

THE CITY OF PITTSBURGH
**STORMWATER
DESIGN MANUAL**



MARCH 2022

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SECTION 1 – INTRODUCTION & PURPOSE OF THE CITY OF PITTSBURGH STORMWATER DESIGN MANUAL

The City of Pittsburgh (city) is uniquely characterized by its connection to its three rivers and its dramatic landscape of high vistas, steep hillsides, and valley ravines. With these unique characteristics come unique technical stormwater management challenges. The **City of Pittsburgh Stormwater Design Manual** (manual) offers technical guidance for compliance with the stormwater management requirements set forth in Title 13, and, to a lesser extent, Titles 4 and 9 of the city's code. This includes the planning, design, and construction of stormwater management infrastructure specifically tailored to conditions often encountered in the city. The contents of the manual are primarily intended to be used by stormwater design professionals, such as engineers, landscape architects, and planners, for projects that trigger the requirements for a stormwater management site plan (SWM site plan) review. The Pittsburgh Water and Sewer Authority (PWSA) has its own public strategy for stormwater that may be independent from the strategies outlined in this manual.

This manual is primarily meant to be used as instructional guidance for stormwater management as part of land development and redevelopment projects to guide applicants throughout the process of developing SWM site plan and supporting documentation as needed.

1.1 STORMWATER MANAGEMENT IN THE CITY OF PITTSBURGH

According to the Pittsburgh National Weather Service, the Pittsburgh region receives on average approximately 37 inches of rainfall per year¹. Depending on global weather patterns and variations, this value can fluctuate up and down on any given year. Based on data from the National Weather Service at Pittsburgh International Airport, there is also an upward trend in annual rainfall as shown in Figure 1.1 below.

¹ Pittsburgh Historical Precipitation Totals 1836 to Current (2021) <https://www.weather.gov/media/pbz/records/hisprec.pdf>

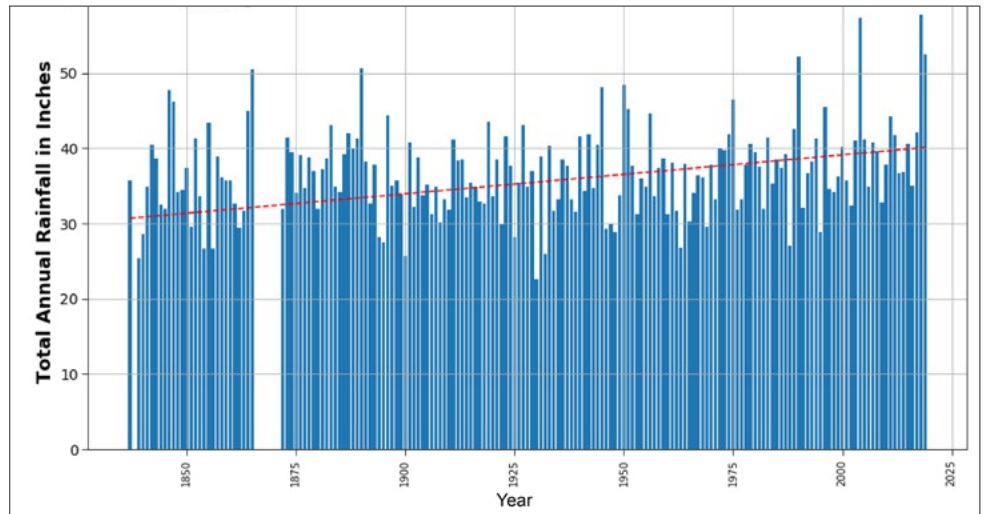


Figure 1.1. Annual Recorded Rainfall 1837 to 2019 in Pittsburgh

Once rainfall hits the surface of the ground and turns into stormwater runoff, it must be properly managed to:

- a. protect the health and safety of residents, and
- b. protect the water quality of rivers and streams.

Achieving these two objectives are the foundation for stormwater management in the city. To achieve these objectives, compliance with regulations at the federal, state, and local levels are required.

Pennsylvania Title 25 Environmental Protection and the Clean Streams Law of 1937

The Commonwealth of Pennsylvania has a long history of enacting legislation with the aim of protecting its rich abundance of water resources. In 1905, the Pennsylvania legislature enacted the Purity of Waters Act, which would eventually be supplanted in 1937 by The Clean Streams Law, which is still in place today. The objective of the Clean Streams Law is to “preserve and improve the purity of the waters of the Commonwealth for the protection of public health, animal and aquatic life, and for industrial consumption, and recreation.” Since 1937, The Pennsylvania Clean Streams Law has undergone several amendments to modernize the Commonwealth’s clean water policies with the latest scientific understanding and broader laws enacted at the federal level. The regulations pertaining to the Clean Stream Laws are found within Pennsylvania Code Title 25—Environmental Protection, primarily Chapters 91 through 111. Many of these laws directly impact stormwater management in the Commonwealth and, in turn, the city. All regulated activities within the city shall be in accordance with these laws.

Clean Water Act of 1972

In response to national outcry from major water polluting incidents in the late 1960s such as the Cuyahoga River fire in Cleveland, Ohio and the Santa Barbara California Offshore Oil Disaster, United States Congress created and passed the Clean Water Act of 1972 (CWA). The CWA established water quality standards (WQS) and the national pollutant discharge elimination system (NPDES) for surface waters throughout the entire United States. The WQS and NPDES permitting system are then to be enforced at the individual state level. For example, in the Commonwealth of Pennsylvania, the Pennsylvania Department of Environmental Protection (PADEP) enforces these WQS by issuing NPDES permits for “end of pipe” discharges to surface waters such as wastewater treatment plant effluent, industrial discharges, combined sewer overflows, and stormwater runoff in areas with separate storm sewer systems. The purpose of the CWA is to address in-stream water quality degradation with the ultimate goal of creating “fishable and swimmable” waters.



Two of Pittsburgh's Remaining Open Air Streams; Nine Mile Run (Shown on Left) and Saw Mill Run (Shown on Right)

Pennsylvania Stormwater Management Act of 1978

After the creation of the CWA, the Commonwealth of Pennsylvania recognized the need to regulate water quantity in addition to water quality. In 1978, the General Assembly created and enacted the Stormwater Management Act, also sometimes referred to as “Act 167”, and conferred the powers of its enforcement for carrying out the Act on the Department of Environmental Resources (now known as the Department of Environmental Protection), and the counties and municipalities of the Commonwealth. The purpose of Act 167 was to provide “for the regulation of land and water use for flood control and stormwater management.” With the passing of Act 167, the Commonwealth recognized the “inadequate management of accelerated runoff of stormwater resulting from development.” Act 167 mandated that every county develop a watershed stormwater plan for each of its watersheds that include “criteria and standards for the control of stormwater runoff from new and redevelopment which are necessary to minimize dangers to property and life.” Act 167 also required every individual city or municipality in Pennsylvania to implement local stormwater ordinances that regulate and limit the runoff from development within the municipality in a manner consistent with the applicable County watershed stormwater plan.

In response to Act 167, Allegheny County has developed, or has assisted in developing, numerous watershed plans, and has developed a model stormwater ordinance for adoption by municipalities. The model stormwater ordinance provides minimum requirements for all new and redevelopment land development projects. Allegheny County watershed plans that overlap with the city include: Girty’s Run, Monongahela River, and Squaw Run. The model ordinance and watershed plans serve as a baseline for the development of updates to Title 13 as well as the content within this manual.

Pittsburgh Stormwater Management Ordinance (Title 13)

All stormwater management regulations pertaining to new and redevelopment projects are located within Title 13 and limited portions of Title 4 related to Illegal Surface Stormwater Connections, and Title 9 for special regulations in the Riverfront and Uptown Zoning Districts. The full city of Pittsburgh Code of Ordinances is available online at www.library.municode.com. This manual provides technical guidance for complying with the regulations of Title 13 and the stormwater specific regulations of Titles 4 and 9. The regulations set forth within Title 13 and portions of Title 4 and 9 were last updated in 2021 through a collaborative process between the Pittsburgh Water and Sewer Authority, various departments within the city of Pittsburgh, and Allegheny County agencies including the Allegheny County Conservation District and the Allegheny County Health Department. Feedback was also solicited from prominent city of Pittsburgh watershed advocacy groups, land development private industry, and practicing engineers, architects, and planners. Final regulations were developed based upon recognized common needs and challenges across all agencies related to stormwater management specifically in the city.

The updated city stormwater code establishes some new requirements for managing stormwater, as well innovative provisions that provide applicants with more flexibility in compliance. Some of the notable revisions to the code include:

- » Relocation of most of the stormwater-related provisions in Title 9 to Title 13.
- » Elimination of the small projects stormwater requirements in Title 9.
- » The addition of public health and safety rates that provide additional levels of stormwater management in particularly flood prone areas of the city.
- » New standards for volume and rate control that account for climate change.
- » Adjustments to the in-lieu fee rate to reflect the actual cost of implementing city-initiated stormwater projects.
- » Expanded provisions for volume control and rate control offsets.
- » Incentive grants and expedited reviews for applicants that chose innovation stormwater management strategies or exceeds regulatory requirements.

The Pittsburgh Water and Sewer Authority/Allegheny County Sanitary Authority CSO EPA Consent Order

Like many older cities in the United States, the city's sewer system is primarily serviced by combined sewer, one pipe that manages both sanitary flows and stormwater, that is owned and operated by PWSA. As a percentage of the total sewers, roughly 75% of the city's sewer system are combined sewers. PWSA's combined sewers are intercepted at hundreds of individual "points-of-connections" between PWSA's combined sewer system and the Allegheny County Sanitary Authority's regional interceptor sewer system. Located at many of the points-of-connections are combined sewer overflow (CSO) discharge pipes that are purposely designed to overflow into Commonwealth rivers and streams during rain events when the system capacity becomes overwhelmed. With the passage of the Clean Water Act of 1972, these overflows are illegal. Over the past several years, Allegheny County Sanitary Authority (ALCOSAN), in partnership with its 83 customer municipalities and PWSA, is in the process of developing and executing a decades long "wet weather" infrastructure upgrade plan to mitigate CSO discharges within the city and county. Mitigating downstream CSO discharges as part of future private, new, and redevelopment is a key area of focus for the city to ensure long-term regional CSO compliance with the Clean Water Act.

City of Pittsburgh/the Pittsburgh Water and Sewer Authority MS4 Permit

Approximately 25% of the city is serviced by a municipal separate storm sewer system (MS4). Given the shared nature of stormwater infrastructure, the city of Pittsburgh and PWSA are co-permittees for the individual MS4 permit for the PADEP NPDES program. As part of the permit requirements, the city of Pittsburgh and PWSA must develop, implement, and enforce a stormwater

management program as well as institute the MS4 six minimum control measures. The six minimum control measures are:

1. Public Education and Outreach on Stormwater Impacts
2. Public Involvement/Participation
3. Illicit Discharge Detection and Elimination (IDD&E)
4. Construction Site Stormwater Runoff Control
5. Post-Construction Stormwater Management (PCSM)
6. Pollution Prevention/Good Housekeeping

Minimum control measures 4 and 5 are directly related to this manual and covered within subsequent sections.

In addition to the six minimum control measures, the joint city of Pittsburgh/PWSA individual MS4 permit also requires the implementation of pollutant reduction plans for all designated section 303(d) impaired waters within the city for each 5-year permit cycle. A map of these impaired waters is provided in **Appendix A: Overlay Districts and Watershed Maps, Figure A1.4 - Commonwealth Impaired Waters**. Direct stormwater discharges by private development activities to within MS4 areas are subject to additional stormwater filtration requirements as stipulated within this manual.

Administering the City's Stormwater Program

Administering the city's stormwater program involves several city agencies. During the city's stormwater application and review process, applicants will primarily interface with reviewers who are part of the Department of City Planning (DCP) or the Department of Permits, License and Inspection (PLI). During the stormwater review process, city reviewers may engage stormwater professionals from PWSA to assist with technical review. Applicants typically do not directly interface with PWSA. Other city agencies, including the Department of Mobility and Infrastructure (DOMI), may be involved in the reviews if projects impact other types of city infrastructure, such as roadways. PLI is responsible for overseeing construction inspection activities and ensuring the requirements within the manual are administered and as stipulated in the SWM site plan.

Interactions between City Requirements and Other Stormwater Management Regulations

The stormwater management requirements set forth in city code have important interactions with other stormwater management regulations, as well as other city approvals. Outside agency requirements include the stormwater requirements set forth in the Allegheny Plumbing Code and (by reference) the International Plumbing Code; post construction stormwater management requirements associated with the NPDES Program that are applicable for development projects with over an acre of earth disturbance; erosion and sediment control and riparian buffer requirements set forth in 25 Pa. Code 102 and administered by the Allegheny County Conservation District; and requirements for connections to the city's sewer system as set forth in the PWSA Developer's Manual.

Applicants should be aware that in some cases, practices and strategies that can be approved under the city's stormwater policies and regulations may not be acceptable to other parties. Where possible, these issues are identified within this manual, but it is the applicant's responsibility to understand and ultimately comply with all applicable regulatory requirements. The city's stormwater reviewers are helpful resources to consult with when starting a project and can help applicants understand where non-city regulations may interact with city regulations, and to get in touch with the appropriate contacts at other agencies. In some cases, joint city department pre-application meetings can be arranged for complex projects.

1.2 DESIGN MANUAL CONTENT AND ORGANIZATION

The intent of this manual is to serve as a companion document to assist applicants in complying with the city's stormwater regulations and the SWM site plan submission and process. Key sections of the manual include:

Section	Summary
1	Provides an overview of stormwater regulations and the design manual organization.
2	Explains the stormwater requirements for different kinds of development projects.
3	Details the process for developing a stormwater management strategy that complies with regulations and fits the needs of the development site, as well as providing an introduction to the range of techniques available to manage stormwater.
4	Provides detailed guidance on the selection and design of specific stormwater management techniques.
5	Details SWM site plan review submission requirements and the review process.
6	Provides guidance on the construction of stormwater management systems.
7	Details operations and maintenance requirements associated with stormwater management systems.

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SECTION 2 – STORMWATER MANAGEMENT REQUIREMENTS

Unmanaged stormwater results in negative impacts to the health and safety of the city's residents and the water quality of rivers and streams. Some public health and safety impacts include street flooding, basement backups, sewer overflows, and landslides. Water quality impacts include increased runoff pollutant concentrations, streambank erosion, loss of aquatic habitat, and reduced groundwater recharge.

To mitigate these issues, the city has adopted stormwater regulations within Title 13 and limited portions of Title 4 and Title 9 to ensure it has an up-to date and effective stormwater management program that meets Federal Clean Water Act and Commonwealth Act 167 laws, among other requirements as well. This manual provides guidance on how to design stormwater systems to meet the requirements of Title 13 and portions of Title 4 and Title 9. There are five key components for meeting the stormwater management requirements within Title 13.

- » Volume controls to capture and manage stormwater runoff water quality volume from frequently occurring rain events.
- » Rate controls to protect health and safety during larger rain events.
- » Stormwater conveyance systems to ensure stormwater is safely transported and discharged.
- » Riparian buffer requirements to protect critical environmental areas adjacent to the city's streams and rivers.
- » Erosion and sedimentation (E&S) controls to reduce water quality impacts from construction activities.

This section provides an overview of the requirements of Title 13 and portions of Title 4 and Title 9 as they relate each of these five elements.

2.1 REGULATED ACTIVITIES

Title 13 requires all regulated activities to achieve the following core objectives:

1. Protect health, safety, and property.
2. Prepare and implement an approved Stormwater Management (SWM) site

WHAT COUNTS AS EARTH DISTURBANCE?

In order to comply with the stormwater regulations, applicants need to understand how the city defines earth disturbance. While this may seem intuitive, it is not always straight forward. For instance, pavement operations that are confined to mill and overlay are not considered to be earth disturbance, while full depth pavement replacement is considered earth disturbance. Planting or regrading a ballfield are other activities that may not immediately come to mind when thinking about earth disturbance, but nevertheless are defined as earth disturbance under Title 13.

WHAT COUNTS AS IMPERVIOUS?

Title 13 provides an in-depth definition of impervious surfaces. As with earth disturbance, the definition may seem intuitive, but is not always straightforward. For example, gravel surfaces, which may seem pervious, are considered by the city to be impervious unless testing shows otherwise. This is due to the level of compaction of many gravel surfaces in urban environments. Confirming impervious surface definitions is a good topic for discussion during pre-application conferences with reviewers. This can save a lot of time and effort in later review stages.

plan (if required based on earth disturbance and/or impervious area thresholds).

3. Incorporate green infrastructure methods whenever feasible.
4. Design, implement, and maintain E&S controls.
5. Meet all requirements under Title 25 Environmental Protection of the Pennsylvania Code, the Pennsylvania Clean Streams Law, and Allegheny County Pennsylvania Storm Water Management Act (Act 167). (It should be noted that meeting these requirements is not a prerequisite of city approval and that applicants need to meet these requirements separately.)



Common forms of earth disturbance activities pictured at a recent PWSA stormwater project

2.1.a. Definition of Regulated Activities

Regulated activities are defined in §1302.01 of Title 13 as “Any earth disturbance activities or any activities that involve the alteration or development of land in a manner that may affect stormwater runoff.”

Earth disturbance is the primary factor that determines whether a project is subject to the city’s stormwater regulations and requirements. Earth disturbance activities are defined in §1302.01 of Title 13 as “A construction or other human activity which disturbs the surface of the land, including, but not limited to: clearing and grubbing;

planting; grading; demolition; excavations; embankments; road construction or full depth repair; building construction; and the moving, depositing, stockpiling, or storing of soil, rock, or earth materials.” As such, project site owners must properly and accurately assess the limits of earth disturbance associated with development projects to determine applicable requirements and the necessary reviews required. As per §1303.01, applicants are required to submit a SWM site plan for review and approval for regulated activities “that result in cumulative earth disturbances equal to or greater than ten thousand (10,000) square feet, or the addition of five thousand (5,000) square feet of impervious area, or lower thresholds as defined in the Zoning Ordinance.” Adjacent lots with impervious area and earth disturbance that are owned by the same owner, even if part of a phased development, shall be considered within the entire SWM site plan.

Regulated activities that are required to submit a SWM site plan are required to meet volume control (see Section 2.2.a) and rate control (see Section 2.2.b) requirements. For more information on the SWM site plan, refer to Section 5 – Stormwater Management Site Plan Review Requirements. A flow chart depicting the required submissions based on impervious area and earth disturbance activities is shown in Figure 2.1.

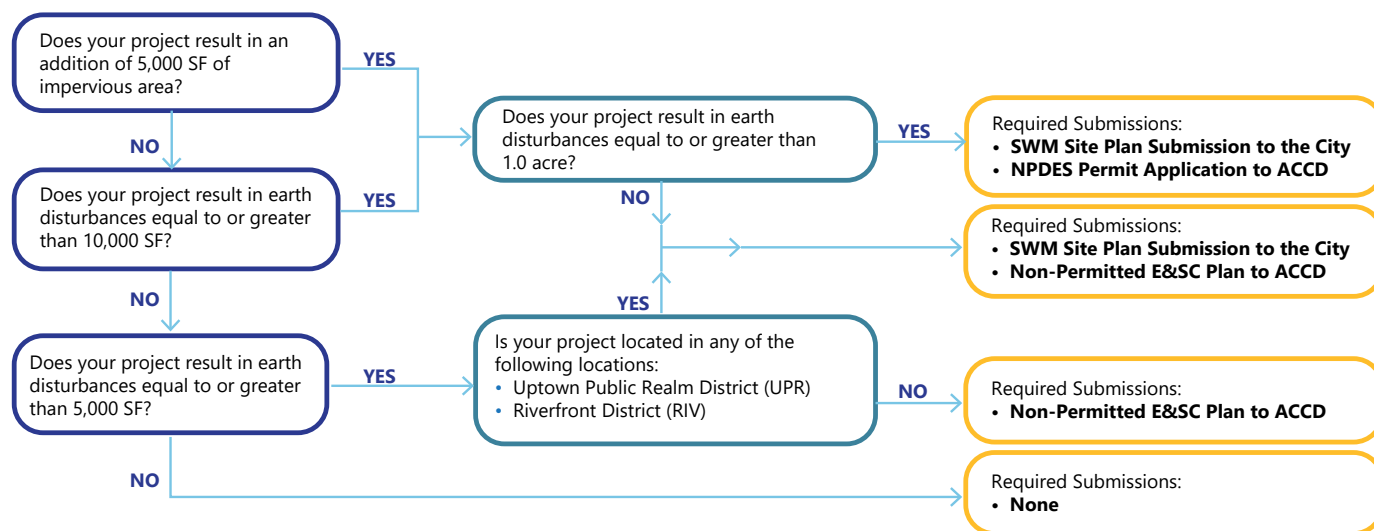


Figure 2.1. Regulated Activities and Required Submissions Flow Chart

2.1.b. Project Location Specific Regulations

To meet the objectives of Title 13, regulated activities within the city may be subject to site specific regulations based on the project's physical location. The following sections provide a summary of each of these cases and how regulated activities may be subject to variation in certain portions of the city. A summary table that shows each of these areas and requirements is provided in Table 2.1, "Project Location Specific Regulations," below.

TABLE 2.1 - PROJECT LOCATION SPECIFIC REGULATIONS

Project Location	Purpose	Summary	Manual Section Details
Riverfront District	Zoning & Landuse	<ul style="list-style-type: none"> Subject to additional riverfront setback requirements Eligible for voluntary Rainwater Points as part of Performance Points System Lower SWM site plan submission threshold 	2.1.b.ii. Special Zoning Districts
Uptown Public Realm District	Zoning & Landuse	<ul style="list-style-type: none"> Eligible for voluntary Rainwater Points as part of Performance Points System Lower SWM site plan submission thresholds 	2.1.b.ii. Special Zoning Districts
Combined Sewer System	Volume Control	<ul style="list-style-type: none"> 100% removal of 95th percentile storm required If removal technically infeasible, provide slow release; follow technical infeasibility determination guidance. 	2.2.a. Volume Control 2.2.a.ii. Drain Down Time 3.6. Technical Infeasibility Determination
Municipal Separate Storm Sewer System	Volume Control	<ul style="list-style-type: none"> 100% removal of 95th percentile storm required If removal technically infeasible, provide slow release and filtration; follow technical infeasibility determination guidance. 	2.2.a. Volume Control 2.2.a.iii. Water Quality Treatment 3.6. Technical Infeasibility Determination
Non Special Regulation Watershed	Rate Control	<ul style="list-style-type: none"> Meet pre and post construction peak flow requirements 	2.2.b.ii. Non-Special Regulation Watersheds
Allegheny County Act 167 Watersheds	Rate Control	<ul style="list-style-type: none"> Include Act 167 release rate percentage in pre and post rate control requirements 	2.2.b.iii. Act 167 Watersheds
Public Health and Safety Watersheds	Rate Control	<ul style="list-style-type: none"> Include Public Health and Safety pre and post rate control requirements 	2.2.b.iv. Public Health and Safety Watersheds
In Both Allegheny County Act 167 and Public Health and Safety Watersheds	Rate Control	<ul style="list-style-type: none"> Meet both regulations; size control strategies for more stringent case 	2.2.b.v. Both Act 167 and Public Health and Safety Watersheds
Non-Sewered Areas	Conveyance	<ul style="list-style-type: none"> Comply with discharges hierarchy and mandatory storm sewer connections distance thresholds Unavoidable discharges to public ROW require alternatives and downstream hydraulic analysis 	2.2.c.ii. Stormwater Discharges Hierarchy 2.2.c.iii. Surface Right-of-Way Discharges 2.2.c.iv. Discharges to Hillsides
Groundwater Seeps and Springs	Conveyance	<ul style="list-style-type: none"> Include groundwater in volume and rate calculations, if routed into BMPs If not routed into BMP, provide safe conveyance of groundwater into storm connection 	2.2.c.v. Groundwater Seeps and Springs
Riparian Buffers	Stream Protection	<ul style="list-style-type: none"> Comply with setback requirements from streambanks Include property easement for qualifying streams 	2.2.d. Riparian Buffers

2.1.b.i. Allegheny County Act 167 Watersheds

In accordance with the Allegheny County Act 167 Phase 2 County-Wide Stormwater Management Plan (Dated May 31, 2018), there are three watersheds which are subject to county provisions within the city. These watersheds are:

- » Girty's Run Watershed
- » Monongahela River Watershed
- » Squaw Run Watershed

Maps of these watersheds are provided in **Appendix A: Overlay Districts and Watershed Maps**. Within each of these watersheds, Allegheny County has established Release Rate Districts. Allegheny County defines Release Rate Districts as “A watershed or portion of a watershed for which a release rate has been established by an adopted Act 167 Stormwater Management Plan.” Within each Release Rate District, specific stormwater release rates are required for regulated activities. For more information on release rate control requirements, refer to Section 2.2.b, “Rate Control.”

2.1.b.ii. Special Zoning Districts

Within Title 9 – Zoning of the City Code, special zoning districts have been established that regulate development to achieve local neighborhood specific outcomes. Two zoning districts that are specifically related to regulated activities and on-site stormwater management are the Riverfront District (§ 905.04) and Uptown Public Realm District (§ 908.04).

Riverfront District

The purpose of the Riverfront District is to “improve the ecological health of its rivers and riverfronts for the benefit of the public through regulation of development along its riverfronts.” Two key components of this code section relating to stormwater management are the protection of riparian buffers and the earth disturbance threshold for compliance with Title 13 requirements.



Convention Center Riverfront Plaza

(Image credit: from Riverlife.org <https://riverlifeepgh.org/riverfront-guide/>)

Riparian buffers are defined Title 13 as “A permanent vegetated area of trees and shrubs located adjacent to streams, lakes, ponds and wetlands.” As stated in Title 9 of the code, “Riparian Buffer Zones are vital elements of riverfronts, and they create and provide protection of surface and ground water quality, water resources, and complex ecosystems that provide food and habitat for unique plant and animal species. Riparian Buffer Zones are essential to the mitigation and control of nonpoint source pollution.” Specific setbacks are stipulated in the code pertaining to the distance from the edge of structures and river pool if a project is located within a Riverfront District. It is important to note that the riparian buffer zone requirements in Title 9 in the Riverfront District and Title 13 may not be mutually exclusive. For more information on riparian buffer zones and associated requirements related to Title 13, refer to 2.2.d, “Riparian Buffers,” within this manual.

The Riverfront District implements a sustainability focused Performance Point System as part of its development standards. One of the bonus point criteria relates to rainwater management. This provision is found under § 915.07 – Performance Points System and focuses on rainwater reuse and stormwater management using preferred stormwater management technology. These technologies are further defined within this manual under Section 3.7, “Stormwater Management Design Strategies” as well as Section 4, “Stormwater Best Management Practice Design Standards.” Developments in the Riverfront District are able to qualify for both Performance Points under Title 9 and grant or technology incentives under Title 13.

The zoning code establish a Riverfront District threshold for the submission of a SWM site plan in accordance with Title 13. Specifically, § under 905.04.F Stormwater Management, a SWM site plan review is required for earth disturbance activities equal to or greater than five thousand (5,000) square feet in area.

Uptown Public Realm District

The Uptown Public Realm District was created to “provide regulations for the development and growth of Uptown as Pittsburgh’s first EcoInnovation District.” Within EcoInnovation districts increased emphasis is placed on sustainability performance standards as part of economic and neighborhood development. Stormwater management goals, including the use of green infrastructure, are included as part of the sustainability performance standards.

The Uptown Public Realm District implements a sustainability focused Performance Points System as part of its development standards. One of the points criteria relates to rainwater management. This provision is found under §915.07 – Performance Points System and focuses on rainwater reuse and stormwater management using preferred stormwater management technology. These technologies are further defined within this manual under Section 3.7, “Stormwater Management Design Strategies” as well as Section 4, “Stormwater Best Management Practice Design Standards.” Developments in the Uptown Public Realm District are able to qualify for both Performance Points under



Uptown Ecolnnovation District

Image credit: <https://pittsburghpa.gov/dcp/eid>

Title 9 and grant or technology incentives under Title 13.

Similar to the Riverfront District, earth disturbance thresholds for submission of a SWM site plan in accordance with Title 13 are also lower within the Uptown Public Realm District. Specifically, § 908.04.C.2 Development Standards Stormwater that “standards (Chapter 1003 and Title Thirteen: Stormwater Management) shall apply to all Project Development Plans with Regulated Activities equal to or greater than five thousand (5,000) square feet in area.”

2.1.b.iii. Public Health and Safety Watersheds

The city has identified watersheds with infrastructure that are subject to capacity restrictions and therefore pose potential risks to public health and safety associated with basement sewage backups and surface flooding. To further minimize the impact of runoff from development within the identified watersheds, regulated activities are subject to additional Public Health and Safety



Washington Boulevard within the Negley Run Public and Health and Safety Watershed

Image credit Rebecca Lessner Post Gazette <https://www.post-gazette.com/local/city/2018/06/06/Washington-Boulevard-floodgates-replacement-failure-Pittsburgh-Allegheny-River-Negley-Run/stories/201806060165>

release rate requirements. Based on system hydraulic modeling and customer complaint information, PWSA combined sewers within the Public Health and Safety watersheds may begin to experience capacity limitations for rain events greater than or equal to the two (2) year event. The Public Health and Safety release rate requires post development peak runoff rates from the ten (10) year event to be equal to or less than the pre-development two (2) year event. A listing and map of the Public Health and Safety watersheds are provided in **Appendix A: Overlay Districts and Watershed Maps**. More information on the Public Health and Safety requirements is provided in Section 2.2.b.iv, “Public Health and Safety Watersheds,” of this manual.

2.1.b.iv. Commonwealth Designated Impaired Waters

In accordance with the Federal Clean Water Act (CWA), the Commonwealth of Pennsylvania is required to assess and list all impaired surface waters. For each impaired surface water, the specific pollutant(s) that are causing the impairment are identified by PADEP. Depending on the pollutant and its suspected source, a total maximum daily load (TMDL) may be imposed on adjacent municipalities to reduce the pollutant discharges to the impaired surface water, and to restore the waterbody to achieve the CWA goals.

Within the city there are several Commonwealth designated impaired surface waters and associated TMDL requirements. A listing and map of these waters are provided in **Appendix A: Overlay Districts and Watershed Maps, Figure A1.4 - Commonwealth Impaired Waters**. Currently the city and PWSA have a joint MS4 permit which includes a pollutant reduction plan to address pollutants contributing to these waters. To ensure regulated activities do not contribute to or cause further impairments, stormwater discharges to Commonwealth surface waters within the city MS4 areas are subject to pollutant filtration requirements as stipulated within Title 13 and this manual. A map of MS4 areas in the city is provided in **Appendix A: Overlay Districts and Watershed Maps, Figure A1.5 - City of Pittsburgh MS4 and CSS Districts**. For more information on filtration requirements refer to Section 2.2.a.iii, “Water Quality Treatment.”

2.1.c. Exemptions

Regulated activities exempt from the requirements within this manual are listed in § 1303.02 – Exemptions of Title 13.

- a.** Agricultural activity is exempt from the SWM site plan preparation requirements of this Title provided that activities are performed according to the requirements of PA Code Title 25, Chapter 102.
- b.** Roadway resurfacing and maintenance projects, which do not increase impervious area, and underground infrastructure projects are exempt from the provisions of this Title, provided that the activities meet the requirements of all other municipal, state and federal requirements.
- c.** Demolition of a residential structure by the city or other governmental body is exempt.
- d.** Exemptions from any provisions of this Title shall not relieve the applicant

from the requirements in Section 1303.01.e through k, which require all disturbance and development activities, regardless of SWM site plan review requirements, to comply with other relevant state and local codes.

- e. The city may deny or revoke any exemption pursuant to this section at any time for any project that the city believes may pose a threat to public health and safety or the environment.
- f. If conditions exist that prevent the reasonable implementation of water quality and/or quantity control practices on site, upon written request by the applicant, the city may at its sole discretion accept off-site stormwater management practices, retrofitting, stream restorations, or other practices that provide water quality and/or quantity control equal or greater than onsite practices for the volume which the applicant has demonstrated to be infeasible to manage and treat on site.

2.1.d. Technical Infeasibility and Fee-in-Lieu

Regulated activities may be considered technically infeasible and pay a fee-in-lieu payment to the city. Guidance for demonstrating technical infeasibility and required associated fee-in-lieu payments are provided within this manual in Section 3.6, “Technical Infeasibility Determination.”

2.2 REGULATIONS AND REQUIREMENTS

The regulations and requirements for Title 13 include five components:

- » **Volume control**
- » **Rate control**
- » **Stormwater conveyance**
- » **Riparian buffers**
- » **Erosion and sediment control**

The following sections provide guidance for meeting each of these requirements within the Title 13.

2.2.a. Volume Control

The objective of the volume control requirement is to improve water quality through the capture, treatment, and removal of pollutants from stormwater runoff using stormwater BMPs, which include a range of technologies such as green roofs and rain gardens. The volume control requirement requires the use of BMPs that permanently remove volume by infiltration, evaporation, or transpiration. Transpiration refers to the process through which water is moved from soil to air via plants. If stormwater is permanently removed, the pollutants within the stormwater are also considered to be largely removed. In situations where this removal is not possible due to feasibility issues, certain detention or “slow-release”

PROPRIETARY SYSTEMS

Proprietary systems such as filtration cartridges can sometimes be used to provide stormwater filtration. Refer to Section 3.7.b.iv, “Innovation Track,” for information about the use proprietary systems.

BMPs can be used. These BMPs typically remove pollutants through a mix of physical, chemical, and biological process before releasing the water back to the sewer system. Slow-release systems are subject to dewatering time requirements and other requirements outlined in Section 2.2.a.iii, “Water Quality Treatment.”

Applicants are required to meet the volume control requirement through the use of preferred and approved stormwater BMPs as described within this manual under Section 3.7 - “Stormwater Management Design Strategies.” Preferred and approved stormwater BMPs shall be designed using the Design Storm Method or Simplified Method as described below.

Design Storm Method

The Design Storm Method (CG-1 in the PABMP Manual) is applicable as a method to meeting the volume requirements for any regulated activity. This method requires detailed modeling based on site conditions. The Design Storm Method consists of the following requirements:

1. *Do not increase the post-development total runoff volume for all storms equal to or less than the two-year, twenty-four-hour duration rainfall event.* This requirement is typically met using a hydraulic routing model (e.g., HydroCAD or similar) using a TR-20 methodology. Rational method calculations are not acceptable for volume calculations.

Model physical catchment parameters such as catchment slope, roughness, time of concentration, etc. shall be determined based on examination of site conditions for both pre- and post-development conditions.

2. *Runoff from at least the annual 95th percentile rainfall event using future climate change rainfall projections shall be permanently removed from the runoff flow, i.e., it shall not be released into the sewer system or surface waters of this Commonwealth.*
3. *Removal options include reuse, evaporation, transpiration, and infiltration.* Demonstration of technical infeasibility for the removal of runoff shall meet infeasibility criteria established within Section 3.6, “Technical Infeasibility Determination.” If removal of runoff is deemed infeasible, and the reviewer agrees, runoff shall be detained and meet design requirement for non-infiltrating BMPs as stipulated within Section 2.2.a.iii, “Water Quality Treatment.” Fee-in lieu payments for not meeting the volume requirement are outlined in Section 3.6.c, “Fee-in-Lieu.”
4. *For modeling purposes, existing (pre-development) non-forested pervious areas shall be calculated using permeability coefficients for meadow in good condition, in an effort to be as conservative as possible in existing conditions modeling.* In addition, twenty (20) percent of pre-development impervious area, when present, shall be calculated using permeability coefficients for meadow in good condition in the model for pre-development conditions. The intent of this provision is to start calculations from a baseline that is closer to naturally occurring, pre-urbanization conditions, realizing that impervious cover has detrimental hydrologic impacts.

Simplified Method

The Simplified Method [CG-2 in the Pennsylvania Best Management Practices (BMP) Manual] provided below is independent of site conditions and should be used if the Design Storm Method is not followed. This method is not applicable to regulated activities greater than one (1) acre of earth disturbance or for projects that require design of stormwater storage facilities. The Simplified Method consists of the following requirements:

1. Stormwater facilities shall capture at least the first two (2) inches of runoff from impervious surfaces.
2. Runoff from at least the 95th percentile rainfall event using future climate change rainfall projections provided in Section 2.2 a.i., “95th Percentile Rain Event,” shall be permanently removed from the runoff flow, i.e., it shall not be released into the sewer system or surface waters of this Commonwealth.
3. Removal options include reuse, evaporation, transpiration, and infiltration. Demonstration of technical infeasibility for the removal of runoff shall meet infeasibility criteria established within Section 3.6, “Technical Infeasibility Determination.” If removal of runoff is deemed infeasible, and the reviewer agrees, runoff shall be detained and meet design requirement for non-infiltrating BMPs as stipulated within Section 2.2.a.iii, “Water Quality Treatment.” Fee-in lieu payments for not meeting the volume requirement are outlined in Section 3.6.c, “Fee in-Lieu”.

2.2.a.i. 95th Percentile Rain Event

To account for climate change and to build in design resilience, the city has adopted a future projection calendar year 2100 value of 1.66-inches which shall be used for design purposes for the 95th percentile rain event. The 95th percentile rain event is defined as the measured precipitation depth accumulated over a twenty-four-hour period for the period of record that is larger than 95% of all daily event occurrences during this period. Analysis of the 95th percentile rain event was performed using hourly rainfall data from the Pittsburgh International Airport from 1953 through 2019. For each year, the observed 95th percentile rainfall event was determined and plotted along with the rolling seven-year average. The results of this analysis are shown in Figure 2.2, “Observed 95th Percentile Rain Event at the Pittsburgh International Airport from 1953 to 2019”.

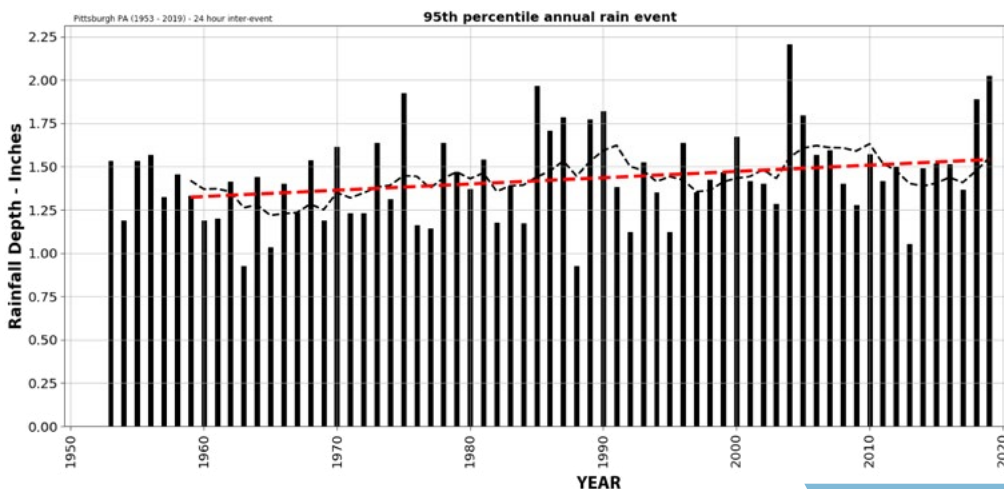


Figure 2.2. Observed 95th Percentile Rain Event at the Pittsburgh International Airport from 1953 to 2019

As shown in the Figure 2.2, there is an observed upward trend in the annual 95th percentile rain event, roughly a 13% increase 1959 to 2019 using the red dashed trend line. The city may update the 2100 95th percentile rain event rainfall depth at its own discretion as new annual rainfall data becomes available.

2.2.a.ii. Drain Down Time

All stormwater BMPs shall completely drain over a period of time not less than twenty-four (24) and not more than seventy-two (72) hours from the end of the design storm. Design calculations shall be based on the tested infiltration rate of the native soils with a factor of safety of 2.0 and the BMP horizontal surface area (footprint). For more information on infiltration testing requirements refer to Section 3.4, “Soil Assessment and Infiltration Testing.”

For systems utilizing an underdrain system that are designed to intentionally return stormwater flows back to the publicly owned sewer system, BMP underdrain orifice sizing shall be designed with the intention to maximize storage capture retention to ensure stormwater is held within the system for as long as possible prior to the seventy-two (72) hour drain down time limit.

Drain down times for non-infiltrating BMPs must be demonstrated via a hydraulic routing model. The drain down time is defined as the time for which 95% of the non-infiltrated facility volume is drained from the facility.

2.2.a.iii. Water Quality Treatment

To meet the volume control requirement in § 1303.03, all runoff from the 95th percentile rain event in Section 2.2.a.i, “95th Percentile Rain Event,” must be detained within the structural BMPs and must meet the drain down requirement in Section 2.2.a.ii, “Drain Down Time,” for any runoff volume for which removal cannot be accomplished via non-structural BMPs, reuse, evaporation, transportation, and/or infiltration that has been deemed infeasible. For more information on demonstrating infiltration technical infeasibility refer to Section 3.4, “Soil Assessment and Infiltration Testing.”

Additionally, within municipal separate storm sewer (MS4) areas, any runoff volume for which removal via reuse, evaporation, transpiration, and infiltration has been deemed infeasible, the un-removed runoff must be treated using a pollutant-removing practice. Preferred and approved structural BMPs in the non-infiltrating, MS4 category as defined in this manual (see Section 3.7.b, “Structural BMPs”) are considered as pollutant removing practices. In the case of porous pavement, dry extended detention, or subsurface systems, applicants may meet the water quality requirement by using a New Jersey Corporation for Advanced Technology (NJCAT) approved Manufactured Treatment Device (MTD) instead of media filtration provided the applicant can demonstrate that the device or combination of devices provide(s) acceptable levels of pollutant removal to meet PADEP requirements. Specifically, water quality treatment must be provided such that the total control volume is subjected to an 85% reduction in total suspended solids (TSS) load and 85% percent reduction in post-development total phosphorus load. This is consistent with the control guideline for total water quality control in Section 3.5 of the BMP Manual. For porous pavement

STORMWATER FILTRATION

The physical process of slowing water down and allowing sediments to settle reduces pollutants since many pollutants such as metals and nutrients are physically bound to sediment particles. Additional pollutant removal through chemical and biological processes occurs as plants take up nutrients like nitrogen, and as stormwater is filtered by passing through soil, sand, and/or gravel media or by soaking into the native soils under a stormwater BMP. Bacteria also play an important role in pollutant removal. Filtration of stormwater runoff typically includes layers of plants, soil, mulch, and gravel.

and subsurface systems, infiltrated volume is considered to provide 100% TSS and phosphorus removal. For porous pavement and subsurface systems that do not infiltrate and instead slow release, pollutant removal is considered negligible, therefore necessitating the need for filtration in MS4 areas.

Applicants requiring a NPDES permit are advised that meeting the water quality requirement as described in this section does not necessarily meet NPDES requirements. The requirements within this section are required within MS4 areas only. For combined sewer areas, applicants should also refer to water quality requirements in Chapter 6 of the PWSA Developer's Manual to ensure that the water quality compliance also meets PWSA standards.

2.2.a.iv. Volume Control Offsets

The volume control offset is intended to provide applicants with more flexibility in complying with the volume control requirement. Per § 1303.03(c)3, applicants may offset part or all of the volume requirement by building volume control offset projects elsewhere on properties where the regulated activity is taking place or within other properties owned by the applicant.

Offsets are particularly useful for projects where the regulated activity is occurring within a more constrained portion of a property. Building a volume offset BMP in a less constrained portion of the property may be far less expensive than building the BMP within the project site and may allow for the applicant to build a surface vegetated BMP that provides additional co-benefits.

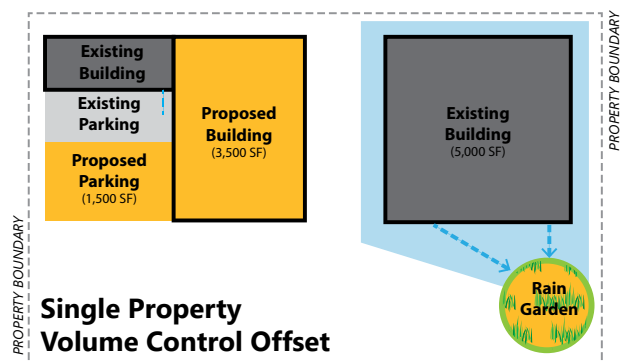


Figure 2.3. Volume Control Offset Approaches

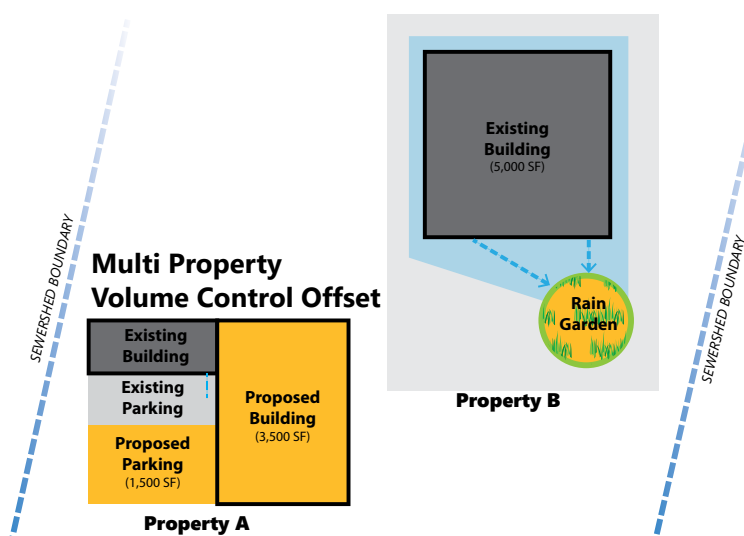
Single Property Volume Control Offset

In this example, a property owner generates a volume control offset by providing volume control for 5,000 SF of impervious surface from an existing building instead of managing runoff from 5,000 SF of impervious surface associated with a proposed building expansion and additional parking.

Multi Property Volume Control Offset

Volume control offsets can be generated on properties other than the property on which the project site is located, if the properties A and B are in common ownership and are within the same sewershed.

Applicants should coordinate with the County for NPDES approvals.



The following conditions apply to volume control offset projects:

- » Inter-owner volume offsets are prohibited (i.e., offsets located on a property not owned by the applicant).
- » The proposed volume offset BMP(s) must be located within the same major sewershed, as sited by Pittsburgh Water and Sewer Authority (PWSA), as the regulated activity. PWSA's interactive mapping application can be used to locate the sewershed.
- » Applicants must provide proof that the volume offset project and the regulated activity are under common ownership.
- » The impervious area managed by the volume offset project must be previously unmanaged impervious area.
- » Non-structural BMPs cannot be used for volume control offsets.
- » Proposed volume offset BMPs must meet the full volume control requirement, including the water quality requirement, for managed impervious surfaces. Partial management of impervious surface is not permitted.
- » Proposed volume offset BMPs shall meet all applicable design, construction, maintenance, requirements associated with structural BMPs.
- » For regulated activities in the MS4 area, the volume offset BMPs must manage a pollutant load that is at least as large, as measured by TSS loading estimates, as the pollutant load associated with the impervious areas to which the offset is being applied. For instance, a BMP managing a 1-acre roof top drainage area with a low pollutant load cannot be used to offset a 1-acre regulated ground level impervious surface with a higher pollutant load. Applicants must provide a quantitative comparison of total pollutant loads for the volume offset BMP and the impervious surface within the project area for which the offset is being applied. The comparison shall be an area-weighted average TSS pollutant load based on established event mean concentrations (EMCs), i.e., from the International BMP database, peer-reviewed literature, etc.
- » Construction of a volume offset BMP must occur either concurrently with or prior to the regulated activity for which the offset is being applied.
- » There are no time restrictions in the use of offset projects. However, the volume control offset BMP must be well maintained at the time it is used as an offset and in perpetuity thereafter. In the event that the volume control requirements change between the certification of a volume control offset BMP and the application of the offset to a regulated activity, the stormwater volume associated with the offset will be prorated based on the relationship between the volume requirement under which the offset BMP was constructed and certified and the volume requirement under which the regulated activity is being constructed.
- » If land on which BMP is used for an offset is sold to another owner, the new owner must continue to maintain the BMP per operation and maintenance agreement requirements set forth in § 1305.02.

- » If any or all of the contributing impervious drainage area draining to a BMP is used for a volume offset is sold to another owner, the owner of the BMP is responsible for verifying that the amount of impervious area within the contributing drainage area to the offset BMP does not change. If the amount of contributing area changes, the owner of the regulated project for which the offset was used is responsible for providing additional volume management if needed.

Volume control offsets do not necessarily apply to meeting post-construction stormwater management requirements set forth by the PADEP in conjunction with an NPDES permit. Applicants proposing work that will require an NPDES permit and who plan to use volume offsets should contact PADEP to determine whether the offsets can be used to meet PADEP requirements.

2.2.a.v. Volume Control Incentive

Volume control incentives recognize that applicants who exceed the regulations should be rewarded for providing an enhanced level of stormwater management. Per § 1303.03 c(1), applicants that manage volume in excess of the volume requirement, up to 2.5 inches of precipitation over contributing impervious surfaces, be eligible for a volume control grant payment. The volume control grant payment is provided per acre-inch of additional volume managed with a minimum threshold of 0.2 acres inch for consideration for the program. The following additional requirements apply to the volume control incentive:

- » Volume control incentives are subject to the availability of funds as they are funded by the stormwater trust fund, which in turn is funded by in-lieu fee payments. The percentage of the stormwater trust fund monies allocated to grants is at the discretion of the city.
- » The incentive volume is defined as the total volume provided minus the required control volume.
- » Volume control incentives can be achieved by enlarging a BMP that is managing runoff from impervious surfaces associated with a regulated activity such that a larger precipitation depth over the regulated impervious surface is managed.
- » Volume control incentives can also be achieved by managing impervious surfaces that are not subject to regulation, either within the same property as the property where the regulated activity is occurring or with other properties under common ownership. This additional management can occur by “upsizing” a BMP that is managing runoff from a regulated activity or by installing a separate BMP.
- » The reimbursement rate is \$71,293.20 per acre-inch of incentive volume provided. The reimbursement rate will be updated periodically to reflect inflation.
- » BMPs associated with volume control incentives are subject to all design, construction, maintenance and other structural BMP requirements set forth in this manual and in the stormwater code.

GRANT PAYMENT

Incentive grants are subject to funding availability and 0.2 acre-inch of additional volume is considered the minimum for consideration for the program. Intent to apply should be indicated as part of the conceptual stormwater plan submission review worksheet.

- » Volume control offsets and incentives can be combined within a single facility. Individual volume units can be used either as offset or incentive volume, not both.
- » Volume control incentive payments will be paid on a reimbursement basis during volume incentive BMP construction. Incentive payments are not available for planning or design.
- » Failure to maintain a volume incentive BMP may result in partial or full revocation and repayment of grant monies, subject to the city's discretion.

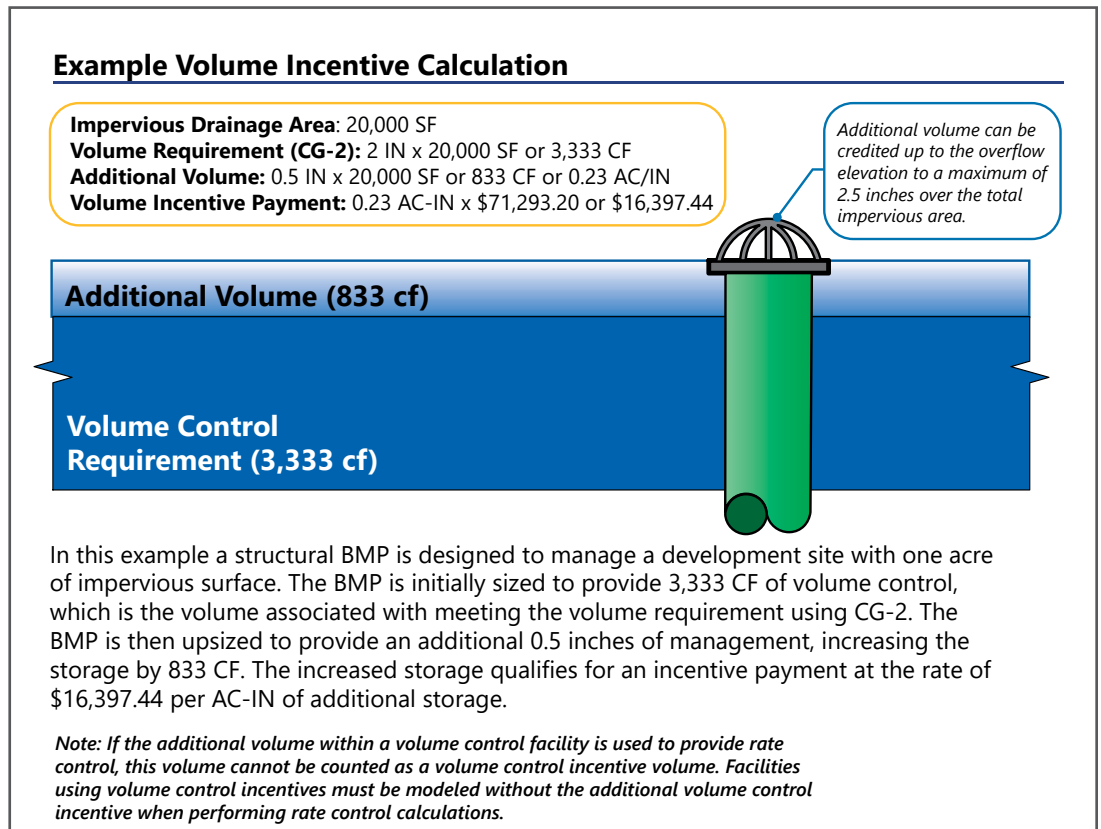


Figure 2.4. Volume Control Incentive Calculation

2.2.a.vi. Technology Incentives

In addition to the volume and rate control incentives outlined in Section 2.2.a.v. and Section 2.2.b.viii., the city offers a technology-based incentive for applicants that meet the volume requirement using a combination of water reuse, real-time controls, and preferred BMPs totaling 100 points per the point system described in the table below. Points are attained as percentages of the total impervious area managed using the incentivized technology.

TABLE 2.2. TECHNOLOGY INCENTIVE POINTS	
Point Value	Description
1 Point	1% of total impervious area required to meet the volume requirement managed using a preferred BMP as described in Section 3.7.b.i.
1 Point	1% of impervious area required to meet the volume requirement managed using active or real-time controls.
1 Point	1% of the volume requirement reused in a water reuse system.
Applicants achieving 100 points will be eligible for a 5-day SWM site plan review.	

2.2.b. Rate Control

The objective of the rate control requirement is to achieve water quantity peak flow reduction using approved retention and/or detention stormwater BMPs. Stormwater runoff from uncontrolled large storm events has the potential to overwhelm the capacity of sewer infrastructure and receiving streams resulting in increased risk to public health and safety due to flooding and basement backups. The rate control requirement limits post-development peak stormwater runoff rates to pre-development rates thereby ensuring that stormwater discharges do not adversely affect the downstream collection system and stream conveyance capacity. This analysis requires detailed modeling of prescribed depth-duration-frequency (DDF) design storm rain events developed based on local rainfall event datasets. For more information on the rain event datasets refer to Section 2.2.b.i, “NOAA Atlas 14 and Climate Change Design Rain Events.”

Rate Control requirements can depend on a project’s location within the city. Applicants should first determine which of the following four categories corresponds to their project site and then consult the referenced manual section to determine the requirement:

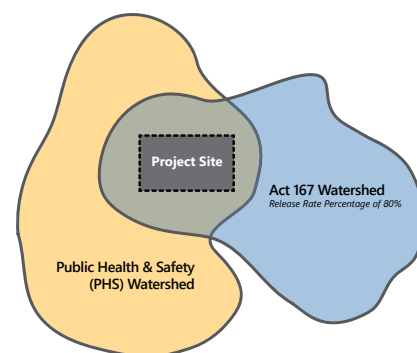
- » Project located in a non-special regulation watershed (Section 2.2.b.ii.)
- » Project located in an Act 167 watershed (Section 2.2.b.iii.)
- » Project located in a Public Health and Safety watershed (Section 2.2.b.iv.)
- » Project located in both an Act 167 and Public Health and Safety watershed (Section 2.2.b.v.)

A map showing each of these areas is provided in [Appendix A: Overlay Districts and Watershed Maps](#).

2.2.b.i. NOAA Atlas 14 and Climate Change Design Rain Events

As part of the modeling analysis for rate control requirements, the use of both present-day and future climate change rainfall DDF values is required. The present-day point precipitation frequency (PF) DDF values shall be obtained from National Oceanic and Atmospheric Administration (NOAA) Atlas-14 for the site location. Future climate change IDF rainfall values for the 24-hour event calculated by Carnegie Mellon University specifically for the city of Pittsburgh presented in Table 2.3, “24-hour Duration Future Climate Change Rainfall Values for the City of Pittsburgh,” shall be used.

Rate Control Requirements & Project Location



Return Period	Requirement for Post-Development Rate	
	Act 167	PHS
1-year	80% of pre-development	100% of pre-development
2-year	80% of pre-development	100% of pre-development
5-year	80% of pre-development	100% of pre-development
10-year	80% of pre-development	2 - year pre-development
25-year	80% of pre-development	100% of pre-development
50-year	80% of pre-development	100% of pre-development
100-year	80% of pre-development	100% of pre-development

Rate control requirements for project sites in PHS and Act 167 watersheds interact such that the most stringent requirement applies for each storm event. In the above example, the project lies within both a PHS and an Act 167 watershed. Looking at the requirements for each event (see table above), the Act 167 rate of 80% of pre-development is more stringent in all cases except for the 10-year storm, in which case the PHS requirement would be applied.

TABLE 2.3. 24-HOUR DURATION FUTURE CLIMATE CHANGE RAINFALL VALUES FOR THE CITY OF PITTSBURGH

(Table adapted from RAND (2020) – results from Carnegie Mellon University)

Return Period (years)	Rainfall Depth (inches)
1	2.1
2	2.3
5	3.3
10	3.9
25	4.8
50	5.6
100	6.4

If the present-day NOAA Atlas 14 rainfall depth value is higher than the future climate projection rainfall value, the NOAA Atlas 14 value shall apply for modeling analysis purposes.

2.2.b.ii. Non-Special Regulation Watersheds

For regulated activities not covered by Act 167 (Section 2.2.b.iii) or Public Health and Safety watersheds (Section 2.2.b.iv) post-development peak discharge rates shall not exceed the pre-development discharge rate for the 1-, 2-, 5-, 10-, 25-, 50-, and 100-year, 24-hour rainfall events. The post development peak discharge rates shall be calculated using future climate change rainfall values and the pre-development peak discharge rates shall be calculated using present-day NOAA Atlas-14 rainfall values.

2.2.b.iii. Act 167 Watersheds

For regulated activities within Act 167 watersheds, the post development peak discharge rate shall not be greater than the pre-development peak discharge rate with the prescribed Act 167 percentage applied for the 1, 2, 5, 10, 25, 50, and 100-year 24-hour rain events. The post development peak discharge rates shall be calculated using future climate change rainfall values and the pre-development peak discharge rates shall be calculated using present-day NOAA Atlas-14 rainfall values.

The following watersheds in the city have Rate Control requirements imposed by Allegheny County's Act 167 plan: Girty's Run, Monongahela River, Squaw Run. Within each of these watersheds designated Act 167 release rate percentages have been established on a sub-watershed level. For map of the release rate percentages refer to **Appendix A, "Overlay Districts and Watershed Maps"**. The percentage applies to the calculated peak discharge for the pre-development conditions. For example, if the pre-development peak flow discharge was calculated as 100 cubic feet per second (cfs) for the 100-year event, and the project were in a sub-basin with a designated release rate percentage of 60%, the calculated pre-development peak flow discharge would be multiplied by 60% and equal to 60 cfs.

2.2.b.iv. Public Health and Safety Watersheds

For watersheds identified on the Public Health and Safety Release Rate maps (see **Appendix A: Overlay Districts and Watershed Maps, Figure A1.3 - Public**

Health and Safety Watershed), regulated activities within these watersheds are subject to Public Health and Safety release rate requirements. The base release rate requirement for projects in the Public Health and Safety Release Rate watersheds are the same as for non-special regulation watersheds for all but the 10-year event:

- » The post development peak discharge rate shall not be greater than the pre-development peak discharge rate for the 1, 2, 5, 25, 50, and 100-year 24-hour rain events. The post development peak discharge rates shall be calculated using future climate change rainfall values and the pre-development peak discharge rates shall be calculated using present-day NOAA Atlas-14 rainfall values.

However, applicants with projects in the Public Health and Safety Release Rate watersheds are required to provide additional control for the 10-year event:

- » The post development peak discharge rate for 10-year, 24-hour event shall not be greater than the pre-development peak discharge rate for the 2-year, 24-hour event. The post development peak discharge rates shall be calculated using future climate change rainfall values and the pre-development peak discharge rates shall be calculated using present-day NOAA Atlas-14 rainfall values.

2.2.b.v. Both Act 167 and Public Health and Safety Watersheds

For regulated activities that overlap both Act 167 and Public Health and Safety watersheds (see sidebar), both cases shall be evaluated with the more stringent rate control requirement governing for each storm event.

2.2.b.vi. Rate Control Modeling Requirements

For modeling purposes, the 24-hour duration shall be used for both present-day and future climate change hydrologic modeling. Natural Resources Conservation Service (NRCS) Type-II distribution shall be applied to both present-day and future climate change rainfall depths in the development of the modeling rainfall hyetograph.

For hydrologic runoff modeling purposes, the following shall apply:

1. Existing (pre-development) non-forested pervious areas shall be calculated using permeability coefficients for meadow in good condition.
2. Twenty (20) percent of the pre-development impervious area, when present, shall be calculated using permeability coefficients for meadow in good condition in the model for pre-development conditions. The intent of this is to start calculations from a baseline that is closer to naturally occurring, pre-urbanization conditions, realizing that impervious cover has detrimental hydrologic impacts.

Model physical catchment parameters such as catchment slope, roughness, time of concentration, etc. shall be determined based on examination of site conditions for both pre- and post-development conditions.

2.2.b.vii. Rate Control Points of Interest

Per § 1303.04(e) rate control requirements can be met within a downstream point of interest (POI), so long as the POI is within the property on which the regulatory activity is occurring and is located upslope of the discharge point to the public sewer system. Under this provision, applicants can offset rate increases caused by increases in impervious area or other cover changes within the project site by implementing non-structural or structural BMPs elsewhere within the contributing area to the POI. Structural or non-structural BMPs must be located on land owned by applicant. Applicants must also provide documentation, such as sewer mapping, indicating that the drainage area outside of the project site drains to the same POI as the regulated impervious surfaces within the POI.

For projects that require NPDES approvals, applicants should note that the use of the rate control POI policy to meet city requirements does not guarantee that this approach will be acceptable to PADEP. Applicants should discuss the approach with PADEP to determine if the approach is suitable for post-construction stormwater management compliance related to NPDES permits.

2.2.b.viii. Rate Control Incentive

Per § 1303.04(e), applicants that provide rate control in excess of the rate control requirement, including Public Health and Safety release rates and Act 167 requirements, may be eligible for a rate control incentive grant. The rate incentive is paid based on the marginal rate control volume, which is defined as the storage provided minus the storage required to fully meet the rate control requirement, including Public Health and Safety release rates and Act 167 requirements. Applicants that exceed the rate control requirement through means other than adding additional storage volume are not eligible for a rate control incentive.

The following additional requirements apply to the rate control incentive:

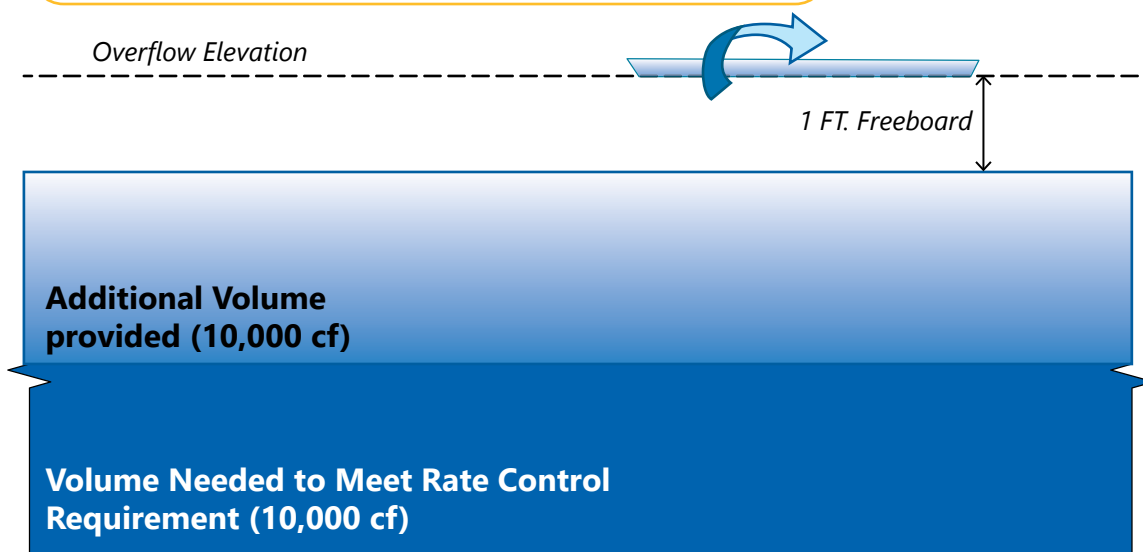
- » Rate control incentives are subject to the availability of funds as they are funded by the stormwater trust fund, which in turn is funded by in-lieu fee payments. The percentage of the stormwater trust fund monies allocated to grants is at the discretion of the city.
- » The rate control incentive volume is defined as the volume of storage provided minus the volume of storage required to meet the rate control requirement.
- » Rate control incentive BMPs must be located in the contributing drainage area to the POI(s) associated with the project site.
- » Non-structural BMPs cannot be used for rate control incentives.
- » The reimbursement rate is \$71,293.20 per acre-inch of incentive volume provided. The reimbursement rate will be updated periodically to reflect inflation.
- » BMPs associated with rate control incentives are subject to all design, construction, maintenance and other structural BMP requirements set forth in this manual and in the stormwater code.



- » Rate control incentive payments will be paid on a reimbursement basis during rate incentive BMP construction. Incentive payments are not available for planning or design.
- » Failure to maintain a rate control incentive BMP may result in partial or full revocation and repayment of grant monies, subject to the city's discretion.
- » Rate control incentive and volume control incentive volumes are not additive. That is, if a unit of excess volume provides both additional volume control and additional rate control beyond that required for compliance, the unit shall be classified as either a volume incentive unit or rate control incentive unit, but not both.

Example Rate Control Incentive Calculation

Impervious Drainage Area: 1 Acre (43,560 SF)
Rate Control Requirement: 10,000 CF
Additional Volume: 10,000 CF
Volume Incentive Payment: 2.75 AC-IN x \$71,293.20 or \$196,056.30



In this example a structural BMP is designed to provide rate control for a development site with one acre of impervious surface. The BMP is initially sized to provide 10,000 CF of control volume (not including 1 FT of freeboard below the emergency spillway elevation. An additional 10,000 CF of storage, or 2.75 AC-IN of storage, is provided, which equates to a rate incentive amount of \$196,056.30.

Figure 2.5. Example Rate Control Incentive Calculation



2.2.c. Stormwater Conveyance Requirements

This section provides design guidance and requirements for stormwater conveyance infrastructure such as inlets, drainage channels, curb openings, junction boxes, flow splitters, weirs, subsurface piping, outlet control structures, and discharge outfalls. This section consists of the following subsections:

- » **Design Storms and Sizing**
- » **Stormwater Discharges Hierarchy**
- » **Surface Discharges**
- » **Discharges to Hillsides**
- » **Groundwater Seeps and Springs**

2.2.c.i. Design Storms and Sizing

All stormwater conveyance infrastructure shall be designed with a capacity to convey the peak flow generated from the 10-year rainfall event from the present-day NOAA Atlas-14 rainfall estimates with a rainfall duration equal to the time of concentration of the site. To account for climate change, the 10-year rainfall peak intensity used for conveyance sizing shall be multiplied by a factor of 1.15. All storm sewer pipes shall be designed to have adequate capacity to safely convey the 10-year storm without surcharging the crown of the pipe. In addition to the 10-year sizing requirements, all stormwater management infrastructure (both conveyance and storage) must provide safe and controlled conveyance and passage of stormwater runoff for the 100-year rainfall event from the present-day NOAA Atlas-14 rainfall estimates with a rainfall duration equal to the time of concentration of the site. To account for climate change, the 100-year rainfall peak intensity shall be multiplied by a factor of 1.23.

Rational method shall be used for calculating peak flow rates for sites under 25 acres. TR-20 curve number hydrology shall be used for calculating peak flow rates for sites over 25 acres. Hydraulic routing model software that calculates in-system peak flow attenuation and potential surcharging effects through conveyance and storage structures is required. The hydraulic routing model shall be used to confirm adequate conveyance based on hydraulic grade line profiles for both the 10-year and 100-year rain events with the climate change factors applied throughout the full extent of the stormwater conveyance and storage system. Surface stormwater conveyance features such as stormwater inlets, curb cuts, and gutter spread shall be sized using U.S. Department of Transportation Federal Highway Administration Hydraulic Engineering Circular No. 22 (FHWA HEC-22) and future climate rainfall estimates provided above.

In addition to the requirements stipulated within this manual, property owners are responsible to comply with all applicable requirements of Article XV of Allegheny County Health Department's Plumbing Code.

2.2.c.ii. Stormwater Discharges Hierarchy

As per § 1303.01.q of Title 13, offsite stormwater discharges from conveyance infrastructure such as drainage ditches, stormwater BMP overflow piping connections, and underdrains shall adhere to the following preferred discharge connection hierarchy:

1. Surface Waters of the Commonwealth
2. Public Separate Storm Sewer System
3. Public Combined Sewer

This hierarchy is established to ensure that stormwater discharges remain separated from public sewers to prevent downstream capacity related flooding and basement backups, especially within the combined sewer system.

If the parcel boundary of the regulated activity is immediately adjacent to a surface water of the Commonwealth, ultimate stormwater discharge after the implementation of volume and rate control stormwater technologies to the Commonwealth surface water is preferred. The owner of the stormwater discharge shall adhere to all Commonwealth permitting regulations, including those under the Pennsylvania Department of Environmental Protection National Pollutant Discharge Elimination System. All stormwater discharges shall be redirected in accordance with Article XV, Plumbing and Building Drainage, of ACHD's Rules and Regulations as well as the latest version of the International Building Code.

For cases when the parcel boundary is not immediately adjacent to a surface water of the Commonwealth, stormwater discharges shall be conveyed to the nearest existing publicly owned separate storm sewer system or the combined sewer system if the parcel boundary is within 300 feet of either sewer. The requirement shall be to discharge to the separate storm sewer system if both sewer types are within the 300-foot distance. If the project site is within 300 feet of a public sewer, the applicant may need to construct off-site conveyance sewers and associated sewer appurtenances to connect to the existing sewer and all costs shall be at the applicant's expense. In instances where technical infeasibility issues (e.g. steep slopes) prevent the construction of new sewers, a waiver may be granted by the reviewer on a case-by-case basis.

Asset ownership and legal easements shall be negotiated on a case-by-case basis between the applicant and the adjacent landowner. All sewer tap-ins and connections to existing public separate storm or combined sewers shall be in accordance with procedures set forth within the PWSA Developer's Manual.

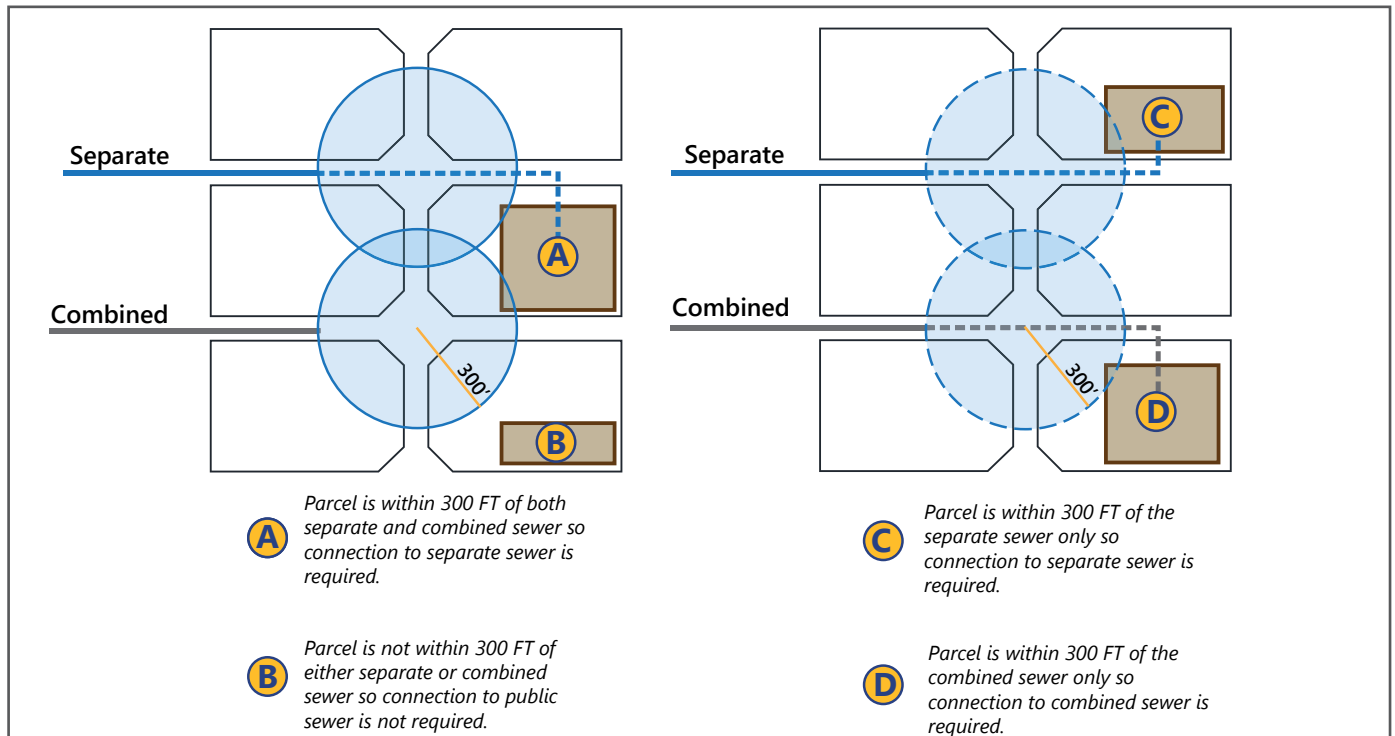


Figure 2.6. Sewer Connection Preference

2.2.c.iii. Surface Right-of-Way Discharges

As per §1303.01.r of Title 13, surface stormwater discharges from a private parcel to the public right-of-way are prohibited due to inadequate existing drainage capacity in many portions of the city's public right-of-way road infrastructure. In the event that surface stormwater discharges to the right-of-way are unavoidable, a Right-of-Way Discharge Alternatives Analysis must be submitted to the city demonstrating that the connection options in Section 2.2.c.iv are not feasible. The Right-of-Way Discharge Alternatives Analysis must demonstrate via engineering analysis that the preferred connection options in Section 2.2.c.ii technically cannot be achieved due to physical barriers or specific site constraints such as steep topography preventing the construction of new storm sewer connections or no public storm sewers is available within 300 feet. The Right-of-Way Discharge Alternatives Analysis shall be stamped by a registered professional engineer in the Commonwealth of Pennsylvania. Undue financial cost burden shall not be a valid reason for right-of-way stormwater discharge as part of the alternatives analysis.

Upon city review and agreement from the SWM site plan reviewer and Department of Mobility and Infrastructure (DOMI) staff that the Right-of-Way Discharge Alternatives Analysis successfully demonstrates that stormwater discharges to right-of-way are unavoidable, a No-Harm Downstream Hydraulic Analysis is required to ensure that sufficient conveyance capacity exists within the right-of-way to convey the proposed stormwater discharge without risk to public safety. The No-Harm Downstream Hydraulic Analysis shall consist of the following general approach:



Image of Typical Lack of Stormwater Capacity Issues in Right-of-Way

1. Calculate the post-construction discharge peak runoff from the regulated activity for each proposed right-of-way discharge. This is the stormwater from the private development that is being discharged to the public right-of-way. Peak runoff calculations shall reflect guidelines provided in Section 2.2.c.i, “Design Storms and Sizing.”
2. Calculate the existing right-of-way peak runoff to the receiving public downstream stormwater surface inlet or direct stream outfall for each proposed right-of-way discharge. Existing peak runoff shall be calculated based on the delineation of the full upstream drainage area including the regulated activity under pre-development conditions. Peak runoff calculations shall implement guidelines provided in Section 2.2.c.i, “Design Storms and Sizing.”
3. Perform a topographical survey of the preferential surface flow path sufficient to generate accurate cross sections and slopes of the existing surface conveyance system. The survey shall be conducted along the full extents of the flow path from the proposed private development all the way to the nearest public downstream stormwater inlet or direct stream outfall. In most cases in the city, the preferential flow path will consist of the public street curb and gutter system. The survey shall capture gutter geometry for critical flow capacity limited locations such as curbs with limited curb reveals, curbcuts for driveways, and sidewalk ramps.
4. Along the full extents of the surface conveyance system or right-of-way portions of the surface flow path, calculate the conveyance system’s capacity (for example, gutter spread calculations) for peak flows. The calculated peak flow is the sum of the peak runoff arising from regulated development peak runoff (step 1) and existing right-of-way peak runoff (step 2). Gutter spread calculations shall adhere to FHWA HEC-22 methodology. Gutter spread computations must be provided for each significant change in condition along the flow length (e.g., change in slope, cross-section, curb height, etc.) or a minimum of every 50 feet.
5. For locations where calculations exceed the existing available surface conveyance system capacity, the existing public right-of-way infrastructure shall be upgraded to fully contain peak flows in a manner consistent with FHWA HEC-22 guidelines at the applicant’s expense. All proposed public right-of-way infrastructure improvements shall be reviewed and approved by the city and must receive associated right-of-way permits. Proposed stormwater discharges to the right-of-way may also be regulated by the Department of Mobility and Infrastructure (DOMI), PWSA, and the Allegheny County Health Department. DOMI would review infrastructure construction in ROW, but would not be expected to review stormwater discharge calculations. The applicant is encouraged to review the latest versions of the DOMI’s Right-of-Way Procedures Manual, PWSA Developer’s Manual, and Article XV Allegheny County Health Department Plumbing Code. If analysis suggests upgrades to the ROW drainage system would prove too costly, construction of new sewers, also at the expense of the applicant, may be considered.

The requirements outlined in this section of the manual apply only to city jurisdiction public rights-of-way. For Pennsylvania Department of Transportation or other privately owned land, the applicant should consult directly with the appropriate parties.

2.2.c.iv. Discharges to Hillsides

Due to changes in topography, steep hillsides, and clay soil conditions, many sections of the city are prone to landslides. All stormwater management practices, as part of regulated activities, are required to consider the potential impact of nearby landslides in potentially landslide prone areas. Both the city and Allegheny County have undertaken analysis identifying landslide prone areas in the city. Maps of these areas can be found in **Appendix A: Overlay Districts and Watershed Maps, Figure A1.6 - Landslide Prone Overlay District**, as well as the following online resources:

- » City of Pittsburgh Landslide Prone Overlay, and
- » Allegheny County Landslide Portal

These data sources shall be used by the applicant as a starting point for determining where landslides and slope instabilities may be most susceptible in the city. This mapping should be considered a guide to the location of landslide prone areas.

Discharge of stormwater to steep hillsides can lead to surface erosion or slope failure and must be avoided to protect public health and safety. Under no circumstances shall stormwater from regulated activities be discharged onto any steep hillsides where an adjacent Commonwealth watercourse or publicly owned combined or storm sewer is available within the connection distance threshold established in Section 2.2.c.ii, “Stormwater Discharges Hierarchy.” Stormwater discharges are strictly prohibited to steep hillsides deemed as landslide prone in the city of Pittsburgh Landslide Prone Overlay or in the Allegheny County Landslide Portal. Additionally, applicants must perform a field delineation and slope stability analysis of landslide prone areas to identify areas not shown in the publicly available GIS layers. Stormwater discharges to any field delineated landslide prone areas are also prohibited.

In instances where stormwater discharge to steep hillsides is technically unavoidable and are not within the city of Pittsburgh Landslide Prone Overlay or the Allegheny County Landslide Portal or a field-delineated landslide prone area, stormwater discharges to steep hillsides may be permissible by the city in limited special cases if the slope of the hillside is less than 25% and a slope stability analysis is provided by a registered professional geotechnical engineer as part of the SWM site plan. In determining the slope threshold, the slope of the hillside shall be measured by determining the hillside toe and top elevations and calculating the average inclination over the elevation difference. The “toe” of a slope is defined as the point of inflection where the lower-most limit of the hillside ground elevation changes less than 10 vertical feet within a horizontal distance of 25 feet; and the “top” of a slope is defined as the point of inflection where the upper-most limit of the hillside ground elevation changes less than 10 feet vertically within a horizontal distance of 25 feet.

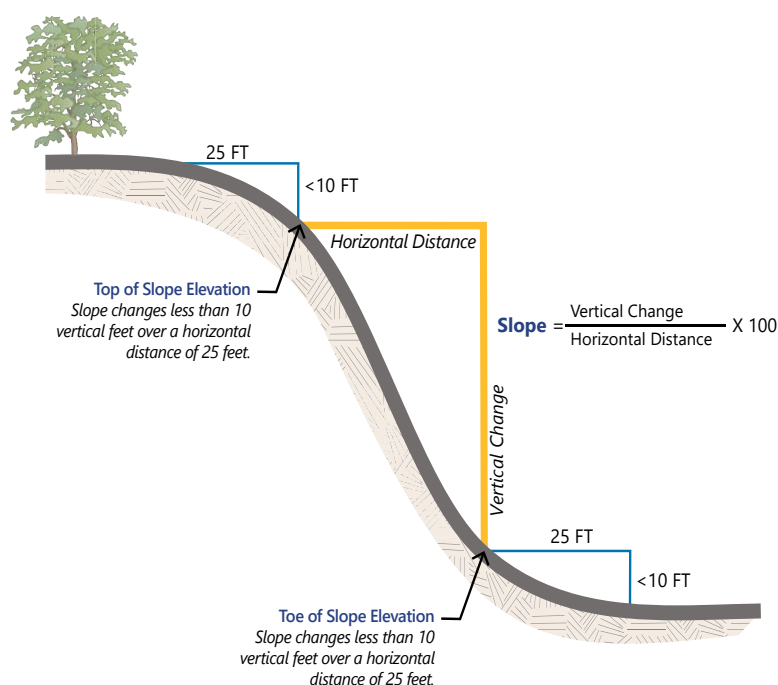


Figure 2.7. Slope Measurement for Determining Slope Thresholds for Hillsides.

Stormwater discharges to hillsides with a slopes greater than 25% can cause erosion or slope failure. The determination of slope percentage for hillsides is shown above.

In the cases where applicants are proposing a direct discharge to a steep hillside, the city may require an independent third-party review of the proposed hillside discharge by an independent geotechnical engineer at the expense of the applicant. All stormwater hillside discharges must be adequately geotechnically stable to prevent erosion and degradation to protect the integrity of the hillside from possible slope failure. All hillside stormwater discharges shall be designed in accordance with Chapter 8, “Open Channels”, of the latest version of the PennDOT’s Drainage Manual and be designed in accordance with conveyance design requirements within this manual including ultimate downstream connection to a Commonwealth watercourse or publicly owned storm or combined sewer in accordance with Section 2.2.c.ii, “Stormwater Discharges Hierarchy.”

Applicants are also prohibited from constructing infiltration facilities on landslide prone areas or where the projected subsurface lateral component of the flow path of infiltrated water intersects with a downslope landslide prone area, whether or not the landslide prone area is located on the property on which the regulated activity is taking place. For specific setback distances from hillsides refer to Section 4.2.a.ii, “Building Protection and Setbacks.”

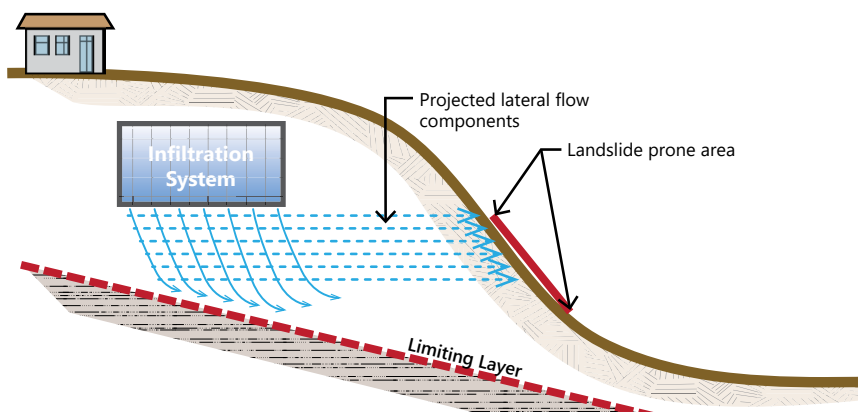


Figure 2.8. Discharges to Landslide Prone Areas.

Infiltration below infiltrating systems can have lateral flow components due to changes in potential and/or the effects of limiting layers. Designers must ensure that lateral flow components do not intersect with landslide prone areas. This may require the use of groundwater modeling to accurately describe the trajectory of infiltrated flow.

2.2.c.v. Groundwater Seeps and Springs

Due to the steep topography in many portions of the city, groundwater seeps and springs sometimes originate from hillsides and discharge onto the surface where they must be properly and safely managed. Unfortunately, the locations of groundwater flows can often be unpredictable and are dependent upon several factors including local geological conditions and seasonal variations in weather patterns, particularly annual precipitation. Typically, groundwater sources are most common in the spring season, often after a winter season with extended periods of snow melt followed by spring rainfall.

As per §1303.01.s of Title 13, all groundwater seeps and springs originating from private property shall be managed and all sources of groundwater shall be safely conveyed on the project site.

Applicants proposing regulated activities shall perform a groundwater sources investigation to identify possible sources of groundwater seeps and springs originating from the property. The investigation should be performed during late winter/early spring (February through May) when flow from groundwater seeps and springs typically are highest. If groundwater seeps and springs are discovered, the location(s) shall be noted on the SWM site plan submission drawings and included as part of the engineer's report. Flow rates shall be calculated based on engineering best practices and/or field measurements. Given that most flows from hillside seeps and springs are often relatively small (less than 10 cfs), estimating flow rates can often be accomplished by concentrating the flow within a single flow path for direct measurement. The flow rate can then be measured using simplified methods such as a manually timed bucket fill test or using a small handheld electromagnetic velocity probe meter along with associated cross-sectional measurements of the flow path. Refer to Measurement and Computation of Streamflow: Volume 1. Measurement of Stage and Discharge by the United States Geological Survey for additional stream flow measurement techniques.

The groundwater discharge shall be either:

- » Routed through the post construction volume and rate control stormwater BMPs and included as a constant baseflow for the calculation and sizing of proposed BMPs. In this instance all volume and rate modeling shall include the maximum seasonal peak groundwater flow rate in the sizing calculations, or
- » Provide a separate groundwater-only conveyance pathway (e.g., pipe or surface swale, etc.) that is independent and does not interact with the performance of post construction volume and rate control stormwater BMPs. The conveyance pathway shall be sized to accommodate the maximum seasonal peak groundwater flow rate in addition to any additional contributing runoff generated tributary to the conveyance system as determined through hydraulic modeling.



A groundwater seep originating from behind retaining wall.

The groundwater discharge from the regulated activity is required to adhere to the stormwater discharges requirements in Section 2.c.ii, “Stormwater Discharges Hierarchy,” and 2.c.iii, “Surface Right-of-Way Discharges,” within this manual. Under no circumstances shall the groundwater be discharged into the sanitary sewer system and shall adhere to all requirements within City Code §433 – Illegal Surface Stormwater Connections.

2.2.d. Riparian Buffers

A riparian buffer is a permanent vegetated area of trees and shrubs located adjacent to streams, lakes, ponds, or wetlands. Riparian buffers are vital elements for waterbodies as they create and provide protection of surface and ground water quality, water resources. Riparian buffers are essential to the mitigation and control of nonpoint source pollution into the city’s waterbodies. Riparian buffers slow overland flow to the stream through the presence of native grasses, trees and shrubs, allowing infiltration/groundwater recharge; causing deposition of sediment, nutrients, pesticides, and other pollutants in the buffer rather than in the stream; and reducing erosion by providing stream bank stabilization. The trees provide shade for streams; keeping waters cooler and reducing evaporation. Riparian buffers also provide valuable ecosystem benefits for habitat and wildlife species.

2.2.d.i. Minimum Management Requirements

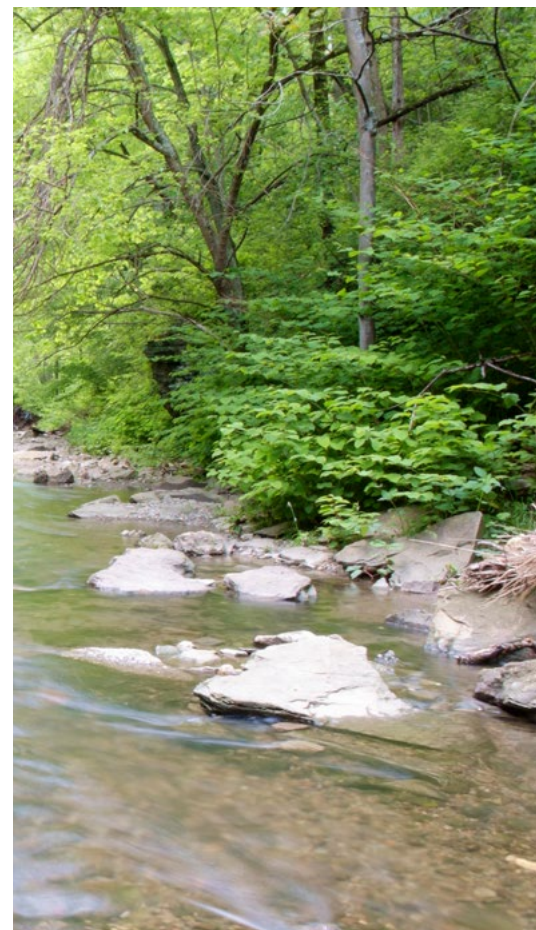
Riparian buffers are required to be protected from development for a minimum of thirty-five (35) feet from the top of the streambank on each side for all streams with a watershed area greater than ten (10) acres. For specific requirements on the minimum riparian buffer requirements for all regulated projects, refer to §1303.05 – Riparian Buffers of Title 13.

More stringent riparian buffer requirements are also required within the Riverfront (RIV) zoning district. Within RIV zoning districts, riparian buffers are required to be protected from development for a minimum of one hundred twenty-five (125) feet from the Project Pool Elevation of the river, however some exceptions to the RIV zoning district riparian buffer requirement may be permitted and/or reduced based on the proposed development activities. The Project Pool Elevation is defined in Title 9 as the hydraulic water surface elevation of the river pool and is measured as seven hundred ten (710) feet (NAVD 1988) on all three (3) rivers (Allegheny, Ohio, and Monongahela). For specific requirements on the minimum riparian buffer requirements in the RIV zoning district refer to §905.04 – RIV, Riverfront.

In addition to specific city requirements, all riparian buffer activities shall be required to meet regulations by the Commonwealth of Pennsylvania under 25 Pa. Code § 102.14. – Riparian buffer requirements.

2.2.d.ii. Easement Creation

As per §1303.05 of Title 13, applicants must create and record a riparian buffer easement for streams with a watershed area greater than ten (10) acres as part of



any subdivision or land development that encompasses a riparian buffer. This rule applies whether or not other requirements of Title 13 apply. The riparian buffer easement is enforceable by the city and applicants need to record the easement at the appropriate County Recorder of Deeds Office. The easement needs to be a perpetual easement that “runs with the land”. The easement needs to allow for continued private ownership and does count toward the minimum lot area required by zoning, unless otherwise specified in the Zoning Ordinance. Development projects with existing improvements within riparian easements should discuss project specific conditions with plan review staff. Refer to Title 9 for riparian buffer zone requirements for riverfronts.

2.2.e. Erosion and Sediment Control

Proper stormwater management and erosion and sediment controls during construction activities are required regardless of the size of the earth disturbance area. Clearing, grading, and other construction related activities expose soil surfaces, leaving them vulnerable to erosion. Soil erosion and sediment loss lead to downstream issues to public infrastructure such as blocked downstream inlets and sewers, causing localized flooding. Soil erosion also carries sediment and associated pollutants to adjacent water bodies leading to water quality degradation and negative impacts on aquatic life.

2.2.e.i. PA Code Title 25, Chapter 102 – Erosion and Sediment Control

The owner of a development site is responsible for ensuring that active construction activities are not in violation of Pennsylvania Title Code 25 Chapters 92 and/or 102 or the Clean Streams Law. All earth disturbance must comply with the erosion and sediment requirements of the PADEP as specified in 25 Pa. Code §102.4. State law requires that an Erosion and Sediment Pollution Control (E&SPC) plan be developed for any projects involving earth disturbance with an area greater than 5,000 square feet (PA Clean Streams Law, Chapter 102).

Applicants must submit E&S plans to Allegheny County Conservation District (ACCD) for review either as part of a National Pollutant Discharge Elimination System (NPDES) permit application for projects with earth disturbance equal to or greater than one acre or as a Non-NPDES plan review submission for projects with earth disturbance equal to or greater than 5,000 square feet (but less than one acre). Proof of submission/review by ACCD is required for Stormwater Management site plan approval by the city (refer to Section 5, “Stormwater Management Site Plan Review Requirements.”)

SECTION 3 – INTEGRATING STORMWATER MANAGEMENT WITH SITE DESIGN

Effectively siting stormwater management strategies within the context of site design is of critical importance for meeting the requirements within Title 13 and this manual. Prior to selecting and implementing non-structural and structural stormwater BMPs, a thorough understanding of both the broader watershed and site-specific challenges, opportunities, and characteristics is required. Section 3 of this manual is intended to provide guidance to applicants to effectively assess their development site in order to properly design stormwater BMPs that meet the site's stormwater requirements. The guidelines presented within Section 3 are not meant to be exhaustive listing all possible watershed and site-specific conditions, but are meant to serve as starting points for commonly encountered conditions specific to Pittsburgh.

3.1 CONDUCTING A SITE ASSESSMENT

Typically, the first step of any development project prior to selecting or designing stormwater BMPs is to perform an analysis of factors at the watershed and site specific scales. Section 3.2 provides guidance for evaluating common watershed scale site factors including broad categories such as whether the site is located within:

- » **A municipal separate storm sewer system (MS4) water quality impaired watershed,**
- » **A combined sewer system (CSS) Public Health and Safety sewershed, or**
- » **An environmental overlay district such as steep slope/ landslide prone areas and undermined areas.**

Inclusion or exclusion within these categories may point to specific design strategies while pointing away from others. Section 3.3 provides guidance for assessing on-site factors and conducting an inventory of potential challenges that may impact the construction of stormwater BMPs in meeting the requirements within Title 13, while section 3.4 details specific requirements for performing on-site soil assessments and

infiltration testing. Once potential locations of stormwater BMPs are chosen, applicants are required to perform soil testing to ensure the feasibility of the designed performance of the proposed stormwater BMPs.

Sections 3.2, 3.3, and 3.4 of this manual provide guidance for informing the appropriate selection of stormwater BMPs to meet the requirements in Title 13. Section 3.5 discusses the process of conducting site factors analysis and presents commonly used approaches for evaluating opportunities and constraints as part of the development of the SWM site plan.

3.2 WATERSHED FACTORS

As a first step in the assessment process, the applicant is required to evaluate watershed factors within and adjacent to the proposed site development. These factors include watershed type (MS4 vs. CSS) as well as whether the project site resides within one or more environmental overlay districts. The overlay districts provide a starting point for the assessment and are not meant to provide a full account of all possible environmental factors that may influence the proper selection and design of stormwater BMPs. Furthermore, due to data limitations, overlay districts may not indicate the complete spatial extents of watershed factors. Table 3.1 provides a summary of watershed type factors and associated reference information, while Table 3.2 provides a summary of environmental overlay district watershed factor reference information.

TABLE 3.1. SUMMARY OF WATERSHED TYPE FACTORS

Watershed Type	Purpose	Mapping Reference
MS4	For determining filtration requirements	Appendix A: Overlay Districts and Watershed Maps; <i>Pittsburgh CSS and MS4 Sewersheds</i>
CSS	For determining Public Health and Safety Release Rate Requirements, if necessary	Appendix A: Overlay Districts and Watershed Maps; <i>Pittsburgh CSS and MS4 Sewersheds</i>
Act 167	For determining Act 167 Release	Appendix A: Overlay Districts and

TABLE 3.2. SUMMARY OF ENVIRONMENTAL OVERLAY DISTRICT WATERSHED FACTORS

Overlay District	Purpose	Mapping Reference
Special Zoning Districts	Indicates location of the Riverfront Zoning District and Uptown Public Realm District	Appendix A: Overlay Districts and Watershed Maps, <i>Special Zoning Districts</i>
Landslide Prone and Steep Slopes Districts	Indicates areas with known landslide potential and steep slopes	Appendix A: Overlay Districts and Watershed Maps, <i>Landslide Prone Overlay District</i>
Undermined Area District	Indicates known undermined areas	Appendix A: Overlay Districts and Watershed Maps, <i>Undermined Area Overlay District</i>
Allegheny County Landslide Portal	Web application that allows user to explore Allegheny County landslide data	https://landslide-portal-alcogis.opendata.arcgis.com/

3.3 SITE SCALE FACTORS

In addition to watershed factors, the applicant must assess site scale factors as part of the development of the SWM site plan. Site scale factors include non-physical features such as property/land use boundaries and physical features such as existing utilities, topography, and soil types that may inform the site layout and placement of stormwater BMPs. Understanding and inventorying these factors helps the designer optimize BMP placement and selection that meet the regulations, are cost effective, and provide co-benefits such as greening and active and passive recreation. For instance, minimizing mass grading and protecting existing natural features can create a more aesthetically pleasing development, while helping to manage stormwater through strategies like disconnection, which can be less expensive than structural BMPs. A thorough inventory also helps reduce risks to public health and safety as well as damage to public and private property during construction.



Four Mile Run Conceptual Design

Table 3.3 provides of list of site scale factors that are required to be inventoried as part of the SWM site plan as well as references and methods obtaining the data.

TABLE 3.3. SITE SCALE INVENTORY FACTORS			
Site Factors	Inventory Examples	Usage	Reference
Non-Physical Features	<ul style="list-style-type: none"> • Property Boundary • Land Use • Zoning • Drainage Easements • Access Easements • Extent of the upstream area draining through the development site 	Identify available area for development and BMPs.	City/County/State GIS data (WPRDC and PASDA), deeds, County records
Special Value Areas	Location and drainage conditions of: <ul style="list-style-type: none"> • Woodlands • Wetlands • Floodplains and flood ways • Rivers, streams, ponds, and other waterbodies, indicating impairment status, if any • Riparian areas and easements • State-designated special protection waters • Trees (DBH 6") 	Identify special value areas that shall be conserved and protected during development.	Topographic survey, aerial photography, local and regional natural resources inventories, Pennsylvania Natural Diversity Inventory (PNDI) surveys, City/County/State GIS (WPRDC and PASDA)
Structures and Paved Areas	<ul style="list-style-type: none"> • Buildings • Parking Lots • Driveways • Retaining walls 	Identify areas that produce runoff and can be managed by BMPs.	Topographic survey, aerial photography
Stormwater Infrastructure	<ul style="list-style-type: none"> • Pipes • Inlets • Manholes • Outfalls 	Identify locations from which to convey stormwater to BMPs or overflow from BMPs.	Topographic survey, utility records
Utilities (gas, electric, sewer, water, etc.)	<ul style="list-style-type: none"> • Service laterals • Mains • Valve boxes • Lot disposal systems • Wells • Overhead and underground electrical • Light poles • Transformers 	Identify vertical and horizontal constraints for development and BMPs.	Topographic survey, utility records, utility locator services (PA One Call, private contractors)
Slopes	<ul style="list-style-type: none"> • Location of slopes $\geq 8\%$ • Location of slopes $\geq 25\%$ 	Identify areas susceptible to erosion and high runoff velocities.	Topographic survey, GIS topographic data
Soils and Geology	<ul style="list-style-type: none"> • Permeability • Hydrologic soil group(s) • Depth to high seasonal high groundwater table • Depth to bedrock 	Determine siting constraints.	United States Department of Agriculture (USDA) Soil Surveys; historic streams maps (fill); hydrologic soil maps; geotechnical reports; existing soil investigation or infiltration reports; historical aerial photography; local or regional groundwater studies or well data; local/ state records; City/County/State GIS (WPRDC and PASDA)
	<ul style="list-style-type: none"> • Undermined areas • Landslide prone areas 	Determine infiltration feasibility.	
	<ul style="list-style-type: none"> • Locations of potential contamination and/or historic fill 	Determine if any environmental hazards are present and if further investigation will be required.	

3.4 SOIL ASSESSMENT AND INFILTRATION TESTING

As per §1304.03.c of Title 13, infiltration testing and a geotechnical investigation report in accordance with this manual are required as part of the SWM site plan. Infiltration testing and the geotechnical investigation report are required as part of all SWM site plan submissions to ensure infiltration BMPs are implemented to the maximum extent practicable in meeting the volume control requirements set forth in Title 13. Infiltration testing and the geotechnical investigation report also provide critical information for assessing the most appropriate stormwater BMPs given the in situ soil conditions. For example, sites with low infiltration rates may be suitable for BMPs that retain water, such as constructed wetlands or ponds, while sites with higher infiltration rates are more suited for infiltration BMPs.

The infiltration testing requirements may be waived by the designated site plan reviewer if the development site or project site is fully within a location where infiltration is prohibited and an infiltration waiver form is provided in accordance with **Appendix B: Infiltration Testing and Geotechnical Requirements and Infiltration Waiver Form**. Infiltration is prohibited in the following locations:

- » Areas with Landslide Prone Overlay District or landslide prone areas identified on the Allegheny County Landslide Portal.
- » BMP placements with steep slopes greater than 15% or within 100 feet of steep slopes greater than 25% or within 200 feet of steep slopes greater than 50%. Refer to Section 4.2.a.ii, “Building Protection and Setbacks” for more information about setback requirements for BMPs.
- » Areas located 200 feet upgradient from a documented historic landslide. The applicant shall consult with the city for locations of known landslides in relation to the development site.
- » Areas within the Undermined Area Overlay District.

While not required, applicants may choose to collect and provide additional site-specific data and make a technical argument for infiltration in these areas as part of their applications. Infiltration testing and geotechnical assessment must be prepared per the requirements provided in **Appendix B: Infiltration Testing and Geotechnical Requirements and Infiltration Waiver Form**. The results of the infiltration testing and geotechnical assessment are used by the designer to inform stormwater BMP selection and as an input to design calculations and modeling as described in Section 2 of this manual. If results of the infiltration testing and geotechnical assessment determine that infiltration is infeasible, applicants are required to submit an Infiltration Waiver Form as part of the SWM site plan submission.

3.5 SITE FACTORS ANALYSIS

Once the watershed and site scale site factors inventory has been completed, the designer uses this information to conduct a site factors analysis. The site factors analysis is used to identify areas that preclude the use of certain types of

stormwater BMPs as well locations that could provide particular opportunities for stormwater management. The site factors analysis plays an integral role in understanding what types of stormwater BMP technologies are most applicable and/or required given the unique site factors that are present. For instance, BMPs within MS4 areas must provide filtration, which may necessitate the need for BMPs with surface vegetation, filtration media, and/or increased infiltration where possible (see Section 3.7.b.i, “Preferred BMPs” for additional information about preferred BMP technologies). The site factors analysis also helps determine optimal location for stormwater management practices given the characteristics of the site as well as the anticipated uses, programming, and site layout.

The selection and application of BMP design strategies (see also Section 3.7, “Stormwater Management Design Strategies”) is highly dependent upon specific site constraints encountered. Applicability/feasibility of BMPs in a given location is determined using a three-tiered system:

- » BMP technology is applicable/feasible
- » BMP technology is applicable/feasible with modifications to the design (some constraints but does not prevent BMP implementation in all cases, subject to review)
- » BMP technology is not applicable/feasible (constraints prevent BMP implementation in all cases)

Site specific constraints commonly encountered in the city include, but are not limited to, the following:

- » Steep slopes and landslide prone areas
- » Undermined areas
- » Unsuitable soil conditions such as low infiltration rates, soil contamination, and urban fill
- » Limiting layers such groundwater and bedrock
- » Environmentally sensitive resources such as mature trees, riparian buffers and wetlands
- » Building, utility, and structure setbacks

Table 3.4 provides an overview of these constraint conditions and the impact of each on the applicability and feasibility of various BMPs. Additional information on specific thresholds and procedures for demonstrating technical infeasibility are provided in Section 3.6. Further, designers are referred to the general and BMP-specific design requirements in Section 4, which also need to be considered when siting BMPs and determining infeasibility/feasibility. Table 3.5 provides an overview of commonly used modification strategies for addressing feasibility issues for BMPs indicated as requiring design modifications within Table 3.4. Specific setback thresholds and guidelines for protection of existing utilities and structures are provided in Section 4.2.a.ii, “Building Protection and Setbacks”.

TABLE 3.4. BMP APPLICABILITY FACTORS FOR TYPICALLY ENCOUNTERED UNDERLYING CONDITIONS SITE CONSTRAINTS

Category	Bioretention	Bioinfiltration	Green Roof	Dry Extended Basins	Constructed Wetland/ Wet Pond	Porous Pavement	Cisterns	Subsurface Infiltration	Sand Filter	Subsurface Detention
Elevated sediment loading	○	○	○	○	○	○	○	○	○	○
Excessive sediment loading	✗	✗	✗	○	○	✗	○	✗	✗	○
Slope (0-8%)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Slope (8-15%)	○	○	✓	○	○	○	✓	○	○	○
Slope (> 15%)	✗	✗	✓	✗	✗	✗	✓	✗	✗	✗
Slope (> 25%)	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Landslide prone	✗	✗	✓	✗	✗	✗	✗	✗	✗	✗
Low infiltration	✓	✗	n/a	✓	✓	○	✓	✗	✓	✓
Undermined areas	○	✗	n/a	○	✗	○	✓	✗	✓	○
Environmental contamination areas	○	✗	n/a	○	✗	○	○	✗	○	○
Unconsolidated Urban Fill < 3 Ft.	○	○	n/a	○	○	○	○	○	○	○
Unconsolidated Urban Fill > 3 Ft.	✗	✗	n/a	✗	✗	✗	✗	✗	✗	✗
Floodway	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Floodplain	○	○	✓	○	○	✗	○	○	○	○
Wetlands	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Within 2 ft. of seasonal high groundwater	○	✗	n/a	✗	✓	✗	✓	✗	✓	✗
Riparian buffers	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Within 2 ft. of bedrock	○	✗	n/a	○	○	○	✓	✗	✓	○
Mature tree or high value mature tree removal or critical root zone disturbance	○	○	n/a	○	○	○	○	✗	○	✗
Exceptional value mature tree removal or critical root zone disturbance	✗	✗	n/a	✗	✗	✗	✗	✗	✗	✗
Utilities within setback thresholds	✗	✗	n/a	✗	✗	✗	✗	✗	✗	✗
Buildings and structures within setback thresholds	✗	✗	n/a	✗	✗	✗	✗	✗	✗	✗
Roof slope > 8%	n/a	○	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
✓	BMP Applicable/Feasible									
○	BMP Potentially Applicable/Feasible With Modifications									
✗	BMP Not Applicable/Infeasible									

TABLE 3.5. SUGGESTED BMP MODIFICATIONS TO ADDRESS SITE CONSTRAINTS

Condition	Suggested BMP Modifications
Elevated or excessive sediment loading	<ul style="list-style-type: none"> • Additional/expanded pretreatment • Reduced hydraulic loading ratio • Pollutant loading source control
Slopes	<ul style="list-style-type: none"> • Check dams and weirs • Energy dissipaters, larger stone/rip-rap to prevent erosion • Stepped pool systems • Adjust system location
Low infiltration (<0.2 in/hr)	<ul style="list-style-type: none"> • Impermeable liner below systems • Slow release underdrain • Stone columns to more permeable sublayer • Add porous media to improve infiltration rates • Adjust system depth or location away from low infiltration zones
Undermined areas	<ul style="list-style-type: none"> • Impermeable liner below systems • Slow release underdrain
Environmental contamination areas	<ul style="list-style-type: none"> • Remediation/removal of contaminated material • Impermeable liner below systems • Slow release underdrain
Uncompacted or urban fill	<ul style="list-style-type: none"> • Excavation and offsite removal of fill and replacement with structural or select fill
Floodplain	<ul style="list-style-type: none"> • Flood protection berms around systems • Elevated systems • Backflow preventers
Groundwater	<ul style="list-style-type: none"> • Shallower systems
Bedrock	<ul style="list-style-type: none"> • Shallower systems • Bedrock removal depending on type of bedrock encountered
Roof slope	<ul style="list-style-type: none"> • Structural reinforcement for vegetation

Site Factor Narrative Description

The following site factors narrative descriptions provide a high level summary along with design considerations for each of the encountered applicability factors listed above. The narratives are by no means a fully exhaustive description of the multitude of potential site conditions within the city and are intended to be used for general design guidance purposes in discussions between designers and the SWM site plan reviewer. It is highly encouraged that the applicant identifies each of these conditions, when encountered, and alerts the designated SWM site plan reviewer as part of the conceptual SWM site plan review stage, see Section 5, “Stormwater Management Site Plan Review Requirements” for more information.

Excessive Sediment Loading

Excessive sediment loading can pose serious risks to structural BMP performance, mainly due to smothering of vegetation and clogging of filter media and infiltration surfaces. These conditions can lead to clogging, an overall reduction in volume and rate control performance, increased maintenance, and reduced service life. In many cases, excessive sediment loading can be mitigated through proper management of potential sediment sources in the contributing watershed, decreasing the loading ratio (discussed in Section 4.2.a.iv, “Loading Ratios”) as



If not well maintained, porous pavement practices like the above the permeable paver parking lot are susceptible to clogging from excessive loading from upstream sediment producing activities.

well as intensifying pretreatment strategies. Pretreatment is discussed later in this manual in Section 4.3, “Pretreatment Technologies”. Watershed sources of sediment include accumulated dust and debris from roadways and other paved surfaces; sediment from eroding and/or poorly vegetated areas, particularly on slopes; and sediment produced during construction activities occurring within the contributing drainage area. Mitigation of watershed sources can include activities such as implementing proper erosion and sediment control practices during construction projects, street sweeping, and aggressive revegetation of poorly vegetated areas.

While most sediment sources can be controlled initially, designers should also consider the resources in place to control sediment sources in the long term. For instance, are dedicated resources available to conduct street sweeping or maintenance of pretreatment devices? Does the watershed contain steeply sloping terrain that is intrinsically prone to erosion? Are there numerous trees overhanging paved areas that will contribute large quantities of pollen, seeds, and/or leaves that could overwhelm pretreatment capacity? Furthermore, designers should consider whether there are proposed uses within the contributing drainage areas that are inherently prone to high rates of sediment loading. These would include paved surfaces associated with industrial operations, warehousing, and material storage operations. In these situations, some BMPs may not be appropriate, even with aggressive pretreatment.

In terms of structural BMP selection, subsurface BMPs that use gravel storage and porous pavement tend to be the most impacted by excessive sediment loading. Buried gravel storage can clog at relatively low levels of accumulation, as sediment builds up in the gravel layers immediately surrounding distribution piping. Porous pavements receiving sediment laden runoff can also quickly clog, although performance can usually be maintained with frequent cleaning. Surface practices that rely heavily on vegetation such as bioinfiltration and bioretention can also be more susceptible to high rates of sediment loading.

In cases where proposed uses/conditions associated with significant sediment loading exist (e.g., industrial use, heavy truck loading, steep slopes, etc.), designers are required to compute the expected sediment loading event mean concentrations (as total suspended solids [TSS]) using data from the International BMP Database or other agreed upon methodology and determine the sediment loading category in Table 3.6. Media filtration, subsurface gravel storage, pervious pavement, green roofs, and bioretention/bioinfiltration are considered infeasible if predicted Event Mean TSS concentrations fall into the excessive sediment loading category. In the case of elevated sediment loading, designers can in most situations look to design modifications, including enhanced pretreatment and lower loading ratios, or more frequent maintenance, to mitigate elevated sediment loads.

TABLE 3.6. SEDIMENT LOADING CATEGORIES

Event Mean Concentration (TSS)	Sediment Loading Category
<75 mg/l	Low sediment loading
75-150 mg/l	Average sediment loading
150-300 mg/l	Elevated sediment loading
>300 mg/l	Excessive sediment loading

Steep Slopes

Steep slopes are commonplace in Pittsburgh and present several challenges for structural BMP performance, ranging from the potential for high velocities for inflows and outflows, extensive regrading needed to create surface storage, and the potential for infiltrated stormwater to create slope failure. Slopes are typically characterized as a percentage, with natural lands having a 25% slope or more recognized as steep slopes within the Pittsburgh zoning code (see Section 906.08). However, slopes significantly lower than 25% can pose performance challenges for many structural BMP types.

Within the context of structural BMP design, designers must analyze both existing and proposed slopes to determine structural BMP feasibility. Proposed slope percentages must be characterized for the entire project site and categorized per Table 3.7 for a distance of 1x the BMP length upstream and downstream of the structural BMP. Slopes should be quantified such that steeper slopes that run for more than 10 feet horizontally or 5 feet vertically are not averaged.

TABLE 3.7. SLOPE CATEGORIES

Existing/ Proposed Slope	Slope Category
0-8%	Mild
8-15%	Medium
15-25%	High
>25%	Steep



Center and Herron Stormwater Facility. Stormwater BMPs arrayed on a hill slope.

Structural BMPs perform most reliably when placed on flatter grades ranging from 0-8%. In the upper range of this category, BMPs require stepped storage cells with check dams to accommodate changes in grade (see Section 4.2.a.v, “General Design Guideline Storage”). Entrance and exit velocities may also become elevated, creating the need for more robust energy dissipaters. Most structural BMPs can also be designed to work within slopes in the medium category, which ranges from 8 to 15%. Porous pavement is considered to be infeasible above 8% due to the potential for high surface velocities that promote bypass.

In the 8-15% slope range, the use of larger inflow pipes, or hydraulic structures such as wellholes are sometimes needed to further moderate inflow and outflow velocities. Energy dissipaters with large riprap or concrete lining are often required to provide adequate velocity protection at inflow points. At the upper range of this category, both surface and subsurface BMPs require frequent check dams and stepped storage cells to accommodate the change in grade. Surface BMPs become increasingly problematic for slopes approaching 15%, and often require either the introduction of retaining structures or large areas of disturbance needed to achieve side slopes than can be readily vegetated. For these reasons, designers are discouraged from siting structural BMPs on slopes above 8% wherever possible.

Designers are strongly discouraged from siting structural BMPs in areas where the slope is above 15% due to an accumulation of issues that compromise performance, result in unnecessarily high levels of earth disturbance, and can lead to public safety hazards due to the potential for slope failure. At this slope range, subsurface and surface BMPs are considered infeasible, and rooftop or in-building management of stormwater are considered the only feasible BMP options.

As slopes approach 25%, designers are strongly urged to avoid earth disturbance altogether, as these areas are highly sensitive, difficult to restore and stabilize, and prone to slope failure. All structural BMPs are considered to be infeasible at slopes in excess of 25%. Additionally, as stipulated in Section 3.4, “Soil Assessment and Infiltration Testing” and Section 4.2.a.ii, “Building Protection and Setbacks”, infiltration BMPs are considered infeasible on slopes greater than 15% or within upgradient buffer areas around greater 25% slopes.

Landslide Prone Areas

Landslide prone areas are, like steep slopes, common within the city of Pittsburgh. Landslide prone areas often co-occur with steep slopes, but also include additional areas that are prone to mass failure due to geotechnical conditions. Developments within areas of the city located with a Landslide-Prone Overlay District are subject to subsurface investigations and additional review as stipulated in Section 906.04 of the city zoning code. In addition to these requirements, the siting of structural BMPs other than green roofs within landslide prone areas is considered infeasible. Structural BMPs that require discharge to or the construction of conveyance piping/channels within landslide

prone areas are also considered to be infeasible. Landslide prone areas include areas in the Landslide-Prone Overlay District as well as areas defined as landslide prone within the Allegheny Landslide Portal. Lands not formally mapped as landslide prone may be prone to landslides due to site specific conditions that may not be mapped formally. If such conditions are suspected, a certification from a geotechnical engineer that the area is landslide prone is required as part of the technical feasibility report.

Undermined Areas

Undermined areas are common within Pittsburgh due to the legacy of coal mining operations. Developments within areas of the city located within an Undermined Area Overlay District are subject to development restrictions, subsurface investigations, and reporting requirements stipulated in Section 906.05 of the city zoning code. Undermined areas are prone to subsidence and settlement and are suboptimal locations for structural BMPs. The city considers infiltrating BMPs infeasible within undermined areas, as are systems that require connection with groundwater such as wet ponds and constructed wetlands. The use of retention-based systems such as bioretention systems can be used on a case-by-case basis with the use of an impermeable liner. The use of cisterns or green roofs are considered feasible in undermined areas, subject to the requirements of Section 906.05.

Low Infiltration

Applicants must demonstrate that infiltration is infeasible as part of the technical infeasibility process for meeting the volume removal requirement. The most common reason for infiltration infeasibility is low infiltration. Infiltration-based BMPs are considered infeasible within areas with tested infiltration rates below 0.2 in/hr as detailed in Section 3.4, “Soil Assessment and Infiltration Testing” and **Appendix B: Infiltration Testing and Geotechnical Requirements and Infiltration Waiver Form**. Designers are encouraged to conduct exploratory investigations to identify areas within the project site that are conducive to infiltration and to site infiltration-based BMPs within these areas. If areas are shown to have low infiltration rates, designers are required to evaluate whether infiltration-based BMPs could be implemented within other areas of the site. This may require the evaluation of alternative site layouts or building configurations. Also, designers must evaluate whether a change in the project design could accommodate infiltration BMPs at an alternative elevation. The city requires that designers review preliminary boring results to identify strata with potentially feasible infiltration rates before concluding that infiltration is infeasible and to demonstrate that infiltration-based BMPs could not be sited in these areas.

Additionally, if strata with feasible infiltration rates are located at lower depths, designers can use stone columns or other vertical conveyance methods to convey water from a BMP located at a higher elevation to underlying areas. Further, designers may mix sand or other porous media into the existing subgrade to achieve a feasible infiltration rate.



Maps of Mines in Allegheny County.

WPA of PA, 1934-1938

Image credit: Penn State University

High Infiltration

Soils with high infiltration rates pose performance challenges for infiltrating practices. High infiltration rates are defined in this manual as having a tested infiltration rate of 10 inches per hour (without a design factor of safety applied). In Pittsburgh, these conditions are commonly associated with unconsolidated urban fill. In such cases, infiltrating stormwater can cause ground subsidence and sinkholes and is therefore considered infeasible. This condition is further addressed below in the unconsolidated urban fill section.

Insufficient Water Reuse

Water reuse is an often-overlooked strategy for meeting the city's volume requirement. As part of the feasibility determination process for meeting the volume removal requirement, applicants must demonstrate that water reuse is infeasible. Potential opportunities for water reuse include non-potable uses such as landscape irrigation, toilet flushing, urban gardening, and wash-down. Water intensive uses such as industrial processes, car washes, and laundry facilities can benefit from water reuse, particularly for process uses that do not require extensive treatment. Stormwater can also be collected and used as make up water for chillers, cooling towers, and steam boilers. Stormwater reuse for potable water needs requires additional treatment but is also feasible in many cases.

Coordinating with building architects and mechanical, electrical, and plumbing engineers to identify water use opportunities early in the design process is critical, as many reuse applications require additional interior controls and plumbing systems. Most storage BMPs can be outfitted to use stored water for reuse purposes, although the most common configurations use cisterns or subsurface chambers. When considering reuse options to meet the volume control requirement, it is important to identify uses that occur throughout the year and that can consistently and predictably use collected water such that storage volume used for volume capture is available for subsequent storm events. Smart controls can help to optimize storage and reuse processes.

Environmental Contamination

Environmental contamination of soil and groundwater is a common issue within Pittsburgh due to historical industrial activity, mining, leaking underground storage tanks, as well as present-day sources of contamination such as gas line leaks and spills. Contaminants may include volatile and semi-volatile organic compounds; heavy metals such as lead, copper, and zinc; pesticides; insecticides; and other compounds. The severity, extent, and specific nature of contamination can vary widely from site to site.

Soil contamination precludes the use of infiltration-based BMPs at a given location unless the contaminated material can be fully removed from that location. Infiltration through contaminated soils can lead to leaching, mobilization, and transport of contaminants into groundwater or downstream surface waters. The extent to which contamination precludes the use of infiltrating practices on an entire project site, however, will depend on the characteristics of the contamination

and the project site itself. For instance, if environmental contamination is documented within a small portion of a large development site, this would not necessarily render infiltration infeasible on the entire site. Applicants would need to conduct testing to determine the extent of contamination throughout the site before demonstrating infiltration infeasibility for the entire site. Contamination may be evaluated per PADEP guidelines, including, but not limited to, comparing testing results to PADEP 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.

Environmental contamination does not typically preclude the use of non-infiltrating BMPs such as subsurface detention and bioretention provided the systems are lined, excavated contaminated material is properly disposed, and BMP installation is performed in accordance with a PADEP Act 2 remediation plan, if applicable, or associated deed restrictions.

Uncompacted Urban Fill

The presence of uncompacted and urban fill is typical of older U.S. cities, and Pittsburgh is no exception. The prevalence of these materials may be higher along former streams, where stream valleys were commonly filled with bricks, fly ash, cinders, and other available materials to flatten grades for development. These areas may have low or highly variable soil bearing capacity and/or high or highly variable infiltration rates. These conditions can lead to differential settlement and sinkholes, particularly if receiving infiltrated stormwater. As a result, the presence of uncompacted urban fill is a significant feasibility issue. The presence of fill alone does not preclude a site from installing infiltrating BMPs. For project sites that anticipate the presence of unstable fill, applicants should work with a geotechnical professional to create a plan of action to identify if unstable fill exists, whether the fill is suitable for infiltration, and, if so, proposed measures to ensure stable subgrade for proposed BMPs. Designers should obtain and review soil boring data to identify and map potential areas of fill. While the installation of most structural BMPs can be accommodated by removing thin pockets of uncompacted urban fill and replacing the material with suitable subgrade material, the placement of structural BMPs over contiguous deposits of unconsolidated fill greater than 3 ft. is considered infeasible (i.e., removal of these deposits is not allowable).



Cut off posts and other debris buried underneath a city sidewalk

Floodplain/floodways

Although many of Pittsburgh's historic streams have been buried, there are still a number of streams with mapped FEMA floodplains and floodways. Other water courses may not have FEMA-mapped flood zones but are nevertheless subject to flooding onto adjacent floodplain surfaces or may have floodplains regulated by PADEP. Placement of BMPs within the limits of mapped FEMA 100-year floodplains (or approximate floodplain areas for those areas without a detailed FEMA flood insurance study) is allowable on a case-by-case basis with



9 Mile Run. Archival image of 9 Mile Run as it was straightened and culverted.

image credit: <https://www.alleghenyfront.org/artist-wants-to-give-people-a-new-view-of-an-urban-stream/#jp-carousel-10497>

design modifications, while the placement of structural BMPs within mapped FEMA floodways (or approximate floodway areas for streams without a defined FEMA flood insurance study) is considered infeasible. Floodways adjacent to unmapped streams can be estimated as a 50 ft. offset on either side of the stream or as otherwise defined by PADEP. Although not recommended, BMPs within the 100-year floodplain (but not within the floodway) can be feasibly implemented in some cases, particularly in large river floodplains for which peak flood elevations are likely to occur long after peak flows associated with local drainage areas. In floodplains surrounding smaller streams, particularly those draining high urbanized areas, flood peaks may be more closely aligned with stormwater runoff peak flows, increasing the potential for frequent inundation of stormwater storage areas with riverine floodwaters. In these cases, designers may be asked to conduct an inundation analysis to demonstrate that riverine flood flows will not inundate the proposed BMP for the full range of storms for which the BMP is designed. In cases where inundation is found to occur, BMPs may be modified using berms or backflow preventers to prevent riverine flows from entering the facility.

Designers should be aware that activities within floodplain areas, including floodways, are subject to PADEP, FEMA, and local floodplain consistency requirements. Guidance regarding compliance with these requirements is outside the scope of this manual.



Iris versicolor blooming in a wetland.

Wetlands

Wetlands are high value resources critical to the maintenance of aquatic ecosystems. The placement of stormwater BMPs within jurisdictional wetlands is considered infeasible under city regulations, even if authorized by PADEP or USACE. Wetland areas must be delineated by a qualified professional experienced in wetland delineation and must be conducted using current accepted USACE guidance and protocols. BMPs and all associated conveyance infrastructure must be located outside of jurisdictional wetlands.

Designers are also advised that the introduction of stormwater into a jurisdictional wetland may be prohibited by PADEP and/or USACE. This would include constructed wetlands or other BMPs that abut or connect to an existing wetland. In these cases, applicants should coordinate directly with PADEP and USACE to determine regulatory compliance and design requirements.

Groundwater

The groundwater table is considered a limiting layer that creates significant feasibility issues for a number of structural BMP types. Groundwater levels may vary considerably across a site, seasonally, and from year to year. Accordingly, soil indicators of seasonal high groundwater table such as soil color are commonly used to indicate the highest elevation to which groundwater influence extends. Infiltration BMPs as well as most surface and subsurface retention/detention BMPs (except for constructed wetlands and wet ponds) must show at least 2 ft. of separation (measured from the bottom of the basin, or underdrain, if present) from the seasonal high groundwater level table, as documented within soil logs or groundwater monitoring data. If groundwater monitoring data is used in lieu of soil indicators, at least 1 year of data is required.

In contrast with most structural BMPs, constructed wetlands and wet ponds must be excavated below seasonal high groundwater to maintain wetland/pond hydrology. Designers of pond and wetland systems must demonstrate via water budget modeling using a water budget model such as WetBud and groundwater level monitoring that sufficient hydrologic inputs (a combination of surface and subsurface flow) exist to maintain wetland/pond conditions, even within drier years. High groundwater can also limit effective storage within constructed wetlands and wet ponds. For these BMPs, effective storage is considered to begin 1 foot above the permanent pool elevation or seasonal high-groundwater level.

Riparian Buffers

Riparian buffers are special protection areas regulated under Section 1303.05 of the city code, as well as within Title 25, Chapter 102 of the PA Code. These regulations restrict several activities within riparian buffers, but also define riparian buffers differently. PADEP regulations restrict all earth disturbance within 150 feet for projects requiring a permit under Chapter 102 and that are located in high-quality or exceptional value watersheds, while city-defined riparian buffers extend for 35 feet along all streams and watercourses that exceed 10 square miles of drainage area. The placement of structural BMPs within

riparian buffers as defined in Title 13 is considered infeasible. However, the placement of stormwater drainage pipes is allowed within city-defined riparian buffers. Placement of structural BMPs within riparian buffers regulated by PADEP is not specifically considered infeasible but would be subject to PADEP requirements and approvals. Discussion of these requirements and approvals is beyond the scope of this manual.

Riparian areas often, although not always, co-occur with regulated floodplains. Accordingly, designers should be aware that some riparian buffer areas may also be subject to floodplain regulations.

Mature Trees

Mature trees provide a multitude of aesthetic and environmental benefits, including carbon capture, habitat, and urban heat island mitigation. Accordingly, designers should avoid the removal of mature trees or earth disturbance within the critical root zone of a mature tree when siting structural BMPs wherever possible. Depending on the size and value of the tree, siting structural BMPs within the critical root zone of a mature tree may be considered infeasible. The critical root zone is defined as a zone with a diameter equal to 12 times the diameter-at-breast height of the tree. Mature trees are defined as trees in good condition as determined by a certified arborist or a landscape architect, with a diameter-at-breast height of more than 18 inches. Specific categories of mature trees are provided in Table

TABLE 3.8. MATURE TREE CLASSIFICATIONS

Mature Tree DBH (inches)	Tree Category
18-24	Mature Tree
24-30	High Value Mature Tree
>30	Exceptional Value Mature Tree

3.8. The placement of subsurface structural BMPs in locations that require the removal or disturbance of a mature tree is considered infeasible for all mature tree categories. The placement of surface structural BMPs that require removal or critical root zone disturbance of trees in the Mature Tree or High Value Mature

Tree categories is discouraged but is allowable on a case-by-case basis. The placement of surface structural BMPs that require removal or critical root zone disturbance of trees in the Exceptional Value Mature Tree category is considered infeasible.

Setbacks

Setbacks are established around buildings, property boundaries, utilities, newly planted trees and other critical features. Setbacks serve a number of purposes including preventing basement flooding due to infiltration near buildings, providing suitable operations and maintenance access for utilities, and avoiding impacts to environmentally sensitive areas and adjacent properties. Placement of structural BMPs within established setback distances is considered infeasible. Designers should keep in mind that setbacks can sometimes be addressed by relocating existing utilities, buildings, structures. Specific setback tolerances are specified in Section 4.2.a.ii, “Building Protection and Setbacks”.



Gas, electric, fiber optic, and other utilities may impose additional siting requirements for siting structural BMPs over, near, or around utility infrastructure. Designers should coordinate with utility owners early in the design process to assess these requirements. Discussion of these requirements is outside the scope of this manual.

Bedrock

Like groundwater, bedrock is considered a limiting layer that creates significant feasibility issues for a number of BMP types. Infiltrating BMPs are required to have a minimum of two feet of separation distance from the bottom of the underdrain to the top of the bedrock surface. The bedrock surface includes any weathered bedrock layers. Other BMP types can be located at or near the bedrock interface. Designers must provide a suitable bedding surface (typically at least 6 in.) for lined BMPs, as well as stormwater chambers, tanks, and cisterns, such that the liner or structure is not placed directly on bedrock, which can lead to ripping, puncturing, or leaking. For vegetated BMPs, a suitable depth of planting media must be provided. If the top of the bedrock surface is weathered bedrock, this material can be removed and replaced with infiltrating media, planting soil, or bedding material, as applicable, to provide the required separation distance.



Coal seam strata in a roadcut for a new development

SECTION 3.6 TECHNICAL INFEASIBILITY DETERMINATION

Technical infeasibility determinations are provided as an option of last resort for applicants that face unique or challenging conditions that preclude the use of particular types of BMPs, or in rare instances, preclude the use of stormwater management all-together. The city encourages applicants to use creative or innovative strategies to incorporate BMPs into the site layout early in the design process and will work with applicants to identify alternative strategies. The city may ask applicants to consider alternative arrangement of proposed features. Technical infeasibility can be granted for a portion of the compliance requirement. For instance, an applicant may provide a technical infeasibility request that applies to a portion of the volume control requirement for a given drainage area.

There are several types of technical infeasibility determination that can apply to regulated activities. Each type of technical infeasibility determination is described below. It is important to note that cost is not a technical feasibility criteria as the city is not able to objectively evaluate cost infeasibility nor the financial capability of applicants. Infeasibility must be demonstrated on a technical basis. Applicants should also note that technical infeasibility determinations made by the city do not imply the same determination by ACCD/PADEP should the project require an NPDES permit.

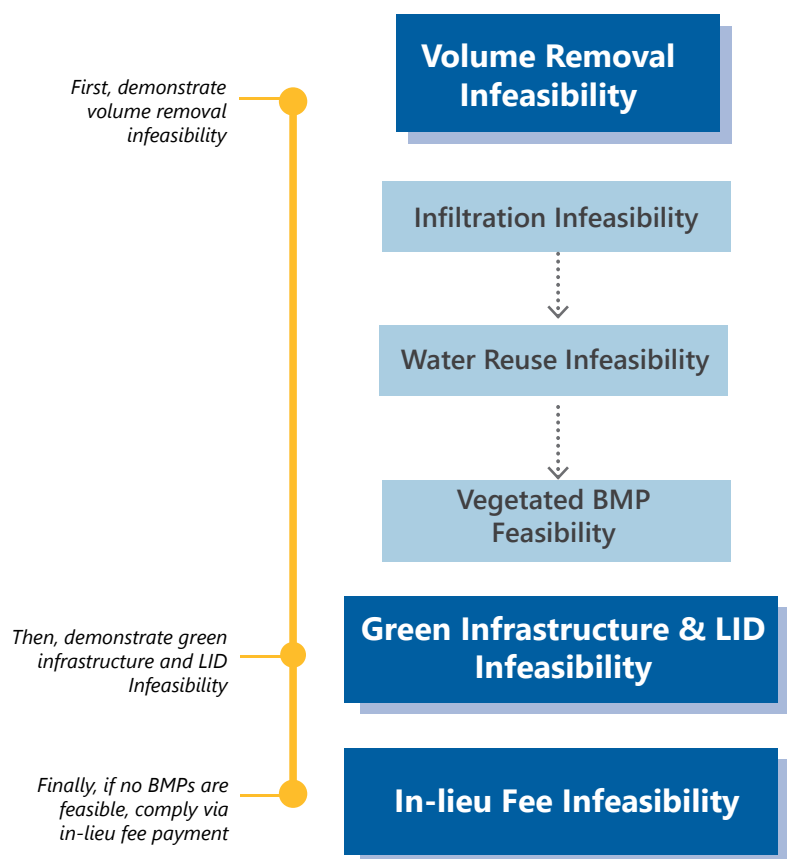


Figure 3.1. Technical Infeasibility Determination

Technical Infeasibility Determination has three parts, which must be completed in order by the applicant and documented in the Technical Infeasibility Report,

Section 3.6.a. Infeasibility Determination Process

Technical infeasibility for volume removal. The volume control requirement in §1303.03 requires that applicants provide a technical infeasibility determination before non-volume removing BMPs are used. This technical infeasibility determination requires that applicants demonstrate for each unique drainage area that 1) infiltration is infeasible 2) water reuse is infeasible 3) the use of a vegetated BMP that provides volume removal via evapotranspiration is not feasible.

- 1. Infiltration infeasibility** – applicants must submit infiltrating testing indicating that infiltrating rates are not suitable for the use of infiltrating BMPs. Applicants are referred to infiltration testing requirements in Section 3.4, “Soil Assessment and Infiltration Testing” and **Appendix B: Infiltration Testing and Geotechnical Requirements and Infiltration Waiver Form**. Applicants should note that infiltration infeasibility must be demonstrated for all potential infiltration BMP locations and must demonstrate why building or site layout could not be modified to permit the location of a BMP on infiltrating soils. Infiltrating testing for a preferred or selected BMP location is not sufficient to provide infiltrating infeasibility. Applicants must consider the potential to use other locations for infiltration
- 2. Water reuse infeasibility** – applicants must submit a narrative describing why water reuse is infeasible. Sufficient reasons for water reuse infeasibility will typically relate to a lack of water reuse need on site. Applicants should consider the full range of water reuse possibilities for the site including both potable and non-potable uses.
- 3. Vegetated BMP infeasibility** – the use of Preferred BMPs listed in Section 3.7.b, “Preferred BMPs” are considered volume removing via evapotranspiration processes even if the practices are not infiltrating. Applicants should refer to technical infeasibility criteria in Table 3.4, Section 3.5 for individual BMP types when demonstrating infeasibility for vegetated BMP infeasibility.

Technical infeasibility for green infrastructure and LID. The stormwater code also requires the use of green infrastructure and LID for meeting both volume and rate control requirements. Preferred practices listed in Section 3.7.b.i., “Preferred BMPs” are considered green infrastructure and LID. Porous pavement practices are also considered green infrastructure and LID. Other technologies on the approved list such as subsurface detention with media filtration are not considered green infrastructure and LID. Applicants proposing the use of an approved BMP that is not considered green infrastructure or LID must submit a technical infeasibility determination report detailing why green infrastructure or LID practices cannot be used for each unique drainage area. Technical infeasibility criteria are provided in Table 3.4, Section 3.5. In addition, the following infeasibility criteria may be used on a case-by-case basis:

- » **Excessive velocities into/out of system.** In some cases, inflow or outflow velocities may be higher than what can be accommodated using energy dissipaters. This can occur, for instance, where structural BMPs are small and opportunities for energy dissipaters are limited.

- » **Conflicts with proposed uses/insufficient space.** Applicants should explain why alternative design layouts could not accommodate the proposed BMP, including adjustment of building heights, etc.
- » **Utility conflicts.** Applicants should explain why utilities could not be moved/relocated to accommodate BMP placement.
- » **Insufficient grade into/out of system.** Applicants should provide calculations demonstrating why conveyance cannot be provided. A variety of conveyance alternatives including swales, trench drains, should be explored.

Technical infeasibility for in-lieu fee. To qualify for an in-lieu fee payment, in addition to successfully demonstrating technical infeasibility for volume removal as described above, applicants must demonstrate that the volume control requirement cannot be met using slow release (i.e., non-infiltrating systems). Applicants should refer to the list of preferred and approved Structural BMPs provided in Section 3.7.b, “Structural BMPs” and must provide a technical infeasibility evaluation for each BMP on the applicable non-infiltrating list, siting specific technical feasibility criteria for each potential location for each drainage area. Applicants must also show that alternative locations, site layouts, or mitigation strategies could not permit the use of a particular BMP. For instance, utility conflicts can often be addressed by relocating the utility or adjusting the BMP layout to avoid the utility. The city will expect applicants to be thorough and comprehensive in their evaluations.

Should technical infeasibility of each non-infiltrating approved and preferred Structural BMP be successfully demonstrated, the next step for applicants would be to either 1) apply for a waiver to use a subsurface detention BMP (see Section 3.7.b.iii, “Approved BMPs with Waiver”) or 2) propose the use of a non-approved BMP using the innovation track option (see Section 3.7.b.iv, Innovation Track”).

Section 3.6.b. Technical Infeasibility Report Requirements

A single technical infeasibility report shall be submitted that addresses all technical feasibility categories. The report shall be arranged by unique drainage area, describing the technical feasibility requests for each unique drainage area for each applicable structural BMP or strategy. Additionally, applicants must explain why alternative site layout arrangements or mitigating strategies could not accommodate the use of each BMP type.

The specific contents of the technical infeasibility report will depend on the technical infeasibility criteria identified. A list of common technical infeasibility issues and associated report requirements are provided in Table 3.9. This is not an exhaustive list. Before submitting a technical infeasibility report, applicants should review infeasibility criteria and consider whether mitigating strategies can be used to permit the use of a particular BMP. Mitigating strategies would commonly include:

- » The use of energy dissipaters, well holes, larger pipe sizes, etc. to moderate velocities.
- » Increases in building height (note: applicants can seek the use of performance

points systems within certain areas under the Title 9 Zoning Code).

- » Reduction in number of units, square footage, etc.
- » Rearrangement of buildings and other site features to facilitate alternative layouts.
- » Reduction in on-site parking or use of structured parking to permit the use of vegetated practices.
- » The use of compact/modular tanks, planters etc. to provide stormwater management in small spaces.
- » The use of BMPs in series.
- » Sediment reduction strategies/pretreatment to reduce sediment loading.
- » Increases in hydraulic loading ratio.
- » Over excavation of unconsolidated fill.
- » Lining of systems in areas of environmental contamination.

Additional suggested design modifications to facilitate the use of specific BMPs are provided in Section 3.5, Table 3.5.

TABLE 3.9. REPORT REQUIREMENTS FOR TECHNICAL INFEASIBILITY CRITERIA	
Technical infeasibility criteria	Report requirement
Excessive sediment loading	Quantitative analysis (see excessive sediment loading narrative section) showing why proposed use will generate sediment loading that will make BMP maintenance infeasible.
Steep slopes	Topographic mapping showing that the area exceeds slope thresholds, including offsets.
Landslide prone or undermined areas	Mapping showing the areas as landslide prone or undermined and area certification from a geotechnical engineer that the area is landslide prone.
Low infiltration	Infiltration testing in accordance with Section 3.4 and Appendix B demonstrating insufficient infiltration rates.
Insufficient water reuse	Narrative explaining why the proposed condition has insufficient need for water reuse or why water uses are infeasible.
Environmental contamination	Report prepared by an environmental professional stipulating that infiltration or other BMPs cannot be installed due to environmental contamination.
Potential for settlement or subsidence/presence of uncompacted fill/Uncompacted urban fill	Report prepared by a geotechnical engineer, including boring logs, showing that BMP cannot be located in a specific areas due to the potential for settlement based on soil bearing capacity. Applicants must also note why over excavation of material is not possible (up to 3 ft of removal).
Floodplain/Floodway	FEMA-compliant mapping of floodway in a published flood insurance rate map or flood insurance study or similar study. Inundation analysis for floodplains/floodways around small streams.
Wetlands	Wetland delineation report prepared in accordance with current USACE methods prepared by an individual with expertise in wetland delineation.
Groundwater	Monitoring well data or boring logs indicating seasonal high groundwater levels.
Riparian buffers	Delineation of riparian buffers along mapped watercourses.
Mature trees	Topographic survey locating mature trees by category. Certified arborist or professional landscape architect report indicating tree condition.
Setbacks	Offsets from field surveyed or proposed structure/utility locations and property boundaries.
Bedrock	Boring logs indicating depth of refusal due to bedrock. Note that weathered bedrock can typically be excavated and replaced and is not considered a limiting layer.

Sections 3.6.c. Fee in-Lieu

The use of fee-in-lieu is an option of last resort intended to provide relief for applicants who face extraordinary circumstances that preclude fully meeting the volume requirement. Fee-in-lieu may be applicable when approved or preferred BMP(s) is considered infeasible less any areas for which the volume control requirement is being met using offsets or via grant of innovation track approval. Fee in-lieu is not provided for rate control requirements. To use fee in-lieu, applicants must submit and obtain approval for a technical infeasibility determination in accordance with Section 3.6.a., “Infeasibility Determination”. The fee-in-lieu is a one time payment and the rate is set at \$600,000 per acre-inch of the required volume for each drainage area managed; however, it may be adjusted annually as warranted. Fee in-lieu payments must be paid prior to commencement of any aspect of construction on the project site. Applicants should note that fee in-lieu payments to the city do not provide relief from PADEP requirements should an NPDES permit be required. Should an NPDES permit be requirement, a separate technical infeasibility determination would need to be made by PADEP.

SECTION 3.7 STORMWATER MANAGEMENT DESIGN STRATEGIES

Applicants will typically use a combination of non-structural strategies and BMPs, as well as Structural BMPs to comply with the city’s stormwater requirements. Applicants should focus initially on the use of non-structural strategies to minimize impervious cover, protect natural features, and adjust the site layout and arrangement of buildings to preserve natural runoff patterns. These strategies will be most useful on larger sites such as campuses and lower density residential developments. Next, applicants will use non-structural BMPs such as disconnections and tree plantings to lower the total amount of impervious cover than needs to be managed. These strategies can be useful in reducing the total cost of compliance and reducing the number and size of Structural BMPs that need to be designed. Finally, applicants will use Structural BMPs to provide additional volume and rate control as needed.

Section 3.7.a. Non-Structural Strategies and BMPs

The city places a high value 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 promote the treatment, infiltration, evaporation, and transpiration of precipitation close to where it falls, and are a primary means by which the designer works to preserve and protect high-value natural features. The city 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 involves 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, and the use of construction staging strategies that limit disturbance and soil compaction.

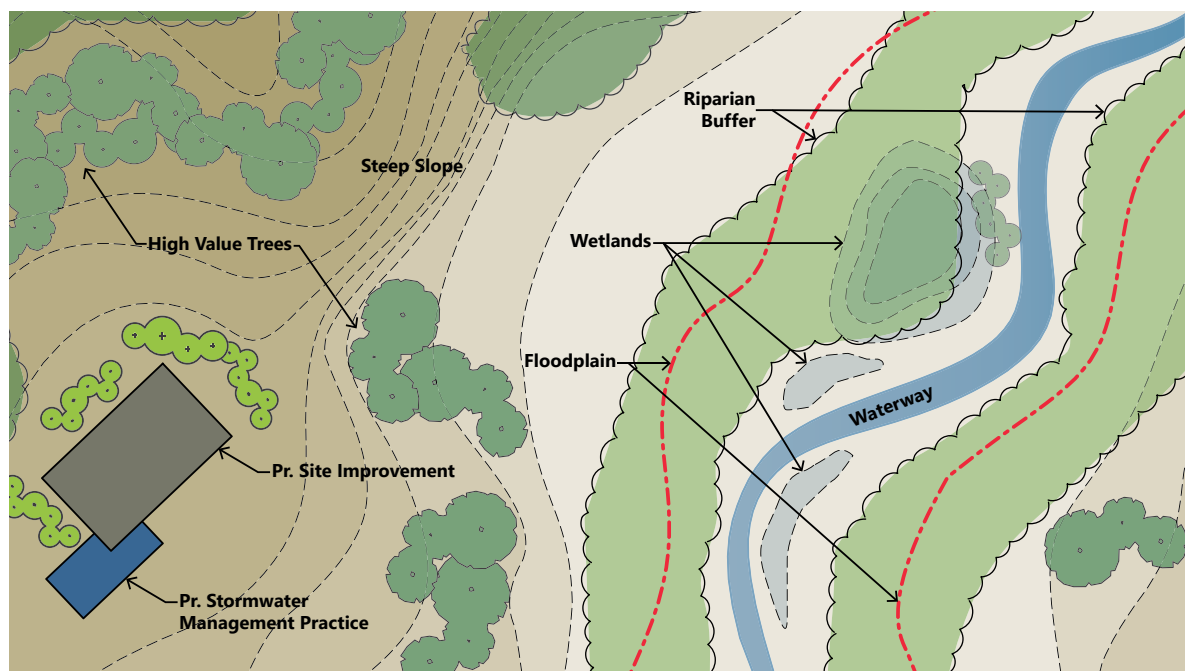
When used in combination, non-structural strategies can result in a variety of environmental and financial benefits. In the designer's interest, the use of non-structural design practices can reduce land clearing and grading costs, reduce the size and cost of stormwater management facilities, reduce 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, 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 project sites within Pittsburgh do not generally possess extensive natural systems, more modest natural systems and features may be of sufficient value to warrant preservation and integration within the development plan. Pittsburgh's many steep, forested hillsides are of particularly value in terms of preservation. Other 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 3.3, "Site Scale Factors" and Section 3.4, "Soil Assessment and Infiltration Testing", to better understand the physical features of an existing property 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.

Analysis of tangible site factors such as high values trees, steep slopes, proximity to floodplains and wetlands should be used to inform optimal siting of built structures as well as BMPs.



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, such as steep slopes. Protection of steep slopes is particularly critical in Pittsburgh, as these environments are plentiful and particularly sensitive to disturbance. 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 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.

Within Pittsburgh, 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 provide 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 the city to recognize the value and function of less extensive natural areas, even to the extent of valuing an individual tree. The city 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.

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. The city provides specific riparian buffer requirements within §1303.05.

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 make an effort to cluster and concentrate structures in order to build on the smallest area possible and minimize extensive impervious surfaces, reserving as much area as possible for “green” cover. By limiting the footprints of buildings, parking areas, and other impervious surface, 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 plant species 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.

Beyond the compliance with the city's stormwater regulations, applicants may want to consider other factors in the stormwater management design to meet immediate development and long-term site needs. This may include designing the site such that it complies with both the Stormwater Regulations and Stormwater quantity and/or quality control requirements for Leadership in Energy and Environmental Design (LEED) certification. Eligible projects may also choose to take advantage of various stormwater management-based performance points to increase a building's height and/or density. If there are large swaths of existing impervious area that will not be disturbed during construction the applicant may want to consider managing these areas as part of a volume offset or incentive, or as part of a rate control strategy that involves a downstream point of interest. These options are described within Section 2.2, "Regulations and Requirements" of this manual.

[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 Section 2 in the following ways:

[Volume Control](#)

Non-structural practices encourage minimizing the use of impervious surfaces, thus reducing the volume of stormwater required to be managed.

[Rate 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.

[Disconnected Impervious Cover](#)

Beyond the non-structural strategies discussed above, applicants can reduce the total amount of impervious cover to be managed using non-structural BMPs that disconnect impervious cover through discharging smaller impervious areas to pervious areas, as well as adding tree plantings adjacent to impervious cover. These strategies are full discussed in Section 4.1, "Non-Structural BMPs".

Section 3.7.b. Structural BMPs

Structural BMPs consist of physical installations that detain, infiltrate, evapotranspire, or collect stormwater for the purposes of meeting volume or rate control requirements. Structural BMPs are used to provide volume and rate control that cannot be met using Non-Structural BMPs. Applicants must fully exhaust the use of Non-Structural Strategies BMPs prior to using Structural

BMPs. Structural BMPs approved for use in Pittsburgh are provided for various use cases including separate sewer and combined sewer areas and infiltrating and non-infiltration conditions.

Section 3.7.b.i. Preferred BMPs

The city has defined preferred BMPs in four use cases, as provided below in Table 3.10. These BMPs provide both volume and water quality benefit, in addition to a wide variety of co-benefits that include urban heat island mitigation, habitat creation for pollinators and other wildlife, and myriad other benefits associated with urban greening. Applicants are highly encouraged, although not required to use preferred BMPs in their site designs. The use of preferred BMPs can be used to qualify for a Preferred Technology Incentive as described in Section 5.3.f. Preferred BMPs are considered Green Infrastructure and LID practices.

TABLE 3.10. LIST OF PREFERRED BMPs BY SEWER TYPE		
Infiltration Condition	Sewer Type	
	MS4/Separate Sewer	Combined Sewer
Infiltrating	<ul style="list-style-type: none"> • Bioinfiltration 	<ul style="list-style-type: none"> • Bioinfiltration
Non-Infiltrating	<ul style="list-style-type: none"> • Bioretention • Constructed wetland/wet pond • Green roof 	<ul style="list-style-type: none"> • Bioretention • Constructed wetland/wet pond • Green roof

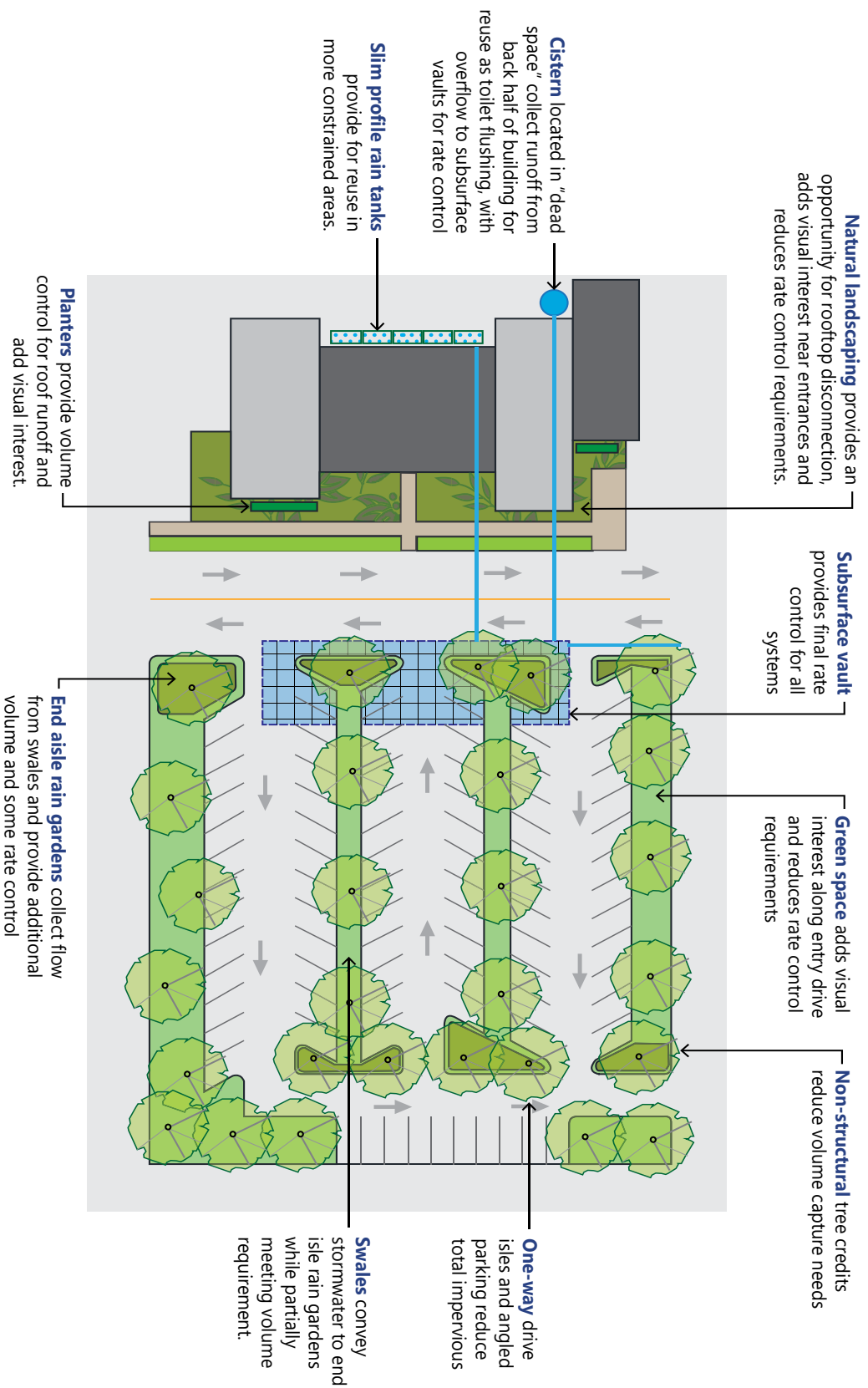
Section 3.7.b.ii. Approved BMPs

If applicants choose not to use Preferred BMPs, the use of Approved BMPs is acceptable for meeting the city's requirements. The city has defined approved BMPs in four use cases, as provided below in Table 3.11. These BMPs provide both volume and water quality benefit, but lack the co-benefits associated with vegetated systems. Porous pavement BMPs are considered Green Infrastructure and LID practices.

TABLE 3.11. LIST OF APPROVED BMPs BY SEWER TYPE		
Infiltration Condition	Sewer Type	
	MS4/Separate Sewer	Combined Sewer
Infiltrating	<ul style="list-style-type: none"> • Porous pavement • Subsurface infiltration 	<ul style="list-style-type: none"> • Porous pavement • Subsurface infiltration
Non-Infiltrating	<ul style="list-style-type: none"> • Porous pavement with slow release and media filtration • Sand filter • Subsurface detention with media filtration • Dry extended detention basin with media filtration 	<ul style="list-style-type: none"> • Porous pavement with slow release • Dry extended detention basin

Section 3.7.b.iii. Approved BMPs with Waiver

For non-infiltrating conditions within the combined sewer, applicants may submit a waiver request for the use of a subsurface detention system. The waiver request must contain a technical infeasibility report documenting why Preferred



Using several BMPs on a site to meet SWM requirements, reuse water, and enhance visual interest.
 Designers have at their disposal a variety of structural and non-structural strategies to fulfill site stormwater needs while simultaneously meeting design and programmatic goals.

or Approved practices are technically infeasible for each unique drainage area and why alternative layouts or other mitigating strategies could not permit the use of preferred or approved practices.

Section 3.7.b.iv. Innovation Track

The city offers an innovation track that facilitates approval of BMPs that are not on the Preferred or Approved BMP list. This could include novel or innovative technologies, which the city encourages applicants to explore and ultimately propose. However, it is also important that innovative technologies are subjected to a thorough review prior to implementation. To facilitate this review, there are three review categories within the innovation track based on whether rigorous performance data collected in accordance with the Technology Acceptance and Reciprocity Partnership (TARP) or Washington State Technology Assessment Protocol – Ecology (TAPE) or prior independent third-party certifications (e.g., NJCAT) are available. The three categories are presented and explained in Table 3.12.

TABLE 3.12. INNOVATION REVIEW TRACK CATEGORIES.

Review Category	Existing Independent Third-Party Certification	Existing TARP or TAPE Compliant Performance Data Available	Summary of Required Submissions
Category 1 – Accelerated Acceptance	Yes	Yes	Third party certification
Category 2 – Innovation Review	No	Yes	Technical evaluation report summarizing TARP or TAPE compliant performance
Category 3 – Pilot Study	No	No	Pilot installation request including data collection/monitoring plan

Innovation Review Technical Evaluation Submission Requirements

Applicants using the Innovation Review must submit a Technical Evaluation Submission with the SWM site plan containing the following:

- » Performance Claim and Rationale
 - Volume management, rate control, contaminant removal efficiency for water quality design storm, etc.
 - Reason for implementation versus approved technologies
- » Innovative Technology or Design Method Description
 - Description of underlying scientific and engineering basis
 - Engineering drawings or process flow diagrams as applicable
- » Construction requirements
 - Full range of operating conditions and optimal conditions to meet the stated performance claims
 - Sizing methodology and supporting calculations
 - Typical construction costs
 - Minimum operations and maintenance requirements including:

- Expected frequency and duration of a typical inspection and maintenance cycle
- Expected service life
- Maintenance access requirements
- Safety considerations
- » Data Collection Methodology and Analysis
 - Description of experimental design and data collection procedures
 - Data quality assurance and quality control plan
- » Significant academic involvement strongly preferred
 - Presentation of long-term physical monitoring of volume control, rate control, and/or other performance capabilities conducted by third party
 - Statistical analysis of data supporting performance claims
- » Conclusions
 - Summary of findings
 - Assumptions and potential limitations
 - Special considerations

Pilot Study Technical Evaluation Submission Requirements

If proposed innovation has not been approved by a third party certification program and data supporting performance claims do not meet accepted protocols (i.e., outlined by TARP or TAPE) or are not available, applicants have the option to submit a request to conduct a pilot study with technical oversight and review from the city. An accepted pilot study proposal constitutes a provisional approval to install a BMP using the proposed innovative approach and performance monitoring using approved data collection methods. Because the success of a pilot study hinges on rigorous methods and execution, significant academic involvement is strongly preferred. If study results substantiate the performance claim to the satisfaction of the city, the innovative technology or design method may be accepted for use wider use. If upon completion of the pilot study and performance analysis, data does not support the initial performance claim, applicants are required to pay an in-lieu fee for the required volume control or install an accepted BMP, as applicable.

Applicants using the Pilot Study Review are required to submit a pilot study proposal for provisional acceptance of an innovative technology or design method. The proposal included with the SWM site plan must include the following:

- » Pilot Performance Claim
 - Volume management, rate control, contaminant removal efficiency for water quality design storm, etc.
 - Pilot Project Description
 - Proposed installation location
 - Site installation requirements

- Full range of operating conditions
- Sizing methodology
- Implementation costs
- Minimum operations and maintenance requirements including:
 - Expected frequency and duration of a typical inspection and maintenance cycle
 - Expected longevity
 - Special requirements for maintenance access
 - Special safety considerations
- » Pilot Project Implementation Plan
 - Description of experimental design and data collection procedures
 - Physical monitoring of water quality/rate control performance conducted by third party
 - Procedures accepted by TARP or TAPE would be strongly preferred
 - Continuous modeling of water quality/rate control performance using rigorous modeling approach to supplement monitoring data encouraged
 - Statistical analysis of data supporting performance claims required
- » Resource-sharing Proposal (optional)
 - Applicants may request to collaborate on performance monitoring tasks and receive technical guidance from the city
 - The level and type of resources assistance should be proposed by the applicant.
- » Use of Standard BMP Agreement
 - Statement stipulating that the applicant would be required to implement an approved BMP or pay an in-lieu fee if the results of the pilot study do not support the initial performance claim.

Projects that require NPDES permits may also require additional review if a proposed innovative technology or method is not included in the PADEP's list of approved alternative BMPs. For applicants who wish to pursue acceptance via any of the three review tracks proposed, new design methods and technologies would have to be submitted to both PADEP and the city for approval separately in instances where NPDES approval is required.

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SECTION 4 – STORMWATER BEST MANAGEMENT PRACTICE DESIGN STANDARDS

Stormwater Best Management Practice (BMP) is defined as activities, facilities, designs, measures, or procedures used to manage stormwater impacts from regulated activities, to meet State Water Quality Requirements, to promote groundwater recharge, and to otherwise meet the purposes of Title 13.

Stormwater BMPs are commonly grouped into one (1) of two (2) broad categories or measures:

- » **Non-structural**
- » **Structural**

Design standards for non-structural BMPs (Section 4.1) and structural BMPs (Section 4.2) are provided within this section of the manual.

4.1 NON-STRUCTURAL BMPS

Non-structural BMPs refer to operational and/or behavior-related practices that attempt to minimize the contact of pollutants with stormwater runoff by introducing runoff to pervious surfaces and maximizing evapotranspiration via dispersion. As part of the submitted SWM site plan, the applicant must thoroughly consider the use of non-structural strategies and finding creative ways of incorporating built features around existing natural areas prior to the implementation of structural BMPs. For an overview of specific strategies related to commonly used non-structural BMPs, refer to Section 3.7.a, “Non-Structural Strategies and BMPs,” of this manual.

Rooftop disconnections, ground pavement disconnections, and tree canopy disconnections are non-structural BMPs may be implemented to partially meet the volume reduction requirements within Title 13. The following sections provide design standards pertaining to each of these non-structural BMP methods for achieving non-structural BMP volume reduction credits.

No more than 25% of the total volume requirement may be met through a combination of non-Structural BMP credits listed in this section. Impervious areas disconnected to non-structural BMPs shall remain classified as impervious for meeting the rate control requirements, however hydraulic modeling may

route the disconnected impervious area subcatchment runoff over the pervious area subcatchment for determining post construction peak runoff calculations.

4.1.a. Rooftop Disconnection

Rooftop disconnection consists of redirecting stormwater runoff from roof conductors to pervious areas. Disconnection to pervious areas promotes sheet flow and increases stormwater infiltration and filtration, and reduction of erosion. Rooftop disconnections to pervious areas may be used to meet the volume requirement. To obtain volume requirement credit from the impervious area rooftop disconnection the following requirements must be met:

- A.** Building storm drainage piping and associated infrastructure may also be regulated by Article XV of the Allegheny County Health Department Plumbing Code.
- B.** The rooftop drainage area to the rooftop disconnection point must be not greater than 500 square feet.
- C.** The pervious area receiving the rooftop disconnection must only receive one unique rooftop disconnection. Multiple rooftop disconnections to a single pervious area are not permissible. Combining rooftop and pavement disconnections (see Section 4.1.b) to a single pervious area is not permissible.
- D.** The slope of the pervious area must be not greater than 5%.
- E.** The disconnection must not be upgradient of an adjacent landslide prone or steep slope. See **Appendix A: Overlay Districts and Watershed Maps** for a map of landslide prone and steep slope areas and Section 4.2.a.ii, “Building Protections and Setbacks,” for steep slope setback distance thresholds.
- F.** The pervious area must not be classified as a NRCS hydrologic soil group “D”. Infiltration and soil testing of the pervious area in-situ soils in accordance with Section 3.4, “Soil Assessment and Infiltration Testing,” is required.
- G.** The flow path of the pervious area must be continuous and uninterrupted by other impervious areas.
- H.** All rooftop disconnections shall have an engineered splash pad at the base of the disconnection to dissipate energy and prevent scour and erosion.
- I.** All runoff from rooftop disconnections shall be directed away from building foundations and structures. See Section 4.2.a.ii, “Building Protections and Setbacks,” for setback distance thresholds.
- J.** An overflow device such as a raised area drain or inlet shall be installed in order to safely manage roof disconnection runoff from large storms.
- K.** All receiving pervious areas for rooftop disconnection must be protected from compaction and erosion and sediment loading during construction activities to preserve the infiltration capacity of the soils. Any pervious areas that have become compacted during construction activities must be scarified and decompacted to restore infiltration capacity of the underlying soils.



External roof leaders such as those shown above for an older structure present an opportunity for rooftop disconnection.

Volume reductions from the rooftop disconnection are determined based on the length of the flow path measured from the point of disconnection to the furthest downstream discharge connection point (i.e., a stormwater inlet or area drain) or introduction of flow to an impervious surface. The flow path distance shall be measured in the most direct route “as the crow flies.” Table 4.1 provides the volume reduction depths based on the calculated flow path.

**TABLE 4.1. ROOFTOP DISCONNECTION
VOLUME REDUCTION DEPTHS**

Pervious Flow Path (Feet)	Runoff Depth Managed From Roof Drainage Area (Inches)
0-14	0.00
15-29	0.20
30-44	0.40
45-59	0.60
60-74	0.80
75+	1.00

4.1.b. Pavement Disconnection

Disconnection of ground level pavement to pervious areas may be used to meet the volume requirement. Similar to rooftop disconnections, redirecting stormwater runoff from ground level pavement to pervious areas promotes sheet flow dispersion and allows for increased infiltration, filtration, and time of concentration of stormwater runoff. To obtain retention volume credit from ground level pavement disconnection the following requirements must be met:

- A. Pavement drainage area must not be greater than 1,000 square feet to each pervious area and generated runoff must uniformly sheet flow to the pervious area and avoid concentrating runoff to the pervious area to a single point of entry. For long continuous and circuitous impervious areas such as walkways and bike paths that exceed 1,000 square feet, these areas may be broken into separate impervious areas for the purposes of the calculation provided that the separate impervious areas discharge to individual separate pervious areas.
- B. The pervious area receiving the pavement disconnection must only receive one unique pavement disconnection. Multiple pavement disconnections to a single pervious area are not permissible. Combining rooftop and pavement disconnections to a single pervious area is not permissible.
- C. The slope of the pervious area must be not greater than 5%.
- D. The disconnection must not be upgradient of an adjacent landslide prone or steep slope. See [Appendix A: Overlay Districts and Watershed Maps](#) for a map of landslide prone and steep slope areas and Section 4.2.a.ii, “Building Protections and Setbacks,” for steep slope setback distance thresholds.

- E. The pervious area must not be classified as a NRCS hydrologic soil group “D.” Infiltration and soil testing of the pervious area in-situ soils in accordance with Section 3.4, “Soil Assessment and Infiltration Testing,” is required.
- F. The flow path of the pervious area must be continuous and uninterrupted by other impervious areas.
- G. All runoff from pavement disconnections shall be directed away from building foundations and structures. See Section 4.2.a.ii, “Building Protections and Setbacks,” for setback distance thresholds.
- H. Runoff from pavement disconnections may also be regulated by Article XV of the Allegheny County Health Department Plumbing Code.
- I. An overflow device such as a raised area drain or inlet shall be installed in order to safely manage pavement disconnection runoff from large storms.
- J. All receiving pervious areas for pavement disconnection must be protected from compaction and erosion and sediment loading during construction activities to preserve the infiltration capacity of the soils. Any pervious areas that have become compacted during construction activities must be scarified and decompacted to restore infiltration capacity of the underlying soils.

Volume reductions from the pavement disconnection are determined based on the ratio of the longest impervious area flow path to the longest pervious area flow path. The flow path distance for each surface shall be measured in the most direct route “as the crow flies.”

Table 4.2. provides the volume reduction depths based on the calculated flow path.

TABLE 4.2. FLOW PATH RATIO TO RUNOFF DEPTH MANAGED	
Flow Path Ratio (Impervious : Pervious)	Runoff Depth Managed (Inches)
0.2:1	0.20
0.4:1	0.40
0.6:1	0.60
0.8:1	0.80
1:1	1.00

4.1.c. Tree Canopy Credits

Protecting existing trees and planting new trees can be used to meet the volume requirements. Only impervious areas that are directly under the tree canopy may be credited considered for disconnection for meeting the volume requirements. Separate design standards are required for existing trees and newly planted trees. The design standards for each are listed below.

Existing Trees

Existing trees may be credited towards meeting the volume requirements based on the criteria listed in Table 4.3 and the condition of the tree is designated as healthy by the reviewer and/or city Arborist.

TABLE 4.3. IMPERVIOUS DISCONNECTION BY EXISTING TREE TYPE

Tree Type	Minimum DBH (inches)	Disconnected Impervious (Square Feet)
Deciduous	4	15% of Canopy Area
Coniferous	6	30% of Canopy Area

The following requirements must be met:

- A. All trees must be species listed in [Appendix C: Approved Plant List](#) of this manual unless otherwise approved by the reviewer.
- B. Tree diameter at breast height (DBH) is measured as the diameter of the tree at a height of 4.5 feet above the ground from the highest elevation adjacent to the trunk.
- C. Only impervious surfaces directly under the existing tree canopy shall be eligible for disconnection.
- D. Tree canopy area must be measured in the field using the International Society of Arboriculture (ISA) recommended methods.
- E. Disconnected area from tree canopy shall not exceed 25% of the impervious area within the project area.
- F. Any impervious area that is both eligible for tree canopy credit and pavement disconnection shall not be double counted. The applicant may only select one non-structural BMP approach for the impervious area and may not take credit for both.

Newly Planted Trees

Newly planted trees may be credited towards meeting the volume requirements based on the criteria listed in Table 4.4.

TABLE 4.4. DISCONNECTED IMPERVIOUS AREA BY NEW TREE TYPE

Tree Type	Minimum Size	Disconnected Impervious Area (Square Feet)
Deciduous	2.5 inch DBH	50
Coniferous	4 foot height	100

The following requirements must be met:

- G. All trees must be species listed in [Appendix C: Approved Plant List](#) of this manual unless otherwise approved by the reviewer.
- H. Disconnected area from tree canopy shall not exceed 25% of the impervious area within the project area.
- I. Size must be clearly specified in project construction documents.
- J. The sum of the calculated volumes from both existing and newly planted trees may be used for meeting volume requirements.

4.2 STRUCTURAL BMPS

Structural BMPs are physical devices and practices that capture, detain, evapotranspiration and/or infiltrate and treat stormwater runoff. Structural stormwater BMPs are permanent appurtenances to the project site. Examples of typical structural BMPs include bioretention/bioinfiltration, green roofs, and porous pavement.

The designer may be able to partially satisfy the SWM Ordinance requirements for volume control (see Section 2.2a) and rate control (see Section 2.2b) through the use of non-structural BMPs. If the volume control and rate control requirements are not completely met by the non-structural BMPs, structural BMPs must be incorporated into the design.

4.2.a. General Design Requirements

General Design Requirements apply to all or multiple BMP types, as specified. Applicants should also refer to BMP specific requirements in this section.

4.2.a.i. BMP Safety

To account for pedestrian safety all BMPs designed for pedestrian access must meet applicable Americans with Disabilities Act (ADA) standards as approved by the reviewer. The fall depth, the vertical distance from any adjacent pedestrian access surface to the bottom most elevation of the BMP surface, shall not exceed 12 inches, unless safety measures are implemented and approved by the reviewer. Examples of fall protection safety measures include but are not limited to fencing, curbing, or hedge rows.

4.2.a.ii. Building Protection and Setbacks

- A.** All BMPs (both infiltrating and non-infiltrating) are to be located at least five (5) feet from the edge of the BMP to the property line to protect existing or future buildings and structures on adjacent properties.
- B.** All infiltrating BMPs must be located at least ten (10) feet from existing buildings and structures. All lined slow-release BMPs must be located at least five (5) feet away from existing buildings and structures. Structures include but are not limited to retaining walls and foundations. Fences shall not be considered structures.
- C.** Only the portion of the BMP that is within the 1:1 zone of influence is required to have an impermeable liner. All infiltrating BMPs must include an impermeable liner (and slow release underdrain) if located within the 1:1 zone of influence of structures and sewers.
- D.** The bottom underdrain invert elevation of the infiltrating BMPs must not be within two (2) feet of bedrock or the seasonal high groundwater.
- E.** All infiltrating BMPs must adhere to the following setbacks from steep slope hillsides:
 - 1.** For hillside slopes greater than or equal to 25%, infiltration BMPs shall be setback one hundred feet (100) from the edge of the BMP to the slope.

2. For hillside slopes greater than or equal to 50%, infiltration BMPs shall be setback two hundred feet (200) from the edge of the BMP to the slope.
 3. Exceptions may be made by the reviewer for short runs of steep hillslopes less than or equal to five (5) feet in vertical height.
 4. The reviewer may require lining and slow release BMPs, regardless of threshold distance, if known historical landslide issues are downgradient from the project site.
- F. All utilities that conflict with a BMP location must be properly protected (e.g. utility sleeve) and/or supported (e.g. concrete cradle). All utility conflicts must be identified and reviewed with the respective utility owner.
- G. All newly planted trees must not be within three (3) feet horizontally of existing sewer and water utilities. Other utilities such as electric (overhead and underground) and gas may require additional setback with the respective owner. The setback distance shall be measured from the edge of the tree at breast height to the edge of the utility. Exceptions to this requirement may be made by the reviewer if the utility is greater than 15 feet in vertical depth.

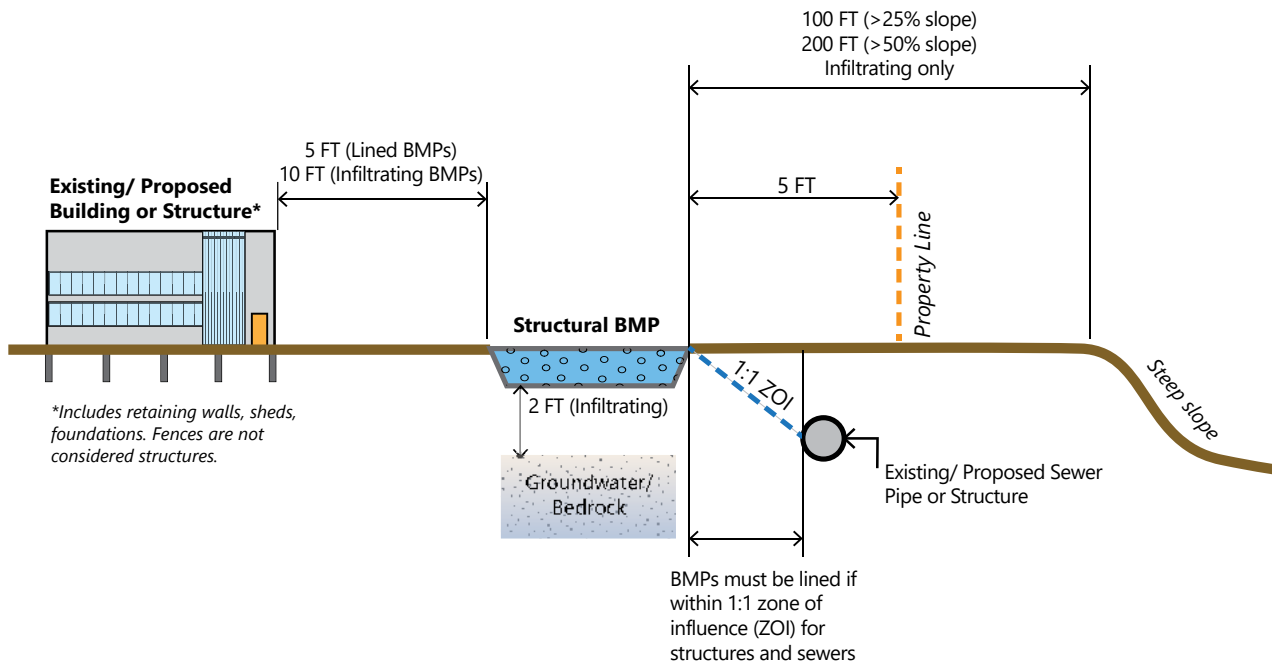


Figure 4.1. Setbacks for Structural BMPs. Setbacks for structural BMPs ensure that BMPs are placed in locations where they can perform optimally and pose the least risk to existing infrastructure.

4.2.a.iii. Pretreatment

Pretreatment of stormwater runoff removes sediment, trash, and debris typically generated in urban environments prior to entering infiltration or filtration BMPs. Sediment, trash, and debris can result in BMPs clogging and often significantly reducing design performance, service life, and in some cases rendering BMPs inoperable. Effective pretreatment increases the BMP operational lifespan and decreases the maintenance requirements of a system by concentrating the majority of the “first flush” pollutants, including sediment and debris, in a pretreatment location. Pretreatment systems employ variety of methods but most commonly involve decreasing peak stormwater velocities to allow sediment to settle or filtering incoming stormwater through vegetation to remove sediment before it reaches a BMP. Sediment forebays, filter strips, and swales, all common forms of pretreatment, can promote sedimentation prior to the introduction of flow to the BMP. Energy dissipators, commonly rock or concrete pads, can help prevent erosion by reducing the energy of high-velocity stormwater entering the BMP. Other pretreatment methods include manufactured devices such as inlet inserts (e.g. filter bags), hydrodynamic separators, and filtration cartridges. More detail on individual pretreatment methods and design criteria is provided in Section 4.3, “Pretreatment Technologies.”



Rock filter strip and pretreatment forebay associated with a stormwater feature.

General Requirements:

- A.** All BMPs used to meet the volume and/or rate control requirements within high pollutant loading hotspots must incorporate pretreatment to prevent BMP performance decline due to pollutants. Pollutant loading hotspots include urban land uses such as parking lots, roadways, and areas with heavy industry that are susceptible to high sediment loading from stormwater runoff.
- B.** Due to the difficulty of cleaning, subsurface systems, particularly if infiltrating, should be sited only where sediment loading from the contributing drainage area is minimal. Refer to Section 3.5, “Site Factors Analysis” for more information on excessive sediment loading

considerations. Subsurface BMPs with high sediment loading should incorporate more intensive pretreatment methods to prevent the storage layer or chamber from clogging. This is particularly critical for gravel storage beds, which cannot be cleaned without full depth replacement.

- C. Inlet structures used to convey surface water directly to subsurface storage (i.e. without forebays) must have sumps to provide additional pretreatment benefits. Sumps shall meet the following design criteria:
 - 1. Sump depth shall be a minimum of 18 inches measured from the floor of the inlet to the bottom invert of the subsurface storage distribution pipe.
- D. All exterior orifices and outlet control structures must include a screen or trash rack to prevent debris from clogging downstream conveyance piping.

4.2.a.iv. Loading Ratios

A loading ratio is a comparison of the impervious drainage area directed to a BMP to the BMP footprint typically used for sizing for non-gray water reuse (e.g. cisterns) systems. Loading ratio is a proxy for sediment loading to a BMP. BMP loading ratio is calculated using the following equation:

$$LR = DA/A$$

Where,

$LR = \text{Loading ratio}$

$DA = \text{Impervious drainage area that drains directly to the BMP, excluding any impervious area within the drainage area that is managed by non-structural BMPs (square feet)}$

$A = \text{Footprint of the BMP at the bottom of ponding elevation (square feet)}$

Loading ratios for BMPs must be below maximum allowable ratios. Table 4.5 defines maximum loading ratios by BMP.

TABLE 4.5. BMP MAXIMUM ALLOWABLE LOADING RATIOS

BMP Type	Max Loading Ratio Based on Drainage Area Type		
	Rooftops	Residential, Commercial, Institutional	Industrial and Streets
Bioinfiltration/Bioretenion	No Max	16	8
Subsurface Infiltration	No Max	10	5
Subsurface Detention	No Max	No Max	No Max
Porous Pavement	No Max	3	2
Green Roofs	1.5	N/A	N/A
Ponds and Wet Basins	No Max	No Max	No Max
Dry Basins	No Max	No Max	No Max
Media Filters*	Vendor Rec.	Vendor Rec.	Vendor Rec.
Cisterns	No Max	N/A	N/A

***For Media Filters follow vendor recommended guidance.**

4.2.a.v. Storage

Storage is the volumetric space for which stormwater is held in order to meet the volume and rate requirements. Storage can occur on the surface of a BMP via ponding, within the void spaces of subsurface elements such as engineered soil, aggregate, distribution piping (perforated or non-perforated), or within manufactured storage devices such as plastic crate systems or gray water reuse cisterns.

- A.** The storage provided by the BMP shall meet the volume requirements (Section 2.2.a). BMPs can be incorporated in series with other non-structural or structural BMPs to meet these requirements. Storage is calculated from the invert of the facility underdrain or low flow orifice to the invert of the overflow control. For structural BMPs, any storage associated with backwater into inflow pipes may count towards meeting volume and rate requirements provided that the BMPs meet drain down requirements as stipulated in Section 2.2.a.ii, “Drain Down Time”.
- B.** The subsurface storage media (e.g. vault, pipe, stone and crate systems) shall have a level bottom.
- C.** On ground slopes greater than 4% internal check dams are required to prevent excessive project site excavation and provide adequate vertical elevation for positive drainage to downstream connections. See Section 4.4.c, “Check Dams,” for design requirements for check dams.
- D.** Subsurface storage media shall be wrapped in geotextile on the top and sides to prevent soil migration into the storage media.



Perforated pipes and open aggregates used as storage for a right-of-way BMP.

- E. If placing below surface filtration system such as bioinfiltration or bioretention, the storage media shall have a minimum soil cover of two (2) feet from the top of the media to the bottom most bowl elevation.
- F. All systems shall have a minimum six (6) inch sand layer installed under the subsurface storage media.
- G. Proprietary/manufactured stormwater storage systems must be designed and installed per manufacturer's specifications.
- H. Anti-seep collars shall be provided on all pipes entering or exiting subsurface storage media.
- I. BMPs must be designed to prevent preferential flow paths of stormwater stored within the subsurface storage area.
- J. The stormwater must be infiltrated or slowly released through a flow control device, such as an orifice connected to an underdrain.

4.2.a.vi. Conveyance

Conveyance features transmit and regulate stormwater flow from the contributing drainage area to a BMP. Typical conveyance features include inlet structures, curb cuts, and distribution piping.

- A. Refer to Section 2.2.c.i, "Design Storms and Sizing," for design storm requirements and calculation guidance for sizing conveyance features.
- B. All conveyance pipes shall have a minimum soil cover of three (3) feet from the crown of the pipe to the ground surface and be properly bedded with stone.



- C. All BMPs shall be installed with perforated underdrain system regardless of infiltration capability of the underlying subsoil. Refer to Section 4.4.a, “Underdrains,” for more detail on underdrains.
- D. Distribution pipes and underdrains within BMPs shall have a slope of 0% to 0.25%. Refer to Section 4.4.a, “Underdrains,” for more detail on underdrains.
- E. All pipe connections into structures from BMPs shall have anti-seep collars to prevent short circuiting of stored water around joints. All pipes shall not exceed a maximum pipe bend of 45 degrees.
- F. All conveyance sizing requirements shall meet Section 2.2.c, “Stormwater Conveyance Requirements,” of this manual and the latest version of the International Plumbing Code.

4.2.a.vii. Outlet Controls

Outlet controls are structures that manage the release of stored stormwater runoff from BMPs. These structures are used to:

- » Meet peak release rate requirements,
- » Meet drain down time requirements (See Section 2.2.a.ii),
- » Provide adequate detention time for water quality treatment requirements (See Section 2.2.a.iii), and
- » Provide safe conveyance of larger storm events (See Section 2.2.c).

Common outlet control structures typically include multistage devices with pipes, orifices, emergency spillways, or weirs for flow control. More detail on individual outlet control methods and design criteria is provided in Section 4.4, “Outlet Controls.”

General Requirements:

- A. All exterior BMP orifices and outlet control structures must include a screen or trash rack to prevent debris from clogging downstream conveyance piping.
- B. Orifices not connected to underdrains shall be at least 2.5 inches in diameter and protected from clogging using a reverse slope pipe. The outlet pipe shall have an anti-seep collar if running through an embankment.
- C. Orifices connected to underdrains shall be no less than ½ inch in diameter. Watertight boot collars or other methods are required to prevent water from entering outlet control structures through pathways other than the underdrain orifice.
- D. For ponds and wet basins, outlet control structures shall be placed in open water areas 4 to 6 feet deep to prevent clogging and to allow the system to be drained for maintenance.
- E. Outlet control structures shall have an emergency overflow that can pass the design storm requirements in Section 2.2.c, “Stormwater Conveyance Requirements.” For BMPs that are intentionally designed

to only receive smaller frequency storm events, the outlet control structure emergency overflow shall be sized according to the maximum design storm received into the system.

- F. All outlet control structures must be easily accessed for routine inspection, maintenance and cleaning.
- G. All BMPs whether infiltrating or non-infiltrating shall have perforated underdrains in the event that BMP infiltration performance is compromised or lower than expected. Refer to Section 4.4.a, “Underdrains,” for detailed information on underdrain design.

4.2.a.viii. Vegetation

Vegetation reduces the volume of stormwater via evapotranspiration and provides myriad other benefits such as erosion control, habitat creation, reduced urban heat island effect, and improved air quality of the surrounding neighborhood. The following section provides guidance for selecting vegetation as part of BMP design.

Plant Materials

- A. Plants must conform to the indicated botanical names and standards of size, culture and quality for the highest grades and standards as adopted by the ANSI Z60.1 - American Standard for Nursery Stock, current edition.
- B. All plants must be nursery grown at certified, reputable nurseries in the same hardiness zone (see Winter Hardiness and Heat Zones below) as the location of the project. Plants should be of local provenance, preferably within 100 miles of the project site to ensure the use of ecotypes that are adapted to local conditions.
- C. All plants must meet specified sizes and be provided as balled and burlapped (B&B), container grown, or plugs grown in trays. Balled and burlapped plants must be freshly dug, unless otherwise approved by the reviewer. Heeled in plants or plants from cold storage are not acceptable. All plants must be sound, healthy, well branched, and free of disease or pests. Plants must be free of physical damage such as bark abrasions, disfiguring knots, sunscald, or unhealed cuts over 3/4 inch. All single stem trees must have a straight trunk; branching height must be one-third to one-half of tree height, and no multiple leaders.
- D. Balled and burlapped plants must have a solid root ball of earth held securely in place by burlap and stout rope. Burlap and rope must be biodegradable, not synthetic material. Loose, broken, or manufactured root balls are not acceptable.
- E. Container grown materials must be healthy, vigorous, well rooted and established in the container in which they are growing. Root systems should reach the sides of the containers to maintain a firm root ball, but not have excessive root growth encircling the inside of the container. Field-potted materials must be potted for delivery as they are dug from the field.

Plant Sizes and Spacing

- F. Plantings must be of sufficient size and spacing to produce 70% coverage after one growing season and 85% coverage within the BMP after two seasons of growth. Cover crop or mulching shall be used to provide cover in between plantings until target vegetation cover is achieved.
- G. Vegetation establishment within BMPs shall principally occur via planting. Seeding may be used, but only as a supplemental strategy.

Designers should take into account the following guidance when evaluating sizing and spacing needs:

- H. Nursery plants are available in a range of sizes, depending on the species and type of stock (woody or herbaceous). Smaller plants are less expensive on a unit basis, but a closer spacing with a larger number of plants is required for adequate coverage. Depending on growth rate, several growing seasons may be needed to produce a more finished landscape appearance.
- I. Shade and flowering trees, which are the largest plants, are usually acquired B&B. It is important to keep in mind the root ball size when specifying B&B trees to ensure the root ball will fit properly within the system dimensions. Shrubs can also be acquired B&B, although container-grown plants are less expensive and equally effective.
- J. Herbaceous plants can be specified as container grown or plugs. Trays with a smaller number of plugs generally have bigger, deeper cells to propagate wildflower and grass species with taproots or deep fibrous root systems. These larger plugs also have faster establishment. Projects may benefit from a mix of plant sizes to balance costs, functional requirements, and aesthetics.
- K. Plants at installation should be tall enough that they are not completely submerged during the design storm events.

Plant spacing depends on the size of the plant at installation, as well as the expected size at maturity. Plants that are large at maturity require greater spacing at installation. Alternatively, a dense planting at the outset can be thinned later as needed if rapid early coverage is desired. General plant spacing based on typical container sizes are shown in Table 4.6.



TABLE 4.6. PLANT SPACING REQUIREMENTS

Container Size	Individual Plant Spacing (Inches)	Plant Row Spacing (Inches)	Number of Plants (per SF)
Plug	6	5.20	4.60
	8	6.90	2.60
	9	7.80	2.00
	12	10.40	1.15
#1, #2	15	13.00	0.75
	18	15.60	0.51
	24	21.00	0.29
#3, #5, #7	30	26.00	0.18
	36	31.00	0.13
	48	41.50	0.072

Plant Species Selection

All plant species must be selected from the approved planting list in **Appendix C: Approved Plant List**, unless approved otherwise by City Plan Review and be appropriately chosen per project site conditions and other considerations, as described below:

Winter Hardiness and Heat Zone

- L. Plants selected for BMPs should be known to thrive in Pittsburgh hardiness zone 6B.
- M. Selected plants must be drought tolerant, except in wetland and wet pond edge zones, for expected summer conditions. Pennsylvania summers can be very hot, and heat tolerance must be considered in plant selection, particularly in highly impervious settings such as open parking lots with minimal shade. The American Horticultural Society (AHS) has developed a Plant Heat Zone Map, divided into 12 zones that indicate the average number of days each year that a given region experiences “heat days”—temperatures over 86°F (30°C). That is the point at which plants begin suffering physiological damage from heat. The zones range from Zone 1 (less than one heat day) to Zone 12 (more than 210 heat days). AHS Plant Heat Zone ratings assume that adequate water is supplied to the roots of the plant.

Microclimate

- N. Planting selection must incorporate consideration of microclimate. Climate at the project site level may vary from the larger scale Winter Hardiness or Heat Zone because of existing and proposed vegetation and structures within or adjacent to the system. Microclimatic variations in shade, soil moisture, air temperature, wind exposure, and other environmental conditions can occur throughout the day or across seasons. These variations can expand the potential species diversity of the system, but it is important to consider the potential impacts on plant establishment and growth over time and select appropriate species accordingly.

Maintenance Access

- O. The designer must select hardy species that will tolerate maintenance activities at maintenance access locations. Vegetated BMPs require maintenance of various system components, such as cleanouts and inlets, as well as the plants themselves. Maintenance equipment may include vector trucks, watering hoses, and wheelbarrows, along with personnel. Planting design should consider the ease with which staff with equipment can access the system.

Species Diversity and Resilience

- P. The number of different species used in a BMP depends on multiple considerations such as environmental conditions, functional and cultural goals, system size, and proximity to other green spaces (parks, greenways, etc.). In general, higher species diversity confers

UNDERSTANDING HEAT ZONES

Not all catalogs, web sites and garden centers currently indicate a plant's Heat Zone, although many sources indicate heat and drought tolerance more generally. Where information is available, two ratings are shown for a given plant, such as 5-10, 11-1. The first pair of numbers is the cold Hardiness Zone. This plant will survive winter temperatures in zones 5 to 10. The second pair of numbers is the Heat Zone. A rating of 11-1 indicates that the plant is heat tolerant in zones 11 through 1.

greater resilience against disease, pests, extreme weather events, and other stressors. However, species diversity must be balanced with the availability of maintenance staff and budgets. Too many different species can be challenging to maintain successfully.

- Q.** The following requirements apply to all vegetated BMPs:
1. No single species should make up more than 10% of a planting or population.
 2. No single genus should make up more than 20% of a planting or population.
 3. Maples (*Acer* spp.) may not comprise more than 5% of any given planting project.
 4. Asian Longhorn Beetle host species may not exceed 25% of any given planting project.
 5. It is recommended that at least 20% of species be evergreen.

Habitat

- R.** Plant selection for BMPs must include consideration of habitat for wildlife to the extent feasible. For example, by selecting flowering plants with lengthy or overlapping bloom periods, designers can create systems that provide pollen and nectar for bees and butterflies from early spring through the fall. Foliage from native species supports invertebrate grazers such as caterpillars, which in turn sustain migratory songbirds and their young. Summer and fall fruits, nuts, and seeds support migratory and overwintering songbirds.
- S.** Native and Naturalized, Noninvasive Species
1. Native species must comprise at least 50% of the plant material for a project. Native species are generally the most optimal in terms of habitat and ecological value, given the longstanding adaptive and often highly specific relationships that have evolved between plants and animals. However, some native species may not be tolerant of harsh urban conditions. Careful use of naturalized, noninvasive introduced species can effectively supplement and enhance designed plant communities.
 2. Invasive ornamental grasses and other invasive plants available in the nursery trade are not permitted to be used in any system (see the PA Department of Conservation and Natural Resources Invasive Plants website for more information).
- T.** Plant Communities
1. Vegetation design for BMPs must reflect a plant community-based approach. In nature, plants form communities, which are essentially groups of compatible plants that interact with each other and the project site. Compatible species should be able to grow and thrive under the same environmental conditions and stresses. Plants in communities typically occupy different parts of the system, both

physically and in terms of resource use. Selecting species to form designed communities should include an understanding of factors such as vertical layering from the ground plane to canopy.

2. Plant species selection must minimize the use of overly aggressive species. Plant species in a community compete for space and resources. Aggressive, rapidly growing species will overwhelm slower-growing species, so consideration should be given to selecting species that are able to maintain a balance to avoid the system becoming dominated by just one or two species.

U. Growth Habit - Height

1. When selecting tree species, potential conflicts with overhead utilities must be considered. Proximity to buildings and other structures must also be considered. Each species has a typical range that is reached at maturity if project site conditions support the growth requirements of the plant. In deeper systems, taller species should be used to be visible at maturity above the pavement grade.



Large scale stormwater management features provide opportunity for habitat connectivity

Plant heights at both installation and maturity should be considered in terms of pedestrian and vehicular circulation and sightlines – especially at intersections. Where applicable, a clear zone between 4' and 7' should be maintained to provide sightlines.

V. Soil Volume

1. Trees shall have sufficient soil volume for root development and healthy growth. For broad canopy trees, two cubic feet of soil shall be provided for every square foot of canopy projection (diameter spread). A number of studies have examined the relationship between tree growth and soil volume. Note that trees are able to share soil volume, so individual soil volume may be slightly lower.

W. Light Requirements

1. A sun/shade analysis for proposed conditions should be completed for each project site to determine which species are best suited for the expected light exposure in the system. Plants have different requirements and tolerances for sunlight and shade that must be considered when developing a planting design for BMPs. Project sites may be exposed to full, intense sunlight all day or be shaded or partially shaded by adjacent trees and buildings. Even the plant palette selected for the BMP can create areas of shade for lower growing plants. The depth of a vegetated BMP can also affect sun exposure, with the concrete walls of the system casting shade similar to a building.

X. Hydrologic Zones

1. Plant selection for BMPs must reflect species characteristics in relation to the hydrology of each BMP which is a function of the designed maximum ponding depth, infiltration rate, draw-down time, stormwater soil mix, and steepness of side slopes. Plant species vary in their tolerance of different moisture conditions. Some species are able to withstand long periods of inundation, while others will perform poorly because of extended periods of ponding and/or saturated soil. Similarly, drought tolerance varies among species. Designers should understand that hydrologic conditions can vary widely within a single BMP, even for smaller BMPs, and vary widely over time. Where possible, a strategy using plants that have a wide moisture tolerance is preferred.

Y. Salinity Tolerance

1. Plants with high salt tolerance should be used in the right-of-way or other high salt environments. Stormwater BMPs adjacent to pavements treated with deicing chemicals expose plants to potential salt damage. Salt carried by runoff may accumulate in the soil from melted snow, or it may be dispersed in an aerosol spray by fast-moving traffic and strong winds along wet, salted roads. Rock salt (sodium chloride), the most commonly used deicer, disrupts soil



For bioinfiltration systems placed next to roadways, designer should consider plant tolerance for a variety of difficult site factors such as large swings in hydrology, high salinity and pollutants when making a selection.

chemistry, structure, and microbial communities, which makes soil unsuitable for proper root growth and development. Salt spray in contact with plant tissues causes damaging desiccation. Note that a plant's tolerance to soil salt may differ from its tolerance to salt spray.

Z. Seasonal Interest

1. Vegetation design should reflect considerations for season interest. Stormwater BMPs provide an opportunity to create attractive neighborhood amenities through the selection of plant species that exhibit characteristics with year-round and seasonal interest. Flowers, fruits, foliage, and bark have various colors and textures that become more or less pronounced throughout the growing season and during winter dormancy. Evergreen species also contribute to winter interest.

4.2.a.ix. Inspections, Routine Maintenance, and Monitoring

Routine inspection and maintenance of BMPs is required to ensure continual performance as designed and to maximize lifespan. As part of the design, considerations for safe and effective access to allow for maintenance is required. To ensure long-term performance and effective inspections and maintenance practices the following elements are required as part of the BMP design:

- A. All surface and subsurface components are required to provide unobstructed and safe access for inspection and maintenance.
- B. All Occupational Safety and Health Administration (OSHA) standards shall be considered as part of the design including but not limited to confined space entry and fall protection. Designers should limit the need for confined space training or fall protection equipment to perform routine inspections and maintenance wherever possible.
- C. Consideration for vacuum truck access for maintenance of conveyance, storage, and outlet control components must be taken into consideration from the initial concept design.
 1. Vehicular access routes must allow for a total load of 68,000 pounds when a standard vacuum truck is fully loaded.
 2. Vehicular access routes must be at least ten feet wide with a maximum slope of 10%.
 3. Soil stabilization or structural paths using permeable grass pavers, geoweb, or other permanent soil stabilization practices may be necessary in some cases.
- D. Every run of pipe shall be accessible at either end of the pipe, at minimum. Access points may include cleanouts and an inlet connection.
- E. The end of all underdrain pipes shall have threaded end caps to allow for maintenance access from the outlet structure.



- F.** Cleanouts, manholes, and other access features shall be provided to allow unobstructed and safe access to BMPs for routine maintenance and inspection of piping and storage systems, and meet the following requirements:

 - 1.** Unobstructed and safe access must be provided to all access features for inspection and maintenance.
 - 2.** Cleanouts shall be included, at minimum, every 75 feet and at the end of all pipes.
 - 3.** Cleanouts shall be located upstream of complicated bends and shall be evenly spaced during straight pipe runs.
 - 4.** All intermediate (mid-run) cleanouts shall be oriented downstream to direct all video pipe inspections towards an inlet or access structure.
 - 5.** Whenever possible, cleanouts shall not be located in driveways or in travel lanes.
- G.** Observation wells and other monitoring port features shall be provided for all subsurface storage systems and shall meet the following requirements:

 - 1.** A minimum of one (1) observation well or monitoring port shall be provided for each BMP, including BMPs that are fully lined with an impermeable liner.
 - 2.** For any subsurface system, an initial observation well needs to be located within 50 feet of the primary inlet. All elements of the system then need to be within 100 feet of this initial observation well, or any subsequent additional observation wells, so that that all elements of the system can be observed.
 - 3.** An observation well shall be located near the center of each storage system to monitor the level and duration of water stored within the system (drain-down time).
 - 4.** For multi-tiered systems and storage systems with check dams, an observation well shall be placed in each tiered storage area.
 - 5.** The observation well shall extend to the bottom of the system but not through impermeable liner if lined. The observation well riser pipe shall be fully perforated to allow water to freely enter and exit the well from all sides.
 - 6.** Adequate inspection and maintenance access to observation wells shall be provided.

Regular or continuous monitoring of the systems using level sensors is also highly encouraged but not required. Regular monitoring allows BMP designs to be improved upon with each successive iteration and allows for possible BMP performance trouble shooting. The data collected can be a useful design tool and can indicate when an established maintenance schedule may be insufficient.

4.2.a.x. Material Standards

Piping

- H. All buried subsoil storm sewer pipe shall conform to the following materials and standards:

Material	Standard
Cast-iron pipe	ASTM A74; ASTM A888; CISPI 301
Polyethylene (PE) plastic pipe	ASTM F405; ASTM F667; CSA B182.1; CSA B182.6; CSA B182.8
Polyvinyl chloride (PVC) plastic pipe (type sewer pipe, SDR 35, PS25, PS50 or PS100)	ASTM D2729; ASTM D3034; ASTM F891; CSA B182.2; CSA B182.4
Reinforced Concrete Pipe (RCP)	STM C14, ASTM C76
Stainless steel drainage systems, Type 316L	ASME A112.3.1
Vitrified clay pipe	ASTM C4; ASTM C700

- I. Backfilling over the pipe shall be to ASTM D2321 or the pipe manufacturer's specifications, whichever is greater. Cover shall be compacted to at least 95 percent of its maximum dry density as determined by ASTM Test D1557, Method D.
- J. Joints shall be watertight according to the requirements of ASTM D3212.
- K. Fittings shall conform to the following materials and standards:

Material	Standard
Cast-iron pipe	ASME B16.4; ASME B16.12; ASTM A74; ASTM A74; ASTM A888; CISPI 301
Polyethylene (PE) plastic pipe	ASTM F2306/F2306M
Polyvinyl chloride (PVC) plastic pipe (type sewer pipe, SDR 35, PS25, PS50 or PS100)	ASTM D2665; ASTM D331; ASTM F1866
Reinforced Concrete Pipe (RCP)	ASTM C443
Stainless steel drainage systems, Type 316L	ASME A112.3.1

- L. Perforated pipe shall have AASHTO Class II perforations. Class II perforations shall be located in the outside valleys of the corrugations, be circular and/or slotted, and evenly spaced around the circumference and length of the pipe. The opening area shall be no less than 0.945 square inches per linear foot (pipe diameters 4 through 10-inches).

Subsurface Storage Aggregate

- M. Subsurface storage aggregate shall consist of uniformly graded, crushed, clean-washed stone meeting AASHTO No. 3 or No. 57 requirements.
- N. Aggregate shall not surpass 0.5% wash loss under ASTM C 117 or AASHTO T-11 testing.



Maintenance and Monitoring Structures

- O.** Cleanouts shall be made of rigid material with a smooth interior having a minimum inner diameter of four (4) inches. Cleanouts shall meet the piping material standards listed above in this section. Covers and frames shall be ductile iron and lockable with a solid cap.
- P.** Observation wells shall be minimum inner diameter of four (4) inches with a smooth interior. The pipe shall meet the piping material standards listed above in this section and be perforated in the BMP storage vertical section to allow for water entry and post construction water level performance monitoring. Covers and frames shall be ductile iron and lockable with a solid cap.
- Q.** Aggregate fill around cleanouts and observation wells shall be clean washed stone and consistent with surrounding storage aggregate in size. In the case of a free-standing observation well which is not located within a given stormwater structure, the aggregate utilized shall be clean washed AASHTO #57.

Geotextile Fabric and Impermeable Liners

- R.** Non-woven geotextile (drainage filter fabric) shall have the following properties at a minimum.
 - 1.** Minimum flow rate 90 gal/min/ft² (ASTM D4491)
 - 2.** Minimum grab tensile strength 200 lbs (ASTM D4632)
 - 3.** Minimum CBR puncture strength 300 psi (ASTM D6241)
 - 4.** Minimum tear resistance 80 lbs (ASTM D4533)
 - 5.** Minimum UV resistance 70% retained strength (ASTM D4355)
- S.** Geotextiles associated with modular proprietary stormwater systems shall be as specified by the manufacturer.
- T.** Impermeable geomembrane liners shall be High Density Polyethylene (HDPE) with a thickness of 40 mil and conform to PennDOT Specifications (Publication 408, Section 736).

4.2.b. Bioinfiltration/Bioretention

Bioretention and bioinfiltration BMPs are vegetated depressions that use surface ponding, plants, soil, and/or subsurface storage media to manage stormwater runoff. Bioretention and bioinfiltration BMPs reduce stormwater pollution by filtering runoff through the various layers of the BMP, including a vegetated soil medium, and reduce stormwater volume through evapotranspiration. Bioretention BMPs slowly release the collected stormwater to the sewer system while bioinfiltration systems permanently remove stormwater through infiltration into the native subsoil. Infiltration systems are required when deemed feasible as they reduce the volume of the stormwater entering the sewer and provide groundwater recharge. These BMPs can also be designed to mitigate peak runoff rates.

Bioretention and bioinfiltration BMPs can be implemented in a variety of applications such as in private parking lots as a basin or within the right-of-way

as a stormwater planter or bumpout. They can also be used in series with other BMP types.

Key Advantages

- » Flexible layout that is easy to incorporate into landscaped areas
- » Effective at reducing stormwater volume and peak runoff rates
- » Provides additional stormwater management through evapotranspiration
- » Improves air quality and reduces carbon footprint
- » Reduces urban heat island effect
- » Provides wildlife habitat
- » Can improve aesthetic appeal and property values of the surrounding neighborhood
- » Creates opportunities for community engagement at schools, libraries, or other highly-visible locations.

Key Limitations

- » May need to be used in combination with other BMPs to fully meet volume control and rate control requirements
- » May be limited by surface-level space constraints

Key Design Considerations

- » On steep or moderately sloped project sites, a multi-tiered system can be constructed to reduce excavation and maintain natural contours. These systems should include berms, check dams, and upstream forebays for pretreatment and/or retention areas.
- » Project sites with space constraints should incorporate planters or tree pits for bioretention/bioinfiltration instead of a basin design.
- » Bioretention/bioinfiltration BMP design should consider both stormwater management capabilities and landscaping value and appeal.
- » Should be integrated with other project site considerations and features such as streetscape design elements and how the project site will be used, as opposed to stand-alone and/or drop-in features.
- » Installations adjacent to walkways or other pedestrian areas shall have raised curbs and/or fencing for pedestrian safety.
- » Ponding should be limited near play areas, schools, or other environments where young children are present.
- » Plant selection should emphasize species that have wide moisture tolerance and are generally tolerant of urban conditions.
- » Pretreatment is essential for controlling sedimentation within bioretention/infiltration areas. Excessive sediment loading can result in poor establishment and rapidly clogging media.

BMP Components and Design Standards

The following section provides an overview of typical components and design standards for bioretention/bioinfiltration BMPs. Refer to Section 4.2.a, “General Design Requirements,” where indicated.

Pretreatment

- A.** Refer to the pretreatment sub-section of Section 4.2.a, “General Design Requirements.”

Conveyance

- B.** Refer to the conveyance sub-section of Section 4.2.a, “General Design Requirements.”

Storage

- C.** The maximum allowable ponding depth for volume control shall be 6 inches unless otherwise approved by the reviewer.
- D.** Bioretention/bioinfiltration BMP basins shall have a maximum side slope of 25%. Steeper slopes may be allowed by the reviewer provided adequate fall protection and safety provisions are implemented as stipulated under Section 4.2.a.i, “BMP Safety and Performance.”
- E.** Bioretention/bioinfiltration BMPs shall have a minimum stormwater soil depth of 18 inches for herbaceous plants, 24 inches for shrubs and 36 inches for trees.
- F.** Bioretention/bioinfiltration BMPs shall have a minimum mulch depth of three (3) inches on the surface.
- G.** Refer also to the storage sub-section of Section 4.2.a, “General Design Requirements.”



Vegetation

- H. Refer to the vegetation sub-section of Section 4.2.a, “General Design Requirements”.
- I. Vegetation shall be selected based on the location within the following four (4) zones. Note: all bioretention/bioinfiltration systems may have not have all four of these zones depending on the BMP setting and configuration.
 1. In-flow or Entry Zone – This zone is typically a high stress area for plants that is characterized by rapid inflow of a large volume of water, with the highest concentration of sediment and pollutants. This area usually requires the most maintenance. Consequently, plants selected for this zone must be able to tolerate these stressors. Deep-rooted grass species are generally suited for this zone and are able to stabilize the soil and prevent erosion.
 2. Lowest Zone – This zone is the deepest part of the BMP and experiences the greatest amount of ponding and fluctuating water levels. Depending on system design, plants may be exposed to the maximum surface ponding depth of 6” of inundation, as well as periods of drying.
 3. Middle Zone – This zone is at the upper limit of ponding, experiences some water level fluctuation and is slightly drier than the Lowest Zone.
 4. Highest Zone – This zone comprises the upper slopes of the system above the ordinary ponding elevation and is the driest part of the BMP, with possible extended periods of drought.



Outlet Control

- J. Refer to the outlet control sub-section of Section 4.2.a, “General Design Requirements.”

Maintenance and Monitoring Considerations

- K. Refer to the maintenance and monitoring sub-section of Section 4.2.a, “General Design Requirements,” and Section 7, “Operations and Maintenance.”



Material Standards

This section provides material standards for bioretention/bioinfiltration BMPs. Refer to the materials sub-section of Section 4.2.a, “General Design Standards,” for additional requirements.

Subsurface Storage

- L. Refer to Section 4.2.c, “Subsurface Infiltration/Detention,” for subsurface storage media standards.

Stormwater Soil

- M.** Stormwater soil shall consist of uniformly mixed individual soil components (topsoil, sand, and compost) that meet the criteria described below.

Topsoil

- N.** Topsoil is soil comprised of loose, friable mineral particles resulting from natural soil formation from the A, E and upper B horizons, or “solum” where most plant roots grow. Topsoil that has been stripped from the project site may be used as stormwater soil providing it meets the specifications. Topsoil shall be free of construction and trash debris, rocks, hydrocarbons, petroleum materials, herbicides, or other harmful contaminants that would negatively impact plant growth.

Topsoil shall comply with the following parameters:

1. USDA soil texture class: loam or sandy loam
2. Organic matter (ASTM F1647, Method A): 1.5% minimum (by dry weight)
3. pH (1 soil : 1 water): 6.0 - 7.5

Sand

- O.** Sands used in the manufacture of stormwater soils shall be clean, sharp, hard, durable natural quartz sands free of loam, clay, limestone (calcareous sand), shale and slate particles, organic matter, and harmful contaminants that would negatively impact plant growth. Round or fine sand, including masonry sand, shall not be used. Sand shall have a ratio of the particle size for 70% passing (D70) to the particle size for 20% passing (D20) shall be 3.0 or less ($D70/D20 < 3.0$). The sand shall have a pH between 6.0 and 7.5.

Compost (Organic Amendment)

- P.** Compost shall be as defined by the “US Composting Council Landscape Architecture / Design Specifications for Compost Use, Planting Bed Establishment with Compost.” Compost shall be a well decomposed, stable, weed-free organic matter source derived from agricultural or food waste; leaf litter and yard trimmings; and/or municipal source-separated solid waste. The product shall contain no substances toxic to plants and shall be reasonably free (< 1% by dry weight) of synthetic foreign matter. The compost will have no objectionable odors and shall not resemble the raw material from which it was derived.

Laboratory analysis shall be no more than 90 days old at time of application.

Compost shall comply with the following parameters:

1. pH: 6.0 - 7.5.
2. Soluble salt content (electrical conductivity, 1 soil : 2 water): maximum 5 dS/m (mmhos/cm).

3. Compost derived from stabilized mushroom soil compost may possess a maximum EC of 10 dS/m (1:2), if the maturity testing is a minimum of 95% and ammonia (NH₄) content is a maximum of 250 ppm.
 4. Moisture content %, wet weight basis: 30 – 60.
 5. Organic Matter Content, % dry weight basis: 30 – 65.
 6. Particle size, dry weight basis: 98% pass through 1/2 inch screen.
 7. Stability carbon dioxide evolution rate: mg CO₂-C/ g OM/ day ≤ 3.
 8. Maturity, seed emergence and seedling vigor, % relative to positive control: minimum 80%.
 9. Physical contaminants (inerts), %, dry weight basis: <0.5%.
 10. Chemical contaminants, mg/kg (ppm): meet or exceed US EPA Class A standard, 40CFR § 503.13, Tables 3 levels.
 11. Biological contaminants select pathogens fecal coliform bacteria, or salmonella, meet or exceed US EPA Class A standard, 40 CFR § 503.32(a) level requirements.
- Q.** Stormwater soil shall meet the requirements set out in Table 4.7 and meet USDA soil texture classifications as sandy loam or loamy sand. Particle size distribution shall follow ASTM F-1632.

TABLE 4.7. STORMWATER SOIL PARTICLE DISTRIBUTION

Particle Type	Size Range	% Volume
Gravel	2.0 – 12.7 mm	≤12
Coarse – Medium Sand	0.25 – 2.0 mm	≥65
Fine – Very Fine Sand	0.07 – 0.25 mm	≤17
Silt	0.002 – 0.07 mm	≤20
Clay	≤ 0.002 mm	5 – 15

- R.** Organic matter shall be 4-7% of mixture by dry weight as measured by ignition using ASTM F1647, Method A. Compost used to achieve the specified organic matter content shall not be added at more than 30% by volume.
- S.** Stormwater soil shall not contain clods of soil greater than three inches in diameter.
- T.** Hydraulic conductivity (ASTM F1815) shall be 2.0 – 6.0 inches/hour at 75% Proctor.
- U.** pH shall be between 6.0 and 7.2.
- V.** Soluble salt content shall not exceed 1.60 mmho/cm when measured as a 1:2 soil-water ratio. Sodium (Na) salinity shall not exceed 700 ppm.
- W.** Cation Exchange Capacity shall not be less than 12 meq/100g.

Mulch

- X.** Mulch shall be double-shredded hardwood bark, aged six months to one year. Particle size shall be 2 inch or less in any dimension with

less than thirty percent (30%) composed of fines. Mulch shall be free of mold, wood chips from boards, dirt, sawdust, stones or other undesirable matter. Mulch shall be natural and undyed.

- Y.** pH between 5.5 and 7.2.
- Z.** Salinity less than 3.0 millimhos per centimeter (mS/cm).

Construction Considerations

- AA.** Refer to Section 4.2.a, “General Design Requirements,” for general and subsurface storage media construction standards.
- AB.** Refer to Section 6, “Construction Guidance,” for additional general construction guidance and required submissions.
- AC.** Stormwater soil shall be tested for each batch upon delivery to the project site to ensure quality assurance.
- AD.** Do not mix, deliver, place, grade, plant or seed stormwater soil when frozen or wet, as after a heavy rain.
- AE.** For systems with subsurface storage, confirm that the top elevation of the storage is at the proper elevation before installing stormwater soil.
- AF.** Place stormwater soil in systems using equipment operating on stable ground adjacent to the system. Do not use rubber-tired or heavy equipment within the perimeter of the system at any time. For larger systems that are not fully accessible from outside the perimeter, use wide-track or balloon tire machines rated with a ground pressure of 4 psi or less.
- AG.** Place stormwater soil in 12-inch depth lifts until the specified depth is achieved. Scarify the surface area of each lift by raking immediately prior to placing the next lift. Overfill by 10 -15% or as needed to allow for settlement of the soil. To encourage settling of stormwater soil, saturate the entire footprint of the BMP area after each lift of soil is placed.
- AH.** Where possible place trees first and fill stormwater soil around the root ball.
- AI.** Perform final grading of the stormwater facility after a twenty-four (24) hour settling period. Final elevations shall be within two (2) inches of elevations shown on drawings to allow for mulch.
- AJ.** Place mulch and hand grade to confirmed, final elevations.
- AK.** Phase work so that equipment to deliver or grade soil does not have to operate over previously installed stormwater soil.

4.2.c. Subsurface Infiltration/Detention

A subsurface infiltration and detention system is an underground storage area which captures and temporarily stores stormwater below an impervious or vegetated surface. Subsurface infiltration and detention systems typically store stormwater runoff until it infiltrates into the native soil below and/or slowly released through an outlet control structure to the sewer system or a downstream BMP. The subsurface storage may consist of clean-washed, open-graded stone aggregate, perforated pipes set in a stone bed, or other proprietary

stormwater storage products. Subsurface infiltration and detention systems can be implemented in series with other BMPs to achieve volume and rate control requirements, however subsurface detention systems without additional filtration will not meet water quality filtration requirements in MS4 areas.

Subsurface infiltration and detention system designs vary by project site and space constraints but are versatile and can be suitable in many different locations. They are typically well-suited for expansive level areas where surface BMPs are not feasible due to program requirements, such as playgrounds, paved areas where porous pavement is not suitable, athletic fields, or turf areas.

Key Advantages

- » Flexible layout that is easy to incorporate beneath project sites.
- » Can manage stormwater in areas with limited surface or rooftop space.
- » Effective at reducing runoff rates and volumes.

Key Limitations

- » May have higher installation and maintenance costs than surface BMPs.
- » Systems can easily clog if stormwater is not pretreated and maintenance is not consistent.
- » Stone based storage systems cannot be cleaned if clogged and require full replacement. This can add significant cost, particularly for systems located under paved areas.
- » No aesthetic or environmental benefits compared to surface BMPs.
- » Subsurface detention systems require additional media filtration to comply with the water quality requirement. This can add significant cost.



Key Design Considerations

- » 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.
- » 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.
- » Pipes, arches, crates, and other proprietary structures may be used for increased void space, however loading ratios should be considered. See Section 4.2.a.iv, “Loading Ratios,” for Loading Ratio requirements.
- » Landscape features or surface BMPs can be implemented on top of the subsurface infiltration or detention system, provided that appropriate separation and barriers are incorporated.
- » Designers should be aware of the potential for shortcutting between the primary storage areas and bedding materials used for outlet controls. Impermeable barriers may be needed to ensure that these areas are not hydrologically connected.
- » Structural suitability to support traffic loading should be considered, where applicable.
- » Buoyancy calculations and anti-floatation measures may be needed for closed storage chambers such as tanks and vaults.

BMP Components and Design Standards

The following section provides an overview of typical components and design standards for subsurface detention and infiltration BMPs. Refer to Section 4.2.a for “General Design Standards”.

Pretreatment

- A.** Refer to the pretreatment sub-section of Section 4.2.a, “General Design Standards”.

Storage

- B.** Refer to the storage sub-section of Section 4.2.a, “General Design Standards”.
- C.** Manufacturer’s guidelines must be followed if using proprietary modular storage structures such as arches, crates, or chambers.

Vegetation

- D.** Subsurface infiltration and detention BMPs do not include vegetation, but they can be used in series with vegetated BMPs such as bioretention/ bioinfiltration BMPs.

Outlet Control

- E.** Refer to the outlet control sub-section of Section 4.2.a, “General Design Standards”.



Maintenance and Monitoring

- F. Refer to the maintenance and monitoring sub-section of Section 4.2.a General Design Standards and Section 7, “Operations and Maintenance.”

Material Standards

This section provides material standards for subsurface infiltration/detention BMPs.

- G. Refer to the materials sub-section of Section 4.2.a, “General Design Standards.”

Construction Considerations

- H. Refer to the construction sub-section of Section 4.2.a, “General Design Standards.”

4.2.d. Porous Pavement

Porous pavement is an alternative to traditional pavement that allows rain and snowmelt to drain through the pavement surface into a subsurface storage bed. This subsurface layer provides storage for stormwater runoff while allowing infiltration into the native soil below, or slow release back to the sewer system. Porous pavement can be used in combination with other BMPs to meet stormwater management requirements.

Types of porous pavement surfaces may include, but are not limited to: porous asphalt, porous concrete (cast-in-place and pre-cast), permeable pavers, reinforced turf, and synthetic turf. 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.

Porous pavement can be designed to be structurally comparable to traditional pavement in order to support vehicular traffic loading. Applications of porous pavement may include parking lanes, parking lots, sidewalks, bike lanes, and recreation surfaces (e.g., athletic courts/fields, running tracks, playgrounds, etc.).

Key Advantages

- » Can be used in place of traditional paving materials.
- » Allows for a highly customizable footprint.
- » Can be used in combination with other BMP types.
- » Can improve drainage and reduce standing water and ice buildup associated with traditional pavement surfaces.
- » Ideally suited for hardscapes, athletic courts, pathways, and other areas with low vehicular loading.
- » Provides secondary benefits such reduction of urban heat island effect, quieter vehicular traffic, and reduction of road glare compared to standard asphalt.

POROUS PAVEMENT FOR RATE CONTROL

The following curve numbers for porous pavement surfaces may be used for rate control calculations:

CN	Hydrologic Soil Group
70	A
70	B
74	C
80	D
70	Ub

Alternative curve number values may be considered when supported by submitted analysis and relevant references, which will be reviewed on a case-by-case basis.

Key Limitations

- » Can be more expensive compared to other BMP types, due to limited loading ratios.
- » May be prone to frequent clogging, particular if run-on is conveyed to the practice.
- » Requires knowledgeable installer.
- » Not recommended in high traffic areas or heavy industrial areas where heavy debris and sediment loads may quickly clog porous surfaces.
- » Not recommended in areas of heavy vehicular loading such as loading docks.
- » Requires regular maintenance with specialized equipment.
- » Not recommended for areas where gasoline or other hazardous materials may be stored or handled.
- » Application of winter deicing salts on the project site should be considered as contact with permeable porous material could result in degradation.

Key Design Considerations

- » Design of paving sections must consider anticipated structural loading.
- » Maintenance access for routine cleaning by regenerative air sweeping equipment must be considered.
- » Porous pavement that receives run-on from adjacent drainage areas may require more frequent maintenance.
- » Installations located under or near tree canopies may require more frequent maintenance. Wind may also introduce pollen, seeds, and other particulates, even if porous pavement is not located directly underneath trees.
- » Consider using for parking overflow or less used parking stalls.
- » Installation of paver systems can provide more aesthetically pleasing look in highly visible public areas.
- » Pre-fabricated modular concrete panel systems can be faster and easier to install and also provide increased realizability versus cast-in-place systems.

BMP Components and Design Standards

The following section provides an overview of typical components and design standards for porous pavement BMPs. Refer to Section 4.2.a for General Design Standards.

Pretreatment

Porous pavement surfaces provide filtration of large particles at the surface. The small voids in the pavement surface provide a barrier to limit sediment, trash, debris and pollutants from entering the subsurface storage layer. Pretreatment is required for any stormwater that directly enters the subsurface storage layer.

- A. Refer to the pretreatment sub-section of Section 4.2.a, “General Design Standards.”

Conveyance

Porous pavement controls the inflow of stormwater to the subsurface storage area via voids in the pavement material surface. Overflow inlets are often included as a redundant capture method downstream of the porous pavement.

- B. Edge restraints must be used for porous pavers and must be in accordance with manufacturer’s minimum specifications. Edge restraints may be used for porous asphalt and porous concrete, as necessary. If not otherwise specified, concrete curbing shall be acceptable in all applications where the curb extends below the paver bedding layer.
- C. Porous pavement shall meet all surface requirements of the latest ADA requirements and accessibility guidelines.
- D. Porous pavement must be certified by H-20 loading or greater for all traffic applications.
- E. Porous pavement surfaces shall have a minimum surface slope of 1% to provide positive drainage in overflow events or in the event of porous surface clogging.
- F. The surface infiltration rate through the porous pavement surface shall be a minimum 60 inches per hour.
- G. Refer to the conveyance sub-section of Section 4.2.a, “General Design Standards.”

Storage

Subsurface storage, typically clean-washed stone, is located directly below the porous pavement surface. Refer to Section 4.2.a.v for General Storage Design Standards. This storage volume temporarily holds the stormwater runoff in the void space allowing for infiltration to the native soils below. The storage layer will vary in depth to meet the volume storage requirements and may also incorporate pipes, arches, or other structures with larger void space if required.

- H. If the stone storage media is comprised of AASHTO #57 stone, a choker course is not required. If the stone storage media is comprised of AASHTO #3 stone, a AASHTO #57 stone choker course is required.
- I. If required, the choker course shall have a minimum depth of two (2) inches or as specified by the manufacturer.
- J. Check dams, if proposed, shall meet the following requirements:
 1. Check dams shall be installed as needed to accommodate significant grade changes and limit the overall system depth while maintaining a flat bottom storage bed.
 2. At least six (6) inches between the top of the check dam and the top of the storage media shall be provided.
 3. Allowable check dam types include:
 - Compacted earthen berms,
 - Concrete,

- PVC, and
 - Plastic lumber.
4. Compacted earthen berm check dams shall be constructed with a maximum 1:1 side slopes and have a minimum top width of 18 inches.
- K. Refer to the storage sub-section of Section 4.2.a, “General Design Standards.”

Vegetation

Porous pavement does not typically include vegetation components, with the exception of reinforced turf applications. However, porous pavement can be used in series with vegetated BMPs such as bioretention/bioinfiltration BMPs.

Outlet Control

- L. Refer to the outlet control sub-section of Section 4.2.a, “General Design Standards.”

Maintenance and Monitoring

- M. Porous pavement BMPs must allow for routine maintenance access by regenerative air sweeping equipment. A minimum width of eight (8) feet is recommended.
- N. Refer to the maintenance and monitoring sub-section of Section 4.2.a, “General Design Standards,” and Section 7, “Operations and Maintenance.”

Material Standards

This section provides material standards for the inlet control, storage media, and outlet control of porous pavement. Refer to the materials sub-section of Section 4.2.a, “General Design Standards,” for general requirements and subsurface stone storage requirements.

Porous Asphalt

- O. Porous asphalt mix design shall result in pavement that accept 60 inches per hour. Testing shall be in accordance with ASTM D6390.
- P. Bituminous surface shall be made of a bituminous mix of 5.75% to 6.75% by weight dry aggregate.
- Q. Asphalt binder course drain-down shall not exceed 0.3% under ASTM D6390 testing.
- R. Asphalt aggregate shall be clean and open-graded.
- S. At least 95% by mass (weight) of aggregate shall have one (1) fractured face and 90% shall have two (2) fractured faces under ASTM D5821 testing.
- T. Flat particles shall have a 5:1 ratio with a 10% maximum and elongated particles shall have a 3:1 ratio with a 20% maximum under ASTM D4791 testing.
- U. Hydrated lime, if required, shall conform to ASTM C 977 and be blended with dry aggregate at a rate of 1.0% by weight.

- V. Asphalt aggregate shall be 100% crushed material with gradations conforming to the tables below:

TABLE 4.8. BINDER COURSE GRADATION	
U.S. Standard Sieve Size	% Passing by Weight
1"	100%
3/4"	90-100%
1/2"	80-100%
3/8"	50-80%
No. 4	10-20%
No. 8	5-10%
No. 40	3-8%
No. 200	0-3%

TABLE 4.9. WEARING COURSE GRADATION	
U.S. Standard Sieve Size	% Passing by Weight
5/8"	100%
1/2"	95-100%
3/8"	70-95%
No. 4	20-40%
No. 8	10-20%
No. 40	0-8%

- W. Asphalt binder shall meet the requirements as specified in AASHTO M320.
- X. Neat asphalt binder shall be modified with a styrene-butadiene-styrene elastomeric polymer or approved equal to create a binder meeting AASHTO M320 requirements. The elastomeric polymer shall not constitute more than 3% by weight of the total binder.
- Y. Asphaltic mix shall be tested for resistance to water stripping under ASTM D 3625 testing. Anti-stripping agents shall be added if results show that the estimated coating area is under 95%.

Porous Concrete

- Z. Porous concrete shall be produced and provided by a National Ready Mixed Concrete Association (NRMCA) certified plant with concrete meeting all specifications of ACI 522.1-08 Section 1.6.1.1
- AA. Porous concrete shall use either Portland Cement Type I or II conforming to ASTM C 150 or Portland Cement Type IP or IS conforming to ASTM C 595.
- AB. Hydrated Lime shall conform to ASTM C 977.
- AC. Aggregate shall be either No. 8 coarse aggregate conforming to ASTM C 33 or No. 89 coarse aggregate conforming to ASTM D 448.
- AD. Aggregate to cement ratio shall be between 4:1 and 4.5:1. Water to cement ratio shall be between 0.34 and 0.40.
- AE. Concrete void space shall be between 15% and 21% conforming with ASTM C 1688.

Permeable Pavers and Grid Systems

- AF. Pavers shall be interlocking concrete pavers with aggregate joints, or pervious concrete pavers with mortared joints. Aggregate joint material, if used, shall follow manufacturer's recommended guidelines.
- AG. All pavers shall comply with ASTM C936 as a minimum for materials, ASTM C140 for compressive strength, and ASTM C979 for coloring and pigmentation.

Construction Considerations

- AH.** Refer to the construction sub-section of Section 4.2.a, “General Design Standards,” for general requirements and subsurface stone storage requirements.

Porous Asphalt

- AI.** Choker course aggregate should be installed and compacted evenly over the surface of subsurface storage. Choker base course shall be sufficient to allow placement of asphalt, but no thicker than one (1) inch in depth.
- AJ.** Vehicles with smooth, clean dump beds shall be used to transport the asphalt mix to the project site.
- AK.** Porous asphalt mix shall not be stored for more than 90 minutes before placement. Asphalt shall be covered to control cooling.
- AL.** Porous bituminous surface course shall be laid in one (1) lift directly over base course.
- AM.** Surface course shall not be compacted until it is cool enough to resist a ten-ton roller. Porosity and permeability may be reduced if more than two (2) passes are performed with the roller.
- AN.** 48 hours of cooling shall be allowed before allowing vehicular traffic on the surface.
- AO.** Porous asphalt pavement shall not be used for equipment or material storage.
- AP.** After hardening, hydrologic performance of the pavement surface will be tested by applying clean water to a single location at the surface at a rate of at least five gallons per minute. The water applied to the surface should readily infiltrate without creating puddles or runoff.

Porous Concrete

- AQ.** Base material shall be wetted immediately before placement of concrete begins.
- AR.** Concrete shall not be placed in cold weather. Cold weather will be identified as three (3) days with an average daily outdoor temperature below 40°F in accordance with ACI 306.1.
- AS.** The process of curing must begin within 20 minutes of placement. Surface should be covered with 6-mil thick polyethylene sheet.

Porous Pavers

- AT.** Gaps at the edge of paved areas shall be filled with cut units. Cut units subject to vehicular traffic shall not exceed 1/3 of unit size.
- AU.** Pavers shall be compacted with at least two passes of the plate compactor. Compactions shall not occur within six feet of unrestrained edges.
- AV.** Additional aggregate shall be added to the opening of joints as needed after each compaction. Excess aggregate shall be swept before compaction begins again.

4.2.e. Green Roofs

Green roofs, also known as vegetated roofs, rooftop gardens, or eco-roofs, manage runoff that would otherwise be generated by impervious rooftops. Green roofs manage stormwater above ground level, which differs from the ground level stormwater management of other BMP types. The runoff is captured, stored, and treated, all within the confines of the roof.

Green roofs are comprised of multiple layers, including vegetation, growing media, geotextile, storage media, and an impermeable liner. Rainfall is stored within these layers until the stormwater is evapotranspired or slow-released.

Green roofs are divided into two general categories: extensive and intensive.

- » Extensive roofs have a thickness less than six (6) inches, resulting in less management capacity compared to intensive roofs. They are typically planted with succulents, grasses, and other drought-resistant species. Extensive roofs tend to be lightweight, require less added structural support, and are more appropriate for retrofit projects than intensive roofs.
- » Intensive roofs have a thickness greater than six (6) inches, resulting in a greater management capacity compared to extensive roofs. They can sustain a more diverse set of plant types and species, but typically require more maintenance, additional structural support, and higher initial investment.

Green roofs can be utilized on most building types as long as the building is structurally capable of supporting the weight and the roof is not excessively sloped. Green roofs can be implemented on existing buildings as a retrofit or on new buildings.

Key Advantages

- » Manages stormwater while maximizing usable space.
- » Avoids ground-level conflicts with other infrastructure.
- » Increases aesthetic and market value of buildings.
- » Does not usually require new sewer connections and instead utilizes existing infrastructure.
- » Does not require excavation for installation.
- » Can reduce heating and cooling costs by stabilizing temperature fluctuations.
- » Reduces urban heat island effect through evaporative cooling measures.
- » Extends the service life of the roof by protecting the underlying liner from physical damage, temperature extremes, and UV radiation degradation.
- » Improves surrounding air quality by filtering out small airborne particulates.
- » Supports small wildlife communities, such as birds and beneficial insects.
- » Reduces the net carbon footprint of the building over its lifecycle.
- » Can be utilized for highly-visible community engagement activities; such as

GREEN ROOFS FOR RATE CONTROL

A curve number of 86 may be used for green roof surfaces for rate control calculations.

Alternative curve number values may be considered when supported by submitted analysis and relevant references, which will be reviewed on a case-by-case basis.

a recreational space, educational space, or as a rooftop garden/farm.

- » Ideal for project sites with ground-level space constraints.
- » Ideal for project sites with buildings that occupy a large percentage of the total parcel area.

Key Limitations

- » Higher initial investment than traditional roofing.
- » Limited to treatment of roof surfaces
- » May need to be irrigated to maintain vegetation.
- » Some studies have shown that green roofs can increase nutrient loading, particularly if fertilized.
- » May need to be combined in series with other BMP types to fulfill stormwater requirements, particularly for rate control.
- » May not be suitable for some retrofit projects depending on the structural capabilities of building.
- » Limited applications on steeply sloping roofs without structural modifications.
- » Maintenance can cause liability concerns due to work on elevated surfaces.

Key Design Considerations

- » Coordination with architectural and structural engineers early in the design process is essential. Green roofs will affect the operation of other building systems (such as HVAC systems) and should be integrated with these systems for potential cost savings.
- » Green roofs are most effective on flat roofs.
- » Green roofs can be combined with solar arrays to achieve both energy production and stormwater management on the same roof surface. Combined subsidies for green roof and solar generation may make the total cost of these systems lower than conventional roofing or stand-alone green roofs.
- » Green roofs can be effectively incorporated into rooftop amenity space, which is particularly attractive for multi-family residential projects. Underlying the green roof and adjacent hard scape/amenity space with a thin storage layer (a.k.a. “pancake” storage”) can increase the volume and rate control performance of the green roof application in amenity-oriented designs.
- » The effectiveness of the green roof system depends on the level of evapotranspiration that occurs and the outlet control structure configuration (i.e. smart controls). This effectiveness can be increased by considering the following features:
 - Include low-transmissivity drainage layers. Limiting the amount of sand within the drainage layers will limit the hydraulic conductivity of the layer and thereby promote water retention;

- Lengthen flow path to outflow drains;
- Introduce new rainfall interception layers;
- Select plants with dense roots;
- Select growth medium with high water capacity; and
- Including a smart valve to regulate outflow

BMP Components and Design Standards

The following section provides an overview of typical components and design standards for green roofs. Refer to Section 4.2.a for General Design Standards.

General

A. Structural Loading

1. Green roofs must be analyzed for structural loading by a licensed structural engineer. The wet weight of the green roof must be considered, and the potential maximum loads must adhere to the American Society of Testing and Materials E2397.

B. Surface Slope

1. Green roofs shall not exceed a surface slope of 2% in any direction without incorporating additional slope stabilization measures.
2. Green roofs with a surface slope greater than 2% shall include battens to secure drainage layers and prevent erosion while vegetation is being established.

C. Proper waterproofing and root barrier layers must be included to meet the latest International Building Code requirements.

1. The bottom and sides of the system must include an impermeable liner. If the impermeable liner is not resistant to root penetration, an additional root barrier layer should be incorporated to protect the impermeable liner.

Pretreatment

- D.** Green roofs receive direct rainfall and may be designed to receive runoff from adjacent roofs, however this should be limited. Refer to Section 4.2.a.iv, “Loading Ratios,” for loading ratio requirements. The sediment and debris content of runoff managed by green roofs is typically low and therefore pretreatment of the runoff is typically not required unless trees overhang the roof or otherwise provide significant organic loading.

Conveyance

- E.** Refer to the conveyance sub-section of Section 4.2.a, “General Design Standards.”
- F.** Any diverted flow from adjacent impervious areas shall be evenly dispersed across the green roof surface through sheet flow or a level spreader.

Storage

- G.** Stormwater storage typically occurs within the following layers:
 - 1.** Growing medium – holds the stormwater runoff in the void space and provides medium for vegetation
 - 2.** Geotextile – prevents sediment and soil migration between the growing medium and underlying drainage layer
 - 3.** Drainage layer – provides conveyance of stormwater beneath the growing medium
 - 4.** Root barrier/impermeable liner – protects the underlying roof from moisture and root intrusion
 - 5.** Roofing system – provides structure and support
- H.** A filter or separation geotextile that allows root penetration shall be placed between the storage media and growing media to prevent migration of the growing media into the storage media.
- I.** For extensive roofs:
 - 1.** The growing media shall have a minimum allowable thickness of three (3) inches.
 - 2.** The drainage layer shall have a minimum depth of 4 inches below the growing media.
- J.** For intensive roofs:
 - 1.** The growing media shall have a minimum allowable thickness calculated as follows:

Minimum thickness of growing media (inches) = 3 inches + [3(Drainage area/Green roof surface area)]*

Vegetation

Vegetation should consist of a diversity of species to increase viability and mitigate extreme weather conditions.

Approximately 50% of the total number of plants should be comprised of four or more different species of native sedum. Approximately 70% of the total number of plants should be evergreen plants in order to protect from erosion during winter months. Other plants should be comprised of shrubs, herbs, meadow grasses, or meadow flowers, depending on the desired appearance and type of green roof.

Other types of plants can also be considered as long as they are resistant to drought and the growing media is adequate for healthy growth. Planting should take place between April 1st – June 15th and/or between September 15th – November 15th. The plantings should be permitted to establish for one full season before adjacent drainage areas are diverted to the green roof. Depending on project site characteristics and climate, irrigation systems may need to be incorporated within intensive green roof BMPs for maximum plant preservation during dry periods.

- K.** Vegetation, once fully established, must cover the area of the growing media.

Outlet Control

Unlike most other BMP types, the stormwater within the storage media will not infiltrate into the ground. Instead, runoff leaves the system via evapotranspiration and slow-release to another BMP or the sewer via an overflow structure, such as a riser, gutter, or roof drain.

- L. Drains, scuppers, and risers must include a grate or lid and pretreatment measures to prevent clogging by debris.

Maintenance and Monitoring

- M. Green roof systems must be sited to allow for safe and routine access for maintenance and monitoring. Typical roof access will be sufficient in most cases.
- N. Gravel or stone walking paths should be included at regular intervals around the systems to provide access to system structures for maintenance personnel to be able to move about the system unimpeded and to protect plants from damage.
- O. Access to maintenance of adjacent building systems, such as HVAC or electrical equipment, should be considered when siting vegetation footprints.
- P. Green roofs must comply with OSHA Fall Protection Safety Standards and the ANSI and ASSE consensus-based fall protection standards.
- Q. Refer to the maintenance and monitoring sub-section of Section 4.2.a, “General Design Standards,” and Section 7, “Operations and Maintenance.”

Material StandardsGrowing Medium

- R. Growing medium shall meet the following criteria:

TABLE 4.10. MEDIUM TESTING REQUIREMENTS

Test Measurement	Acceptable Range	Testing Method
Moisture Content	≥ 35 %	ASTM E2399
Porosity at water capacity	≥ 6 %	ASTM E2399
Water permeability	≥ 0.25 in/min (15 in/hr)	ASTM E2399
Soluble Salts	≤ 2 mmhos/cm	DPTA
Total Organic Matter	≥ 10 %, ≤ 3 %	MSA
pH	≥ 7.5, ≤ 6.0	MSA

- S. Medium shall be able to withstand freezing and thawing.
- T. Medium must have a saturated permeability of at least six (6) inches per hour (ASTM E2399).

Geotextile

- U. Refer to Material Standards sub-section under Section 4.2.a, “General Design Requirements,” for geotextile standards.

Drainage Layer

- V. Synthetic drainage layers are acceptable if the depth of the drainage layer is less than five inches.

- W.** Granular drainage layers are required whenever the drainage depth is five inches or greater.
- X.** Granular drainage layers shall meet the following criteria:

TABLE 4.11. DRAINAGE LAYER REQUIREMENTS		
Test Measurement	Acceptable Range	Testing Standard
Abrasion Resistance	≤ 25% loss	ASTM C 131 96
Porosity	≥ 25%	ASTM C 29
Soundness	≤ 5% loss	ASTM C 88
Particles passing ½" Sieve	≥ 75%	ASTM C 136

- Y.** Thickness of the granular layer shall be two inches at minimum. Granular drainage layer may be used in conjunction with a synthetic layer.

Impermeable Liner and Root Barrier

- Z.** The following materials are permitted and shall meet the corresponding standard:

PVC liners shall meet ASTM D4434.

EDPM liners shall meet ASTM D4637.

TPO liners shall meet ASTM D6878.

- AA.** Liner shall have waterproof seals at all seams, corners, and other protrusions.
- AB.** Liner shall abide by most recent building codes of the city of Pittsburgh and the International Building Code.

Vegetation

- AC.** All selected plantings must be able to withstand extreme weather, such as high winds, heat, or cold and shall be self-sustaining and tolerant of drought conditions.
- AD.** Roof planting shall avoid *Sedum sarmentosum*, otherwise known as star sedum, gold moss, or graveyard moss.

Construction Considerations

- AE.** Roofs shall have impermeable liners and root barrier/impermeable liner protection layer. Liner shall be inspected for any irregularities with both liner and layer upon installation.
- AF.** Placement of drainage layer, shall be done with care to prevent damaging impermeable liner.
- AG.** If irrigation system is to be installed it is recommended to test the system upon installation and prior to backfilling of geotextile and/or soil.
- AH.** Sedum can be used to establish vegetation using fresh cuttings in the autumn or spring.
- AI.** Perennial plants shall be established as plugs or container plants in the period between April and November. Newly installed plants shall be irrigated as required.

- AJ.** Perennial plants may be established from seeds outside of the summer period (June, July, and August).
- AK.** Full establishment of vegetation may take up to two growing seasons. High wind environments may require wind scour blanket or hydromulch to prevent erosion during the establishment period. Permanent placement of these anti erosion practices may be necessary in some cases.

4.2.f. Ponds and Wet Basins

Ponds, and wet basins, are basins planted with native species that manage stormwater runoff. Unlike conventional detention basins that are covered with mowed lawn, or urban bioretention systems with rigid geometry and hard edges, these basins are designed to appear as naturally occurring features in a landscape.

Three types of basins are described in this section. Regardless of the specific design attributes, all function both to manage stormwater and provide ecosystem services (e.g., wildlife habitat, heat island mitigation, etc.)

Pond and Wet Basin

A pond or a wet basin (also called a retention pond) is a basin with a permanent pool or ponded area that provides water quality treatment and temporary storage capacity for stormwater runoff above the permanent pool.

Wet basins require a connection with shallow groundwater or an adequate source of inflow to maintain a permanent pool. They are best suited to low-lying areas that serve as collection points for stormwater runoff, although it is also possible to convey runoff into ponds via subsurface piping from other BMPs. Almost any drainage area where soils are impermeable enough to support permanent ponding can be feasible for a wet basin.

Stormwater Wetland

A constructed stormwater wetland, like a wet pond, has areas of long-term or persistent soil saturation as well as permanently ponded water. The configuration of a wetland (e.g., microtopography, extent of ponding, flow path, and plant zones, etc.) is more complex than a wet basin, and several variations on the design are possible:

- » Shallow wetlands with a large surface area that provide water quality improvement through displacement of the permanent pool,
- » Extended detention shallow wetlands that use extended detention for water quality and peak rate control,
- » Pocket wetlands that serve smaller drainage areas, and
- » Pond/wetland systems that combine a wet basin and a constructed wetland.

Although constructed wetlands provide habitat and aesthetic value, they are unlikely to have the full range of ecological functions as a naturally occurring wetland and are designed mainly for water quality improvement and rate control.

Both wet basins and constructed wetlands improve the quality of stormwater runoff through settling, filtration, chemical and biological decomposition, uptake and volatilization, and adsorption. Pollutant removal—including suspended solids, heavy metals, total phosphorus, total nitrogen, and pathogens—varies in effectiveness by season as vegetation undergoes dormancy and ambient temperatures rise and fall.

Key Advantages

- » Can be effective at meeting rate control requirements.
- » Although not typically considered volume-reducing BMPs since they are intentionally designed to not infiltrate via a permanent pool, wet basins and constructed wetlands can achieve some volume reduction through evapotranspiration, especially for small storms.
- » Can support native wildlife populations while improving air and water quality.
- » Can reduce urban heat island effects.
- » More aesthetically pleasing than traditional detention basins and other non-vegetated BMP types.
- » Can create opportunities for education and community engagement when sited near schools, libraries, or other public spaces.
- » Centrally located facility can reduce costs and concentrate maintenance needs versus more decentralized networks.
- » Can be effectively paired with other volume reduction BMPs.
- » Capable of accommodating high loading ratios with effective pretreatment.

Key Limitations

- » Requires a large dedicated ground surface area.
- » May include areas of deep water, which require enhanced safety measures to protect residents, customers, or other property users.
- » May attract geese and other wildlife that pose a nuisance to surrounding areas.
- » Cannot be used to meet volume requirement without additional upstream BMPs or basin modifications such as subsurface storage.
- » Cannot be used to meet the water quality requirement without additional filtration.
- » Can be difficult to provide rate control for smaller more frequent events, particularly for smaller drainage areas. This is due to the limitation on minimum outlet structure orifice sizes associated with open basin systems.
- » Clogging of outlet structures can occur without effective pretreatment.

Key Design Considerations

- » To ensure proper function and persistence of ponded areas, adequate contributing drainage area is required (typically 10 acres minimum for a wet pond or wetland; 5 acres for a pocket wetland). A detailed analysis,

including a water budget, may be required to demonstrate adequate base or groundwater flow. The analysis must include all inputs and outputs to the system, including runoff, direct precipitation, groundwater inflow, evapotranspiration, and groundwater outflow.

- » Underlying soils must be relatively impermeable. Soils that are capable of infiltration should not be converted to impermeable systems.
- » Constructed wetlands should be designed with a meandering flow path using berms and grading where space allows for a longer travel time. Longer residence time in the system improves water quality treatment.
- » The discharge from wet basins can have undesirable thermal effects on downstream water bodies supporting cold water fish species. Designers are required to mitigate warm water impacts by planting shade trees around the perimeter, designing the system as a series of pools that can allow cooling to occur before discharge, and positioning the outlet structure in the deep pool to allow for withdrawal of colder bottom water.
- » An analysis of effects to groundwater elevations must be included in siting and design of construction wetland and pond systems to avoid adverse hydraulic impacts, such as raising a seasonally or year-round high water table and causing unwanted surficial ponding nearby or off project site.
- » Goose deterrent/antigrazing measures are typically needed to protect new plant installations during the establishment period.
- » Care should be taken to ensure that constructed wetlands and wet ponds do not attract songbirds in near reflective surfaces (e.g., office windows, etc.) that could be prone to birdstrike.
- » Wildlife blinds, observation platforms, and boardwalks can be incorporated into systems for additional recreational and educational value and to promote community engagement.
- » Access for maintenance for sediment removal.
- » Placement of emergency spillway/overflow should be considered so as to protect public safety during large events.
- » The design of adequately sized forebays for pretreatment is critical to avoiding smothering of plantings and loss of storage volume within the primary basin.

BMP Components and Design Standards

The following section provides an overview of typical components and design standards for pond and wet basin BMPs. Refer to Section 4.2.a for General Design Standards.

General

- A. Depending on the size of the drainage area and the height of the basin embankment, a dam permit may be required. Refer to the latest PADEP dam safety requirements when designing large basin BMPs.
- B. Basins must have a length-to-width ratio of at least 2:1 to the extent possible.

- C. Interior basin side slopes must be 4:1 to 5:1 (H:V) or flatter, and 10:1 maximum for aquatic safety benches. Exterior side slopes must not exceed 3:1 (H:V).
- D. The minimum allowable freeboard is 1 foot (above the maximum calculated water surface elevation within the basin).
- E. Impoundment banks must be less than 15 feet high and shall be fenced around all sides to prevent entry.
- F. Two aquatic safety benches, each 4 to 6 feet wide, must be adjacent to all areas where water depth exceeds 4 feet at normal pool. The first bench must be located 1 to 1.5 feet above the normal water surface elevation and second should be 2 to 2.5 feet below the water surface.

Pretreatment

- G. Basins and stormwater wetlands must have a forebay at all major inflow points to capture sediment and reduce erosion from inflow. Forebays must comprise 10 to 15 percent of the total permanent pool volume and should be 4 to 6 feet deep, or at least as deep as the other open water areas.
- H. The bottom of the forebay can be lined with a hardened material such as stone or concrete to facilitate sediment removal.
- I. Within the forebay permanent vertical markers must be installed to indicate the depth of sediment accumulation.
- J. Refer to the pretreatment sub-section of Section 4.2.a, “General Design Standards.”

Conveyance

- K. Refer to the conveyance sub-section of Section 4.2.a, “General Design Standards.”

Storage

Basins store stormwater runoff in two ways: permanent storage and temporary storage. Permanent storage consists of the inflow and retention of the water required to support the ecosystem, and is associated with the volume of water below the primary low flow outlet control elevation. Temporary storage (which includes both extended detention volume and flood control volume) is comprised of the volume between the low flow orifice and the uppermost overflow orifice or spillway. Water within the temporary storage area will undergo evapotranspiration or slow release and/or bypass, and typically remains in the basin for less than 72 hours. Only the temporary storage volume will be considered meeting the volume, rate, or water quality control requirement.

- L. Refer to the storage sub-section of Section 4.2.a, “General Design Standards.”

Outlet Control

- M. Refer to the outlet sub-section of Section 4.2.a, “General Design Standards.”

Vegetation

- N. Constructed wetlands and wet ponds have a range of hydrologic zones with varying levels of inundation and extent of soil saturation, as well as drier upland areas. Plants selected for these systems must be adapted for the particular hydrologic conditions of a given zone. Typically, these systems have a zone of deep, persistent ponding (pool zone) surrounded by areas of shallower water (marsh zone). Shallow water zones transition to a semi-wet zone that may experience a low level of seasonal inundation or saturated soil.
 1. The pool zone usually has a standing water depth between 2 and 6 feet (8 feet maximum), which supports floating and submerged (depending on water clarity) vegetation but is too deep for most emergent species. The depth of the pool should be shallow enough to prevent thermal stratification (i.e. the development of warm surface and cool bottom water zones during summer months) but deep enough to minimize algal blooms and resuspension by storms and strong winds of previously deposited materials. The addition of bubblers and other types of aeration system can help keep waters well mixed and oxygenated during the summer.
 2. The marsh zone has shallower standing water depths than the pool zone, usually just up to 18 inches. This zone is further characterized as high marsh (0 – 6 inches deep) or low marsh (6 – 18 inches deep), with specific emergent vegetation typical of each area. In constructed wetlands, the marsh zone should comprise at least 60 percent of the water surface area, where as for wet ponds, the marsh zone will typically occupy just a small fringe around the perimeter of the pond.
 3. Plants in the semiwet zone or shoreline fringe (0 – 12 inches above water surface elevation) are species adapted to the more variable hydrology in this zone, which is the interface between wetland and upland.
 4. A 25-foot-wide vegetative buffer from the maximum water surface elevation is recommended for ecological and aesthetic value. Perimeter vegetation at least 24 inches tall will help to deter Canada geese and other nuisance wildlife.
- O. Refer to the vegetation sub-section of Section 4.2.a, “General Design Requirements.”

Maintenance and Monitoring

- P. Regular, effective maintenance is essential to ensure basins meet design performance requirements. All system components that receive and/or trap floatable trash, debris and sediment must be inspected for clogging and excessive accumulation and be accessible for cleaning using vector trucks or other vehicles. Soil stabilization or structural paths using permeable grass pavers may be necessary to provide vehicular access.

- Q. Even with regular annual maintenance, constructed wetlands and wet ponds accumulate sediment, and a full cleanout cycle should be considered as part of the overall maintenance plan.
- R. Water levels and flow volumes must be measured at regular intervals following installation to ensure that hydrologic conditions are similar to the designed condition. If hydrologic conditions are significantly different, this could suggest the need for adjustments to the outlet structure design, a problem with the inflow conveyance system, or the need to adjust the planting palette to match the actual condition.
- S. Wet pond systems may become nutrient rich over time, leading to water quality problems such as algae blooms, excessive weed growth, and low oxygen levels. A yearly monitoring program is suggested to monitor chlorophyll, phosphorus, and water clarity. Based on this monitoring, additional measures to restore water quality may be needed. These may include winter drawdown, addition of algaecides such as copper sulfate, dredging, alum treatment, and the addition of additional pretreatment measures. Selection of appropriate water quality management measures is beyond the scope of this manual. A professional lake or pond management specialist should be consulted.
- T. Wet ponds and wetlands are typically not problematic with respect to mosquitos given that the establishment of natural vegetation facilitates the development of natural predator communities. However, open water areas such as forebays can sometimes act as a breeding area for mosquito larvae. Typically, mosquito “dunks” can be added to small open water areas. These products release a natural and non-toxic surface coating which impedes the development of larvae.
- U. Refer to the maintenance and monitoring subsection of Section 4.2.a, “General Design Standards,” and Section 7, “Operations and Maintenance.”

Material Standards

Subsoil

- V. Underlying subsoils must have limited permeability to retain a permanent pool. Infiltration and soil testing in accordance with Section 3.4, “Soil Assessment and Infiltration Testing,” is required to demonstrate that a permanent pool would be technically feasible.

Planting Soil

- W. Organic soils should be used in the emergent planting zones of wet ponds and constructed wetlands. If natural topsoil from the project site is to be used to create an aquatic planting substrate, it must have at least 8% organic carbon content by weight in the A-horizon for sandy soils and 12% for other soil types.
- X. Equal portions of organic and mineral materials are required for any imported planting medium.
- Y. Imported soil materials must be free of seeds or plant parts from invasive species (see DCNR Invasive Species website).
- Z. Planting soil depth must be at least 12 inches.

Construction Considerations

- AA.** The BMP area must be isolated from the contributing drainage area prior to the start of construction and all inflow must be diverted until the system is completed and stabilized.
- AB.** The area to be used for a wet pond or stormwater wetland should be excavated to the required depth to achieve the designed bottom elevation, including planting soil and an impermeable liner, if specified. Excavation below the water table may create the need for significant dewatering systems, typically involving the use of pumping. The design of such dewatering systems is beyond the scope of this manual. A geotechnical engineer with experience in dewatering design should be consulted.
- AC.** Planting material must be properly packed and handled during all phases of work, including transport and on-site installation, to prevent injury and/or desiccation of plants. Plants must be kept from freezing and kept moist, cool and covered to be protected from precipitation, wind, and other weather.

4.2.g. Dry Basins

Dry basins are earthen impoundments planted with vegetation that are intentionally designed to be dry between precipitation events. During precipitation events, stormwater runoff from adjacent development is conveyed to the basin by a network of upstream stormwater inlets and conveyance piping. Once stormwater runoff reaches the basin, the runoff is temporarily stored within the basin by using a multi-stage outlet structure that restricts the water from exiting the basin. The outflow structure and basin are typically designed in an iterative process to attenuate stormwater runoff peaks and meet associated volume and rate control requirements. Some marginal water quality benefit is also provided within the basin by promoting sediment particle settling. Pretreatment devices such as sediment forebays are required due to commonly high loading ratios. Effective pretreatment will dissipate energy, concentrate sediment, debris, and litter, and provide for a more effective long-term operation and maintenance of the facility.

Key Advantages

- » Centrally located facility can reduce costs and concentrate maintenance needs versus more decentralized BMP networks.
- » Provides rate control for large storm events.
- » Can be effectively paired with other volume reduction BMPs.
- » Capable of accommodating high loading ratios with effective pretreatment.
- » Naturalized meadow, shrub, and tree plantings can provide significant habitat value and visual interest.

Key Limitations

- » Cannot be used to meet volume requirement without additional upstream BMPs.
- » Often requires a large footprint, which may be an issue for more constrained project sites.
- » Can be difficult to provide rate control for smaller more frequent events, particularly for smaller drainage areas. This is due to the limitation on minimum outlet structure orifice sizes associated with open basin systems.
- » Clogging of outlet structures can occur without effective pretreatment.
- » May include areas of deep water during rain events, which require enhanced safety measures to protect residents, customers, or other property users.

Key Design Considerations

- » Access for maintenance must be provided to allow cleaning of sediment forebay (sediment) and basin berms (woody debris).
- » Placement of emergency spillway/overflow should be considered so as to protect public safety during large events.
- » Dry basins experience extremes in hydrologic conditions, including significant inundation and extended drought. As a result, plantings selected within the extended detention zones of dry basins must be able to withstand significant swings in soil moisture.
- » The design of adequately sized forebays for pretreatment is critical to avoiding smothering of plantings and loss of storage volume within the primary basin.
- » Wildlife blinds, observation platforms, and boardwalks can be incorporated into systems for additional recreational and educational value and to promote community engagement.

BMP Components and Design Standards

The following section provides an overview of typical components and design standards for dry basins. Refer to Section 4.2.a, “General Design Requirements.”

Pretreatment

- A.** Refer to the pretreatment sub-section of Section 4.2.a, “General Design Requirements.”
- B.** Basins must have a forebay at all major inflow points to capture sediment and reduce erosion from inflow.
- C.** The bottom of the forebay can be a hardened material to facilitate sediment removal.
- D.** Within the forebay permanent vertical markers should be installed to indicate the depth of sediment accumulation.

Conveyance

- E.** Refer to the conveyance sub-section of Section 4.2.a, “General Design Requirements.”

Storage

- F. Depending on the size of the drainage area and the height of the basin embankment, a dam permit may be required. Refer to the latest PADEP dam safety requirements when designing large basin BMPs.
- G. Interior basin side slopes must be 4:1 to 5:1 (H:V) or flatter, and 10:1 maximum for aquatic safety benches. Exterior side slopes must not exceed 3:1 (H:V).
- H. The minimum allowable freeboard is 1 foot (above the maximum calculated water surface elevation within the basin). Impoundment banks should be less than 15 feet high and shall be fenced around all sides to prevent entry.
- I. Refer to the storage sub-section of Section 4.2.a, “General Design Requirements,” if paired with subsurface storage.

Outlet Control

- J. Outlet control structures are typically multistage devices with pipes, orifices, or weirs for flow control. Orifices, if used, must be at least 2.5 inches in diameter and protected from clogging. The outlet pipe must have an anti-seep collar through the embankment.
- K. Trash racks/overflow grates are required for outlet structures but must not obstruct outflow or act as the hydraulic control for the system.
- L. Online facilities should have an emergency spillway that can pass the 100-year storm safely with 1 foot of freeboard.
- M. Refer to the outlet sub-section of Section 4.2.a, “General Design Standards.”

Vegetation

- N. Vegetation is an essential part of a dry basins, helping to enhance pollutant removal, limit erosion, provide habitat, support soil microbes, shade and cool water, and contribute to extended water circulation and flow path.
- O. Dry basin systems have a range of hydrologic zones with varying levels of inundation and extent of soil saturation, as well as drier upland areas. Plants selected for these systems must be adapted for the particular hydrologic conditions of a given zone. Typically, these systems have a semiwet zone that may experience a low level of seasonal inundation or saturated soil as well as extended detention zones that experience periodic wetting and drying during storm events. Dryer zones occur on basin banks above the extended detention zone and are typically planted with drought tolerant species.
- P. A 25-foot-wide vegetative buffer from the edge of the bottom of basin is recommended for ecological and aesthetic value. Perimeter vegetation at least 24 inches tall will help to deter Canada geese.
- Q. Refer to the vegetation sub-section of Section 4.2.a, “General Design Requirements.”

Maintenance and Monitoring

- R.** Regular, effective maintenance is essential to ensure basins meet design performance requirements. All system components that receive and/or trap floatable trash, debris and sediment must be inspected for clogging and excessive accumulation and be accessible for cleaning using vacuum trucks or other vehicles. Soil stabilization or structural paths using permeable grass pavers may be necessary to provide vehicular access.
- S.** Even with regular annual maintenance, dry basins and associated forebays accumulate sediment, and a full cleanout cycle should be considered as part of the overall maintenance plan.
- T.** Refer to the maintenance and monitoring subsection of Section 4.2.a, “General Design Standards,” and Section 7, “Operations and Maintenance.”

Material Standards

Planting Soil

- U.** Organic soils should be used in the emergent planting zones of dry basins. If natural topsoil from the project site is to be used to create an aquatic planting substrate, it must have at least 8% organic carbon content by weight in the A-horizon for sandy soils and 12% for other soil types.
- V.** Equal portions of organic and mineral materials are required for any imported planting medium.
- W.** Imported soil materials must be free of seeds or plant parts from invasive species (see DCNR Invasive Species website).
- X.** Planting soil depth must be at least 12 inches.

Construction Considerations

- Y.** The basin area must be isolated from the contributing drainage area prior to the start of construction and all inflow must be diverted until the system is completed and stabilized.
- Z.** The area to be used for the basin should be excavated to the required depth to achieve the designed bottom elevation, including planting soil and an impermeable liner, if specified.
- AA.** Planting material must be properly packed and handled during all phases of work, including transport and on-site installation, to prevent injury and/or desiccation of plants. Plants must be kept from freezing and kept moist, cool, and covered to be protected from precipitation, wind, and other weather.

4.2.h. Media Filters

Media filters are structures or excavated areas containing a layer of sand, compost, organic material, peat, or other proprietary filter media or manufactured filter devices that reduce pollutant levels in stormwater runoff. Media filters are primarily used as part of a water quality improvement BMP treatment train in conjunction with other BMPs in series. Media filters are typically not designed for achieving storage volume or peak rate requirements, but instead are combined with other BMPs to meet the full set of stormwater management requirements.

Media filters are commonly used on project sites where the use of vegetated filtration BMPs is infeasible and achieving water quality requirements is needed. The application of media filters are most commonly placed either upstream or downstream of detention practices such as dry basins that do not provide needed water quality pollutant reductions to meet water quality requirements within this manual.

Key Advantages

- » 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 vegetated BMPs.
- » Can be designed to be visible from the surface or completely subsurface, located beneath parking lots or other impervious areas.
- » Media blends can be customized to provide enhanced levels of removal for particular pollutants of interest.
- » Effective when paired with subsurface or surface detention and volume reducing BMPs.

Key Limitations

- » Do not offer aesthetic value, improved air quality, and habitat creation associated with vegetated BMPs.
- » May have sizing requirements that result in large footprints due to allowable filtration rates for filter media such as sand.
- » May have frequent operation and maintenance and filter replacement costs.

Key Design Considerations

- » A primary design consideration for filters is the project site drainage area and resultant pollutant loading and runoff volume/rate to the filter. The use of preferred or approved BMPs should first be considered before selecting a media filter.
- » Surface filtration may not function as well in the winter if located at or near the ground surface due to freezing conditions. Media filter performance during cold weather conditions is required which may require locating the system below the frost line.
- » The potential for high velocities and scour must be evaluated for flows entering the media filter. High velocities can displace filter media if not controlled and kept to a minimum. Supercritical flows within the media filter shall not be present.
- » High flow bypass mechanisms shall be considered when implementing media filters.
- » Filter media shall be selected and sized to match the required rate of stormwater flow for the BMP. The designer should carefully consider the hydraulic conductivity filtration rate of the selected media and the available storage volume while balancing the need for contact time for increasing pollutant removal performance.

- » The maintenance access for the filter system must be considered. Filter systems require frequent maintenance and may require specialized maintenance equipment.
- » Proprietary media filters are not pre-approved for use and must comply with Innovation Track requirements in Section 3.7.b.iv, “Innovation Track.”

BMP Components and Design Standards

The following section provides an overview of typical components and design standards for media filters. Refer to Section 4.2.a, “General Design Requirements.”

Pretreatment

- A.** If using proprietary media filters, manufacturer’s guidance should be followed for recommended pretreatment prior to media filter.
- B.** Refer to the pretreatment sub-section of Section 4.2.a, “General Design Requirements.”

Conveyance

- C.** All filters should be designed so that larger storms may safely overflow or bypass the filter. Flow splitters, multistage chambers, and other devices may be used. A flow splitter may be necessary to allow only a portion of the runoff to enter the filter. This would create an “off-line” filter, where the volume and velocity of runoff entering the filter is controlled. If the filter is “on-line,” excess flow should be designed to bypass the filter without scouring or displacing filtration materials within the media filter.
- D.** Designer must evaluate the hydraulic grade line through the media filter during water quality storm event and design storm events, if an on-line media filter system, to ensure peak rates and peak flow bypass mechanisms are adequately sized.
- E.** Filters must be designed so that stormwater runoff entering the filter is evenly distributed and uniform across the entire top area of the filter. Entering velocity must be controlled to non-erosive levels. A level spreader may be used to spread flow evenly across the filter surface during all storms associated with the volume control requirement without eroding the filter material. Parking lots may be designed to convey runoff via sheet flow to filters. Small riprap or riverstone edges may be used to reduce velocity and distribute flow. Flow control devices such as flow splitters and weirs can also be used to regulate high velocities and peak flows from entering the media filter.
- F.** If using proprietary media filter, manufacturer’s guidance must be followed for conveyance of flows to and from the media filter.
- G.** Refer to the conveyance sub-section of Section 4.2.a, “General Design Requirements.”

Storage

- H.** The media filter storage must be sized to allow the filter to pass the water quality volume requirement storm event.

- I. There are no minimum and maximum storage volume requirements for media filters as the storage volume will be dependent upon drainage area flow rate to each media filter. If used in series with other BMPs, the media filter storage volume may be used and credited for meeting the volume requirements provided they meet drain down requirements. Only the downstream most BMP must meet drain down requirements.
- J. For media using soil and sand mixtures, the minimum filter media depth must be 18 inches.
- K. For media filters using soil and sand mixtures, storage volume is a function of the top area, depth of the filter, and the media content hydraulic conductivity. Size of the storage shall be based on the following equation:
 - $A = V \times d / (k \times t(h+d))$
 - A = Surface area of filter (square feet)
 - V = Water quality storm event runoff volume (cubic feet)
 - d = Depth of filter media (minimum 1.5 feet)
 - t = Drawdown time (days), not to exceed 72 hours
 - h = Head (average in feet)
 - k = Hydraulic conductivity (feet/day)
- L. Hydraulic conductivity for calculating flow-through rates and media filter sizing shall be 4.0 feet per day to account for reduction in filtration performance rates over time as the media loads with pollutants and solids. Calculations using this assumed rate are required as part of the SWM site plan submission are required.
- M. Stone or coarse material such as large gravel shall not be used as filter media for achieving water quality requirements. Stone may be used for bedding for underdrain, if necessary, but shall not be included in the filtration component of the system. Stone shall be separated from the filter media by geotextile and or a gravel filter.
- N. Filter media additives such as perlite, zeolite, granular activated carbon, and iron filings may be approved provided documentation in accordance with Section 3.7.b.iv, "Innovation Track," is provided.
- O. Open bottom media filtration systems are permissible for additional infiltration volume removal provided soil assessment and infiltration testing in accordance with Section 3.4, "Soil Assessment and Infiltration Testing," is performed. Losses through the open bottom may be considered in the overall sizing of the filter.
- P. For proprietary media filters, manufacturer's guidance should be followed for storage sizing requirements.

Outlet Control

- Q. For proprietary media filters, manufacturer's guidance should be followed for outlet controls.
- R. Refer to the outlet sub-section of Section 4.2.a, "General Design Standards."

Proprietary Media Filters

- S.** For the usage of proprietary media filters, the applicant shall refer to Section 3.7.b.iv, “Innovation Track,” for third-party certification requirements.

Maintenance and Monitoring

- T.** Regular, effective maintenance is essential to ensure media filters meet design performance requirements. Even effective media filters will eventually clog with sediments as designed. When a media filter has accumulated significant amounts of sediment, the filter’s hydraulic conductivity is reduced, and with it, the ability of the filter to remove pollutants. If inspection reveals clogging or significant sediment accumulation with the media, some or all portions of the filter media may require replacement.
- U.** Media filters should be designed with sufficient maintenance access (e.g., clean-outs, room for surface cleaning, manholes with ladder system, etc.). Media filters that are visible and simple in design are more likely to be maintained correctly.
- V.** For proprietary media filters, the manufacturer’s design guidance must be followed for inspection and maintenance access.
- W.** Refer to the maintenance and monitoring subsection of Section 4.2.a, “General Design Standards,” and Section 7, “Operations and Maintenance.”

Material Standards

Media Filter Sand

- X.** Sand, if used, shall have a grain size between 0.02 to 0.04 inches and meet AASHTO M-6 or ASTM C-33 standards.

Stone

- Y.** Stone aggregate shall consist of uniformly graded, crushed, clean-washed stone meeting AASHTO No. 3 or No. 57 requirements. Aggregate shall not surpass 0.5% wash loss under ASTM C 117 or AASHTO T-11 testing.

Additives and Other Filter Media

- Z.** Filter media other than sand be may use with Innovation Track approval. Approvals are granted on a case-by-case basis based on information submitted by the applicant in accordance with Section 3.7b. iv, “Innovation Track.” At a minimum, applicants must demonstrate that the filter media is capable of meeting the water quality requirement over a reasonable service life and would not pose undo maintenance requirements.

Geotextile

- AA.** Geotextile, if used, shall meet 4.2.a.x Material Standards.

Construction Considerations

- AB.** Provide erosion and sedimentation control protection on the project 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 and longevity. The designer is referred to the latest edition of the Pennsylvania Department of Environmental Protection (PADEP) Erosion and Sediment Pollution Control Program Manual for information on design standards for erosion and sedimentation control practices.
- AC.** Excavate filter area to proposed depth, providing appropriate shoring and sheeting for deep excavations.
- AD.** If using a proprietary system, install in accordance with manufacturer's recommendations.
- AE.** Place filter media in six-inch to eight-inch lifts within structure or excavated area, over the underdrain and storage stone, if present and cover with debris screen, stone filter layer, or non-woven fabric.

4.2.i. Cisterns

Cistern BMPs are stormwater storage tanks with the purpose of collecting stormwater for volume control and rate control.

Cistern BMPs are customizable. While there are many prefabricated designs to choose from, cisterns can take many shapes and configurations depending on the design requirements and user preferences and needs. Cistern BMPs can be sited in a variety of locations. Surface tanks are located above the ground, typically adjacent to buildings or on top of roofs. Subsurface tanks are located beneath the ground, often underneath paved or vegetated surfaces. Interior tanks are located within a building, typically in a basement or within another dedicated mechanical space, while exterior tanks are located exterior to a building.

This manual does not provide guidance on water quality standards and treatment procedures for any reuse applications. Third party professional guidance by a qualified individual is recommended to make sure all cistern components comply with all city, state, and federal water quality regulations.

Key Advantages

- » Can be utilized in small, constrained spaces, including interior applications.
- » Allows for flexible, customizable design options and configurations.
- » Reduces potable water demand/usage when runoff is re-purposed for grey or landscaping applications.
- » Promotes sustainability and provides community engagement options when used on public projects or at highly visible project sites.

Key Limitations

- » Any collected stormwater designated for reuse is limited by city, state, and federal code restrictions.

- » A cistern, without reuse function, cannot be used to address the water quality requirement unless all volume reducing options have been deemed infeasible - see Section 3.6, “Technical Infeasibility Determination”.
- » Cisterns may require additional downstream BMPs to meet water quality, volume control or rate control requirements.
- » Cisterns do not typically contribute aesthetic value of buildings and/or project sites to the same extent as surface vegetation BMPs such as bioretention.

Key Design Considerations

- » Cistern conveyance typically consists of gutters, downspouts, and pipes. Minimizing the length of conveyance systems is important. Cisterns should be gravity-fed where feasible. Pumps can be used if necessary.
- » Cistern treatment requirements vary according to reuse applications. Sediment filtration may be sufficient for outdoor, non-potable use. Additional treatment such as disinfection for microorganisms may be required for indoor reuse.
- » Cisterns may need to be located underground (below the frost line) or indoors if freezing conditions are of concern. Alternatively, cisterns may be heat traced or placed in a heated enclosure.
- » Underground cisterns must account for buoyancy considerations including the design of anti-floatation measures if needed and buoyance calculations.

BMP Components and Design Standards

The following section provides an overview of typical components and design standards for cistern BMPs. Refer to Section 4.2.a for General Design Standards. The design of internal distribution, treatment, and pumping systems is beyond the scope of this manual. Cisterns may be exempt from Section 4.2.a.ii, “Building Protection and Setbacks” provided they are structurally sound and do not compromise the integrity of adjacent infrastructure or hillsides.

General

- A.** Cistern foundations must be designed by an appropriate design professional. Cisterns, especially above-ground cisterns, must be placed on a structurally sound foundation to prevent damage from settling.

Pretreatment

Cisterns utilize various types of pretreatment methods, depending on the end-use of the harvested water and the characteristics of the contributing drainage area. Primary types of pretreatment methods utilized for cistern BMPs are gutter screens and first flush diverters.

Gutter screens remove trash and debris from roof gutters and downspouts before runoff is conveyed into the storage tank.

First flush diverters (or roof washers) reroute the first pulse of stormwater away from the cistern to a first flush chamber or onto a surface BMP.

The first flush of stormwater runoff carries the majority of sediment and pollutants (e.g., sand, dust, pollen, hydrocarbons, etc.) that have collected on the impervious areas since the previous rain event. First-flush diverters prevent contaminants, sediment, and small debris from entering the cistern.

Pretreatment requirements for cisterns are as follows:

- B.** The inflow conveyance system shall include, at minimum, a screen to prevent leaves, debris, and small animals from entering the cistern.
- C.** First-flush diverters shall be sized to capture approximately the first one to three gallons of stormwater per 100 square feet of drainage area in the first-flush chamber. Diverted stormwater shall not be excluded from management/treatment requirements but shall be diverted to an alternative BMP.

Conveyance

Cisterns typically collect water from impervious roof area via gutters or overflow drains. The runoff is gravity-fed from the collection point, through the gutters, downspouts, and conveyance piping, into the storage tank.

- D.** For underground cisterns connected to the public sewer, a pump, pressure tank, and backflow preventer
- E.** Refer to the conveyance sub-section of Section 4.2.a, “General Design Requirements.”

Storage

Cistern BMPs store water within a closed tank, commonly made of polyethylene or pre-cast concrete. Multiple cistern tanks can be utilized in series or parallel to meet design requirements. Tanks should be sited as close to the end-use location as possible to minimize the distribution system piping and requirements.

- F.** Cistern shall be sized to meet drain down time requirements and the volume generated from the drainage area for the water quality volume requirement.
- G.** Only the volume of water that is harvested or slow-released in accordance with the drain down requirements in Section 2.2.a, “Volume Control,” can be used to meet the volume control requirement. Any remaining volume must be managed by other BMPs.
- H.** Cisterns designed for slow release only cannot be used to meet the water quality requirement without supplemental filtration.
- I.** Cisterns located exterior to buildings will require drainage of any stored volume before freezing events.
- J.** Refer to the storage sub-section of Section 4.2.a, “General Design Standards.”

Vegetation

Cistern BMPs do not include vegetation, but they can be used in series with vegetated BMPs such as bioretention/bioinfiltration BMPs and green roofs.

Outlet Control

- K.** Stormwater volume used for compliance must be designed to be slowly-released and meet the volume control drain down requirements in Section 2.2.a, “Volume Control.”
- L.** The overflow must be near the top of the storage unit. Under no cases shall water be allowed to backup into the rain conductors and onto the associated roof.
- M.** Refer to the outlet sub-section of Section 4.2.a, “General Design Standards.”

Maintenance and Monitoring

- N.** First-flush pretreatment systems that capture sediments are required and shall have accessible cleanouts.
- O.** Inspection and maintenance access features, such as panels, ports, and manholes, shall have sufficient space for inspection and maintenance of the storage area, and be secured with a lock to prevent unwanted entry.
- P.** Ladder access must be provided for cisterns greater than four feet in height.
- Q.** Observation ports are sufficient to monitor tank volume. However, volume gauges/sensors at accessible locations allow tank levels to be monitored without entering the tank itself.
- R.** Cistern drainage access points must be readily accessible.
- S.** Long term cleaning of the cistern should be considered relating to potential water quality including build up of algae or organics on cistern walls. The cistern should be regularly inspected for these conditions including checking for odors and algae. Follow cistern manufacturer’s recommended guidelines for cleaning and inspection of cistern.
- T.** Refer to the maintenance and monitoring sub-section of Section 4.2.a, “General Design Standards” and Section 7, “Operations and Maintenance.”

Material Standards

- U.** Cisterns shall be constructed of fiberglass, stainless steel, concrete, plastic, or other non-corrosive watertight material.
- V.** Galvanized steel, wood, and other materials prone to environmental decay or corrosion are prohibited.
- W.** Cisterns shall be opaque or protected from direct sunlight to inhibit algae growth.
- X.** All pre-manufactured products shall have a watertight rating for the life of the cistern.
- Y.** Service ways, when used, shall have lockable manhole covers. Multiple service ways should exist to accommodate repairs, cleaning, and inspection.

Construction Considerations

- Z.** Cisterns shall be installed according to the manufacturer's specifications.
- AA.** Temporary flow diversions shall be installed before construction begins.
- AB.** Refer to the construction sub-section of Section 4.2.a, "General Design Standards."

4.3 PRETREATMENT TECHNOLOGIES

Per §1303.01.p of Title 13, pretreatment is required for all BMPs located in high pollutant loading hotspot areas. Pollutant loading hotspot areas include urban land uses such as parking lots, roadways, and areas with commercial or heavy industry. For general pretreatment design requirements refer to Section 4.2.a.iii, "Pretreatment." The strategies listed below are options available to the applicant for meeting pretreatment requirements.

4.3.a. Sediment Forebays

Sediment forebays, also called forebays, are pools or excavated depressions located immediately down-gradient of the stormwater inflow point(s) of an BMP. Forebays slow stormwater runoff, allowing sediment and other larger particles to settle out prior to the introduction of flow into the BMP proper. In doing so, the forebay concentrates maintenance needs within a smaller, more easily accessible area (i.e., the forebay) and reduces costly, complicated maintenance needs within the main BMP.

Uses

Forebays are typically used as pretreatment for BMPs such as bioinfiltration/bioretention basins, wet ponds, extended dry detention basins, and constructed wetlands.

Design Requirements

Forebays are designed to provide easily accessible basins or pools within which sediments, pollutants, trash, and debris can settle and accumulate before they enter the larger stormwater management system. Forebays may be vegetated or lined with hard materials to reduce influent stormwater velocities and promote settling of suspended pollutants. Particularly severe storms may produce high influent velocities and high rates of sedimentation capable of damaging earthen sides and stripping vegetation. Grass and other herbaceous plants with grass-like characteristics that can tolerate periodic inundation and dry periods are typically used in forebays.

Table 4.12 summarizes specific design requirements.

TABLE 4.12. SUMMARY OF DESIGN REQUIREMENTS FOR SEDIMENT FOREBAYS.	
#	Requirements
1	Sediment forebays within large BMPs, such as ponds and wet basins, must contain 10% to 15% of the total permanent pool volume of the larger BMP.
2	For sediment forebays within smaller BMPs such as bioinfiltration/bioretention basins, the storage volume must be sized to retain 0.25 inches of runoff per acre of contributing directly connected impervious area (DCIA), if feasible, with a minimum of 0.1 inch per impervious acre.
3	A check dam must physically separate the sediment forebays from its associated BMP. The check dam should span the entire width of the basin. See Section 4.4.c, "Check Dams," for check dam requirements.
4	Inlet controls for forebays must include riprap, stone placed in concrete, or an equivalent energy dissipation device to rapidly reduce the inflow velocity for erosion/scour protection and to encourage settlement of suspended solids.
5	Permanent vertical markers constructed of durable materials must be installed within the sediment 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.

4.3.b. Filter Strips

Filter strips are typically comprised of dense vegetation that treats stormwater runoff from adjacent impervious areas by reducing runoff velocity and removing suspended pollutants. Depending on siting and design conditions, filter strips may also infiltrate a portion of stormwater runoff.

Uses

Filter strips are often used as pretreatment for bioinfiltration/bioretention basins and wet ponds. Depending on the project site layout and stormwater conveyance design, however, they may also provide effective pretreatment for subsurface infiltration and subsurface detention BMPs.

Design Requirements

In all design cases where vegetation is to be established, the planting regime should be as dense as the soil conditions can sustain. At a minimum, vegetative cover should be maintained at 85%. To achieve this, 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. This is particularly important at the upper portions of the filter strip, which receive stormwater runoff with higher sheet flow velocities than lower portions of the filter strip. Meadow grasses, shrubs, and other approved native plant mixes are typically used in filter strips. Turf grass is not permissible because it is

less effective at attenuating flow, promoting infiltration, and protecting against erosion.

Table 4.13 summarizes specific design requirements below.

TABLE 4.13. SUMMARY OF DESIGN REQUIREMENTS FOR FILTER STRIPS	
#	Requirements
1	The maximum allowable flow path to a filter strip, without the installation of energy dissipaters and/or flow spreaders, is 75 feet for impervious cover.
2	The maximum contributing drainage area must be less than five acres and must not exceed a drainage area to filter strip area ratio (drainage area:filter strip area) of 6:1.
3	The average contributing drainage area slope must be less than 5%, unless energy dissipation and/or flow spreaders are provided up-gradient of the filter strip.
4	The average filter strip slope must not exceed 5% unless check dams or retentive grading is provided.
5	Filter strips with slopes that exceed 5% should implement check dams to encourage ponding and prevent scour and erosion of the filter strip area.
6	The slope (parallel to the flow path) of the top of the filter strip, after a flow spreading device, must be less than 1% and gradually increase to the designed value to protect from erosion and undermining of the device.

4.3.c. Swales

Swales are vegetated open channels that are often used to convey stormwater runoff at a reduced velocity to a downstream BMP. The increased flow path length and energy dissipation associated with swales also helps to remove suspended pollutants, protect against scouring in downstream BMPs, and may provide some infiltration along the vegetated conveyance path.

Uses

Swales are often used as pretreatment for bioinfiltration/bioretention basins. When not used for conveyance and/or pretreatment, swales may be considered narrow bioinfiltration/bioretention basins. This section focuses on the use of swales as pretreatment structures.

Design Requirements

An effective swale design will balance the need for infiltration and treatment during small storms with need for conveyance during large storms. Swales must meet requirements within Section 2.2.c, “Stormwater Conveyance Requirements” and must be designed to limit erosion. Protection against erosion can be achieved in part through the use of check dams, which are flow control structures that

allow water to temporarily pool, as well as deep-rooted, native vegetation.

Table 4.14 summarizes specific design requirements below.

TABLE 4.14. SUMMARY OF DESIGN REQUIREMENTS FOR SWALES	
#	Requirements
1	Swales are to be located along contours and natural drainage pathways.
2	In areas with slopes exceeding 4% and infiltration is deemed feasible in accordance with Section 3.4, swales must have check dams to allow for ponding, which provides temporary storage, increases infiltration, reduces peak flows, and helps protect against erosion.
3	Swales should have soil capable of supporting dense, deep-rooted vegetation and allow for infiltration. Imported soil may be needed.
4	Subsurface storage in accordance with Section 4.2.a may be added beneath the soil, particularly in areas designed to allow ponding, to increase storage and promote infiltration.

4.3.d. Inlet Inserts

Inlet inserts include structural screens, hoods, traps, racks, geotextile filter bags, and suspended catch basin inserts inserted into the inlet that filter sediments/debris before it can enter a downstream BMP. Inlet inserts are particularly important to prevent the clogging of BMP distribution piping systems. Inlet inserts such as hoods and racks may help protect against floatables such as trash and debris. Other types of inlet inserts including suspended catch basin inserts and geotextile filter bags can remove large, suspended sediment particles in addition to removing floatables.

Uses

Inlets inserts are typically applicable to bioinfiltration/bioretention basins, subsurface infiltration and detention SMPs, and ponds and wet basins.

Design Requirements

Inlet insert selection for pretreatment should reflect the size and concentration of target pollutants as well as siting and design characteristics. For instance, inlet inserts capable of removing suspended sediments (e.g., geotextile filter bags) should be used if influent stormwater has high sediment concentrations. Inlet inserts are available from a number of vendors to fit most standard inlets, or can be customized to fit non-traditional inlet configurations. Some considerations when selecting an inlet insert are the mesh opening size, mesh durability, storage capacity, and ease of access. Inlet inserts shall follow manufacturer's recommended design guidelines.

4.3.e. Hydrodynamic Separators

Hydrodynamic separators include proprietary manufactured devices are designed to store, filter, or capture incoming floatables, heavy metals, oils, debris, and suspended solids using vortex separation and gravity. Generally, separators focus on the removal of oils and larger particulates and are less effective at removing

smaller particulates (e.g., silts and clay sized particles) or neutral buoyancy organic particles such as sticks and seeds. These systems are commonly made of precast concrete or preformed (plastic or fiberglass) structures that are ordered to fit the project design criteria and are installed by setting in place as a unit by crane or earthwork equipment. Hydrodynamic separators may be appropriate when dealing with siting and design characteristics that severely constrain space available for pretreatment.

Uses

Hydrodynamic separators are typically used for subsurface BMPs and subsurface retrofits. Separators can be used upstream of a subsurface system to provide pretreatment but are also commonly used to provide water quality treatment of flows exiting a subsurface system.

Design Considerations

Depending on the manufacturer, hydrodynamic separators have different pollutant removal rates that should be evaluated before selecting the system. Design considerations for hydrodynamic separators include the capacity and removal rates for various pollutants of interest, system longevity, and maintenance access. Access for maintenance is critical as these systems often require frequent cleaning between rain events to ensure continual pollutant removal performance. Typically, manufacturers can provide design support in sizing and system configuration to meet a variety of design requirements.

Hydrodynamic separators should be installed and used according to manufacturer specifications.

4.3.f. Filtration Technologies

Filtration technologies include manufactured devices designed to provide enhanced removal of pollutants such as suspended solids, metals, hydrocarbons, and nutrients. Filtration occurs by routing stormwater through some type of proprietary media blend for which stormwater is “filtered” through a porous geotextile or steel mesh. Media components include perlite, a volcanic rock, leaf media, zeolite, activated carbon and combinations thereof. Filtration pretreatment systems commonly include inlets or manhole like structures where media is contained within removable cartridges.

Uses

Filtration technologies are used to meet water quality requirements in conjunction with non-infiltrating BMPs. Filtration technologies can be used upstream of a subsurface system to provide pretreatment but are also commonly used to provide water quality treatment of flows exiting a subsurface system.

Design Requirements

Filtration technologies should be selected and sized to match the required rate of stormwater flow to meet the water quality volume requirement for the BMP. The designer should carefully consider the filtration rate of the device or media used as well as storage volume constraints to correctly size filtration systems. Typically, manufacturers can provide design support in sizing and system configuration to meet a variety of design requirements.

Depending on the manufacturer, filtration technologies have different pollutant removal rates that should be evaluated before selecting the system. Filtration technologies should be installed and used according to manufacturer specifications. If used to meet the water quality requirement (as opposed to as pretreatment) filtration technologies must demonstrate pollutant removal performance at an equivalent level required by New Jersey Corporation for Advanced Technology (NJCAT) certification and the Technology Assessment Protocol-Ecology (TAPE) developed by the Washington State Department of Ecology. See Section 3.7.iv, “Innovation Track,” for additional requirements.

4.4 OUTLET CONTROLS

Outlet controls manage how stored stormwater runoff is released from a BMP. These controls can be used to limit peak release rates from the BMP as well as provide safe overflow conveyance of larger storm events. Common outlet structures include inlets, underdrains, domed risers, orifices, and weirs. For general outlet control design requirements refer to Section 4.2.a.vii, “Outlet Controls.”

4.4.a. Underdrains

Underdrains are typically perforated pipes in stone layers or trenches that intercept, collect, and convey stormwater that has percolated through soil, a designed aggregate, and/or geotextile, in order to drain the BMP after a storm event. Underdrains allow stormwater to leave BMPs, either via infiltration or through an outlet control structure. Connecting underdrains to an outlet control structure is an effective method to control the ponding elevation, drawdown time, or release rate through weirs and/or orifices, particularly if infiltration is not possible.

Uses

Depending on siting and design conditions, underdrain may or may not be capped. Solid caps prevent the flow of water out of the underdrain completely and are used for infiltrating systems. Caps with orifices are used for slow-release systems. Solid underdrain caps may be later drilled with an orifice if infiltration rates slow due to sediment accumulation or other issues. All caps must be threaded for removal and maintenance access.

Design Requirements

Table 4.15 summarizes design requirements for underdrains.

TABLE 4.15. SUMMARY DESIGN REQUIREMENTS FOR UNDERDRAINS

#	Requirements
1	Underdrains must not be less than 4 inches in diameter and meet piping material standards. Underdrains shall be well-based in a layer of aggregate, with a minimum cover depth of 4 inches and a minimum bedding depth of 4 inches.
2	Underdrains must have a minimum of 4 inches of vertical separation between the pipe and the boundary of the subsurface storage.
3	Underdrains must be fitted with a solid threaded cap for maintenance access for infiltrating systems.
4	Underdrains must have an orifice with a minimum orifice diameter of ½ inch for slow-release systems.
5	Underdrains must have a minimum length of 20 feet, where feasible.
6	Underdrains pipes must have a slope of 0% to 0.25% within the BMP.
7	Underdrains must connect subsurface storage media between any tiered multi-cell systems or between check dams.

4.4.b. Risers

Risers are vertical pipe structures typically connected to a horizontal overflow pipe or an additional outflow control structure underground. Risers are typically made of concrete or plastic and come in a wide variety of configurations. Risers are designed to control the amount of water ponded within a BMP via orifices, weirs, or overflow grates and provide positive overflow.

Uses

Risers are typically used in bioinfiltration/bioretention BMPs, as well as constructed wetlands, wet ponds, and dry ponds.

Design Requirements

Risers should be equipped with one or more control orifices, weirs or overflow grates. The specific sizing, elevation, and configuration of outlet controls will depend on the design objectives and specific hydraulic requirements associated with the BMP. Risers must have a domed grate or slotted lid to prevent clogging by debris and trash.

4.4.c. Check Dams

Check dams are engineered barriers designed to control the release of stormwater from BMPs, between individual treatment cells in the case of multi-cell BMPs, or between forbays and storage areas. Check dams can be located within pretreatment devices, surface BMPs, or within outlet control structures.

The purpose of check dams are to:

- » Increase storage within surface depressions such as swales.
- » Encourage ponding in areas where the settling of solids and infiltration through vegetation and soil media can occur.



- » Regulate the flow of stormwater from a forebay to the main storage area of the BMP.
- » Discharge overflow or bypass flow within a BMP to downstream conveyance systems.
- » Dissipate energy, reduce peak release rates, and control erosion.

Uses

Weirs may be used in a wide variety of BMPs including bioinfiltration/bioretention BMPs, subsurface storage BMPs, and pretreatment swales as well as within BMP outlet structure boxes to convey large storm event flows.

Design Requirements

Check dams shall be impermeable materials and constructed of rot resistant material such as steel plates, poured concrete, or plastic wood. Treated lumber is not acceptable. Impermeable check dams do not allow water to pass through the weir material, resulting in ponding behind the structure that promotes more effective storage and infiltration. However, impermeable check dams can present problems if infiltration slows over time. Check dams are often implemented in project sites with moderate to steep slopes. Check dams must be evenly spaced and with elevations that do not exceed the maximum allowable water storage/ponding depth for the associated BMP. All check dams shall be keyed into the surrounding native soil (bottom and sides) a minimum of 12 inches where the check dam interfaces with a concrete edge or other structural feature. If the BMP is lined or if has poor infiltration, a low flow underdrain system and orifice with an accompanying clean out port shall be installed through the face of each weir or check dam. Orifice sizing may be required for each individual cell to ensure drain down requirements are met within each storage cell. If check dams are placed in lined or poor infiltrating systems, drain down calculations for each individual cell may be required.

4.4.d. Low Flow Devices

Low flow devices are manufactured and/or proprietary systems that regulate the discharge flow rate from BMPs. 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. These structures are particularly useful in achieving a slower draindown time in cases where the applied head on the minimum conventional orifice size causes a faster draindown time than permissible. This is commonly an issue with smaller drainage areas or BMPs that store water vertically (like cisterns) and thus tend to have higher hydraulic head on the low flow orifice.

Uses

Low flow devices are typically applicable to subsurface detention BMPs but may also be applicable to bioretention basins, cisterns, wet ponds, and green roofs.

Design Considerations

Low flow devices are evaluated on a project-specific basis since project site conditions, such as sediment loading and/or drainage area size, can impact a product's ability to meet stormwater requirements. Consultation with stormwater plan review staff as early as possible in the SWM site plan review process is encouraged.

4.4.e. Level Spreaders

Level spreaders are outlet controls that are designed to uniformly distribute concentrated flow over a large area. Level spreaders are commonly composed of poured-in-place concrete or stone-filled trenches in which water fills up within the trench and overflows over a levelled concrete weir. Level spreaders help reduce concentrated flow, thereby reducing erosion and increasing the design life of many BMPs. Level spreaders alone do not, however, provide the level of rate control needed to meet rate control requirements.

Uses

Level spreaders may be used for bioinfiltration/bioretention BMPs, wet ponds, and subsurface infiltration and detention BMPs. Level spreaders are commonly used to introduce spread flow to filter strips and pervious area disconnections.

Design Considerations

While there are many kinds of level spreaders, all level spreader designs follow the same general 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.

Level spreaders must safely diffuse and convey flows in accordance with the requirements in Section 2.2.c., “Stormwater Conveyance Requirements”. Level spreader performance can be strongly influenced by relatively small changes in elevation, which can cause erosion-causing rivulets to form. Materials and design approaches must be used to protect against erosion and deformation of the level spreader. This commonly includes ensuring that the level spreader is placed on suitable bedding material and solid subgrade, to minimize elevation changes because of freeze/thaw processes and differential settlement. Level spreaders

must be carefully monitored over time to detect and correct areas of settlement or elevation change. Level spreaders may not be composed of wood or other organic materials that are prone to degradation over time.

4.5 CONTINUOUS MONITORING AND ADAPTIVE CONTROL SYSTEMS

Continuous monitoring and adaptive control (CMAC) systems use cloud-based technologies, on-site sensors, and weather forecasts to make real-time adjustments to BMP release rates. These systems use actuated valves that are controlled via an electronic valve actuator thus regulating the effective size of a control orifice. An emerging technology, CMAC systems have shown great potential in the ability to combine real-time monitoring of conditions (e.g., water level and storage volume) with remote adjustment of flow control structures (e.g., flow control valves). CMAC systems can be used to optimize release rates, release rate timing, and storage capacity ahead of storms, and may be particularly effective for small (i.e., “undersized”) and urban BMPs. CMAC systems can be used in conjunction with a variety of BMP types including bioretention/infiltration, subsurface detention and infiltration, constructed wetlands, and dry ponds.

Applicants that implement CMAC systems are eligible for incentives points. See Section 2.2.a.vi, “Technology Incentives” for more information and specific requirements.

Requirements

CMAC systems contain mechanical components and sensors that can be subject to corrosion, performance issues due to sediment and debris jams, and buildup of organic materials. All CMAC valves must be shown to be corrosion resistant. Designers should be particularly mindful of introducing sediment or debris laden flow. Generally, only flow that has been filtered via media filtration should be introduced to a CMAC valve. Valves and sensors must be easily accessible and regularly inspected and maintained. Sensors and valves must be subjected to routine performance tests to ensure proper functioning and sensors must be routinely calibrated in accordance with manufacturer recommendations. Calibration and performance test records must be kept and must be accessible for review by stormwater inspectors. All CMAC systems must be equipped with a redundant power supply to ensure operation during storm events in the event of a loss of primary power. Backup power sources that need to be manually enabled are not permitted. Actuated valve assemblies must be housed within a dedicated valve box or vault structure. All systems using CMAC must also conform to static sizing requirements.

Specialized control equipment includes and is not limited to any installed stormwater detention system components which require use of an external power source, including pumping and/or automated flow control system. Operation and maintenance agreements must also specify the party responsible

for providing use of a power source for the equipment, the party responsible for the maintenance and operation of the control equipment and provisions which allow the city of Pittsburgh to access the equipment.

4.6 RAINWATER REUSE

Rainwater reuse systems consist of BMPs (e.g., cisterns) that harvest rainwater which can be used as a resource. Rainwater can be collected, stored, and reused on project sites for many purposes, including reclaimed water use in architectural features and source-water for industrial use. Rainwater reuse is considered volume reducing and is highly encouraged to meet volume requirements. Rainwater reuse that is unused must meet drain down requirements. All projects implementing rainwater reuse must meet all county and state regulations.

Applicants that implement water reuse are eligible for incentives points. See Section 2.2.a.vi, “Technology Incentives” for more information and requirements.

Design Requirements

- A. Refer to Section 4.2.i, “Cisterns,” for cistern design requirements.

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SECTION 5 –STORMWATER MANAGEMENT SITE PLAN REVIEW REQUIREMENTS

5.1 INTRODUCTION

Applicants proposing regulated activities that require the approval of a stormwater management (SWM) site plan as specified in Title 13 (§1303.01) or those pursuing Rainwater Performance Points via the performance point system specified in Title 9 (§915.07.E) are required to complete the SWM site plan review process. The SWM site plan review process consists of two review steps — conceptual stormwater management plan (conceptual SWM plan) review and stormwater management site plan (SWM site plan) review. Figure 5.1 summarizes the two-step stormwater plan review process.

Conceptual SWM plan review helps applicants and stormwater plan review staff to confirm stormwater management requirements for a project, provides the opportunity for applicants to confirm their proposed approach to stormwater management for their project site prior to completing more detailed engineering design development, and provides the applicant the opportunity to notify stormwater plan review staff of any proposed non-standard approaches to meet

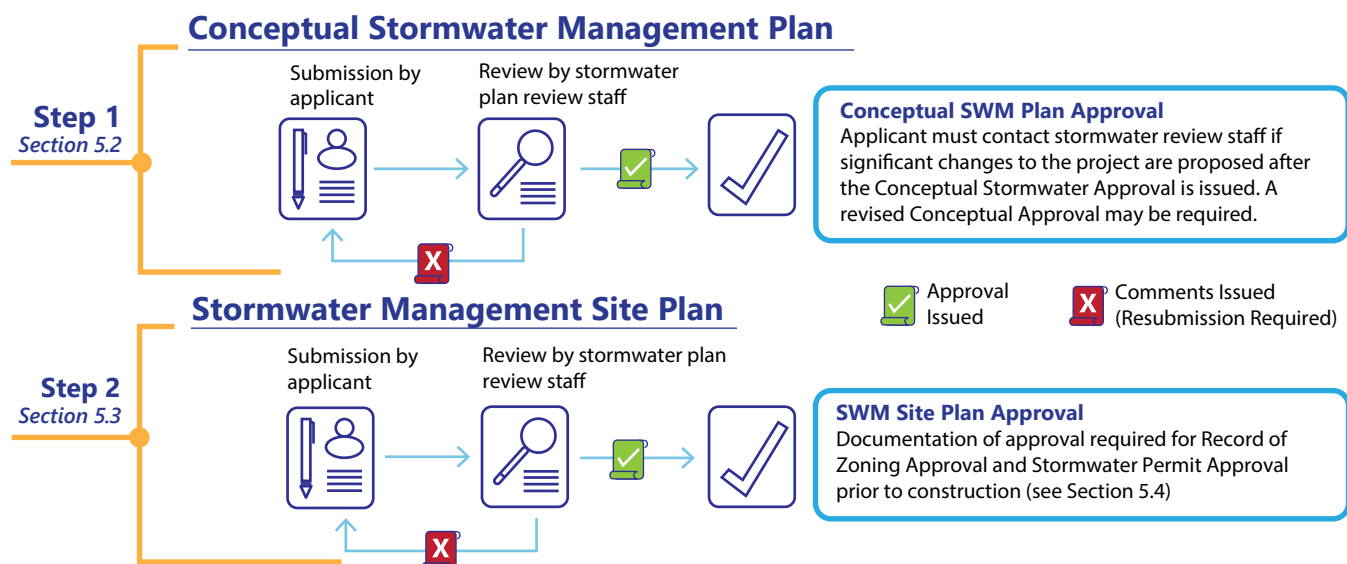


Figure 5.1. Two-step review process overview

CITY, STATE, AND FEDERAL REGULATED ACTIVITIES

Applicants should note that other approvals from local, state, and federal agencies may be required for projects requiring a SWM site plan approval, including but not limited to National Pollution Discharge Elimination System (NPDES) Permit approval from the Pennsylvania Department of Environmental Protection (PADEP) and/or the Allegheny County Conservation District (ACCD) and Plumbing Permit approval through the Allegheny County Health Department (ACHD). In addition, projects with greater than or equal to 5,000 square feet of earth disturbance may require an Erosion and Sediment Control (E&SC) Plan but not require an approved SWM site plan, if not located in Riverfront District (RIV) or Uptown Public Realm District (UPR) zoning districts. In these instances, applicants must provide submit proof of E&SC Plan submission to ACCD to receive Building and/or Land Operations Permits from the City. The intent of this manual section is not to provide exhaustive guidance on the relationships between the stormwater plan review process and these other approvals. Applicants are referred to Section 2.1.a., "Definition of Regulated Activities" as well as Sections 5.5 and 5.6 of this manual for additional information.

stormwater management requirements or the applicant's intent to pursue stormwater management incentives. At the end of this review phase, stormwater plan review staff will issue a Conceptual SWM plan approval which allows applicants to move to the next step in the stormwater plan review process.

SWM site plan review is the second step in the stormwater plan review process. At the end of this review step, the city will issue a SWM site plan approval. A SWM site plan approval is not a permit for construction, but rather one of several prerequisite approvals that must be obtained before obtaining zoning approval, also known as the Record of Zoning Approval (ROZA). A Stormwater Permit (see Section 5.4) must be obtained before any regulated earth disturbance and/or construction activities may begin at the project site. The city will issue a plan review summary documenting the SWM site plan approval and the Stormwater Permit concurrently.

5.2 CONCEPTUAL SWM PLAN REVIEW

The conceptual SWM plan review submission is the applicant's initial opportunity to obtain feedback from stormwater plan review staff concerning the proposed stormwater management strategy associated with their project. The applicant shall submit the conceptual SWM plan submission package concurrently with the Zoning and Development Review (ZDR) application (if applicable) for the project to ensure that the proposed site improvements and associated earth disturbance provided in the conceptual SWM plan submission package is consistent with information reviewed by zoning staff. Conceptual SWM plan approval cannot be issued until ZDR passes Initial Review. Applicants can refer to the Division of Zoning and Development Review (Zoning Division) website for additional information: <https://pittsburghpa.gov/dcp/zoning>

5.2.a. Conceptual SWM Plan Review Overview

Table 5.1 list components that must be included in the conceptual SWM plan submission package. All submission components shall be completed in accordance with requirements outlined in this manual. Each of these components is further detailed in the sections below. Stormwater plan review staff will not review submissions that are deemed administratively incomplete.

TABLE 5.1. SUMMARY OF CONCEPTUAL SWM PLAN SUBMISSION PACKAGE REQUIREMENTS

#	Conceptual SWM Plan Submission Package Component
0	Conceptual SWM Plan Submission Package Checklist (Section 5.2.b.)
1	Conceptual SWM Plan Review Worksheet and Required Attachments (Section 5.2.c.)
2	Conceptual SWM Plan (Section 5.2.d.)
3	Documentation of Rainwater Points for Performance Point System (Section 5.2.e.)
4	Infiltration Testing and Geotechnical Investigation Report (Section 5.2.f.)
5	Documentation of Eligibility for Hardship Waiver (Section 5.2.g.)
6	Conceptual SWM Plan Review Fee (Section 5.2.h.)

5.2.b. Conceptual SWM Plan Submission Package Checklist (required)

Refer to [Appendix D: SWM Plan Submission Worksheet and Checklists](#) for the conceptual SWM plan submission package checklist.

5.2.c. Conceptual SWM Plan Review Worksheet (required)

Table 5.2 summarizes project information applicants are required to provide in the conceptual SWM plan review worksheet (see [Appendix D: SWM Plan Submission Worksheet and Checklists](#)).

TABLE 5.2. SUMMARY OF CONCEPTUAL SWM PLAN REVIEW WORKSHEET INFORMATION AND REQUIRED ATTACHMENTS

#	Requirement
1	Applicant, project location, property owner, and developer information
2	Applicability and determination of regulatory requirements based on: <ul style="list-style-type: none"> • Earth disturbance • Existing impervious area • Proposed impervious area • Change in impervious area • Location (e.g., combined sewer system vs. municipal separate storm sewer system area, location with Act 167 or districts with special requirements) • Anticipated stormwater discharge location • Presence of groundwater seeps and springs • Adjacent riparian buffers
3	Intent to pursue any of the following: <ul style="list-style-type: none"> • Alternative compliance • Volume control offsets • Performance points (RIV and UPR Zoning Districts) • Rate control offsets • Volume or rate control incentives • Technology incentives • Hardship waiver for expedited SWM site plan review
4	Intent to use stormwater management innovative technologies through an innovation track submission
5	Required Attachments: <ul style="list-style-type: none"> • Narrative of overall stormwater management approach (i.e., minimizing impervious cover and disturbance area, maximizing use of non-structural BMPs, etc.) • Site photos

5.2.d. Conceptual SWM Plan (required)

Table 5.3 summarizes project information applicants are required to provide in the conceptual SWM plan.

TABLE 5.3. CONCEPTUAL SWM PLAN INFORMATION REQUIREMENTS	
#	Requirement
1	Drawings adhere to General Drafting Requirements (See Appendix E: General Drafting Requirements)
2	Identification of areas for proposed non-structural and structural stormwater volume and rate control BMPs including: <ul style="list-style-type: none">• Locations• Extents• Type(s)• Conceptual footprints and volumes (both for non-structural and structural BMPs)• Proposed stormwater conveyance into and out of BMPs• Discharge locations and safe overflow connections• Known locations of groundwater seeps and springs
3*	Plan call outs and tabular information designating: <ul style="list-style-type: none">• Proposed stormwater volume control offsets• Rate control points of interest• Additional or enlarged BMPs qualifying for stormwater management volume or rate incentives• Accounting of points if preferred technology incentives are being requested• Proposed BMPs targeted for innovation track approval
* Required only if applicable to project	

5.2.e. Documentation of Rainwater Points for Performance Point System (required if applicable)

Applicants who intend to pursue performance point in the Riverfront (RIV) and Uptown Public Realm (UPR) zoning districts by achieving Rainwater Goals (Title Nine: Zoning, §915: Environmental Performance Standards, Section 07.D) must provide documentation with conceptual SWM plan review materials explaining how the project will satisfy the requirements. Applicants should refer to the Department of City Planning website (<https://pittsburghpa.gov/dcp/process-guide>) for process guides for pursuing rainwater performance points.

5.2.f. Infiltration Testing and Geotechnical Investigation Report (encouraged but not required)

Applicants are encouraged to submit infiltration test results and a geotechnical investigation report as attachments with conceptual SWM plan review materials. This information will help in facilitate initial discussions with stormwater plan review staff regarding technical infeasibility due to infiltration or subsurface conditions. Refer to Section 3.4, “Soil Assessment and Infiltration Testing” for more information on these requirements.

5.2.g. Documentation of Eligibility for Hardship Waiver

Applicants who intend to pursue hardship waivers and/or expedited 5 business-day SWM site plan review must provide documentation of eligibility. Eligible applicants are:

- » Small businesses,
- » Minority/Women/Disadvantaged/Veteran-Owned Business Enterprises (M/W/D/VBE), and
- » Affordable housing applicants.

5.2.g.i Small Businesses

Small businesses are defined as those businesses or non-governmental organizations (NGOs) that are certified as a small business by the United States Small Business Administration (SBA), including its subsidiaries and affiliates, and that have existed and operated for at least 2 years. In the case of a Limited Liability Corporation (LLC) acting as a development company, the SBA requirements are to be applied to the largest member/shareholder in the LLC.

5.2.g.ii Minority/Women/Disadvantaged/Veteran Business Enterprises

M/W/D/VBE businesses are defined as those businesses possessing M/W/D/VBE certification from at least one of the following agencies/organizations:

- » Allegheny County MWDBE Certification
- » National Minority Supplier Development Council (regional affiliates are also acceptable)
- » National Women Business Owners Corporation (NWBOC)
- » Pennsylvania Department of Transportation (PennDOT)
- » Pennsylvania Unified Certification Program (any State or Municipal Certification Program)
- » Port Authority of Allegheny County
- » Small Business Administration 8a Certification
- » U.S. Department of Transportation (Federal DOT)
- » Veterans Business Resource Center (VetBiz)
- » Women Business Enterprise National Council (WBENC)

5.2.g.iii Affordable Housing Applicants

Affordable housing applicants are defined as applicants proposing a mix of residential units that includes at least 10% of the units that meet inclusionary rental and/or owner-occupied units as well as an intention to meet the affordability period requirements set forth in Title 9.

5.2.h. Conceptual SWM Plan Review Fee

Refer to Fee Schedule published on the City's website: <https://pittsburghpa.gov/dcp/fees>.

5.2.i. Conceptual SWM Plan Review Process

Applicants are required to submit the conceptual SWM plan submission package online at OneStopPGH under the Stormwater Permit application. Hard copy submissions may also be permitted upon approval of the stormwater plan review staff. For applicants submitting to OneStopPGH, the applicant will receive an automatic email confirmation that the submission has been received. Stormwater plan review staff will notify the applicant in writing within 15 business days whether the conceptual SWM plan is approved, disapproved, or requires additional documentation. If a longer notification period is provided by other statute, regulation, or ordinance, stormwater plan review staff will notify the applicant.

Stormwater plan review staff may either disapprove the submission and require a resubmission or, in the case of minor deficiencies, accept and approve submission of modifications. Stormwater plan review staff will not review or approve administratively incomplete conceptual SWM plan submission packages.

Upon receiving a conceptual SWM plan approval, applicants move to the SWM site plan review step of the stormwater plan review process. Before submitting the SWM site plan submission package, however, stormwater plan review staff encourages applicants to contact Allegheny County Health Department (ACHD) and conduct pre-plumbing permit application coordination and review with ACHD for all projects with stormwater management BMPs.

Conceptual SWM plan approval will expire after one (1) year from the date of issuance as dated on the approval. Applicants may request to renew the application for one (1) additional year provided the request is submitted prior to the expiration of the approval. A lapsed approval, however, will not be renewed more than once. Applicants may renew applications with a written statement without requiring the filing of a new application, and renewal will have the same effect as the original approval. If no renewal is granted within one-year period allowed for renewals, however, the original approval shall be void and have no further effect.

5.3 SWM SITE PLAN REVIEW

The SWM site plan review is the second review phase in the stormwater plan review process. Applicants can submit a SWM site plan review submission package after receiving a conceptual approval from the city.

The site layout and stormwater management design included with the SWM site plan review submission package must be consistent with the design that was approved during the conceptual review phase. If significant changes are made to the project after the issuance a conceptual approval, the conceptual approval

shall be voided requiring the applicant to resubmit a revised conceptual SWM plan through OneStopPGH and be re-issued a new conceptual approval before proceeding to the SWM site plan review phase. If there are significant changes to stormwater management strategies, the applicant must communicate rationale for changes to stormwater plan review staff as part of the revised conceptual SWM plan submission narrative. Examples of significant changes include but are not limited to:

- » Changes in proposed limits of earth disturbance.
- » Changes in proposed impervious area (such as building footprint or location).
- » Changes in stormwater conveyance and discharge.
- » Changes in the type, location, sizing, and/or location of BMPs or changes to the stormwater management strategy.

Conceptual review appeals can be made to the Zoning Board of Adjustment (ZBA): <https://pittsburghpa.gov/dcp/zba>. Applicants must have an associated ZDR in place for their project to go through the ZBA process. Applicants should contact the DCP environmental plan reviewer assigned to the project to schedule a hearing.

5.3.a. SWM Site Plan Review Overview

Table 5.4 summarizes items that shall be included in the SWM site plan submission package. All submission components shall be completed in accordance with requirements outlined in this manual. Stormwater plan review staff will not review submissions that are deemed administratively incomplete.

TABLE 5.4. SWM SITE PLAN SUBMISSION PACKAGE COMPONENTS

#	SWM Site Plan Submission Review Package Component
0	SWM Site Plan Submission Package Checklist (Section 5.3.b.)
1	SWM Site Plan (Section 5.3.c.)
2	SWM Site Plan Report (Section 5.3.d.)
3	Volume Control Offset and/or Rate Offsets Strategy and Supporting Documentation (Section 5.3.e.)
4	Volume, Rate, and Technology Incentives Strategy and Supporting Documentation (Section 5.3.f.)
5	Documentation of Rainwater Points for Density Bonuses (Section 5.3.g.)
6	Innovation Track Review Request and Supporting Documentation (Section 5.3.h.)
7	SWM Site Plan Review Fee (Section 5.3.i.)

5.3.b. SWM Site Plan Submission Package Checklist (required)

Refer to **Appendix D: SWM Plan Submission Worksheet and Checklists** for the SWM Site Plan Submission Package Checklist.

5.3.c. SWM Site Plan (required)

Table 5.5 summarizes project information applicants are required to provide in the SWM site plan.

TABLE 5.5. SWM SITE PLAN INFORMATION REQUIREMENTS	
#	Requirement
1	Drawings adhere to General Drafting Requirements (See Appendix E: General Drafting Requirements)
2	Plan and profile drawings of all SWM BMPs and stormwater conveyance features with the following information: <ul style="list-style-type: none">• Locations• Extents• Type(s)• Footprints and volumes• Proposed stormwater conveyance into and out of BMPs• Discharge locations and safe overflow connections
3	Plan call outs and tabular information designating: <ul style="list-style-type: none">• Proposed stormwater volume and rate control offsets• Rate control points of interest• Additional or enlarged BMPs qualifying for stormwater management volume or rate incentives• Accounting of points if preferred technology incentives are being requested• Proposed BMPs proposed for innovation track approval

5.3.d. SWM Site Plan Report (required)

Table 5.6 summarizes project information applicants are required to provide in the SWM site plan report and suggested report organization.

TABLE 5.6. SWM SITE PLAN REPORT INFORMATION REQUIREMENTS

#	Report Section	Requirements
1	Cover	Signed and sealed by a Qualified Professional
2	Project Stormwater Management Approach	<ul style="list-style-type: none"> • Project narrative • Applicable City Stormwater Regulations • Applicable State and Federal Stormwater Regulations/Permit Requirements • Expected project schedule
3	Existing Conditions	<ul style="list-style-type: none"> • Description of site and drainage areas • Soil survey map • Characterization and description of Hydrologic Soil Groups • Other environmental or geological factors (e.g. legacy contamination, undermined areas, etc.)
4	Stormwater Runoff Design Computations and Documentation	<p>Refer to Title 13 and Section 2.2 – Regulations and Requirements of this Manual. Must include:</p> <ul style="list-style-type: none"> • Description of volume and rate control calculations method(s) • Volume, rate control, and pipe capacity calculations • Model files (as applicable) • Model outputs (i.e., hydrograph summaries, ponding) • Effect(s) of the project (in terms of runoff volumes, water quality, and peak flows) on surrounding properties, aquatic features, and on any existing stormwater conveyance system that may be affected by the project
5	Drainage Area Documentation	<ul style="list-style-type: none"> • Pre- and post-development BMP and inlet drainage area delineations including roof leaders and tree canopy areas • Area of drainage (acres) and time of concentration to each BMP and POI • Runoff coefficients within each drainage area
6	Infiltration and Geotechnical Report	<p>Refer to manual Section 3.4, “Soil Assessment and Infiltration Testing” for requirements. Documents must be signed and sealed by a professional engineer and included as an attachment to the SWM site plan submission package.</p>
7	Proof of Applicable State and/or Federal Permits*	<p>Proof of submission of a Soil Erosion and Sediment Control Plan to the Allegheny County Conservation District (ACCD) or approval of Non-Permitted Plan as applicable (Refer to Chapter 2).</p> <p>Applicants must provide proof of application for state or federal permits. Permits may include General (PAG-02), Individual National Pollutant Discharge Elimination System (NPDES) Permit for Stormwater Discharges Associated with Construction Activities, or Erosion and Sediment Control Permit (ESCP) as applicable.</p>
8	Technical Infeasibility Report*	<p>Justification if BMPs other than non-structural, preferred or approved BMPs are proposed to achieve the volume, rate and water quality controls under Title 13. Refer to Section 2.2 - Regulations and Requirements.</p> <p>Technical justification of infeasibility for any drainage areas for which the applicant proposes to fulfill the volume control requirement through the payment of an in-lieu fee. To qualify for alternative compliance, the Technical Infeasibility Report must conclusively demonstrate the infeasibility of on-site management of impervious drainage area to meet volume control requirements for the regulated development. Refer to Section 3.6 – Technical Infeasibility Determination of this Manual. Reports must be prepared and signed by a licensed professional engineer in the Commonwealth of Pennsylvania.</p>
9	Operations and Maintenance (O&M) Agreement	O&M Agreement for all existing and proposed SWM BMPs signed by the responsible party. O&M agreements must include an O&M site map identifying all SWM BMPs and drainage features. Section 7, “Operations and Maintenance” of this manual for additional requirements.

* Only required if applicable

5.3.e. Volume Control Offset and/or Rate Offsets Strategy and Supporting Documentation (required if applicable)

Applicants who propose to fulfill the volume and/or rate control requirement(s) with volume and/or rate control offsets must submit required documentation to stormwater plan review staff as part of SWM site plan for consideration. Applicants are required to submit within the SWM site plan the information in Table 5.7. While applicants may opt to use offsetting strategies, stormwater plan review staff are not obligated to approve such strategies. Refer to Section 2.2.a.iv., “Volume Control Offsets” of this manual for information about volume control offset requirements. Refer to Section 2.2.b.vii., “Rate Control Points of Interest” of this manual for additional information about rate control offsets.

TABLE 5.7. REQUIRED DOCUMENTATION FOR VOLUME AND RATE CONTROL OFFSETS	
#	Requirement
1	Documentation that BMP(s) will achieve the same compliance standards for volume and/or rate control as directly managing stormwater from the proposed development project
2	Documentation that proposed development and proposed volume offset BMP(s) are sited on parcels under the same ownership
3	Documentation that proposed volume offsets meet the additional volume and/or rate control offset requirements in Section 2.2.a.iv and in Section 2.2.b.vii.
4	Documentation (sewer mapping or equivalent) that impervious areas drain to a single common POI (for rate offsets).

5.3.f. Volume, Rate, and Technology Incentives Strategy and Supporting Documentation (required if applicable)

Applicants must provide detailed information regarding volume, rate, and technology incentives. This information is summarized in Table 5.8.

TABLE 5.8. REQUIRED SUPPORTING DOCUMENTATION FOR VOLUME, RATE AND TECHNOLOGY INCENTIVE STRATEGY AND SUPPORTING DOCUMENTATION	
#	Requirement
1	Narrative explaining the design strategies and/or use technologies (i.e., active controls and/or water reuse) to achieve: <ul style="list-style-type: none">• Volume incentive• Rate incentives, and/or• Technology incentives.
2	Calculations supporting the volume and rate incentive volumes reported on the SWM site plan, including modelling where needed, for each BMP for which volume or rate control incentives are being requested.
3	Calculations supporting the technical incentive point totals reported in the SWM site plan.

Refer to Sections 2.2.a.v., “Volume Control Incentive”, 2.2.a.vi. “Technology Incentives”, and 2.2.b.viii. “Rate Control Incentive” of this manual for incentive requirements.

5.3.g. Documentation of Rainwater Points for Performance Point System (required if applicable)

Applicants who have pursued performance points in the Riverfront (RIV) and Uptown Public Realm (UPR) zoning districts by achieving Rainwater Goals (Title Nine: Zoning, §915: Environmental Performance Standards, Section 07.D) must provide documentation within SWM site plan submission package that the SWM site plan satisfies the requirements. Applicants should refer to the Department of City Planning website (<https://pittsburghpa.gov/dcp/process-guide>) for process guides for pursuing rainwater performance points.

5.3.h. Innovation Track Review Request and Supporting Documentation

Applications are directed to Section 3.7(b)iv, “Innovation Track” of this manual for submittal information for innovation track applications.

5.3.i. SWM Site Plan Review Fee

Refer to Fee Schedule published on the City’s website: <https://pittsburghpa.gov/pli/pli-fees/?&title=pli-fees>

5.3.j. SWM Site Plan Submission and Review Process

Applicants submit the SWM site plan submission package online at OneStopPGH along with the SWM site plan review fee. The applicant will receive an automatic email confirmation that the submission has been received. Stormwater plan review staff will notify the applicant in writing within 45 days whether the SWM site plan is approved, disapproved, or requires additional documentation. If a longer notification period is provided by other statute, regulation, or ordinance, stormwater plan review staff will notify the applicant.

For qualifying applicants (affordable housing developers, small-businesses, and M/W/BE businesses), stormwater plan review staff will provide a 5-business day SWM site plan review. Expedited 5-business day SWM site plan review is also available for eligible projects that use a combination of preferred vegetated practices, active control systems, and water reuse systems to meet the majority of the volume requirement, see Section 2.2.a.vi, “Technology Incentives” for more information.

Stormwater plan review staff may require a resubmission or, in the case of minor deficiencies, accept and approve submission of modifications. Stormwater plan review staff will not review or approve administratively incomplete SWM site plan submission packages.

If stormwater plan review staff disapproves the SWM site plan, the city will state the reasons for the disapproval in writing in the form of a comment letter. Revisions to a SWM site plan can be approved if requirements of the code are met. Resubmission of a modified SWM site plan submission package may be required if a modification to an approved SWM site plan involves:

- » Change in BMPs or techniques
- » Relocation or redesign of BMPs
- » Soil or other conditions are not as stated on the approved SWM site plan

Applicants may resubmit the SWM site plan with the revisions addressing comments.

Information on the PLI appeals process can be found here: <https://pittsburghpa.gov/pli/pli-appeals>

Applicants can seek a variance from the Board of Appeals for three reasons:

1. The true intent of the Uniform Construction Code was incorrectly interpreted.
2. The provisions of the Uniform Construction Code do not apply.
3. An equivalent form of construction is to be used.

This process is only applicable to decisions made regarding the SWM site plan review process regarding technical infeasibility and technical review.

5.4 STORMWATER PERMIT

Prior to construction of any elements of the SWM site plan, the applicant must obtain a Stormwater Permit. A Stormwater Permit must be obtained before any regulated earth disturbance and/or construction activities may begin at the project site.

Both the SWM conceptual review and SWM site plan review processes are housed under the Stormwater Permit process through the OneStopPGH portal. Submission of a Conceptual SWM Plan will initiate the Stormwater Permit application process. The Stormwater Permit will be issued concurrently with the plan review summary documenting the SWM site plan approval. The following approvals, as applicable, must be obtained prior to Stormwater Permit issuance:

- » Record of Zoning Approval from the Department of City Planning
- » NPDES Permit for Stormwater Discharges Associated with Contribution Activities or review Non-Permitted E&SC Plan by Allegheny County Conservation District

Applicants are encouraged, but not required, to obtain or apply for Plumbing Permits from Allegheny County Health Department prior to or concurrently with submission of Stormwater Permit applications.

Applicants are referred to the PLI Permits webpage for complete information regarding Stormwater Permit applications, application review, permit issuance, permit inspection, permit completion, and permit fees:

<https://pittsburghpa.gov/pli/pli-permits>

For more information regarding construction, refer to Section 6, “Construction Guidance”.

5.5 LAND DEVELOPMENT PROCESS IN PITTSBURGH

Applicants submitting for SWM site plan approval are typically also pursuing a range of other approvals relating to land development in the city. Table 5.9. summarizes additional permits and approvals that are commonly required for land development projects in Pittsburgh.

TABLE 5.9. ADDITIONAL PERMITS AND APPROVALS FOR LAND DEVELOPMENT PROJECTS

Permits and Approvals	Issued By
Land Operations Permit	Pittsburgh Permits, Licenses, & Inspections (PLI)
Building Permit	PLI
Plumbing Permit	Allegheny County Health Department (ACHD)
Right of Way Permit	Pittsburgh Department of Mobility & Infrastructure (DOMI)
Encroachment Permit	DOMI
Water and Sewer Use Approval	Pittsburgh Water and Sewer Authority (PWSA)
DEP Sewage Facilities Planning Module	Pennsylvania Department of Environmental Protection (PADEP)
Water/Sewer Tap-in Plan Review Approval	PWSA
Extension or Relocation Approval	PWSA
Tap Termination Permits	PWSA

5.6 COUNTY AND PADEP PERMITS

In addition to city approvals, projects involving earth disturbance commonly require additional approvals through County-level and State agencies. 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 City of Pittsburgh Stormwater Management Regulations. NPDES Permits for land development in Pittsburgh are issued by the Allegheny County Conservation District (ACCD) or PA DEP. City stormwater plan review staff do not issue NPDES Permits. The applicant should contact ACCD staff directly with questions concerning NPDES Permits. Municipal Notifications (such as those required under PA Acts 67, 68, and 127 of 2000) must be sent to City stormwater plan review staff with the assigned project tracking number listed on all notifications. Refer to Section 2.2.e.i. PA Code Title 25, Chapter 102 – Erosion and Sediment Control in this Manual.

Upon completion of permanent stabilization and installation of BMPs, applicants must send copies of a NPDES notice of termination to stormwater plan review staff through OneStopPGH.

Stormwater plan review staff recommend that NPDES Permit Applications are submitted to the ACCD when SWM site plan submission packages are sent to city stormwater plan review staff.

SECTION 6

SECTION 6 – CONSTRUCTION GUIDANCE

6.1 INTRODUCTION

Construction of BMPs requires careful execution and inspection to ensure that BMPs are installed properly and function as intended, and to minimize the impacts of construction activities on the surrounding environment. Section 6, “Construction Guidance”, provides guidance for developers, engineers, and contractors pertaining to construction-related topics.

The City of Pittsburgh conducts construction inspections during BMP installation to verify that correct installation practices are used and to confirm the BMPs are installed in accordance with the approved SWM site plan and approved construction documents of the Stormwater Permit.



A stormwater bumpout at Nagley and Woodmont Road through various stages of construction

6.2 CONSTRUCTION DOCUMENTS

No stormwater construction work within the approved SWM site plan shall commence without the issuance of a Stormwater Permit. Refer to Section 5 for information regarding submission and approvals of SWM site plans and Stormwater Permits.

Upon issuance of a Stormwater Permit, the applicant must obtain a copy of the approved construction documents at the OneStopPGH counter or through the OneStopPGH portal.

6.3 FIELD CHANGES

All field changes shall comply with the following:

1. All field changes must be documented by the owner/contractor in project record drawings and provided to the design professional for preparation of the record drawings. For additional requirements refer to Section 6.7, “Stormwater Permit Completion Documents”.
2. An amendment to Stormwater Permit shall be required for the following types of changes:
 - A. Modification of the setbacks.
 - B. Changes to BMP types.
 - C. Changes that may impact stormwater volume control or rate control performance such as changes to:
 - BMP storage volume,
 - hydraulic control elevations, and
 - contributing drainage areas.
 - D. Unforeseen field conditions that may impact technical infeasibility (see Section 3.6 “Technical Infeasibility Determination”).

All work impacted by these changes shall cease until the amendment is approved and issued.

6.4 PERMIT HOLDER AND DESIGN PROFESSIONAL RESPONSIBILITIES

6.4.a. Permit Holder Responsibilities

The permit holder is responsible to:

- A. Install BMPs under a valid issued Stormwater Permit.
- B. Maintain valid PLI general contractor trade license for duration of the Stormwater Permit.
- C. Maintain a copy of Stormwater Permit approved construction documents and approved SWM site plan at job site for use by stormwater inspector, ACCD inspector, and design professional.
- D. Install all BMPs in accordance the approved SWM site plan, the approved construction documents of the Stormwater Permit, Title 13 requirements, and the requirements of this manual.

- E. Notify the ACCD to schedule erosion and sediment control inspections and to submit documentation of these inspection records as a close-out document via the OneStopPGH portal.
- F. Submit documentation of NPDES permit inspections as close-out documents via the OneStopPGH portal.
- G. Notify stormwater inspector and qualified professional of any damage caused by significant storm events.
- H. Request Stormwater Permit inspections of BMPs per PLI's current rules and regulations.
- I. Keep work exposed until authorized to be concealed by PLI stormwater inspector.
- J. Hold covering, backfilling, or sealing any BMP until the information required for the record drawing(s) and the construction certification package has been acquired as confirmed by the design professional.
- K. Provide access and means for inspection of BMPs, including any required testing.
- L. Provide field measurements, including elevations, as requested by the design professional and stormwater inspector.
- M. Provide copies of all testing of components of BMPs as close-out documents via the OneStopPGH portal.
- N. Submit copies of approved construction submittals stamped by a qualified professional as close-out documents via OneStopPGH.
- O. Implement best practices for site development and BMP construction. Implementation is critical for preventing costly and environmentally-damaging issues from occurring. Examples of best practices that are critical for effective BMP construction are summarized in Table 6.1.

TABLE 6.1. BEST PRACTICES FOR BMPS CONSTRUCTION

Topic	Best Practice
Erosion and Sedimentation Control	All BMP footprints and existing conveyance structures downstream of construction activities must be protected from erosion and sedimentation.
	E&S measures must be properly installed and maintained until the site is stabilized.
	All inflow points must be blocked to prevent water from entering the BMP until the BMP construction is complete and any areas of earth disturbance have been stabilized with vegetation.
Protection of Infiltration Footprint	Clearly delineate marking of infiltration footprint.
	Compaction of the infiltration footprint of a BMP must be avoided as it can reduce the BMP's capacity to hold and infiltrate stormwater
	Construction equipment must not be stored on the BMP footprint.
	Heavy vehicles must not be driven over the BMP footprint.
Stone Storage	Stone used for stormwater storage must be clean and free of debris (i.e., "double washed" clean run) to ensure that the void spaces between the stone are available for stormwater storage (i.e., not clogged with sediment).
Subgrade Preparation	Ensure adequate compaction of subgrade below structures.
Plantings	Install plantings within designated planting windows. Water thoroughly immediately after installation.
Elevation Tolerances	Final elevations of media layers (e.g., sand, stone, soil, etc.) and flow control structures must not deviate greater than or less than 1 inch from design elevations. Any proposed elevation changes must be approved by the qualified professional and city stormwater inspector assigned to the project.



E&S BMPs are to be kept in place until soil materials can be stabilized by vegetation or mechanical means.

6.4.b. Qualified Professional Responsibilities

The qualified professional is responsible to:

- A.** Be present during the installation of all components of a BMP.
- B.** Review construction submittals of material inspection and testing certifications for each batch of product used. Submittals must clearly specify the types, qualities, and quantities of the materials purchased. The materials for which submittals are required may include, but are not limited to, the following:
 - 1. Stone
 - 2. Geotextile fabric
 - 3. Perforated pipes
 - 4. Subsurface storage units
 - 5. Bioinfiltration/bioretenention media
 - 6. Filter media
 - 7. Porous pavement
 - 8. Impervious liners
 - 9. Precast concrete structures
 - 10. Pretreatment inlet inserts
 - 11. Vegetation or plantings
 - 12. Proprietary stormwater management systems/devices/components.
- C.** Notify the permit holder, owner, and stormwater inspector of all elements that do not conform to the approved SWM site plan, approved

stormwater construction documents, Title 13 requirements, and requirements of this manual.

- D. Completion of construction certification package table for all post-construction BMPs. For additional requirements refer to Section 6.7.b, “Construction Certification Package”.

6.5 INSPECTION AGENCIES

Erosion and sediment control inspections during construction are performed by the Allegheny County Conservation District. Stormwater permit inspections of BMPs are performed by PLI stormwater inspectors. Stormwater inspection requesting and scheduling, including lead times for standard inspections and off-hour inspections requirements shall conform to PLI’s current Rules and Regulations. Note that PADEP National Pollutant Discharge Elimination System (NPDES) Permit inspections and compliance are under the charge of ACCD/DEP.

6.6 STORMWATER PERMIT INSPECTION PROCESS

6.6.a. Required Inspections

The following inspections are required: **pre-construction, underground, and final**. Additional inspections may be required to confirm compliance with Title 13 and this manual.

6.6.b. Inspection Results

The stormwater inspector will notify the permit holder of all failed items after inspections are performed. An itemized inspection report is available to the permit holder via the OneStopPGH portal. No work under the Stormwater Permit may proceed until a passed inspection has been granted. The permit holder is responsible to correct all failed items and request re-inspection. The owner is responsible to cover the cost of corrective actions and/or work.

6.6.c. Pre-construction Inspection

Following issuance of a Stormwater Permit and prior to the start of BMP construction, the permit holder is responsible for requesting the pre-construction inspection. The permit holder, or their authorized agent and qualified professional shall be present for pre-construction inspection.

The following topics shall be reviewed:

- A. Contractor/owner documentation requirements during the construction process (e.g., survey data, photos, material receipts/submittals, etc.)
- B. Construction certification package, record drawing requirements and table of all post-construction BMPs
- C. Permits and any special conditions associated with permits
- D. Project construction sequence
- E. Limits of disturbance



An inspector observing pipe installation associated with a subsurface detention BMP.

- F. Special protection zones (i.e., infiltration areas where heavy equipment tracking would be prohibited)
- G. Identification of construction hold points / milestones (e.g., prior to backfill of subsurface features, etc.) defined in the approved SWM site plan and/or Stormwater Permit that require the contractor to notify the stormwater inspector or design professional
- H. Discussion of proper construction practices for BMPs (e.g., a protection of infiltration/filtration areas, use of clean-washed stone, thorough review of critical elevations/dimensions that impact BMP performance, etc.)
- I. Communication protocols
- J. Working hours
- K. Safety measures
- L. Anticipated construction schedule



An onsite pre-construction meeting

6.6.d. Underground Inspection

Underground inspection shall be made after trenches or ditches are excavated and bedded, piping installed, and before any backfill is put in place. Underground inspections may be approved in phases as follows:

- A. Verification of elevations of structures and excavations prior to and at each stage of backfill
- B. Installation of geotextile or impermeable liner
- C. Subgrade preparation for pavement and curb installation
- D. Placement of plants

6.6.e. Final Inspection

Final inspection shall be requested after the BMPs within the SWM site plan are complete and is ready for service and prior to the removal of E&S control measures. The permit holder shall submit all required completion documents as

close-out documents via the OneStopPGH portal. Failure to provide required documents will result in a failed inspection. All work shall be complete and in accordance with the approved SWM site plan, approved stormwater permit documents, Title 13, and the requirements of this manual. This final inspection process is in addition to, not a substitute for, PADEP Notice of Termination (NOT) for NPDES permitted projects.

6.7 STORMWATER PERMIT COMPLETION DOCUMENTS

6.7.a. Record Drawings

The Stormwater Permit holder and owner are responsible for providing record drawings of all BMPs included in the approved SWM site plan, Stormwater Permit approved construction drawings/documents, Title 13, and the requirements of this manual. The owner is responsible for complying with NPDES completion requirements. The stormwater record drawing submission shall:

- A. Include an explanation of any discrepancies with the construction plans.
- B. Record drawings shall accurately represent the site's as-built conditions, including, at a minimum, all locations (latitude and longitude coordinates of central location of BMP), dimensions, elevations, materials as constructed and installed, and clearly identify items that changed from approved documents.
- C. Tabular and other supporting documentation shall be provided.
- D. Record drawings must be prepared and sealed by the qualified professional(s).
- E. Clearly be identified as record drawings with updated date.

6.7.b. Construction Certification Package

The construction certification package shall include:

- A. The post-construction submission must include a certification of completion signed by the qualified professional(s), or the qualified professional's representative for the project, verifying that all post-construction BMPs have been constructed according to the approved plans and specifications.
- B. A table of all post-construction BMPs with BMP type, drainage area, BMP footprint (infiltrating footprint if applicable), and latitude and longitude coordinates from the center of each BMP must be included. If any qualified professionals contributed to the construction plans, then each qualified professional must sign the certificate of completion.
 1. Each measurement documented on the forms must be dated and initialed by the qualified professional who took, or whose designee took, the measurement. Once all of the required measurements have been appropriately documented, the qualified professional must execute and date the form.

- C.** The construction certification package must also include electronic photographs documenting all BMP installations. The photographs must clearly depict the installation of all components of the BMP. In all cases, provide multiple views to clearly document the extent and configuration of the installation. Photographs documenting proper installation of buried components, such as geotextile liners are particularly important. For each photograph, clearly label the subject, view angle, and location of the photos on a reference plan. Components to be photographed may include, but is not limited to, photographs of the following:

 - 1.** Basin excavation
 - 2.** Subgrade preparation
 - 3.** Fabric or liner placement
 - 4.** Stone placement
 - 5.** Filter media placement
 - 6.** Pipe placement
 - 7.** Pipe perforation
 - 8.** Subsurface vault installation
 - 9.** Pretreatment system installation
 - 10.** Inlet control installation
 - 11.** Outlet control installation
 - 12.** Landscaping

SECTION 7 – OPERATIONS AND MAINTENANCE

7.1 INTRODUCTION

Stormwater BMPs require sustained maintenance to ensure long-term function and safety. Following construction, it is the responsibility of the property owner to maintain all BMPs in perpetuity. An Operations and Maintenance (O&M) Agreement, which contains provisions of maintenance responsibilities and an O&M Plan, is essential for the functional success of a BMP. The O&M Plan establishes maintenance responsibilities and protocols to ensure the proper and sustained function of a BMP. Maintenance responsibilities under the O&M Agreement include conducting routine and corrective maintenance, performing inspections, and notifying the city of Pittsburgh if any further site improvements are planned to the property that could affect BMP function or regulatory compliance, such as changes in site grading or stormwater drain location/configuration, as well as addition of new impervious areas, such as walkways, patios, decks, driveways, parking lots, sheds, or buildings.

Operations and maintenance tasks and frequencies for each BMP must be documented in the O&M Plan for each project. While not exhaustive, typical BMP maintenance tasks and frequencies are provided in **Appendix F: Operation and Maintenance** for reference. It is important to conduct routine inspection and maintenance to identify and remedy problems as they arise, before they become larger problems that may require intensive re-design or construction to address. Inspections should typically occur every three months and after every storm greater than one inch. More frequent inspection (e.g., weekly to monthly inspection) of some BMP features (e.g., inlets, outlets, and vegetation) in the first year after installation may also be needed to verify successful establishment and/or installation, as well as to determine optimal routine maintenance frequencies needed to ensure proper BMP function.

It is also important to consider how the condition of the site and any other contributing drainage areas may affect the long-term function of the BMP. In particular, owners should identify and mitigate any introduction of sediment or debris into the BMP. This could include repaving areas of pavement that are in poor condition, stabilizing any poorly vegetated landscape or lawn areas, and

providing covering for mulch, debris, soil, or sand storage areas located upstream of the BMPs. Sediment loading can significantly increase maintenance costs and decrease the service life of the BMP. Additionally, owners should be aware of any utilities that might be passing near, within or under the BMPs. Alternatively, utility owners should be made aware of the need to avoid disruption to the BMP during utility repairs and the need to make repairs to any damage incurred.

Implementation of BMP O&M will depend on the type of BMP as well as the capabilities/resources of the owner. For some common tasks such as weeding and watering, owners can self-perform these tasks, particularly if the owner has a facilities maintenance staff or contracts with a landscape contractor for grounds maintenance. For other tasks, particularly those involving the clean out of subsurface features like storage chambers, inlets, and pipes or cleaning of porous pavements, contracting with an outside specialty contractor is typically required.

When conducting BMP inspections and maintenance, it is critical to establish and adhere to strict safety protocols for maintenance workers. State and federal guidelines such as those administered by Occupational Safety and Health Administration (OSHA) standards shall be adhered to based on the type of maintenance activity. These protocols include but are not limited to:

- » Use of personal protective equipment (PPE)
- » Training in the proper use of maintenance equipment
- » Limiting vehicle and pedestrian access during maintenance
- » Providing fall protection and training for maintenance conducted on roofs or other elevation surfaces (OSHA Standard 1926.503)
- » Providing confined space entry training for personnel entering confined spaces (OSHA Standard 1910.146)

7.2 OPERATIONS AND MAINTENANCE REQUIREMENTS

The owner is responsible for all operation and maintenance associated with privately-owned stormwater BMPs unless otherwise agreed upon in the O&M Agreement (see Section 7.3). The city has the right to perform maintenance at the owner's expense, and may take additional enforcement actions against an owner for any failure to fulfill O&M responsibilities.

Facilities, areas, or structures used as BMPs shall be enumerated as permanent real estate appurtenances and recorded as deed restrictions or conservation easements that run with the land, including an Operations and Maintenance Agreement. The preparation of deed restrictions or conservation easements shall conform to requirements set forth in this manual. In addition, the O&M plan included as a component of the SWM site plan, shall be recorded as a restrictive deed covenant that runs with the land.

7.3 OPERATION AND MAINTENANCE AGREEMENTS

Prior to final approval of the SWM site plan, the property owner shall sign and record an O&M agreement, as approved by the plan reviewers, covering all stormwater control facilities which are to be privately owned. The O&M Agreement shall incorporate the O&M Plan and the following provisions:

- » The owner, successor and assigns shall maintain all facilities in accordance with the approved maintenance schedule in the O&M agreement.
- » The owner shall maintain the stormwater control facilities to ensure that the stormwater management performance standards are being met.
- » The owner shall convey to the city conservation easements to assure access for periodic inspections by the city as necessary.
- » The owner shall keep on file with the city the name, address, and contact information of the person or company responsible for maintenance activities; in the event of a change, new information shall be submitted by the owner to the city within ten (10) working days of the change.
- » If the owner fails to adhere to the O&M agreement, the city may perform the services required at the owner's expense and charge the owner appropriate fees. Nonpayment of fees may result in a lien against the property.

7.4 BMP INSPECTION AND MAINTENANCE GUIDANCE

7.4.a. Inspections

The landowner or the owner's designee (including the city for dedicated and owned facilities) shall inspect SWM BMPs, facilities and/or structures installed under Title 13 according to the following frequencies, at a minimum, to ensure the BMPs, facilities and/or structures continue to function as intended:

- » Every three months or as prescribed in **Appendix F: Operations and Maintenance**.
- » During or immediately after the cessation of a ten-year or greater storm. For more information on storm recurrence intervals, see NOAA Atlas 14 precipitation estimates.

Inspections are critical for identifying maintenance needs and any performance or safety issues. As such, inspections should be performed by qualified personnel with training in stormwater BMP performance and maintenance, such as the National Green Infrastructure Certification Program (NGICP). Inspections vary by BMP type and site-specific conditions, but generally consist of the following:

- » Inspection of storage areas, pipes, pretreatment devices, and inlet and outlet controls to identify clogging, poor drainage, or significant accumulation of sediment and debris.
- » Inspection of vegetated areas to identify invasive species, sediment

accumulation, poor plant growth, disease or distressed plantings, areas of poor vegetation cover, and erosion.

- » Identification of safety hazards including areas of settlement, cracked or buckling concrete, ponded water in or around pedestrian travelways, and damage to perimeter fencing, if present.

A written inspection report shall be created to document each inspection. The inspection report shall contain the date and time of the inspection, the individual(s) who completed the inspection, the location of the BMP, facility or structure inspected, observations on performance, and recommendations for improving performance, if applicable. Any repairs or corrective maintenance work recommended within the inspection report must be implemented in a timely manner and similarly documented. Inspection reports shall be kept onsite and furnished to city inspectors upon request.



A routine inspection of a bioretention BMP.

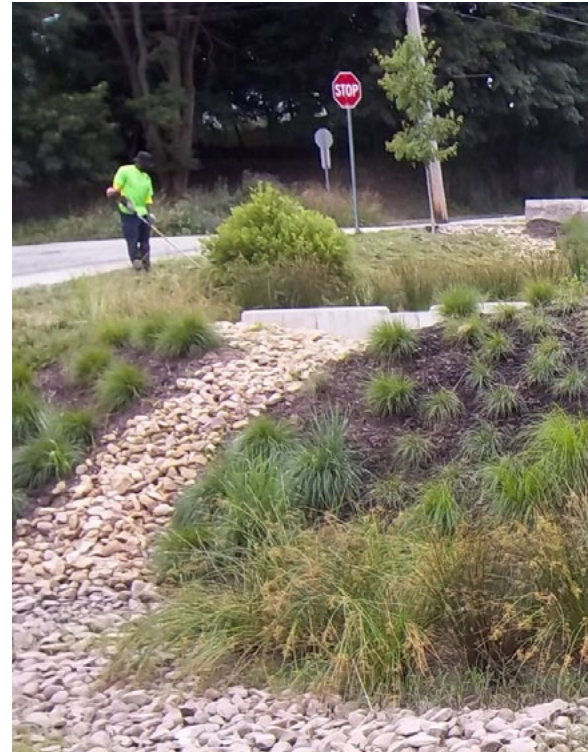
7.4.b Routine Maintenance

Required routine maintenance is BMP- and site-specific. However, typical routine maintenance tasks include the following:

- » Removal of sediment and debris from inlets and outlet control structures, storage areas, porous pavements and pipes;
- » Replacement of worn bolts, latches, and other appurtenances;
- » Minor asphalt or concrete patching and repair;
- » Minor erosion repairs including slope stabilization;
- » Minor replanting, reseeding, and re-grading;

- » Establishment watering for new plantings during the first two to three years after the initial planting;
- » Emergency watering during prolonged dry periods;
- » Removal of invasive plants or weed species;
- » Replanting, reseeding, and regrading;
- » Mulching; and
- » Pruning of trees and shrubs, as appropriate, prior to winter months.

These tasks are associated with BMPs that are generally in good condition and properly functioning. If BMPs are not properly functioning, more extensive maintenance or repairs may be needed, which may include full excavation, removal, and replacement of permanently clogged media or porous surfaces. Corrective maintenance may require the engagement of design professionals to diagnose and design solutions to address significant performance issues, as well as specialized, heavy equipment to implement repairs.



Routine maintenance of a bioretention BMP.