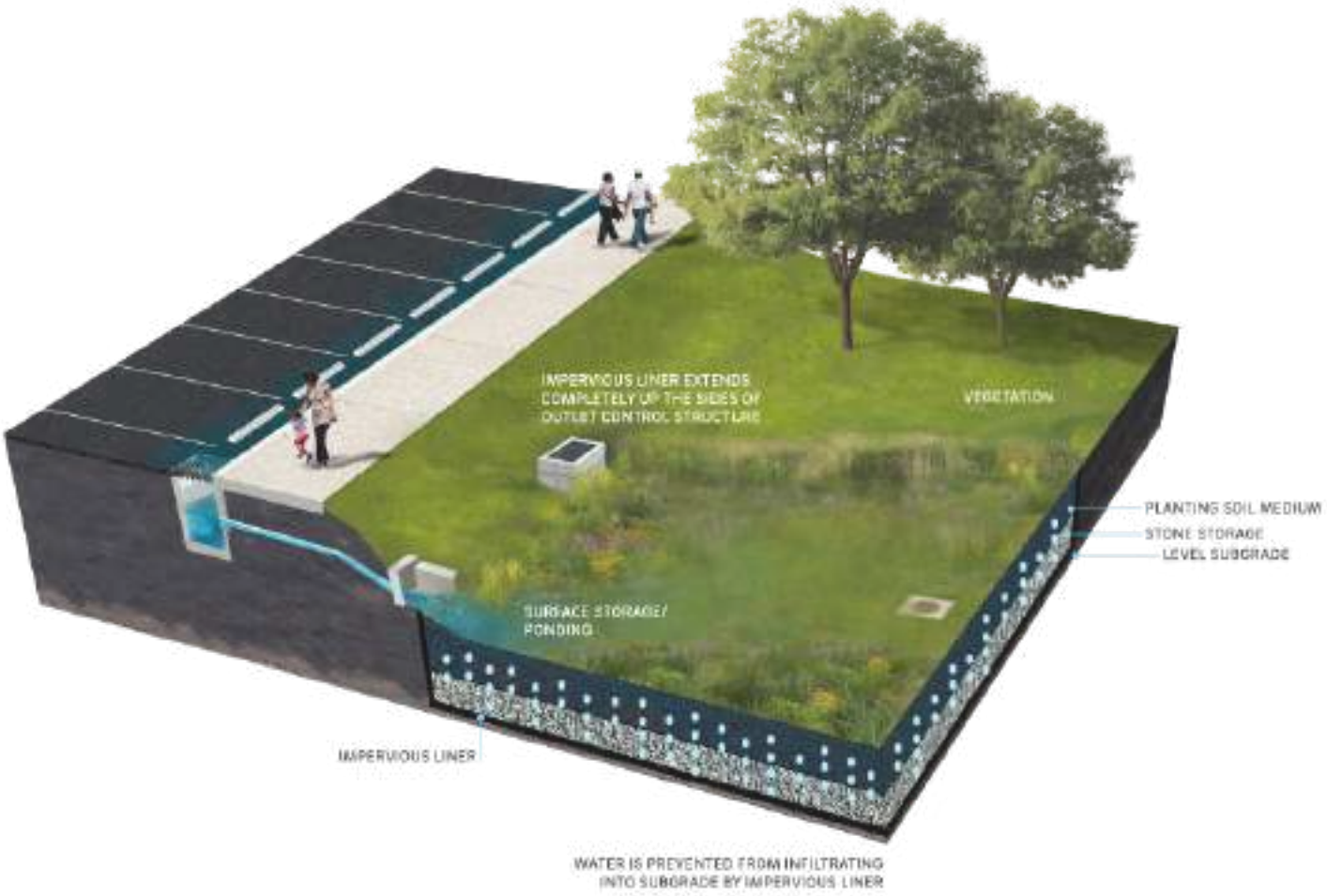
Key limitations of impervious liners

- Not readily visible for maintenance inspections
- Typically require significant excavation to repair

Key design considerations for impervious liners

- Impervious liners are not required for all non-infiltrating SMPs. For example, even if the infiltration potential of underlying soils is limited due to low infiltration rates, bioretention SMPs must be constructed without impervious liners.
- Clay liners should be of an appropriate design as specified by a geotechnical engineer.

Figure 4.12-8: Impervious liner with typical features



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Impervious liner design and material standards

1. Impervious liners are required, as appropriate, to prevent infiltration into areas of soil contamination.
2. Impervious liners, if needed, must be installed to prevent infiltration SMPs from infiltrating stormwater within the zone of influence of any nearby sewers or sewer laterals. The zone of influence is defined by the area within a 1:1 (H:V) slope line from the outer edge of a sewer or sewer lateral.
3. All impervious liners must exhibit a permeability less than or equal to 10^{-6} cm/sec.
4. Impervious liners must be continuous and extend completely up the sides of any structures that are located within the lined basin footprint to the ground surface. If additional liner material must be added to extend up the structures, the additional liner sections must be joined to the rest of the liner with an impervious seam per the manufacturers' recommendation.
5. Compacted till liners:
    a. The minimum allowable compacted till liner thickness is 18 inches (after compaction).
    b. Soil must be compacted to 95% minimum dry density, modified proctor method (ASTM D-1557).
    c. Soil must be placed in six-inch lifts.
    d. Soils to be used must meet the gradation in Table 4.12-4:

Table 4.12-4: Compacted till liner soil gradation

Sieve size	Percent passing
6-inch	100
#4	70–100
#200	20

6. Clay liners
    a. The minimum allowable clay liner thickness is 12 inches (after compaction).
    b. Clay liners must conform to the specifications outlined in Table 4.12-5, per the *Stormwater Management Manual for Western Washington* (2012):

Table 4.12-5: Clay liner specifications

Property	Test method	Unit	Specifications
Permeability	ASTM D-2434	cm/sec	1×10^{-6} max.
Plasticity index of clay	ASTM D-423 & D-424	Percent	Not less than 15
Liquid limit of clay	ASTM D-2216	Percent	Not less than 30
Clay particles passing	ASTM D-422	Percent	Not less than 30
Clay compaction	ASTM D-2216	Percent	95% of Standard Proctor Density

7. Geomembrane liners
    a. Geomembrane liner material must be polyvinyl chloride (PVC), polypropylene (PP), linear low-density polyethylene (LLDPE), or high-density polyethylene (HDPE).
        i. PVC geomembranes must have a thickness of 30 mil and must conform to the physical requirements stipulated in ASTM D7176: Standard Specification for Non-Reinforced Polyvinyl Chloride (PVC) Geomembranes Used in Buried Applications.
        ii. PP geomembranes must have a thickness of 30 or 36 mil and must conform to the physical requirements stipulated in the Geosynthetic Research Institute (GRI) GM18 Standard Specifications for PP geomembranes.
        iii. LLDPE geomembranes must have a thickness of 40 mil and must conform to the physical requirements stipulated in the Geosynthetic Research Institute (GRI) GM17 Standard Specifications for LLDPE geomembranes.
        iv. HDPE geomembranes must have a thickness of 60 mil and must conform to the physical requirements stipulated in the Geosynthetic Research Institute (GRI) GM13 Standard Specifications for HDPE geomembranes.
    b. Geomembrane liner material must be resistant to mildew, rot, ultraviolet radiation, insects, and rodents.
    c. For fully-lined SMPs, geotextile must be placed on either side of the entire geomembrane liner to protect it from the in-situ soil outside the liner and the overlying stone or soil storage inside the liner. The geotextile must meet, or exceed, the strength properties outlined in Table 4.12-6.
    d. For partially-lined SMPs, geotextile must be placed on either side of the geomembrane liner to protect it from the in-situ soil outside the liner and the overlying stone or soil storage inside the liner. The geotextile placed outside the liner must meet, or exceed, the strength properties outlined in Table 4.12-6. The geotextile placed between the liner and the overlying stone or soil storage must be in accordance with the geotextile specifications listed within the respective SMP's "Storage Area Material Standards" elsewhere in Chapter 4.
    e. A minimum four-inch sand layer must be placed beneath the geomembrane liner and geotextile to provide a stable, even bottom and prevent uneven settling and punctures to the liner.
    f. Boot collars must be included at any point where a pipe penetrates a geomembrane liner. This includes utility crossings, distribution pipes, and underdrain pipes.

Table 4.12-6: Geotextile strength properties for impervious liner protection

Geotextile property	Test method	Geotextile property requirements*
Weight	ASTM D5261	≥ 16 oz./sq. yd.
Grab Tensile Strength, in machine and x-machine direction	ASTM D4632	≥ 380 lbs.
Grab Failure Strain, in machine and x-machine direction	ASTM D4632	> 50%
Seam Breaking Strength (if seams are present)	ASTM D4632 and ASTM D4884 (adapted for grab test)	≥ 220 lbs.
Puncture Resistance	ASTM D4833	≥ 180 lbs.
Tear Strength, in machine and x-machine direction	ASTM D4533	≥ 145 lbs.
Ultraviolet (UV) Radiation	ASTM D4355	≥ 70% strength stability retained, after 500 hrs. in weatherometer

*Average roll values. Test results must meet or exceed these values.

8. Concrete liners:
   a. Concrete must be minimum five inches thick, Class A or better, with ordinary surface finish.
   b. When underlying soil is clay or if it has an unconfined compressive strength of 0.25 tons per square foot or less, the concrete must have a minimum six-inch compacted aggregate base composed of coarse sand and river stone, crushed stone, or equivalent, with diameter of 0.75 inch to one inch.

4.12.8 Micro siphon drain belts

Micro siphon drain belts are drainage systems that use capillary pressure to wick water out of the soil or filter media and convey it through small siphon channels to collector drainpipes. They are typically flexible, extruded, PVC strips of variable widths with micro channels on one side. The belts can be installed at various depths within filter media or underlying soil, and their flexible shape can contour to the shape of the installed surface. Micro siphon drain belts may be used in combination with other techniques, such as layering of porous media to regulate outflow. They can also be connected to underdrains and used in conjunction with outlet control structures.

When can micro siphon drain belts be used?

Depending on the site layout and stormwater conveyance design, micro siphon drain belts may be applicable to bioretention basins, subsurface detention SMPs, ponds and wet basins, green roofs, blue-green roofs, and media filters. Micro siphon drain belts can be used in conjunction with underdrains and impervious liners when infiltration is not feasible. For example, they can be used to collect and convey drainage from a large area to a central underdrain. They can also be used for applications in which water must be drawn away from foundations, retaining walls, or other boundaries.

Key advantages of micro siphon drain belts

- Can meet very low release rate requirements
- Can collect stormwater over a large surface area
- Allow for vegetative and media filtration prior to the release of stormwater back into downstream conveyance systems
- Resist clogging, as the capillary action that pulls water into the micro channels does not transport solids
- Constructed of material that is both flexible and durable, making the belts easy to install and resistant to compression or other degradation over time

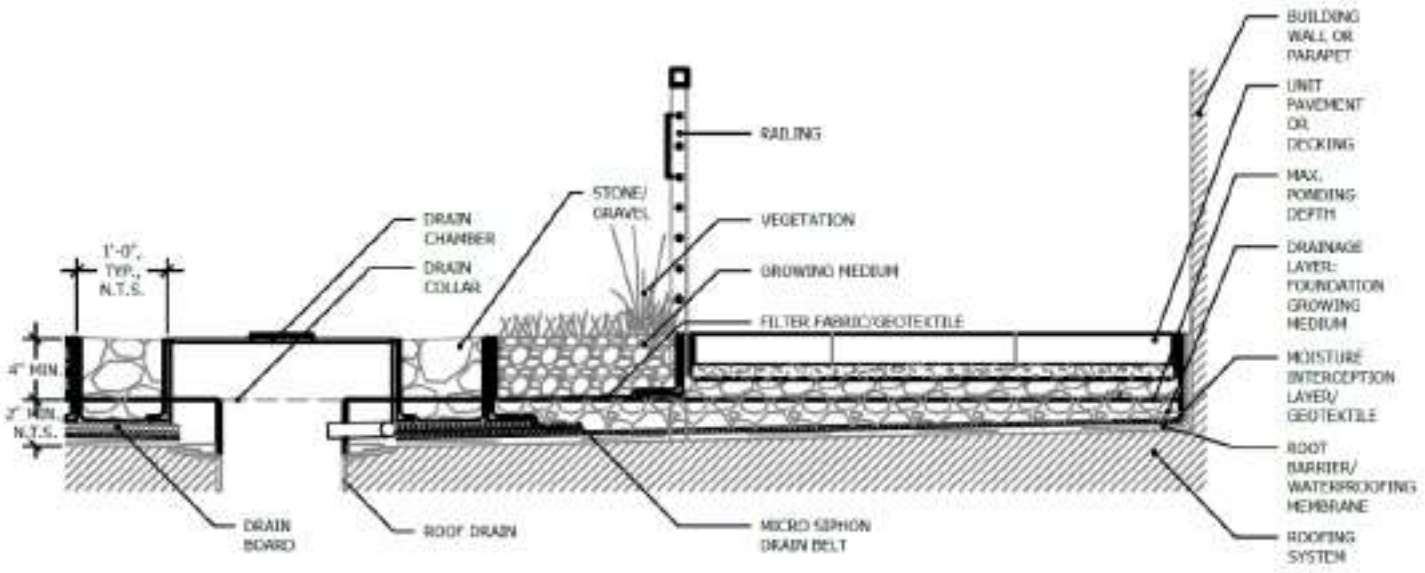
Key limitations of micro siphon drain belts

- Have limited system depth due to maximum allowable head
- Do not allow for inspection of system without excavation

Key design considerations for micro siphon drain belts

- Installation with the micro channels facing downward limits clogging of the micro channels, as gravity allows particulates to fall out when water is pulled into the micro siphon channels.
- To help prevent or minimize the potential for clogging by root intrusion, locate trees and plants with aggressive root systems away from micro siphon drain belts.

Figure 4.12-9: Micro siphon drain belt application in a blue-green roof



Micro Siphon Drain Belt application in a Blue-Green Roof

Micro siphon drain belt design and material standards

1. Micro siphon drain belts must connect to a downslope underdrain or collector pipe. The elevation of the belt in the immediate vicinity of the downslope connection must be at least four inches above the top of the underdrain or collector pipe. Alternatively, for vegetated SMPs on-structure where depth is limited, such as blue-green roofs, a belt slope of 1% to 2%, with a curve of the tail of the belt down to the connection pipe, must be maintained.
2. The end of the micro siphon drain belt that is not connected to the collector pipe must be sealed to prevent the intrusion of solids or other clogging materials. The sealant must be suitable for use in submerged environments.
3. A minimum belt slope of 1% is required to ensure drainage, but a belt slope of 3% to 5% is recommended to maintain laminar flow within the micro channels.
4. Micro siphon drain belts must be installed in a layer of sand. Sand used must be ASTM C-33 aggregate concrete sand with grain size between 0.02 inches and 0.08 inches. Alternatively, for vegetated SMPs on-structure where depth is limited, such as blue-green roofs, the micro siphon drain belt may be installed in the foundation growing medium layer with a minimum depth of 0.25 inches of media below the belt or per manufacturer's recommendations.
5. Manufacturer's recommendations must be followed to determine the number, size, and specific configuration of belts required to provide adequate flow capacity for specific applications.
6. Flow rate for an eight-inch-wide micro siphon drain belt with a minimum saturated cover (head) of four inches is calculated as follows. The calculated flow rate can be divided by two for a four-inch-wide micro siphon drain belt.

$$Q_{belt} = 0.00106 + 0.00025H$$
$$\text{where } Q_{belt} = flowrate\,(cfs),\ H = head\,(ft),\ H = 0.33\text{-}ft\ minimum$$

4.12.9 Low flow devices

Low flow devices are prefabricated or proprietary systems that regulate the discharge flow rate from SMPs. Types of low flow devices include, but are not limited to, floating or constant-head orifices and vortex outlet control devices. *Floating*, or *constant-head, orifices* regulate low flow discharges through the use of a floating intake structure. *Vortex outlet control devices* use induced helical flow to restrict flow rates.

Low flow devices are evaluated on a project-specific basis since site conditions, such as sediment loading and/or drainage area size, can impact a product's ability to meet Stormwater Regulations. PWD has developed a list, accessible on the PWD Development Services Resource Directory, of **low flow devices** ☛ water.phila.gov/development/resources/#low-flow that may be used to comply with the Stormwater Regulations.



An example of a low flow device in Philadelphia

When can low flow devices be used?

A low flow device is an outlet control that is typically applicable to subsurface detention SMPs. Depending on the site layout and stormwater conveyance design, low flow devices may be applicable to bioretention basins, cisterns, ponds and wet basins, green roofs, blue roofs, and media filters. A low flow device can be used to assist with meeting small release rate requirements, particularly for small drainage areas and sites with challenging design constraints for which the implementation of traditional slow release outlet devices, such as orifices, does not allow for compliance.

Key advantages of low flow devices

- Allow SMPs with footprint constraints to meet maximum release rate requirements
- Allow smaller release rates with larger orifice diameters than traditional orifice outlet controls, alleviating clogging and other operational concerns
- Accompanied by manufacturer's readily available product specifications, design guidance, installation considerations, and expected performance

Key limitations of low flow devices

- More difficult to customize to the particular requirements of individual sites because they are pre-engineered devices
- May require more intensive inspection and maintenance than more traditional, passive outlet controls

Key design considerations for low flow devices

1. Design specifications and vendor information should be carefully reviewed to assess likely performance, maintenance, and longevity.
2. Products used within ultra-urban settings that have demonstrated a strong track record of performance should be prioritized for design.
3. The effective head on the orifice, release rate requirements, and its opening size should all be evaluated to determine an appropriate product based on manufacturer-provided performance curves.

Low flow device design and material standards

1. The following information must be submitted for each proposed low flow device as part of the applicant's Post-Construction Stormwater Management Plan (PCSMP) Review Phase Submission Package. Preliminary consultations with PWD prior to submission are encouraged.
   a. Performance/discharge curves;
   b. Third-party certifications;
   c. Hydrologic and hydraulic model files, if applicable;
   d. Product specifications;
   e. Manufacturer's guidelines for installation;
   f. Construction sequence; and
   g. Maintenance requirements, including product life and replacement schedule, if applicable

   PWD will review low flow device performance documentation submissions during the PCSMP Review Phase and will provide the applicant with comments or requests for additional information. All comments and requests for information must be addressed before PWD may issue approval.
2. Appropriate design measures must be taken to prevent clogging for all orifices.
3. Suitable access must be provided to inspect and maintain all orifices.

4.13 Landscaping

4.13.1 Landscaping introduction

Landscaping is a critical element to improve both the function and appearance of vegetated SMPs. Plants can improve the performance and lifespan of the stormwater management practice (SMP) by reducing stormwater runoff volumes and sediment load. In addition, vegetated SMPs can provide significant environmental, social, and economic benefits. Vegetation in urban environments can mitigate the urban heat island and reduce energy demands, improve air quality, provide wildlife habitat, improve human health, and increase land values. Integrated stormwater landscapes can also provide construction cost savings, reduced maintenance, and improved long-term functionality.

A successful landscape must begin with an understanding of the site. Urban environments present numerous challenges for plant survival such as increased heat, extreme weather events, pollutants, and vandalism. Additionally, SMPs bring their own set of challenges including space constraints, engineered soils, and stormwater flow. Furthermore, the landscape of a site will evolve over time. Successful landscape designs will also consider the intended site uses, preferences of the property owner and site users, and maintenance capabilities and schedules. Each site will have unique challenges and require unique solutions to ensure that the project is beautiful and functional.

As discussed in **Section 3.2.7** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-2-stormwater-management-design/#3.2.7, Planting and Vegetation Guidance, vegetated SMPs are among the most preferred SMP types, and well-designed landscaping can provide many benefits to the site's function and provided benefits. Well-designed landscapes provide longevity benefits in addition to aesthetics to a site. The designer is directed to **Section 3.2.7** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-2-stormwater-management-design/#3.2.7 for more information on why these types of SMPs provide benefit. This section will offer guidance on the technical landscaping considerations for vegetated SMPs, however the designer should reference the following individual SMP Sections of Chapter 4 for SMP-specific guidance regarding vegetation:

- **4.1 Bioinfiltration/Bioretention** ☛ p. 4
- **4.3 Green Roofs** ☛ p. 45
- **4.14 Blue-Green Roofs** ☛ p. 239
- **4.7 Ponds and Wet Basins** ☛ p. 106
- **4.9 Media Filters** ☛ p. 134
- **4.10 Pretreatment** ☛ p. 148

Effective landscape design may incorporate any number of these or other types of vegetation and materials, and the designer should not feel limited by the guidance provided in this Manual. Successful landscape plans will combine the appropriate materials and designs specific to each site.



Kemble Park, Philadelphia

4.13.2 Landscaping site selection and layout considerations

Vegetation guidance is a critical component of many different stormwater management strategies, including structural and non-structural designs.

One method that designers can use to reduce DCIA is through disconnection of impervious areas to pervious areas. Specific guidance for disconnection strategies is provided in **Section 3.1.5** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-1-site-assessment-and-stormwater-management-strategies/#3.1.5, Disconnection Impervious Cover. This section may assist the designer to select landscaping that considers impervious area stormwater flow.

If the designer plans to implement vegetated SMPs on site, this chapter can supplement the information provided within that SMP's dedicated chapter in this manual. This section should be used in conjunction with **Section 4.1** ☛ p. 4, Bioinfiltration/Bioretention, in most cases. It may also be a helpful reference for:

- **4.7 Ponds and Wet Basins** ☛ p. 106
- **4.3 Green Roofs** ☛ p. 45
- **4.14 Blue-Green Roofs** ☛ p. 239
- **4.10 Pretreatment** ☛ p. 148
- **4.11 Inlet Controls** ☛ p. 166
- **4.12 Outlet Controls** ☛ p. 182

Landscaping design should be site-specific. The **GSI Landscape Design Guidebook** ☛ water.phila.gov/wp-content/uploads/files/gsi-landscape-design-guidebook.pdf was developed by the landscape architects of the *Green City, Clean Waters* program to provide all designers with experience-based content and knowledge, enabling this site-specific landscaping design for any green stormwater infrastructure SMP within the City of Philadelphia. Chapter 2 of the **GSI Landscape Design Guidebook** ☛ water.phila.gov/wp-content/uploads/files/gsi-landscape-design-guidebook.pdf (page 14) specifically discusses Site Assessment and Landscape Design Guidelines. The following characteristics should be considered from the site analysis when developing plans for a vegetated SMP.

Site selection

- When selecting a location for the SMP, the designer should consider the site's physical variables and the effects they will have on the SMP. The designer is referred to pages 16 and 17 of *Site Conditions* in the **GSI Landscape Design Guidebook** ☛ water.phila.gov/wp-content/uploads/files/gsi-landscape-design-guidebook.pdf for further guidance on site variables.
- Some variables to consider include amount of sunlight received and solar orientation, wind speed and direction, temperature gain, and surface character. For example, sites facing northeast receive morning sun and tend to be cooler and wetter than those facing southwest. Also, runoff from asphalt will be hotter than that from concrete because asphalt's dark color absorbs more solar energy. Combinations of these variables create different micro-climates and should be taken into account when placing the SMP and selecting plants.

Figure 4.13-1: Micro-climate diagram from the **GSI Landscape Design Guidebook** ☛ water.phila.gov/wp-content/uploads/files/gsi-landscape-design-guidebook.pdf



Shade tolerance and direct sunlight

The light requirements for each species are listed as ranges between full shade and full sun. At the bottom of the range—full shade—plants thrive in conditions where they receive filtered, or dappled, light for the entire day (such as under an oak tree). In the middle of the range are plants that grow best in partial shade, where they are in full shade for two to three hours during midday. Plants that require full sun should be sited so that they receive five or more hours of direct sun during the growing season. Some plants requiring full sun may still do well in a partial shade environment, depending on the quality and duration of the light the plants receive when they are not in shade.

Figure 4.13-2: Micro-climate and landscape design from **GSI Landscape Design Guidebook** ☛ water.phila.gov/wp-content/uploads/files/gsi-landscape-design-guidebook.pdf



Womrath Park Rain Garden

Hydrologic zones

- For planting within a stormwater management practice (SMP), it is necessary to determine what hydrologic zones will be created within the SMP. Hydrologic zones describe the degree to which an area is inundated by water (the designer is referred to **Figure 4.13-3** ☛ p. 223 for an example of hydrologic zones in a bioinfiltration/bioretention basin). Plants have differing tolerances to inundation and, as an aid to landscape designers, these plant tolerance levels have been divided into six zones and corresponding appropriate plant species have been identified. In **Table I-1** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists/#Table_I.1 of **Appendix I** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists, each plant species has a corresponding hydrologic zone provided to indicate the most suitable planting location for successful establishment. While the most common zones for planting are listed in parentheses, the listing of additional zones indicates that a plant may survive over a broad range of hydrologic conditions. Just as plants may, on occasion, be found outside of their hardiness zone, they may also be found outside of their hydrologic zone. Additionally, hydrologic conditions in an SMP may fluctuate in unpredictable ways; thus, the use of plants capable of tolerating wide varieties of hydrologic conditions greatly increases a successful planting. Conversely, plants suited for specific hydrologic conditions may perish when hydrologic conditions fluctuate, thus exposing the soil and increasing the chance for erosion.

- **Table I-1** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists/#Table_I.1, in addition to hydrologic zones, also includes drought tolerance and salt tolerance classifications. These parameters may also be used for vegetation selection for a site's characteristics. The designer is referred to **Appendix I** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists for more information.
- The designer should also consider the entrance zone of the SMP. From page 34 of the **GSI Landscape Design Guidebook** ☛ water.phila.gov/wp-content/uploads/files/gsi-landscape-design-guidebook.pdf, "The point where stormwater will be entering the SMP can be a difficult area for selecting plants. This zone is typically where there will be the highest velocity and volume of water entering as well as the highest concentration of sediment and pollutant loads. Therefore, selecting durable species that have strong structures and root systems is critical."

Figure 4.13-3: Hydrologic zones of a bioinfiltration/bioretention basin



☛ water.phila.gov/wp-content/uploads/images/swmg-figure-4-1-3-hydrologic-zones-bioinfiltration-basin.png

The *lowest zone (hydrologic zones 2–4)* contains plant species adapted to standing and fluctuating water levels and frequent inundation. Frequently used native plants include the following species. The designer is referred to **Table I-1** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists/#Table_I.1 in **Appendix I** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists for a complete listing.

Table 4.13-1: Frequently used native plants for hydrologic zones 2–4

Frequently used native plants for hydrologic zones 2–4	
asters (*Aster spp.*)	winterberry (*Ilex verticillata*)
goldenrods (*Solidago spp.*)	arrowwood (*Viburnum dentatum*)
bergamot (*Monarda fistulosa*)	sweet pepperbush (*Clethra alnifolia*)
blue-flag iris (*Iris versicolor*)	bayberry (*Myrica pensylvanica*)
sedges (*Carex spp.*)	buttonbush (*Cephalanthus occidentalis*)
ironweed (*Vernonia noveboracensis*)	swamp azalea (*Rhododendron viscosum*)
blue vervain (*Verbena hastata*)	elderberry (*Sambucus canadensis*)
joe-pye weed (*Eupatorium spp.*)	red maple (*Acer rubrum*)
swamp milkweed (*Asclepias incarnata*)	river birch (*Betula nigra*)
switchgrass (*Panicum virgatum*)	sweetgum (*Liquidambar styraciflua*)
shrub dogwoods (*Cornus spp.*)	northern white cedar (*Juniperus virginiana*)

The *middle zone (hydrologic zones 4–5)* is slightly drier than the lowest zone, but plants should still tolerate fluctuating water levels. Frequently used native plants include the following species. The designer is referred to **Table I-1** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists/#Table_I.1 in **Appendix I** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists for a complete listing.

Table 4.13-2: Frequently used native plants for hydrologic zones 4–5

Frequently used native plants for hydrologic zones 4–5	
black snakeroot (*Cimicifuga racemosa*)	spicebush (*Lindera benzoin*)
switchgrass (*Panicum virgatum*)	hackberry (*Celtis occidentalis*)
spotted joe-pye weed (*Eupatorium maculatum*)	willow oak (*Quercus phellos*)
cutleaf coneflower (*Rudabeckia lacinata*)	winterberry (*Ilex verticillata*)
frosted hawthorn (*Crataegus pruinosa*)	slippery elm (*Ulmus rubra*)
marginal wood fern (*Dryopteris marginalis*)	viburnums (*Viburnum spp.*)
ironwood (*Carpinus caroliniana*)	witch-hazel (*Hamamelis virginiana*)
serviceberry (*Amelanchier canadensis*)	steeplebush (*Spiraea tomentosa*)
obedient plant (*Physostegia virginiana*)	blueberry (*Vaccinium spp.*)

The *outer zone (hydrologic zones 5–6)* generally supports plants adapted to drier conditions. Frequently used native plants include the following species. The designer is referred to **Table I-1** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists/#Table_I.1 in **Appendix I** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists for a complete listing.

Table 4.13-3: Frequently used native plants for hydrologic zones 5–6

Frequently used native plants for hydrologic zones 5–6	
herbaceous plants	juniper (*Juniperus communis*)
basswood (*Tilia americana*)	sweet-fern (*Comptonia peregrina*)
white oak (*Quercus alba*)	eastern red cedar (*Juniperus virginiana*)
scarlet oak (*Quercus coccinea*)	smooth serviceberry (*Amelanchier laevis*)
black oak (*Quercus velutina*)	American holly (*Ilex opaca*)
American beech (*Fagus grandifolia*)	sassafras (*Sassafras albidum*)
black chokeberry (*Aronia melanocarpa*)	white pine (*Pinus strobus*)

Screening and aesthetics

- Some SMP elements such as chain link fences, concrete bulkheads, outfalls, riprap, berm embankments planted only with grasses, exposed pipe, banks, retaining walls greater than two feet high, and access roads are generally not aesthetically pleasing. When these elements face public right-of- ways or other private property, they should be screened with plant materials.
- The designer is strongly encouraged to integrate aesthetically pleasing landscape design into the SMP design.

4.13.3 Landscaping design considerations

The planting recommendations within this section are informed by research, local experience, and/or standard landscape industry methods for design and construction.

General planting design guidance

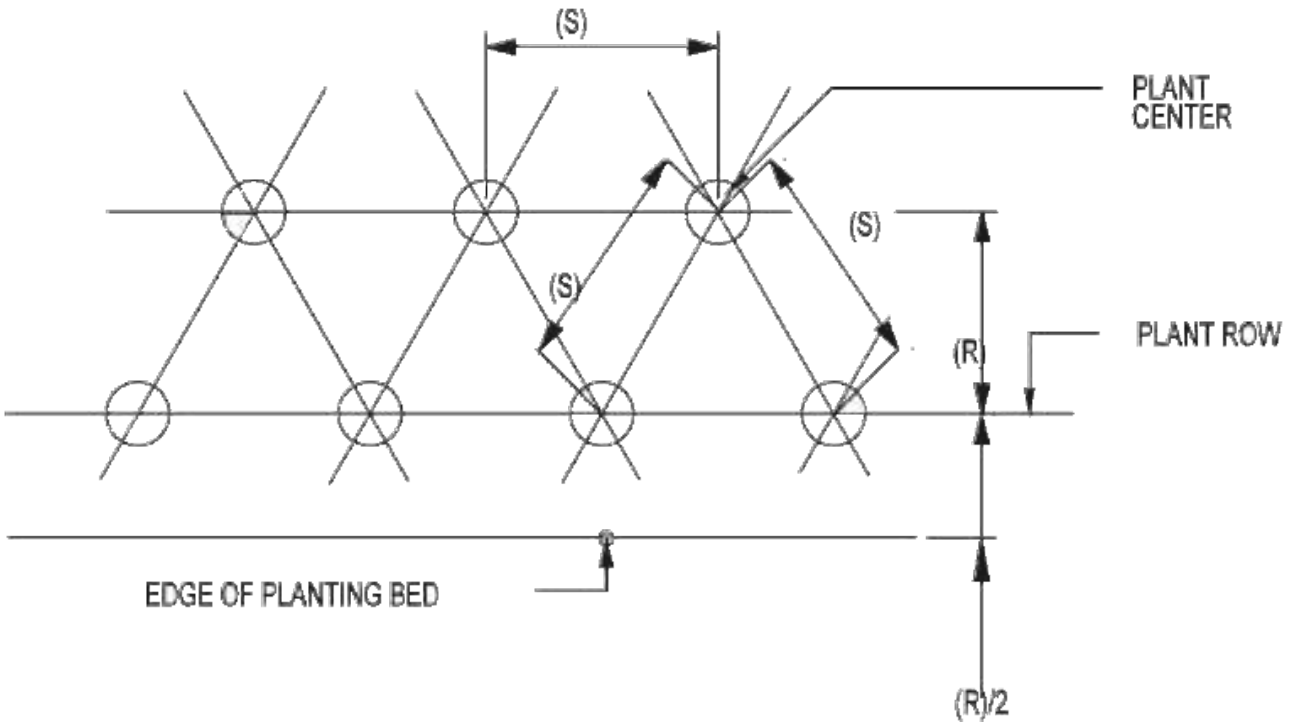
- Selected plant materials must be appropriate for soil, hydrologic, and other site conditions.
- Vegetated SMPs must use appropriate native and recommended non-invasive species from **Appendix I** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists.
- The design for planting should minimize the need for herbicides, fertilizers, pesticides, or soil amendments at any time before, during, and after construction and on a long-term basis.
- Plantings should be designed to minimize the need for mowing, pruning, and irrigation.
- Seed must be applied at the rates specified by the suppliers. If plant establishment cannot be achieved with seeding by the time of substantial completion of the SMP portion of the project, the contractor must plant the area with sod, plugs, container plants, or some other means to complete the specified plantings and protect against erosion.
- The designer may recommend a diversity of tree species and avoid overused species to reduce the risk of disease or insect infestation.
- The designer should avoid combinations of plants that will harm one another. For example, a designer should not plant junipers next to rust-susceptible plants like crabapples.
- The designer should consider the mature size of any plant and ensure that it has enough space to grow. The designer should also consider critical lines of sight for vehicular or pedestrian traffic.
- It is essential that impervious surfaces be graded toward the vegetated areas that are used as SMPs, and that these SMPs are depressed to allow for flow and/or surface ponding.

Quantity and spacing

Spacing of plant containers will depend on the plants' characteristics. Smaller containers and plant varieties typically require tighter spacing than larger containers or larger mature growth. The designer is referred to the **GSI Landscape Design Guidebook** ☛ water.phila.gov/wp-content/uploads/files/gsi-landscape-design-guidebook.pdf (page 19) for more assistance. Generally, six-inch to twelve-inch centers with triangular spacings for plugs are recommended.

Figure 4.13-4: Recommended plant spacing

SPACING (S)	PLANT ROW (R)	PLANTS/SF.
6"	5.2"	4.6
8"	6.9"	2.6
9"	7.8"	2.0
12"	10.4"	1.15
15"	13.0"	0.75
18"	15.6"	0.51
24"	21.0"	0.29
30"	26.0"	0.18
36"	31.0"	0.13
48"	41.5"	0.072



☛ water.phila.gov/wp-content/uploads/images/swmg-figure-4-13-4-recommended-plant-spacing.png

Mature canopy spread

The "Mature Canopy Spread" column of **Table I-1** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists/#Table_I.1 in **Appendix I** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists gives the SMP designer a rough estimate of the diameter (or spread) of a tree species' branching when it has matured. This information indicates what the light conditions will be like beneath the tree for understory plantings; how much space should be left open between the tree planting pit and any vertical structures, such as buildings; how far apart the trees should be planted; and it gives an idea, along with the mature height of the species, of the tree's growth habit. The mature canopy spread also provides a rough idea for how much leaf surface area will be available to intercept stormwater before it reaches the ground.

Species selection and arrangement

- Existing native and non-native adapted vegetation should be preserved where possible.
- Noxious and invasive weeds must not be specified or used. The designer is referred to **Table I-2** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists/#Table_I.2 in **Appendix I** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists for a list of native and recommended non-invasive plant species. Aggressive species should be used carefully to avoid spreading to other areas.
- Stream and water buffers should be planted with trees, shrubs, ornamental grasses, and herbaceous materials, where possible, to stabilize banks and provide shade. This will help to reduce thermal warming, reduce erosion, increase roughness, and protect habitat.
- Plantings that will require routine or intensive chemical applications (e.g., turf areas) should be avoided. Low-maintenance ground cover should be used as an alternative to turf.
- The designer should consider possible stressors (e.g., wind, exposure, exposure to runoff pollutants such as deicing salt, salt tolerance, insects, drought and inundation tolerance, and disease), micro-climates, and sunlight conditions when laying out the planting plan. If the planting plan includes overseeding, which is the process of laying seed atop existing vegetation without disturbing the soil, species appropriate for overseeding should be considered. The designer is referred to Table 4.13-4 below for a list of species appropriate for overseeding. Overseeding can be beneficial for initial plant establishment, improving the plant density and coverage, and introducing new varieties to existing landscaping.
- Aesthetics and visual characteristics should be a prime consideration when developing planting plans. Plant form, texture, color, bloom time, and fragrance are important to the overall feel of the site. Plants can be used to enhance and frame desirable views or screen undesirable views. Care should be taken to not block views at entrances, exits, or along difficult road curves.
- The time of year when the site will be most active should be considered to decide which season to emphasize most prominently. The designer may choose to use flowering perennials as accents that will bloom throughout the growing season and include shrubs with interesting winter structure to showcase during the dormant season. Some characteristics the designer should keep in mind are evergreen needles, fall foliage color, seasonal fruits and flowers, bark texture, and leaf color. The designer is referred to the **GSI Landscape Design Guidebook** ☛ water.phila.gov/wp-content/uploads/files/gsi-landscape-design-guidebook.pdf for more information.
- Where such conditions exist, trees and shrubs should be placed in a manner that restricts pedestrian access to steep pools or slopes without blocking maintenance access.
- Existing and proposed utilities must be identified and considered.

- Other considerations for designers for plant selection and arrangement are planting in massings, an appropriate number of species, enhancing habitat, defining an edge, plant height, site lines, and other site contexts. The designer is referred to pages 20 through 27 of the **GSI Landscape Design Guidebook** ☛ water.phila.gov/wp-content/uploads/files/gsi-landscape-design-guidebook.pdf for more information.

Table 4.13-4: Species appropriate for overseeding

Species appropriate for overseeding	
Aquilegia canadensis	Columbine
Andropogon ternarius	Splitbeard Bluestem
Bouteloua curtipendula	Side Oats Gramma
Coreopsis grandiflora	Large-Flowered Tickseed
Coreopsis lanceolata	Lanceleaf Coreopsis
Gaillardia pulchella	Indian Blanket
Monarda sp.	—
Penstemon sp.	—
Schizachyrium scoparium	Little Bluestem
Sporobolus asper	Tall Dropseed

Figure 4.13-5: Plant seasonality from the **GSI Landscape Design Guidebook** ☛ water.phila.gov/wp-content/uploads/files/gsi-landscape-design-guidebook.pdf



Philadelphia Zoo – Plantings selected provide interest during all seasons along a busy corridor.

Plant nativity

- A native plant is any indigenous species that subsisted in the region prior to settlement by Europeans. Each species within the "Nativity" column of **Table I-1** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists/#Table_I.1 in **Appendix I** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists is located within a range of nativity to Philadelphia. Plants known to have existed in Philadelphia County are native to Philadelphia, while a wider geographic range lists plants native to the state, but not necessarily to the county. The widest geographic range lists a few species native to the United States, though not necessarily to Pennsylvania. The plants listed that are not specifically native to Philadelphia are included because of their demonstrated success within SMPs.
- Invasive plants reproduce rapidly, degrade, and take over natural ecosystems. Under no circumstance should they be planted in a SMP. Because of appealing characteristics, some of these plants are available for sale, and care should be taken not to purchase them. Additionally, the ability to identify and remove them before they can establish themselves is important, as they almost always invade due to their gregarious reproductive strategies. They can be especially hard to eradicate once they take hold. The designer is referred to **Table I-2** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists/#Table_I.2 in **Appendix I** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists for a list of species to avoid.

Embankments, spillways, and dams

- Planting trees, shrubs, and/or any type of woody vegetation is not allowed on structural embankments.
- All emergency spillways should be stabilized with plant material that can withstand strong flows. Root material should be fibrous and substantial but lack a taproot.
- Trees or shrubs known to have long taproots should not be planted within the vicinity of an earthen dam or subsurface drainage facilities.
- Trees and shrubs should be planted at least 25 feet away from a principal spillway structure and at least 15 feet away from a dam's toe of slope.

Mulch and soil media

- The mulch layer helps maintain soil moisture and avoid surface sealing that reduces permeability. Mulch helps prevent erosion and provides a micro-environment suitable for soil biota at the mulch/soil interface. It also serves as a pretreatment layer, trapping the finer sediments that remain suspended after the primary pretreatment.
- For herbaceous plantings, mulch must be applied to cover all soil between plants.
- Care should be exercised to use the appropriate amount of mulch—any more than three to four inches can negatively impact growing conditions and cause excessive nutrients to leach into the SMP.
- Mulch must be weed-free. Manure mulching and high-fertilizer hydroseeding are prohibited in a SMP area during and after construction.
- Mulch should be kept three inches away from tree trunks, woody vegetation, and the base of herbaceous vegetation.
- Permanent irrigation systems are allowed, but the designer is encouraged to minimize the need for permanent irrigation. Innovative methods for watering vegetation are encouraged, such as the use of cisterns and air conditioning condensate.
- To ensure landscape plant survival and overall stormwater facility functional success, the design and construction documents must include elements that help achieve these results.

- The characteristics of the soil for the bioinfiltration/bioretention SMP are arguably as important as the facility location, size, and treatment volume. The soil must be permeable enough to allow runoff to filter through the media, while having characteristics suitable to promote and sustain a robust vegetative cover crop. In addition, much of the nutrient pollutant uptake (nitrogen and phosphorus) is accomplished through adsorption and microbial activity within the soil profile. Therefore, the soils must balance soil chemistry and physical properties to support biotic communities above and below ground.

4.13.4 Landscaping material standards

Landscaping relies on informed design and material standards for successful landscapes. Designers should consider the following material guidance for selecting and sourcing materials for the site.

Storage area material standards

1. Stone designed for stormwater storage must be uniformly graded, crushed, clean-washed stone. PWD defines "clean-washed" as having less than 0.5% wash loss, by mass, when tested per American Association of State Highway and Transportation Officials (AASHTO) T-11 wash loss test. AASHTO No. 3 and No. 57 stone can meet this specification.
2. Sand, if used, must be AASHTO M-6 or American Society of Testing and Materials (ASTM) C-33 sand and must have a grain size of 0.02 to 0.04 inches.
3. Planting soil medium
    a. Planting soil should meet all the specifications listed below and should be a fertile, natural soil, free from large stones, roots, sticks, clods, plants, peat, sod, pockets of coarse sand, pavement and building debris, glass, noxious weeds including invasive species, infestations of undesirable organisms and disease-causing pathogens, and other extraneous materials harmful to plant growth.
    b. The texture of planting soil should conform to the classification within the United States Department of Agriculture triangle for Sandy Loam or Loamy Sand. Planting soil should be a mixture of sand, silt, and clay particles as required to meet the classification. Ranges of particle size distribution, as determined by pipette method in compliance with ASTM F-1632, are as follows:
        i. Sand (0.05 to 2.0 mm): 50 – 85%
        ii. Silt (0.002 to 0.05mm): 40% maximum
        iii. Clay (less than 0.002mm): 10% maximum
        iv. Gravel (2.0 to 12.7 mm): 15% maximum
    c. Planting soil should be screened and free of stones larger than a half-inch (12.7 millimeters) in any dimension. No more than 10% of the soil volume should be composed of soil peds greater than one inch.
    d. Clods, or natural clumps of soils, greater than three inches in any dimension should be absent from the planting soil. Small clods ranging from one to three inches and peds, natural soil clumps under one inch in any dimension, may be present but should not make up more than 10% of the soil by volume.
    e. The pH of the planting soil should have a range of 5.8 to 7.1.
    f. Soluble salts should be less than 2.0 mmhos/cm (dS/m), typically as measured by 1:2 soil-water ratio basic soil salinity testing. Sodic soils (Exchangeable Sodium Percentage greater than 15 and/or Sodium Adsorption Ratio greater than 13) are not acceptable for use, regardless of amendment.
    g. Organic content of planting soil should have a range of 3% to 15% by weight, as determined by loss on ignition (ASTM D2974). To adjust organic content, planting soil may be amended, prior to placing and final grading, with the addition of organic compost.
4. Mulch, if used, must be free of weeds and must consist of aged, double-shredded hardwood bark mulch or leaf mulch that has been shredded sufficiently to limit risk of matting, which can limit surface infiltration rates. For hydroseeding, paper mulch may be used. Approved mulching materials include organic materials such as compost, bark mulch, leaves, as well as small river gravel, pumice, or other inert materials. Grass clippings should not be used as mulch.

5. Geotextile must consist of polypropylene fibers and meet the following specifications (AASHTO Class 1 or Class 2 geotextile is recommended):
    a. Grab Tensile Strength (ASTM-D4632): ≥ 250 lbs
    b. CBR Puncture Strength (ASTM-D6241): ≥ 500 lbs
    c. Flow Rate (ASTM-D4491): ≥ 95 gal/min/ft2
    d. UV Resistance after 500 hours (ASTM-D4355): ≥ 70%
    e. Tear Resistance (ASTM-D4533): ≥ 80 lbs
    f. Heat-set or heat-calendared fabrics are not permitted.

Vegetation material standards

6. Trees and shrubs must be freshly dug and grown in accordance with good nursery practice.
7. Perennials and herbaceous plants must be healthy, well-rooted specimens.
8. A native grass/wildflower seed mix can be used as an alternative to groundcover planting. Seed mix must be free of weed seeds.
9. Use of invasive plants is not permitted. All plants and trees must be appropriate and compatible with soil, hydrologic, light, and other site conditions. Biodiversity should also be considered. The designer is referred to **Appendix I** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists for plant lists.
10. SMP soils should provide adequate infiltration rates and be suitable for healthy tree and vegetation growth. Soil analysis must be conducted within the SMP area to determine appropriate levels and types of soil amendments. The designer is referred to **Section 3.3.6** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-3-infiltration-testing-and-soil-assessment-for-smp-design/#3.3.6, Evaluation of Infiltration Testing Results, for additional guidance and requirements for soil amendment installation.
11. If topsoil exists on-site and is stockpiled for re=use, appropriate erosion control measures, as required by the latest edition of the ***PA DEP Erosion and Sediment Pollution Control Program Manual*** ☛ https://www.dep.pa.gov/Business/Water/CleanWater/StormwaterMgmt/Stormwater%20Construction/Pages/E-S%20Resources.aspx, must be used.

4.13.5 Landscaping construction guidance

Careful consideration of issues like soil compaction, infiltration performance, and sediment control are critical to ensure proper vegetated SMP functionality and reduce long-term maintenance needs. Poor oversight of construction activities could result in the need for substantial reconstruction to address performance problems.

General landscaping sequence

1. Provide erosion and sedimentation control protection on the site such that construction runoff is directed away from the proposed vegetated SMP location. The designer is referred to the latest edition of the ***PA DEP Erosion and Sediment Pollution Control Program Manual*** ☛ https://www.dep.pa.gov/Business/Water/CleanWater/StormwaterMgmt/Stormwater%20Construction/Pages/E-S%20Resources.aspx for information on design standards for erosion and sedimentation control practices.
2. Critical areas, including vegetated SMPs, must be physically marked prior to any land disturbance activities to avoid soil disturbance and compaction during construction. Install construction fencing around these critical areas.
3. After allowing for settlement, complete final grading within about two inches of the proposed design elevations, leaving space for top dressing of mulch or mulch/compost blend.
4. Seed and plant vegetation as indicated on the plans and specifications.
5. Place mulch and hand grade to final elevations.
6. Water vegetation at the end of each day for two weeks after planting is completed.
7. Water vegetation regularly during first year to ensure successful establishment.

Establishment and stabilization

- Establishment procedures must include control of invasive weeds, prevention of damage from animals and vandals, use of erosion control mats and fabrics in channels, temporary diversion of flows from seeded areas until stabilized, mulching, re-staking, watering, and mesh or tube protection replacement, to the extent needed to ensure plant survival.
- Generally, there are two planting seasons in a calendar year; Spring begins in March and ends in May, and Fall begins in September and ends in November, but planting is temperature dependent and varies year to year.
- Unwanted vegetation in the SMP area should be removed during site preparation with equipment appropriate for the type of material encountered, and site conditions. It is recommended that the maximum amount of pre-existing native vegetation be retained and protected.
- No material storage or heavy equipment is allowed within the SMP area after site clearing and grading has been completed, except to excavate and grade, as needed, to build the SMP. No compaction of infiltration areas must occur during this excavation.
- After the SMP area is cleared and graded, any necessary soil amendments should be added and tilled into the existing soil to the depth specified for each SMP. No tilling should occur within the drip line of existing trees. After tilling is complete, no other construction traffic must be allowed in the area, except for planting and related work. Where topsoil is needed, it should be spread to a depth of four to eight inches and lightly compacted to a minimum thickness of four inches—this provides organic matter and important nutrients for the plant material. The use of topsoil allows vegetation to become established faster and roots to penetrate deeper. This ensures quicker and more complete stabilization, making it less likely that the plants will wash out during a heavy storm.

- Newly installed plant material requires water in order to recover from the shock of being transplanted. A source of water should be provided during establishment of the SMP, especially during dry periods. This will reduce plant loss and provide the new plant materials with a chance to establish root growth.
- Establishment procedures must be applied temporarily (typically ranges from 8 weeks to 2 years). These measures include control of invasive weeds, prevention of damage from animals and vandals, the use of erosion control mats and fabrics in channels, temporary diversion of flows from seeded areas until stabilized, mulching, re-staking, watering, and mesh or tube protection replacement, to the extent needed to ensure plant survival.
- To ensure landscape plant survival and overall stormwater facility functional success, the design and construction documents must include elements that help achieve these results.
- Construction specifications and details must include staking, irrigation schedule, soil amendments, plant protection, overplanting, and potentially, mycorrhizal inoculation.

Table 4.13-5: Planting construction specifications

Specification element	Elements
Sequence of construction	Describe site preparation activities, soil amendments, etc.; address erosion and sediment control procedures; specify step-by-step procedure for plant installation through site clean-up.
Contractor's responsibilities	Specify the contractors' responsibilities, such as watering, care of plant material during transport, timeliness of installation, repairs due to vandalism, etc.
Planting schedule and specifications	Specify the materials to be installed, the type of materials (e.g., B&B, bare root, containerized); time of year of installations, sequence of installation of types of plants; fertilization, stabilization seeding, if required; watering and general care.
Maintenance	Specify inspection periods; mulching frequency (annual mulching is most common); removal and replacement of dead and diseased vegetation; treatment of diseased trees; watering amount and schedule after initial installation (once per day for 14 days is common); repair and replacement of staking and wires.
Warranty	All systems should contain a two-year warranty. Specifications should contain the warranty period, the required survival rate, and expected condition of plant species at the end of the warranty period.

4.13.6 Landscaping maintenance guidance

Vegetation maintenance is design-specific with the plants, grading, SMP layout, as well as external factors all influencing the types and frequencies of activities required to keep vegetated SMP functioning properly. The designer should consider maintenance when evaluating the different variables associated with landscape design. The designer is referred to pages 30 and 31 of the **GSI Landscape Design Guidebook** ☛ water.phila.gov/wp-content/uploads/files/gsi-landscape-design-guidebook.pdf for landscaping recommendations, in addition to the below guidance.

Maintenance considerations

- The designer should carefully consider the long-term vegetation management strategy for the SMP, keeping in mind the maintenance legacy for the future owners. The O&M Agreement will include requirements to ensure vegetation cover in perpetuity.
- When appropriate, the designer should provide signage to help educate the public about SMPs and designate limits of mowing (wildflower areas, meadows, etc.).
- The edge of the basin may be designated by woody vegetation to further designate limits of mowing and foot traffic.
- Planting in massings (each group consisting of one to three individuals of the same species) may support maintenance efforts by simplifying plant identification.

Maintenance activities

General recommended maintenance activities for landscaped areas are summarized in Table 4.13-6 below. More comprehensive maintenance guidance, including means and methods of various landscaping related maintenance activities like weeding, mowing, mulching, watering, and pest and disease management, are available in the **GSI Maintenance Manual** ☛ water.phila.gov/wp-content/uploads/files/gsi-maintenance-manual.pdf.

Table 4.13-6: Landscaping maintenance guidelines

Early maintenance activity	Frequency
Water vegetation at the end of each day for two weeks after planting is completed.	Daily for two weeks after installation
Water vegetation regularly to ensure successful establishment.	Every four days during periods of four or more days without rain, June through August for the first year after installation
Inspect vegetation for signs of disease or distress.	Biweekly for the first year after installation
Inspect inlet controls, outlet structures, and storage areas for trash and sediment accumulation.	Monthly for the first year after installation to determine ongoing maintenance frequency

Ongoing maintenance activity	Frequency
Remulch bare areas.	As needed
Treat diseased trees and shrubs.	As needed
Keep overflow free and clear of leaves.	As needed
Inspect soil and repair eroded areas.	Monthly
Remove litter and debris.	Monthly
Clear leaves and debris from overflow.	Monthly
Inspect trees and shrubs to evaluate health, replacing if necessary.	Quarterly
Inspect underdrain cleanouts.	Quarterly
Add additional mulch.	Quarterly
Inspect for sediment build-up, erosion, and vegetative conditions.	Quarterly
Evaluate the drain down time of the SMP after a storm of at least one inch within no more than 24-hours to ensure an SMP drain down time of less than 72 hours.	Ongoing
Maintain records of all inspections and maintenance activity.	Ongoing

The designer is referred to **Section 4.1** ☛ p. 4, Bioinfiltration/Bioretention, **Section 4.3** ☛ p. 45, Green Roofs, **Section 4.14** ☛ p. 239, Blue-Green Roofs, **Section 4.7** ☛ p. 106, Ponds and Wet Basins, **Section 4.9** ☛ p. 134, Media Filters, **Section 4.10** ☛ p. 148, Pretreatment, **Section 4.11** ☛ p. 166, Inlet Controls, and **Section 4.12** ☛ p. 182, Outlet Controls, for information on maintenance guidance for specific SMP types, pretreatment, inlet controls, and outlet controls.

4.14 Blue-Green Roofs

Download summaries of this SMP and its maintenance guidance, with quick reference information for clients and developers:

- **Blue-Green Roofs SMP One-Sheet** ☛ water.phila.gov/wp-content/uploads/files/blue-green-roofs-smp-one-sheet.pdf
- **Blue-Green Roof Maintenance Guidance One-Sheet** ☛ water.phila.gov/wp-content/uploads/files/blue-green-roof-maintenance-guidance.pdf

4.14.1 Blue-green roof introduction

Blue-green roofs are a hybrid system consisting of a green roof (moisture-interception layer/geotextile, drainage layer, engineered growing medium, and vegetation above the roofing system and its waterproofing membrane) and a blue roof, a portion of the roof that will become flooded during storm events to aid in the retention of runoff to be used by the green roof vegetation.

Blue-green roofs provide the combined benefit of the detention and slow-release function of a blue roof with the contaminant removal function of a green roof. The key advantage of the blue-green roof compared to the green roof is that the maximum tributary area can be potentially increased with the use of an outlet control component designed to meet PWD's rate of discharge and drain down time requirements.

The design of blue-green roofs is not limited to the design parameters presented within this text, which focuses on a minimum media depth with a roof drain restrictor system designed to retain water and to meet the maximum Water Quality discharge rates. The designer is referred to **Section 4.12** ☛ p. 182 for information on outlet controls.



An example of a blue-green roof in Philadelphia

Where can blue-green roofs be used?

A blue-green roof can be considered for installation on a fully built-out or highly constrained site. They can be installed on many types of roofs, including terraces, high-rise building roofs, and low-podium or at-grade on-structure installations. Generally, blue-green roofs are more appropriate for roofs with mild pitches (0–2%), due to structural loading considerations.

Blue-green roofs can also be installed as a Stormwater Retrofit on existing buildings with flat, mildly sloped, or terraced roofs after confirmation of adequate structural loading capacity, waterproofing, and protection of rooftop utilities.

Key advantages of blue-green roofs

- Manage stormwater runoff without occupying surface-level space
- Well-suited for sites where roofs make up a large portion of the total impervious area and for sites with ground-level space constraints
- Require no minimum flow path of runoff across the green roof surface since runoff is restricted at the outfall
- Typically require no additional sewer connections besides those already provided for the building
- Promote the retention, slow release, and evapotranspiration of precipitation
- Enhance building aesthetics and market value
- Help regulate building temperature in both the summer and winter, thus reducing cooling and heating costs
- Reduce urban heat island effect by providing evaporative cooling
- Can improve air quality by filtering particulate matter
- Extend the service life of the roof by protecting the underlying roof membrane from mechanical damage, shielding it from UV radiation, and buffering temperature extremes
- Require no excavation
- Can be designed to provide spaces for recreation, supplement bird habitat, develop educational resources, and create new opportunities for urban food production
- Can provide educational benefits, especially when used at public and/or highly visible sites such as schools, recreation centers, libraries, etc.
- Assume less risk for projects within the floodplain
- Eligible for inclusion in an Expedited Post-Construction Stormwater Management Plan (PCSMP) Review project

Key limitations of blue-green roofs

- May need to be combined with other SMPs to meet the Flood Control requirement
- More expensive to install than most conventional roofs
- May result in increased cost or limited Stormwater Retrofit opportunities for existing buildings and structures due to additional loading associated with ponded water on roof
- May have limited Stormwater Retrofit feasibility for existing buildings and structures due to structural loading limitations

Key design considerations for blue-green roofs

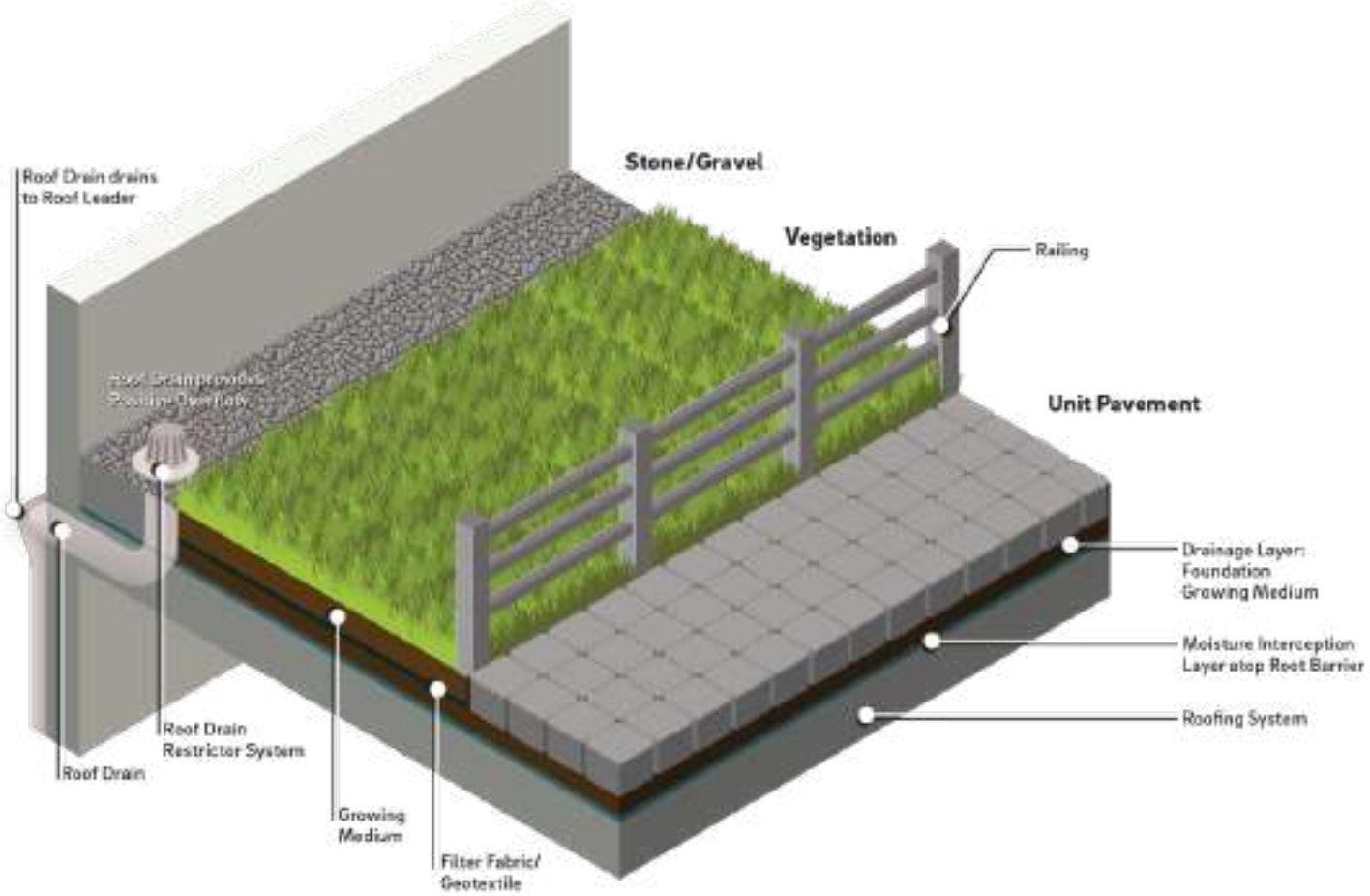
- Blue-green roof systems utilizing controlled flow roof drains generally require flat or nearly flat roofs (e.g., less than 2% slope). It may be feasible to use check dams when slopes are higher than 2%.
- Stormwater management can be improved by introducing measures to enhance evapotranspiration. Measures may include:
  - Introducing low-transmissivity drainage layers;
  - Lengthening seepage pathways to drains;
  - Introducing rainfall interception layers;
  - Selecting plants with dense root habits; and
  - Selecting growing medium with high water-holding capacity.
- Plant density and coverage are more significant for stormwater performance than specific species type (note that species selections remain important from a habitat and ecosystems perspective). Long-term species selection is flexible provided the plant cover is continuous, the root masses are persistent, and:
  - Plant species are not invasive;
  - Plant cover is perennial (i.e., present in winter); and
  - Plant species are biodiverse. For more information, the designer is referred to Sections **4.14.3** ☛ p. 246 and **4.14.4** ☛ p. 250 for vegetation design and material standards, respectively, below.
- Blue-green roofs should include a significant percentage of evergreen plants to minimize erosion in winter months.
- For stormwater management purposes, artificial or synthetic turf roofs are not considered green roofs and must be combined with other SMPs.
- For any blue-green roof that discharges onto an adjacent property, a drainage easement is required.
- Building mechanical systems, roof furniture, and other appurtenances installed on the roof should not be compromised by roof ponding during rain events and must not cause damage to the roof membrane.
- Coordination of blue-green roof design with the design of building heating, ventilation, and air conditioning (HVAC) systems can help to maximize operational cost savings. For example, some research suggests that green roofs can improve building energy efficiency by lowering the temperature of air at the intakes for climate control systems.

Blue-green roof types

The blue-green roof includes a type of green roof combined with a roof drain restrictor system used to retain water in the base of the profile for subsequent plant transpiration, with eventual discharge to the roof drain. The designer is referred to **Section 4.3.1** ☛ p. 45 for green roof types.

4.14.2: Blue-green roof components

Figure 4.14-1: Partially paved blue-green roof with typical features



Inlet control component

For blue-green roofs that receive runoff from roof directly connected impervious area (DCIA), inlet control systems may convey and control the flow of stormwater from the contributing catchment area to the blue-green roof. Distribution piping may be used to evenly disperse run-on water throughout the blue-green roof. The designer is referred to **Section 4.11** ☛ p. 166, Inlet Controls, for more information on inlet controls.

Storage area component

Blue-green roof storage areas temporarily hold stormwater before it can either be used by plants through evapotranspiration or be released downstream at a controlled rate. Storage areas for green roofs typically are composed of the following components:

The ***growing medium*** supports plant growth and provides for storage of stormwater within voids. The storage capacity is a function of medium depth, surface area, and total void space. The total growing medium depth includes, as applicable, the primary growing medium, root-friendly moisture retention products, and root-friendly drainage aggregates such as ***foundation growing medium*** (lightweight drainage aggregate) as a base. Storage in ***roof drain restrictor systems*** is determined by the roof slope and geometry relative to both the height of the restrictor and the depth of the growing medium.

Filter fabric, also called ***separation fabric***, or ***geotextile***, prevents migration of soil into the underlying drainage layer of the green roof.

A ***drainage layer*** may incorporate measures to intercept and retain percolated rainfall as it moves through the green roof storage area. Examples include synthetic sheets with waffle-type cups to hold water and specialized fabrics or mats with high capillary indices. Drainage products that have low horizontal flow rates and allow deep growth of plant roots are required for green roofs managing runoff from adjacent tributary surfaces. Root-friendly drainage products include foundation growing medium (lightweight drainage aggregates) and waffled reservoir sheets where the cups are filled with lightweight aggregate.

Moisture interception layers are thick geotextiles or other porous materials that retain water and help protect the underlying roof deck. Moisture interception layers can help increase moisture availability to plants between rain events.

Root barriers are impermeable liners or membranes that protect the underlying roof deck from moisture and plant root intrusion. Similar to blue roof storage, blue-green storage areas are underlain by a waterproofing membrane. Some waterproofing membrane materials are inherently root resistant, whereas others require an additional root barrier.

Numerous waterproofing membrane systems are commonly available, including modified bitumen roofing (MBR), waterproof types of single-ply roofing, metal roof panels, spray polyurethane foam roofing, synthetic rubber membranes, thermoplastic membranes, and liquid-applied (including polyurethane-based and polymer-modified bituminous products) roofing. While high quality MBR systems (multiple MBR sheets tiled to reduce seam susceptibility) are suitable for blue roof usage, lower quality MBR systems (multiple layers of asphaltic sheets) are not recommended due to their seams that allow water to penetrate.

Underlying ***roofing systems*** typically consist of a structural deck, its supporting structures, and a traditional overlying waterproofing system. Because of their durability and lack of seams, a hot fluid applied, rubberized asphalt, fabric reinforced roofing system is well-suited for blue-green roofs. Cold liquid-applied systems are equally effective due to strict regulations on the use of the propane-fired devices for hot fluid systems.

Vegetation component

Blue-green roof plant material is designed to take up much of the water that falls on the roof during a storm event. Plant cover is instrumental in controlling wind erosion of the underlying blue-green roof materials. It mitigates soil moisture loss and water erosion, transpires captured moisture back into the atmosphere, and provides evaporative cooling. Plant material also collects dust and creates oxygen. Some blue-green roofs may also have irrigation systems to support plant growth during dry periods.

Outlet control component

Outlet controls within a blue-green roof system can provide a range of functions, including the following:

- Meeting drain down time requirements;
- Controlling the rate of discharge from the SMP and limiting water surface elevations during various storm events; and/or
- Bypassing of flows from large storm events.

Outlet controls may include orifices, weirs, roof drain restrictors, risers, scuppers, impervious liners, micro siphon drain belts, and/or low flow devices. The designer is referred to **Section 4.12** ☛ p. 182, Outlet Controls, for more information.

Roof drain restrictor blue-green roofs use a roof drain restrictor that is placed over the roof drain. These devices restrict flow through an outlet control within the drain assembly, causing temporary ponding on the roof. They may be purchased commercially through a manufacturer, or a manufacturer can customize an outlet control sized for a specific development. The number and sizing of weirs and orifices are based on a predetermined relationship between the water depth approaching the drain and the flow rate entering the drain. The overflow mechanism of the device determines the maximum ponding depth.

Micro siphon drain belts are drainage systems that use capillary pressure to wick water out of the soil or filter media and convey it through small siphon channels to collector drainpipes. Their application within a blue-green roof allows for the collection of stormwater over a large surface area and for meeting very low release rate requirements. Micro siphon drain belts must connect to a downslope collector pipe or roof drain, and they may be installed in the foundation growing medium layer. The designer is referred to **Section 4.12.8** ☛ p. 213 for more information on designing micro siphon drain belt systems within a blue-green roof.

Paving component

Paved walkways, stepping stones, patios, and paver or stone perimeter strips are common elements of blue-green roof designs. Non-vegetated surfaces that discharge runoff into the vegetated area of the blue-green roof must count toward the impervious runoff loading ratio.

Inspection and maintenance access component

Safe and easy inspection and maintenance access to all major components within a blue-green roof is critical to ensuring long-term performance. Dependent on roof height and slope, blue-green roof inspection and maintenance access components may consist of permanent or temporary safety monitoring systems, guardrail and safety net systems, warning line systems, and/or personal fall arrest systems. Inspection and maintenance access systems for blue-green roofs may also include long-term leak detection systems for locating and managing leaks.

In the case of accessible roof terraces for residential settings, the provision of a railing with a maintenance gate that separates the vegetated green roof from accessible areas is required. The railing can be metal, wood, or glass. Bird-friendly glass with a Threat Factor Rating of 1–25 is highly recommended. Pet access to green roofs that are certified as SMPs should be restricted, as urine, pet digging, and habitual foot traffic can all damage plants and growing medium, leading to potential erosion and diminished rainfall management performance.

4.14.3 Blue-green roof design standards

General design standards

1. Structural requirements:
    a. Structural loading must be considered for all blue-green roof designs, and blue-green roof design must be coordinated with a licensed structural engineer for both new building construction and retrofits to existing structures.
    b. A structural engineer must verify that the building will support the weight of the blue-green roof.
    c. Design calculations must consider the fully saturated media and flooded storage weight of the blue-green roof. Due to their water holding capacity, blue-green roofs typically weigh more than 45 pounds per square foot and are most common in new construction where the roofing design can accommodate these loads.
    d. Potential maximum loads must be based on American Society of Testing and Materials (ASTM) E2397.
2. The entirety of the blue-green roof footprint must be considered, and modeled as, DCIA. Accordingly, a Natural Resources Conservation Service curve number of 98 must be used for the blue-green roof, where required for hydrologic calculations.
3. Vegetated green roof portions of the blue-green roof are permitted a DCIA reduction equal to the entire area of the vegetated footprint solely for the predevelopment to post-development impervious area reduction calculation during the determination of potential exemption from the Channel Protection and Flood Control requirements.
4. The total impervious roof area within the designated boundary of a blue-green roof footprint must not exceed the total vegetated green roof area, which is equivalent to a maximum hydraulic impervious runoff loading ratio of 1:1.
5. The following are exempt from being counted as tributary impervious area when installed on a blue-green roof:
    a. Pervious pavers containing planted openings; and
    b. Drain chambers, including an adjacent stone margin with an offset distance from the chamber edge of 12 inches or less. All other stone/gravel margins or perimeters must be considered roof DCIA, unless they are graded to allow flow over or through vegetated green roof area, in which case, they may be counted as tributary impervious area to the green roof portion of the blue-green roof.
6. The maximum allowable ponding depth is one inch below the top of the foundation growing medium. For roof drain restrictor systems, this ponding depth maximum can be set at least five feet from the restrictor.
7. The maximum allowable drain down time is 72 hours after the 24-hour storm event.
8. Positive overflow must be provided and comply with the Philadelphia Plumbing Code
9. The flooded storage area of the blue-green roof area must be underlain by a waterproofing membrane.
10. Root barrier layers must conform to the requirements of the waterproofing provider for each project.

Inlet control design standards

11. If runoff is conveyed via piping, a distribution piping manifold must be embedded in a gravel strip to dissipate energy and promote uniform flow. The designer is referred to **Section 3.4.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-4-how-to-show-compliance/#3.4.2 for information on design standards for distribution piping.
12. The designer is referred to **Section 4.11** ☛ p. 166 for information on design standards for inlet control systems.

Storage area design standards

13. For roof drain restrictor blue-green roofs that rely solely on growing medium to retain the Water Quality Volume (WQv):
    a. The minimum allowable thickness of the green roof growing medium for a 1:1 loading ratio is six inches, including two inches of foundation growing medium, which serves as the drainage layer.
    b. Any contributing impervious surface built atop a blue-green roof must either allow for sheet flow runoff onto the vegetated portion of the roof, like unit pavement, or be slotted, like decking. The minimum two-inch thickness of foundation growing medium required for the blue-green roof must extend under the entire extent of that surface area.
    c. The top one inch of the foundation growing medium must be maintained above the flooded elevation, starting five feet from the roof drain restrictor, to promote aerated conditions in the growing medium.
    d. The roof drain restrictor must include an outfall device which limits the WQv discharge flow rate to comply with applicable Water Quality requirements.
    e. In areas that will receive tributary discharge, the blue-green roof must not include a high-transmissivity drainage layer, defined as a layer with a transmissivity of greater than 0.005 m^2/s (ASTM D4716), where such products limit plant root access to tributary runoff. In general, this will exclude most synthetic sheet drains, including peg-style or egg carton style drains. High-transmissivity drainage layers will allow runoff to effectively flow under the blue-green roof, minimizing contact with growing medium and plant roots. Typical foundation growing medium (also called granular aggregate or coarse granular green roof medium), with a grain-size distribution complying with ASTM gradation No. 7 will satisfy the requirement, as will also a variety of mats and composite drainage layer assemblies.
14. The storage system must provide adequate storage to control release rates to meet all applicable Stormwater Regulations. The designer is referred to **Section 3.2.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-2-stormwater-management-design/#3.2.3 for information on using SMPs in series.
15. Saturated permeability of the growing medium, in its compacted state [ASTM E2399], must not be less than six inches per hour.
16. Filter or separation fabric must allow root penetration but prevent the growing medium from passing through into the drainage layer.
17. A drainage layer is required to promote aerated conditions in the growing medium and to convey excess runoff during large rainfall events.

Vegetation design standards

18. When fully established, the selected plantings must thoroughly cover the growing medium. Mature plant cover must be a minimum of 80% on established green roofs, with contiguous non-vegetated areas no larger than three square feet (i.e., a 24-inch diameter circle).
19. Plant coverage must persist year-round. While individual plants may exhibit seasonal dormancy, vegetation coverage in winter months must be maintained. Mulch should be limited to 0.25 inches of compost if used as a temporary component in an establishment planting. Mulching can jeopardize green roof performance by clogging the geotextiles within the system and increasing system weights. Mulching also inhibits the reseeding of plants, which is a necessary process for long-term species persistence.
20. Plants that are appropriate for, and compatible with, the site conditions must be chosen. The designer is referred to **Section 4.13** ☛ p. 218 for additional landscaping guidance and **Appendix I** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists for plant lists.

Outlet control design standards

21. The contributing drainage area of impervious rooftop to each disconnected discharge point must be equal to, or less than, 500 square feet.
22. Roof drain restrictors must be sized according to the desired release rate and ponding depth.
23. Internal drainage, including provisions that cover and protect drains or scuppers, must anticipate the need to manage large rainfall events without inundating the cover.
24. All drains and scuppers must be covered and protected by an enclosure, typically a square or round chamber with a locking lid. These chambers are designed to prevent clogging of the drains by debris.
25. The roof drainage system and the remainder of the site drainage system must safely convey roof runoff to the storm sewer, combined sewer, or receiving water.
26. Emergency outflow must be set at an elevation above the height of the roof drain restrictor.
27. The designer is referred to **Section 4.12** ☛ p. 182 for information on design standards for outlet control systems.

Inspection and maintenance access design standards

28. Blue-green roofs must be designed to allow for safe access and working conditions for green roof inspection and maintenance personnel. This access must be a permanent feature of the building, such as a pilot house, roof hatch, or exterior stairs to the blue-green roof. Retractable, unsecured ladders should not be required for routine maintenance and inspections due to safety concerns. The design may include other permanent personal safety measures. For blue-green roofs, designers must specifically assess applicability to Occupational Safety and Health Administration (OSHA) Fall Protection Safety Standards and the American National Standards Institute (ANSI) and American Society of Safety Engineers (ASSE) consensus-based fall protection standards.
29. Easy access must be provided to each of the outlet controls, low flow discharge points, and overflow connections to permit removal of debris under saturated conditions.
30. Seams, corners, penetrations, mounts, or platforms for mechanical utilities, and any other areas of the roofing membrane where risk of leakage is highest, must be inspected for damage or failure and repaired in a manner consistent with the membrane material.
31. For accessible residential roof terraces, a railing with a maintenance gate that separates the vegetated green roof from accessible areas must be provided. The railing can be metal, wood, or glass. Bird-friendly glass with a Threat Factor Rating of 1–25 is highly recommended.

Figure 4.14-2: Blue-green roof standard detail

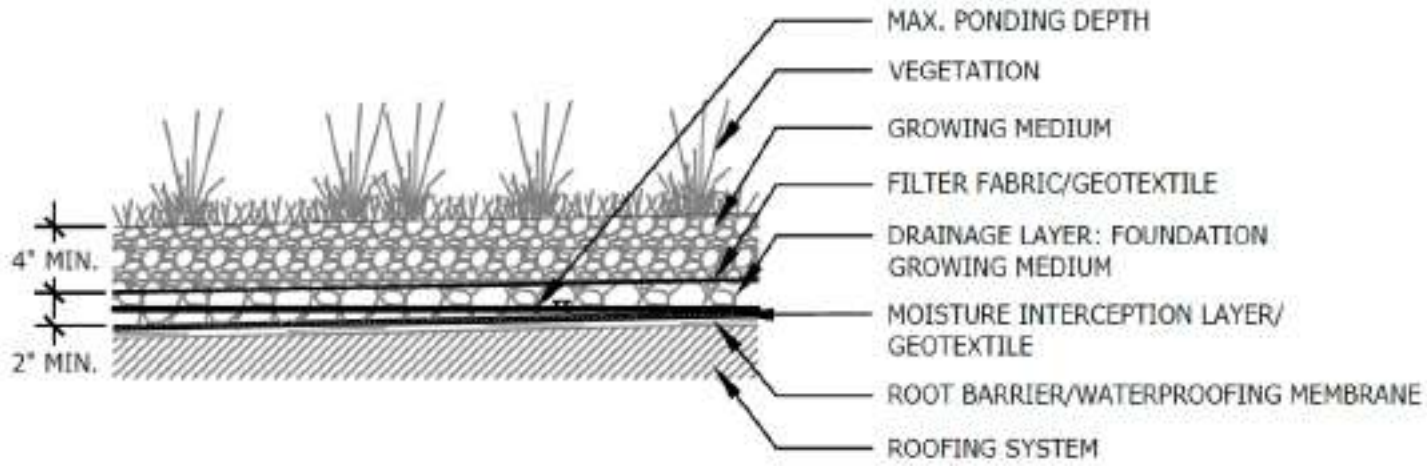
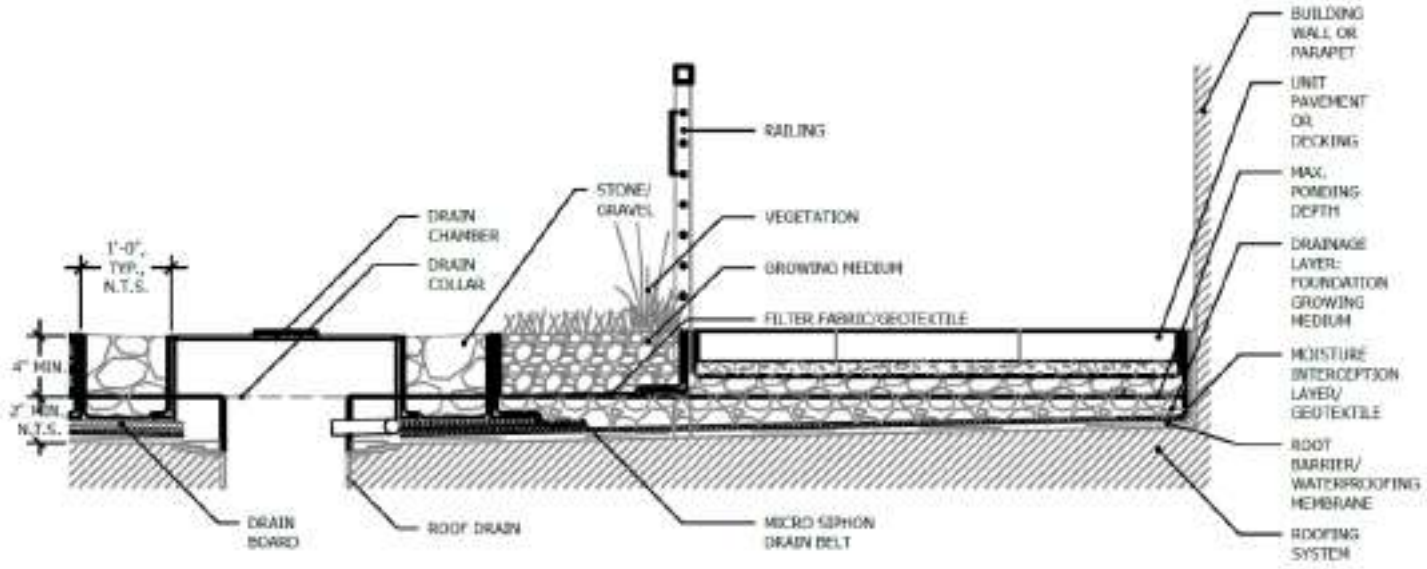


Figure 4.14-3: Partially paved blue-green roof with micro siphon drain belt standard detail



(The designer is referred to **Appendix L** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/l-standard-details to download Standard Detail CAD files.)

4.14.4 Blue-green roof material standards

Inlet control material standards

1. The designer is referred to **Section 4.11** ☛ p. 166 for information on material standards for inlet control systems.

Storage area material standards

2. Green roof growing medium must be a lightweight mineral material with added organic material that meets the following specifications:
   a. Moisture content at maximum water holding capacity (ASTM E2399 or FLL): 40% to 60% (vol)
   b. Porosity at maximum water holding capacity (ASTM E2399 or FLL): 10% to 15%
   c. Density at maximum water holding capacity (ASTM E2399 or FLL): ≤ 85 lbs/ft3
   d. Total organic matter (MSA): 6% to 10% (dry weight)
   e. pH (MSA): 6.5 to 7.8
   f. Soluble salts (DPTA saturated media extraction): ≤ 2 mmhos/cm
   g. Water permeability (ASTM E2399 or FLL): 0.25 in/min to 1.25 in/min
   h. Grain-size distribution consisting of ≤ 4.5% passing for clay (0.002 mm) and 5% to 15% passing for silt (0.05 mm). Clay and silt together must not exceed 15%.
   i. The nutrients must be initially incorporated in the formulation of a suitable mix for the support of the specified plant materials.
   j. The medium must withstand freeze/thaw cycles.
3. Foundation growing medium (lightweight drainage aggregate) must be composed of a blended medium that meets the following specifications:
   a. Density at maximum water capacity (ASTM E2399-05): ≤ 65 lbs/ft3
   b. Maximum water holding capacity: 15% to 25%
   c. Water permeability (ASTM E2396-05): ≥ 25 in/min
   d. Total organic matter by loss on ignition (ASTM F1647): ≤ 1%
   e. Porosity (ASTM C29): 20% to 65%
   f. Grain-size distribution (ASTM C136) consisting of the following gradations:
      i. Pct. Passing US#18 sieve (1.0 mm): ≤ 5%
      ii. Pct. Passing ¼-inch sieve: ≤ 30%
      iii. Pct. Passing 3/8-inch sieve (9.5 mm): ≥ 75%
      iv. Pct. Passing ½-inch sieve (12 mm): 100%
4. Geotextile must consist of polypropylene fibers and meet the following specifications:
   a. Grab Tensile Strength (ASTM-D4632): 70 lbs to 120 lbs
   b. CBR Puncture Strength (ASTM-D6241): 120 lbs to 340 lbs
   c. Flow Rate (ASTM-D4491): 130 gal/min/ft2 to 200 gal/min/ft2
   d. UV Resistance after 500 hrs. (ASTM-D4355): 70%
   e. Tear Resistance (ASTM-D4533): 30 lbs to 50 lbs
   f. Heat-set or heat-calendared fabrics are not permitted.

5. Root Barrier/Waterproofing Membrane
    a. PVC, EPDM, and thermal polyolefin (TPO) are permitted and inherently root resistant.
    b. All waterproof membranes must meet appropriate ASTM specifications. PVC membranes must meet ASTM D4434 requirements, EPDM membranes must meet ASTM D4637 requirements, and TPO membranes must meet ASTM D6878 requirements.
    c. Waterproofing membrane must be fully waterproof with properly sealed seams, corners, and protrusions to prevent any intrusion of standing water above the membrane.
    d. Roofing membranes must meet all building code requirements and guidelines of the City of Philadelphia.

Vegetation material standards

6. Invasive species are not permitted in green roof planting. All plants must be appropriate and compatible with soil, hydrologic, light, and other site conditions. The designer is referred to **Appendix I** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists for plant lists.
7. Plant species must be biodiverse. Species diversity for green roofs is defined as follows:
    a. Sedum: Include at least two genera (i.e., both *Sedum* and *Phedimus*) and six different species or cultivars in planting plans.
    b. Native or adaptive grasses: Provide at least two genera and three different species, if grasses are included in the design.
    c. Native or adaptive perennials: Provide at least three genera and four different species, if perennials are included in the design.
8. Plant establishment:
    a. Plant establishment may be achieved through plugs, mats, container plants and/or seed.
    b. The inclusion of seed as a supplement to live plants is required. The designer is referred to **Section 4.13.3** ☛ p. 226, Landscape Design Considerations, for a list of species appropriate for overseeding on green roofs.
    c. Temporary erosion control measures must be provided appropriate to the planting method during the plant establishment period.
9. Perennials, grasses, grass-like plants, and groundcover plants must be healthy, well-rooted specimens.
10. Green roof plantings must be able to withstand heat, cold, and high winds. After establishment, the plants must be self-sustaining and tolerant of drought conditions, with little to no need for fertilizers or pesticides.
11. The only sedum known to be invasive, and which must be avoided is *Sedum sarmentosum*, also known as star sedum, gold moss, stringy stonecrop, or graveyard moss.

Outlet control material standards

12. The designer is referred to **Section 4.12** ☛ p. 182 for information on material standards for outlet control systems.

Inspection and maintenance access materials standards

13. Personal protection systems must comply with OSHA Fall Protection Safety Standards and the ANSI and ASSE consensus-based fall protection standards.

4.14.5 Blue-green roof construction guidance

Proper construction of blue-green roofs is essential to ensure long-term functionality and reduce long-term maintenance needs. Blue-green roof systems are best installed by experienced roofing contractors with expertise in installing flat roof membranes over new or existing roof structures. A standard construction sequence for proper blue-green roof system installation is provided below. This can be modified to reflect different blue-green roof system applications or expected site conditions.

1. Inspect waterproof membrane along the roof and parapet wall or any irregularities that will interfere with drainage or may cause leaks. Do not continue until roofer has addressed defects. Confirm height of membrane is at least six inches above the peak ponding elevation as per the SMP designs.
2. Confirm all edges, seams, corners, protrusions, and other anomalies are sealed in a watertight manner consistent with the installation specifications of the membrane manufacturer.
3. Install root barrier layer, if required.
4. Install moisture management layer or geotextile, as appropriate to the design.
5. Install drainage layer.
6. Install filter fabric, as appropriate to the design.
7. Install growing medium, as specified.
8. Install irrigation system within the growing medium, if included in design.
9. Test the irrigation system, if included in design.
10. Install outlet controls in a manner consistent with the City's Building and Plumbing Codes and guidelines. The designer is referred to **Section 4.12** ☛ p. 182 for information on sizing and installation of outlet control systems. Outlet systems must include a bypass/overflow mechanism to permit rapid discharge when the storage volume of the blue-green roof system is exceeded.
11. Finish installing and grading growing medium.
12. Install wind protection, if included in the design. A wind scour blanket or hydromulch may be required to prevent erosion during the establishment period. It generally takes about two growing seasons for full establishment. High wind environments may necessitate permanent wind blankets.
13. Establish vegetation:
    a. Blue-green roof vegetation can be effectively established by broadcasting fresh sedum cuttings during the spring and fall months. Depending on seasonal conditions, irrigation may be required after planting.
    b. Many perennial plants can be installed as plugs or container plants between April and November. Depending on the time of planting, temporary irrigation may be required.
    c. Perennials can be established from seed, except during the months of June, July, and August.

4.14.6 Blue-green roof maintenance guidance

Maintenance of blue-green roof systems emphasizes maintaining drainage capacity, the health of vegetation, and prevention of clogging via periodic removal of sediment and debris from outlet areas. To maximize the blue-green roof's lifespan, inspect all facility components, including vegetation, growing medium, filter fabric, drainage layer, and visible portions of the waterproof membrane.

Regardless of plant density and coverage, control of weed species is encouraged as part of long-term maintenance. The designer is referred to the ***Landscape Design Guidebook*** ☛ water.phila.gov/wp-content/uploads/files/gsi-landscape-design-guidebook.pdf for more detail.

General recommended maintenance activities for blue-green roof systems are summarized in Table 4.14-1.

Table 4.14-1: Blue-green roof maintenance guidelines

Early maintenance activity	Frequency
Inspect outlet structures, and storage areas for trash and sediment accumulation.	Monthly for the first year after installation to determine ongoing maintenance frequency
Water vegetation in the early morning.	Every day for the first two weeks after planting.
	Every four days for the first year after planting, during periods of four or more days without rain, during June through August.
Hand-weed non-target/invasive plants.	Every three months for the first two years after planting.
Inspect vegetation for signs of disease or distress. Treat or replace as necessary.	Every two weeks for the first year after planting.

Ongoing maintenance activity	Frequency
Remove debris from drainage outlets and outlet screens to prevent clogging.	During inspections or as needed to ensure performance
Remove debris from secondary drainage/overflows.	During inspections or as needed to ensure performance
Remove excessive buildup of sediment around the outlet controls or within the storage cells.	During inspections or as needed to ensure performance
Roof drains must be cleared when soil substrate, vegetation, debris or other materials clog the drain inlet. Under normal operating conditions, all roof discharge must be filtered, and medium must not be vulnerable to migration towards the drains. Sources of sediment and debris must be identified and corrected.	As needed
Break up ice formation around outlets and overflows.	As needed during winter months
Maintain plant material to provide a minimum of 80% foliage cover during warm months. If coverage rate is declining, determine the reason (e.g., soil nutrition or soil moisture conditions) and implement remedial measures.	As needed (see below)
Remove weeds manually and use herbicide only in extreme instances of weed infestations that compromise the plant cover integrity and when herbicides are permitted on a project site (e.g., certain sustainability rating systems do not allow chemical herbicides on site). Remove weeds entirely.	As needed (see below)
Thin any overgrown areas of vegetation	As needed
Inspect for leaks	During inspections or as needed to ensure performance
Inspect root development. If root zone is not well developed, determine the reason (e.g., soil nutrition, soil moisture conditions) and implement remedial measures.	Quarterly
Inspect permanent irrigation system and adjust irrigation dosing rates as needed to optimize plant performance and water-use efficiency.	Quarterly
Inspect growing medium for evidence of erosion from wind or water. If erosion channels are evident, a problem with the drainage system or with the growing medium is present. Surface ponding or runoff must not occur except during very large rainfall events. Correct the problem, then refresh the affected areas with additional growing medium and provide temporary soil stabilization.	Quarterly
In early spring, manually cut dormant herbaceous vegetation from the previous growing season to four to six inches above the ground.	Annually
Inspect drain-inlet pipe and containment system.	Annually
Test growing medium for soluble nitrogen content. Fertilize as needed.	Annually
Maintain records of all inspections and maintenance activity.	Ongoing

During the plant-establishment period, conduct at least three to four maintenance visits yearly for basic weeding, fertilization, and in-fill planting. Thereafter, conduct at least two annual inspection and light weeding visits (irrigated assemblies will require more frequent maintenance).

Herbicides must be avoided to prevent root penetration of waterproofing.

Apply organic or chemical fertilizer according to soil-testing results to maintain soluble nitrogen (nitrate and ammonium ion) levels between one and four ppm. Mature compost is the best nutrient source for fertilization.

Exercise spill prevention measures from mechanical systems located on roofs when handling substances that can contaminate stormwater.

The designer is referred to **Section 4.12** ☛ p. 182, Outlet Controls, and **Section 4.13** ☛ p. 218, Landscaping, for information on maintenance guidance for outlet controls and landscaping.

4.15 Drainage Wells

Download summaries of this SMP and its maintenance guidance, with quick reference information for clients and developers:

- **Drainage Wells SMP One-Sheet** ☛ water.phila.gov/wp-content/uploads/files/drainage-wells-smp-one-sheet.pdf
- **Drainage Well Maintenance Guidance One-Sheet** ☛ water.phila.gov/wp-content/uploads/files/drainage-well-maintenance-guidance.pdf

4.15.1 Drainage well introduction

Drainage well stormwater management practices (SMPs) are perforated stormwater manholes that detain runoff and allow it to infiltrate into the surrounding soil. Stormwater flows into the drainage well where it collects within the manhole structure and surrounding open-graded stone. Drainage wells are typically constructed from precast concrete or a thermoplastic (typically polyvinyl chloride, or PVC). Drainage wells are a specific application of subsurface infiltration and are typically deeper than other types of infiltration SMPs. The designer is referred to **Section 4.4** ☛ p. 64 for more general information on subsurface infiltration SMPs.

Drainage wells can be combined with other SMPs in series to meet the Philadelphia Water Department (PWD) Stormwater Regulations (Stormwater Regulations). The designer is referred to **Section 3.2.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-2-stormwater-management-design#3.2.3 for information on using SMPs in series.

This design guidance provides flexibility for designers to dynamically model drainage wells. Dynamic routing allows designers to account for the volume of water infiltrated into the ground in real time, which allows the drainage well to have less storage and be shallower. Design of drainage wells is not limited to the examples discussed within this text. Successful stormwater management plans will combine appropriate materials and designs specific to each site.



An example of a precast concrete drainage well in Philadelphia

Where can drainage wells be used?

Drainage wells must have underlying soils that, when tested pursuant to the protocol described later in this section (**Section 4.15.3** ☛ p. 262), are determined to be infiltration-feasible. They can be used to manage stormwater on both small and large sites, but may be especially useful on smaller sites, where open space for bioinfiltration/bioretention SMPs and horizontal area for subsurface infiltration are limited. For large sites, multiple drainage wells can be integrated throughout the site to manage larger areas. Provided that overburden loads and utility conflicts are evaluated, they can be sited beneath lawns and recreational areas, as well as parking lots and other hardscape surfaces. Drainage wells can also be dynamically sized to save space or reduce the depth of the SMPs.

Key advantages of drainage wells

- Can be useful on smaller sites with limited area available for bioinfiltration or subsurface infiltration footprints
- Can be easier to maintain than other subsurface infiltration types
- Less reliant on infiltration through the bottom surface of the SMP than other subsurface infiltration SMPs. Therefore, reduction in infiltration through the bottom of the SMP as a result of clogging may not be as detrimental to the long-term performance of drainage wells as it is to other subsurface infiltration SMPs.
- Eligible for dynamic sizing

Key limitations of drainage wells

- Can be more costly and more challenging to install than surface practices like bioinfiltration SMPs, as well as more difficult to maintain post-construction
- Because identification of the seasonal high-water table is so important to the design of a drainage well, and because drainage wells are generally deeper than other subsurface SMPs, monitoring of the water table over a period of time using groundwater monitoring wells is recommended. Monitoring may lengthen the time needed for design. Furthermore, if monitoring reveals a water surface elevation that is too high for the drainage well to function properly, alternate siting or an alternate design would be necessary.
- Not appropriate for runoff with high sediment loads without robust pretreatment
- Requires regularly scheduled inspections because the maintenance needs are not easily visible
- Does not improve natural aesthetics or provide the ancillary environmental benefits associated with vegetated SMPs, such as habitat creation and improved air quality

Key design considerations for drainage wells

- Must be constructed in soils suitable for infiltration. Infiltration in both vertical and horizontal directions should be considered.
- Drainage wells can be dynamically designed, which may save space or reduce the depth of the SMPs. These SMPs must statically store one inch of runoff and be shown, via dynamic routing, to manage 1.5 inches of runoff throughout the design storm, without overflow.
- The horizontally exfiltrating section of the drainage well should not be constructed in unstable fill. Designers are specifically cautioned against siting drainage wells in inappropriate fill high in ash, cinder, or brick fragments, which are prone to dissolving or washout. Horizontal infiltration should occur below any problematic fill.

- Must confirm depth to bedrock, water table, or other hydraulically limiting layers.
- Because drainage wells may be deeper than other subsurface infiltration SMPs, careful identification of the seasonal high water table is especially important. Continuous soil borings from the surface to a depth five feet below the proposed drainage well bottom is required. Further drilling to the observed water surface elevation and installation of a groundwater monitoring well and monitoring of the water surface elevation over a period of time (generally, from March through October) are recommended. Monitoring data and evaluation of samples from the continuous soil borings should be used to physically identify the seasonal high groundwater table. This must be reported in the Geotechnical Report, further outlined in **Section 3.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-3-infiltration-testing-and-soil-assessment-for-smp-design.
- Appropriate pretreatment should be provided to remove sediment and debris before discharging to a drainage well system. A pretreatment approach should be developed based on the expected level of sediment loading and difficulty of sediment removal.
- Manhole structure diameter, the dimensions of the surrounding open-graded stone, and the depth of the drainage well system should be adjusted to provide appropriate runoff volume storage and management.
- Long-term maintenance must be carefully considered when evaluating drainage well systems. The system and maintenance access should be located in an area where maintenance and potential repairs can be conducted with minimal disturbance to surrounding uses.
- Improper installation of manholes has been known to result in subsidence in the area directly around the manhole. Proper compaction of stone and suitability of surrounding soils must be verified to minimize subsidence in the area around the drainage well.
- Structural suitability for overburden support and traffic loading should be considered, where applicable.
- Areas of soil contamination or unstable soils may need to be remediated or stabilized prior to drainage well installation.
- For any drainage well that discharges onto an adjacent property, a drainage easement is required.

Drainage well materials

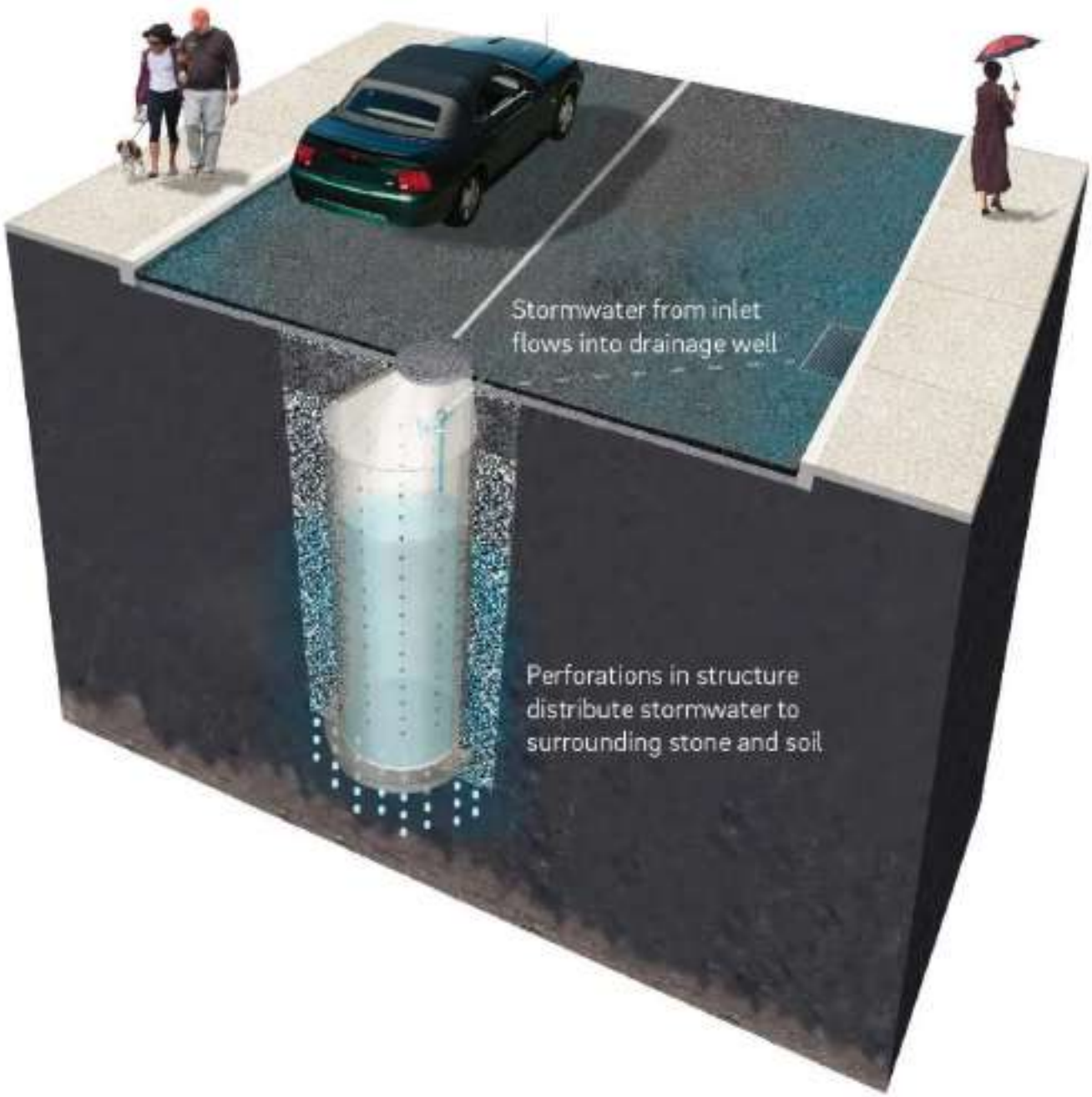
Drainage wells may be designed and constructed in a variety of sizes and materials. In this section, we discuss two main types of material:

Precast concrete drainage wells consist of a perforated, reinforced precast concrete manhole, with cast iron frame and cover, surrounded by open-graded stone. Precast concrete drainage wells are typically designed for AASHTO HS-20 loading and are therefore able to be used under areas that experience vehicle traffic, like driveways and parking lots.

Thermoplastic drainage wells consist of a perforated, thermoplastic (typically PVC) manhole, with steel frame and cover, surrounded by open-graded stone. Thermoplastic drainage wells are typically designed for AASHTO H-20 loading and are therefore able to be used under areas that experience vehicle traffic, like driveways and parking lots. However, precast concrete drainage wells may be preferable where heavy vehicle loads are anticipated.

4.15.2 Drainage well components

Figure 4.15-1: Precast concrete drainage well with typical features



Pretreatment component

Pretreatment systems capture trash, sediment, and pollutants from stormwater runoff before delivery to the infiltration area. Pretreatment needs will vary significantly depending on the contributing drainage area composition and use. Pretreatment can include structures such as sumped and trapped inlets, sediment/grit chambers or separators, media filters, inlet inserts, or other appropriate prefabricated or proprietary designs to remove sediment, floatables, and/or hydrocarbons from stormwater runoff prior to being conveyed to a drainage well. Pretreatment can also consist of filter strips, forebays, and swales. The designer is referred to **Section 4.10** ☛ p. 148, Pretreatment, for more information on pretreatment systems.

Inlet control component

Inlet control systems convey and control the flow of stormwater from the contributing catchment area to a drainage well. Inlet control needs will vary depending on the design of stormwater conveyance systems and the site layout. The designer is referred to **Section 3.4.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-4-how-to-show-compliance#3.4.2 for guidance on stormwater conveyance system design.

Inlet controls may include flow splitters, curbless design/curb openings, energy dissipaters, and inlets. The designer is referred to **Section 4.11** ☛ p. 166, Inlet Controls, for more information on inlet controls.

Storage area component

Storage areas within drainage wells temporarily hold stormwater runoff as it infiltrates into surrounding soils. The storage component of a drainage well is typically constructed of a perforated precast concrete or thermoplastic manhole, surrounded by open-graded stone. The open space within the manhole and the void spaces between the stones store stormwater until it can infiltrate into the surrounding soils. Accounting for these void spaces, the drainage well's storage volume may be calculated using the width of excavation measured at the extents of the stone surrounding the well (i.e. excavation diameter) and the depth of the well from the bottom of the stone to the overflow invert (i.e. infiltrating depth).

Outlet control component

Outlet controls within a drainage well can provide a range of functions, including the following:

- Controlling how much water is stored for infiltration;
- Meeting drain down time requirements;
- Controlling the rate of discharge from the SMP and limiting water surface elevations during various storm events; and/or
- Bypassing of flows from large storm events

Outlet controls may include orifices or overflow pipes. The designer is referred to **Section 4.12** ☛ p. 182, Outlet Controls, for more information on outlet controls. Typically, a separate structure outside the drainage well manhole is needed to regulate discharge from a drainage well that does not infiltrate into surrounding soils.

Inspection and maintenance access component

Safe and easy inspection and maintenance access to all major components within a drainage well system is critical to ensuring long-term performance. Access points provide access to the drainage well manhole as well as inlet and outlet controls, both for inspections and routine maintenance.

4.15.3 Drainage well design standards

If infiltration is deemed feasible, the designer may elect to dynamically design the drainage well. The dynamically designed SMP must still meet all applicable requirements, but it may be designed to statically store one inch of runoff, rather than the full 1.5-inch Water Quality Volume (WQv). If this strategy is chosen, the designer must show, via dynamic routing, that the full 1.5-inch WQv is managed throughout the design storm, without overflow.

General design standards

1. The maximum allowable drain down time is 72 hours after the 24-hour storm event.
2. There is no maximum directly connected impervious area (DCIA) to SMP footprint loading ratio.
3. Positive overflow must be provided for large storm events, up to and including the 100-year, 24-hour storm, or, if the project is exempt from Flood Control, the ten-year, 24-hour storm. Overflow structures and pipes must be designed to convey at least the ten-year, 24-hour storm.
4. The minimum allowable distance between the edge of a drainage well's stone storage bed and any adjacent private property line is ten feet. It is acceptable for drainage wells to be located directly adjacent to the public right-of-way (ROW).
5. The minimum allowable distance between the edge of a drainage well's stone storage bed and any building or retaining wall is ten feet. The following requirements and exceptions apply:
    a. For existing and proposed buildings with basements, the setback is measured from the basement wall.
    b. For existing buildings without basements and existing retaining walls, the setback is measured from the foundation and may be waived if a signed and sealed geotechnical analysis is submitted that evaluates the impacts of infiltration and excavation on the existing foundation and determines it to be feasible.
    c. For proposed buildings without basements and proposed retaining walls, the setback is measured from the foundation and may be waived if the foundation is proposed to be designed with the drainage well's proximity in mind.
6. When siting two or more drainage wells near each other, the lateral clearance between the edges of their stone storage beds must be twice the distance of the height of the perforated well section.
7. Infiltration requirements:
    a. The drainage well must be located at least two feet above any poorly infiltrating soils, seasonal high groundwater table, bedrock, or other hydraulically limiting zone.
    b. For hydrologic modeling, a soil permeability coefficient (k_{20}), calculated per the protocol described below in 7c(vi), must be applied to the wetted area of the drainage well, spanning the perforated sides and bottom, to determine infiltration characteristics.
    c. Because drainage wells utilize infiltration through the bottom as well as the sides, the infiltration testing protocol is different than other for other subsurface infiltration SMPs. Infiltration testing for drainage wells must be performed according to the following procedure, which is a modified version of the United States Bureau of Reclamation (USBR) Procedure 7300, *Performing Field Permeability Testing by the Well Permeameter Method:*
        i. Install a PVC well cap on one end of a four-inch inner diameter, Schedule 40 PVC well screen and lower into a borehole (ASTM D6151-08). The cap should be securely attached, making a positive seal. Sections of well screen should be added corresponding to the proposed length of perforated sections of the planned drainage well.

ii. A section of solid PVC casing corresponding to the depth below the ground surface to the top of the drainage well perforations should be connected to the slotted well screen section and extended to the ground surface.

iii. PVC well screen shall be new and flush threaded as per ASTM standards (ASTM D6724). The slot size of the well screen should be 0.060 inches (60 slot). The annulus between the well screen and the borehole should be filled with gravel pack, U.S. Silica FilPro #4 or equivalent.

iv. Infiltration testing shall be conducted by measuring the flow rate that is needed to maintain a constant head in the well. Use of a reservoir and float valves as described in USBR 7300 is suitable, but not required. Variations to the reservoir set up and the maintenance of the constant head are permitted as long as measurement of flow can be accurately made. Constant head should be maintained within one foot of the surface (keeping the water level above the slotted screen interval at all times). Once the water level has stabilized, record the volume loss from the constant head reservoir over time. Specific increments are not given in the USBR 7300 procedure, but regular increments should be used, at least every 15 minutes. As per USBR 7300, the test should be continued for at least 4 hours without letting the reservoir completely empty.

v. Upon completion of the infiltration test and all relevant logs, the well screen should be removed (if possible) and the hole backfilled with the cuttings. The surface should generally be restored using a concrete or asphalt patch. If the PVC materials cannot be retrieved, the casing extension should be removed or should be cut to at least six inches below the surface.

vi. The permeability coefficient (k_{20}) should be computed as follows:

- If the depth to the water table or impermeable layer is greater than three times the depth of the water in the test well:

$$k_{20} = \frac{qV}{2\pi h^2}\left\{ ln\left[\frac{h}{r} + \sqrt{\left(\frac{h}{r}\right)^2 + 1}\right] - \frac{\sqrt{1+\left(\frac{h}{r}\right)^2}}{\frac{h}{r}} + \frac{1}{\frac{h}{r}}\right\}$$

- If the depth to the groundwater table or impermeable layer is less than three times the depth of water in the well:

$$k_{20} = \frac{qV}{2\pi h^2}\left[\frac{ln\left(\frac{h}{r}\right)}{\frac{1}{6} + \frac{1}{3}\left(\frac{h}{T_u}\right)^{-1}}\right]$$

- **Where:**
  - k_{20} = coefficient of permeability at 20 degrees Celsius
  - h = height of water in the well
  - r = radius of the well
  - q = discharge rate of water from the well for steady-state constant head condition (determined from the straight line of a graph of total volume vs time (see Figure 7 in USBR 7300)
  - V = viscosity of water at 20 degrees Celsius
  - T_u = unsaturated distance between the water surface in the well and the water table

d. If the drainage well location is used as a temporary sediment basin during construction, the invert elevation of the infiltration SMP must be a minimum of three feet below the bottom elevation of the pre-basin-conversion sediment basin.

e. A drainage well within the zone of influence of any nearby basements, sewers or sewer laterals, or other subsurface conditions where infiltration is not advisable must be installed with an impervious liner. The zone of influence is defined by the area within a 1:1 (H:V) slope line from the outer edge of a sewer or sewer lateral.

8. Structural suitability for overburden support and traffic loading must be considered, where applicable.

Pretreatment design standards

9. Acceptable form(s) of pretreatment must be incorporated into design. Pretreatment of runoff from all inlets is required. At a minimum, this can be achieved through the use of sumps and traps for inlets, sump boxes with traps downstream of trench drains, and filter strips for overland flow.
10. The designer is referred to **Section 4.10** ☛ p. 148, Pretreatment, for more information on design standards for pretreatment systems.

Inlet control design standards

11. The designer is referred to **Section 4.11** ☛ p. 166, Inlet Controls, for information on design standards for inlet control systems.

Storage area design standards

12. The storage area must provide static storage for the WQv between the bottom elevation of the SMP and the elevation of the lowest outlet, including storage voids. For dynamically designed drainage wells, static storage of only one inch of the WQv must be provided if the designer demonstrates, through dynamic routing, that the full 1.5-inch WQv is managed throughout the design storm, without overflow.
13. The maximum allowable static storage volume without supporting documentation (defined below) is the runoff volume from the one-year, 24-hour storm.
14. The maximum allowable static storage volume with supporting documentation is the runoff volume from the ten-year, 24-hour storm. Requirements for supporting documentation include a letter, signed and sealed by both the geotechnical and design engineer, indicating that the proposed design is recommended, with the following components acknowledged and considered. The designer is encouraged to contact PWD for further guidance when pursuing this design.

    a. A summary of the long-term impacts to the neighboring properties, including, but not limited to subsidence, change in basement moisture/water, and structural damage;

    b. The location of the groundwater table;

    c. References to other projects that have successfully infiltrated more than the one-year, 24-hour storm event; and

    d. Rigorous pretreatment to promote longevity of the infiltration SMP.

15. When SMPs are used in series, the storage areas for all SMPs must provide cumulative static storage for the WQv, but there is no minimum storage requirement for each individual SMP used in series.
16. Drainage wells can be designed with additional storage beyond the WQv and with outlet controls that allow all remaining applicable Stormwater Regulations to be met.
17. Void space provided by drainage wells must be as specified by the manufacturer and noted in supporting documentation.

18. Bedding and foundations:
    a. Drainage wells must be adequately bedded on stone to prevent settling or subsidence.
    b. Bedding thickness may vary according to system requirements, but must not be less than six inches.
    c. Over-excavation and replacement of loose or unstable subsurface material may be required if such conditions are encountered. A geotechnical engineer or other appropriate design professional should be consulted for additional guidance.
    d. Foundations/footers must be provided as warranted by system loading, geotechnical conditions, and manufacturer's recommendations. Foundation designs must be performed by an appropriate design professional.
19. The storage design must account for potential loading from vehicles, as appropriate, based on expected maximum active loading, including consideration for emergency vehicles.
20. A porosity of 0.40 must be used for stone storage volume calculations.
21. Stone must be separated from existing soil media by a geotextile, to prevent sand, silt, and sediment from entering the system. A pea gravel filter may be used on the bottom in lieu of a geotextile.
22. Stone must be separated from the perforated manhole by a geotextile or geogrid to prevent stone from falling into the manhole.
23. Drainage wells must have a level bottom. If installed in series, along a slope, drainage wells must use a terraced elevation system.

Outlet control design standards

24. The designer is referred to **Section 4.12** ☛ p. 182, Outlet Controls, for information on design standards for outlet control systems.

Inspection and maintenance access design standards

25. Manholes must be accessible, to allow unobstructed and safe access to drainage wells for routine inspection and maintenance. Inlet and outlet controls must also contain access panels or other access features to inspect and maintain the same.
26. Ladder access is required for drainage wells greater than four feet in height.

Figure 4.15-2: Precast concrete drainage well standard detail

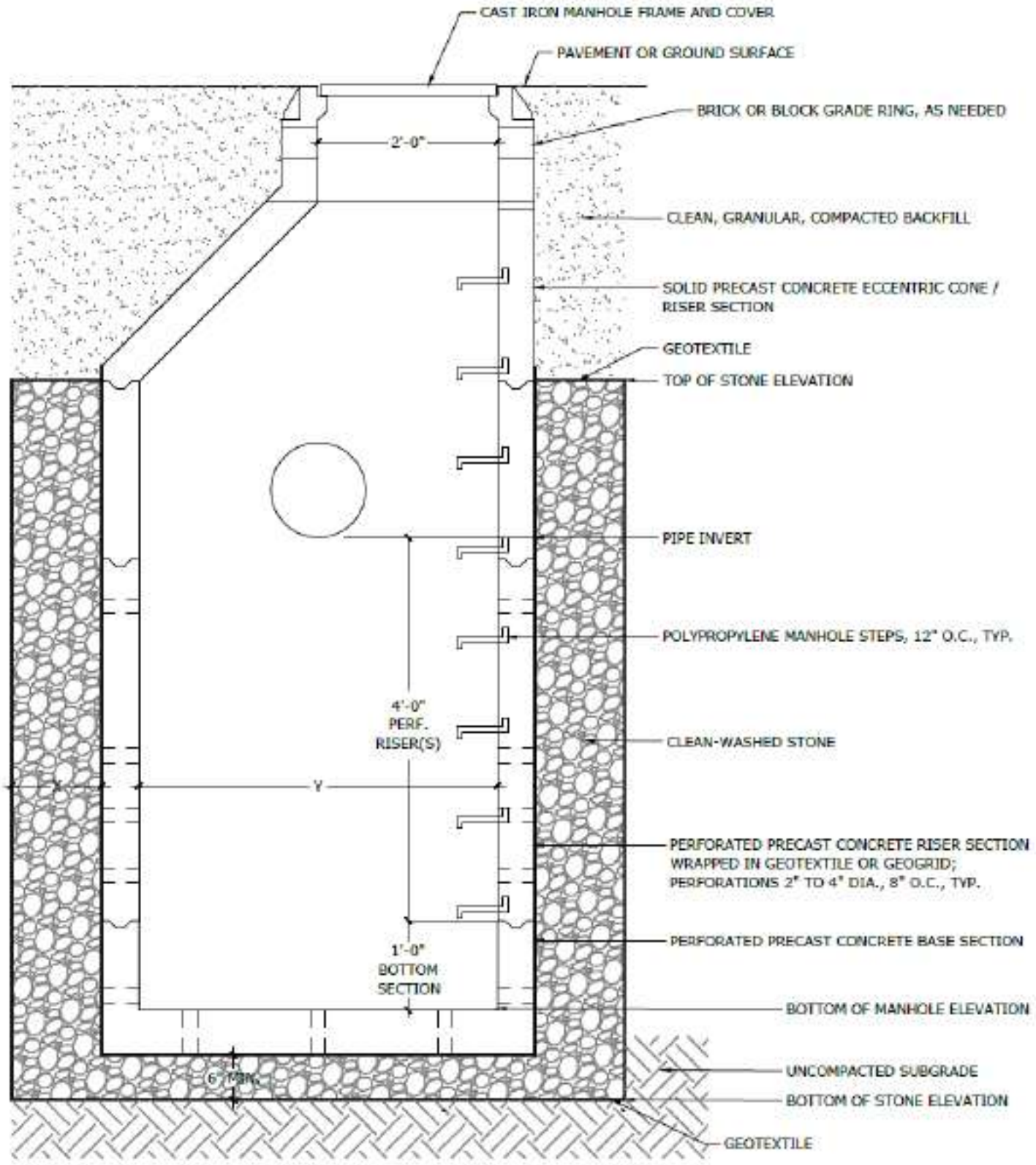
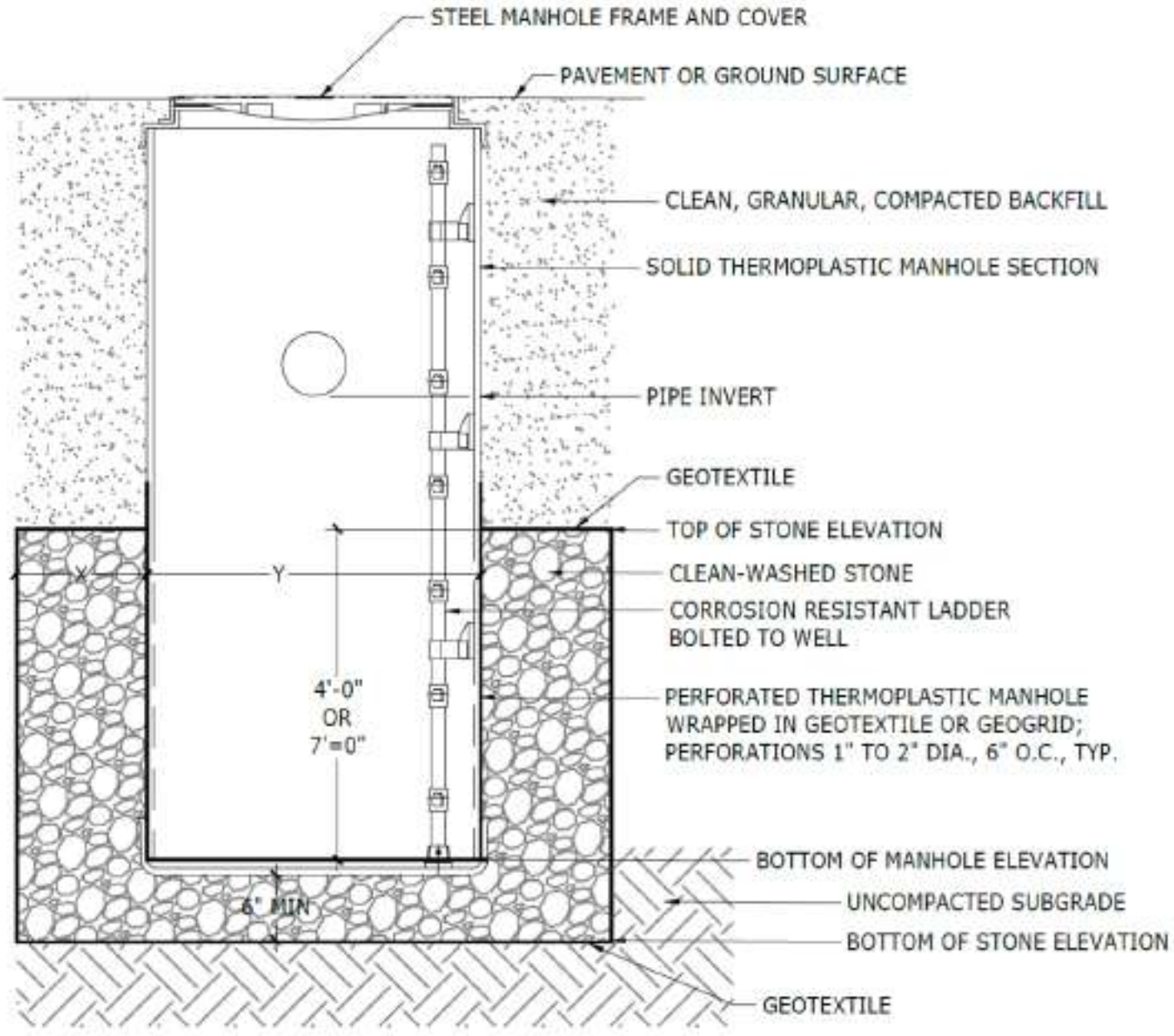


Figure 4.15-3: Thermoplastic drainage well standard detail



(The designer is referred to **Appendix L** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/l-standard-details to download Standard Detail CAD files.)

4.15.4 Drainage well material standards

Pretreatment material standards

1. The designer is referred to **Section 4.10** ☛ p. 148, Pretreatment, for information on materials standards for pretreatment systems.

Inlet control material standards

2. The designer is referred to **Section 4.11** ☛ p. 166, Inlet Controls, for information on material standards for inlet control systems.

Storage area material standards

3. Precast concrete drainage well manholes must meet the following specifications:
    a. Concrete risers: five-inch thick, 4,000 psi concrete, 3×12 WWF (six gauge) reinforcement
    b. Base section: nine-inch thick, 4,000 psi concrete, #4 rebar reinforcement, six inches on center
    c. Perforations: two to four-inch diameter, eight inches on center
    d. Connections to be made with non-shrink grout
4. Thermoplastic drainage well manholes must meet the following specifications:
    a. Thermoplastic well sections: PVC
    b. Perforations: one to two-inch diameter, six inches on center
    c. Connections to be made with like materials per manufacturer recommendations
5. Stone designed for stormwater storage must be uniformly graded, crushed, clean-washed stone. PWD defines “clean-washed” as having less than 0.5% wash loss, by mass, when tested per American Association of State Highway and Transportation Officials (AASHTO) T-11 wash loss test. AASHTO No. 3 and No. 57 stone can meet this specification.
6. Geotextile, if used, must consist of polypropylene fibers and meet the following specifications (AASHTO Class 1 or Class 2 geotextile is recommended):
    a. Grab Tensile Strength (ASTM-D4632): ≥ 250 lbs
    b. CBR Puncture Strength (ASTM-D6241): ≥ 500 lbs
    c. Flow Rate (ASTM-D4491): ≥ 95 gal/min/ft2
    d. UV Resistance after 500 hrs (ASTM-D4355): ≥ 70%
    e. Tear Resistance (ASTM-D4533): ≥ 80 lbs
    f. Heat-set or heat-calendared fabrics are not permitted
7. Geogrid, if used, must meet the following specifications:
    a. Maximum Apparent Opening Size (AOS): 0.25-inch
    b. Grab Tensile Strength (ASTM-D4632): ≥ 205 lbs
    c. CBR Puncture Strength (ASTM-D6241): ≥ 500 lbs
    d. UV Resistance after 500 hrs (ASTM-D4355): ≥ 70%
    e. Tear Resistance (ASTM-D4533): ≥ 80 lbs

Outlet control material standards

8. The designer is referred to **Section 4.12** ☛ p. 182, Outlet Controls, for information on material standards for outlet control systems.

Inspection and maintenance access material standards

9. Manhole covers must allow access to drainage well.

4.15.5 Drainage well construction guidance

Proper construction and careful consideration of soil compaction, infiltration performance, and sedimentation control of drainage wells are essential to ensure long-term functionality and reduce long-term maintenance needs and costs. Construction oversight is critical. At a minimum, verification of volumes, grades, and elevations must be performed prior to backfill.



An example of a drainage well installation in Philadelphia

1. If the contractor proposes to install deep drainage wells, especially if using drilled caissons, a Vibration Monitoring Plan is recommended. The contractor should monitor vibrations and stop work and reevaluate the proposed system with the Engineer if excessive vibrations are identified.
2. Areas for proposed drainage wells must be physically marked as heavy equipment exclusion zones prior to any land-disturbing activities to avoid soil disturbance and compaction during construction. Install construction fencing around drainage well areas. If areas are compacted during construction, additional infiltration testing and potential redesign may be required.
3. Provide erosion and sedimentation control protection on the site such that construction runoff is directed away from the proposed drainage well. Sediment deposited in a drainage well during construction, may significantly reduce SMP performance. The designer is referred to the latest edition of the *Pennsylvania Department of Environmental Protection (PA DEP) Erosion and Sediment Pollution Control Program Manual* for information on design standards for erosion and sedimentation control practices.
4. Drainage well areas may not be used as sediment traps during construction, unless at least three feet of soil are left in place while the area is serving as a sediment trap and subsequently removed during construction after the contributing drainage areas have been stabilized.
5. Complete site elevation grading and stabilize all disturbed soil. Stabilization of disturbed areas must be implemented before finalizing the drainage well's excavation and construction.
6. Excavate drainage well to proposed depth and manually grade and scarify the horizontal and vertical existing soil surfaces. The bottom of the drainage well footprint must be at a level grade.
7. Existing subgrade must not be compacted or subject to excessive construction equipment prior to placement of geotextile and stone bed. The use of machinery to load stone from outside of the drainage well footprint is recommended. Stone should be carefully placed in the drainage well excavation. Should the subgrade be compacted during construction, additional testing of soil infiltration rates and SMP redesign may be required. Rock construction entrances must not be located on top of areas proposed for drainage wells.
8. Place geotextile and stone immediately after approval of subgrade preparation to prevent accumulation of debris or sediment. Prevent runoff and sediment from entering the drainage well excavation during the placement of the geotextile and stone.
9. Place geotextile in accordance with manufacturer's standards and recommendations.
10. Install bedding stone in lifts no greater than eight inches. Lightly compact each layer with equipment, keeping equipment movement over stone bedding material to a minimum. Install stone to grades indicated on the drawings.
11. All stone that is used in the drainage well system must remain free of sediment. If sediment enters the stone, the contractor may be required to remove the sediment and replace with clean washed stone.
12. Confirm and document invert elevations and dimensions of all structures such as connections and pipes prior to backfill.
13. Backfill to finished grade. Ensure backfill is properly compacted in accordance with specifications. Ensure backfill process does not disrupt pipe placement and configuration.
14. Structures such as inlet boxes, reinforced concrete boxes, inlet controls, and outlet controls must be constructed according to manufacturer's guidelines or design professional's guidance.
15. Complete surface grading above and around drainage well, using suitable equipment to avoid excess compaction.
16. Once the site is permanently stabilized with vegetation or hardscaping, remove temporary erosion and sediment control measures.

4.15.6 Drainage well maintenance guidance

Maintenance of drainage wells focuses on the periodic removal of sediment and debris from pretreatment and storage areas. Sediment removal from vaults, chambers, and pipes is typically conducted using vacuum or flushing systems. Considerations for inspection and maintenance equipment access to the drainage well and associated structures are critical to successful long-term maintenance. Guidance on the use and operation of vacuum or flushing sediment removal equipment is beyond the scope of this Manual; a maintenance professional should be contacted for additional details. As applicable, drainage well maintenance procedures must meet OSHA confined space entry requirements.

General recommended maintenance activities for drainage wells are summarized in Table 4.15-1.

Table 4.15-1: Drainage well maintenance guidelines

Early maintenance activity	Frequency
Inspect erosion control and flow spreading devices until soil settlement and vegetative establishment of contributing areas has occurred.	Biweekly
Inspect inlet controls, outlet structures, and storage areas for trash and sediment accumulation. Remove debris and sediment as necessary.	Monthly for the first year after installation to determine ongoing maintenance frequency

Ongoing maintenance activity	Frequency
Regularly clean out gutters and catch basins to reduce sediment load to drainage well. Clean intermediate sump boxes, replace filters, and otherwise clean pretreatment areas in directly connected systems.	As needed
Remove sediment and debris from drainage well pretreatment sediment/grit chamber or separator, if applicable, when the sediment zone is 3/4 full. Sediment and debris build up may need to be removed by a professional. Consult with a professional as necessary.	As needed
Remove sediment and debris from drainage well when the sediment accumulates to three inches or more.	As needed
Replace filter bags for pretreatment devices. Please ensure filter bag is installed properly.	Quarterly
Inspect drainage well and control structures.	Quarterly
Remove floating debris and accumulated petroleum products from the system and all components.	Quarterly
Evaluate the drain down time of the drainage well after a storm of at least one inch to ensure a drain down time of less than 72 hours.	Ongoing
Maintain records of all inspections and maintenance activity.	Ongoing

The designer is referred to **Section 4.10** ☛ p. 148, Pretreatment, **Section 4.11** ☛ p. 166, Inlet Controls, and **Section 4.12** ☛ p. 182, Outlet Controls, for information on maintenance guidance for pretreatment, inlet controls, and outlet controls.

5 Construction Guidance

5.0 Introduction

Site development and stormwater management practice (SMP) construction require careful execution and inspection to ensure that SMP elements function properly and that impacts of construction activities on the surrounding environment are minimized. Chapter 5, Construction Guidance, provides guidance for developers, engineers, and contractors on construction-related topics, including construction inspections (**Section 5.1** ☛ p. 2), commonly encountered construction issues (**Section 5.2** ☛ p. 8), and construction documentation (**Section 5.3** ☛ p. 11). Specific construction guidelines for each SMP are provided in **Chapter 4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4.

The Philadelphia Water Department (PWD) provides construction oversight during SMP installation in order to verify that correct installation practices are used and to focus on the protection of infiltration areas from compaction by construction equipment. PWD construction oversight includes inspection reporting and enforcement activities.

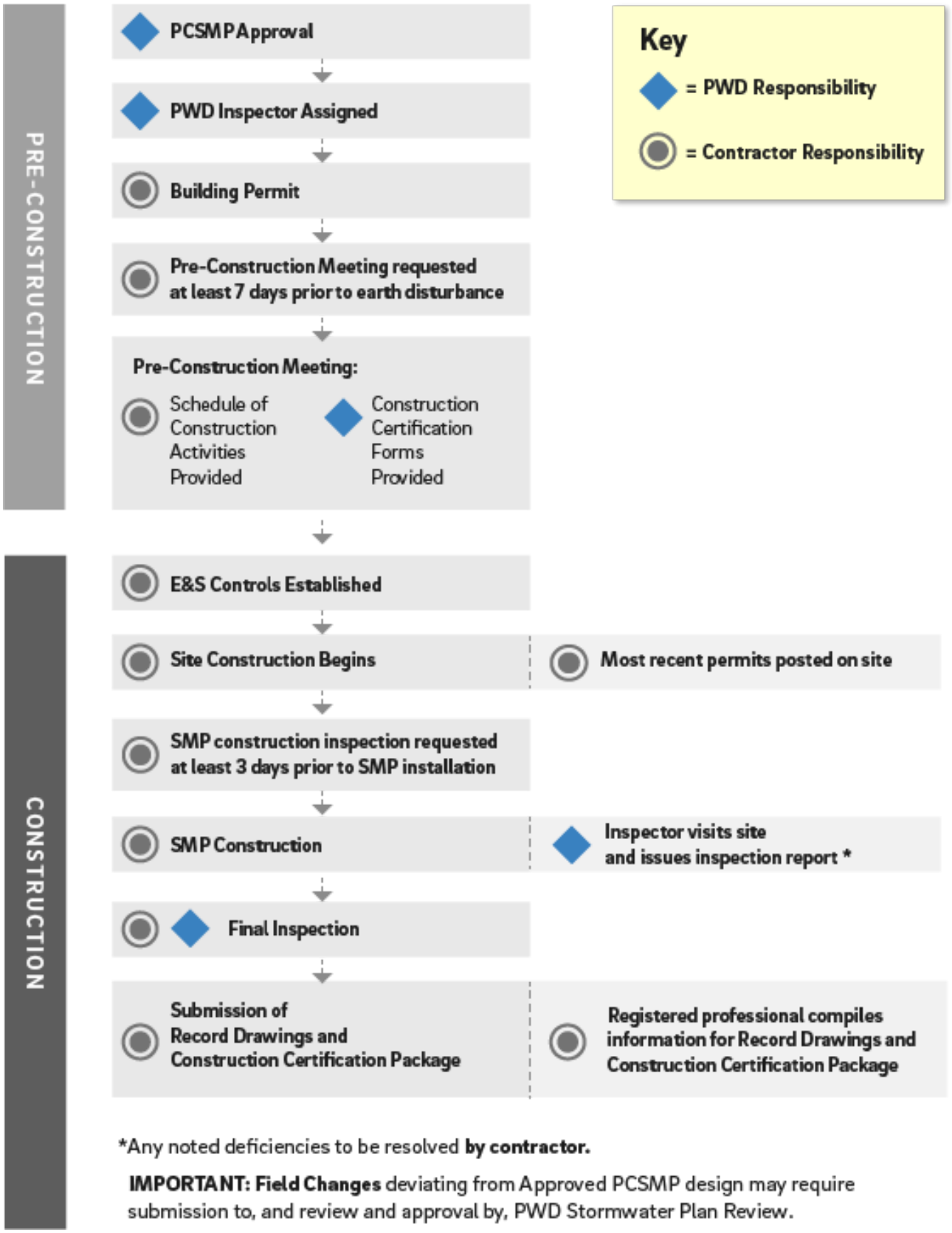
Section 5.1 ☛ p. 2 explains the purposes of construction inspections and provides guidance on the construction inspection process including PWD contact information, assignment of a PWD Stormwater Inspector (PWD Inspector), preconstruction meeting, documentation requirements during the construction process, final inspections, and post-construction submission requirements.

Section 5.2 ☛ p. 8 includes common construction issues associated with Erosion and Sediment Control (E&S) and SMP installation in order to help minimize or avoid them. **Section 5.2.1** ☛ p. 8 describes common E&S-related construction issues including protection of City-owned inlets and other E&S-related construction issues. **Section 5.2.2** ☛ p. 9 describes common SMP-related construction issues including protection of infiltration areas, use of clean stone, pipe loading, and inspection and documentation. PWD requires contractors to submit construction documentation at the close of the project to ensure that the SMP and its elements were constructed in general accordance with the Approved Post-Construction Stormwater Management Plan (PCSMP). Record Drawing(s) are required from the applicant for SMP verification and represent a key component of PWD's compliance reporting.

5.1 Construction Inspection

Effective construction inspection addresses both Erosion and Sediment Control (E&S) and stormwater management practice (SMP) construction. To supplement construction oversight provided by the property owner and the designer, the Philadelphia Water Department (PWD) inspects both E&S measures and SMP installation to verify that the site is maintained properly and correct installation practices are used. PWD staff inspects the site at several stages of the construction process, and inspections may occur both on a scheduled and a complaint-driven basis. An overview of the construction inspection process is shown in Figure 5.1-1.

Figure 5.1-1: Overview of construction inspection process



☛ water.phila.gov/wp-content/uploads/images/swmg-figure-5-1-1-overview-of-construction-inspection-process.png

PWD's inspections serve a number of purposes. For instance, PWD must verify and document the installation of SMP elements prior to backfill in order to prevent costly repairs and/or re-excavation that may be needed either during or after construction. PWD's inspections are also critical to ensure the long-term performance of SMPs and minimize future enforcement scenarios stemming from improper installation practices. PWD Inspectors verify that infiltration areas are correctly sized, shielded from sediment loading prior to site stabilization, and protected from compaction.

PWD Inspectors are authorized to access sites under authority provided by **Philadelphia Code (§14-306(1)(a))** ☛ https://codelibrary.amlegal.com/codes/philadelphia/latest/philadelphia_pa/0-0-0-289399#JD_14-306. PWD Inspectors will inspect the project site throughout construction.

5.1.1 Coordinating inspections with other PWD units

Different PWD units may inspect multiple parts of construction projects (E&S, SMP installation, sewer connections, pumping, private cost construction, etc.). The following divisions can be contacted based on project needs:

Table 5.1-1: PWD unit contact information

Unit name	Phone number	Inspection type
Stormwater Inspections	(215) 685-6387	E&S Measures SMP Construction
Water Transport Records	(215) 685-6270	Water and Sewer Connections
Construction Division	(215) 685-6345	Private Cost Construction
Industrial Waste	(215) 685-6085	Pumping of Stormwater

Stormwater Inspections must be contacted for all site development and SMP construction projects. PWD Water Transport Records (WTR) must be contacted for any inspections related to water and/or sewer connections. Written approval from WTR following the completion of certain sewer connection requirements will be required for project close-out. A permit is required for sewer tie-ins six inches in diameter or larger. Direct pumping of stormwater to a storm inlet or manhole is prohibited. The PWD Industrial Waste Unit should be contacted for all pumping needs, including permits. If the project includes the construction of public infrastructure using private money (Private Cost Project), the contractor must contact the PWD Construction Division to arrange an inspection at least seven days in advance of work. The designer is referred to **Section 2.5** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-5-pwds-development-review-process for additional information on the role of these units.

5.1.2 Preconstruction processes

Assignment of PWD Inspector

Following Post-Construction Stormwater Management Plan (PCSMP) approval, project contacts supplied by the applicant will receive an email from Stormwater Inspections that assigns a PWD Inspector to the project. This PWD Inspector will be the main contact for E&S and SMP inspections. PWD will only email the project contacts that have been provided by the applicant at the time of PCSMP Approval. As such, the email may be sent to the design engineer, but not the contractor, particularly if a contractor had not been selected at the time of PCSMP Review Phase submission. It is the responsibility of the applicant to ensure that all necessary parties have been notified that an inspector has been assigned. If unaware of the specific PWD Inspector for the project, the applicant should contact Stormwater Inspections.

Once the PCSMP Approval Letter is received, the applicant can obtain a Building Permit for the project from the City of Philadelphia Department of Licenses and Inspections (L&I), pending the receipt of other required approvals. PWD Stormwater Plan Review or Stormwater Billing and Incentives must be notified of any changes to the Approved E&S and PCSMP, layout, and/or materials prior to installation. Field changes may require new PWD and Pennsylvania Department of Environmental Protection (PA DEP) approvals, in addition to approval by the design engineer. The designer is referred to **Section 2.3.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-3-review-phases#2.3.1, PCSMP Review Phase, for more information on field changes.

Preconstruction meeting

After a Building Permit and a PA DEP National Pollutant Discharge Elimination System (NPDES) Permit (if applicable) have been obtained, but prior to the start of construction activities, a preconstruction meeting must be held with the contractor, design engineer, an owner's representative, and the PWD Inspector for any projects that have received a PCSMP Approval. PWD may also require an E&S-only preconstruction meeting for certain projects in the Development Exemption or Demolition Review Paths. The PWD Inspector must be provided with at least seven days notification to schedule this meeting.

At the preconstruction meeting, the PWD Inspector will provide the contractor with the Construction Certification Forms (**Appendix J** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/j-construction-certification-package) that were prepared for each SMP by the design engineer during the PCSMP Review Phase. The contractor must provide the PWD Inspector with an estimated schedule for the placement of geotextile, stone, storage media, piping, soil, etc.

5.1.3 Construction processes

Once construction begins, the contractor must ensure that copies of the Approved PCSMP, E&S Plan, and NPDES Permit (if applicable) are available on-site at all times. The most recently PWD-approved versions of these plans must be used for SMP construction.

The contractor must provide at least three days' notice to the assigned PWD Inspector prior to the installation of any SMP elements. This is especially critical for subsurface system elements, as without proper inspection prior to backfill or closure of any SMP elements, the PWD Inspector may request re-excavation in order to verify correct installation.

Throughout construction observation, the PWD Inspector will regularly send out (via email) inspection reports that detail any deficiencies or issues observed related to SMP construction or E&S measures. PWD expects the contractor to respond to any issues in a timely fashion, and, depending on the type of issue, may provide a timeframe for the contractor to remediate the issue.

In instances where major E&S issues are observed, the PWD Inspector will issue a Notice of Violation and Order to Correct (NOV) to fix any E&S concerns with a re-inspection date listed. If these concerns are not addressed by the date of re-inspection, PWD will pursue a Stop Work Order that will remain in place until the project is brought back into compliance.

During any stage of work, if the PWD Inspector determines that SMPs are not being installed in accordance with the most recently Approved PCSMP, or that adequate E&S practices are not being implemented on-site, and the contractor is not responsive to such notice by PWD, the site may be subject to a Stop Work Order and/or other enforcement measures. This also applies to projects found to be disturbing earth without the appropriate approvals or inadequate E&S measures.

5.1.4 Final inspection

A final inspection will be conducted by the PWD Inspector to confirm the constructed conditions of the site and general accordance with the Approved PCSMP prior to the issuance of the Certificate of Occupancy or equivalent. PWD may request that L&I withhold the Certificate of Occupancy for any project with outstanding issues until these issues are adequately addressed. The contractor must be present on-site for completion of the final inspection. A Post-Construction Stormwater Management (PCSM) Final Inspection Report will be issued identifying the SMPs found to be complete as well as any deficiencies identified during the inspection. All deficiencies identified during PWD's final inspection and report must be addressed prior to any re-inspections.

Upon completion of PWD's final inspection process, an updated PCSM Final Inspection Report will be issued indicating that all components of the SMP construction are complete and the as-built conditions of the site are in general accordance with the Approved PCSMP. Final inspection reporting and its conclusions are preliminary, and the final determination of site compliance will be based on the Record Drawing and Construction Certification Package (CCP) for the site. The Record Drawing and CCP should be provided at the time of the final inspection, if possible. Final inspection is required for Record Drawing compliance. A Record Drawing compliant letter is required for a project to be eligible for stormwater credit (**Section 6.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-6/6-3-stormwater-credits).

5.1.5 Post-construction submissions

If not submitted during the final inspection, the project's Record Drawing and CCP must be submitted to PWD for review following the final inspection. Submitted Record Drawing(s) must also incorporate any constructed variations/discrepancies documented in the PCSM Final Inspection Report.

For PA DEP Notice of Termination (NOT) for NPDES Permits, PWD is required to sign off on completion of the project prior to PA DEP issuance of the NOT. PWD will not provide a sign-off without a PCSM Final Inspection Report deemed complete, a complete CCP, and compliant Record Drawing(s).

5.2 Common Construction Issues

An understanding of common construction issues associated with Erosion and Sediment Control (E&S) measures and stormwater management practices (SMPs) is an important component of effective construction inspections and can help to minimize or avoid these issues. Avoiding these issues streamlines regulatory approval, minimizes negative impacts to the surrounding environment, promotes long-term SMP function, and reduces the cost and duration of construction activities.

5.2.1 Erosion and sediment-related construction issues

Proper E&S measures are required to keep sediment and pollutants out of existing and proposed sewer systems and, ultimately, Philadelphia's waterways. The goals of E&S measures are to minimize the amount of erosion that takes place and to keep all sediment accumulation within the earth disturbance boundary. E&S measures are also critical to the protection of existing on-site infrastructure and to reducing the risk of downstream impacts like sediment blockages. Approved E&S measures must be installed and inspected prior to the start of any earth disturbance activities. These E&S measures must be maintained and functional throughout the duration of construction, until the site has been stabilized.

Protection of City-owned inlets

Any city-owned inlets that receive stormwater runoff from the construction site must be protected. Contractors need to pay special attention to inlets located at the lowest points, as these will likely receive the most sediment and need to be maintained the most frequently. City-owned inlet protection should not be the primary means of E&S, but an important safeguard to supplement keeping sediment on-site through continuous E&S maintenance, including prevention of sediment tracking off-site.

Additional erosion and sediment issues

Silt fencing must be properly trenched into the ground and backfilled to properly control sediment run-off from any disturbed areas. E&S controls must also be placed around SMP elements to prevent sediment loading from any surrounding unstabilized, disturbed areas. Also, in order to prevent SMP clogging and off-site impacts, all SMP inlets and other on-site inlets must be protected for the full duration of construction activities and until the site has achieved final stabilization. Bioinfiltration/bioretention basins and subsurface infiltration basins may be used as sedimentation basins during construction. The contractor is referred to **Section 4.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-1-bioinfiltration-bioretention and **Section 4.4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-4-subsurface-infiltration, respectively, for requirements for the use of these SMPs as temporary sediment basins.

5.2.2 Stormwater management practice-related construction issues

Compaction or sedimentation within infiltration areas and the use of stone containing fines are among the most common construction issues that can affect the infiltration capacity, and thus the performance and suitability, of an SMP.

Protection of infiltration areas

Protection of infiltration areas is important because, with the exception of SMPs designed to function as disconnected impervious cover (DIC), infiltration SMPs are designed based on testing that is performed on undisturbed soils prior to installation. Compaction of these areas could change infiltration rates and cause the SMP to underperform, leading to the need for redesign and/or reconstruction of the SMP. For these reasons, soil compaction should be minimized, even in areas not proposed for infiltration SMPs, to the extent practicable. The best strategy to avoid compaction is to simply avoid equipment traffic within proposed infiltration areas, before, during, and after SMP construction. Where construction equipment traffic is necessary, timber matting or low pressure equipment must be used.

If compaction of infiltration areas is required due to site constraints, the contractor must scarify the ground surface to minimum depths of eight inches for minor compaction and 12 inches for major compaction within the infiltration footprint prior to SMP installation.

Requirements for protecting infiltration areas

- Do not use heavy equipment such as excavators, loaders, or dump trucks within the infiltration area, before or after excavation.
- Establish heavy equipment exclusion zones so that infiltration areas are clearly protected.
- Install orange construction fence or silt fence around the exclusion zones.
- Keep equipment out of the infiltration area to the maximum extent possible.
- Consider equipment limitations and maneuverability during design to facilitate operation of equipment outside the infiltration area.
- Do not locate rock construction entrances on top of areas proposed for infiltration practices.



An example of infiltration area protection during construction in Philadelphia

Use of clean stone

Clean-washed stone must be used where indicated by SMP designs. Clean-washed stone must not only be delivered to the site in a clean state, but also stored, moved, and installed in a manner that does not introduce fines. Failure to install appropriately clean stone could impact infiltration performance and require redesign and/or reconstruction. The PWD Inspector may test a sample of stone at any time it is suspected of not meeting required standards. Stone will be tested using the AASHTO T-11 wash loss test and must have less than 0.5% wash loss.

Pipe loading

Sufficient temporary cover of piping must be provided during all stages of construction, and heavy loads on these pipes must be avoided. Heavy loads can cause separation or damage to the pipe system that, while not necessarily readily apparent, could lead to long-term functionality and maintenance concerns. Any stone placed on top of piping must be placed gently (i.e., not dumped) to avoid these issues.

Inspection and documentation

The contractor must ensure that all subsurface SMP elements have been inspected by PWD and fully documented (survey data, photos, etc.) prior to backfilling these areas to prevent corrective actions that could include re-excavation to affirm correct installation practices.

5.3 Construction Documentation

It is important, both for the property owner and for the Philadelphia Water Department (PWD), to ensure that all stormwater management practices (SMPs) are constructed in strict accordance with the Approved Post Construction Stormwater Management Plan (PCSMP). Even small variations in the characteristics of an SMP (e.g., footprint area, elevations, layer thicknesses, pipe sizing) can have significant effects on the SMP's ability to perform its designed stormwater management function. To verify that SMPs have been properly installed, a Construction Certification Package and Record Drawing(s) for all PCSMP components must be prepared and submitted to PWD at the conclusion of construction activities. The contractor must maintain copies of all books, records, and documents pertaining to PCSMP construction for a period of five years following completion of the contract.

5.3.1 Construction Certification Package

As previously discussed, the contractor must install all on-site SMPs, conveyance piping, structures, and any other feature associated with the stormwater management design in strict accordance with the Approved PCSMP. The Construction Certification Package provides PWD with documentation that SMPs have been properly installed. Stormwater Retrofits have different requirements for Construction Certification Packages; the applicant is referred to **Section 2.3.4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-3-review-phases#2.3.4 for Stormwater Retrofit submission guidance.

Prior to construction

SMP Construction Certification Forms are part of the Construction Certification Package. Prior to construction, an SMP Construction Certification Form must be prepared by the design engineer for each on-site SMP and provided to PWD for review as part of the PCSMP Review Phase (**Section 2.3.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-3-review-phases#2.3.1). A blank Construction Certification Package template, which houses the SMP Construction Certification Forms and instructions, can be found in **Appendix J** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/j-construction-certification-package. Each Form must indicate the measurements that are most critical to the listed SMP's ability to perform its designed function (e.g., elevations, outlet control sizes, surface areas, layer depths, etc.). Each phase of a phased project should have its own SMP Construction Certification Forms created. It is recommended that the SMP Construction Certification Form(s) be included in the construction bid documents for the project to ensure that the selected contractor is aware of the requirement that the Forms be completed during construction. The project's sequence of construction must identify all stages of SMP construction where a registered professional is required to document the specific elevations and measurements found on the SMP Construction Certification Form(s). The sequence of construction must also state each phase of construction for phased projects. The applicant is referred to **Section 5.3.2** ☛ p. 16 for clarification on PWD Stormwater Plan Review's definition of "registered professional."

If a project field change necessitates a revision to any information on the submitted SMP Construction Certification Forms, they must be updated accordingly and submitted along with the PCSMP Field Change submission.

During construction

During the preconstruction meeting, the PWD Inspector will provide copies of the Construction Certification Package, as prepared and customized by the engineer and found acceptable by PWD during the PCSMP Review Phase. In order to demonstrate that all SMPs are properly installed, a registered professional must complete the SMP Construction Certification Forms contained within the Construction Certification Package. Each measurement documented on the Forms must be dated and initialed by the registered professional who took, or whose designee took, the measurement. Once all the required measurements have been appropriately documented, the registered professional must execute and date the Form. *The contractor should not cover, backfill, or seal any SMP until the information required for the Record Drawing(s) and the Construction Certification Package has been acquired.*

All elevations identified on the Forms must be documented as they are measured. These Forms must be on-site and available for PWD inspection at all times. Upon completion of construction, SMP Construction Certification Forms must be submitted to PWD as part of the Construction Certification Package, and the measurements documented on these Forms must be reflected on the Record Drawing(s), which are discussed in the next Section.

The Construction Certification Package provided to PWD must include electronic copies of receipts for materials that pertain to SMPs. The material receipts must clearly specify the types, qualities, and quantities of the materials purchased. The materials for which receipts are required may include, but are not limited to, the following:

- Stone,
- Geotextile fabric,
- Perforated pipes,
- Subsurface storage units,
- Bioinfiltration/bioretention media,
- Filter media,
- Porous surfaces,
- Impervious liners,
- Precast concrete structures,
- Traps or hoods,
- Vegetation or plantings, and
- Proprietary stormwater management systems/devices/components.

The Construction Certification Package must also include electronic copies of photographs documenting all SMP installations. The photographs must clearly depict the installation of all components of the SMP. This may include, but is not limited to, photographs of the following:

- Basin excavation,
- Subgrade preparation,
- Fabric or liner placement,
- Stone placement,
- Filter media placement,
- Pipe placement,
- Pipe perforation,
- Subsurface vault installation,
- Pretreatment system installation,
- Inlet control installation,
- Outlet control installation, and
- Landscaping.

Representative photographs of SMP installations are shown below.



An example of pipe diameter measurement during construction in Philadelphia



An example of SMP installation in Philadelphia

5.3.2 Record Drawings

Along with the Construction Certification Package, PWD requires that Record Drawing(s) be submitted at the close of the project, or each phase of the project, to ensure that the SMPs and their elements were constructed in general accordance with the Approved PCSMP, and to document any field changes. Record Drawing(s) are required for SMP verification and are a key component of PWD's compliance reporting.

Record Drawings are construction drawings revised to represent the site's as-built conditions, including, at a minimum, all locations, dimensions, elevations, and materials as constructed and installed. PWD uses Record Drawing(s) to verify compliance of the constructed site with the **PWD Stormwater Regulations** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/c-pwd-stormwater-regulations (Stormwater Regulations) and to document and verify the quantity of stormwater managed on a site. If compliance issues were observed during construction, PWD may request that the City of Philadelphia Department of Licenses and Inspections (L&I) **hold the Certificate of Occupancy** ☛ water.phila.gov/development/stormwater-plan-review/co-holds until the Record Drawing Review Phase or final inspection is complete. It is critical that the Record Drawing(s) reflect any changes from the Approved PCSMP design, approved field change or otherwise, that may affect the performance of the SMPs.

It is important that the property owner/developer be aware of the Record Drawing requirements both within this Manual and the Stormwater Regulations, budget accordingly, and consider these requirements when issuing the project for construction bid. Phased projects may also require Record Drawing submission at the completion of each phase.

To properly prepare Record Drawing(s), the contractor must keep the Approved PCSMP on-site at all times throughout the construction process and document all changes from the Approved PCSMP as they occur. PWD recommends marking up and tracking changes on an actual copy of the Approved PCSMP to simplify preparation of the Record Drawing(s). Using the Approved PCSMP as a base, the Record Drawing(s) should highlight information confirmed to be in accordance with the Approved PCSMP in yellow and must identify any deviations in red ink. The Record Drawing(s) must be clear and legible.

Record Drawings may be prepared by *registered professionals*, which PWD Stormwater Plan Review defines as Professional Engineers, Registered Architects, Landscape Architects, Professional Land Surveyors, Professional Geologists, or Licensed Contractors. PA DEP may have different requirements concerning the types of professionals who may prepare Record Drawings. For projects that require an NPDES Permit, the applicant is strongly encouraged to refer to PA DEP's requirements for Record Drawings before selecting a professional to prepare Record Drawing(s) for PWD. The preparer of the plan must provide the Record Drawing drafting date and prominently display their signature and professional seal, or, in the case of Licensed Contractors, their signature, printed name, business title, company name, and L&I Contractor License Number, all of which must be clearly labeled, on each Record Drawing plan sheet. Most non-residential and some condominium projects confirmed to be in compliance with the Stormwater Regulations or Stormwater Retrofit design standards through a Record Drawing review and final inspection may be eligible for credit toward their Stormwater Management Service Charge (Stormwater Charge). The applicant is referred to **Section 6.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-6/6-3-stormwater-credits for more information on the stormwater credits.

For more information on requirements for the Record Drawing Submission Package, and its submission and review process, the designer is referred to **Section 2.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-3-review-phases, *Review Phases*, and the Record Drawing Requirements table, **Table E-8** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/e-plan-and-report-checklists/table-e-8-record-drawing-requirements, in **Appendix E** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/e-plan-and-report-checklists. Samples demonstrating how Approved PCSMP plan sheets should be marked up in order to prepare Record Drawings are provided in **Appendix K** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/k-record-drawing-sample.

6 Post-Construction and Operations and Maintenance Guidance

Chapter 6 Post-Construction and Operations and Maintenance Guidance

6.0 Introduction

Chapter 6, Post-Construction and Operations and Maintenance Guidance, provides direction for the property owner on how to inspect and maintain stormwater management practices (SMPs) and associated drainage areas (**Section 6.1** ☛ p. 2). PWD conducts regular post-construction stormwater management maintenance inspections on private property. Enforcement procedures will be utilized when necessary for deficiencies found during these inspections (**Section 6.2** ☛ p. 6). Chapter 6 also provides information on stormwater credits, for which property owners may be eligible following SMP construction, in **Section 6.3** ☛ p. 7.

6.1 Property Owner Inspections and Maintenance

Post construction, the property owner assumes responsibility for inspecting and maintaining all installed stormwater management practices (SMPs) and associated drainage areas in accordance with their Operations and Maintenance (O&M) Agreement. Additionally, there may be other O&M responsibilities from the Philadelphia Water Department (PWD) Stormwater Regulations (Stormwater Regulations) (**Section 1.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1/1-2-stormwater-regulations), design criteria for Stormwater Retrofit projects that have received Stormwater Grant funding, and Philadelphia Property Maintenance Code requirements that apply. SMPs and associated drainage areas must be continually inspected and maintained to ensure the long-term functionality of the approved design. Property owners are expected to document the inspection and maintenance activity for each SMP. Maintenance and inspection records should be submitted when applying for Stormwater Credit renewals (**Section 6.3** ☛ p. 7). These records can also assist PWD staff during the Department's own periodic inspections. An SMP-specific and site-specific SMP Maintenance Guide, prepared by the designer and reviewed by PWD during the Post-Construction Stormwater Management Plan (PCSMP) Review Phase, should be provided to the property owner as a road map for the long-term upkeep of on-site SMPs. The Manual's **Appendix G** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/g-smp-maintenance-guide-documents includes a compiled SMP Maintenance Guide sample for reference, along with SMP Maintenance Schedule Form templates and related maintenance information.

Operations and Maintenance Agreement

O&M Agreements are created during the development phase of a project and recorded against the property's deed with the Philadelphia Department of Records. Accordingly, these Agreements remain tied to the land—not the owner—whenever the property is sold or otherwise conveyed. Thus, when a new owner acquires the property, they also assume all maintenance responsibilities outlined in the Agreement. PWD does not pursue legal action against property owners for projects that do not advance to construction.

The property owner of record is bound by the O&M Agreement and must maintain the SMPs so that they perform adequately and as designed. Furthermore, the Agreement requires that the property owner maintain the site in accordance with the Approved PCSMP and prohibits alterations, including the conversion of pervious areas to impervious cover, without authorization from PWD. In certain types of developments, a Homeowner's Association (HOA) or Condominium Association (COA) may assume maintenance responsibilities. In these cases, PWD recommends that all O&M responsibilities associated with SMPs be incorporated into the legal declaration of the HOA or COA.

Property owner inspections

As described in **Chapter 4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-0-introduction, SMPs consist of multiple components (e.g., inflow, conveyance, storage, outflow, vegetation, and so on). Each of these components must be regularly inspected and maintained to ensure proper functionality. Property owners, or those parties designated to conduct inspections on an owner's behalf, must have a strong working knowledge and understanding of each SMP and its critical design components prior to conducting inspections (**Chapter 4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-0-introduction).

Frequent property owner SMP inspections are critical to identifying and remediating minor maintenance concerns before they potentially become major issues requiring costly repairs. Property owners should perform routine inspections at least four times per year, preferably at the close of each season, though additional inspections are recommended throughout the year—particularly during and after large rain events—to ensure that SMPs are functioning as designed.

An inspection's primary purpose is to ensure the SMP is functioning correctly; if it is not, corrective actions must be identified to restore proper function. An optimally functioning SMP will allow water to freely enter each inflow point, collect within its storage areas, infiltrate into the soil, and—depending on the design—freely drain through an outlet control structure to a downstream conveyance system. During inspections, owners should look for the following conditions:

- Emergency spillways and overflows are clear of debris;
- Plants within properly functioning SMPs are healthy and thriving;
- Bare soil or areas of active erosion are not present;
- Structures appear sound and in good condition, with no signs of settlement; and
- Storage areas are slowly draining following significant rain events (in no more than 72 hours) and are free of significant accumulations of sediment, debris, and trash that would substantially reduce available storage volume.

If any of these conditions are absent, maintenance is likely required. Detailed information on conducting inspections is available in **Chapter 4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-0-introduction, within each individual SMP section.

Owners should note that proper and thorough inspection may require special certifications for confined space entry and/or special equipment, like closed-circuit television systems to inspect pipes. It is the property owner's responsibility to ensure all inspections are conducted safely, following all applicable regulations and using the appropriate equipment.

Property owner maintenance

By conducting routine SMP maintenance, property owners can identify and address minor maintenance tasks and reduce the need for larger, more expensive repairs in the future. If SMPs begin to fail, the subsequent increase in stormwater loading on the sewer systems may contribute to backups and combined sewer overflows into nearby rivers. This can cause harm to aquatic life, endanger public health and safety, and violate State and Federal water quality laws.

The necessary routine maintenance will be determined by the characteristics of the property's site and installed SMPs. The owner is advised to review **Chapter 4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4 for maintenance guidance specific to their property's SMP types. While Chapter 4's maintenance guidelines present typical maintenance tasks and frequencies for the various SMPs described, be aware that SMP Maintenance Guides are SMP- and site-specific. These guides are prepared by the project's designer and should be provided to, and implemented by, the property owner for long-term O&M of the on-site SMPs.

Although each property's maintenance will be determined by its site and installed SMPs, examples of common routine maintenance tasks include, but are not limited to, the following:

- Removal of sediment and debris from inlets and outlet control structures, storage areas, and conveyance pipes;
- Clearing trash, sediment, and debris from outlet structure trash racks and orifices;
- Jetting/flushing and vacuuming of subsurface basin pipes;
- Regular maintenance of pretreatment structures including removal of sediment and debris from permanent filter bags and resetting dislodged pretreatment hoods;
- Establishment watering for new plantings (during the first two to three years after the initial planting);
- Emergency watering during prolonged dry periods;
- Minor replanting, reseeding, and re-grading;
- Removal of invasive plants or weed species and replanting with approved species (The owner is referred to **Appendix I** ☛ water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists, Plant Lists, for more information);
- Pruning of trees and shrubs, as appropriate, prior to winter months;
- Mulching (taking care to maintain proper relative elevations with adjacent stormwater structures);
- Replacement of worn bolts, latches, and other appurtenances;
- Minor asphalt or concrete patching/repair;
- Maintenance of porous surfaces to ensure proper infiltration, and;
- Minor erosion repairs, including slope stabilization.

The above tasks are associated with SMPs that are generally in good condition and properly functioning. If SMPs are *not* properly functioning, more extensive maintenance or repairs may be needed. These may include, but are not limited to, full excavation or removal and replacement of permanently clogged media, porous surfaces, or subsurface components.

Proper execution of routine maintenance tasks may require entry to confined spaces and/or the use of specialized equipment. Property owners are responsible for safely conducting maintenance activities per applicable regulations and using the appropriate equipment and properly trained personnel. Some SMPs, such as porous surfaces and subsurface basins, require specialized equipment and/or training to maintain. PWD has a list of **local contractors** ☛ water.phila.gov/wp-content/uploads/files/smp-maintenance-contractors.pdf who provide SMP maintenance services. This list is not all-inclusive and does not constitute a recommendation of the companies contained there; rather, these are businesses that have a track record of performing stormwater management maintenance. The property owner may, of course, hire any qualified stormwater professional of their choice.

Site modifications

Any proposed changes to a site's SMPs, drainage configurations, or cover type must be approved by PWD to confirm that the modification will not adversely affect the property's continued compliance with the Stormwater Regulations or approved stormwater management design. This includes notifying PWD if any site improvements are planned to the property that could impact SMP functionality or regulatory compliance, such as changes in site grading, stormwater drain location/configuration, or the addition of new impervious areas like walkways, patios, decks, driveways, parking lots, sheds, or buildings. Modifications may require the submission of a **field change** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-3-review-phases/#fieldchanges for PWD review and approval prior to initiation. Unauthorized removal or modifications of any SMPs or drainage areas will result in enforcement actions by PWD.

6.2 Post-Construction Stormwater Management Maintenance Inspections and Enforcement

As a part of its compliance obligations under agreements with the Pennsylvania Department of Environmental Protection, the Philadelphia Water Department (PWD) is required to periodically inspect and ensure the proper operation and maintenance of all stormwater management practices (SMPs) and associated drainage areas installed on private properties.

6.2.1 PWD Post-Construction Inspections

PWD periodically inspects properties to check the functionality of the SMPs and associated drainage areas. Department staff will contact the property owner of record to schedule these inspections, which will generally occur within standard business hours. During an inspection, PWD inspectors confirm that SMPs are being maintained in accordance with the approved Post-Construction Stormwater Management Plan (PCSMP) and Operations and Maintenance (O&M) Agreement, and that all SMPs and drainage areas are functioning as designed. After inspection, PWD will provide the property with a Post-Construction Stormwater Management Maintenance Inspection Report detailing the results of the inspection and identifying any SMPs or features requiring maintenance or corrective action. The property owner is responsible for addressing all required corrective actions by the deadline indicated in the report. If a project remains noncompliant due to unresponsiveness, or has not reached compliance by a communicated deadline, the project will be referred to Post-Construction Enforcement. Certain site conditions may warrant immediate referral to Post-Construction Enforcement.

6.2.2 PWD Post-Construction Enforcement

Deadlines to submit documentation or complete required corrective actions will be provided during the Post-Construction Enforcement process. Documentation requirements and deadlines must both be met to avoid escalated enforcement action. Enforcement may include, though is not limited to, the issuance of a Notice of Violation and Order to Correct (NOV), suspension of stormwater billing credits, imposition of daily fines, issuance of an administrative order, filing of an enforcement action in court, and abatement by the City and billing for expenses (including administrative expenses).

In some cases, post-construction field changes may be required to correct a non-compliant site condition. The submission process and requirements for a post-construction field change will be communicated by the Post-Construction Enforcement case coordinator.

6.3 Stormwater Credits

All properties within the city of Philadelphia are charged a monthly **Stormwater Management Service Charge** ☛ water.phila.gov/stormwater/billing (Stormwater Charge). Residential customers are charged a flat rate, and non-residential, condominium, and multi-family residential customers (more than four dwelling units per parcel) are charged by the amount of gross and impervious areas on the parcel. To determine a property's current monthly Stormwater Charge, the Philadelphia Water Department's (PWD's) **Stormwater Parcel Viewer** ☛ stormwater.phila.gov/parcelviewer/map can be used. If a parcel appears to be charged incorrectly, the applicant may contact **pwd.stormwaterappeals@phila.gov** or refer to the ***Stormwater Management Service Charge Credits and Appeals Manual*** ☛ water.phila.gov/wp-content/uploads/files/stormwater-credits-appeals-manual.pdf (*Credits and Appeals Manual*) for more information on how to adjust the charge.

To assist non-residential, condominium, and multi-family residential customers (more than four dwelling units per parcel) in reducing their stormwater fees, PWD has implemented **Stormwater Credits** ☛ water.phila.gov/stormwater/incentives/credits. This program is administered by PWD **Stormwater Billing** ☛ water.phila.gov/stormwater/billing and **Incentives** ☛ water.phila.gov/stormwater/incentives and provides financial incentives to customers who help the City meet its stormwater management goals by mitigating stormwater runoff using stormwater management practices (SMPs) and preserving existing conditions on the parcel that are favorable for stormwater management, such as high-quality vegetated areas and disconnecting impervious areas from the sewer system. Building and maintaining these stormwater-friendly characteristics on a site is one way for property owners to play a part in the City's climate change adaptation efforts. In addition, property owners who choose to install and maintain functioning SMPs, retain pervious open space, and/or incorporate stormwater disconnections on their site may be eligible for stormwater credits. The **Stormwater Credits Explorer** ☛ stormwater.phila.gov/explore can be used to estimate the stormwater credits savings for implementing SMPs. To apply for stormwater credits, a **Stormwater Credits Application (Form B)** ☛ water.phila.gov/wp-content/uploads/files/form-b.pdf must be completed after construction has concluded, PWD has approved the submitted Record Drawings, the property has a recorded O&M Agreement, and all water accounts and applicable fines associated with the property are brought up to date.

There is no fee to apply for stormwater credits with a Form B. Credits expire four years from their effective date. It is the property owner's responsibility to submit a **Stormwater Credits Renewal Application (Form C)** ☛ water.phila.gov/wp-content/uploads/files/form-c.pdf at least 30 days before the expiration date, along with a Renewal Fee. Records of inspections and maintenance activities are required to support credit renewal applications. Applicants are referred to the ***Credits and Appeals Manual*** ☛ water.phila.gov/wp-content/uploads/files/stormwater-credits-appeals-manual.pdf for more comprehensive guidance.

Appendices

Appendix Index

Appendix	Description
A. Glossary ☛ p. 3	List of key words or terms included in the text of the Manual.
B. Abbreviations ☛ p. 7	Compiled list and explanations of all abbreviations used in the Manual.
C. PWD Stormwater Regulations ☛ p. 10	The Stormwater Regulations, presented in Appendix C, have been developed in accordance with the Philadelphia Code §14-704(3), and they consist of four major Post-Construction Stormwater Management (PCSM) Requirements: Water Quality, Channel Protection, Flood Control, and Public Health and Safety (PHS) Release Rate. In addition, all earth disturbance activity must comply with the Erosion and Sediment Control (E&S) requirements of the Pennsylvania Department of Environmental Protection, as specified in 25 Pa. Code §102.4. The objectives of these requirements include reducing pollution in runoff, recharging the groundwater table and increasing stream base flows, restoring more natural site hydrology, reducing combined sewer overflows (CSOs), reducing the quantity, frequency and duration of CSOs, protecting stream channels and banks, fish habitat and infrastructure from erosion and sedimentation, and reducing or preventing flooding in areas downstream of development sites.
D. Watershed and PHS Release Rate Maps ☛ p. 11	Watershed location plays an important role in identifying how the Stormwater Regulations, specifically the Post-Construction Stormwater Management Requirements, are applied to a project. Once the location of the development site is determined, Appendix D may be used to evaluate its Flood Management District, sewershed, and PHS Release Rate area, if applicable. If they are unable to confirm any area, the applicant should contact Stormwater Plan Review.
E. Plan and Report Checklists ☛ p. 12	Section 2.3 provides Review Phase Submission Package checklists as well as detailed guidance on the submission process. Appendix E includes checklists itemizing the submittal requirements of plans and reports required for Review Phase Submission Packages. By ensuring that plans and reports meet the requirements identified in each checklist, the applicant can streamline their project's Review Phase.
F. Design Guidance Checklists ☛ p. 28	The Philadelphia Water Department's Stormwater Plan Review Design Guidance Checklists, contained in Appendix F, are a supplemental list of guidelines for regulatory compliance, plan creation, hydrologic modeling and calculations, and the design of specific stormwater management practices. They are provided to assist in the formation of both sound, compliant stormwater management designs and complete Post-Construction Stormwater Management Plan (PCSMP) submissions. The designer should use the checklists as guidance during the design and calculation stages, or as useful quality assurance/quality control checks prior to PCSMP Review Phase submission.

G. SMP Maintenance Guide Documents ☛ p. 105	Appendix G contains an SMP Maintenance Guide sample and associated template documents. An SMP-specific, site-specific SMP Maintenance Guide, prepared by the designer and submitted to, and reviewed by, PWD during the PCSMP Review Phase, should be provided to and implemented by the property owner as a guide for long-term operations and maintenance of the SMPs on-site. SMP Maintenance Guide instructions are available on the first page of the SMP Maintenance Guide Information document to steer the designer through the creation of these items. The SMP Maintenance Guide must include a Site Map and a separate Maintenance Schedule Form for each SMP to allow the property owner to track all maintenance activities for their site. A sample of a compiled SMP Maintenance Guide is available in this Appendix For reference. SMP Maintenance Guidance One-Sheets are also available for each SMP detailed in this Manual in order to provide guidance on SMP maintenance activities and frequencies, including recommended SMP maintenance schedules.
H. Infiltration Testing Log ☛ p. 106	Appendix H contains a template log for documenting infiltration testing results. This Infiltration Testing Log includes guidance for documenting soil characteristics and is required to be completed and submitted as part of the Geotechnical Report during the Post-Construction Stormwater Management Plan Review Phase.
I. Plant Lists ☛ p. 107	Lists of native and recommended non-invasive plants and prohibited invasive plants and noxious weeds.
J. Construction Certification Package ☛ p. 111	It is important, both for the property owner and for the Philadelphia Water Department (PWD), to ensure that all stormwater management practices (SMPs) are constructed in strict accordance with the Approved Post-Construction Stormwater Management Plan (PCSMP). The Construction Certification Package (CCP) provides PWD with documentation that SMPs have been properly installed. Consisting of photographs, material receipts, and SMP Construction Certification Forms that must be customized by the design engineer prior to PCSMP Approval, the CCP must be kept on-site and completed by a registered professional during construction. Appendix J contains a description of the required CCP documentation and a collection of customizable SMP Construction Certification Forms to be populated with key information during construction and installation.
K. Record Drawing Sample ☛ p. 112	Along with the Construction Certification Package, the Philadelphia Water Department (PWD) requires that Record Drawing(s) be submitted at the close of the project to ensure that the stormwater management practices (SMPs) and their elements were constructed in general accordance with the Approved Post-Construction Stormwater Management Plan (PCSMP), and to document any field changes. Record Drawing(s) are required for SMP verification and are a key component of PWD's compliance reporting. Samples that demonstrate how Approved PCSMP plan sheets should be marked-up in order to prepare Record Drawings are provided in Appendix K.
L. Standard Details ☛ p. 113	Typical construction details for several SMPs, including all of PWD's highest-preference SMPs, such as bioinfiltration/bioretention basins, porous surfaces, and green roofs, and for SMP-related structures, such as cleanouts, observations wells, and outlet control structures, are available for download in AutoCAD (*.dwg) format in Appendix L. These Standard Details incorporate design specifications pursuant to each SMP's respective design and material requirements. The designer is encouraged, though not required, to use them for PCSMP creation when possible.
M. PCSMP Project Closeout ☛ p. 115	Appendix M details the PCSMP project closeout procedure required of an applicant upon the conclusion of the project's construction.

A. Glossary

Applicant: A property owner, developer, or other person or entity who has submitted an application to the Philadelphia Water Department (PWD) for approval to engage in, or be exempt from, any Regulated Activity at a Development Site in the City of Philadelphia.

Combined Sewer Overflows (CSO): A combined sewer overflow is an intermittent overflow or other untreated discharge from a municipal combined sewer system to the water of the Commonwealth occurring before the sewage treatment plant.

Conceptual Stormwater Management Plan: A preliminary stormwater management plan used by PWD Stormwater Plan Review to understand what is proposed at the project site, to confirm the proposed project limits of disturbance (LOD), and to assess the proposed stormwater management strategy. Conceptual Stormwater Management Plan requirements are described in **Chapter 2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2 of this Manual.

Demolition: The razing or destruction, whether entirely or in significant part, of a building, structure, site, or object; including the removal of a building, structure, site, or object from its site or the removal or destruction of the façade or surface.

Design Storm: The magnitude and temporal distribution of precipitation from a storm event defined by probability of occurrence (e.g., five-year storm) and duration (e.g., 24 hours), used in the design and evaluation of stormwater management systems.

Developer: Any landowner, agent of such landowner, or tenant with the permission of such landowner, who makes or causes to be made a subdivision of land or land Development project prior to issuance of the Certificate of Occupancy.

Development: Any human-induced change to a tract of land, whether public or private. Development encompasses, but is not limited to, New Development, Redevelopment, Demolition, and Stormwater Retrofit. It includes the entire Development Site, even when the project is performed in phases.

Development Site: The land area where any Development activities are planned, conducted, or maintained, regardless of individual parcel ownership. It includes contiguous areas of disturbance across Streets and other rights of way, or private streets and alleys, during any stage of or on any portion of a larger common plan of development or sale.

Diffused drainage discharge: Drainage discharge not confined to a single point location or channel, such as sheet flow or shallow concentrated flow.

Directly connected impervious area (DCIA): An Impervious Surface that is directly connected to the drainage system. DCIA generates surface runoff with a direct hydraulic connection to on-site drainage systems (e.g., inlets, curbs and gutters, pipes, etc.), PWD's drainage systems, or stormwater management practices (SMPs) without flowing over pervious areas.

Disconnected impervious cover (DIC): Impervious cover from which runoff is directed toward pervious areas for management within the landscape.

Earth disturbance: Any construction or other activity that disturbs the surface of land, including but not limited to, excavations, embankments, land development, subdivision development, and the moving, depositing, or storing of soil, rock, or earth. Other examples of earth disturbance in the context of PWD Stormwater Regulations are listed in **Section 1.1.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1/1-1-applicability-factors#1.1.3.

Erosion and Sediment (E&S) Control Plan: A site-specific plan consisting of both drawings and a narrative that identifies measures to minimize accelerated erosion and sedimentation before, during, and after Earth Disturbance. E&S Plan requirements are described in **Chapter 2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2 of this Manual.

Evaporation and transpiration (evapotranspiration): Evaporation is the process by which water changes from a liquid to gas. Transpiration is the process by which water moves through a plant and evaporates into the atmosphere from its leaves and exterior surfaces. The sum of evaporation and transpiration are commonly referred to as evapotranspiration.

Existing conditions: Physical conditions on the site including land use, impervious surface, topography, vegetation, soils, and hydrology that exist on the site on the date the owner starts the development process.

Groundwater recharge: The replenishment of existing natural underground water supplies from precipitation or overland flow without degrading groundwater quality.

Hotspots: Areas where land use or activities have contaminated the soil underlying the site such that infiltration of stormwater would likely cause groundwater contamination through leaching of the soil.

Impervious liner: A physical barrier to prevent water from crossing a system boundary such as infiltrating through the subgrade beneath a stormwater management practice. Liners may include, but are not limited to, compacted till liners, clay liners, geomembrane liners, and concrete liners.

Impervious surface: Any building, pavement, or other material that substantially bars the natural infiltration of surface water into the soil.

Infiltration: The process by which water enters the soil from the ground surface and can be measured as a rate.

Management District: Sub-area delineations that determine peak rate attenuation requirements. A Development Site located in more than one Management District shall conform to the requirements of the district into which the site discharges

Manual: The most recent version of the **Philadelphia Stormwater Management Guidance Manual** ☛ water.phila.gov/development/stormwater-plan-review/manual.

New Development: Development project on a tract of land where structures or impervious surfaces never existed or were removed before January 1, 1970.

Non-structural design: Stormwater management practices that incorporate, preserve, and protect existing natural features while promoting the treatment, infiltration, evaporation, and transpiration of precipitation close to where it falls.

Operations & Maintenance (O&M) Agreement: An agreement or declaration outlining the maintenance requirements associated with the Post-Construction Stormwater Management Plan.

Pavement disconnection: A type of DIC, and a reduction in DCIA, where pavement runoff is directed to a vegetated area that allows for infiltration, filtration, and an increased time of concentration.

Post-Construction Stormwater Management Plan (PCSMP): A complete stormwater management plan set as described in the PWD Stormwater Regulations and in this Manual. PCSMP submission package requirements are described in **Section 2.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-3-review-phases of this Manual.

Predevelopment condition: For New Development and Redevelopment, the dominant land use for the previous ten years preceding the planned project.

Record Drawings: Construction drawings revised to represent the as-built conditions.

Redevelopment: Development on a tract of land that includes, but is not limited to, the demolition or removal of existing structures or impervious surfaces and replacement with new impervious surfaces. This includes replacement of impervious surfaces that have been removed on or after January 1, 1970.

Registered professional: A licensed Professional Engineer, Registered Architect, Landscape Architect, Professional Land Surveyor, Professional Geologist, or Licensed Contractor registered in the Commonwealth of Pennsylvania.

Regulated activity: Development on a Development Site in the City of Philadelphia that results in an area of Earth Disturbance greater than or equal to 15,000 square feet, greater than or equal to 5,000 square feet in the Darby and Cobbs Creeks Watershed, or as otherwise required by local, State, or Federal requirements. The area of Earth Disturbance during the construction phase determines requirements for the erosion and sediment (E&S) controls and post-construction stormwater management.

Review Path: A linear series of submission, review, and approval/exemption procedures the applicant will navigate to demonstrate a project's compliance with, or exemption from, the PWD Stormwater Regulations.

Review Phase: A step in a Review Path. Each Review Path has one or more Phases. Each Phase corresponds to one or more submittals of information for PWD's review.

Roof runoff isolation: The routing of runoff from non-vehicular roof area that is not commingled with untreated runoff.

Rooftop disconnection: A type of DIC, and a reduction in DCIA, where a roof downspout is directed to a vegetated area which allows for infiltration, filtration, and increased time of concentration.

Sewershed: An area of land, or catchment, which drains via storm drain infrastructure to a common outlet point.

Site assessment: An investigation of the administrative and physical factors that shape the development and stormwater management plan for a proposed site. The assessment consists of three components: collection of background site factors, site factors inventory, and site factors analysis.

Small Residential Development: A project proposing less than one acre of earth disturbance consisting of buildings used exclusively as one- or two-family dwellings.

Storage volume: The volume of stormwater runoff that can be held within the above-ground surface area and the pore spaces of any subsurface media or structure of a stormwater management practice.

Stormwater management practice (SMP): Any man-made or natural structure, system, landscape feature, channel, or improvement designed, constructed, installed, and/or used to detain, infiltrate, or otherwise control stormwater runoff quality, rate, or quantity.

Stormwater pretreatment: Techniques employed to remove pollutants before they enter the SMP, including, but not limited to, the techniques listed as pretreatment in this Manual.

Stormwater Retrofit: The voluntary rehabilitation and/or installation of SMPs on a property to better manage stormwater runoff.

Street: Tract of land or part thereof with public access used for vehicular and/or pedestrian traffic, which is maintained by a City Agency, City Related Agency, other Government Agency, or a Non-Profit Organization Created by the City, as determined by the Department.

Street Maintenance Activities: Earth disturbance activities within an existing street as determined by the Department and described in the Manual's **Section 1.1.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-1/1-1-applicability-factors#1.1.3.

Tree disconnection credit: A type of DIC, and a reduction in DCIA, where existing or newly proposed tree canopy from an approved species list extends over, or is in close proximity to, impervious area.

Triple Bottom Line: The SMP's ability to provide social, environmental, and economic benefits (land value, energy efficiency, etc.).

Watershed: An area of land that contains a common set of drainage pathways, streams, and rivers that all discharge to a single large body of water, such as a river, lake, or ocean.

B. Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
ANSI	American National Standards Institute
ASSE	American Society of Safety Engineering
ASTM	American Society of Testing and Materials
BMP	Best management practice
CCP	Construction Certification Package
CCTV	Closed circuit television
CIP	Cast iron pipe
cfs	Cubic feet per second
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERM	Civil Engineering Reference Manual
CN	Curve Number
CO&A	Consent Order and Agreement
CSO	Combined Sewer Overflow
CWA	Clean Water Act (1972)
DCIA	Directly connected impervious area
DIC	Disconnected impervious cover
DOR	Department of Records
EMC	Event mean concentration
EMI	Electromagnetic induction
E&S	Erosion and Sediment Control
EPDM	Ethylene propylene diene terpolymer
ERSA	Existing Resources and Site Analysis
ET	Evapotranspiration
FLL	German Landscape Research, Development and Construction Society
FEMA	Federal Emergency Management Agency
GPR	Ground penetrating radar
GSI	Green stormwater infrastructure
HDPE	High-density polyethylene
HOA	Homeowners association
HSG	Hydrologic Soil Group
IDF	Intensity-duration-frequency
IWU	Industrial Waste Unit
LEED	Leadership in Energy and Environmental Design

L&I	Department of Licenses and Inspections
LOD	Limit of disturbance
LTCPU	Long-Term Control Plan Update
MSC	Medium-Specific Concentration
MS4	Municipal Separate Storm Sewer System
NJCAT	New Jersey Center for Advanced Technology
NJ DEP	New Jersey Department of Environmental Protection
NPDES	National Pollutant Discharge Elimination System
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NOT	Notice of Termination
NOV	Notice of Violation and Order to Correct
NRCS	Natural Resources Conservation Service
O&M	Operations and Maintenance
OPA	Office of Property Assessment
OSHA	Occupational Safety and Health Administration
PA DEP	Pennsylvania Department of Environmental Protection
PCPC	Philadelphia City Planning Commission
PCSM	Post-Construction Stormwater Management
PCSMP	Post-Construction Stormwater Management Plan
PHS	Public Health and Safety
POA	Point of analysis
PUD	Planned Unit Development
PVC	Polyvinyl chloride
PWD	Philadelphia Water Department
RCP	Reinforced concrete pipe
ROW	Right-of-Way
SIU	Significant industrial user
SMP	Stormwater management practice
SPLP	Synthetic Precipitation Leachate Procedure
SPT	Standard Penetration Test
SRD	Small Residential Development
SSPA	Steep Slope Protection Area
SWTR	Surface Water Treatment Rule
TAPE	Technology Assessment Protocol – Ecology
TARP	Technology Acceptance and Reciprocity Partnership

TSS	Total suspended solids
TMDL	Total maximum daily load
TPO	Thermal polyolefin
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGBC	United States Green Building Council
USGS	United States Geological Survey
VCP	Vitrified clay pipe
WQv	Water Quality volume
WTR	Water Transport Records
WWO	Wissahickon Watershed Overlay
ZBA	Zoning Board of Adjustment

C. PWD Stormwater Regulations

The Philadelphia Water Department (PWD) Stormwater Regulations (Stormwater Regulations), presented in Appendix C, have been developed in accordance with **Philadelphia Code §14-704(3)** ☛ https://codelibrary.amlegal.com/codes/philadelphia/latest/philadelphia_pa/0-0-0-293389, and they consist of four major Post-Construction Stormwater Management Requirements: Water Quality, Channel Protection, Flood Control, and Public Health and Safety Release Rate. In addition, all earth disturbance activity must comply with the Erosion and Sediment Control requirements of the Pennsylvania Department of Environmental Protection, as specified in **25 Pa. Code §102.4** ☛ https://www.pacodeandbulletin.gov/Display/pacode?file=/secure/pacode/data/025/chapter102/s102.4.html.

The objectives of these requirements include:

- Reduce pollution in runoff
- Recharge the groundwater table and increase stream base flows
- Restore more natural site hydrology
- Reduce combined sewer overflows (CSOs)
- Reduce the quantity, frequency and duration of CSOs
- Protect stream channels and banks, fish habitat and infrastructure from erosion and sedimentation
- Reduce or prevent flooding in areas downstream of development sites

The details of the Stormwater Regulations can be found within ***Chapter 6: Stormwater*** ☛ water.phila.gov/wp-content/uploads/files/pwd-regulations-chapter-6.pdf of the **PWD Regulations** ☛ water.phila.gov/regulations.

D. Watershed and PHS Release Rate Maps

Watershed location plays an important role in identifying how the Stormwater Regulations, specifically the Post-Construction Stormwater Management Requirements, are applied to a project. Once the location of the development site is determined, Appendix D may be used to evaluate its Flood Management District, sewer service area, and Public Health and Safety (PHS) Release Rate area, if applicable. If they are unable to confirm any area, the applicant should contact Stormwater Plan Review. These maps are approximations of sewershed boundaries. The applicant must refer to their project's point of stormwater discharge when determining which requirements apply to their project.

- **Philadelphia Watersheds: Flood Management Districts Map** ☛ water.phila.gov/wp-content/uploads/files/flood-management-districts.pdf
- **Philadelphia Watersheds: Sewer Service Areas Map** ☛ water.phila.gov/wp-content/uploads/files/sewersheds.pdf
- **Public Health and Safety (PHS) Release Rates Map** ☛ water.phila.gov/wp-content/uploads/files/public-health-and-safety-release-rates-map.pdf

E. Plan and Report Checklists

Section 2.3 provides Review Phase Submission Package checklists as well as detailed guidance on the submission process. Appendix E includes checklists itemizing the submittal requirements of plans and reports required for Review Phase Submission Packages. By ensuring that plans and reports meet the requirements identified in each checklist, the applicant can streamline their project's Review Phase.

- **Table E-1: General Plan Sheet Requirements** ☛ p. 13
- **Table E-2: Existing Conditions Plan Requirements** ☛ p. 14
- **Table E-3: Conceptual Stormwater Management Plan Requirements** ☛ p. 15
- **Table E-4: Erosion and Sediment Control Plan Requirements** ☛ p. 17
- **Table E-5: Standard Erosion and Sediment Control Notes** ☛ p. 19
- **Table E-6: Standard Sequence of Construction Notes** ☛ p. 22
- **Table E-7: Post-Construction Stormwater Management Plan Report Requirements** ☛ p. 23
- **Table E-8: Record Drawing Requirements** ☛ p. 27

Table E-1: General Plan Sheet Requirements

#	Each plan sheet submitted to PWD must be legible and include the following items:
1	Project name
2	PWD project tracking number
3	Revision date(s)
4	Title of plan sheet
5	Signature and seal of Registered Professional (dated) for Final Construction Drawings
6	Plan scale including measurable scale bar (1" = 10', 20', 30', 40', 50', 60', or 100') (50' or less for Record Drawings)
7	North arrow
8	Legend that clearly shows all symbols, line types, and hatchings used on the plan
9	All proposed changes or additions to existing conditions should be represented on the plan in a line weight heavier than that used for existing conditions
10	Street lines, street names, rights-of-way, and easements
11	A note indicating the plan's vertical datum must be included. The Philadelphia Vertical Datum (City Datum) must be used.

Table E-2: Existing Conditions Plan Requirements

#	Requirement
1	General plan presentation requirements listed in Table E-1
2	Name of owner and designer
3	Site address (must match current Philadelphia Office of Property Assessment (OPA) records)
4	Location map including site location within watershed(s)
5	Property lines, all metes, bounds, boundaries, dimensions, building lines, and setbacks (must match current OPA records)
6	Street lines, street names, lot names, easements, other land divisions, and their purposes and confirmed locations
7	Location and boundaries of all existing rights-of-way, easements, cartway widths for all streets and private roads, and drainage rights-of-way
8	Location and size of all existing site features and impervious areas within 25 feet of the proposed earth disturbance even if those features are on an adjacent property
9	Location of all existing active and abandoned utilities (water, sewer, stormwater), including stormwater management practices above and below ground within 25 feet of the limit of disturbance
10	Identification of the nearest watercourses/water bodies (within 100 feet)
11	Existing topography of site (contours, sub-basins, etc.) in one-foot contour intervals (minimum) on-site and on adjacent lands within 25 feet of the property line and on the full width of abutting public lands, and private rights-of-way and easement(s)
12	Identification of any special features of the site (natural depressions, natural berms, flood plains, etc.)
13	Identification of the type and extent of vegetation, and the location and species identification of any trees that measure greater than six inches diameter at breast height
14	Location and boundaries of proposed demolition, including all structures and pavement to be removed and all utilities to be capped or plugged
15	Location of any existing on-site disposal systems (septic tanks) and drain fields

Table E-3: Conceptual Stormwater Management Plan Requirements

#	Requirement
1	General plan presentation requirements listed in Table E-1
2	Name of owner and designer
3	Site address (existing and proposed, if different)
4	Location map including site location within watershed(s)
5	Property lines, subdivision or lot consolidation lines, all metes, bounds, boundaries, dimensions, building lines and setbacks (if two or more lines (property lines, limits of disturbance (LOD) lines, right-of-way line, etc.) coincide at the same location or over one another on the plan, separate them on additional plan sheets)
6	Street lines, street names, lot names, easements, other land divisions, and their purposes and confirmed locations
7	Location of boundaries of all existing and proposed rights-of-way, easements, cartway widths for all streets and private roads, and drainage rights-of-way to remain post-construction (any proposed changes to the City plan should also be noted with an ordinance number, if known)
8	Location/outline of all existing structures to remain within 25 feet of the limit of disturbance
9	Location of all existing active and abandoned utilities (water, sewer, stormwater), including stormwater management practices, to remain above and below ground within 25 feet of the limit of disturbance
10	Existing topography of site (contours, sub-basins, etc.) in one-foot contour intervals (minimum) on-site and on adjacent lands within 25 feet of the property line and on the full width of abutting public lands, and private rights-of-way and easement(s)
11	Location of all right-of-way encroachments, such as egress wells, stairs, light poles, trees, building overhangs, etc.
12	Delineation, labeling, and square footage of the proposed LOD, including all utility connections, sidewalk replacement, stockpiles, and construction entrances within the LOD. The LOD should not only take into consideration proposed improvements, but also areas likely to be disturbed during construction, such as for the installation of erosion and sediment control measures.
13	Proposed topography of site (distinguish between existing and proposed contours) in two-foot contour intervals (minimum)
14	Identification of all proposed site improvements, such as buildings, basements, parking lots, driveways, landscaping, SMPs, drainage, etc., that should be distinguished from any existing features to remain
15	Location and dimensions of all existing and proposed driveways, curb cuts, and off-street parking lots
16	Proposed building lines with street setback lines and distances to other existing and proposed buildings if within 15 feet
17	Proposed lot lines and lot identification numbers, dimensions, and areas
18	Delineation of impervious surfaces
19	Location of vegetation identified for preservation and planned landscape areas
20	Location of all proposed water and fire utility connections, including proposed sizes, if known Water meter/meter pit must be shown within 35 feet of the property/house/right-of-way line (show dimension from property line to metered structure) Include backflow prevention on the water line, when applicable
21	Location of all proposed sanitary sewer and stormwater connections, including proposed sizes, if known (sewer connections made directly into inlets and manholes are not permitted)

22	Delineation of all proposed disconnected impervious cover within the LOD
23	Identification of areas of proposed stormwater management, including locations, extent, and types of SMPs, as well as safe overflow connections
24	Location of all existing and proposed roof and yard drains and their connections to SMPs or sewer (connection points must be included within the LOD)
25	For all infiltration SMPs, identification of loading ratio not exceeding 16:1 for directly connected impervious area (DCIA) to infiltration area footprint of surface-vegetated SMPs, and not exceeding 10:1 for DCIA to infiltration area footprint of subsurface infiltration SMPs
26	Extent and boundaries of 100-year floodplain in relation to the project
27	Depiction of post-development hydrology of the site with flow lines and/or drainage areas including discharge points from property and type of discharge (diffused, concentrated, piped, etc.)
28	Location of any proposed on-site disposal systems (septic tanks) and drain fields
29	Number of dwelling units for proposed residential buildings

Table E-4: Erosion and Sediment Control Plan Requirements

#	Requirement
1	General plan presentation requirements listed in Table E-1
2	Name of owner and designer
3	Site address (existing and proposed, if different)
4	Location map including site location within watershed(s)
5	Property lines, subdivision or lot consolidation lines, all metes, bounds, boundaries, dimensions, building lines and setbacks (if two or more lines (property lines, limits of disturbance (LOD) lines, right-of-way line, etc.) coincide at the same location or over one another on the plan, separate them on additional plan sheets)
6	Street lines, street names, lot names, easements, other land divisions, and their purposes and confirmed locations
7	Location of boundaries of all existing and proposed rights-of-way, easements, cartway widths for all streets and private roads, and drainage rights-of-way to remain post-construction (any proposed changes to the City plan should also be noted with an ordinance number, if known)
8	Location/outline of all existing structures to remain within 25 feet of the limit of disturbance
9	Location of all existing utilities (water, sewer, stormwater), including stormwater management practices, to remain above and below ground within 25 feet of the limit of disturbance
10	Existing topography of site (contours, sub-basins, etc.) in one-foot contour intervals (minimum) on-site and on adjacent lands within 25 feet of the property line and on the full width of abutting public lands, and private rights-of-way and easement(s)
11	Location of all right-of-way encroachments, such as egress wells, stairs, light poles, trees, building overhangs, etc.
12	Delineation, labeling, and square footage of the proposed LOD, including all utility connections, sidewalk replacement, stockpiles, and construction entrances within the LOD. The LOD should not only take into consideration proposed improvements, but also areas likely to be disturbed during construction, such as for the installation of erosion and sediment control measures.
13	Proposed topography of site (distinguish between existing and proposed contours) in one-foot contour intervals (minimum)
14	Identification of all proposed site improvements, such as buildings, basements, parking lots, driveways, landscaping, SMPs, drainage, etc., that should be distinguished from any existing features to remain
15	Location and dimensions of all existing and proposed driveways, curb cuts, and off-street parking lots, with distances from lot lines
16	Proposed building lines with street setback lines and distances to other existing and proposed buildings if within 15 feet
17	Proposed lot lines and lot identification numbers, dimensions, and areas
18	Delineation of impervious surfaces
19	Location of vegetation identified for preservation and planned landscape areas
20	Location of all proposed water and fire utility connections, including proposed sizes, if known Water meter/meter pit must be shown within 35 feet of the property/house/right-of-way line (show dimension from property line to metered structure) Include backflow prevention on the water line, when applicable

21	Location of all proposed sanitary sewer and stormwater connections including proposed sizes, if known (sewer connections made directly into inlets and manholes are not permitted)
22	Extent and boundaries of 100-year floodplain in relation to the project
23	Depiction of post-development hydrology of the site with flow lines and/or drainage areas including discharge points from property and type of discharge (diffused, concentrated, piped, etc.)
24	Location of any proposed on-site disposal systems (septic tanks) and drain fields
25	Location of all proposed erosion and sediment control measures, including, but not limited to, inlet protection, silt fence and/or compost filter sock, rock filter outlet, rock construction entrance, pumped water filter bag, concrete washout station, and stockpiles, which must be surrounded by silt fencing
26	Dimensions of rock construction entrance(s), which must be, at minimum, 50 feet in length and 20 feet in width
27	Tree protection fencing around existing trees proposed to remain
28	Geotextile or filter stone for erosion protection of soil beneath any proposed riprap
29	Objects of considerable mass (i.e. concrete blocks, sand bags, etc.) immediately downslope of any compost socks placed on paved surfaces (at same intervals as recommended by sock manufacturer for stakes)
30	The designer must prescribe dust control measures that are appropriate to the project. The designer is referred to the City of Philadelphia Department of Public Health Air Management Services ***Construction/Demolition/Earthworks Dust Control Requirements FAQ*** ☛ www.phila.gov/media/20190211104838/Dust-Control-Guideline-FAQ-20190205a-__FINAL.pdf for guidance.
31	Standard construction details from the *PA DEP Erosion and Sediment Pollution Control Manual* (2012 or latest) for inlet protection, silt fence and/or compost filter sock, rock filter outlet, rock construction entrance, pumped water filter bag, concrete washout station, and stockpile location (if any of these erosion and sediment control measures do not apply to the project site, justification must be provided as notes on the plan)
32	Standard Erosion and Sediment Control Notes listed in Table E5, as applicable
33	Standard Sequence of Construction Notes listed in Table E6, as applicable
34	Electronic signature and seal of a licensed professional if project's limit of disturbance exceeds 5,000 square feet
35	Orange construction fencing or silt fencing around existing SMPs, above and below ground, within 25 feet of the LOD. The distance between existing SMPs to remain and the LOD must be at least ten feet.
36	Number of dwelling units for proposed residential buildings

Table E-5: Standard Erosion and Sediment Control Notes

#	Note
1	An Industrial Waste Permit will be required should pumping to City-owned infrastructure become necessary during construction. All pumping of water from any work area shall be done according to the procedure described in this plan, over undisturbed vegetated areas.
2	Inlet protection should be provided for all inlets owned by PWD that are located within one block of the project site.
3	PWD is not responsible for any cleaning or repairs needed on City-owned infrastructure due to failure of any erosion and sediment control practices. *(applicant to indicate responsible party)*
4	Inspection and maintenance of all erosion and sediment control best management practices shall occur on a weekly basis, before any anticipated precipitation events, and after all precipitation events.
5	The maximum height for stockpiles areas shall be 20 feet. The maximum side slope for stockpile areas shall not exceed 2:1.
6	The rock construction entrance thickness shall be constantly maintained on-site. A stockpile shall be maintained on-site for this purpose. At the end of each construction day, all sediment deposited on paved roadways shall be removed and returned to the construction site. In no case shall the sediment be washed, shoveled, or swept into any roadside ditch, storm sewer, or surface water.
7	Filter fabric fence should be installed at level grade. Both ends of each fence section should be extended at least 8 feet upslope at 45 degrees to the main barrier alignment. Support stakes shall be spaced at a maximum of 8 feet. Sediment must be removed when accumulations reach ½ the above ground height of the filter fence.
8	Any fence section which has been undermined or topped must be immediately replaced with a rock filter outlet. Sediment must be removed when accumulations reach 1/3 the height of the outlet.
9	Erosion control blanketing shall be installed on all slopes 3H:1V or steeper within 50 feet of a surface water and on all other disturbed areas specified on the plan maps and/or detail sheets.
10	Immediately upon discovering unforeseen circumstances posing the potential for accelerated erosion and/or sediment pollution, the operator shall implement appropriate best management practices to minimize the potential for erosion and sediment pollution and notify PWD and PA DEP.
11	Until the site is stabilized, all E&S BMPs shall be maintained properly. Maintenance shall include inspections of all E&S BMPs prior to any anticipated storm event, after each runoff event and on a weekly basis. All preventative and remedial maintenance work, including clean out, repair, replacement, regrading, reseeding, remulching, and renetting, must be performed immediately. If the E&S BMPs fail to perform as expected, replacement BMPs, or modifications of those installed, will be required.
12	All earth disturbances, including clearing and grubbing, as well as cuts and fills, shall be done in accordance with the approved E&S Plan. A copy of the approved drawings must be available at the project site at all times. PWD shall be notified of any changes to the approved plan prior to implementation of those changes. PWD may require a written submittal of those changes for review and approval at its discretion.
13	At least three (3) days prior to starting any earth disturbance activities, or expanding into an area previously unmarked, the Pennsylvania One Call System Inc. shall be notified at 1-(800) 242-1776 for the location of existing underground utilities.
14	All earth disturbance activities shall proceed in accordance with the sequence provided on the plan drawings. Deviation from that sequence must be approved in writing by PWD and the PA DEP prior to implementation.

15	Areas to be filled are to be cleared, grubbed, and stripped of topsoil to remove trees, vegetation, roots, and other objectionable material.
16	Clearing, grubbing, and topsoil stripping shall be limited to those areas described in each stage of the construction sequence. General site clearing, grubbing, and topsoil stripping may not commence in any stage of the project until the E&S BMPs specified by the BMP sequence for that stage have been installed and are functioning as described in this E&S Plan.
17	At no time shall construction vehicles be allowed to enter areas outside the limit of disturbance boundaries shown on the plan maps. These areas must be clearly marked and fenced off before clearing and grubbing operations begin.
18	A log showing dates that E&S BMPs were inspected as well as any deficiencies found and the date they were corrected shall be maintained on the site and be made available to PWD at the time of inspection.
19	All sediment removed from BMPs shall be disposed of in the following manner: *(applicant to describe disposal method)*
20	Areas which are to be topsoiled shall be scarified to a minimum depth of three to five inches — six to 12 inches on compacted soils — prior to placement of topsoil. Areas to be vegetated shall have a minimum four inches of topsoil in place prior to seeding and mulching. Fill outslopes shall have a minimum of two inches of topsoil.
21	All fills shall be compacted as required to reduce erosion, slippage, settlement, subsidence, or other related problems. Fill intended to support buildings, structures, and conduits, etc. shall be compacted in accordance with local requirements or codes.
22	All earthen fills shall be placed in compacted layers not to exceed nine inches in thickness.
23	Fill materials shall be free of frozen particles, brush, roots, sod, or other foreign or objectionable materials that would interfere with or prevent construction of satisfactory fills.
24	Frozen materials or soft, mucky, or highly compressible materials shall not be incorporated into fills.
25	Fill shall not be placed on saturated or frozen surfaces.
26	Seeps or springs encountered during construction shall be handled in accordance with the standard and specification for subsurface drain or other approved method.
27	All graded areas shall be permanently stabilized immediately upon reaching finished grade. Cut slopes in competent bedrock and rock fills need not be vegetated. Seeded areas within 50 feet of a surface water, or as otherwise shown on the plan drawings, shall be blanketed according to the standards of this plan.
28	Immediately after earth disturbance activities cease in any area or subarea of the project, the operator shall stabilize all disturbed areas. During non-germinating months, mulch or protective blanketing shall be applied as described in the plan. Areas not at finished grade, which will be reactivated within one year, may be stabilized in accordance with the temporary stabilization specifications. Those areas which will not be reactivated within one year shall be stabilized in accordance with the permanent stabilization specifications.
29	Permanent stabilization is defined as a minimum uniform, perennial 70% vegetative cover or other permanent non-vegetative cover with a density sufficient to resist accelerated erosion. Cut and fill slopes shall be capable of resisting failure due to slumping, sliding, or other movements.
30	E&S BMPs shall remain functional as such until all areas tributary to them are permanently stabilized or until they are replaced by another BMP approved by PWD and PA D EP.
31	After final site stabilization has been achieved, temporary E&S BMPs must be removed or converted to permanent post-construction stormwater management practices. Areas disturbed during removal or conversion of the E&S BMPs shall be stabilized immediately. In order to ensure rapid revegetation of disturbed areas, such removal/conversions are to be done only during the germinating season.

32	Sediment basins and/or traps shall be kept free of all construction waste, wash water, and other debris having potential to clog the basin/trap outlet structures and/or pollute the surface waters. *(when applicable)*
33	During construction, the selected contractor is expected to follow the PCSMP approved by PWD. No change or deviation from the Approved PCSMP is permitted without prior approval from PWD.
34	All work associated with PWD water conveyance and sewer infrastructure shall be done in accordance with the City of Philadelphia Water Department "Water Main Standard Details and Corrosion Control Specifications", 1985 edition, and "Standard Details and Standard Specifications For Sewers", 2019 edition.
35	Contact PWD Water Transport Records (1101 Market Street, 2nd Floor, Phone: (215) 685-6271) for additional approvals and permits required for all water services, meters, and connections to the existing and/or proposed PWD facilities
36	All building materials and wastes shall be removed from the site and recycled or disposed of in accordance with the PADEP's Solid Waste Management Regulations at 25 PA Code 260.1 et seq., 271.1, and 287.1 et seq. No building materials or wastes or unused building materials shall be burned, buried, dumped, or discharged at the site.
37	A Dust Control Permit will be required when completely demolishing a building or structure that is more than three (3) stories, greater than forty (40) feet tall, or encompasses more than ten thousand (10,000) square feet; completely or partially demolishing any building or structure by implosion; or engaging in earthworks, defined as "clearing, grubbing, or earth disturbance of any land in excess of 5,000 square feet."
38	The applicant must provide an affirmative statement confirming there will not be a conflict between any existing stormwater management practices above or below ground, located within 25 feet of the limit of disturbance, and proposed to remain, and the proposed design shown on the plans. (when applicable)

Table E-6: Standard Sequence of Construction Notes

#	Note
1	At least seven (7) days prior to any earth disturbance, the Inspections Coordinator of PWD (Office: (215) 685-6387) must be called to schedule a preconstruction meeting.
2	At least three (3) days prior to *(applicant to name each SMP)* installation, the Inspections Coordinator of PWD (Office: (215) 685-6387) must be called to schedule an inspection *(for each SMP).*
3	All stone that makes up the *(applicant to name each infiltration SMP)* must remain free of sediment. If sediment enters the stone, the contractor may be required to remove the sediment and replace it with clean-washed stone.
4	Upon completion of all earth disturbance activities and permanent stabilization of all disturbed areas, the owner and/or operator shall contact Inspections Coordinator of PWD (Office: (215) 685-6387) for a final inspection prior to removal/conversion of the E&S BMPs.
5	As soon as slopes, channels, ditches, and other disturbed areas reach final grade, they must be stabilized. Cessation of activity for four (4) days or longer requires temporary stabilization.
6	The NPDES Notice of Termination (N.O.T.) must be submitted to PA DEP upon completion of construction *(when applicable)*.
7	Water pumped from work areas should be treated for sediment removal prior to discharging to a “surface water” *(when applicable)*.

Table E-7: Post-Construction Stormwater Management Plan Report Requirements

PCSMP Report Section*	Requirements
Cover	• Signed and sealed by a Professional Engineer

Introduction / Project Description	• Project summary
	• Stormwater management summary
	  ▪ Applicable PWD Stormwater Regulations
	  ▪ Applicable State and Federal regulatory/permit requirements
	• Existing site and drainage conditions summary

Project Soils	• Soil survey map • Hydrologic Soil Group discussion

Stormwater Management	• Stormwater management design methodology
	  ▪ Rainfall depths and distribution, if applicable (Section 3.4)
	  ▪ Runoff estimation method, if applicable (Section 3.4)
	  ▪ Flow and storage routing methods, if applicable (Section 3.4)
	• Stormwater analysis summary and discussion
	• Proposed stormwater management design
	  ▪ Proposed stormwater management practice (SMP) summaries, if proposed
	  ▪ Infiltration summary
	  ▪ Proposed disconnected impervious cover (DIC) summaries, if proposed
	  ▪ Proposed Stormwater Management Banking or Trading discussion, if proposed (Section 3.2.4)
	  ○ Type of Stormwater Management Banking or Trading proposed
	  ○ Description of area(s) proposed to be banked or traded
	  ○ Square footage(s) of area(s) proposed to be banked or traded
	  ○ Justification for the proposed bank or trade, including reasons why management of the required area(s) is not feasible and why PWD may benefit from the proposal
	  ▪ Proposed fee in lieu discussion, if proposed (Section 3.4.1)
	  ○ Square footage(s) of area(s) for proposed fee in lieu
	  ○ All Water Quality stormwater management strategies considered and rejected
	  ○ Justification for the proposed fee in lieu, including reasons why all considered stormwater management strategies are not feasible or advisable

Appendices	• Stormwater analysis calculations
	  ▪ Static storage calculations, if applicable (Section 3.4.1)
	  ▪ Predevelopment and post-development Tc calculations, if applicable (Section 3.4.1)
	  ▪ Predevelopment and post-development hydrologic modeling, if applicable (Section 3.4.1)
	  ○ Model routing
	  ○ Input parameters
	  ○ Hydrograph summaries
	  ○ Pond summaries
	  ○ Hydrologic modeling input files, if applicable
	• Pipe capacity calculations

The following items are required, but may be included in the PCSMP Report or submitted separately as part of the PCSMP Review Phase Submission Package.

PCSMP Report Section*	Requirements
Drainage Area Plan(s)	• Predevelopment and post-development drainage areas (including any off-site area) • Location of point(s) of analysis (POA) • Pertinent existing stormwater infrastructure necessary to define existing drainage conditions
Inlet Drainage Area Plan	• Predevelopment and post-development inlet drainage area delineations (including any roof leaders) • Calculated areas of drainage and time of concentration to each inlet • Impervious and pervious cover and runoff coefficients within each drainage area
PWD Stormwater Plan Review Online Technical Worksheet ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-3/3-4-how-to-show-compliance/#Worksheet	• PDF printout of completed Online Technical Worksheet. For submissions via the Project Dashboard on the PWD **Stormwater Plan Review** ☛ www.pwdplanreview.org website, a PDF is automatically generated and submitted.

Geotechnical Report	• Signed and sealed by a Professional Engineer • Detailed description of testing procedure and materials/apparatus used • Weather information at time of testing and previous 24 hours (temperature, rainfall, etc.) • Engineer's analysis and summary of all results including soil classification (in accordance with ASTM D2488) and site evaluation • Engineer's affirmative or negative recommendation on feasibility of infiltration, with justification • Infiltration Testing and Soil Characterization Plan (including, but not limited to, topographic/existing features of the site showing location of test pits/borings and infiltration tests) • Field boring/test pit logs for soil profiling • Infiltration Testing Log (Appendix H provides a template, which shows minimum level of information that must be provided) • Sieve analysis results per ASTM D422-63,down to No. 200 sieve, and USCS classification per ASTM D2487 of each sample • Photographs of testing
Media Filter Design Documentation ☛ water.phila.gov/development/resources/#media-filter	• Inflow and outflow event mean concentrations and percent removals for Total Suspended Solids (TSS) for sand/media filters (Designs must demonstrate a maximum effluent event mean concentration of 15 milligrams per liter for TSS at a POA downstream of the SMP) • Third-party certifications for proprietary media filters • Hydrologic and hydraulic model files, if applicable • Product specifications for proprietary media filters • Manufacturer's guidelines for installation for proprietary media filters • Construction sequence • Maintenance requirements, including product life and replacement schedule, if applicable
Low Flow Device Design Documentation ☛ water.phila.gov/development/resources/#low-flow	• Performance/discharge curves • Third-party certifications • Hydrologic and hydraulic model files, if applicable • Product specifications • Manufacturer's guidelines for installation • Construction sequence • Maintenance requirements, including product life and replacement schedule, if applicable

SMP Maintenance Guide (Appendix G) ☛ p. 105	• SMP Maintenance Guide Introduction
	  ▪ Customized, from the third page of the SMP Maintenance Guide Information document provided in Appendix G, to be site-specific
	  ▪ Provides under its cover an SMP Maintenance Guide Site Map and SMP Maintenance Schedule Forms
	• SMP Maintenance Guide Site Map
	  ▪ Identifies the on-site SMPs and key SMP-related features which require maintenance, using unique, legible, labels, and provides a list of structures and SMP-related features, identifying the associated SMP(s) for each
	  ▪ Includes a Color Legend that adheres to the Color Legend provided in the SMP Maintenance Guide document provided in Appendix G
	  ▪ Sized 11” x 17” (Multiple sheets may be used, if necessary)
	  ▪ Consistent in format with the SMP Maintenance Guide Sample’s Site Map, provided in Appendix G
	• SMP Maintenance Schedule Forms
	  ▪ Customized from the templates provided in Appendix G to be site-specific for each proposed SMP
	  ▪ Provide for inspection of each SMP and SMP-related structure, including routine maintenance, repair, and replacement
	  ▪ Provide for a report documenting each inspection and all SMP maintenance activities performed as a result of the inspections

Construction Certification Package with Customized SMP Construction Certification Forms (Appendix J) ☛ p. 111	• One site-specific SMP Construction Certification Form for each SMP

Proof of Applicable State and/or Federal Permits	• Typical permits (as applicable):
	  ▪ Pennsylvania Code and Charter Chapter 102 NPDES National Pollutant Discharge Elimination System Phase II Permit for Construction Activities
	  ▪ Pennsylvania Code and Charter Chapter 105: Water Obstruction and Encroachment General and Joint Permits
	  ▪ Other applicable permits (Sections 2.5, 2.6, and 2.7 provide resources to assist in determining which permits may apply)
	• Proof of issuance is required for PWD sign-off on a Building Permit; however, the applicant must only prove that they have applied for all applicable permits via copies of permit applications, application receipts, or notification letters from relevant agencies
	• For Pennsylvania Land Recycling Program (Act 2) sites, proof of notice to PA DEP for both an intent to remediate and notification of work to an existing Act 2 site is required

**The PCSMP Report section divisions/organization listed are not required, but are provided by PWD to aid the applicant in organizing the required inclusions in the PCSMP Report.*

Table E-8: Record Drawing Requirements

Record Drawing Requirements ☛ water.phila.gov/wp-content/uploads/files/record-drawing-requirements.pdf

#	Requirement
1	General plan presentation requirements listed in Table E-1 (The preparer of the Record Drawing(s) must prominently display their signature and professional seal, or, in the case of Licensed Contractors, their signature, printed name, business title, company name, and City of Philadelphia Department of Licenses and Inspections Contractor License Number, all of which must be clearly labeled, on each Record Drawing plan sheet.)
2	Labeling on each document as “Project Record” with large, red letters
3	Record Drawing drafting date on each sheet
4	Drawing scale of 1”=50’ or less
5	Information confirmed to be in accordance with the Approved Post-Construction Stormwater Management Plan (PCSMP) highlighted in yellow
6	Information that deviates from the Approved PCSMP highlighted in red
7	Benchmark elevation, description, and location on each plan sheet
8	Horizontal variations greater than one foot shown dimensionally or through stations
9	Vertical elevation variations greater than 0.1 feet shown for all design elevations shown
10	Locations of all proposed stormwater management practices (SMPs) in plan view
11	Distance from lot lines to the constructed SMPs
12	Locations of utilities
13	Spot grade elevations and/or contour lines at one-foot intervals
14	Stormwater flow direction arrows
15	Elevations across dam embankments
16	Elevations at the top of risers
17	Elevations at the invert and rim of all orifice openings in risers and control structures
18	Elevations across emergency spillways
19	Elevations across the bottom of ponds (excluding wet ponds)
20	Elevations for of all inlet and outlet controls
21	Elevations at inverts of all pipes, swales, and drains
22	Measurements and invert elevations for all orifices, weirs, and other flow control devices
23	Pipe and culvert material, length, size, and slope, inlet and outlet locations, and rim and invert elevations
24	Information for any energy dissipation measures
25	Drainage areas for each SMP, if they differ from the Approved PCSMP
26	Detail or cross-section of each SMP with all pertinent elevations labeled

F. Design Guidance Checklists

The Philadelphia Water Department's Stormwater Plan Review Design Guidance Checklists contained in Appendix F are a supplemental list of guidelines for regulatory compliance, plan creation, hydrologic modeling and calculations, and the design of specific stormwater management practices. They are provided to assist in the formation of both sound, compliant stormwater management designs and complete Post-Construction Stormwater Management Plan (PCSMP) submissions. The designer should use the checklists as guidance during the design and calculation stages or as useful quality assurance/quality control checks prior to PCSMP Review Phase submission.

- **F.1 Stormwater Regulation Compliance** ☛ p. 29
- **F.2 Post-Construction Stormwater Management Plan** ☛ p. 31
- **F.3 Erosion and Sediment Control** ☛ p. 38
- **F.4 Disconnected Impervious Cover** ☛ p. 41
- **F.5 Infiltration Testing and Soil Assessment** ☛ p. 44
- **F.6 Hydrologic Model and Calculation Methods** ☛ p. 47
- **F.7 Bioinfiltration/Bioretention** ☛ p. 50
- **F.8 Porous Surfaces** ☛ p. 55
- **F.9 Green Roofs** ☛ p. 59
- **F.10 Subsurface Infiltration** ☛ p. 63
- **F.11 Cisterns** ☛ p. 67
- **F.12 Blue Roofs** ☛ p. 70
- **F.13 Ponds and Wet Basins** ☛ p. 72
- **F.14 Subsurface Detention** ☛ p. 74
- **F.15 Media Filters** ☛ p. 78
- **F.16 Pretreatment** ☛ p. 82
- **F.17 Inlet Controls** ☛ p. 84
- **F.18 Outlet Controls** ☛ p. 86
- **F.19 Landscaping** ☛ p. 95
- **F.20 Blue-Green Roofs** ☛ p. 97
- **F.21 Drainage Wells** ☛ p. 101

F.1 Stormwater Regulation Compliance

F.1.1 Water Quality

1. Infiltrating projects
    a. Verify that all DCIA within the project's limits of earth disturbance is routed to an SMP. [Section 1.2.1; Section 3.4.1]
    b. Verify infiltration of the Water Quality Volume from all DCIA within the limits of earth disturbance. This is achieved by providing static storage of the Water Quality Volume below the lowest outlet elevation of each SMP. [Section 3.4.1]
    c. Verify that the SMP drains within the acceptable 72-hour period after the 24-hour storm event. [Section 1.2.1; Section 3.4.1]
2. Non-infiltrating projects located in Combined Sewer Areas
    a. Verify that 100% of the Water Quality Volume is routed through an acceptable pollutant-reducing practice. Refer to Table 3.1-3 of the Manual for reference. [Section 1.2.1; Section 3.4.1]
    b. Verify that the hydrologic calculations include routing of the Water Quality storm event. [Section 1.2.1; Section 3.4.1]
    c. Verify that the release rate for the Water Quality Volume does not exceed 0.05 cfs per acre of DCIA. [Section 1.2.1; Section 3.4.1]
    d. Verify that the SMP drains within the acceptable 72-hour period after the 9-hour storm event. [Section 1.2.1; Section 3.4.1]
3. Non-infiltrating projects not located in Combined Sewer Areas
    a. Verify that 100% of the Water Quality Volume is routed through an acceptable pollutant-reducing practice. Refer to Table 3.1-3 of the Manual for reference. [Section 1.2.1; Section 3.4.1]
    b. Verify that the SMP drains within the acceptable 72-hour period after the 24-hour storm event. [Section 1.2.1; Section 3.4.1]

F.1.2 Channel Protection

1. Verify if the Channel Protection requirement is applicable.
    a. The project is exempt from Channel Protection if it is a Redevelopment project with less than one acre of earth disturbance. [Section 1.2.1]
    b. The project is exempt from Channel Protection if it is a Redevelopment project which reduces impervious area within the limits of earth disturbance (excluding public right-of-way) by at least 20%, based on a comparison of predevelopment impervious area to post-development DCIA. [Section 1.2.1]
    c. The project is exempt from Channel Protection if it is a Redevelopment project located in the Delaware Direct Watershed or that discharges to the Lower Schuylkill River, Manayunk Canal, or Mingo Creek. [Section 1.2.1]
2. Verify that runoff from all DCIA, within the project's limits of earth disturbance, for the one-year, 24-hour storm event is released at a maximum rate of 0.24 cfs per acre of DCIA in no more than 72 hours. [Section 1.2.1; Section 3.4.1]

F.1.3 Flood Control

1. Verify if the Flood Control requirement is applicable.
    a. The project is exempt from Flood Control if it is a Redevelopment project that reduces impervious area within the limits of earth disturbance (excluding public right-of-way) by at least 20%, based on a comparison of predevelopment impervious area to post-development DCIA. [Section 1.2.1]
    b. The project is exempt from Flood Control if it is a Redevelopment project located in Flood Management District C that discharges directly to the Delaware Direct or Lower Schuylkill main channels without the use of City infrastructure. [Section 1.2.1]
    c. The project is exempt from Flood Control if it is a Redevelopment project located in District C-1 that discharges directly to the Tookany/Tacony-Frankford main channel or major tributaries without the use of City infrastructure. This exemption applies only to peak rates of runoff for storm events greater than the five-year storm. [Section 1.2.1]
    d. The project is exempt from Flood Control if it is a Redevelopment project located in the Delaware Direct Watershed or that discharges to the Lower Schuylkill River, Manayunk Canal, or Mingo Creek, but situated outside of District C, that can discharge directly to the Delaware Direct or Lower Schuylkill main channels without the use of City infrastructure. [Section 1.2.1]
2. Verify that the project meets or reduces peak rates of runoff, as determined by its Flood Management District, from predevelopment to post-development conditions during certain storm events. Refer to Table 3.4-1 of the Manual for reference. [Section 1.2.1; Section 3.4.1]

F.1.4 Public Health and Safety Release Rate

1. If a Public Health and Safety (PHS) release rate applies to the project, verify that, for all areas within the project's limit of earth disturbance (pervious and impervious, alike), the post-development peak runoff release rate does not exceed the project-specific PHS Release Rate requirement (cfs per acre of limit of disturbance) when routing the one-year through ten-year, 24-hour storm events. [Section 1.2.1]

F.1.5 Expedited PCSMP Reviews

1. Disconnection Green Review
    a. Verify that the project is a Redevelopment project that is exempt from the Channel Protection and Flood Control requirements. [Section 2.4.1]
    b. Verify that 95% or more of the post-construction impervious area within the project's limits of earth disturbance is disconnected in accordance with Section 3.1.5. [Section 2.4.1]
    c. Verify that the project's intent to qualify for a Disconnection Green Review is indicated on the submitted ERSA Application. [Section 2.4.1]
2. Surface Green Review
    a. Verify that 100% of post-construction impervious area within the project's limits of earth disturbance is managed by disconnected impervious cover (DIC), bioinfiltration/bioretention basins, and/or blue-green roofs. [Section 2.4.2]
    b. Verify that the project's intent to qualify for a Surface Green Review is indicated on the submitted ERSA Application. [Section 2.4.2]
    c. Verify that the project is not proposing to use Stormwater Management Trading as a compliance strategy. [Section 2.4.2]

F.2 Post-Construction Stormwater Management Plan

F.2.1 PCSMP drawings

1. General
   a. Verify that all plans meet all of the PWD general plan sheet requirements listed in Appendix E, Table E-1. [Section 2.3.1]
   b. Verify that all plans meet, at minimum, all of the Conceptual Stormwater Management Plan requirements listed in Appendix E, Table E-3. [Section 2.3.1]
   c. Verify that all plans, reports, and calculations are signed and sealed by a Professional Engineer licensed in the Commonwealth of Pennsylvania. [Section 2.3.1; Appendix E, Table E-1]
   d. Verify that final plans for construction are provided for the project. Only Final Construction Drawings will be considered for PCSMP Approval by PWD Stormwater Plan Review. [Section 2.3.1]
   e. Verify that a north arrow, legend, and scale are provided on plans. [Appendix E, Table E-1]
   f. Verify that the proposed building footprint is labeled. [Appendix E, Table E-1]
   g. Verify that all acronyms and symbols are identified in the plan legends. [Appendix E, Table E-1]
   h. Verify that the plan legend is consistent with the plan view. [Appendix E, Table E-1]
   i. Verify that all plan drawings are legible. [Section 2.3.1; Appendix E, Table E-1]
2. Existing Conditions Plan
   a. Verify that the Existing Conditions Plan meets all of the PWD general plan sheet requirements listed in Appendix E, Table E-1. [Section 2.1.1]
   b. Verify that the Existing Conditions Plan meets all of the specific requirements for Existing Conditions Plans listed in Appendix E, Table E-2. [Section 2.1.1]
   c. Verify that the locations of all existing active and abandoned utilities (water, sewer, stormwater), including SMPs above and below ground, within 25 feet of the LOD are clearly labeled on the Existing Conditions Plan. The distance between existing SMPs to remain and the LOD must be at least ten feet. [Appendix E, Table E-2; Appendix E, Table E-4]
3. Details
   a. Verify that construction details are provided for all stormwater management practices. [Section 2.3.1]
   b. Verify that a pipe connection detail is provided for the proposed connection(s) to the existing storm sewer(s). [Section 3.4.2]
   c. Verify that dimensions of the proposed outlet control structure are provided. [Section 4.12.1, 6]

4. Drainage Area Plans
    a. Verify that drainage boundaries are based on site topography and include the entire tributary area, including any off-site drainage, if applicable. [Section 3.4.1; Appendix E, Table E-7]
    b. Verify that common points of analysis are chosen to compare predevelopment and post-development conditions. [Section 3.4.1; Appendix E, Table E-7]
    c. Verify that points of analysis are clearly labeled on the plans and in the stormwater model. [Section 3.4.1; Appendix E, Table E-7]
    d. Verify that pertinent existing stormwater infrastructure necessary to define the existing drainage conditions, including roof leaders, is shown. [Appendix E, Table E-7]
    e. Verify that the inlet drainage area for each inlet, trench drain, yard drain, and/or area drain is indicated on the plans and that the following information is clearly labeled and accurate for each area: [Appendix E, Table E-7]
        i. Inlet drainage area
        ii. Inlet time of concentration
        iii. Impervious and pervious cover within each inlet drainage area
        iv. Runoff coefficient
    f. Verify that the roof drainage area for each roof leader is indicated on the plans. [Appendix E, Table E-7]
    g. Verify that boundaries and square footages of Stormwater Management Banking or Trading areas, if proposed, are clearly identified on the plans. [Section 3.2.4]
    h. Verify that boundaries and square footages of fee in lieu areas, if proposed, are clearly identified on the plans. [Section 3.4.1]
    i. Verify that Small Residential Development areas, if proposed, are clearly identified on the plans. [Section 2.3.1]
        i. Verify that the number of dwelling units for proposed residential buildings is provided.
        ii. Verify that the footprints of any buildings used exclusively as one- or two-family dwellings are provided.
        iii. Verify that boundaries and square footages of Small Residential Development areas are provided.

F.2.2 Grading design

1. Verify that the proposed grading is provided. [Section 2.3.1]
    a. Verify that there is positive slope away from the proposed buildings.
    b. Verify that proposed contours are closed or tie into the existing contours at the limit of earth disturbance.
    c. Verify that spot grades are provided as necessary.
2. Verify that all DCIA within the project's limit of earth disturbance is captured, especially at the site's ingress and egress areas. [Section 1.2.1; Section 3.4.1]

F.2.3 Utilities and storm sewer design

1. Verify that the length, material, size, and slope of all piping associated with stormwater conveyance and roof drainage systems are clearly labeled on the plans. [Section 3.4.2]
2. Verify that pipe lengths, slopes, and inverts are accurate. Compare pipe information to profiles, if provided, for consistency. [Section 3.4.2]
3. If roof runoff isolation is proposed as a non-infiltrating pollutant-reducing practice, verify that the runoff discharges into a combined sewer and that the runoff is routed from a non-vehicular roof area that is not commingled with untreated runoff. [Section 3.1.7]
4. Verify that no piping conflicts exist. [Section 3.4.2]
5. Verify that inlets are not connected in series. Wye connections, or similar, may be used to ensure that inlets are offline. [Section 3.4.2]
6. Verify that roof drainage systems do not tie directly into an inlet. [Section 3.4.2]
7. Verify the separation distance between all utility crossings. A minimum of 12 inches of vertical clearance is required when a sanitary sewer line crosses above a storm sewer line. The sanitary sewer must be encased in concrete if the clearance is less than 12 inches. [Section 3.4.2]
8. Verify that any manholes between outlet structures and sewer connections in combined sewer areas have sanitary (non-vented) covers. [Section 3.4.2]
9. Verify that a cleanout is provided, at minimum, every 100 feet, at the end of all pipes, and for all 90-degree pipe bends in the storm sewer system and that a cleanout detail is provided on the plans. [Section 3.4.2]
10. If curb cuts or non-standard inlets are used to capture runoff, especially from driveways or roadways where the inlets are not in a sump condition, verify that the one-year, 24-hour storm event will be captured by the inlet. [Section 3.4.2]
11. Verify that the invert elevation(s) for the proposed connection(s) to the existing City sewer is/are specified. [Section 3.4.2]
12. Verify that the outlet culvert(s) is/are right-sized to minimize impacts on PWD infrastructure. [Section 3.4.2]
13. Verify that all stormwater conveyance pipe material is in compliance with the City of Philadelphia Plumbing Code (Plumbing Code). [Section 3.4.2]
14. Verify that a minimum cover of 36 inches is provided over all private storm sewer pipes, in accordance with the Plumbing Code. [Section 3.4.2]
15. Verify that stormwater conveyance pipes are designed with a minimum velocity of two feet per second. Designs should attempt to maintain velocity without sacrificing SMP depth. [Section 3.4.2]
16. Verify that all proposed connections to the City sewer are right-sized to convey the necessary flow while minimizing the pipe diameter. [Section 3.4.2]
17. Verify that all proposed connections to the City sewer will be inspected by PWD Water Transport Records. Instructions for obtaining a sewer connection permit can be found on the **Water & Sewer Permits page** ☛ water.phila.gov/development/connections/permits. Refer to Section 2.5 for more information on Water Transport Records. [Section 3.4.2]
    a. Verify that commercial buildings and residential buildings with four or more stories have separate fire service connections.
    b. Verify that any sewer or water connection is made directly to the pipe and not directly to a manhole or street inlet.

c. Verify that any sewer or water connection is made perpendicular to the pipe to which the connection is proposed.

d. Verify that any sewer or water connection is smaller in diameter than the PWD pipe to which the connection is proposed. The minimum allowable sanitary sewer pipe diameter is 5 inches, and the minimum allowable storm and combined sewer pipe diameter is 6 inches.

e. Verify that all PWD sewer and water mains to which connections are proposed are labeled with correct sizes and materials.

f. Verify that, for MS4 separate sewer areas, sanitary sewer connections are made for sanitary laterals and storm sewer connections are made for storm sewer conveyance.

g. Verify that for combined sewer areas, sanitary and storm sewer piping is kept separate. A fresh air inlet must be proposed on each pipe.

h. Verify that connections are made to an active sewer or water main.

i. Verify that connections are not made to an intercepting sewer or transmission main.

j. Verify that connections are not made to a private sewer or water main or to existing lateral on an adjacent property.

k. Verify that no structures, private drainage infrastructure (e.g., inlets, pipes, manholes, SMPs, etc.), or vertical encroachments are proposed within any public or drainage right-of-way.

l. Verify that only RCP or rigid pipe connections are made to PWD infrastructure. Plastic pipe connections are not permitted.

m. Verify that any sanitary lateral connection to a sanitary-only public sewer is smaller in diameter than the house drain and is in no case less than 5 inches in diameter.

n. Verify that any stormwater lateral is no smaller than 6 inches in diameter.

o. Verify that any combined sanitary and stormwater lateral is no smaller than 6 inches in diameter.

18. Verify that at least two feet of clearance between the bottom of the SMP and the crown of the City sewer pipe, and/or a backflow prevention device, is provided to alleviate potential flooding from the City sewer which is regularly at full capacity. [Section 3.4.2]

19. Verify that Private Cost plans are submitted to the PWD Design Branch for review, if applicable. Refer to Section 2.5 for more information on Private Cost project requirements. [Section 2.5]

    a. Verify that all Private Cost work (i.e., extensions of PWD infrastructure, such as new sewer or water mains) or modifications to existing infrastructure (i.e., moving inlets, fire hydrants, etc.) are labeled on the plans.

    b. Verify that all PWD pipes to be abandoned are properly labeled on the plans.

    c. Verify that all City streets or drainage rights-of-way to be abandoned are properly labeled on the plans.

    d. Verify that all laterals and proposed Private Cost sewer or water mains are designed to flow by gravity.

20. Verify that a copy of the plans is submitted to the Department of Licenses and Inspections (L&I) for review if the project proposes an oil/water separator. Refer to Section 2.6 for more information on L&I permitting. [Section 2.6]

21. Verify that stormwater conveyance piping and SMPs are not receiving runoff from fueling station pads for gas stations. The drainage area under a pad's canopy must be treated by an oil/water separator then discharge directly to the sanitary sewer system. [Section 3.4.2]

22. Verify that any project which proposes stormwater conveyance piping or SMPs that encroach onto an adjacent property has obtained a drainage easement. [Section 3.4.2]
23. Verify that any abandoned length of sewer within 20 feet of the boundaries of a proposed SMP is proposed to be either removed or filled with controlled density fill (flowable fill) and bulkheaded and meet the following specifications. [Section 3.4.2]
    a. Class F Fly Ash Slurry Backfill with a maximum compressive strength of 75 psi should be used for flowable fill, in accordance with the PennDOT Specification Publication 408, 2001, or latest revision, for flowable backfill, non-structural.
    b. The open ends of sewers to be abandoned must be sealed with a bulkhead, consisting of nine-inch-thick brick masonry with non-shrink grout.
    c. When an existing storm sewer is rerouted for connection to a proposed SMP (inflow) or a proposed SMP is connecting to an existing sewer (outflow), an anti-seep collar (either a prefabricated anti-seep collar or bentonite clay trench dam) must be provided along the proposed storm sewer pipe.
24. Verify that any abandoned sewer inlet connection is proposed to be cut and capped at least five feet from the exterior of the inlet and meet the following specifications. [Section 3.4.2]
    a. A foam debris plug must be installed six to 12 inches into the exposed end of the abandoned storm sewer lateral.
    b. The abandoned lateral must be filled with concrete behind the plug, to form a concrete bulkhead.
25. Verify that the distance between any active length of building sewer, private sewer, or public sewer and the boundaries of a proposed SMP is at least 20 feet from the outside of the pipe, unless vertical clearance is provided between the bottom of the sewer and the top of the SMP. It is acceptable for SMPs to be located directly adjacent to the public right-of-way (ROW). [Section 3.4.2]
26. Verify that the distance between any active inlets or laterals, whether publicly or privately owned, and the boundaries of a proposed SMP is at least ten feet from the outside of the structure or pipe, unless the inlets or laterals drain to the SMP. It is acceptable for SMPs to be located directly adjacent to the public ROW. [Section 3.4.2]
27. Verify that, for all pipes entering or exiting the proposed SMP storage media, an anti-seep collar (either a prefabricated anti-seep collar or bentonite clay trench dam) is provided and is sufficiently sized and distanced from the edge of the storage media, where space allows, to prevent water from traveling along the outside of the pipes. [Section 3.4.2]
28. If an existing SMP, above or below ground, is located within 25 feet of the LOD and proposed to remain, verify that the applicant has provided an affirmative statement confirming there will not be a conflict between the existing SMP and the proposed design shown on the plans. [Appendix E, Table E-5]

F.2.4 PCSMP Report

1. Verify that the PCSMP Report meets all of the specific PCSMP Report requirements listed in Appendix E, Table E-7. [Section 2.3.1]
2. Verify that the PCSMP Report is signed and sealed by a Professional Engineer licensed in the Commonwealth of Pennsylvania. [Section 2.3.1; Appendix E, Table E-7]
3. Verify that the PWD Stormwater Plan Review Online Technical Worksheet is completed, as necessary, and submitted with the PCSMP Review Phase Submission Package. [Section 3.4.1; Appendix E, Table E-7]

4. Operations and Maintenance Agreement
   a. Verify that a site-specific SMP Maintenance Guide is provided. [Section 6.1; Appendix E, Table E-7]
      i. Verify that an SMP Maintenance Guide Introduction is included.
         A. Verify that the introduction is customized, from the third page of the SMP Maintenance Guide Information document provided in **Appendix G** ☛ p. 105, to be site-specific.
         B. Verify that the introduction provides under its cover an SMP Maintenance Guide Site Map and SMP Maintenance Schedule Forms.
      ii. Verify that an SMP Maintenance Guide Site Map is included.
         A. Verify that the SMP Maintenance Guide Site Map identifies the on-site SMPs and key SMP-related features which require maintenance, using unique, legible, labels, and provides a list of structures and SMP-related features, identifying the associated SMP(s) for each.
         B. Verify that the SMP Maintenance Guide Site Map includes a Color Legend that adheres to the Color Legend provided in the SMP Maintenance Guide document provided in **Appendix G** ☛ p. 105.
         C. Verify that the SMP Maintenance Guide Site Map is sized 11” x 17”. (Multiple sheets may be used, if necessary.)
         D. Verify that the SMP Maintenance Guide Site Map is consistent in format with the SMP Maintenance Guide Sample’s Site Map, provided in **Appendix G** ☛ p. 105.
      iii. Verify that a site-specific SMP Maintenance Schedule Form is included for each proposed SMP and SMP-related structure, using the templates provided in **Appendix G** ☛ p. 105.
         A. Verify that each schedule is customized from the templates provided in **Appendix G** ☛ p. 105 to be site-specific for each proposed SMP and SMP-related feature.
         B. Verify that each schedule provides for inspection of the SMP or SMP-related structure, including routine maintenance, repair, and replacement.
         C. Verify that each schedule provides for a report documenting each inspection and all SMP maintenance activities performed as a result of the inspections.
   b. Verify that the “Operations and Maintenance Agreement Information” section of the Online Technical Worksheet is completed. [Section 2.3.1; Appendix E, Table E-7]
      i. Verify that the listed property owner is consistent with the property owner named in Public Records.
      ii. Verify that the business title of the provided signatory is appropriate to the property owner business entity.
      iii. Verify that a legal description of the property is provided in an electronically editable (Word document) format.
   c. Verify that a copy of the Agreement of Sale, or similar documentation, is provided to demonstrate the current owner’s intent to convey the property to the developer, if applicable.
   d. Verify that documentation supporting a lot consolidation or subdivision plan is provided to demonstrate the intent to change the address of the current property, if applicable.

5. Construction Certification Package
    a. Verify that a site-specific SMP Construction Certification Form is provided for each proposed SMP, customized by the project's design professional and to be completed by a registered professional during construction. [Section 5.3.1; Appendix E, Table E-7]
    b. Verify that each SMP Construction Certification Form is customized to adequately record and verify all required measurements that are most critical to the listed SMP's ability to perform its designed function (e.g., elevations, outlet control sizes, surface areas, layer depths, etc.) [Section 5.3.1]
6. Verify that proof of application for applicable State and Federal permits is submitted with the PCSMP Review Phase Submission Package. This can be in the form of copies of permit applications, application receipts, or notification letters from relevant agencies. Applicable State permits include, but are not limited to, a PA DEP NPDES Permit if one acre or more of earth disturbance activity is proposed. [Section 2.3.1; Appendix E, Table E-7]
7. Verify that a discussion on proposed Stormwater Management Banking and Trading is provided, if applicable. [Section 3.2.4; Appendix E, Table E-7]
    a. Verify that the type of Stormwater Management Banking or Trading proposed is provided.
    b. Verify that a description of the area(s) proposed to be banked or traded is provided.
    c. Verify that the square footage(s) of area(s) proposed to be banked or traded is provided.
    d. Verify that justification for the proposed bank or trade, including reasons why management of the required area(s) is not feasible and why PWD may benefit from the proposal, is provided.
8. Verify that a discussion on proposed fee in lieu is provided, if applicable. [Section 3.4.1; Appendix E, Table E-7]
    a. Verify that the square footage(s) of area(s) for proposed fee in lieu is provided.
    b. Verify that all Water Quality stormwater management strategies considered and rejected are outlined.
    c. Verify that justification for the proposed fee in lieu, including reasons why all considered stormwater management strategies are not feasible or advisable, is provided.

F.3 Erosion and Sediment Control

F.3.1 E&S Plans

1. Verify that the E&S Plans meet all of the E&S Plan requirements listed in Appendix E, Table E-4. [Section 2.3.1]
2. Verify that the E&S Plans include all standard E&S notes listed in Appendix E, Table E-5. [Section 2.3.1]
3. Verify that the boundaries of, and total area encompassed by, the limit of earth disturbance are clearly indicated on the plans and that the area is consistent with the area provided on the PWD Stormwater Plan Review Online Technical Worksheet. [Section 2.3.1; Appendix E, Table E-4]
4. Verify that the limit of disturbance includes all off-site storm and utility connections. [Appendix E, Table E-4]
5. If a PA DEP NPDES Permit has not been applied for, verify that the limit of disturbance remains less than one acre. Site disturbance limits within approximately 10% of one acre are more likely to reach or exceed one acre during construction. Therefore, PWD recommends applying for a PA DEP NPDES Permit in such a situation. Should a site inspection reveal more than one acre of earth disturbance, the site will be required to apply for a PA DEP NPDES Permit. The site will be subject to the enforcement actions outlined in the Stormwater Regulations until the applicant receives an approved NPDES Permit. [Section 2.3.1]
6. Verify that soil compaction has been minimized, even in areas not proposed for infiltration SMPs, to the extent practicable. [Section 5.2.2]
7. Verify that the E&S Plans propose, in plan view, the location of any orange construction fence or silt fence proposed to protect and mark infiltration areas. [Section 5.2.2]
8. Verify that inlet protection is provided for all inlets owned by PWD that are located within one block of the project site on the plans. [Appendix E, Table E-5]
9. Verify that the E&S Plans propose silt fence and/or compost filter sock along all downward-sloping areas of the project site's perimeter. [Appendix E, Table E-4]
10. Verify that any proposed stockpile locations are clearly labeled on the plans. [Appendix E, Table E-4]
11. Verify that the E&S Plans propose silt fence surrounding any proposed stockpile areas. [Appendix E, Table E-4]
12. Verify the dimensions of the rock construction entrance. The minimum length is 50 feet, and the minimum width is 20 feet. [Appendix E, Table E-4]
13. Verify that the rock construction entrance is not located on top of any proposed infiltration practice. It may be necessary to phase the erosion and sediment control plan to avoid compaction of the infiltration area. [Section 5.2.2]
14. Verify that the E&S Plans propose tree protection fencing around existing trees that are proposed to remain and be used for tree disconnection credit. [Appendix E, Table E-4]
15. When compost filter socks are placed on paved surfaces, verify that the E&S Plans indicate that some objects of considerable mass (i.e. concrete blocks, sand bags, etc.) are to be used immediately downslope of the socks (at the same intervals as recommended by the sock manufacturer for stakes) in order to help hold them in place. [Appendix E, Table E-5]
16. Verify that the E&S Plans propose a concrete washout station. [Appendix E, Table E-4]
17. Verify that the E&S Plans propose dust control measures appropriate to the project. Refer to the City of Philadelphia Department of Public Health Air Management Services *Construction/Demolition/Earthworks Dust Control Requirements FAQ* for guidance. [Appendix E, Table E-4]

18. Verify that the E&S Plans propose, in plan view, orange construction fencing or silt fencing around any existing SMPs, above and below ground, within 25 feet of the LOD. The distance between existing SMPs to remain and the LOD must be at least ten feet. [Appendix E, Table E-4]

F.3.2 Sequence of construction

1. Verify that the E&S Plans include all standard sequence of construction notes listed in Appendix E, Table E-6. [Section 2.3.1]
2. Verify that sequences of construction are provided for both overall construction and the construction of each proposed individual SMP. [Section 2.3.1]
3. Verify that the sequence of construction properly identifies all stages of SMP construction for which a registered professional must document the specific elevations and measurements found on the SMP Construction Certification Form(s) within the Construction Certification Package. [Section 5.3.1]
4. For soil amendments, verify that the following sequence of construction is clearly noted on the plans. [Section 3.3.6]
    a. Excavate two feet below the proposed infiltration bed invert elevation.
    b. Manually grade and scarify the existing soil surface. The bottom of the infiltration bed shall be at a level grade. The existing subgrade shall not be compacted or subject to excessive construction equipment.
    c. Place geotextile filter fabric immediately after approval of subgrade preparation in accordance with manufacturer's standards and recommendations.
    d. Amend in-situ soil. [Provide instructions for amending the in-situ soil. Soil amendment media can include compost, mulch, manures, sand, and manufactured microbial solutions.] The project geotechnical engineer should be on-site to observe installation of soil amendments.
    e. Place two feet of amended soil across the entire cross-section of the infiltration bed. Lightly compact each layer with light equipment, keeping equipment movement over storage bed subgrades to a minimum.
    f. Perform infiltration testing of the amended soil layer. A minimum of three infiltration tests must be performed within the amended soil layer. The procedure used must be the double-ring infiltrometer test, soil sampling and characterization are also required, and all must be in compliance with the current Philadelphia Stormwater Management Guidance Manual. Prior to infiltration testing, PWD must be called (office: (215) 685-6387) to schedule an observation. The engineer must provide a signed and sealed Geotechnical Report. All information must be submitted to PWD for review and approval before proceeding with construction. If soil amendments are installed, and the tested infiltration rate is determined to be outside of the PWD allowable range of 0.4 to ten inches per hour or varies significantly from the design infiltration rate, additional soil amendments and/or a system redesign will be required. Once the infiltration test results are reviewed and determined by PWD to be acceptable, proceed with installation of the infiltration practice.
    g. Soil amendments shall not be compacted or subject to excessive construction prior to the placement of geotextile and stone bed.
    h. Place geotextile and infiltration bed aggregate immediately after approval of soil amendment preparation to prevent accumulation of debris and sediment. Prevent runoff and sediment from entering the storage bed during the placement of the geotextile and aggregate bed.
    i. Place geotextile in accordance with manufacturer's standards and recommendations. Adjacent strips of filter fabric shall overlap a minimum of 16 inches. Fabric shall be secured at least four feet outside of bed.

j. Install aggregate course in lifts of six to eight inches. Lightly compact each layer with light equipment, keeping equipment movement over storage bed subgrades to a minimum. If proposed, install storage structures (e.g., pipes, arches, crates, etc.) during stone bed placement. Install aggregate to grades indicated on the drawings.

k. Complete surface grading above subsurface infiltration system, using suitable equipment to avoid excess compaction.

F.3.3 E&S details

1. Verify that an inlet protection detail is provided on the plans. Verify that appropriate inlet protection details are provided for inlets in the public right-of-way. For roadways maintenance purposes, PWD does not allow inlet protection that includes stone or berms to be used in the public right-of-way. [Section 2.3.1; Appendix E, Table E-4]
2. Verify that details for silt fence and/or compost filter socks are provided on the plans. Refer to Standard Details #4-1 and 4-7 through 4-10 of the *PA DEP Erosion and Sediment Pollution Control Program Manual* (2012 or latest) for guidance. [Section 2.3.1; Appendix E, Table E-4]
3. Verify that a rock filter outlet detail is provided on the plans. Refer to Standard Detail #4-6 of the *PA DEP Erosion and Sediment Pollution Control Program Manual* (2012 or latest) for guidance. [Section 2.3.1; Appendix E, Table E-4]
4. Verify that a rock construction entrance detail is provided on the plans. Refer to Standard Details #3-1 and 3-2 of the *PA DEP Erosion and Sediment Pollution Control Program Manual* (2012 or latest) for guidance. [Section 2.3.1; Appendix E, Table E-4]
5. Verify that a pumped water filter bag detail is provided on the plans. Refer to Standard Detail #3-16 of the *PA DEP Erosion and Sediment Pollution Control Program Manual* (2012 or latest) for guidance. [Section 2.3.1; Appendix E, Table E-4]
6. Verify that a concrete washout station detail is provided on the plans. Refer to Standard Detail #3-18 of the *PA DEP Erosion and Sediment Pollution Control Program Manual* (2012 or latest) for guidance. [Section 2.3.1; Appendix E, Table E-4]
7. If riprap is proposed, verify that the E&S Plans include a riprap detail which shows that geotextile or filter stone is provided for erosion protection of the soil beneath the riprap. Refer to Standard Details #9-1 through 9-3 of the *PA DEP Erosion and Sediment Pollution Control Program Manual* (2012 or latest) for guidance. [Appendix E, Table E-4]

F.4 Disconnected Impervious Cover

F.4.1 Rooftop disconnection

1. Verify that any proposed rooftop disconnection is clearly labeled on the plan. [Section 3.4.1]
2. Verify that the contributing area of rooftop to each disconnected discharge is 500 square feet or less. [Section 3.1.5]
3. Verify that the soil of the pervious area is not designated as a hydrologic soil group “D” or equivalent. [Section 3.1.5]
4. Verify that the overland flow path of the pervious area has a slope of 5% or less. [Section 3.1.5]
5. Verify the percentage of roof area being disconnected based on the flow length over pervious area. Refer to Table 3.1-2 of the Manual for appropriate DCIA reductions. [Section 3.1.5]
6. Verify consistency between the rooftop disconnection information provided on the plans and that which is provided on the PWD Stormwater Plan Review Online Technical Worksheet.

F.4.2 Pavement disconnection

1. Verify that any proposed pavement disconnection is clearly labeled on the plan. [Section 3.4.1]
2. Verify that the contributing flow path over the impervious surface is no more than 75 feet. [Section 3.1.5]
3. Verify that the length and width of overland flow over pervious areas is greater than, or equal to, the length and width of the contributing flow path over impervious pavement. [Section 3.1.5]
4. Verify that the overland flow is non-concentrated sheet flow over a vegetated area (flow through a swale is not eligible for pavement disconnection credit). [Section 3.1.5]
5. Verify that the soil of the pervious area is not designated as a hydrologic soil group “D” or equivalent. [Section 3.1.5]
6. Verify that the contributing impervious area has a slope of 5% or less. [Section 3.1.5]
7. Verify that the overland flow path of the pervious area has a slope of 5% or less. [Section 3.1.5]
8. If discharge is concentrated at one or more discrete points, verify that no more than 1,000 square feet discharges to any one point. In addition, an erosion control measure, such as a gravel strip, is required for concentrated discharges. Erosion control measures are not required for non-concentrated discharges along the entire edge of pavement; however, there must be provisions for the establishment of vegetation along the pavement edge and temporary stabilization of the area until vegetation becomes established. [Section 3.1.5]
9. Verify consistency between the pavement disconnection information provided on the plans and that which is provided on the PWD Stormwater Plan Review Online Technical Worksheet.

F.4.3 Tree disconnection credit

1. Existing tree disconnection credit
    a. Verify that any existing tree proposed to be used for disconnection is clearly labeled on the plan as such. [Section 3.4.1]
    b. Verify that the species of the existing trees proposed to be used for disconnection credit are provided and are not any of the invasive species included in **Appendix I** ☛ p. 107. [Section 3.1.5]
    c. Verify that the caliper sizes of the existing trees proposed to be used for disconnection credit are provided and at least four-inch caliper. [Section 3.1.5]
    d. Verify that the canopies of existing trees proposed to be used for disconnection credit are field measured. Alternatively, verify that an annotated aerial photo clearly showing the existing tree canopy limits is provided. [Section 3.1.5]
    e. Verify that only impervious area located directly under the canopy area of any existing tree proposed to be used for disconnection credit is being considered disconnected. [Section 3.1.5]
    f. Verify that overlapping existing tree canopy area is not counted twice toward disconnection credit. [Section 3.1.5]
    g. Verify that the DCIA reduction credit for both new and existing trees is no greater than 25% of the total ground-level impervious area, unless the width of the impervious area is less than ten feet. Up to 100% of narrow impervious areas (e.g., sidewalks and trails) may be disconnected through the application of tree credits. [Section 3.1.5]
    h. Verify consistency between the existing tree disconnection credit information provided on the plans and that which is provided on the PWD Stormwater Plan Review Online Technical Worksheet.
    i. Verify that the existing trees proposed to be used for disconnection credit are located outside of the public right-of-way. [Section 3.1.5]
2. New tree disconnection credit
    a. Verify that any new tree proposed to be used for disconnection is clearly labeled on the plan as such. [Section 3.4.1]
    b. Verify that the proposed species of the new trees are provided and found on **Table I-1** ☛ p. 110, the recommended and native non-invasive plant list, in **Appendix I** ☛ p. 107. [Section 3.1.5]
    c. Verify that the new trees are proposed to be planted within ten feet of ground-level impervious area, within the limits of earth disturbance, and outside of the public right-of-way. [Section 3.1.5]
    d. Verify that the caliper sizes of new deciduous trees are provided and at least two-inch caliper. [Section 3.1.5]
    e. Verify that the heights of new evergreen trees are provided and at least six feet tall. [Section 3.1.5]
    f. Verify that the 100-square foot DCIA reduction is being applied to the impervious area adjacent to the tree. [Section 3.1.5]
    g. Verify that overlapping 100-square foot DCIA reduction areas corresponding to adjacent new trees are not being counted twice toward disconnection credit. [Section 3.1.5]
    h. Verify that the DCIA reduction credit for both new and existing trees is no greater than 25% of the total ground-level impervious area, unless the width of the impervious area is less than ten feet. Up to 100% of narrow impervious areas (e.g., sidewalks and trails) may be disconnected through the application of tree credits. [Section 3.1.5]
    i. Verify consistency between the new tree disconnection credit information provided on the plans and that which is provided on the PWD Stormwater Plan Review Online Technical Worksheet.

F.4.4 Green roof

1. Verify that the green roof design meets all applicable Design Guidance Checklist standards noted in **Appendix F.9** ☛ p. 59, Green Roofs.
2. Verify consistency between the green roof disconnection area information provided on the plans and that which is provided on the PWD Stormwater Plan Review Online Technical Worksheet.

F.4.5 Porous surfaces

1. Verify that the porous surface design meets all applicable Design Guidance Checklist standards noted in **Appendix F.8** ☛ p. 55, Porous Surfaces.
2. Verify consistency between the porous surface disconnection area information provided on the plans and that which is provided on the PWD Stormwater Plan Review Online Technical Worksheet.

F.5 Infiltration Testing and Soil Assessment

F.5.1 Soil characterization

1. Verify that an Infiltration Testing and Soil Characterization Plan is provided with the submitted Geotechnical Report. [Section 3.3.1; Appendix E, Table E-7]
2. Verify that information on the soil stratum and groundwater for each SMP area is obtained and provided. The invert elevation of any infiltration SMP must be at least two feet above any limiting zone, such as groundwater, bedrock, or impermeable soils. [Section 3.3.2; Section 3.3.6; Appendix H]
3. For exploratory test pits, verify the following:
    a. For projects with 15,000 square feet or more of earth disturbance, verify that a minimum of two test pits are completed for each SMP footprint. For projects with less than 15,000 square feet of earth disturbance, verify that a minimum of one test pit is completed for each SMP footprint. [Section 3.3.2]
    b. Verify that at least one test pit for each SMP is excavated to a minimum depth of four feet below the proposed infiltration interface of the SMP, which is the lowest elevation where infiltration is proposed (the SMP bottom elevation), or until bedrock or fully saturated conditions are encountered. When conditions prevent the over-excavation of test pits to the minimum required depth, soil borings, in addition to the under-excavated test pits, are used in conjunction with double-ring infiltrometer testing to provide soil classification down to the required depths. [Section 3.3.2]
4. For hollow-stem auger boreholes (soil borings), verify the following:
    a. Verify that a minimum of one soil boring is conducted for each cased borehole infiltration test. [Section 3.3.2]
    b. Verify that all soil borings are advanced to a depth of ten feet below the SMP bottom elevation or until auger refusal with continuous split spoon sampling. [Section 3.3.2]
    c. Verify that the inner tube used is no less than four inches in diameter. [Section 3.3.2]
    d. Verify that all soil borings are conducted pursuant to the Hollow-Stem Auguer Borehole Procedure provided in Section 3.3.4. [Section 3.3.4]
5. For soil sampling, verify the following:
    a. Verify that three soil samples are taken per acre of SMP footprint area, with a minimum of one soil sample per SMP. [Section 3.3.2]
    b. Verify that at least one soil sample is taken at an elevation within one vertical foot of the infiltration interface (SMP bottom elevation). [Section 3.3.2]
    c. Verify that at least one soil sample is taken from the location of an infiltration test and that a sieve analysis of the sample is conducted. [Section 3.3.2]
    d. Verify that the soil samples are classified according to ASTM D2487 (Standard Practice for Classification of Soils for Engineering Purposes [Unified Soil Classification System]) and ASTM D2488 (Standard Practice for Description and Identification of Soils [Visual-Manual Procedure]). [Section 3.3.2]
    e. Verify that the soil samples undergo laboratory particle size analysis according to ASTM D422-63 (Standard Test Method for Particle-Size Analysis of Soils), down to the No. 200 sieve. [Section 3.3.2]
    f. Verify that split spoon sampling, if performed, is completed in accordance with ASTM D1586 (Standard Test Method for SPT and Split-Barrel Sampling of Soils) and that blow count data is collected from the soil samples. [Section 3.3.2]

F.5.2 Infiltration testing

1. Verify that at least one test is conducted within one vertical foot of the proposed bottom elevation of infiltration for each SMP. [Section 3.3.3]
2. Verify that the infiltration tests are performed within 25 horizontal feet of each proposed infiltration SMP. [Section 3.3.3]
3. Verify that a presoak is performed for one hour immediately prior to infiltration testing. [Section 3.3.3]
    a. Verify that ten-minute measurement intervals are used between infiltration test readings when the drop in the water level during the last 30 minutes of the presoaking period is two inches or more. [Section 3.3.5]
    b. Verify that 30-minute measurement intervals are used between infiltration test readings when the drop in the water level during the last 30 minutes of the presoaking period is less than two inches. [Section 3.3.5]
4. Verify that either the double-ring infiltrometer or cased borehole testing method is used. [Section 3.3.3]
5. For the double-ring infiltrometer testing method, verify the following:
    a. Verify that five infiltration tests are conducted per acre of SMP footprint and a minimum of three tests are conducted. [Section 3.3.3]
    b. Verify that the diameter of the inner ring is no less than six inches. [Section 3.3.3]
    c. Verify that test pits are excavated in order to conduct double-ring infiltrometer testing. [Section 3.3.2; Section 3.3.3]
    d. Verify that no more than two double-ring infiltration tests are conducted within the same test pit. [Section 3.3.3]
    e. Verify that all tests are conducted pursuant to the Double-Ring Infiltrometer testing procedure provided in Section 3.3.5. [Section 3.3.5]
6. For the cased borehole testing method, verify the following:
    a. Verify that eight infiltration tests are conducted per acre of SMP footprint and a minimum of three tests are conducted. [Section 3.3.3]
    b. Verify that the inner diameter of the casing is no less than four inches. [Section 3.3.3]
    c. Verify that infiltration tests are not completed within the same borehole as the hollow-stem auger borehole soil characterization studies, but rather are completed no less than five feet, and no more than ten feet, away from the soil characterization borehole locations. [Section 3.3.2; Section 3.3.3]
    d. Verify that all tests are conducted pursuant to the Cased Borehole testing procedure provided in Section 3.3.5. [Section 3.3.5]
7. For drainage wells' hydrologic modeling, verify that a soil permeability coefficient (k_{20}), calculated per the protocol described in **Section 4.15.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-15-drainage-wells/#4.15.3, 7c(vi), is applied to the wetted area of the drainage well, spanning the perforated sides and bottom, to determine infiltration characteristics. [Section 4.15.3, 7b]
8. For drainage wells, verify that infiltration testing is performed according to the procedure described in **Section 4.15.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-15-drainage-wells/#4.15.3, 7c. [Section 4.15.3, 7c]
9. Verify that a minimum of eight readings are completed, or a stabilized rate of drop is obtained, whichever occurs first. A stabilized rate of drop means a difference of 0.25 inch or less of drop between the highest and lowest readings of four consecutive readings. [Section 3.3.3, Section 3.3.5]

10. Verify that an Infiltration Testing Log is provided with the submitted Geotechnical Report. Refer to Appendix H for a blank template. [Section 3.3.4; Section 3.3.5]

F.5.3 Evaluation of infiltration testing results

1. Verify that the highest infiltration rate from the test results for any SMP is discarded before calculation of the geometric mean of the tested infiltration rates when more than three tests are conducted for the SMP. [Section 3.3.6]
2. Verify that the geometric mean is used to determine the average of the tested infiltration rates. [Section 3.3.6]
3. Verify that a default value based on one decimal digit less than the smallest detectable reading for that particular test method/equipment is used in calculating the geometric mean when a measured rate of zero inches per hour is obtained through testing. [Section 3.3.6]
4. Verify that the geometric mean of the tested infiltration rates is between 0.4 and ten inches per hour. Infiltration is to be considered infeasible in soils with mean tested infiltration rates of less than 0.4 inches per hour. Soils with mean tested infiltration rates in excess of ten inches per hour require soil amendments. [Section 3.3.6]
5. Verify that a factor of safety of two is applied to the geometric mean of the tested infiltration rates to obtain the SMP-specific design infiltration rate to be used for all further design and calculations. [Section 3.3.6]
6. Verify that a Geotechnical Report is submitted that meets all of the Geotechnical Report requirements listed in Appendix E, Table E-7. [Section 3.3.6]
7. When infiltration has been found to be infeasible, verify that a waiver from the infiltration requirement is requested via the Online Technical Worksheet. If the waiver is requested due to unacceptable infiltration rates, verify that a Geotechnical Report is submitted. If the waiver is requested due to contamination, verify that electronic copies of environmental reports for any testing completed, as well as a justification letter from the geotechnical engineer or environmental professional, are submitted. [Section 3.3.6]
8. Verify that a copy of any Phase I or Phase II environmental site assessment prepared for the site is provided. [Section 3.1.1]

F.5.4 Soil amendments

1. Verify that soil amendments are proposed for any infiltration practice with a mean tested infiltration rate in excess of ten inches per hour. [Section 3.3.6]
2. Verify that the soil amendments span the entire cross-section of the infiltrating SMP. [Section 3.3.6]
3. Verify that the soil amendments extend a minimum of two feet below the bottom elevation of the infiltrating SMP. [Section 3.3.6]
4. Verify that a conservative infiltration rate is used in the stormwater routing calculations during the design of the SMP. [Section 3.3.6]
5. Verify that a soil amendment sequence of construction is provided on the plans pursuant to Appendix F.3.2, Sequence of Construction. [Section 3.3.6]

F.6 Hydrologic Model and Calculation Methods

F.6.1 Hydrologic model

1. Verify that all DCIA within the project's limits of earth disturbance is routed to an SMP. [Section 1.2.1; Section 3.4.1]
2. Verify that the modeled drainage areas are accurate and consistent with the plans' drainage areas. [Section 3.4.1]
3. Verify that all SMP bypass areas within the project's limit of earth disturbance are accounted for in the hydrologic calculations' stormwater model. [Section 3.4.1]
4. Verify that the links are correct. A point of analysis (POA) must be determined for comparison of the predevelopment and post-development conditions. A POA may serve one or several drainage areas and/or SMPs. Multiple POAs must be identified for project sites with multiple points of discharge. Points of analysis should only be linked when they drain to the same sewershed or waterway. [Section 3.4.1]
5. Verify that the routing of devices within the stormwater model is provided and consistent with the plan's proposed design. [Section 3.4.1]
6. Verify that the stormwater outlet controls configuration is correct and consistent with the plans. [Section 3.4.1]
7. Verify that runoff from pervious and impervious areas is calculated separately. Weighted curve number values between pervious and impervious areas are not acceptable. [Section 3.4.3]
8. Verify that the precipitation depths used for all design storm events are in accordance with the design rainfall data listed below, pursuant to *PennDOT Drainage Manual*, Chapter 7, Appendix A, Field Manual For Pennsylvania Design Rainfall Intensity Charts From NOAA Atlas 14 Version 3 Data (2010 or latest). [Section 3.4.3]

Design precipitation depth (inches)							
Duration	1-year	2-year	5-year	10-year	25-year	50-year	100-year
24 hours	2.83	3.40	4.22	4.95	6.10	7.16	8.43

9. Verify that the Manning's n values used within the stormwater model are correct and consistent with the plans' proposed pipe material. A Manning's n value of 0.013 must be used for RCP, VCP, and CIP, and a value of 0.011 must be used for PVC and HDPE. [Section 3.4.3]
10. Verify that the stormwater model uses the minimum time step allowable by the implemented hydrologic software (which is 0.01 hours in HydroCAD and 1 minute in Hydraflow or a maximum of 0.01 hours. [Section 3.4.3]
11. Verify that the SMP storage provided is correct and consistent with the plans. A porosity of 0.20 for soil media, 0.30 for sand, and 0.40 for stone must be used. [Chapter 4]

F.6.2 Runoff estimation

1. Verify that the appropriate NRCS Curve Number Method curve number values are used in the runoff estimation calculations. Refer to Table 3.4-2 of the Manual. [Section 3.4.1; Section 3.4.3]
2. When performing Water Quality slow release rate calculations for a project in a combined sewer area for which infiltration is not feasible, verify that a curve number of 98 is used with a precipitation depth of 1.7 inches when routing the Water Quality storm event. [Section 3.4.1]
3. When performing Flood Control calculations, verify that all non-forested pervious areas are considered meadow in good condition for predevelopment runoff calculations. Non-forested pervious area consists of the following cover types: meadow, grass/lawn, brush, gravel, dirt, porous surfaces, and any combination of these cover types. [Section 3.4.1]
4. When performing Flood Control calculations for a Redevelopment project, verify that, in addition to any other pervious area, 20% of the existing impervious cover, when present, is considered meadow (good condition) for the predevelopment runoff calculations. [Section 3.4.1]
5. Verify that the stormwater model for Water Quality compliance analysis uses the PWD Design Storm rainfall distribution. Refer to Table 3.4-4 of the Manual. [Section 3.4.3]
6. Verify that the stormwater models for Channel Protection, Flood Control, and PHS Release Rate compliance analyses use the NRCS Type II 24-hour rainfall distribution. Refer to Table 3.4-5 of the Manual. [Section 3.4.3]

F.6.3 Flow routing

1. Verify that time of concentration calculations are provided for all predevelopment areas. [Section 3.4.1]
2. Verify that the time of concentration paths are shown on the drainage area maps and are labeled with slopes, cover types, and lengths for each type of flow (sheet, shallow concentrated, etc.). [Section 3.4.1; Appendix E, Table E-7]
3. Verify that the time of concentration paths are shown from the hydraulically most distant point of the drainage area to a point of interest within the drainage area, and that the paths are perpendicular to each area's contours. [Section 3.4.3]
4. Verify that the minimum post-development time of concentration used for any path is six minutes. [Section 3.4.1; Section 3.4.3]
5. Verify that the correct two-year design precipitation depth (P-2) is used in the sheet flow component of the time of concentration calculations. [Section 3.4.3]
6. Verify that the correct Manning's n values (roughness coefficients) are used in the sheet flow component of the time of concentration calculations. Refer to Table 3.4-6 of the Manual. [Section 3.4.3]
7. Verify that a maximum sheet flow length of 100 feet is used if the flow is not concentrated. [Section 3.4.3]

F.6.4 Stormwater conveyance pipe capacity

1. Verify that pipe capacity calculations are provided for all stormwater conveyance pipes that are not connected to the roof drainage system. [Section 3.4.2]
2. Verify that all storm sewer pipes are sized to have adequate capacity to safely convey the ten-year, 24-hour storm event without surcharging the crown of the pipe. [Section 3.4.2]
3. Verify the runoff coefficients used in the pipe capacity calculations. A runoff coefficient value of 0.35 must be used for pervious areas, and 0.95 must be used for impervious areas. [Section 3.4.2]
4. Verify the precipitation intensity used in the pipe capacity calculations. The precipitation intensity for a five-minute inlet concentration time in the ten-year storm event must be 6.96 inches per hour. [Section 3.4.2]
5. Verify that the Manning's n values used with Manning's Equation for calculating full channel pipe flow are correct and consistent with the plans. A Manning's n value of 0.013 must be used for RCP, VCP, and CIP, and a value of 0.011 must be used for PVC and HDPE. [Section 3.4.2]
6. Verify that all roof drainage systems are sized pursuant to the Philadelphia Plumbing Code. [Section 3.4.2]
    a. Verify that the minimum size of a storm drain or any of its branches that drain a roof or area drain is three inches in diameter.
    b. Verify that the main roof drain has a slope that is greater than 1/16 inch per foot.

F.7 Bioinfiltration/Bioretention

F.7.1 Bioinfiltration/bioretention plan standards

1. Verify that the plans include an appropriate sequence of construction that is specific to the construction of the bioinfiltration/bioretention SMP. Refer to Section 4.1.5 for guidance. [Section 2.3.1]
2. To avoid soil disturbance and compaction during construction, verify that the bioinfiltration area is proposed to be clearly marked before any site work begins. [Section 4.1.5, 2]
3. Verify that the plans include an appropriate cross-sectional detail for the bioinfiltration/bioretention SMP. [Section 2.3.1]

F.7.2 Bioinfiltration/bioretention design standards

1. Verify that the SMP drains within the acceptable 72-hour period after the 24-hour storm event. [Section 4.1.3, 1]
2. Verify that the loading ratio of DCIA to the horizontal footprint of the bioinfiltration/bioretention SMP does not exceed 16:1. [Section 4.1.3, 2]
3. Verify that positive overflow is provided for large storm events, up to and including the 100-year, 24-hour storm event, or, if the project is exempt from Flood Control, the ten-year, 24-hour storm. [Section 4.1.3, 3]
4. Verify that overflow structures and pipes are designed to convey at least the ten-year, 24-hour storm event. [Section 4.1.3, 3]
5. Verify that the distance between the contour of a bioinfiltration/bioretention basin's Water Quality Volume elevation and any adjacent private property line is at least ten feet. This includes fully or partially lined basins. Exceptions can be made for water-tight planter boxes with their own structural integrity. It is acceptable for SMPs to be located directly adjacent to the public right-of-way (ROW) (unless a deed restriction is put in place extending at least ten feet from the perimeter of the SMP). [Section 4.1.3, 4]
6. Verify that the distance between the contour of a bioinfiltration/bioretention basin's Water Quality Volume elevation and any building or retaining wall is at least ten feet. This includes fully or partially lined basins. The following requirements and exceptions apply: [Section 4.1.3, 5]
    a. For existing and proposed buildings with basements, the setback is measured from the basement wall and may be waived if the basin is a water-tight planter box with its own structural integrity.
    b. For existing buildings without basements and existing retaining walls, the setback is measured from the foundation and may be waived if a signed and sealed geotechnical analysis is submitted that evaluates the impacts of infiltration and excavation on the existing foundation and determines it to be feasible.
    c. For proposed buildings without basements and proposed retaining walls, the setback is measured from the foundation and may be waived if the foundation is proposed to be designed with the basin's proximity in mind.
7. Verify that the invert elevation of a bioinfiltration SMP is at least two feet above any poorly infiltrating soils, seasonal high groundwater table, bedrock, or any other limiting zone. [Section 4.1.3, 6b]
8. For hydrologic modeling, verify that the design infiltration rate is applied to the horizontal surface area (SMP footprint), not the wetted area. If necessary, for the purpose of meeting the Water Quality requirement, infiltration can be assumed through the horizontal projection of the wetted area up to the Water Quality Volume (WQv) water surface elevation. [Section 4.1.3, 6c]
9. Verify that the soils underlying a bioinfiltration SMP are determined to be infiltration feasible. [Section 4.1.3, 6d]

10. Verify that any soils with test infiltration rates in excess of ten inches per hour are proposed to receive soil amendments. [Section 4.1.3, 6e]
11. If the infiltration SMP is used as a temporary sediment basin during construction, verify that the invert elevation of the infiltration SMP is a minimum of three feet below the bottom elevation of the pre-basin-conversion sediment basin. [Section 4.1.3, 6f]
12. Verify that any infiltrating SMP within the zone of influence of any nearby sewers or sewer laterals is installed with an impervious liner. The zone of influence is defined by the area within a 1:1 (H:V) slope line from the outer edge of a sewer or sewer lateral. [Section 4.1.3, 6g].
13. Verify that pretreatment is provided for all runoff entering the bioinfiltration/bioretention SMP, including pretreatment of runoff from all inlets. At a minimum, this can be achieved through the use of sumps and traps for inlets, sump boxes with traps downstream of trench drains, and filter strips for overland flow. [Section 4.1.3, 8]
14. Verify that energy dissipaters, such as riprap stone, are proposed at all locations of concentrated inflow. [Section 4.1.3, 9]
15. Verify that the storage area for a bioinfiltration SMP provides static storage for the WQv between the bottom elevation of the SMP and the elevation of the lowest outlet, including the planting soil medium and stone storage void space. The minimum allowable ponding depth below the lowest outlet device is three inches. Bioinfiltration basins may also be sized per the Bioinfiltration/Bioretention Basin Sizing Table (Table 4.1-4 of the Manual) to ensure that storage requirements are achieved. For dynamically designed bioinfiltration SMPs, static storage of only one inch of the WQv must be provided if the designer demonstrates, through dynamic routing, that the full 1.5-inch WQv is managed throughout the design storm, without overflow. [Section 4.1.3, 11]
16. Verify that the storage area for a bioretention SMP provides adequate storage to control release rates to meet all applicable Stormwater Regulations. All permanent pool areas must be excluded from the SMP's storage volume estimation. Void space in the soil and/or stone layers beneath the bioretention area surface may be considered part of the available volume of the SMP. Bioretention basins may also be sized per the Bioinfiltration/Bioretention Basin Sizing Table (Table 4.1-4 of the Manual) to ensure that storage and Water Quality release rate requirements are achieved. [Section 4.1.3, 12]
17. If the basin is sized per the Bioinfiltration/Bioretention Basin Sizing Table (Table 4.1-4 of the Manual), verify that the orifice diameter proposed is appropriate to the applicable DCIA drainage area range. [Section 4.1.3]
18. Verify that the maximum storage volume statically stored within the bioinfiltration/bioretention SMP without supporting documentation (defined below) is the runoff volume from the one-year, 24-hour storm event. [Section 4.1.3, 13]

19. Verify that the maximum storage volume statically stored within the bioinfiltration/bioretention SMP with supporting documentation is the runoff volume from the ten-year, 24-hour storm event. Requirements for supporting documentation include a letter, signed and sealed by both the geotechnical and design engineer, indicating that the proposed design is recommended, with the following components acknowledged and considered. The designer is encouraged to contact PWD for further guidance when pursuing this design. [Section 4.1.3, 14]
    a. A summary of the long-term impacts to the neighboring properties, including, but not limited to subsidence, change in basement moisture/water, and structural damage;
    b. The location of the groundwater table;
    c. References to other projects that have successfully infiltrated more than the one-year, 24-hour storm event; and
    d. Rigorous pretreatment to promote longevity of the infiltration SMP.
20. Verify that, when SMPs are used in series, the storage areas for all SMPs provide cumulative static storage for the WQv. [Section 4.1.3, 15]
21. Verify that the side slopes for all open storage areas do not exceed 2(H):1(V) (the recommended side slope is 3(H):1(V)), and that the side slopes of all mowed areas do not exceed 4(H): 1(V) to avoid "scalping" by mower blades. [Section 4.1.3, 17]
22. Verify that the porosity values used for storage volume calculations are as follows: [Section 4.1.3, 18]
    a. Soil media: 0.20
    b. Sand: 0.30
    c. Stone: 0.40
23. Verify that the stone storage layer is separated from soil media by a geotextile or pea gravel filter to prevent sand, silt, and sediment from entering the SMP. [Section 4.1.3, 19]
24. Verify that the stone storage system for a bioinfiltration SMP has a level bottom or use a terraced system if installed along a slope. [Section 4.1.3, 20]
25. Verify that the planting soil medium has a minimum depth of two feet. [Section 4.1.3, 21]
26. Verify that any impervious liner, if necessary, is not interrupted by structures within the basin footprint. The plans must indicate that the impervious liner is to be continuous and extend completely up the sides of any structures that are located within the lined basin footprint to the ground surface. If additional liner material must be added to extend up the structures, the additional liner sections are to be joined to the rest of the liner with an impervious seam per the manufacturers' recommendations. [Section 4.1.3, 24]
27. Verify that an underdrain is provided and that it meets the following requirements:
    a. Underdrains must be surrounded by a sand or stone layer to filter sediment and facilitate drainage. [Section 4.1.3, 25a]
    b. The minimum allowable depth of a sand or stone filter layer above and beneath the underdrain is six inches, which must extend across the entire basin bottom. [Section 4.1.3, 25b]
    c. Underdrains must be surrounded by a geotextile fabric, if sand is used. [Section 4.1.3, 25c]
    d. Underdrains for bioinfiltration basins must remain capped to facilitate infiltration into native soils. [Section 4.1.3, 25d]

e. For bioretention SMPs located in the combined sewer area where infiltration is infeasible, underdrains must be capped with an appropriately sized orifice to control release rates to meet all applicable Stormwater Regulations. Orifice diameter for flow-regulating underdrains may be determined based on the Bioinfiltration/Bioretention Basin Sizing Table (Table 4.1-4 of the Manual) for basins meeting the minimum requirements of the Standard Detail (Figure 4.1-4 of the Manual). [Section 4.1.3, 25e]

f. For bioretention SMPs located in the separate sewer area, where infiltration is infeasible, flow through the underdrain may be modeled as exfiltration at a rate of two inches per hour over the basin footprint. This exfiltration flow must be routed through the primary outlet of the bioretention area, not discarded from the stormwater model. [Section 4.1.3, 25f]

g. The outlet pipe of an outlet control structure must have an invert at or below the invert of the underdrain. Setting the outlet pipe invert at a minimum of 7.5 inches below that of the underdrain is recommended. [Section 4.1.3, 25g]

28. Verify that an adequate number of appropriately placed cleanouts, manholes, access panels and other access features are provided to allow unobstructed and safe access to the bioinfiltration/bioretention SMP for routine maintenance and inspection of inflow, outflow, underdrains, and storage systems. [Section 4.1.3, 27]

F.7.3 Bioinfiltration/bioretention material standards

1. Verify that stone designed for stormwater storage is specified on the plans as being uniformly graded, crushed, clean-washed stone and that it is noted that PWD defines “clean-washed” as having less than 0.5% wash loss, by mass, when tested per the AASHTO T-11 wash loss test. AASHTO No. 3 and No. 57 stone can meet this specification. [Section 4.1.4, 3]
2. Verify that sand, if proposed, is specified on the plans to be AASHTO M-6 or ASTM C-33 sand and to have a grain size of 0.02 inches to 0.04 inches. [Section 4.1.4, 4]
3. Verify that the planting soil medium is specified on the plans as meeting the following specifications:
   a. Planting soil should be a fertile, natural soil, free from large stones, roots, sticks, clods, plants, peat, sod, pockets of coarse sand, pavement and building debris, glass, noxious weeds including invasive species, infestations of undesirable organisms and disease causing pathogens, and other extraneous materials harmful to plant growth. [Section 4.1.4, 5a]
   b. The texture of planting soil should conform to the classification within the United States Department of Agriculture triangle for Sandy Loam or Loamy Sand. Planting soil should be a mixture of sand, silt, and clay particles as required to meet the classification. Ranges of particle size distribution, as determined by pipette method in compliance with ASTM F-1632, are as follows: [Section 4.1.4, 5b]
      i. Sand (0.05 to 2.0 mm): 50 – 85%
      ii. Silt (0.002 to 0.05 mm): 40% maximum
      iii. Clay (less than 0.002 mm): 10% maximum
      iv. Gravel (2.0 to 12.7 mm): 15% maximum
   c. Planting soil should be screened and free of stones larger than a half-inch (12.7 millimeters) in any dimension. No more than 10% of the soil volume should be composed of soil peds greater than one inch. [Section 4.1.4, 5c]
   d. Clods, or natural clumps of soils, greater than three inches in any dimension should be absent from the planting soil. Small clods ranging from one to three inches and peds, natural soil clumps under one inch in any dimension, may be present but should not make up more than 10% of the soil by volume. [Section 4.1.4, 5d]

e. The pH of the planting soil should have a range of 5.8 to 7.1. [Section 4.1.4, 5e]

f. Soluble salts should be less than 2.0 mmhos/cm (dS/m), typically as measured by 1:2 soil-water ratio basic soil salinity testing. Sodic soils (Exchangeable Sodium Percentage greater than 15 and/or Sodium Adsorption Ratio greater than 13) are not acceptable for use regardless of amendment. [Section 4.1.4, 5f]

g. Organic content of planting soil should have a range of 3% to 15%, by weight, as determined by loss on ignition (ASTM D2974). To adjust organic content, planting soil may be amended, prior to placing and final grading, with the addition of organic compost. [Section 4.1.4, 5g]

4. Verify that mulch, if proposed, is specified to be free of weeds and consist of aged, double-shredded hardwood bark mulch or leaf mulch that has been shredded sufficiently to limit risk of matting, which can limit surface infiltration rates. For hydroseeding, paper mulch may be used. Approved mulching materials include organic materials such as compost, bark mulch, leaves, as well as small river gravel, pumice, or other inert materials. Grass clippings should not be used as mulch. [Section 4.1.4, 6]
5. Verify that geotextile is specified on the plans to consist of polypropylene fibers and to meet the following specifications (AASHTO Class 1 or Class 2 geotextile is recommended): [Section 4.1.4, 7]
    a. Grab Tensile Strength (ASTM-D4632): ≥ 205 lbs
    b. CBR Puncture Strength (ASTM-D6241): ≥ 500 lbs
    c. Flow Rate (ASTM-D4491): ≥ 95 gal/min/ft2
    d. UV Resistance after 500 hrs (ASTM-D4355): ≥ 70%
    e. Tear Resistance (ASTM-D4533): ≥ 80 lbs
    f. Heat-set or heat-calendared fabrics are not permitted
6. Verify that native grass/wildflower seed mix, if proposed as an alternative to groundcover planting, is free of weed seeds. [Section 4.1.4, 10]
7. Verify that the proposed bioinfiltration/bioretention SMP plantings are indicated on the plans and are non-invasive. Refer to **Appendix I** ☛ p. 107 for plant lists. [Section 4.1.4, 11]
8. Verify that the underdrain is made of continuously perforated high-density polyethylene (HDPE) plastic piping with a smooth interior and a minimum inner diameter of four inches. HDPE pipe must be specified on the plans to meet the specifications of AASHTO M252, Type S or AASHTO M294, Type S. [Section 4.1.4, 12]
9. Verify that cleanouts are made of material with a smooth interior having an inner diameter that is no less than six inches. If the connecting pipe is eight inches in diameter or larger, verify that the cleanout is eight inches in diameter. [Section 4.1.3, 14]

F.8 Porous Surfaces

F.8.1 Porous surface plan standards

1. Verify that the plans include an appropriate sequence of construction that is specific to the construction of the porous surface. Refer to Section 4.2.5 for guidance. [Section 2.3.1]
2. To avoid soil disturbance and compaction during construction, verify that the infiltration area is proposed to be clearly marked before any site work begins. [Section 4.2.5, 1]
3. Verify that the plans include an appropriate cross-sectional detail for the porous surface. [Section 2.3.1]

F.8.2 Porous surface design standards

1. Verify the drainage area directed to any proposed porous surface. The porous surface cannot receive any runoff in addition to the direct (1:1) rainfall onto it. For porous surface over a structural SMP, the additional runoff must be conveyed directly to the underlying SMP. The porous surface over the structural SMP footprint must be considered, and modeled as, DCIA. The SMP beneath the porous surface requires infiltration testing. [Section 4.2.1]
2. For porous surface over a structural SMP, if infiltration is feasible, verify that the porous surface design meets all Design Guidance Checklist design standards noted in Appendix F.10, Subsurface Infiltration. [Section 4.2.3, 2]
3. For porous surface over a structural SMP, if infiltration is infeasible, verify that the porous surface design meets all Design Guidance Checklist design standards noted in Appendix F.14, Subsurface Detention. [Section 4.2.3, 3]
4. For porous surface DIC systems:
    a. Verify that the porous surface DIC is installed on-site such that it does not create any areas of concentrated infiltration or discharge. [Section 4.2.3, 1a]
    b. Verify that the surface slope in any direction across porous surface does not exceed 5%. [Section 4.2.3, 1b]
    c. Verify that the choker course depth is a minimum of two inches. [Section 4.2.3, 1c]
    d. If an underdrain is proposed, verify that the first 1.5 inches of runoff are stored below the lowest invert of the underdrain. [Section 4.2.3, 1d]
    e. Verify that an appropriate porous surface curve number value is used when performing Flood Control calculations. [Section 4.2.3, 1e]
    f. Verify that the stone storage bed depth is a minimum of eight inches, except when located beneath walkways or play surfaces, for which a depth of four inches is allowable. [Section 4.2.3, 6a]
    g. Verify that stone is separated from soil media by a separation barrier, such as a geotextile or a pea gravel filter, to prevent sand, silt, and sediment from entering the system. [Section 4.2.3, 6b]
    h. Verify that the stone storage system has a level bottom. Terraced systems may be used to maintain a level infiltration interface with native soil while accommodating significant grade changes. [Section 4.2.3, 6c]
5. Verify that pretreatment is provided for all runoff entering the porous surface, including pretreatment of runoff from all inlets. At a minimum, this can be achieved through the use of sumps and traps for inlets and sump boxes with traps downstream of trench drains. [Section 4.2.3, 4]
6. Verify that, when SMPs are used in series, the storage areas for all SMPs provide cumulative static storage for the WQv. [Section 4.2.3, 9]

7. Verify that any impervious liner, if necessary, lines a minimal portion of the total porous area. If a significant area needs to be lined, porous surface may not be an appropriate management strategy. [Section 4.2.3, 10]
8. Verify that underdrains, if proposed for porous surface DIC systems, meet the following requirements:
    a. Underdrains must be surrounded by a sand or stone layer to filter sediment and facilitate drainage. [Section 4.2.3, 11a]
    b. The minimum allowable thickness of a sand or stone filter layer is six inches both above and beneath the underdrain. [Section 4.2.3, 11b]
    c. To prevent clogging, underdrain pipes must be surrounded by a geotextile fabric if a sand layer is used. [Section 4.2.3, 11c]
9. Verify that inlets or area drains are provided for all porous surface areas in excess of 5,000 square feet, in order to provide positive overflow. [Section 4.2.3, 12]
10. Verify that an adequate number of appropriately placed cleanouts, manholes, access panels and other access features are provided to allow unobstructed and safe access to the structural SMPs beneath porous surface for routine maintenance and inspection of inflow, outflow, underdrains, and storage systems. [Section 4.2.3, 14]
11. Verify that observation wells are provided for SMPs that include stone storage and that they meet the following requirements:
    a. The observation well must be placed at the invert of the stone bed. [Section 4.2.3, 15a]
    b. The observation well must be located near the center of the stone bed system to monitor the level and duration of water stored within the SMP (drain down time). A minimum of six inches of clearance must be provided between the edge of the observation well's concrete ring or frame and any nearby site features (curbing, tree pits, sidewalk edge, etc.). Plan view dimensioning for the proposed location of the observation well, relative to the boundaries of the SMP it lies within, must be provided on the plans. [Section 4.2.3, 15b]
    c. Adequate inspection and maintenance access to the observation well must be provided. [Section 4.2.3, 15c]
    d. An observation well located in a paved area must be outfitted with a cover and frame. The cover plate must be installed flush with the surrounding surface at finished grade, and grading should drain away from the observation well wherever possible. The solid section of the observation well must extend into the cover frame enough such that a bentonite/cement seal can be placed around the well within the frame, and a solid slip-on cap can be fitted onto the pipe end. [Section 4.2.3, 15d]
    e. An observation well located in an unpaved area must have a concrete ring or frame poured for support, with three lengths of rebar evenly spaced around the ring and three inches from its outer edge. The observation well should be located outside of the ponding area of any surface SMPs. If, due to space limitations, an observation well must be placed in the ponding area of a surface SMP, the concrete ring and well cover must extend three inches above the SMP's maximum ponding depth. [Section 4.2.3, 15e]
    f. The observation well must include a slotted section within the storage layer of the SMP. The top of the slotted well section must extend to a minimum of six inches below the top of the SMP storage layer, and the slotted section must extend down the entire depth of the SMP. [Section 4.2.3, 15f]
12. Verify that access features are provided for all underground storage systems that are not stone storage beds. [Section 4.2.3, 16a]
13. Verify that a sufficient number of access points in the system are provided to efficiently inspect and maintain the infiltration area. [Section 4.2.3, 16b]

14. For cast-in-place vault systems, verify that access features consist of manholes or grated access panels or doors. Grated access panels are preferred to maintain airflow. [Section 4.2.3, 16c]
15. For grid storage or other manufactured systems, verify that the manufacturer's recommendations are followed. [Section 4.2.3, 16d]
16. Verify that ladder access is proposed for vaults greater than four feet in height. [Section 4.2.3, 16e]
17. Verify that header pipes, at minimum 36-inch diameter, connected to manholes at each corner of the subsurface system are provided. Alternatively, smaller header pipes may be used if cleanouts are provided on the manifold/header pipe junction for each distribution pipe. The cleanouts must be on alternating sides of the SMP. [Section 4.2.3, 16f]

F.8.3 Porous surface material standards

1. Verify that permeable paver and grid systems, if proposed, are specified on the plans as meeting the following specifications: [Section 4.2.4, 2]
    a. Permeable paver and grid systems must conform to manufacturer specifications.
    b. The systems must have a minimum flow through rate of five inches per hour and a void percentage of no less than 10%.
    c. Gravel used in interlocking concrete pavers or plastic grid systems must be well-graded and washed to ensure permeability.
2. Verify that stone designed for stormwater storage, if proposed, is specified on the plans as being uniformly graded, crushed, clean-washed stone and that it is noted that PWD defines "clean-washed" as having less than 0.5% wash loss, by mass, when tested per the AASHTO T-11 wash loss test. AASHTO No. 3 and No. 57 stone can meet this specification. [Section 4.2.4, 4a]
3. Verify that all aggregates used within a porous surface system meets the following requirements: [Section 4.2.4, 4b]
    a. Maximum wash loss: 0.5% per AASHTO T-11
    b. Minimum durability index: 35 per ASTM D3744
    c. Maximum abrasion: 10% for 100 revolutions and 50% for 500 revolutions per ASTM C131
4. Verify that all choker course aggregate meets the specifications of AASHTO No. 57 and meets the gradation listed in Table 4.2-3 of the Manual. [Section 4.2.4, 4c]
5. Verify that sand, if proposed, is specified on the plans to be AASHTO M-6 or ASTM C-33 sand and to have a grain size of 0.02 inches to 0.04 inches. [Section 4.2.4, 5]
6. Verify that storage chambers for porous surface over a structural SMP, if proposed, are specified on the plans as meeting the following specifications: [Section 4.2.4, 6]
    a. Pipe used within a subsurface infiltration SMP must be continuously perforated and have a smooth interior with a minimum inner diameter of four inches.
    b. High-density polyethylene (HDPE) pipe, if proposed, must meet the specifications of AASHTO M252, Type S or AASHTO M294, Type S.
    c. Any pipe materials outside the SMP are to meet City Plumbing Code Standards.

7. Verify that geotextile, if proposed, is specified on the plans to consist of polypropylene fibers and to meet the following specifications (AASHTO Class 1 or Class 2 geotextile is recommended): [Section 4.2.4, 7]
    a. Grab Tensile Strength (ASTM-D4632): ≥ 205 lbs
    b. CBR Puncture Strength (ASTM-D6241): ≥ 500 lbs
    c. Flow Rate (ASTM-D4491): ≥ 95 gal/min/ft^2
    d. UV Resistance after 500 hrs (ASTM-D4355): ≥ 70%
    e. Tear Resistance (ASTM-D4533): ≥ 80 lbs
    f. Heat-set or heat-calendared fabrics are not permitted
8. Verify that underdrains, if proposed, are made of continuously perforated HDPE plastic piping with a smooth interior and a minimum inner diameter of four inches. HDPE pipe must be specified on the plans to meet the specifications of AASHTO M252, Type S or AASHTO M294, Type S. [Section 4.2.4, 8]
9. Verify that the observation well is specified on the plans as meeting the following specifications:
    a. The observation well must consist of slotted plastic pipe with a minimum inner diameter of four inches and a solid cap at the surface. The slotted section of the well must consist of PVC slotted well screen with 0.01-inch slot size and an attached perforated PVC cap at the bottom. [Section 4.2.4, 10a]
    b. The observation well's cover must be ductile iron in a gray iron frame. [Section 4.2.4, 10b]
    c. For an observation well located in an unpaved area, the well's concrete ring must be a minimum of six inches wider in any dimension than the cover frame, of equal depth as the cover frame itself, and poured atop a minimum of six inches of AASHTO #57 stone bedding. A frame conforming to these minimum dimensions may be circular or square. [Section 4.2.4, 10c]
10. Verify that cleanouts are made of material with a smooth interior having an inner diameter that is no less than six inches. If the connecting pipe is eight inches in diameter or larger, verify that the cleanout is eight inches in diameter. [Section 4.2.4, 11]

F.9 Green Roofs

F.9.1 Green roof plan standards

1. Verify that the plans include an appropriate sequence of construction that is specific to the construction of the green roof. Refer to Section 4.3.5 for guidance. [Section 2.3.1]
2. Verify that the plans include an appropriate cross-sectional detail for the green roof. [Section 2.3.1]
3. Verify that a roof drainage plan is provided and that the roof drainage is consistent with the green roof design. [Appendix E, Table E-7]

F.9.2 Green roof design standards

1. Verify that runoff from impervious roof area onto the green roof is dispersed evenly across the green roof surface and passes through the growing medium either by sheet flow or a level spreading device. [Section 4.3.3, 1]
2. Verify that the flow path of runoff across the green roof surface is greater than or equal to the contributing DCIA length. [Section 4.3.3, 2]
3. Verify that structural loading is considered for the green roof design, and that the green roof design is coordinated with a licensed structural engineer for both new building construction and retrofits to existing structures. [Section 4.3.3, 3a]
4. If runoff estimation calculations are required, verify that the correct curve number for the proposed green roof is used in the calculations. Refer to Table 3.4-2 of the Manual. [Section 4.3.3, 4a]
5. If flow routing is required, verify that the rational coefficient used is 0.40. [Section 4.3.3, 4b]
6. If flow routing is required, verify that the time of concentration used is six minutes. [Section 4.3.3, 4c]
7. Verify that the total amount of impervious surfaces within the designated boundary of the green roof footprint does not exceed one-third of the combined area. [Section 4.3.3, 5]
8. Verify that all stone/gravel margins or perimeters are considered roof DCIA, unless they are graded to allow flow over or through vegetated green roof area, in which case, they may be counted as tributary impervious area to the green roof. Stone margins adjacent to drain chambers, with an offset distance from the chamber edge of 12 inches or less, are exempt from being counted as tributary impervious area when installed on a green roof, in addition to pervious pavers containing planted openings. [Section 4.3.3, 6]
9. Verify that root barrier layers conform to the requirements of the waterproofing provider for each project. [Section 4.3.3, 7]
10. If runoff is conveyed via piping, verify that a distribution piping manifold embedded in a gravel strip, along with an appropriate detail, is provided on the plans to dissipate energy and promote uniform flow. [Section 4.3.3, 8]

11. For green roofs that receive direct (1:1) rainfall only, verify the following:
    a. The minimum allowable thickness of the green roof growing medium is four inches. This can include both an upper course of growing medium and a base layer of foundation growing medium (lightweight drainage aggregate), together comprising a dual media system. The foundation growing medium must be a low-transmissivity drainage layer, defined as a layer with a transmissivity of 0.005 m^2/s or less (ASTM D4716) that is available to plant roots. For this dual media green roof, the minimum allowable thicknesses of the planting layer and foundation growing medium drainage layer are three inches and one inch, respectively. [Section 4.3.3, 10a]
    b. Green roofs that meet minimum growing medium thickness requirements are permitted a DCIA reduction equal to the entire area of the green roof. [Section 4.3.3, 10b]
12. For green roofs that receive runoff from contributing impervious roof catchments, verify the following:
    a. Impervious roof areas that direct runoff onto the green roof cannot exceed 50% of the green roof area, which is equivalent to a maximum hydraulic impervious runoff loading ratio of 0.5:1. [Section 4.3.3, 11a]
    b. The minimum thickness of the green roof growing medium must be calculated as follows, where the "impervious roof area to green roof area" ratio is less than or equal to 0.50. A minimum depth of four inches is required: [Section 4.3.3, 11b]
    *Minimum thickness (in inches) of green roof growing medium = 4 inches + [3 * (Impervious roof area / Green roof area)]*
    c. Green roofs that meet minimum growing medium thickness requirements are permitted a DCIA reduction equal to the entire area of the green roof. Impervious roof areas that drain to these green roofs can be also considered as disconnected impervious cover, and, thus, included in the green roof's DCIA reduction. [Section 4.3.3, 11c]
    d. In areas that will receive tributary discharge, verify that the plans include specifications that demonstrate that the drainage layer is not a high-transmissivity drainage layer, defined as a layer with a transmissivity of greater than 0.005 m^2/s (ASTM D4716), where such products limit plant root access to tributary runoff. In general, this will exclude most synthetic sheet drains, including peg-style or egg-carton-style drains. High-transmissivity drainage layers allow runoff to effectively flow under the green roof, minimizing contact with growing medium and plant roots. Typical foundation growing medium (also called granular aggregate or coarse granular green roof medium), with a grain-size distribution complying with ASTM gradation No. 7 will satisfy the requirement, as will also a variety of mats and composite drainage layer assemblies. [Section 4.3.3, 11d]
    e. Verify that any deck built atop a green roof that does not allow for sheet flow runoff is slotted, and that the minimum thickness of growing medium required for the green roof is maintained under the entire extent of the deck. [Section 4.3.3, 11e]
13. Verify that the plans indicate that the saturated permeability of the growing medium, in its compacted state [ASTM E2399], is not less than six inches per hour. [Section 4.3.3, 12]
14. Verify that a drainage layer is provided to promote aerated conditions in the growing medium and to convey excess runoff during large rainfall events. [Section 4.3.3, 14]
15. Verify that the contributing area of impervious rooftop to each disconnected discharge point is equal to, or less than, 500 square feet. [Section 4.3.3, 18]
16. Verify that details are provided on the plans that demonstrate that all drains and scuppers are covered and protected by an enclosure, typically a square or round chamber with a locking lid. These chambers are designed to prevent clogging of the drains by debris. [Section 4.3.3, 20]
17. Verify that the roof drainage system and the remainder of the site drainage system safely convey roof runoff to the storm sewer, combined sewer, or receiving water. [Section 4.3.3, 21]

18. Verify that the green roof is designed to allow for safe access and working conditions for green roof inspection and maintenance personnel. This access must be a permanent feature of the building, such as a pilot house, roof hatch, or exterior stairs to the green roof. Retractable, unsecured ladders should not be required for routine maintenance and inspections due to safety concerns. The design may include other permanent personal safety measures. For green roofs, designers must specifically assess applicability to Occupational Safety and Health Administration (OSHA) Fall Protection Safety Standards and the American National Standards Institute (ANSI) and American Society of Safety Engineers (ASSE) consensus-based fall protection standards. [Section 4.3.3, 23]
19. For accessible residential roof terraces, verify that a railing with a maintenance gate that separates the vegetated green roof from accessible areas is provided. The railing can be metal, wood, or glass. Bird-friendly glass with a Threat Factor Rating of 1–25 is highly recommended. [Section 4.3.3, 24]

F.9.3 Green roof material standards

1. Verify that the green roof growing medium is specified on the plans to be a lightweight mineral material with added organic material that meets the following specifications: [Section 4.3.4, 2]
    a. Moisture content at maximum water holding capacity (ASTM E2399 or FLL): 40% to 60% (vol)
    b. Porosity at maximum water holding capacity (ASTM E2399 or FLL): 10% to 15%
    c. Density at maximum water holding capacity (ASTM E2399 or FLL): ≤ 85 lbs/ft3
    d. Total organic matter (MSA): 6% to 10% (dry weight)
    e. pH (MSA): 6.5 to 7.8
    f. Soluble salts (DPTA saturated media extraction): ≤ 2 mmhos/cm
    g. Water permeability (ASTM E2399 or FLL): 0.25 in/min to 1.25 in/min
    h. Grain-size distribution consisting of ≤ 4.5% passing for clay (0.002 mm) and 5% to 15% passing for silt (0.05 mm). Clay and silt together must not exceed 15%.
    i. The nutrients must be initially incorporated in the formulation of a suitable mix for the support of the specified plant materials.
    j. The medium must withstand freeze/thaw cycles.
2. Verify that the foundation growing medium (lightweight drainage aggregate) is specified on the plans to be composed of a blended medium that meets the following specifications: [Section 4.3.4, 3]
    a. Density at maximum water capacity (ASTM E2399-05): ≤ 65 lbs/ft^3
    b. Maximum water holding capacity: 15% to 25%
    c. Water permeability (ASTM E2396-05): ≥ 25 in/min
    d. Total organic matter by loss on ignition (ASTM F1647): ≤ 1%
    e. Porosity (ASTM C29): 20% to 65%
    f. Grain-size distribution (ASTM C136) consisting of the following gradations:
        i. Pct. Passing US#18 sieve (1.0 mm): ≤ 5%
        ii. Pct. Passing ¼-inch sieve: ≤ 30%
        iii. Pct. Passing 3/8-inch sieve (9.5 mm): ≥ 75%
        iv. Pct. Passing ½-inch sieve (12 mm): 100%

3. Verify that geotextile is specified on the plans to consist of polypropylene fibers and to meet the following specifications: [Section 4.3.4, 4]
    a. Grab Tensile Strength (ASTM-D4632): 70 lbs to 120 lbs
    b. CBR Puncture Strength (ASTM-D6241): 120 lbs to 340 lbs
    c. Flow Rate (ASTM-D4491): 130 gal/min/ft2 to 200 gal/min/ft2
    d. UV Resistance after 500 hrs (ASTM-D4355): 70%
    e. Tear Resistance (ASTM-D4533): 30 lbs to 50 lbs
    f. Heat-set or heat-calendared fabrics are not permitted
4. For vegetated cover assemblies with an overall thickness of five inches or greater, verify that the drainage layer is specified on the plans to meet the following specifications: [Section 4.3.4, 5b]
    a. Abrasion resistance (ASTM-C131-96): ≤ 25% loss
    b. Soundness (ASTM-C88): ≤ 5% loss
    c. Porosity (ASTM-C29): ≥ 25%
    d. Percent of particles passing 1/2-inch sieve (ASTM-C136): ≥ 75%
    e. The minimum thickness of the granular layer must be two inches. The granular layer may be installed in conjunction with a synthetic reservoir sheet.
5. Verify that all waterproof membranes meet appropriate ASTM specifications. PVC membranes must meet ASTM D4434 requirements, EPDM membranes must meet ASTM D4637 requirements, and TPO membranes must meet ASTM D6878 requirements. [Section 4.3.4, 6b]
6. Verify that all waterproofing membranes are fully waterproof with properly sealed seams, corners, and protrusions to prevent any intrusion of standing water above the membrane. [Section 4.3.4, 6c]
7. Verify that roofing membranes meet all building code requirements and guidelines of the City of Philadelphia. [Section 4.3.4, 6d]
8. Verify that the proposed green roof plantings are indicated on the plans and that the proposed plantings and are non-invasive. Refer to **Appendix I** ☛ p. 107 for plant lists. [Section 4.3.4, 7]
9. Verify that at least two genera of sedums (i.e., both Sedum and Phedimus) and six different species or cultivars of sedums are indicated on the plans. [Section 4.3.4, 8a]
10. Verify that native or adaptive grasses, if proposed, include at least two genera and three different species. [Section 4.3.4, 8b]
11. Verify that native or adaptive perennials, if proposed, include at least three genera and four different species. [Section 4.3.4, 8c]
12. Verify that seed, as a supplement to live plants, is included in the proposed plantings. Refer to Section 4.13.3, Landscape Design Considerations, for a list of species appropriate for overseeding on green roofs. [Section 4.3.4, 9b]
13. Verify that temporary erosion control measures are provided that are appropriate to the planting method during the plant establishment period. [Section 4.3.4, 9c]
14. Verify that Sedum sarmentosum, also known as star sedum, gold moss, stringy stonecrop, or graveyard moss, is not proposed. [Section 4.3.4, 12]

F.10 Subsurface Infiltration

F.10.1 Subsurface infiltration plan standards

1. Verify that the plans include an appropriate sequence of construction that is specific to the construction of the subsurface infiltration SMP. Refer to Section 4.4.5 for guidance. [Section 2.3.1]
2. To avoid soil disturbance and compaction during construction, verify that the infiltration area is proposed to be clearly marked before any site work begins. [Section 4.4.5, 1]
3. Verify that the plans include an appropriate cross-sectional detail for the subsurface infiltration SMP. [Section 2.3.1]

F.10.2 Subsurface infiltration design standards

1. Verify that the SMP drains within the acceptable 72-hour period after the 24-hour storm event. [Section 4.4.3, 1]
2. Verify that the loading ratio of DCIA to the horizontal footprint of the subsurface infiltration SMP does not exceed 10:1. [Section 4.4.3, 2]
3. Verify that positive overflow is provided for large storm events, up to and including the 100-year, 24-hour storm event, or, if the project is exempt from Flood Control, the ten-year, 24-hour storm. [Section 4.4.3, 3]
4. Verify that overflow structures and pipes are designed to convey at least the ten-year, 24-hour storm event. [Section 4.4.3, 3]
5. Verify that the distance between subsurface infiltration basins and any adjacent private property line is at least ten feet. This includes partially lined basins. It is acceptable for SMPs to be located directly adjacent to the public right-of-way (ROW) (unless a deed restriction is put in place extending at least ten feet from the perimeter of the infiltrating SMP). [Section 4.4.3, 4]
6. Verify that the distance between subsurface infiltration basins and any building or retaining wall is at least ten feet. This includes partially lined basins. The following requirements and exceptions apply: [Section 4.4.3, 5]
    a. For existing and proposed buildings with basements, the setback is measured from the basement wall.
    b. For existing buildings without basements and existing retaining walls, the setback is measured from the foundation and may be waived if a signed and sealed geotechnical analysis is submitted that evaluates the impacts of infiltration and excavation on the existing foundation and determines it to be feasible.
    c. For proposed buildings without basements and proposed retaining walls, the setback is measured from the foundation and may be waived if the foundation is proposed to be designed with the basin's proximity in mind.
7. Verify that the invert elevation of the subsurface infiltration SMP is at least two feet above any poorly infiltrating soils, seasonal high groundwater table, bedrock, or any other limiting zone. [Section 4.4.3, 6b]
8. For hydrologic modeling, verify that the design infiltration rate is applied to the horizontal surface area (SMP footprint), not the wetted area. [Section 4.4.3, 6c]
9. Verify that the soils underlying the subsurface infiltration SMP are determined to be infiltration feasible. If infiltration feasibility is unknown and determination is deferred until construction, the applicant must submit two complete designs (e.g. plans, calculations, Online Technical Worksheet, etc.) for both infiltrating and non-infiltrating scenarios to be fully reviewed. A PCSMP Conditional Approval will be issued, and the approval letter will feature both plan sets. Following infiltration testing, only the applicable design's plan set will be included on the PCSMP Approval Letter. [Section 4.4.3, 6d]

10. Verify that any soils with test infiltration rates in excess of ten inches per hour are proposed to receive soil amendments. [Section 4.4.3, 6e]
11. If the infiltration SMP is used as a temporary sediment basin during construction, verify that the invert elevation of the infiltration SMP is a minimum of three feet below the bottom elevation of the pre-basin-conversion sediment basin. [Section 4.4.3, 6f]
12. Verify that any infiltrating SMP within the zone of influence of any nearby sewers or sewer laterals is installed with an impervious liner. The zone of influence is defined by the area within a 1:1 (H:V) slope line from the outer edge of a sewer or sewer lateral. [Section 4.4.3, 6g]
13. Verify that pretreatment is provided for all runoff entering the subsurface infiltration SMP, including pretreatment of runoff from all inlets. At a minimum, this can be achieved through the use of sumps and traps for inlets, sump boxes with traps downstream of trench drains, and filter strips for overland flow. [Section 4.4.3, 8]
14. Verify that the storage area provides static storage for the Water Quality Volume (WQv) between the bottom elevation of the subsurface infiltration SMP and the elevation of the lowest outlet, including storage voids. Storage or distribution pipes alone are not sufficient in providing static storage. A minimum of at least three inches of forced storage via an outlet control device is recommended in order to give the statically stored volume time to infiltrate. [Section 4.4.3, 11]
15. Verify that the maximum storage volume statically stored within the subsurface infiltration SMP without supporting documentation (defined below) is the runoff volume from the one-year, 24-hour storm event. [Section 4.4.3, 12]
16. Verify that the maximum storage volume statically stored within the subsurface infiltration SMP with supporting documentation is the runoff volume from the ten-year, 24-hour storm event. Requirements for supporting documentation include a letter, signed and sealed by both the geotechnical and design engineer, indicating that the proposed design is recommended, with the following components acknowledged and considered. The designer is encouraged to contact PWD for further guidance when pursuing this design. [Section 4.4.3, 13]
    a. A summary of the long-term impacts to the neighboring properties, including, but not limited to subsidence, change in basement moisture/ water, and structural damage;
    b. The location of the groundwater table;
    c. References to other projects that have successfully infiltrated more than the one-year, 24-hour storm event; and
    d. Rigorous pretreatment to promote longevity of the infiltration SMP.
17. Verify that, when SMPs are used in series, the storage areas for all SMPs provide cumulative static storage for the WQv. [Section 4.4.3, 14]
18. Verify that void space provided by linear chamber systems, plastic grids, or other related structures is as specified by the manufacturer and noted in supporting documentation. [Section 4.4.3, 16]
19. Verify that pipe, vault, grid, and chamber storage areas are adequately bedded with stone to prevent settling or subsidence. [Section 4.4.3, 17a]
20. Verify that bedding thickness is not less than six inches. [Section 4.4.3, 17b]
21. Verify that foundations/footers are provided as warranted by system loading, geotechnical conditions, and manufacturer's recommendations. Foundation designs must be performed by an appropriate design professional. [Section 4.4.3, 17d]
22. Verify that the storage design accounts for potential loading from vehicles, as appropriate, based on expected maximum active loading, including consideration for emergency vehicles. [Section 4.4.3, 18]

23. Verify that the porosity values used for storage volume calculations are as follows: [Section 4.4.3, 19]
    a. Soil media: 0.20
    b. Sand: 0.30
    c. Stone: 0.40
24. Verify that the stone storage layer, if proposed, is separated from soil media by a geotextile or pea gravel filter to prevent sand, silt, and sediment from entering the system. [Section 4.4.3, 20]
25. Verify that stone storage systems have a level bottom or use a terraced system if installed along a slope. [Section 4.4.3, 21]
26. Verify that an adequate number of appropriately placed cleanouts, manholes, access panels and other access features are provided to allow unobstructed and safe access to the subsurface infiltration SMP for routine maintenance and inspection of inflow, outflow, underdrains, and storage systems. [Section 4.4.3, 23]
27. Verify that observation wells are provided for SMPs that include stone storage and that they meet the following requirements:
    a. The observation well must be placed at the invert of the stone bed. [Section 4.4.3, 24a]
    b. The observation well must be located near the center of the stone bed system to monitor the level and duration of water stored within the SMP (drain down time). A minimum of six inches of clearance must be provided between the edge of the observation well's concrete ring or frame and any nearby site features (curbing, tree pits, sidewalk edge, etc.). Plan view dimensioning for the proposed location of the observation well, relative to the boundaries of the SMP it lies within, must be provided on the plans. [Section 4.4.3, 24b]
    c. Adequate inspection and maintenance access to the observation well must be provided. [Section 4.4.3, 24c]
    d. An observation well located in a paved area must be outfitted with a cover and frame. The cover plate must be installed flush with the surrounding surface at finished grade, and grading should drain away from the observation well wherever possible. The solid section of the observation well must extend into the cover frame enough such that a bentonite/cement seal can be placed around the well within the frame, and a solid slip-on cap can be fitted onto the pipe end. [Section 4.4.3, 24d]
    e. An observation well located in an unpaved area must have a concrete ring or frame poured for support, with three lengths of rebar evenly spaced around the ring and three inches from its outer edge. The observation well should be located outside of the ponding area of any surface SMPs. If, due to space limitations, an observation well must be placed in the ponding area of a surface SMP, the concrete ring and well cover must extend three inches above the SMP's maximum ponding depth. [Section 4.4.3, 24e]
    f. The observation well must include a slotted section within the storage layer of the SMP. The top of the slotted well section must extend to a minimum of six inches below the top of the SMP storage layer, and the slotted section must extend down the entire depth of the SMP. [Section 4.4.3, 24f]
28. Verify that access features are provided for any subsurface infiltration SMP that is not comprised of a stone storage bed. [Section 4.4.3, 25a]
29. Verify that a sufficient number of access points in the SMP are provided to efficiently inspect and maintain the infiltration area. [Section 4.4.3, 25b]
30. For cast-in-place vault systems, verify that access features consist of manholes or grated access panels or doors. Grated access panels are preferred to maintain airflow. [Section 4.4.3, 25c]

31. For grid storage or other manufactured systems, verify that the manufacturer's recommendations are followed. [Section 4.4.3, 25d]
32. Verify that ladder access is proposed for vaults greater than four feet in height. [Section 4.4.3, 25e]
33. Verify that header pipes, at minimum 36-inch diameter, connected to manholes at each corner of the subsurface infiltration SMP are provided. Alternatively, smaller header pipes may be used if cleanouts are provided on the manifold/header pipe junction for each distribution pipe. The cleanouts must be on alternating sides of the SMP. [Section 4.4.3, 25f]

F.10.3 Subsurface infiltration material standards

1. Verify that stone designed for stormwater storage, if proposed, is specified on the plans as being uniformly graded, crushed, clean-washed stone and that it is noted that PWD defines "clean-washed" as having less than 0.5% wash loss, by mass, when tested per the AASHTO T-11 wash loss test. AASHTO No. 3 and No. 57 stone can meet this specification. [Section 4.4.4, 3]
2. Verify that sand, if proposed, is specified on the plans to be AASHTO M-6 or ASTM C-33 sand and to have a grain size of 0.02 inches to 0.04 inches. [Section 4.4.4, 4]
3. Verify that storage pipe, if proposed, is specified on the plans as meeting the following specifications:
    a. Pipe used within the subsurface infiltration SMP must be continuously perforated and have a smooth interior with a minimum inner diameter of four inches. [Section 4.4.4, 5a]
    b. High-density polyethylene (HDPE) pipe, if proposed, must meet the specifications of AASHTO M252, Type S or AASHTO M294, Type S. [Section 4.4.4, 5b]
    c. Any pipe materials outside the SMP are to meet City Plumbing Code Standards. [Section 4.4.4, 5c]
4. Verify that geotextile, if proposed, is specified on the plans to consist of polypropylene fibers and to meet the following specifications (AASHTO Class 1 or Class 2 geotextile is recommended): [Section 4.4.4, 6]
    a. Grab Tensile Strength (ASTM-D4632): ≥ 205 lbs
    b. CBR Puncture Strength (ASTM-D6241): ≥ 500 lbs
    c. Flow Rate (ASTM-D4491): ≥ 95 gal/min/ft2
    d. UV Resistance after 500 hrs (ASTM-D4355): ≥ 70%
    e. Tear Resistance (ASTM-D4533): ≥ 80 lbs
    f. Heat-set or heat-calendared fabrics are not permitted.
5. Verify that the observation well is specified on the plans as meeting the following specifications:
    a. The observation well must consist of slotted plastic pipe with a minimum inner diameter of four inches and a solid cap at the surface. The slotted section of the well must consist of PVC slotted well screen with 0.01-inch slot size and an attached perforated PVC cap at the bottom. [Section 4.4.4, 8a]
    b. The observation well's cover must be ductile iron in a gray iron frame. [Section 4.4.4, 8b]
    c. For an observation well located in an unpaved area, the well's concrete ring must be a minimum of six inches wider in any dimension than the cover frame, of equal depth as the cover frame itself, and poured atop a minimum of six inches of AASHTO #57 stone bedding. A frame conforming to these minimum dimensions may be circular or square. [Section 4.4.4, 8c]
6. Verify that cleanouts are made of material with a smooth interior having an inner diameter that is no less than six inches. If the connecting pipe is eight inches in diameter or larger, verify that the cleanout is eight inches in diameter. [Section 4.4.4, 9]

F.11 Cisterns

F.11.1 Cistern plan standards

1. Verify that the plans include an appropriate sequence of construction that is specific to the construction of the cistern. Refer to Section 4.5.5 for guidance. [Section 2.3.1]
2. Verify that the plans include an appropriate cross-sectional detail for the cistern. [Section 2.3.1]

F.11.2 Cistern design standards

1. Verify that irrigation as a use for runoff stored in a cistern is not a proposed strategy for meeting the Stormwater Regulations. [Section 4.5.1]
2. Verify that the time for drain down/withdrawal from the cistern for any portion of storage intended to meet the Water Quality requirement is within the acceptable 72-hour period after the 24-hour storm event. If the water demand fluctuates seasonally, verify that the cistern drains within 72 hours based on usage in all seasons. [Section 4.5.3, 1]
3. Verify that positive overflow is provided for large storm events, up to and including the 100-year, 24-hour storm event, or, if the project is exempt from Flood Control, the ten-year, 24-hour storm. [Section 4.5.3, 2]
4. Verify that overflow structures and pipes are designed to convey at least the ten-year, 24-hour storm event. [Section 4.5.3, 2]
5. Verify that the minimum allowable freeboard above maximum ponding depth is four inches or the diameter of the outlet pipe, whichever is greater. [Section 4.5.3, 3]
6. Verify that the proposed indoor uses and pipe labeling and routing (i.e., separate stud bays) are allowable per the City's Building and Plumbing Codes (administered by the City of Philadelphia Department of Licenses and Inspections (L&I)). [Section 4.5.3, 5]
7. Verify that appropriate treatment and management of harvested rainwater is proposed per State and Federal codes. [Section 4.5.3, 5]
8. In cases where a municipal backup supply is used, verify that rainwater harvesting systems propose backflow preventers or air gaps to keep non-potable harvested water separate from the potable water supply. Distribution and waste pipes, internal to the building, must be designated as such per the City's Building and Plumbing Codes (administered by L&I). [Section 4.5.3, 6]
9. Verify that pretreatment is provided for all runoff entering the cistern, including pretreatment of runoff from all inlets. At a minimum, this can be achieved through the use of sumps and traps for inlets, sump boxes with traps downstream of trench drains, and filter strips for overland flow. [Section 4.5.3, 8]
10. Verify that gutters and downspouts are fitted with leaf/debris screens along the entire length of the gutter leading to the cistern tank. Leaf/debris screens must be made from a corrosion-resistant material with screen openings in the range of 0.25 inches to 0.50 inches. Leaf screens must be inspected on a regular basis to prevent accumulated leaves and debris from clogging the gutter openings. [Section 4.5.3, 9a]
11. Verify that all inlets and vents to a cistern are protected by 1/6-inch stainless steel mesh screens, which keep insects, vermin, leaves and other debris from entering the cistern. [Section 4.5.3, 9b]
12. Verify that approximately one to two gallons of water per 100 square feet of roof collection surface are diverted to a first-flush chamber instead of the cistern tank. [Section 4.5.3, 10a]
13. Verify that, once the first-flush chamber is full, the remainder of the stormwater is directed to the cistern tank. A slow release control valve or drip system is typically included in the design to empty the first-flush chamber automatically in between storm events. [Section 4.5.3, 10b]

14. Verify that the first-flush diverter system includes an accessible cleanout. [Section 4.5.3, 10c]
15. Verify that the storage area provides adequate storage for the Water Quality Volume (WQv) between the overflow elevation and the controlling low flow orifice elevation. If the water reuse demand is less than the WQv, and only a portion of the WQv drains down or is withdrawn in 72 hours, only that portion of volume will be considered for compliance, and the remainder of the WQv must be managed by an additional SMP in series. Refer to Section 3.2.3 for information on using SMPs in series. Any portion of the storage that will not drain down or be withdrawn within 72 hours must be excluded from the system's storage volume estimation. [Section 4.5.3, 12]
16. Verify that, when SMPs are used in series, the storage areas for all SMPs provide cumulative static storage for the WQv. [Section 4.5.3, 13]
17. Verify that detailed calculations to demonstrate the anticipated daily, 72-hour, and monthly water use are provided. For toilet use, volume must be calculated based on the number of flushes per day multiplied by gallons per flush. [Section 4.5.3, 15]
18. If volume in excess of the WQv is proposed for on-site reuse and the volume is estimated by a weekly water balance of rainfall and water reuse, verify that the difference on a weekly basis between rainfall depth (in Table 4.5-1 of the Manual) and water depth is estimated. This deficit must be multiplied by the roof drainage area to obtain an estimate of the cistern volume needed. [Section 4.5.3, 16]
19. Verify that the cistern is watertight and sealed using a water-safe, non-toxic substance. [Section 4.5.3, 17]
20. Verify that cistern storage areas are adequately bedded with stone to prevent settling or subsidence. [Section 4.5.3, 18a]
21. Verify that bedding thickness is not less than six inches. [Section 4.5.3, 18b]
22. Verify that foundations/footers are provided as warranted by system loading, geotechnical conditions, and manufacturer's recommendations. Foundation designs must be performed by an appropriate design professional. [Section 4.5.3, 18d]
23. Verify that the storage design for subsurface cisterns accounts for potential loading from vehicles, as appropriate, based on expected maximum active loading, including consideration for emergency vehicles. [Section 4.5.3, 19]
24. Verify that the overflow conveyance has a capacity equal to or greater than the inflow pipe(s) and has a diameter and slope sufficient to drain the cistern while maintaining an adequate freeboard height. [Section 4.5.3, 20]
25. Verify that the overflow conveyance is screened to prevent access to the cistern by small mammals and birds. [Section 4.5.3, 20]
26. Verify that the discharge from the overflow is directed to an acceptable flow path that will not cause erosion. [Section 4.5.3, 20]
27. Verify that an adequate number of appropriately placed cleanouts, manholes, access panels and other access features are provided to allow unobstructed and safe access to the cistern for routine maintenance and inspection of inflow, outflow, underdrains, and storage systems. [Section 4.5.3, 22]
28. Verify that access features are provided for all subsurface cisterns. [Section 4.5.3, 23a]
29. Verify that a sufficient number of access points in the subsurface cistern are provided to efficiently inspect and maintain the storage area. [Section 4.5.3, 23b]
30. For cast-in-place vault systems, verify that access features consist of manholes or grated access panels or doors. Grated access panels are preferred to maintain airflow. [Section 4.5.3, 23c]
31. For manufactured systems, verify that the manufacturer's recommendations are followed. [Section 4.5.3, 23d]

32. Verify that ladder access is proposed for vaults greater than four feet in height. [Section 4.5.3, 23e]
33. Verify that the access opening for a subsurface cistern is installed in such a way as to prevent surface or groundwater from entering through the top of any fittings, and verify that it is secured/locked to prevent unwanted entry. [Section 4.5.3, 23f]

F.11.3 Cistern material standards

1. Verify that the cistern is not constructed of non-galvanized steel, wood, or other products prone to environmental corrosion/decay. [Section 4.5.4, 3]
2. Verify that the cistern is opaque or otherwise shielded to prevent the growth of algae. [Section 4.5.4, 5]
3. Verify that cleanouts are made of material with a smooth interior having an inner diameter that is no less than six inches. If the connecting pipe is eight inches in diameter or larger, verify that the cleanout is eight inches in diameter. [Section 4.5.4, 7]
4. Verify that the first-flush diverter system includes an accessible cleanout. [Section 4.5.4, 8]
5. Verify that serviceways consist of manhole openings with lockable manhole covers. Depending on the size of the cistern, multiple serviceway openings are recommended to support inspection, repair, and cleaning. [Section 4.5.4, 9]

F.12 Blue Roofs

F.12.1 Blue roof plan standards

1. Verify that the plans include an appropriate sequence of construction that is specific to the construction of the blue roof. Refer to Section 4.6.5 for guidance. [Section 2.3.1]
2. Verify that the plans include an appropriate cross-sectional detail for the blue roof. [Section 2.3.1]
3. Verify that a roof drainage plan is provided and that the roof drainage is consistent with the blue roof design. [Appendix E, Table E-7]

F.12.2 Blue roof design standards

1. Verify that structural loading is considered for the blue roof design, and that the blue roof design is coordinated with a licensed structural engineer for both new building construction and retrofits to existing structures. [Section 4.6.3, 1]
2. Verify that the maximum surface ponding depth is four to six inches. [Section 4.6.3, 2]
3. Verify that the SMP drains within the acceptable 72-hour period after the 24-hour storm event. [Section 4.6.3, 3]
4. Verify that positive overflow is provided for large storm events, up to and including the 100-year, 24-hour storm event, or, if the project is exempt from Flood Control, the ten-year, 24-hour storm. [Section 4.6.3, 4]
5. Verify that overflow structures and pipes are designed to convey at least the ten-year, 24-hour storm event. [Section 4.6.3, 4]
6. Verify that the blue roof storage area is underlain by a waterproofing membrane. [Section 4.6.3, 5]
7. Verify that the storage system provides adequate storage to control release rates to meet all applicable Stormwater Regulations. [Section 4.6.3, 7]
8. Verify that a porosity of 0.40 is used for ballast stone. [Section 4.6.3, 9]
9. For roofs without ballast, verify that enough weight is provided to secure the waterproofing membrane. [Section 4.6.3, 10]
10. For roofs with ballast, verify that the depth and porosity of the ballast are accounted for when calculating the potential storage volume. [Section 4.6.3, 10]
11. Verify that roof drain restrictors, if proposed, are sized according to the desired release rate and ponding depth. [Section 4.6.3, 11]
12. Verify that safe access to the blue roof is provided for periodic cleaning, inspection, and maintenance by trained building personnel. Easy access must be provided to each of the outlet controls, low-flow discharge points, and overflow connections to permit removal of debris under saturated conditions. [Section 4.6.3, 13]

F.12.3 Blue roof material standards

1. Verify that stone or gravel used for ballast within the stormwater storage area, if proposed, is specified on the plans as being uniformly graded, clean-washed stone, either crushed or smooth, and that it is noted that PWD defines “clean-washed” as having less than 0.5% wash loss, by mass, when tested per the AASHTO T-11 wash loss test. AASHTO No. 3 and No. 57 stone can meet this specification. [Section 4.6.4, 2a]
2. Verify that the size of the stone, if proposed, does not exceed the mesh size of the outlet control screen or slots. Ballast stone typically falls within the size range of 3/8 inch to two inches. [Section 4.6.4, 2b]
3. Verify that ballast, if proposed, meets all American Society of Testing and Materials (ASTM) D1863 requirements for mineral aggregate used on built-up roofs. [Section 4.6.4, 2c]
4. Verify that all waterproof membranes meet appropriate ASTM specifications. PVC membranes must meet ASTM D4434 requirements, EPDM membranes must meet ASTM D4637 requirements, and TPO membranes must meet ASTM D6878 requirements. [Section 4.6.4, 3b]
5. Verify that all waterproofing membranes are fully waterproof with properly sealed seams, corners, and protrusions to prevent any intrusion of standing water above the membrane. [Section 4.6.4, 3c]
6. Verify that roofing membranes meet all building code requirements and guidelines of the City of Philadelphia. [Section 4.6.4, 3d]

F.13 Ponds and Wet Basins

F.13.1 Pond and wet basin plan standards

1. Verify that the plans include an appropriate sequence of construction that is specific to the construction of the pond or wet basin. Refer to Section 4.7.5 for guidance. [Section 2.3.1]
2. Verify that the plans include an appropriate cross-sectional detail for the pond or wet basin. [Section 2.3.1]

F.13.2 Pond and wet basin design standards

1. Verify that the SMP drains within the acceptable 72-hour period after the 24-hour storm event. [Section 4.7.3, 1]
2. Verify that positive overflow is provided for large storm events, up to and including the 100-year, 24-hour storm event, or, if the project is exempt from Flood Control, the ten-year, 24-hour storm. [Section 4.7.3, 2]
3. Verify that overflow structures and pipes are designed to convey at least the ten-year, 24-hour storm event. [Section 4.7.3, 2]
4. Verify that, during the 100-year storm, 24-hour storm event, or, if the project is exempt from Flood Control, the ten-year, 24-hour storm, the freeboard between the peak storage elevation and the emergency spillway invert elevation is a minimum of one foot. [Section 4.7.3, 3]
5. Verify that the distance between the emergency spillway crest elevation and the top-of-berm elevation is a minimum of one foot. [Section 4.7.3, 4]
6. Verify that the basin length-to-width ratio is a minimum of 2:1. [Section 4.7.3, 5]
7. Verify that the basin has a minimum width of ten feet. [Section 4.7.3, 6]
8. Verify that the sediment forebay has a minimum length of ten feet. [Section 4.7.3, 7]
9. Verify that the distance between the basin inflow and outflow points is maximized. [Section 4.7.3, 8]
10. Verify that a curve number of 98 is used for the area below the water surface elevation, where required for hydrologic calculations. [Section 4.7.3, 9]
11. Verify that all areas deeper than four feet must have two aquatic safety benches extending a combined total of 15 feet, at minimum, inward from the perimeter of the basin. One bench must be above the normal water surface elevation and extend up to the pond side slopes at a maximum slope of 10%. The other bench must be below the water surface extending into the pond at a 10% slope to a maximum depth of 18 inches. [Section 4.7.3, 10]
12. Verify that a dewatering mechanism is proposed for facilities that are not in connection with groundwater. [Section 4.7.3, 11]
13. Verify that pretreatment is provided for all runoff entering the pond or wet basin, including pretreatment of runoff from all inlets. At a minimum, this can be achieved through the use of sumps and traps for inlets, sump boxes with traps downstream of trench drains, and filter strips for overland flow. [Section 4.7.3, 12]
14. Verify that energy dissipaters, such as riprap stone, are proposed at all locations of concentrated inflow. [Section 4.7.3, 14]
15. Verify that the storage area provides static storage for the Water Quality Volume (WQv) between the overflow elevation and the basin's water surface. All permanent pool areas must be excluded from the SMP's storage volume estimation. [Section 4.7.3, 16]

16. Verify that the side slopes for all open storage areas do not exceed 2(H):1(V) (the recommended side slope is 3(H):1(V)), and that the side slopes of all mowed areas do not exceed 4(H): 1(V) to avoid "scalping" by mower blades. [Section 4.7.3, 18]
17. Verify that a minimum planting soil medium depth of 18 inches is provided under emergent planting zones. [Section 4.7.3, 19]
18. Verify that the planting design provides for at least 85% cover of the emergent vegetation zone (the area of the pond that is less than 18 inches deep) and buffer area. [Section 4.7.3, 23]
19. Verify that a vegetated pond buffer extends outward 25 feet from the permanent pool. [Section 4.7.3, 24]
20. Verify that energy dissipaters, such as riprap stone, are placed at the end of the primary outlet to prevent erosion. [Section 4.7.3, 26]
21. Verify that the primary and low-flow outlets are protected from clogging by an external trash rack. [Section 4.7.3, 27]
22. Verify that the emergency spillway does not direct flow toward neighboring properties. [Section 4.7.3, 28]
23. Verify that stabilized vehicular access is provided for sediment removal. Areas must be at least nine feet wide, have a maximum slope of 15%, and be stabilized as needed to provide load support for vehicles. [Section 4.7.3, 30]

F.13.3 Pond and wet basin material standards

1. Verify that the planting soil medium is specified on the plans as meeting the following specifications: [Section 4.7.4, 3]
   a. Hydrologic soil groups "C" and "D" are suitable, without modification, for underlying soils.
   b. If natural topsoil from the site is to be used, it must have at least 8% organic carbon content by weight in the A-horizon for sandy soils and 12% for other soil types.
   c. If planting soil is imported, it must be made up of equivalent proportions of organic and mineral materials.
2. Verify that native grass/wildflower seed mix, if proposed as an alternative to groundcover planting, is free of weed seeds. [Section 4.7.4, 6]
3. Verify that the proposed pond or wet basin plantings are indicated on the plans and are non-invasive. Refer to **Appendix I** ☛ p. 107 for plant lists. [Section 4.7.4, 7]

F.14 Subsurface Detention

F.14.1 Subsurface detention plan standards

1. Verify that the plans include an appropriate sequence of construction that is specific to the construction of the subsurface detention SMP. Refer to Section 4.8.5 for guidance. [Section 2.3.1]
2. Verify that the plans include an appropriate cross-sectional detail for the subsurface detention SMP. [Section 2.3.1]

F.14.2 Subsurface detention design standards

1. Verify that the SMP drains within the acceptable 72-hour period after the 24-hour storm event. [Section 4.8.3, 1]
2. Verify that positive overflow is provided for large storm events, up to and including the 100-year, 24-hour storm event, or, if the project is exempt from Flood Control, the ten-year, 24-hour storm. [Section 4.8.3, 2]
3. Verify that overflow structures and pipes are designed to convey at least the ten-year, 24-hour storm event. [Section 4.8.3, 2]
4. Verify that the distance between subsurface detention basins and any adjacent private property line is at least ten feet. This includes lined basins. Exceptions can be made for water-tight vaults with their own structural integrity, such as concrete or fiberglass vaults. It is acceptable for SMPs to be located directly adjacent to the public right-of-way (ROW) (unless a deed restriction is put in place extending at least ten feet from the perimeter of the infiltrating SMP). [Section 4.8.3, 4]
5. Verify that the distance between subsurface detention basins and any building or retaining wall is at least ten feet. This includes lined basins. The following requirements and exceptions apply: [Section 4.8.3, 5]
    a. For existing and proposed buildings with basements, the setback is measured from the basement wall and may be waived if the basin is a water-tight vault with its own structural integrity, such as a concrete or fiberglass vault.
    b. For existing buildings without basements and existing retaining walls, the setback is measured from the foundation and may be waived if a signed and sealed geotechnical analysis is submitted that evaluates the impacts of residual infiltration and excavation on the existing foundation and determines it to be feasible.
    c. For proposed buildings without basements and proposed retaining walls, the setback is measured from the foundation and may be waived if the foundation is proposed to be designed with the basin's proximity in mind.
6. Verify that pretreatment is provided for all runoff entering the subsurface detention SMP, including pretreatment of runoff from all inlets. At a minimum, this can be achieved through the use of sumps and traps for inlets, sump boxes with traps downstream of trench drains, and filter strips for overland flow. [Section 4.8.3, 6]
7. Verify that the storage area provides adequate storage to control release rates to meet all applicable Stormwater Regulations. All permanent pool areas must be excluded from the SMP's storage volume estimation. [Section 4.8.3, 9]
8. Verify that pipe, vault, grid and chamber storage areas are adequately bedded with stone to prevent settling or subsidence. [Section 4.8.3, 10a]
9. Verify that bedding thickness is not less than six inches. [Section 4.8.3, 10b]
10. Verify that foundations/footers are provided as warranted by system loading, geotechnical conditions, and manufacturer's recommendations. Foundation designs must be performed by an appropriate design professional. [Section 4.8.3, 10d]

11. Verify that the storage design accounts for potential loading from vehicles, as appropriate, based on expected maximum active loading, including consideration for emergency vehicles. [Section 4.8.3, 11]
12. Verify that the porosity values used for storage volume calculations are as follows: [Section 4.8.3, 13]
    a. Soil media: 0.20
    b. Sand: 0.30
    c. Stone 0.40
    d. Void space provided by linear chamber systems, plastic grids, or other related structures must be as specified by the manufacturer and noted in supporting documentation.
13. Verify that the stone storage layer, if proposed, is separated from soil media by a geotextile or pea gravel filter to prevent sand, silt, and sediment from entering the system. [Section 4.8.3, 14]
14. Verify that any impervious liner, if necessary, is not interrupted by structures within the basin footprint. The plans must indicate that the impervious liner is to be continuous and extend completely up the sides of any structures that are located within the lined basin footprint to the ground surface. If additional liner material must be added to extend up the structures, the additional liner sections are to be joined to the rest of the liner with an impervious seam per the manufacturers' recommendations. [Section 4.8.3, 16]
15. Verify that an adequate number of appropriately placed cleanouts, manholes, access panels, and other access features are provided to allow unobstructed and safe access to the subsurface detention SMP for routine maintenance and inspection of inflow, outflow, underdrains, and storage systems. [Section 4.8.3, 17]
16. Verify that observation wells are provided for SMPs that include stone storage and that they meet the following requirements:
    a. The observation well must be placed at the invert of the stone bed. [Section 4.8.3, 18a]
    b. The observation well must be located near the center of the stone bed system to monitor the level and duration of water stored within the system (drain down time). A minimum of six inches of clearance must be provided between the edge of the observation well's concrete ring or frame and any nearby site features (curbing, tree pits, sidewalk edge, etc.). Plan view dimensioning for the proposed location of the observation well, relative to the boundaries of the SMP it lies within, must be provided on the plans. [Section 4.8.3, 18b]
    c. Adequate inspection and maintenance access to the observation well must be provided. [Section 4.8.3, 18c]
    d. An observation well located in a paved area must be outfitted with a cover and frame. The cover plate must be installed flush with the surrounding surface at finished grade, and grading should drain away from the observation well wherever possible. The solid section of the observation well must extend into the cover frame enough such that a bentonite/cement seal can be placed around the well within the frame, and a solid slip-on cap can be fitted onto the pipe end. [Section 4.8.3, 18d]
    e. An observation well located in an unpaved area must have a concrete ring or frame poured for support, with three lengths of rebar evenly spaced around the ring and three inches from its outer edge. The observation well should be located outside of the ponding area of any surface SMPs. If, due to space limitations, an observation well must be placed in the ponding area of a surface SMP, the concrete ring and well cover must extend three inches above the SMP's maximum ponding depth. [Section 4.8.3, 18e]
    f. The observation well must include a slotted section within the storage layer of the SMP. The top of the slotted well section must extend to a minimum of six inches below the top of the SMP storage layer, and the slotted section must extend down the entire depth of the SMP. [Section 4.8.3, 18f]

17. Verify that access features are provided for any subsurface detention SMP that is not comprised of a stone storage bed. [Section 4.8.3, 19a]
18. Verify that a sufficient number of access points in the SMP are provided to efficiently inspect and maintain the storage area. [Section 4.8.3, 19b]
19. For cast-in-place vault systems, verify that access features consist of manholes or grated access panels or doors. Grated access panels are preferred to maintain airflow. A minimum of 50 square feet of grate area is recommended for permanent pool designs. [Section 4.8.3, 19c]
20. For grid storage or other manufactured systems, verify that the manufacturer's recommendations are followed. [Section 4.8.3, 19d]
21. Verify that ladder access is provided for vaults greater than four feet in height. [Section 4.8.3, 19e]
22. Verify that header pipes, at minimum 36-inch in diameter, connected to manholes at each corner of the subsurface detention SMP are provided. Alternatively, smaller header pipes may be used if cleanouts are provided on the manifold/header pipe junction for each distribution pipe. The cleanouts must be on alternating sides of the SMP. [Section 4.8.3, 19f]

F.14.3 Subsurface detention material standards

1. Verify that stone designed for stormwater storage, if proposed, is specified on the plans as being uniformly graded, crushed, clean-washed stone, and that it is noted that PWD defines “clean-washed” as having less than 0.5% wash loss, by mass, when tested per the AASHTO T-11 wash loss test. AASHTO No. 3 and AASHTO No. 57 stones can meet this specification. [Section 4.8.4, 3]
2. Verify that sand, if proposed, is specified on the plans to be AASHTO M-6 or ASTM C-33 sand and to have a grain size of 0.02 inches to 0.04 inches. [Section 4.8.4, 4]
3. Verify that storage pipe, if proposed, is specified on the plans as meeting the following specifications:
    a. Pipe used within the subsurface detention SMP must have a minimum inner diameter of four inches. [Section 4.8.4, 5a]
    b. High-density polyethylene (HDPE) pipe must meet the specifications of AASHTO M252, Type S or AASHTO M294, Type S. [Section 4.8.4, 5b]
    c. Any pipe materials outside the SMP are to meet the City Plumbing Code Standards. [Section 4.8.4, 5c]
4. Verify that geotextile, if proposed, is specified on the plans to consist of polypropylene fibers and to meet the following specifications (AASHTO Class 1 or Class 2 geotextile is recommended): [Section 4.8.4, 6]
    a. Grab Tensile Strength (ASTM-D4632): ≥ 205 lbs
    b. CBR Puncture Strength (ASTM-D6241): ≥ 500 lbs
    c. Flow Rate (ASTM-D4491): ≥ 95 gal/min/ft2
    d. UV Resistance after 500 hrs (ASTM-D4355): ≥ 70%
    e. Tear Resistance (ASTM-D4533): ≥ 80 lbs
    f. Heat-set or heat-calendared fabrics are not permitted
5. Verify that the observation well is specified on the plans as meeting the following specifications:
    a. The observation well must consist of slotted plastic pipe with a minimum inner diameter of four inches and a solid cap at the surface. The slotted section of the well must consist of PVC slotted well screen with 0.01-inch slot size and an attached perforated PVC cap at the bottom. [Section 4.8.4, 8a]
    b. The observation well’s cover must be ductile iron in a gray iron frame. [Section 4.8.4, 8b]
    c. For an observation well located in an unpaved area, the well’s concrete ring must be a minimum of six inches wider in any dimension than the cover frame, of equal depth as the cover frame itself, and poured atop a minimum of six inches of AASHTO #57 stone bedding. A frame conforming to these minimum dimensions may be circular or square. [Section 4.8.4, 8c]
6. Verify that cleanouts are made of material with a smooth interior having an inner diameter that is no less than six inches. If the connecting pipe is eight inches in diameter or larger, verify that the cleanout is eight inches in diameter. [Section 4.8.4, 9]

F.15 Media Filters

F.15.1 Media filter plan standards

1. Verify that the plans include an appropriate sequence of construction that is specific to the construction of the media filter. Refer to Section 4.9.5 for guidance. [Section 2.3.1]
2. Verify that the plans include an appropriate cross-sectional detail for the media filter. [Section 2.3.1]

F.15.2 Media filter design standards

1. Verify that the following information is submitted for each proposed media filter as part of the applicant's Post-Construction Stormwater Management Plan (PCSMP) Review Phase Submission Package: [Section 4.9.3, 1]
   a. Inflow and outflow event mean concentrations and percent removals for Total Suspended Solids (TSS) for sand/media filters (Designs must demonstrate a maximum effluent event mean concentration (EMC) of 15 milligrams per liter for TSS at a point of analysis (POA) downstream of the SMP);
   b. Third-party certifications for proprietary media filters;
   c. Hydrologic and hydraulic model files, if applicable;
   d. Product specifications for proprietary media filters;
   e. Manufacturer's guidelines for installation for proprietary media filters;
   f. Construction sequence; and
   g. Maintenance requirements, including product life and replacement schedule, if applicable.
2. For proprietary media filters, verify the following:
   a. Verify that the manufacturer's design guidance for appropriate pretreatment is followed. [Section 4.9.3, 7]
   b. Verify that the manufacturer's design guidance for inlet control configuration is followed. [Section 4.9.3, 9]
   c. Verify that the manufacturer's design guidance for filter sizing is followed. [Section 4.9.3, 11]
   d. Verify that the manufacturer's design guidance for outlet control configuration is followed. [Section 4.9.3, 22]
   e. Verify that the manufacturer's design guidance for inspection and maintenance access is followed [Section 4.9.3, 27]
3. Verify that the SMP drains within the acceptable 72-hour period after the 24-hour storm event. [Section 4.9.3, 2]
4. Verify that the filter footprint is sized pursuant to the filter media flow-through rate. [Section 4.9.3, 3]
5. Verify that positive overflow is provided for large storm events, up to and including the 100-year, 24-hour storm event, or, if the project is exempt from Flood Control, the ten-year, 24-hour storm. [Section 4.9.3, 4]
6. Verify that overflow structures and pipes are designed to convey at least the ten-year, 24-hour storm event. [Section 4.9.3, 4]
7. Verify that proposed filters without detention are able to convey the ten-year, 24-hour storm event. [Section 4.9.3, 5]
8. Verify that proposed filters with detention are designed to safely store and/or convey the 100-year, 24-hour storm event. [Section 4.9.3, 6]

9. Verify that pretreatment is provided for all runoff entering the media filter, including pretreatment of runoff from all inlets. At a minimum, this can be achieved through the use of sumps and traps. [Section 4.9.3, 8]
10. Verify that the filter system provides enough storage to allow the Water Quality storm to flow through the filter media. Upstream SMPs can be used to store this flow. [Section 4.9.3, 12]
11. Verify that, when SMPs are used in series, the storage areas for all SMPs provide cumulative static storage for the Water Quality Volume (WQv). [Section 4.9.3, 13]
12. Verify that the porosity values used for storage volume calculations are as follows: [Section 4.9.3, 15]
    a. Soil media: 0.20
    b. Sand: 0.30
    c. Stone: 0.40
    d. Porosity values of any proprietary rapid media should be obtained from the appropriate manufacturer.
13. Verify that filters have a minimum surface area as computed by the following equation: [Section 4.9.3, 16a]

$$A_f = \frac{(WQv \; x \; 0.8)}{k}$$

WHERE:

>A_f = surface area of the filter (square feet);
WQv = Water Quality Volume, the 1.5-inch Water Quality Volume over directly connected impervious area (DCIA) (cubic feet); and
k = saturated hydraulic conductivity of the filter media (feet per day)

14. Verify that a filtration rate of two inches per hour for sand and soil is used when computing surface area (accounting for the reduction in filtration rates for sand over time due to build-up of fine material). [Section 4.9.3, 16b]
15. Verify that the determination of filtration rate for proprietary or mixed media is obtained from manufacturers or from evaluation of similar applications. High filtration rates at installation associated with some media types may yield small required surface area values. Verify that the assumed infiltration rate accounts for the potential for filter systems to clog over time. [Section 4.9.3, 16c]
16. Verify that the filter media depth is a minimum of 18 inches (greater depths may be used but do not alter filter sizing requirements). [Section 4.9.3, 17]
17. Verify that stone is not used as filter media. It can be used within filter systems to provide additional storage. [Section 4.9.3, 18]
18. Verify that pipe, vault, grid, and chamber storage areas are adequately bedded with stone to prevent settling or subsidence. [Section 4.9.3, 19a]
19. Verify that bedding thickness is not less than six inches. [Section 4.9.3, 19b]
20. Verify that foundations/footers are provided as warranted by system loading, geotechnical conditions, and manufacturer's recommendations. Foundation designs must be performed by an appropriate design professional. [Section 4.9.3, 19d]
21. Verify that the storage design accounts for potential loading from vehicles, as appropriate, based on expected maximum active loading, including consideration for emergency vehicles. [Section 4.9.3, 20]
22. Verify that the system has a level bottom and uses a terraced system, if installed along a slope. [Section 4.9.3, 21]

23. Verify that impervious liners are provided for all filter systems not contained in impermeable structures. [Section 4.9.3, 23]
24. Verify that any impervious liner, if necessary, is not interrupted by structures within the filter footprint. The plans must indicate that the impervious liner is to be continuous and extend completely up the sides of any structures that are located within the lined filter footprint to the ground surface. If additional liner material must be added to extend up the structures, the additional liner sections are to be joined to the rest of the liner with an impervious seam per the manufacturers' recommendations. [Section 4.9.3, 23]
25. Verify that an underdrain is provided for any non-infiltrating system and that it meets the following requirements:
    a. Underdrains must be surrounded by a sand layer or stone to filter sediment and facilitate drainage. [Section 4.9.3, 24a]
    b. The minimum allowable depth of a sand or stone filter layer above and beneath the underdrain is six inches. [Section 4.9.3, 24b]
    c. Underdrains must be surrounded by a geotextile fabric if sand is used. [Section 4.9.3, 24c]
    d. The outlet pipe of an outlet control structure must have an invert at or below the invert of the underdrain. Setting the outlet pipe invert at a minimum of 7.5 inches below that of the underdrain is recommended. [Section 4.9.3, 24d]
26. For filters located in the separate sewer area, where infiltration is infeasible, flow through the underdrain may be modeled as exfiltration at a rate of two inches per hour for sand media and at an appropriate rate for other filter media, then routed through the underdrain system. Verify that this exfiltration flow is routed through the primary outlet of the filter, not discarded from the stormwater model. Determination of filtration rate for proprietary or mixed media must be obtained from the manufacturer or from evaluation of similar applications. [Section 4.9.3, 25]
27. Verify that an adequate number of appropriately placed manholes, access panels and other access features are provided to allow unobstructed and safe access to the media filter for routine maintenance and inspection of inflow, outflow, underdrains, and storage systems. [Section 4.9.3, 28]
28. Verify that access features are provided for underground storage SMPs within which filters are contained and that are not stone storage beds. [Section 4.9.3, 29a]
29. Verify that a sufficient number of access points in the SMP are provided to efficiently inspect and maintain the storage area. [Section 4.9.3, 29b]
30. For cast-in-place vault systems within which filters are contained, verify that access features consist of manholes or grated access panels or doors. Grated access panels are preferred to maintain airflow. [Section 4.9.3, 29c]
31. Verify that ladder access is proposed for vaults, within which filters are contained, greater than four feet in height. [Section 4.9.3, 29f]

F.15.3 Media filter material standards

1. Verify that stone, if proposed, designed for stormwater storage is specified on the plans as being uniformly graded, crushed, clean-washed stone and that it is noted that PWD defines “clean-washed” as having less than 0.5% wash loss, by mass, when tested per the AASHTO T-11 wash loss test. AASHTO No. 3 and No. 57 stone can meet this specification. [Section 4.9.4, 3a]
2. Verify that stone, if proposed, is separated from filter media by a geotextile or a pea gravel filter. [Section 4.9.4, 3b]
3. Verify that sand used as filter media, if proposed, is specified on the plans to be clean, medium to fine sand, and to have organic material meeting the specifications of AASHTO M-6 or ASTM C-33 sand and a grain size of 0.02 inches to 0.04 inches. [Section 4.9.4, 4a]
4. Verify that sand used as filter media, if proposed, is capable of generating a maximum effluent EMC of 15 milligrams per liter for TSS accumulated at a POA downstream of the SMP. [Section 4.9.4, 4b]
5. Verify that peat, if proposed, has an ash content of less than 15%, a pH range of 3.3 to 5.2, and a loose bulk density range of 0.12 g/cc to 0.14 g/cc. [Section 4.9.4, 5b]
6. Verify that any filter media other than sand or peat is capable of generating a maximum effluent EMC of 15 milligrams per liter for TSS accumulated at a POA downstream of the SMP, meets all other filter design and water quality specifications set forth in Section 4.9, and has a demonstrated record of high performance within urban settings. [Section 4.9.4, 5c]
7. Verify that geotextile, if proposed, is specified on the plans to consist of polypropylene fibers and to meet the following specifications (AASHTO Class 1 or Class 2 geotextile is recommended): [Section 4.9.4, 6]
    a. Grab Tensile Strength (ASTM-D4632): ≥ 205 lbs
    b. CBR Puncture Strength (ASTM-D6241): ≥ 500 lbs
    c. Flow Rate (ASTM-D4491): ≥ 95 gal/min/ft2
    d. UV Resistance after 500 hrs (ASTM-D4355): ≥ 70%
    e. Tear Resistance (ASTM-D4533): ≥ 80 lbs
    f. Heat-set or heat-calendared fabrics are not permitted
8. Verify that underdrains, if proposed, are made of continuously perforated HDPE plastic piping with a smooth interior and a minimum inner diameter of four inches. HDPE pipe must be specified on the plans to meet the specifications of AASHTO M252, Type S or AASHTO M294, Type S. [Section 4.9.4, 7]

F.16 Pretreatment

F.16.1 Filter strip design and material standards

1. Verify that the plans include an appropriate sequence of construction that is specific to the construction of the filter strip. Refer to Section 4.10.2 for guidance. [Section 2.3.1]
2. If discharge of concentrated flow to the filter strip is proposed, verify that a level spreading device is proposed to provide uniform sheet flow. [Section 4.10.2, 2]
3. If filter strips are proposed in high-use areas, verify that precautions are taken to minimize disturbance of the filter strip, such as signage fences, and placement of sidewalks or paths to minimize pedestrian or vehicular traffic. [Section 4.10.2, 3]
4. If energy dissipaters and/or flow spreaders are not proposed to be installed with the filter strip, verify that the flow path to the filter strip does not exceed 75 feet for impervious ground cover or 150 feet for pervious ground cover. [Section 4.10.2, 4]
5. Verify that the contributing drainage area does not exceed five acres and does not exceed a drainage area to filter strip area ratio of 6:1. [Section 4.10.2, 5]
6. If no energy dissipaters and/or flow spreaders are provided up-gradient of the filter strip, verify that the slope of the contributing drainage area to the filter strip does not exceed 5%. [Section 4.10.2, 6]
7. Verify that the slope of the filter strip does not exceed 8%. Slopes less than 5% are generally preferred. Filter strips with slopes that exceed 5% should implement check dams to encourage ponding and prevent scour and erosion of the filter strip area. [Section 4.10.2, 7]
8. Verify that the slope (parallel to the flow path) of the top of the filter strip, after a flow spreading device, is less than 1% and gradually increases to the designed value to protect from erosion and undermining of the device. [Section 4.10.2, 8]
9. Verify that the plans indicate that plants must be established at the time of filter strip completion (at least three months after seeding), and that runoff must not be allowed to flow across the filter strip until the vegetation is established. [Section 4.10.2, 9]
10. Verify that the filter strip length is in accordance with Table 4.10-2 of the Manual. [Section 4.10.2, 10]
11. For contributing flow paths less than 30 feet in length, verify that the filter strip length is in accordance with Figure 4.10-1 of the Manual. [Section 4.10.2, 11]
12. For contributing flow paths greater than 30 feet in length, verify that the filter strip meets the required flow characteristics for maximum velocity and depth listed in Table 4.10-3 of the Manual. [Section 4.10.2, 12]

F.16.2 Forebay design and material standards

1. Verify that the plans include an appropriate sequence of construction that is specific to the construction of the forebay. Refer to Section 4.10.3 for guidance. [Section 2.3.1]
2. For forebays within large SMPs such as ponds and wet basins, verify that the forebay contains 10% to 15% of the total permanent pool volume of the larger SMP. [Section 4.10.3, 1]
3. For forebays within smaller SMPs such as bioinfiltration/bioretention basins, verify that the storage volume is sized to retain 0.25 inches of runoff of contributing directly connected impervious area (DCIA), with an absolute minimum of 0.1 inch of runoff. [Section 4.10.3, 2]
4. Verify that the plans include a stone berm to physically separate the forebay from its associated SMP. The berm should span the entire width of the basin. [Section 4.10.3, 3]

5. Verify that the plans include inlet controls for the forebay, including riprap aprons, stone placed in concrete, or some other type of energy dissipation device to rapidly reduce the inflow velocity for erosion/scour protection and to encourage settlement of suspended solids. [Section 4.10.3, 4]
6. Verify that the plans indicate that permanent vertical markers constructed of durable materials are to be installed within the forebay area to indicate the sediment depth. [Section 4.10.3, 5]
7. Verify that adequate inspection and maintenance access is provided to allow for periodic sediment removal; this is most commonly provided via stabilized and mildly sloping graded areas that can be accessed by heavy equipment. [Section 4.10.3, 6]
8. Verify that exit velocities from the forebay are non-erosive. Refer to the latest edition of the *Pennsylvania Department of Environmental Protection (PA DEP) Erosion and Sediment Pollution Control Program Manual* for information on design standards for erosion and sedimentation control practices. [Section 4.10.3, 7]

F.16.3 Swale design and material standards

1. Verify that the plans include an appropriate sequence of construction that is specific to the construction of the swale. Refer to Section 4.10.4 for guidance. [Section 2.3.1]
2. If a swale is designed as a primary SMP, verify that the swale meets all Design Guidance Checklist design standards noted in Appendix F.7, Bioinfiltration/Bioretention, as well as all applicable swale Design Guidance Checklist design standards below. [Section 4.10.4, 1]
3. Verify that the swale can convey the ten-year, 24-hour storm event with a minimum of six inches of freeboard and a maximum depth of 18 inches. Flow over check dams may be estimated using a weir equation. [Section 4.10.4, 2]
4. Verify that the swale is designed to resist erosion. It is recommended that the swale convey the two-year, 24-hour storm event without erosion. The latest edition of the *PA DEP Erosion and Sediment Pollution Control Program Manual* is recommended as a reference for these calculations. Verify that soil mix, vegetation, and temporary or permanent stabilization measures are adjusted as needed. [Section 4.10.4, 3]
5. Verify that the plans indicate that plants must be established at the time of swale completion (at least three months after seeding). [Section 4.10.4, 4]
6. Verify that energy dissipaters are provided at points of concentrated inflow into the swale. [Section 4.10.4, 5]
7. Verify that the side slopes for all parabolic channel swales do not exceed 2(H):1(V) (the recommended side slope is 3(H):1(V)), and that the side slopes of all mowed areas do not exceed 4(H): 1(V) to avoid “scalping” by mower blades. [Section 4.10.4, 7]
8. Verify that check dams intended to provide ponding in swale SMP designs are not porous, as water should be ponded behind each check dam and forced to infiltrate. If the swales are only being used for conveyance or to increase time of concentration, etc., check dams may be porous. [Section 4.10.4, 8]

F.17 Inlet Controls

F.17.1 Flow splitter design and material standards

1. Verify that the bypass elevation is set, at minimum, at the design storage elevation in the SMP. Flow will then only start to bypass the SMP once it exceeds the design storage elevation of the SMP. The design storage elevation is the water surface elevation at which the SMP storage area contains the runoff volume from a design storm event (for example, the WQv or the 10-year, 24-hour storm). [Section 4.11.2, 1]
2. Verify that positive overflow is provided for large storm events, up to and including the 100-year, 24-hour storm event, or, if the project is exempt from Flood Control, the ten-year, 24-hour storm. [Section 4.11.2, 2]
3. Verify that overflow structures and pipes are designed to convey at least the ten-year, 24-hour storm event. The system should have enough capacity to transmit larger flows over the bypass weir without surcharging the structure. [Section 4.11.2, 2]

F.17.2 Curbless design/curb opening design and material standards

1. If flow is to be introduced through curb openings, verify that the pavement edge is slightly higher than the elevation of the vegetated areas within the SMP. [Section 4.11.3, 1]
2. Verify that curbless design/curb openings are designed to convey flow into an SMP without inducing erosive conditions. Integration of energy dissipaters is recommended where appropriate. [Section 4.11.3, 2]
3. Verify that curb openings are designed to reduce bypass of gutter flow past the curb opening. This is a common problem with many curb openings that are oriented perpendicular to flow. [Section 4.11.3, 3]
4. If curb openings are used to capture runoff, especially from driveways or roadways where the curb openings are not in a sump condition, verify that documentation that runoff from the one-year, 24-hour storm event will be captured by the curb opening is provided. [Section 4.11.3, 4]
5. Verify that erosion control fabric, if proposed, is designed in accordance with the channel design procedures in the latest edition of the *Pennsylvania Department of Environmental Protection (PA DEP) Erosion and Sediment Pollution Control Program Manual*, or per the manufacturer's specifications. [Section 4.11.3, 6]
6. Verify that curb openings are designed as gaps in otherwise continuous sections of concrete or granite curb conforming to the specifications of the *City of Philadelphia Department of Streets, Standard Construction Items (1997)*. [Section 4.11.3, 7]
7. Verify that all subsurface portions of concrete or granite curb (i.e. below finished pavement grade) are continuously installed within the extents of the curb opening. [Section 4.11.3, 8]
8. Verify that curb openings are appropriately sized to convey the design discharge. Curb openings are typically 12 to 48 inches wide. Verify that curb openings are at least eight inches wide to prevent clogging and for ease of maintenance. [Section 4.11.3, 10]

F.17.3 Energy dissipater design and material standards

1. Verify that an energy dissipater is proposed if flow is concentrated at the entrance to a surface SMP. [Section 4.11.4, 1]
2. Verify that riprap is designed and sized in accordance with the riprap apron design procedures in the latest edition of the *PA DEP Erosion and Sediment Pollution Control Program Manual* or *U.S. Army Corps of Engineers, Hydraulic Engineering Center Circular 14 (HEC-14)*. [Section 4.11.4, 2]
3. Verify that riprap stone is angular, graded stone aggregate meeting the specifications of *PennDOT Publication 408, Section 703.2, Coarse Aggregate, Type A*. [Section 4.11.4, 3]
4. For stream outfalls, verify that the energy dissipation design tools HEC 11, HEC 14, and HEC 15 are used for riprap, energy dissipaters, and flexible linings, respectively. [Section 4.11.4, 4]

F.17.4 Inlet design and material standards

1. Verify that inlets are not connected in series. Similarly, roof drainage systems must not be directly connected to inlets. [Section 4.11.5, 1]
2. Verify that all inlets include a sump and trap or sump and hood for pretreatment of stormwater runoff. The sump depth must be at least 15 inches below the bottom of the trap or at least 12 inches below the bottom of the hood. [Section 4.11.5, 2]
3. If non-standard inlets are used to capture runoff, especially from driveways or roadways where the inlets are not in a sump condition, verify that documentation that runoff from the one-year, 24-hour storm event will be captured by the inlet is provided. [Section 4.11.5, 3]
4. Verify that inlet spacing is designed to prevent water from overtopping the curb and gutter or drainage ditch. [Section 4.11.5, 4]
5. Verify that inlets are sized based on the size of the contributing drainage area, the amount of sediment expected from the discharging waters, the size and frequency of runoff events, and the amount of maintenance expected, recognizing that an undersized system will require more frequent maintenance. For large inlet drainage areas, area drains and yard drains 18 inches in diameter or smaller, or smaller than 2’ x 2’, should be upsized to at least 2’ x 2’ inlets. [Section 4.11.5, 5]
6. Verify that all area drains and yard drains 18 inches in diameter or smaller, or smaller than 2’ x 2’, include a permanent pretreatment device, such as a filter bag insert, for pretreatment of stormwater runoff. [Section 4.11.5, 6]
7. Verify that all inlets on sites that generate pollutants, such as loading docks, material storage facilities, junk yards, and waste collection and disposal sites, include a permanent filter bag insert. [Section 4.11.5, 8]

F.18 Outlet Controls

F.18.1 General design standards

1. Verify that outlet controls provide positive overflow for their associated SMP, allowing stormwater to flow out of the SMP when the water level reaches a maximum design elevation in a subsurface feature or a maximum ponding depth in a surface feature without surcharging the SMP. Positive overflow from an SMP can either flow to another SMP or to an approved point of discharge. [Section 4.12.1, 2]
2. Verify that outlet control structures are sized to convey at least the ten-year, 24-hour storm event without surcharging the structure. [Section 4.12.1, 2]
3. Verify that the outlet controls are designed to convey flows from the SMP up to the 100-year, 24-hour storm event, or, if the project is exempt from Flood Control, the ten-year, 24-hour storm, without surcharging the SMP. If flow reaches the SMP via a flow splitter, this structure can provide the positive overflow. [Section 4.12.1, 2]
4. Verify that outlet controls are located so as to be easily and readily accessible for maintenance purposes. [Section 4.12.1, 3]
5. Verify that subsurface outlet control structures remain free of any obstruction preventing manhole lids from being removed for accessibility and maintenance. [Section 4.12.1, 4]
6. Verify that outlet control structures are sealed with a waterproof membrane, such as bituminous tar or similar. [Section 4.12.1, 5]
7. Verify that a watertight seal for all pipe connections in the outlet control structure is provided, such as rubberized boot collars, water stop grouting rings with non-shrink grout, or similar. [Section 4.12.1, 6]
8. Verify that precast structure sections are interlocked using key joints fitted with bituminous tar, gaskets, or similar, to prevent water intrusion. [Section 4.12.1, 7]
9. Verify that a watertight seal is provided between the precast structure and the impermeable weir. [Section 4.12.1, 8]
10. Verify that an anti-seep collar (either a prefabricated anti-seep collar or a bentonite clay trench dam) is provided on all outlet pipes and is sufficiently sized and distanced from the outlet structure to prevent water from traveling along the outside of the outlet pipe. An anti-seep collar detail must be provided on the plans. Refer to the *PA DEP Erosion and Sediment Pollution Control Program Manual* (2012 or latest) for guidance. [Section 4.12.1, 9]
11. Verify that all outlet control structures in combined sewer areas include a sump and trap or sump and hood. The sump depth must be at least 15 inches below the bottom of the trap or at least 12 inches below the bottom of the hood, and the traps or hoods must be air-tight. [Section 4.12.1, 10]
12. Verify that ladder bars are included within all outlet control structures. [Section 4.12.1, 11]
13. Verify that any manholes between outlet structures and sewer connections in combined sewer areas have sanitary, non-vented covers. [Section 4.12.1, 12]
14. Verify that outlet control structures have solid, non-grated, tops. [Section 4.12.1, 13]
15. Verify that the outlet pipe of an outlet control structure has an invert at or below the invert of the inlet pipe(s). Setting the outlet pipe invert at a minimum of 7.5 inches below that of the inlet pipe(s) is recommended. [Section 4.12.1, 14]
16. Verify that the outlet pipe of an outlet control structure directed to the City sewer is not designed to be used as flow attenuation for its associated SMP. Upstream outlet control devices, such as an orifice or weir, must control the flow for all design storms up to, and including, the 100-year storm. [Section 4.12.1, 15]

17. Verify that proprietary and subscription-based active outlet controls are designed with a passive default control that complies with applicable Stormwater Regulations in the case that the subscription is canceled or lapsed. [Section 4.12.1, 16]

F.18.2 Orifice design and material standards

1. Verify that the orifice diameter for a traditional orifice (i.e., that which is not part of an underdrain) is no smaller than one inch. [Section 4.12.2, 1]
2. Verify that the orifice diameter for an underdrain orifice (i.e., that which is located at the capped end of an underdrain) is no smaller than 0.5 inch. [Section 4.12.2, 1]
3. Verify that a trash rack is provided for any orifice draining surface basins. [Section 4.12.2, 2]
4. To prevent clogging, verify that screening is provided over any traditional orifice three inches in diameter or smaller. The dimensions of the openings within the screening must be half the diameter of the orifice. The screening should be separated from the orifice, not placed directly over the orifice. A minimum 12-inch sump must be provided beneath the invert of the orifice to prevent the collection of debris. [Section 4.12.2, 3]
5. Verify that one manhole access lid on each side of the orifice is provided for maintenance access. The manholes must be located no farther than two horizontal feet from the orifice. Adequate space to perform maintenance on the orifice must be provided; it is recommended that at least four feet by three feet of space be provided on each side of the orifice. [Section 4.12.2, 4]
6. Verify that suitable access is provided to inspect and maintain all orifices. [Section 4.12.2, 6]

F.18.3 Weir design and material standards

1. For impermeable weirs in outlet control structures, verify the following:
    a. Verify that weir walls consist of concrete that is poured monolithically, and that the sides and bottom of the weir are to be tied into the outlet control structures using rebar reinforcement. [Section 4.12.3, 3a]
    b. Verify that weir walls have a minimum thickness of six inches. [Section 4.12.3, 3b]
    c. Verify that weir walls are entirely watertight, including the sides and bottom of the weir wall. [Section 4.12.3, 3c]
    d. Verify that a minimum of 18 inches of clearance is provided above the top of the weir wall. [Section 4.12.3, 3d]
    e. Verify that one manhole access lid on each side of the weir wall is provided for maintenance access. The manholes must be located no farther than two horizontal feet from the weir wall. [Section 4.12.3e]
2. For check dams, verify the following:
    a. Verify that check dams, when placed within swales, are evenly spaced and no more than six to 12 inches high. [Section 4.12.3, 4a]
    b. Verify that check dams that provide ponding in swales and are designed for infiltration are not porous, as water should be ponded behind each check dam and forced to infiltrate. [Section 4.12.3, 4b]
3. For spillways, verify the following:
    a. Verify that, during the 100-year, 24-hour storm event—or, if project is exempt from Flood Control, the ten-year, 24-hour storm event—a minimum of one foot of freeboard is provided between the ponding elevation and the invert elevation of the emergency spillway. [Section 4.12.3, 5a]
    b. Verify that a minimum of one foot is provided between the invert elevation of the emergency spillway and the top-of-berm elevation. [Section 4.12.3, 5b]
    c. Verify that all emergency spillways are stabilized with stone, geotextile, or plant material that can withstand strong flows. [Section 4.12.3, 5c]
    d. Verify that spillway flow is not directed toward neighboring properties. [Section 4.12.3, 5d]

F.18.4 Riser design and material standards

1. Verify that riser design balances providing positive overflow with allowing for adequate static storage. Overflow must be provided at the maximum Water Quality storm ponding depth for all SMPs and, for bioinfiltration/bioretention basins, at the minimum height to provide sufficient static storage of the Water Quality Volume (WQv). [Section 4.12.4, 1]
2. Verify that riser pipes are specified on the plans to be constructed of high-density polyethylene (HDPE) plastic, corrugated metal, concrete, or other weather resistant material. [Section 4.12.4, 2]
3. Verify that riser boxes are constructed of precast or cast-in-place concrete with reinforcing as warranted. All concrete must be specified on the plans to be Class C, conforming to the specifications of the *City of Philadelphia Department of Streets, Standard Construction Items (1997)*. [Section 4.12.4, 3]
4. Verify that trash racks or screens are proposed with the riser and that they are specified on the plans to be constructed of durable, weather-resistant materials resistant to photo-degradation, weathering, oxidation, or other corrosive impacts. [Section 4.12.4, 4]

F.18.5 Underdrain design and material standards

1. Verify that underdrains are provided for all bioinfiltration/bioretention SMPs. For bioinfiltration SMPs, a solid cap must be provided at the end located within the outlet control structure to promote infiltration. For bioretention SMPs located in the combined sewer area, a cap must be provided at the end located within the outlet control structure, and it must be outfitted with an orifice, sized appropriately to meet all applicable release rate requirements. [Section 4.12.5, 1]
2. Verify that all underdrains are designed to be level (i.e., with no slope). [Section 4.12.5, 2]
3. Verify that all underdrains are constructed of continuously perforated HDPE plastic piping with a smooth interior and a minimum inner diameter of four inches. HDPE pipe must be specified on the plans to meet the specifications of AASHTO M252, Type S or AASHTO M294, Type S. [Section 4.12.5, 3]
4. Verify that all underdrains are surrounded by a sand or stone layer to filter sediment and facilitate drainage. [Section 4.12.5, 4]
5. Verify that the sand or stone layer surrounding the underdrain is specified on the plans to be at least six inches both above and beneath the underdrain. [Section 4.12.5, 5]
6. If a sand layer is proposed, verify that the underdrain is surrounded by geotextile fabric to prevent clogging. [Section 4.12.5, 6]
7. Verify that stone surrounding an underdrain is specified on the plans as being uniformly graded, crushed, clean-washed stone and that it is noted that PWD defines “clean-washed” as having less than 0.5% wash loss, by mass, when tested per the AASHTO T-11 wash loss test. AASHTO No. 3 and No. 57 stone can meet this specification. [Section 4.12.5, 7]
8. Verify that sand, if proposed, is specified on the plans to be AASHTO M-6 or ASTM C-33 sand and to have a grain size of 0.02 inches to 0.04 inches. [Section 4.12.5, 8]
9. Verify that geotextile fabric is placed between the stone layer and surrounding soil to prevent sediment contamination. [Section 4.12.5, 9]
10. Verify that geotextile is specified on the plans to consist of polypropylene fibers and to meet the following specifications (AASHTO Class 1 or Class 2 geotextile is recommended): [Section 4.12.5, 10]
    a. Grab Tensile Strength (ASTM-D4632): ≥ 205 lbs
    b. CBR Puncture Strength (ASTM-D6241): ≥ 500 lbs
    c. Flow Rate (ASTM-D4491): ≥ 95 gal/min/ft2
    d. UV Resistance after 500 hrs (ASTM-D4355): ≥ 70%
    e. Tear Resistance (ASTM-D4533): ≥ 80 lbs
    f. Heat-set or heat-calendared fabrics are not permitted
11. Verify that cleanouts or maintenance access structures are provided at the end of all underdrain pipes and that a cleanout detail is provided on the plans. [Section 4.12.5, 11]
12. Verify that cleanouts are provided for all 90-degree bends, located upstream of complicated bends, and evenly spaced during straight pipe runs and that a cleanout detail is provided on the plans. [Section 4.12.5, 12]
13. Verify that all intermediate cleanouts and domed riser pipe connections are located upstream of the connected outlet control structure to allow for cleaning equipment to flush in the direction of the structure. [Section 4.12.5, 13]
14. Verify that an anti-seep collar is installed around outlet pipes passing through embankments and that an anti-seep collar detail is provided on the plans. Refer to the *PA DEP Erosion and Sediment Pollution Control Program Manual* (2012 or latest) for guidance. [Section 4.12.5, 14]

15. Verify that cleanouts are made of material with a smooth interior having an inner diameter that is no less than six inches. If the connecting pipe is eight inches in diameter or larger, verify that the cleanout is eight inches in diameter. [Section 4.12.5, 15]
16. Verify that the outlet pipe of an outlet control structure has an invert at or below the invert of the underdrain. Setting the outlet pipe invert at a minimum of 7.5 inches below that of the underdrain is recommended. [Section 4.12.5, 16]

F.18.6 Level spreader design and material standards

1. Verify the level spreader length. Level spreader length for a dense grass ground cover condition must be 13 linear feet for every one cubic feet per second (cfs) of flow during the ten-year, 24-hour storm event. Level spreader length for forested areas with no ground cover must be 100 linear feet for every one cfs of flow during the ten-year, 24-hour storm event. [Section 4.12.6, 1]
2. Verify that all level spreaders are designed to safely diffuse flows up to, and including, the 100-year, 24-hour storm event. [Section 4.12.6, 2]
3. Verify that the edge of the level spreader over which flow is distributed is specified on the plans to be exactly level. If there are small variations in height on the downstream lip, small rivulets will form. Experience suggests that variations of more than 0.25 inch can cause water to re-concentrate and potentially cause erosion downstream of the level spreader. The site selected for the installation of a level spreader must be a level grade (a constant horizontal elevation, to within +/- four inches). [Section 4.12.6, 3]
4. Verify that the downslope side of the level spreader is clear of debris. [Section 4.12.6, 4]
5. Verify that the first three feet downslope of the level spreader is stabilized with soil/turf reinforcement matting and grass or other approved vegetation and that matting specifications are provided on the plans. [Section 4.12.6, 5]
6. Verify that level spreaders are not constructed in newly deposited fill. [Section 4.12.6, 6]
7. For level spreaders that do not direct discharge to a receiving stream or sewer, verify that the distance between the level spreader and any downslope property boundary is no less than 15 feet. If this requirement cannot be met, a drainage easement may be required. [Section 4.12.6, 7]
8. For level spreaders that direct discharge to a receiving stream or sewer via overland flow, verify that the distance between the level spreader and any receiving stream or sewer is no greater than 100 feet. Distances greater than 100 feet but less than 150 feet may be considered on a case-by-case basis for very mild slopes (less than or equal to 1%) and heavily vegetated (grassy) areas. [Section 4.12.6, 8]
9. Verify that the first ten feet downslope of the level spreader does not exceed a slope of 4%. [Section 4.12.6, 9]
10. Verify that earthen berms, treated lumber, and geotextile-covered berms are not used as level spreaders. [Section 4.12.6, 10, 11, 12]

11. For concrete curbs, troughs, and half-pipes, verify the following:
    a. Verify that concrete curbs, troughs, and half-sections of pipe are between four and 12 inches deep. [Section 4.12.6, 13a]
    b. Verify that curbs and troughs are specified on the plans to be constructed of Class C concrete or reinforced concrete, conforming to the specifications of the *City of Philadelphia Department of Streets, Standard Construction Items (1997)*. [Section 4.12.6, 13b]
    c. Verify that half-pipes are specified on the plans to be either Class C concrete or reinforced concrete, conforming to the specifications of the *City of Philadelphia Department of Streets, Standard Construction Items (1997)* or HDPE plastic meeting the specifications of AASHTO M252, Type S or AASHTO M294, Type S. [Section 4.12.6, 13c]
12. For subsurface discharge through level perforated pipes (bubble-up level spreaders), verify the following:
    a. Verify that perforated pipes are between four and 12 inches in diameter. HDPE pipe must be specified on the plans to meet AASHTO M252, Type S or AASHTO M294, Type S standards. [Section 4.12.6, 14a]
    b. Verify that the pipes are enveloped in stone and that the stone is specified on the plans as being uniformly graded, crushed, clean-washed stone and that it is noted that PWD defines "clean-washed" as having less than 0.5% wash loss, by mass, when tested per the AASHTO T-11 wash loss test. AASHTO No. 3 and No. 57 stone can meet this specification. [Section 4.12.6, 14b]
    c. Verify that geotextile is placed between the stone aggregate and soil. [Section 4.12.6, 14c]
    d. Verify that geotextile is specified on the plans to consist of polypropylene fibers and to meet the following specifications (AASHTO Class 1 or Class 2 geotextile is recommended): [Section 4.12.6, 14d]
        i. Grab Tensile Strength (ASTM-D4632): ≥ 205 lbs
        ii. CBR Puncture Strength (ASTM-D6241): ≥ 500 lbs
        iii. Flow Rate (ASTM-D4491): ≥ 95 gal/min/ft2
        iv. UV Resistance after 500 hrs (ASTM-D4355): ≥ 70%
        v. Tear Resistance (ASTM-D4533): ≥ 80 lbs
        vi. Heat-set or heat-calendared fabrics are not permitted
13. For surface discharge to plunge pools, verify the following:
    a. Verify that the plans specify that underlying soils within plunge pools remain undisturbed, uncompacted, and protected from heavy equipment to preserve infiltration capacities. [Section 4.12.6, 16a]
    b. Verify that riprap stone is sized in accordance with the riprap apron design procedures in the latest edition of the *PA DEP Erosion and Sediment Pollution Control Program Manual*. [Section 4.12.6, 16b]

F.18.7 Impervious liner design and material standards

1. Verify that the impervious liner is specified on the plans to have a permeability of less than, or equal to, 10^{-6} cm/sec. [Section 4.12.7, 3]
2. Verify that the plans indicate that the impervious liner is to be continuous and extend completely up the sides of any structures that are located within the lined basin footprint to the ground surface. If additional liner material must be added to extend up the structures, the additional liner sections are to be joined to the rest of the liner with an impervious seam per the manufacturers' recommendation. [Section 4.12.7, 4]
3. For compacted till liners, verify the following:
    a. Verify that the compacted till liner thickness is no less than 18 inches (after compaction). [Section 4.12.7, 5a]
    b. Verify that soil is compacted to 95% minimum dry density, modified proctor method (ASTM D-1557). [Section 4.12.7, 5b]
    c. Verify that soil is placed in six-inch lifts. [Section 4.12.7, 5c]
    d. Verify that the proposed soils are specified on the plans as meeting the gradation listed in Table 4.12-4 of the Manual. [Section 4.12.7, 5d]
4. For clay liners, verify the following:
    a. Verify that the clay liner thickness is no less than 12 inches (after compaction). [Section 4.12.7, 6a]
    b. Verify that the clay liner is specified on the plans as meeting the specifications listed in Table 4.12-5 of the Manual. [Section 4.12.7, 6b]
5. For geomembrane liners, verify the following:
    a. Verify that the geomembrane liner material is specified on the plans to be polyvinyl chloride (PVC), polypropylene (PP), linear low-density polyethylene (LLDPE), or high-density polyethylene (HDPE). [Section 4.12.7, 7a]
        i. For PVC geomembranes, verify that the liner has a thickness of 30 mil and conforms to the physical requirements stipulated in ASTM D7176: Standard Specification for Non-Reinforced Polyvinyl Chloride (PVC) Geomembranes Used in Buried Applications. [Section 4.12.7, 7a(i)]
        ii. For PP geomembranes, verify that the liner has a thickness of 30 or 36 mil and conforms to the physical requirements stipulated in the Geosynthetic Research Institute (GRI) GM18 Standard Specifications for PP geomembranes. [Section 4.12.7, 7a(ii)]
        iii. For LLDPE geomembranes, verify that the liner has a thickness of 40 mil and conforms to the physical requirements stipulated in the Geosynthetic Research Institute (GRI) GM17 Standard Specifications for LLDPE geomembranes. [Section 4.12.7, 7a(iii)]
        iv. For HDPE geomembranes, verify that the liner has a thickness of 60 mil and conforms to the physical requirements stipulated in the Geosynthetic Research Institute (GRI) GM13 Standard Specifications for HDPE geomembranes. [Section 4.12.7, 7a(iv)]
    b. Verify that the geomembrane liner material is specified on the plans to be resistant to mildew, rot, ultraviolet radiation, insects, and rodents. [Section 4.12.7, 7b]
    c. For fully-lined SMPs, verify that a geotextile is placed on either side of the entire geomembrane liner to protect it from the in-situ soil outside the liner and the overlying stone or soil storage inside the liner. The geotextile must be specified on the plans to meet, or exceed, the strength properties listed in Table 4.12-6 of the Manual. [Section 4.12.7, 7c]

d. For partially-lined SMPs, verify that a geotextile is placed on either side of the geomembrane liner to protect it from the in-situ soil outside the liner and the overlying stone or soil storage inside the liner. The geotextile placed outside the liner must be specified on the plans to meet, or exceed, the strength properties listed in Table 4.12-6 of the Manual. The geotextile placed between the liner and the overlying stone or soil storage must be specified on the plans to be in accordance with the geotextile specifications listed within the respective SMP's "Storage Area Material Standards" elsewhere in Chapter 4. [Section 4.12.7, 7d]

e. Verify that a minimum four-inch sand layer is placed beneath the geomembrane liner and geotextile to provide a stable, even bottom and prevent uneven settling and punctures to the liner. [Section 4.12.7, 7e]

f. Verify that boot collars are included at any point where a pipe penetrates a geomembrane liner. This includes utility crossings, distribution pipes, and underdrain pipes. [Section 4.12.7, 7f]

6. For concrete liners, verify the following:

   a. Verify that the concrete is no less than five inches thick, Class A or better, with ordinary surface finish. [Section 4.12.7, 8a]

   b. When underlying soil is clay or if it has an unconfined compressive strength of 0.25 ton per square foot or less, verify that the concrete has a minimum six-inch compacted aggregate base composed of coarse sand and river stone, crushed stone, or equivalent, with diameter of 0.75 inch to one inch. [Section 4.12.7, 8b]

F.18.8 Micro siphon drain belt design and material standards

1. Verify that the micro siphon drain belt connects to a downslope underdrain or collector pipe and that the elevation of the belt in the immediate vicinity of the downslope connection is at least four inches above the top of the underdrain or collector pipe. Alternatively, for vegetated SMPs on-structure where depth is limited, such as blue-green roofs, a belt slope of 1% to 2%, with a curve of the tail of the belt down to the connection pipe, must be maintained. [Section 4.12.8, 1]

2. Verify that the end of the micro siphon drain belt that is not connected to the collector pipe is sealed to prevent the intrusion of solids or other clogging materials. The sealant must be suitable for use in submerged environments. [Section 4.12.8, 2]

3. Verify that a minimum belt slope of 1% is proposed. A belt slope of 3% to 5% is recommended to maintain laminar flow within the micro channels. [Section 4.12.8, 3]

4. Verify that the micro siphon drain belt is proposed to be installed in a layer of sand. Sand used must be ASTM C-33 aggregate concrete sand with grain size between 0.02 inches and 0.08 inches. Alternatively, for vegetated SMPs on-structure where depth is limited, such as blue-green roofs, the micro siphon drain belt may be installed in the foundation growing medium layer with a minimum depth of 0.25 inches of media below the belt or per manufacturer's recommendations. [Section 4.12.8, 4]

5. Verify that manufacturer's recommendations are followed to determine the number, size, and specific configuration of belts required to provide adequate flow capacity for specific applications. [Section 4.12.8, 5]

6. Verify that the flow rate for an eight-inch-wide micro siphon drain belt with a minimum saturated cover (head) of four inches is calculated as follows. The calculated flow rate can be divided by two for a four-inch-wide micro siphon drain belt. [Section 4.12.8, 6]

$$Q_{belt} = 0.00106 + 0.00025H$$
$$where\ Q_{belt} = flowrate\ (cfs),\ H = head\ (ft),\ H = 0.33\text{-}ft\ minimum$$

F.18.9 Low flow device design and material standards

1. Verify that the following information is submitted for each proposed low flow device as part of the applicant's Post-Construction Stormwater Management Plan (PCSMP) Review Phase Submission Package. [Section 4.12.9, 1]
   a. Performance/discharge curves;
   b. Third-party certifications;
   c. Hydrologic and hydraulic model files, if applicable;
   d. Product specifications;
   e. Manufacturer's guidelines for installation;
   f. Construction sequence; and
   g. Maintenance requirements, including product life and replacement schedule, if applicable.
2. Verify that appropriate design measures are taken to prevent clogging for all orifices. [Section 4.12.9, 2]
3. Verify that suitable access is provided to inspect and maintain all orifices. [Section 4.12.9, 3]

F.19 Landscaping

- The designer is referred to **Appendix F.4.3** ☛ p. 41 for design requirements of tree disconnection credits.
- The designer is referred to **Appendix F.7** ☛ p. 50 for design requirements of bioinfiltration/bioretention basins.
- The designer is referred to **Appendix F.9** ☛ p. 59 for design requirements of green roofs.
- The designer is referred to **Appendix F.13** ☛ p. 72 for design requirements of ponds and wet basins.
- The designer is referred to **Appendix F.20** ☛ p. 97 for design requirements of blue-green roofs.

F.19.1 Landscaping material standards

1. Verify that stone designed for stormwater storage is specified on the plans as being uniformly graded, crushed, clean-washed stone and that it is noted that PWD defines “clean-washed” as having less than 0.5% wash loss, by mass, when tested per the AASHTO T-11 wash loss test. AASHTO No. 3 and No. 57 stone can meet this specification. [Section 4.13.4, 1]
2. Verify that sand, if proposed, is specified on the plans to be AASHTO M-6 or ASTM C-33 sand and to have a grain size of 0.02 inches to 0.04 inches. [Section 4.13.4, 2]
3. Verify that the planting soil medium is specified on the plans as meeting the following specifications:
    a. Planting soil should be a fertile, natural soil, free from large stones, roots, sticks, clods, plants, peat, sod, pockets of coarse sand, pavement and building debris, glass, noxious weeds including invasive species, infestations of undesirable organisms and disease causing pathogens, and other extraneous materials harmful to plant growth. [Section 4.13.4, 3a]
    b. The texture of planting soil should conform to the classification within the United States Department of Agriculture triangle for Sandy Loam or Loamy Sand. Planting soil should be a mixture of sand, silt, and clay particles as required to meet the classification. Ranges of particle size distribution, as determined by pipette method in compliance with ASTM F-1632, are as follows: [Section 4.13.4, 3b]
        i. Sand (0.05 to 2.0 mm): 50 – 85%
        ii. Silt (0.002 to 0.05 mm): 40% maximum
        iii. Clay (less than 0.002 mm): 10% maximum
        iv. Gravel (2.0 to 12.7 mm): 15% maximum
    c. Planting soil should be screened and free of stones larger than a half-inch (12.7 millimeters) in any dimension. No more than 10% of the soil volume should be composed of soil peds greater than one inch. [Section 4.13.4, 3c]
    d. Clods, or natural clumps of soils, greater than three inches in any dimension should be absent from the planting soil. Small clods ranging from one to three inches and peds, natural soil clumps under one inch in any dimension, may be present but should not make up more than 10% of the soil by volume. [Section 4.13.4, 3d]
    e. The pH of the planting soil should have a range of 5.8 to 7.1. [Section 4.13.4, 3e]
    f. Soluble salts should be less than 2.0 mmhos/cm (dS/m), typically as measured by 1:2 soil-water ratio basic soil salinity testing. Sodic soils (Exchangeable Sodium Percentage greater than 15 and/or Sodium Adsorption Ratio greater than 13) are not acceptable for use regardless of amendment. [Section 4.13.4, 3f]

g. Organic content of planting soil should have a range of 3% to 15%, by weight, as determined by loss on ignition (ASTM D2974). To adjust organic content, planting soil may be amended, prior to placing and final grading, with the addition of organic compost. [Section 4.13.4, 3g]

4. Verify that mulch, if proposed, is specified to be free of weeds and consist of aged, double-shredded hardwood bark mulch or leaf mulch that has been shredded sufficiently to limit risk of matting, which can limit surface infiltration rates. For hydroseeding, paper mulch may be used. Approved mulching materials include organic materials such as compost, bark mulch, leaves, as well as small river gravel, pumice, or other inert materials. Grass clippings should not be used as mulch. [Section 4.13.4, 4]
5. Verify that geotextile is specified on the plans to consist of polypropylene fibers and to meet the following specifications (AASHTO Class 1 or Class 2 geotextile is recommended): [Section 4.13.4, 5]
   a. Grab Tensile Strength (ASTM-D4632): ≥ 205 lbs
   b. CBR Puncture Strength (ASTM-D6241): ≥ 500 lbs
   c. Flow Rate (ASTM-D4491): ≥ 95 gal/min/ft2
   d. UV Resistance after 500 hrs (ASTM-D4355): ≥ 70%
   e. Tear Resistance (ASTM-D4533): ≥ 80 lbs
   f. Heat-set or heat-calendared fabrics are not permitted
6. Verify that native grass/wildflower seed mix, if proposed as an alternative to groundcover planting, is free of weed seeds. [Section 4.13.4, 8]
7. Verify that the proposed plantings are indicated on the plans and are non-invasive. Refer to Appendix I for plant lists. [Section 4.13.4, 9]

F.20 Blue-Green Roofs

F.20.1 Blue-green roof plan standards

1. Verify that the plans include an appropriate sequence of construction that is specific to the construction of the blue-green roof. Refer to Section 4.14.5 for guidance. [Section 2.3.1]
2. Verify that the plans include an appropriate cross-sectional detail for the blue-green roof. [Section 2.3.1]
3. Verify that a roof drainage plan is provided and that the roof drainage is consistent with the blue-green roof design. [Appendix E, Table E-7]

F.20.2 Blue-green roof design standards

1. Verify that structural loading is considered for the blue-green roof design, and that the blue-green roof design is coordinated with a licensed structural engineer for both new building construction and retrofits to existing structures. [Section 4.14.3, 1a]
2. Verify that the entirety of the blue-green roof is considered, and modeled as, DCIA, and that a curve number of 98 is used for the blue-green roof, where required for hydrologic calculations. [Section 4.14.3, 2]
3. Verify that vegetated green roof portions of the blue-green roof receive a DCIA reduction equal to the entire area of the vegetated footprint solely for the predevelopment to post-development impervious area reduction calculation during the determination of potential exemption from the Channel Protection and Flood Control requirements. [Section 4.14.3, 3]
4. Verify that the total impervious roof area within the designated boundary of a blue-green roof footprint does not exceed the total vegetated green roof area, which is equivalent to a maximum hydraulic impervious runoff loading ratio of 1:1. [Section 4.14.3, 4]
5. Verify that all stone/gravel margins or perimeters are considered roof DCIA, unless they are graded to allow flow over or through vegetated green roof area, in which case, they may be counted as tributary impervious area to the green roof portion of the blue-green roof. Stone margins adjacent to drain chambers, with an offset distance from the chamber edge of 12 inches or less, are exempt from being counted as tributary impervious area when installed on a blue-green roof, in addition to pervious pavers containing planted openings. [Section 4.14.3, 5]
6. Verify that the maximum ponding depth is one inch below the top of the foundation growing medium. For roof drain restrictor systems, this ponding depth maximum can be set at least five feet from the restrictor. [Section 4.14.3, 6]
7. Verify that the SMP drains within the acceptable 72-hour period after the 24-hour storm event. [Section 4.14.3, 7]
8. Verify that positive overflow is provided for large storm events, up to and including the 100-year, 24-hour storm event, or, if the project is exempt from Flood Control, the ten-year, 24-hour storm. [Section 4.14.3, 8]
9. Verify that the flooded storage area of the blue-green roof area is underlain by a waterproofing membrane. [Section 4.14.3, 9]
10. Verify that root barrier layers conform to the requirements of the waterproofing provider for each project. [Section 4.14.3, 10]
11. If runoff is conveyed via piping, verify that a distribution piping manifold embedded in a gravel strip, along with an appropriate detail, is provided on the plans to dissipate energy and promote uniform flow. [Section 4.14.3, 11]

12. For roof drain restrictor blue-green roofs that rely solely on growing medium to retain the Water Quality Volume (WQv), verify the following:
    a. The minimum allowable thickness of the roof growing medium for a 1:1 loading ratio is six inches, including two inches of foundation growing medium, which serves as the drainage layer. [Section 4.14.3, 13a]
    b. Any contributing impervious surface built atop a blue-green roof must either allow for sheet flow runoff onto the vegetated portion of the roof, like unit pavement, or be slotted, like decking. The minimum two-inch thickness of foundation growing medium required for the blue-green roof must extend under the entire extent of that surface area. [Section 4.14.3, 13b]
    c. The top one-inch of the foundation growing medium must be maintained above the flooded elevation, starting five feet from the roof drain restrictor, to promote aerated conditions in the growing medium. [Section 4.14.3, 13c]
    d. The roof drain restrictor must include an outfall device which limits the WQv discharge flow rate to comply with applicable Water Quality requirements. [Section 4.14.3, 13d]
    e. In areas that will receive tributary discharge, the blue-green roof must not include a high-transmissivity drainage layer, defined as a layer with a transmissivity of greater than 0.005 m^2/s (ASTM D4716), where such products limit plant root access to tributary runoff. In general, this will exclude most synthetic sheet drains, including peg-style or egg carton style drains. High-transmissivity drainage layers will allow runoff to effectively flow under the blue-green roof, minimizing contact with growing medium and plant roots. Typical foundation growing medium (also called granular aggregate or coarse granular green roof medium), with a grain-size distribution complying with ASTM gradation No. 7 will satisfy the requirement, as will also a variety of mats and composite drainage layer assemblies. [Section 4.14.3, 13e]
13. Verify that the storage system provides adequate storage to control release rates to meet all applicable Stormwater Regulations. [Section 4.14.3, 14]
14. Verify that the plans indicate that the saturated permeability of the growing medium, in its compacted state [ASTM E2399], is not less than six inches per hour. [Section 4.14.3, 15]
15. Verify that a drainage layer is provided to promote aerated conditions in the growing medium and to convey excess runoff during large rainfall events. [Section 4.14.3, 17]
16. Verify that the contributing area of impervious rooftop to each disconnected discharge point is equal to, or less than, 500 square feet. [Section 4.14.3, 21]
17. Verify that roof drain restrictors are sized according to the desired release rate and ponding depth. [Section 4.14.3, 22]
18. Verify that details are provided on the plans that demonstrate that all drains and scuppers are covered and protected by an enclosure, typically a square or round chamber with a locking lid. These chambers are designed to prevent clogging of the drains by debris. [Section 4.14.3, 24]
19. Verify that the roof drainage system and the remainder of the site drainage system safely convey roof runoff to the storm sewer, combined sewer, or receiving water. [Section 4.14.3, 25]
20. Verify that the emergency outflow is set at an elevation above the height of the roof drain restrictor. [Section 4.14.3, 26]

21. Verify that the blue-green roof is designed to allow for safe access and working conditions for blue-green roof inspection and maintenance personnel. This access must be a permanent feature of the building, such as a pilot house, roof hatch, or exterior stairs to the blue-green roof. Retractable, unsecured ladders should not be required for routine maintenance and inspections due to safety concerns. The design may include other permanent personal safety measures. For blue-green roofs, designers must specifically assess applicability to Occupational Safety and Health Administration (OSHA) Fall Protection Safety Standards and the American National Standards Institute (ANSI) and American Society of Safety Engineers (ASSE) consensus-based fall protection standards. [Section 4.14.3, 28]
22. Verify that easy access is provided to each of the outlet controls, low flow discharge points, and overflow connections to permit removal of debris under saturated conditions. [Section 4.14.3, 29]
23. For accessible residential roof terraces, verify that a railing with a maintenance gate that separates the vegetated green roof from accessible areas is provided. The railing can be metal, wood, or glass. Bird-friendly glass with a Threat Factor Rating of 1–25 is highly recommended. [Section 4.14.3, 31]

F.20.3 Blue-green roof material standards

1. Verify that the green roof growing medium is specified on the plans to be a lightweight mineral material with added organic material that meets the following specifications: [Section 4.14.4, 2]
    a. Moisture content at maximum water holding capacity (ASTM E2399 or FLL): 40% to 60% (vol)
    b. Porosity at maximum water holding capacity (ASTM E2399 or FLL): 10% to 15%
    c. Density at maximum water holding capacity (ASTM E2399 or FLL): ≤ 85 lb/ft3
    d. Total organic matter (MSA): 6% to 10% (dry weight)
    e. pH (MSA): 6.5 to 7.8
    f. Soluble salts (DPTA saturated media extraction): ≤ 2 mmhos/cm
    g. Water permeability (ASTM E2399 or FLL): 0.25 in/min to 1.25 in/min
    h. Grain-size distribution consisting of ≤ 4.5% passing for clay (0.002 mm) and 5% to 15% passing for silt (0.05 mm). Clay and silt together must not exceed 15%.
    i. The nutrients must be initially incorporated in the formulation of a suitable mix for the support of the specified plant materials.
    j. The medium must withstand freeze/thaw cycles.
2. Verify that the foundation growing medium (lightweight drainage aggregate) is specified on the plans to be composed of a blended medium that meets the following specifications: [Section 4.14.4, 3]
    a. Density at maximum water capacity (ASTM E2399-05): ≤ 65 lbs/ft^3
    b. Maximum water holding capacity: 15% to 25%
    c. Water permeability (ASTM E2396-05): ≥ 25 in/min
    d. Total organic matter by loss on ignition (ASTM F1647): ≤ 1%
    e. Porosity (ASTM C29): 20% to 65%
    f. Grain-size distribution (ASTM C136) consisting of the following gradations:
        i. Pct. Passing US#18 sieve (1.0 mm): ≤ 5%
        ii. Pct. Passing ¼-inch sieve: ≤ 30%
        iii. Pct. Passing 3/8-inch sieve (9.5 mm): ≥ 75%
        iv. Pct. Passing ½-inch sieve (12 mm): 100%

3. Verify that geotextile is specified on the plans to consist of polypropylene fibers and to meet the following specifications: [Section 4.14.4, 4]
    a. Grab Tensile Strength (ASTM-D4632): 70 lbs to 120 lbs
    b. CBR Puncture Strength (ASTM-D6241): 120 lbs to 340 lbs
    c. Flow Rate (ASTM-D4491): 130 gal/min/ft2 to 200 gal/min/ft2
    d. UV Resistance after 500 hrs (ASTM-D4355): 70%
    e. Tear Resistance (ASTM-D4533): 30 lbs to 50 lbs
    f. Heat-set or heat-calendared fabrics are not permitted.
4. Verify that all waterproof membranes meet appropriate ASTM specifications. PVC membranes must meet ASTM D4434 requirements, EPDM membranes must meet ASTM D4637 requirements, and TPO membranes must meet ASTM D6878 requirements. [Section 4.14.4, 5b]
5. Verify that all waterproofing membranes are fully waterproof with properly sealed seams, corners, and protrusions to prevent any intrusion of standing water above the membrane. [Section 4.14.4, 5c]
6. Verify that roofing membranes meet all building code requirements and guidelines of the City of Philadelphia. [Section 4.14.4, 5d]
7. Verify that the proposed green roof plantings are indicated on the plans and that the proposed plantings and are non-invasive. Refer to **Appendix I** ☛ p. 107 for plant lists. [Section 4.14.4, 6]
8. Verify that at least two genera of sedums (i.e., both Sedum and Phedimus) and six different species or cultivars of sedums are indicated on the plans. [Section 4.14.4, 7a]
9. Verify that native or adaptive grasses, if proposed, include at least two genera and three different species. [Section 4.14.4, 7b]
10. Verify that native or adaptive perennials, if proposed, include at least three genera and four different species. [Section 4.14.4, 7c]
11. Verify that seed, as a supplement to live plants, is included in the proposed plantings. Refer to Section 4.13.3, Landscape Design Considerations, for a list of species appropriate for overseeding on green roofs. [Section 4.14.4, 8b]
12. Verify that temporary erosion control measures are provided that are appropriate to the planting method during the plant establishment period. [Section 4.14.4, 8c]
13. Verify that Sedum sarmentosum, also known as star sedum, gold moss, stringy stonecrop, or graveyard moss, is not proposed. [Section 4.14.4, 11]

F.21 Drainage Wells

F.21.1 Drainage well plan standards

1. Verify that the plans include an appropriate sequence of construction that is specific to the construction of the drainage well. Refer to Section 4.15.5 for guidance. [Section 2.3.1]
2. To avoid soil disturbance and compaction during construction, verify that the infiltration area is proposed to be clearly marked before any site work begins. [Section 4.15.5, 1]
3. Verify that the plans include an appropriate cross-sectional detail for the drainage well. [Section 2.3.1]

F.21.2 Drainage well design standards

1. Verify that the SMP drains within the acceptable 72-hour period after the 24-hour storm event. [Section 4.15.3, 1]
2. Verify that positive overflow is provided for large storm events, up to and including the 100-year, 24-hour storm event, or, if the project is exempt from Flood Control, the ten-year, 24-hour storm. [Section 4.15.3, 3]
3. Verify that overflow structures and pipes are designed to convey at least the ten-year, 24-hour storm event. [Section 4.15.3, 3]
4. Verify that the distance between the edge of a drainage well's stone storage bed and any adjacent private property line is at least ten feet. It is acceptable for SMPs to be located directly adjacent to the public right-of-way (ROW) (unless a deed restriction is put in place extending at least ten feet from the perimeter of the infiltrating SMP). [Section 4.15.3, 4]
5. Verify that the distance between the edge of a drainage well's stone storage bed and any building or retaining wall is at least ten feet. The following requirements and exceptions apply: [Section 4.15.3, 5]
    a. For existing and proposed buildings with basements, the setback is measured from the basement wall.
    b. For existing buildings without basements and existing retaining walls, the setback is measured from the foundation and may be waived if a signed and sealed geotechnical analysis is submitted that evaluates the impacts of infiltration and excavation on the existing foundation and determines it to be feasible.
    c. For proposed buildings without basements and proposed retaining walls, the setback is measured from the foundation and may be waived if the foundation is proposed to be designed with the drainage well's proximity in mind.
6. Verify that, when siting two or more drainage wells near each other, the lateral clearance between the edges of their stone storage beds is twice the distance of the height of the perforated well section. [Section 4.15.3, 6]
7. Verify that the invert elevation of the drainage well is at least two feet above any poorly infiltrating soils, seasonal high groundwater table, bedrock, or other hydraulically limiting zone. [Section 4.15.3, 7a]
8. For hydrologic modeling, verify that a soil permeability coefficient (k_{20}), calculated per the protocol described in Section 4.15.3, 7c(vi), is applied to the wetted area of the drainage well, spanning the perforated sides and bottom, to determine infiltration characteristics. [Section 4.15.3, 7b]
9. Verify that infiltration testing for drainage wells is performed according to the procedure described in Section 4.15.3, 7c. [Section 4.15.3, 7c]

10. If the drainage well location is used as a temporary sediment basin during construction, verify that the invert elevation of the infiltration SMP is a minimum of three feet below the bottom elevation of the pre-basin-conversion sediment basin. [Section 4.15.3, 7d]
11. Verify that any drainage well within the zone of influence of any nearby basements, sewers or sewer laterals, or other subsurface conditions where infiltration is not advisable is installed with an impervious liner. The zone of influence is defined by the area within a 1:1 (H:V) slope line from the outer edge of a sewer or sewer lateral. [Section 4.15.3, 7e]
12. Verify that pretreatment is provided for all runoff entering the drainage well, including pretreatment of runoff from all inlets. At a minimum, this can be achieved through the use of sumps and traps for inlets, sump boxes with traps downstream of trench drains, and filter strips for overland flow. [Section 4.15.3, 9]
13. Verify that the storage area provides static storage for the WQv between the bottom elevation of the drainage well and the elevation of the lowest outlet, including storage voids. For dynamically designed drainage wells, static storage of only one inch of the WQv must be provided if the designer demonstrates, through dynamic routing, that the full 1.5-inch WQv is managed throughout the design storm, without overflow. [Section 4.15.3, 12]
14. Verify that the maximum storage volume statically stored within the drainage well without supporting documentation (defined below) is the runoff volume from the one-year, 24-hour storm event. [Section 4.15.3, 13]
15. Verify that the maximum storage volume statically stored within the drainage well with supporting documentation is the runoff volume from the ten-year, 24-hour storm event. Requirements for supporting documentation include a letter, signed and sealed by both the geotechnical and design engineer, indicating that the proposed design is recommended, with the following components acknowledged and considered. The designer is encouraged to contact PWD for further guidance when pursuing this design. [Section 4.15.3, 14]
    a. A summary of the long-term impacts to the neighboring properties, including, but not limited to subsidence, change in basement moisture/water, and structural damage;
    b. The location of the groundwater table;
    c. References to other projects that have successfully infiltrated more than the one-year, 24-hour storm event; and
    d. Rigorous pretreatment to promote longevity of the infiltration SMP.
16. Verify that, when SMPs are used in series, the storage areas for all SMPs provide cumulative static storage for the WQv. There is no minimum storage requirement for each individual SMP used in series [Section 4.15.3, 15]
17. Verify that void space provided by drainage wells is as specified by the manufacturer and noted in supporting documentation. [Section 4.15.3, 17]
18. Verify that drainage wells are adequately bedded with stone to prevent settling or subsidence. [Section 4.15.3, 18a]
19. Verify that bedding thickness is not less than six inches. [Section 4.15.3, 18b]
20. Verify that foundations/footers are provided as warranted by system loading, geotechnical conditions, and manufacturer's recommendations. Foundation designs must be performed by an appropriate design professional. [Section 4.15.3, 18d]
21. Verify that the storage design accounts for potential loading from vehicles, as appropriate, based on expected maximum active loading, including consideration for emergency vehicles. [Section 4.15.3, 19]
22. Verify that a porosity of 0.40 is used for stone storage volume calculations. [Section 4.15.3, 20]

23. Verify that the stone storage layer, if proposed, is separated from soil media by a geotextile to prevent sand, silt, and sediment from entering the system. A pea gravel filter may be used on the bottom in lieu of a geotextile. [Section 4.15.3, 21]
24. Verify that the stone storage layer, if proposed, is separated from the perforated manhole by a geotextile or geogrid to prevent stone from falling into the manhole. [Section 4.15.3, 22]
25. Verify that drainage wells have a level bottom or use a terraced system if installed along a slope, in series. [Section 4.15.3, 23]
26. Verify that manholes are accessible, to allow unobstructed and safe access to drainage wells for routine inspection and maintenance, and that inlet and outlet controls also contain access panels or other access features to inspect and maintain the same. [Section 4.15.3, 25]
27. Verify that ladder access is proposed for drainage wells greater than four feet in height. [Section 4.15.3, 26]

F.21.3 Drainage well material standards

1. Verify that precast concrete drainage well manholes, if proposed, meet the following specifications: [Section 4.15.4, 3]
    a. Concrete risers: five-inch thick, 4,000 psi concrete, 3×12 WWF (six gauge) reinforcement
    b. Base section: nine-inch thick, 4,000 psi concrete, #4 rebar reinforcement, six inches on center
    c. Perforations: two to four-inch diameter, eight inches on center
    d. Connections to be made with non-shrink grout
2. Verify that thermoplastic drainage well manholes, if proposed, meet the following specifications: [Section 4.15.4, 4]
    a. Thermoplastic well sections: PVC
    b. Perforations: one to two-inch diameter, six inches on center
    c. Connections to be made with like materials per manufacturer recommendations
3. Verify that stone designed for stormwater storage, if proposed, is specified on the plans as being uniformly graded, crushed, clean-washed stone and that it is noted that PWD defines “clean-washed” as having less than 0.5% wash loss, by mass, when tested per the AASHTO T-11 wash loss test. AASHTO No. 3 and No. 57 stone can meet this specification. [Section 4.15.4, 5]
4. Verify that geotextile, if proposed, is specified on the plans to consist of polypropylene fibers and to meet the following specifications (AASHTO Class 1 or Class 2 geotextile is recommended): [Section 4.15.4, 6]
    a. Grab Tensile Strength (ASTM-D4632): ≥ 205 lbs
    b. CBR Puncture Strength (ASTM-D6241): ≥ 500 lbs
    c. Flow Rate (ASTM-D4491): ≥ 95 gal/min/ft2
    d. UV Resistance after 500 hrs (ASTM-D4355): ≥ 70%
    e. Tear Resistance (ASTM-D4533): ≥ 80 lbs
    f. Heat-set or heat-calendared fabrics are not permitted.
5. Verify that geogrid, if proposed, is specified on the plans to meet the following specifications: [Section 4.15.4, 7]
    a. Maximum Apparent Opening Size (AOS): 0.25-inch
    b. Grab Tensile Strength (ASTM-D4632): ≥ 205 lbs
    c. CBR Puncture Strength (ASTM-D6241): ≥ 500 lbs
    d. UV Resistance after 500 hrs (ASTM-D4355): ≥ 70%
    e. Tear Resistance (ASTM-D4533): ≥ 80 lbs
6. Verify that manhole covers allow access to drainage wells. [Section 4.15.4, 9]

G. SMP Maintenance Guide Documents

Appendix G contains an SMP Maintenance Guide sample and associated template documents.

An SMP-specific, site-specific SMP Maintenance Guide, prepared by the designer and submitted to, and reviewed by, PWD during the PCSMP Review Phase, should be provided to and implemented by the property owner as a guide for long-term operations and maintenance of the SMPs on-site.

The SMP Maintenance Guide must include an SMP Maintenance Guide Introduction, an SMP Maintenance Guide Site Map, and a separate SMP Maintenance Schedule Form for each SMP and SMP-related feature, in order to allow the property owner to track all maintenance activities for their site.

SMP Maintenance Guide instructions are available on the first page of the SMP Maintenance Guide Information document to steer the designer through the creation of these items. A sample of a compiled SMP Maintenance Guide is available in this Appendix For reference. SMP Maintenance Guidance One-Sheets are also available for each SMP detailed in this Manual in order to provide guidance on SMP maintenance activities and frequencies, including recommended SMP maintenance schedules.

- **SMP Maintenance Guide Information (DOC)** ☛ water.phila.gov/wp-content/uploads/files/smp-maintenance-guide-information.docx
- **SMP Maintenance Schedule Forms (XLS)** ☛ water.phila.gov/wp-content/uploads/files/smp-maintenance-schedule-forms.xlsx
- **SMP Maintenance Guide Sample (PDF)** ☛ water.phila.gov/wp-content/uploads/files/smp-maintenance-guide-sample.pdf
- **SMP Maintenance Guidance One-Sheets (PDF)** ☛ water.phila.gov/wp-content/uploads/files/smp-maintenance-guidance.pdf

H. Infiltration Testing Log

Appendix H contains a template log for documenting infiltration testing results. This Infiltration Testing Log includes guidance for documenting soil characteristics and is required to be completed and submitted as part of the Geotechnical Report during the Post-Construction Stormwater Management Plan Review Phase.

- **Infiltration Testing Log Template** ☛ water.phila.gov/development/wp-content/uploads/files/infiltration-testing-log-template.xlsx (XLSX)
- **Infiltration Testing Log Template** ☛ water.phila.gov/development/wp-content/uploads/files/infiltration-testing-log-template.pdf (PDF)

I. Plant Lists

Native and recommended non-invasive plants

A list of trees, shrubs, and herbaceous plants suitable for planting in stormwater management facilities are included in **Table I-1** ☛ p. 110. The list is intended as a guide for general planting purposes and planning considerations. Knowledgeable landscape designers and nurseries can provide additional information for considering specific conditions for successful plant establishment.

Table I-1 ☛ p. 110 lists native and recommended plants, trees, shrubs, and herbaceous plants and is organized by type and Latin name. Additional information given for each species includes common name, National Wetland Indicator Status, hydrologic zone, inundation tolerance, drought tolerance, salt tolerance, mature canopy spread, mature height, light requirements, nativity, commercial availability, and notes to provide guidance for application and selection. For example, some trees are well-suited to landscaped areas that will receive stormwater runoff, while others may not tolerate the additional moisture.

National Wetland Indicator Status

The National Wetland Indicator Status (from Region 1, Reed, 1988) has been included to show "the estimated probability of a species occurring in wetlands versus non-wetlands" (Reed, 1988). Reed defines the indicator categories as follows:

- Obligate wetland (OBL): Plants which nearly always (more than 99% of the time) occur in wetlands under natural conditions.
- Facultative wetland (FACW): Plants which usually occur in wetlands (from 67 to 99% of the time), but occasionally are found in non-wetlands.
- Facultative (FAC): Plants which are equally likely to occur in wetlands and non-wetlands, and are found in wetlands from 34 to 66% of the time.
- Facultative upland (FACU): Plants which usually occur in non-wetlands (from 67 to 99% of the time), but occasionally are found in wetlands.
- Upland (UPL): Plants which almost always (more than 99% of the time) occur in non-wetlands under natural conditions.
- A given indicator status shown with a "+" or a "-" means that the species is more (+) or less (-) often found in wetlands than other plants with the same indicator status without the "+" or "-" designation.

Hydrologic zones

For planting within a stormwater management practice (SMP), it is necessary to determine what hydrologic zones will be created within the SMP. Hydrologic zones describe the degree to which an area is inundated by water (the designer is referred to **Figure 4.1-3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-1-bioinfiltration-bioretention/#Figure_4.1-3 for an example of hydrologic zones in a bioinfiltration/bioretention basin). Plants have differing tolerances to inundation, and, as an aid to landscape designers, these plant tolerance levels have been divided into six zones and corresponding appropriate plant species have been identified. In **Table I-1** ☛ p. 110, each plant species has a corresponding hydrologic zone provided to indicate the most suitable planting location for successful establishment. While the most common zones for planting are listed in parentheses, the listing of additional zones indicates that a plant may survive over a broad range of hydrologic conditions. Just as plants may, on occasion, be found outside of their hardiness zone, they may also be found outside of their hydrologic zone. Additionally, hydrologic conditions in an SMP may fluctuate in unpredictable ways; thus, the use of plants capable of tolerating wide varieties of hydrologic conditions greatly increases a successful planting. Conversely, plants suited for specific hydrologic conditions may perish when hydrologic conditions fluctuate, thus exposing the soil and increasing the chance for erosion.

Inundation tolerance

Since the Wetland Indicator Status alone does not provide an indication of the depth or duration of flooding that a plant will tolerate, the “Inundation Tolerance” column is designed to provide further guidance. If a plant is capable of withstanding permanent saturation, the depth of this saturation is listed (for example, “saturated” indicates the soil can be moist at all times, “sat, 0–6”“ indicates that the species can survive in constantly moist soil conditions with up to six inches of standing water). Conversely, a plant may only tolerate seasonal inundation – such as after a storm event – or may not tolerate inundation at all. This type of plant would be well-suited for an SMP that is expected to drain quickly or in the drier zones of the SMP.

Drought tolerance (N=none; L=low; M=medium; H=high)

The “Drought Tolerance” column is meant to provide a way for SMP designers to select appropriate native plants that can survive in hot summer conditions, with a minimum of irrigation. Drought tolerance is defined as the relative tolerance of the plant to drought conditions compared to other plants in the same region (USDA, 2005).

Salt tolerance (N=none; L=low; M=medium; H=high; U=unknown)

This column ranks the relative tolerance of a species to salt content in the soil. If U (unknown) is displayed, no research was found for that particular species.

Mature canopy spread

This column gives the SMP designer a rough estimate of the diameter (or spread) of a tree species’ branching when it has matured. This information indicates what the light conditions will be like beneath the tree for understory plantings; how much space should be left open between the tree planting pit and any vertical structures, such as buildings; how far apart the trees should be planted; and it gives an idea, along with the mature height of the species, of the tree’s growth habit. The mature canopy spread also provides a rough idea for how much leaf surface area will be available to intercept stormwater before it reaches the ground. The designer should also consider critical lines for sight for vehicular or pedestrian traffic.

Mature height

This column provides the approximate mature height of plant species in optimal growing conditions. This height may be reduced dramatically in the urban environment where light, space, and other factors may not be as readily available as in a forest or field setting. However, by providing as much space as possible for a plant to grow and by choosing appropriate species for a planting area, improved – if not optimal – growing conditions can be achieved. For example, a tree planted in a sidewalk pit measuring four feet by four feet may only reach half its mature height, while a tree planted in a four-foot-wide "trough" style planting bed will grow taller and live longer, because it will have greater access to air and water.

Light requirement

The light requirements for each species are listed as ranges between full shade and full sun. At the bottom of the range – full shade – plants thrive in conditions where they receive filtered, or dappled, light for the entire day (such as under an oak tree). In the middle of the range are plants that grow best in partial shade, where they are in full shade for two to three hours during midday. Plants that require full sun should be sited so that they receive five or more hours of direct sun during the growing season. Some plants requiring full sun may still do well in a partial shade environment, depending on the quality and duration of the light the plants receive when they are not in the shade.

Nativity

A native plant is an indigenous species that occurred in the region prior to settlement by the Europeans. In this column, each species is located within a range of nativity to Philadelphia. Plants known to have existed in Philadelphia County are native to Philadelphia, while a wider geographic range lists plants native to the state, but not necessarily to the county. The widest geographic range lists a few species native to the United States, but not necessarily to Pennsylvania. The plants listed that are not specifically native to Philadelphia are included because of their demonstrated success within SMPs.

Commercial availability (C=Container; P=Plug; S=Seed)

Herbaceous plants often come in a form known as a plug. These are often grown and sold in trays of 50 of the same species. They are essentially very small container plants, with a root/soil mass about an inch wide and two to four inches long. Most species available in plug form are also sold as seed. Often, a combination of plugs and seed will be used to establish a SMP quickly and provide immediate visual interest and stabilization.

Container-grown plants include trees, shrubs, and herbaceous plants. This is an excellent alternative to the far more expensive balled-and-burlapped (B&B) form of trees and shrubs, although the size of the tree is almost always smaller. Nurseries often provide a few container sizes for each species. This information is provided as guidance, and determining what is currently commercially available will require the designer to contact nurseries and plant providers directly.

Notes

PWD has included recommendations for street trees in the "Notes" column of Table I-1 to assist designers in selection of vegetation most appropriate for the harsh conditions that are often associated in close proximity to streets. It is likely that most of these areas will be hot in summer months until the trees become established.

Table I-1: Native and recommended non-invasive plants

Table I-1 is too large to display in the browser. **Download a PDF copy** ☛ water.phila.gov/wp-content/uploads/files/table-i-1-non-invasive-plants-1.pdf.

Prohibited invasive plants and noxious weeds

Invasive plants reproduce rapidly, degrade, and take over natural ecosystems. Under no circumstance should they be planted in a SMP. Nonetheless, because of appealing characteristics, some of these invasive plants are available for sale; care should be taken not to purchase them. Cultivating an ability to identify and remove invasives before they establish themselves is advantageous; due to their gregarious reproductive strategies, they can be especially difficult to eradicate once they take hold. For a list of invasive species to avoid planting, the designer is referred to the **Invasive Plant Fact Sheets webpage** ☛ https://www.dcnr.pa.gov/Conservation/WildPlants/InvasivePlants/InvasivePlantFactSheets/Pages/default.aspx from the Pennsylvania Department of Conservation and Natural Resources (DCNR).

Noxious weeds, as defined by the **Pennsylvania Department of Agriculture** ☛ https://www.agriculture.pa.gov/Plants_Land_Water/PlantIndustry/NIPPP/Pages/Controlled-Plant-Noxious-Weed.aspx, "are identified as a plant that is determined to be injurious to public health, crops, livestock, agricultural land or other property and cannot be sold, transported, planted, or otherwise propagated in Pennsylvania." Under no circumstance should they be planted within an SMP. Table I-2, below, highlights a list of prohibited noxious weeds.

Table I-2: Prohibited noxious weeds

Prohibited noxious weeds, as identified in Pennsylvania Code Section 110.1: Noxious Weed Control List
• Marijuana (Cannabis sativa) • Purple Loosestrife (Lythrum salicaria) • Canada Thistle (Cirsium arvense) • Multiflora Rose (Rosa multiflora) • Johnson Grass (Sorghum halepense) • Musk Thistle, or Nodding Thistle (Carduus nutans) • Bull Thistle, or Spear Thistle (Cirsium vulgare) • Jimson Weed (Datura stramonium) • Mile-a-minute (Polygonum perfoliatum) • Kudzu (Pueraria lobata) • Shattercane (Sorghum bicolor) • Giant Hogweed (Heracleum mantegazzianum) • Goatsrue (Galega officinalis)

J. Construction Certification Package

It is important, both for the property owner and for the Philadelphia Water Department (PWD), to ensure that all stormwater management practices (SMPs) are constructed in strict accordance with the Approved Post-Construction Stormwater Management Plan (PCSMP).

The Construction Certification Package (CCP) provides PWD with documentation that SMPs have been properly installed. The CCP consists of photographs, material receipts, and SMP Construction Certification Forms that must be customized by the design engineer prior to PCSMP Approval; these documents must be kept on-site and completed by a registered professional during construction.

Appendix J contains a description of the required CCP documentation and a collection of customizable SMP Construction Certification Forms to be populated with key information during construction and installation.

- **Construction Certification Package** ☛ water.phila.gov/development/wp-content/uploads/files/construction-certification-package.docx (DOCX)
- **Construction Certification Package** ☛ water.phila.gov/development/wp-content/uploads/files/construction-certification-package.pdf (PDF)

K. Record Drawing Sample

Along with the Construction Certification Package, the Philadelphia Water Department (PWD) requires that Record Drawing(s) be submitted at the close of the project to ensure that the stormwater management practices (SMPs) and their elements were constructed in general accordance with the Approved Post-Construction Stormwater Management Plan (PCSMP), and to document any field changes. Record Drawing(s) are required for SMP verification and are a key component of PWD's compliance reporting and post-construction inspection procedures. Samples demonstrating how Approved PCSMP plan sheets should be marked-up in order to prepare Record Drawings are provided in Appendix K.

- **Record Drawing Sample** ☛ water.phila.gov/wp-content/uploads/files/appendix-k-record-drawing-sample.pdf (PDF)
- **Record Drawing Sample Construction Details** ☛ water.phila.gov/wp-content/uploads/files/appendix-k-record-drawing-sample-construction-details.pdf (PDF)

L. Standard Details

Typical construction details for several SMPs, including all of PWD's highest-preference SMPs, such as bioinfiltration/bioretention basins, porous surfaces, and green roofs, and for SMP-related structures, such as cleanouts, observations wells, and outlet control structures, are available for download in AutoCAD (*.dwg) format in Appendix L. These Standard Details incorporate design specifications pursuant to each SMP's respective design and material requirements. The designer is encouraged, not required, to use them for PCSMP creation when possible.

- **Standard Details (All)** ☛ water.phila.gov/wp-content/uploads/files/pwd-stormwater-standard-details.zip
  - **Bioinfiltration/Bioretention Basin Standard Detail** ☛ water.phila.gov/wp-content/uploads/files/bioinfiltration-bioretention-basin.dwg
  - **Blue-Green Roof Standard Detail** ☛ water.phila.gov/wp-content/uploads/files/blue-green-roof.dwg
  - **Cleanout in Paved Area Standard Detail** ☛ water.phila.gov/wp-content/uploads/files/cleanout-in-paved-area.dwg
  - **Cleanout in Right-of-Way Standard Detail** ☛ water.phila.gov/wp-content/uploads/files/cleanout-in-right-of-way.dwg
  - **Cleanout in Unpaved Area Standard Detail** ☛ water.phila.gov/wp-content/uploads/files/cleanout-in-unpaved-area.dwg
  - **Double Manhole Outlet Control Structure Standard Detail** ☛ water.phila.gov/wp-content/uploads/files/double-manhole-outlet-control-structure.dwg
  - **Green Roof (Dual Media) Standard Detail** ☛ water.phila.gov/wp-content/uploads/files/green-roof-dual-media.dwg
  - **Green Roof (Single Media) Standard Detail** ☛ water.phila.gov/wp-content/uploads/files/green-roof-single-media.dwg
  - **Observation Well in Paved Area Standard Detail** ☛ water.phila.gov/wp-content/uploads/files/observation-well-in-paved-area.dwg
  - **Observation Well in Unpaved Area Standard Detail** ☛ water.phila.gov/wp-content/uploads/files/observation-well-in-unpaved-area.dwg
  - **Partially Paved Blue-Green Roof with Micro Siphon Drain Belt Standard Detail** ☛ water.phila.gov/wp-content/uploads/files/partially-paved-blue-green-roof-with-micro-siphon-drain-belt.dwg
  - **Partially Paved Green Roof with Typical Features Standard Detail** ☛ water.phila.gov/wp-content/uploads/files/partially-paved-green-roof-with-typical-features.dwg
  - **Porous Surfaces Standard Detail** ☛ water.phila.gov/wp-content/uploads/files/porous-surfaces.dwg
  - **Precast Concrete Drainage Well Standard Detail** ☛ water.phila.gov/wp-content/uploads/files/precast-concrete-drainage-well.dwg
  - **Riser Outlet Control Structure Standard Detail** ☛ water.phila.gov/wp-content/uploads/files/riser-outlet-control-structure.dwg
  - **Subsurface Infiltration Basin (Pipe in Stone) Standard Detail** ☛ water.phila.gov/wp-content/uploads/files/subsurface-infiltration-basin-pipe-in-stone.dwg
  - **Terraced Porous Surfaces Standard Detail** ☛ water.phila.gov/wp-content/uploads/files/terraced-porous-surfaces.dwg

- **Thermoplastic Drainage Well Standard Detail** ☛ water.phila.gov/wp-content/uploads/files/thermoplastic-drainage-well.dwg
- **Trap with Fresh Air Inlet Standard Detail** ☛ water.phila.gov/wp-content/uploads/files/trap-with-fresh-air-inlet.dwg
- **Underdrain Connection Standard Detail** ☛ water.phila.gov/wp-content/uploads/files/underdrain-connection.dwg
- **Underdrain Orifice Standard Detail** ☛ water.phila.gov/wp-content/uploads/files/underdrain-orifice.dwg

M. PCSMP Project Closeout

At the conclusion of construction, the applicant is responsible for ensuring project closeout with the Philadelphia Water Department (PWD). To complete the project closeout process, the following criteria must be met:

1. Resolve all construction violations (Sections **5.1.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-5/5-1-construction-inspection/#5.1.3 and **5.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-5/5-2-common-construction-issues).
2. Pay all review fees in full (**Section 2.3.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-2/2-3-review-phases/#2.3.1).
3. Obtain a Post-Construction Stormwater Management (PCSM) Final Inspection Report indicating all stormwater management practice (SMP) construction as complete (**Section 5.1.4** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-5/5-1-construction-inspection/#5.1.4).
4. Execute and record an Operations and Maintenance (O&M) Agreement reflecting the constructed conditions (**Section 6.1** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-6/6-1-property-owner-inspections-and-maintenance).
5. Submit a compliant Record Drawing (**Section 5.3.2** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-5/5-3-construction-documentation/#5.3.2).

Once the closeout process is complete, PWD will resolve the "Hold Permit Completion" on the "PWD Stormwater Mgmt. Review" for the associated Licenses and Inspections (L&I) building permit(s) in **eCLIPSE** ☛ www.phila.gov/departments/department-of-licenses-and-inspections/eclipse-faqs. Applicants do not need to contact PWD to request resolution of the eCLIPSE permit(s) hold. At closeout, PWD will automatically resolve the hold in eCLIPSE for all associated permits on all eligible projects.

For phased projects, the applicant may choose to complete the closeout criteria in piecemeal and request that PWD resolve the hold on permits that are ready for occupancy even if the entire project is not yet complete.

In addition, once the project closeout is complete, non-residential projects may apply for Stormwater Credits on their monthly water bill (**Section 6.3** ☛ water.phila.gov/development/stormwater-plan-review/manual/chapter-6/6-3-stormwater-credits).