GREEN INFRASTRUCTURE GUIDANCE MANUAL

FOR NEW JERSEY

RUTGERS
New Jersey Agricultural Experiment Station

GREEN INFRA-STRUCTURE

ACKNOWLEDGMENTS

This document has been prepared by the Rutgers Cooperative Extension Water Resources Program with funding provided by Surdna Foundation, the National Fish and Wildlife Foundation, and the New Jersey Agricultural Experiment Station. This work is intended to provide guidance for the identification, design, and implementation of green infrastructure practices throughout New Jersey.

WELCOME

Rutgers, The State University of New Jersey is the land grant university for New Jersey. In 1914 the Cooperative Extension Service (CES) was created within the land grant universities to provide research-based knowledge to improve people's lives. In New Jersey, Rutgers Cooperative Extension (RCE) helps the diverse population of New Jersey adapt to a rapidly changing society and improves lives through an educational process using science-based knowledge. The RCE Water Resources Program is one of many specialty programs under the RCE system. Our mission is to identify and address community water resources issues using sustainable and practical science-based solutions.

Since 2002, the RCE Water Resources Program has been working with communities throughout New Jersey to address stormwater related issues. During this period, the RCE Water Resources Program has developed and delivered education and outreach programs on stormwater best management practices (BMPs), both structural and non-structural, to help promote low impact development (LID) on our undeveloped lands. In areas that have already been developed, the RCE Water Resources Program has been promoting the use of green infrastructure practices to retrofit existing development for better stormwater management.

Green infrastructure is an approach to stormwater management that is cost-effective, sustainable, and environmentally friendly. Green infrastructure practices capture, filter, absorb, and reuse stormwater to help restore the natural water cycle by reducing stormwater runoff, promoting infiltration, and enhancing evapotranspiration. These efforts have included developing and delivering educational programming coupled with the design and implementation of demonstration green infrastructure projects. Even with these outreach efforts, some communities remain hesitant to adopt green infrastructure practices and require further guidance. To address this need, the RCE Water Resources Program developed this green infrastructure manual for New Jersey based on BMPs from across the nation and our experience in New Jersey.

OUR MISSION IS TO IDENTIFY AND ADDRESS COMMUNITY WATER RESOURCES ISSUES USING SUSTAINABLE AND PRACTICAL SCIENCE-BASED SOLUTIONS

The manual that follows was created to translate our experience with green infrastructure design into guidance for communities and design professionals. With extensive knowledge in designing, implementing, and maintaining green infrastructure throughout urban and suburban areas in New Jersey, we hope this document will help communities become aware of opportunities for green infrastructure and encourage its adoption.

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WHY THIS MANUAL?

The following manual was created for communities with combined sewer systems (CSS) and municipal separate storm sewer systems (MS4s). The guidance provided is beneficial to planning and design professionals, municipal engineers and officials, community groups, and inspired residents who are interested in installing green infrastructure practices to reduce negative impacts caused by stormwater runoff.

With a focus on green infrastructure for stormwater management, this guidance document will provide an important resource for stakeholders to better manage stormwater within their community. This manual provides users with information on the fundamental function and benefits of select green infrastructure practices and technical design standards. It describes the design process for a green infrastructure practice, guiding the user through the process from site identification to implementation. Using the details in this manual, stakeholders as well as design professionals that are planning to implement green infrastructure practices into existing development will understand the process from start to finish.

One goal of this document is to provide direction for actively engaging the public in the long-term control planning (LTCP) process and associated permit regulations of combined sewer overflows (CSOs) and municipal separate storm sewer (MS4) systems. The manual will act as a tool for planning and design professionals looking to retrofit green infrastructure practices into existing development. The following topics are included in this manual:

- **UNDERSTANDING THE FUNDAMENTAL FUNCTION AND BENEFITS OF GREEN INFRASTRUCTURE SYSTEMS**
- **LEARNING TO IDENTIFY OPPORTUNITIES FOR GREEN INFRASTRUCTURE**
- **LEARNING THE PROCESS FOR DESIGNING GREEN INFRASTRUCTURE RETROFIT PROJECTS**
- **UNDERSTANDING HOW TO INTEGRATE GREEN INFRASTRUCTURE INTO COMMUNITY PLANNING AND PERMIT REGULATIONS**

The manual provides diagrams, engineering details, anticipated benefits, and examples of implementation of green infrastructure. All information provided is based on our experience with planning, designing, and implementing green infrastructure throughout New Jersey in combination with the research conducted on other green infrastructure initiatives across the nation.

KEY TERMS

1 Best management practice (BMP)

Activities or structural improvements that help reduce the quantity and improve the quality of stormwater runoff

2 Combined sewer overflow (CSO)

During rain events, stormwater flows can exceed the capacity of the combined sewer system and/or the sewage treatment plant causing an overflow of a slurry of untreated wastewater and stormwater to local waterways.

3 Combined sewer system (CSS)

A wastewater collection system designed to carry sanitary sewage (consisting of domestic, commercial, and industrial wastewater) and stormwater (surface drainage from rainfall or snowmelt) in a single pipe to a treatment facility

4 Connected impervious surface

When stormwater runoff flows directly from an impervious surface to a local waterway or a sewer system, the impervious surface is considered “connected” or “directly connected.”

5 Disconnected impervious surface

When stormwater runoff flows from an impervious surface onto a pervious surface or into a green infrastructure practice prior to entering a local waterway or a sewer system, the impervious surface is considered “disconnected.”

6 Green infrastructure practice

A stormwater management practice that captures, filters, absorbs, and/or reuses stormwater to help restore the natural water cycle by reducing stormwater runoff, promoting infiltration, and/or enhancing evapotranspiration

7 Impervious cover assessment (ICA)

Readily available land use/land cover data from the New Jersey geographic information system (GIS) database are used to determine the percentage of impervious cover in municipalities by subwatershed. The ICA includes calculations of stormwater runoff volumes associated with impervious surfaces.

8 Impervious cover reduction action plan (RAP)

A plan that identifies opportunities to retrofit specific sites with green infrastructure practices to reduce the impacts of stormwater runoff from impervious surfaces

9	Impervious surface	Any surface that has been covered with a layer of material so that it is highly resistant to infiltration by water; examples include but are not limited to paved roadways, paved parking areas, and building roofs
10	Long-term control plan (LTCP)	A systemwide evaluation of the sewage infrastructure and the hydraulic relationship between sewers, precipitation, treatment capacity, and overflows which identifies measures needed to eliminate or reduce the occurrence of CSOs
11	Low impact development (LID)	A land planning and engineering design approach that emphasizes conservation and use of on-site natural features to manage stormwater runoff and protect water quality
12	Municipal separate storm sewer system (MS4)	A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains) that transports stormwater runoff to local waterways or stormwater facilities such as a detention basin

13 Nonpoint source (NPS) pollution

"Nonpoint source pollution" is also called "people pollution." It is the pollution that comes from our everyday lives. It is the fertilizers that wash off our farms and lawns. It is the pet waste that washes into our streams. It is the sediment (or soil) that erodes from our lands into our local waterways. It is the oil and grease that comes from our parking lots. Finally, it is the pollutants such as nitrogen, phosphorus, and heavy metals that settle out of our atmosphere onto our roads and rooftops. When it rains, stormwater runoff carries nonpoint source pollution that may ultimately wash into our waterways.

14 Pervious surface

Any surface that allows water to pass through it (e.g., lawn area)

15 Stormwater runoff

Water from rain or melting snows that can become "runoff" flowing over the ground surface and returning to lakes and streams

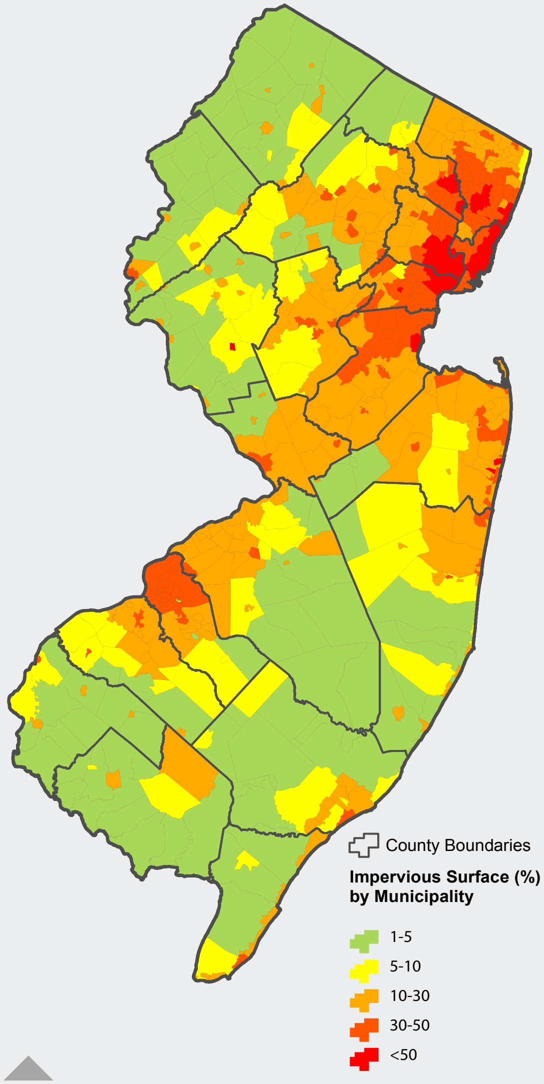
RETROFIT NEW JERSEY

1

CHAPTER

STORMWATER MANAGEMENT

Stormwater management is still a new concept to many communities across the nation. In New Jersey, there are many areas developed prior to the 1970s where stormwater management is virtually non-existent. While the first detention basins were constructed in the late 1970s, it was not until 2004 that stormwater management for new development became more comprehensive. This lack of focus on stormwater management prior to 2004 has resulted in a plethora of water quality issues and flooding problems during small storm events. Primarily due to the lack of stormwater management, New Jersey's streams are polluted and are no longer fishable or swimmable. With development came an increase in impervious surfaces, which resulted in increases in stormwater runoff volumes that quickly discharge to local waterways. Stream banks are eroding, and stream channels are downcutting, damaging local roads, bridges, and buildings due to the flashy hydrology created from uncontrolled stormwater runoff from impervious surfaces. This problem will escalate as climate change brings more intense storms to New Jersey.



The figure above shows the total percentage of impervious cover per municipality in New Jersey.[3]

This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been verified by NJDEP and is not state-authorized.

With a lack of stormwater management and high density development throughout the state, too many impervious surfaces are draining directly to local waterways, combined sewer systems, and separate sewer systems. By preventing stormwater runoff from flowing directly into the local waterways or sewer systems, we can reduce flooding and improve water quality. These flooding reductions and water quality improvements make communities more resilient to climate change and improve the quality of life for New Jersey residents.

New Jersey is 8,723 square miles in size, 7,354 square miles in land and 1,369 square miles in water. According to David J. Nowak and Eric J. Greenfield,[1] New Jersey has covered 12.1% of the land with impervious surfaces, which is 1,055 square miles of impervious cover or 675,200 acres of impervious cover. During a one-inch rainfall event, 18.3 billion gallons of stormwater drains from these surfaces. This is enough water to fill up MetLife Stadium 38 times.[2] Many of these impervious surfaces are directly connected to our local waterways, meaning that every drop of rain that lands on these surfaces drains directly to a stream, river, lake or bay without any treatment or having the opportunity to infiltrate into the soil. Pollutants accumulate on these impervious surfaces and are washed into New Jersey's waterways during storm events. Additionally, these impervious surfaces prevent rainfall from infiltrating into the ground to replenish the state's aquifers. Limited infiltration of rainwater results in reduced base flow to the local streams that rely on groundwater during the dry summer months.

Unfortunately, the picture is much grimmer for the 21 communities in New Jersey that rely on combined sewers for stormwater and wastewater management. These areas are some of the oldest urban centers in the state and have an average impervious

[1]Nowak, D.J., and E.J. Greenfield. 2012. Trees and Impervious Cover in the United States. *Landscape and Urban Planning* 107(2012): 21-30.
[2]Volume of MetLife Stadium is 64,500,000 cubic feet
[3]NJ Department of Environmental Protection (NJDEP), Office of Information Resources Management (OIRM), Bureau of Geographic Information System (BGIS). 2012. *Land use/Land cover Data.*

cover of 55%, which is 66 square miles of impervious cover or 42,240 acres of impervious cover. When it rains in these communities, the aged infrastructure of the combined sewer systems often cannot handle the runoff volumes; this results in system overflows of both sewerage and stormwater to local waterways, streets, and basements of the community. This creates an environmental problem and human health issue for the residents of these communities.

Impervious surfaces are surfaces covered with a material that is highly resistant to water infiltration. Examples include, but are not limited to, paved roadways, paved parking areas, and building roofs.

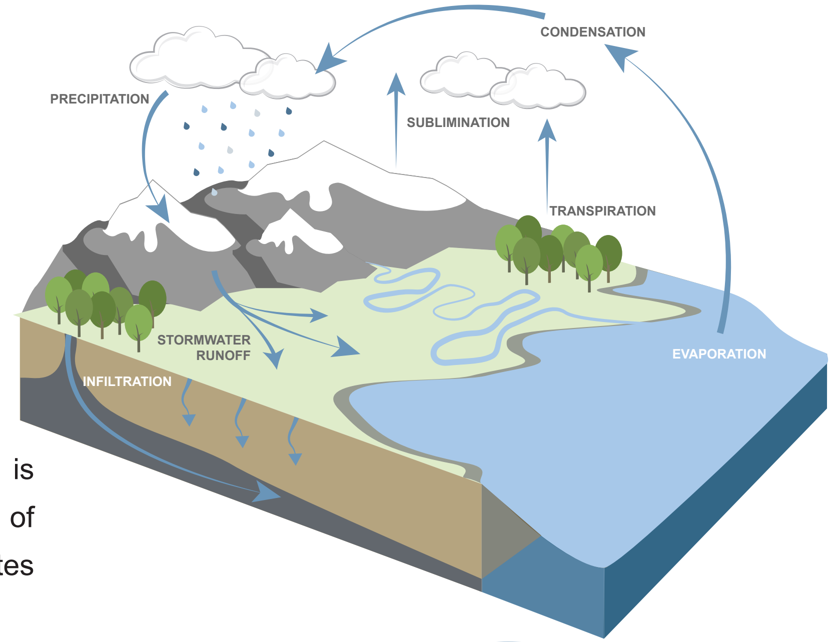
It is imperative that communities take these water quality problems into consideration given the environmental and human health issues for residents throughout the state. Green infrastructure is one solution to help remediate these problems. Green infrastructure practices are designed as a small-scale approach to stormwater management that addresses runoff near its source and is cost-effective, sustainable, and environmentally friendly. These projects are designed to intercept, capture, filter, absorb, and reuse stormwater to help restore the natural hydrologic cycle. In New Jersey, existing developed areas can be retrofitted with these green infrastructure practices to help improve water quality, reduce flooding, and enhance climate resiliency throughout the state.

MUNICIPALITY	COUNTY	% IMPERVIOUS COVER
Bayonne City	Hudson	41.4%
Camden City	Camden	42.8%
East Newark Borough	Hudson	60.0%
Elizabeth City	Union	58.1%
Fort Lee Boro	Bergen	51.7%
Gloucester City	Camden	32.3%
Hackensack City	Bergen	56.6%
Harrison Town	Hudson	55.7%
Hoboken City	Hudson	74.2%
Jersey City	Hudson	53.4%
Kearny Town	Hudson	32.5%
Newark City	Essex	57.8%
North Bergen Township	Hudson	50.1%
Paterson City	Passaic	53.0%
Perth Amboy City	Middlesex	48.7%
Ridgefield Park Village	Bergen	38.1%
Town of Guttenberg	Hudson	67.9%
Trenton City	Mercer	47.1%
Union City	Hudson	70.4%
Weehawken Township	Hudson	58.4%
West New York Town	Hudson	69.0%

The table above shows the total percentage of impervious cover for each combined sewer overflow community in New Jersey based upon NJDEP geographic information system (GIS) land use/land cover data from 2012.

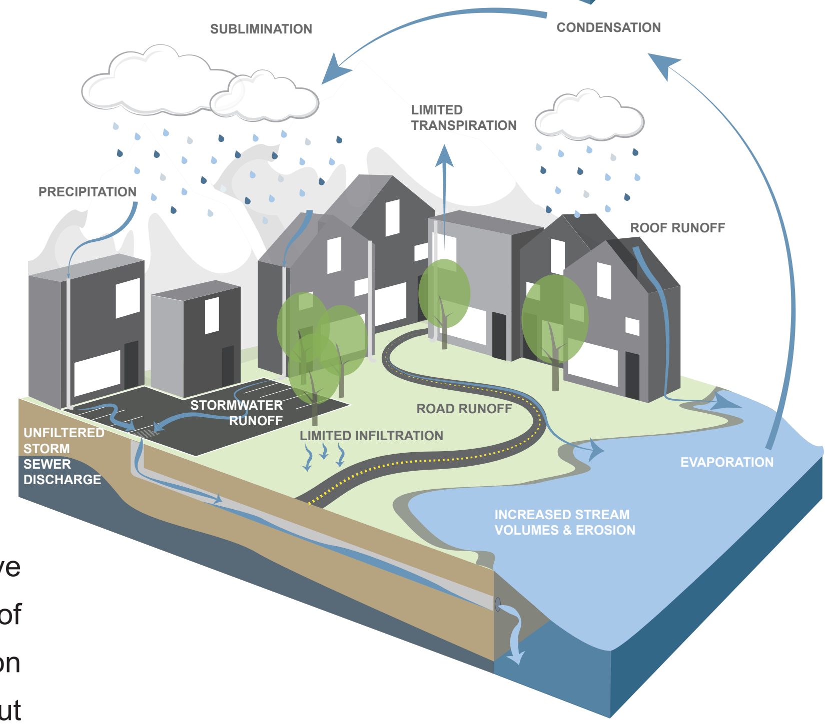
THE EFFECT OF THE URBAN WATER CYCLE

The natural water cycle for undeveloped land has 10% runoff, 50% infiltration, and 40% evapotranspiration (a combination of evaporation from standing water and transpiration from vegetation). As these natural lands are replaced with development and impervious cover, runoff increases, and infiltration and evapotranspiration decrease. This causes flash flooding in streams, leading to scouring, downcutting, and stream bank erosion. This causes localized flooding in areas where culverts and bridge openings cannot handle increased stream flow. This runoff results in more **nonpoint source pollution** as stormwater flushes pollutants from impervious surfaces to local waterways. Additionally, as more impervious surfaces are created, there is less infiltration of stormwater in the aquifers. These aquifers provide baseflow to the streams in dry weather months. When the aquifers are not recharged with rainfall, the aquatic communities become degraded due to low baseflow.



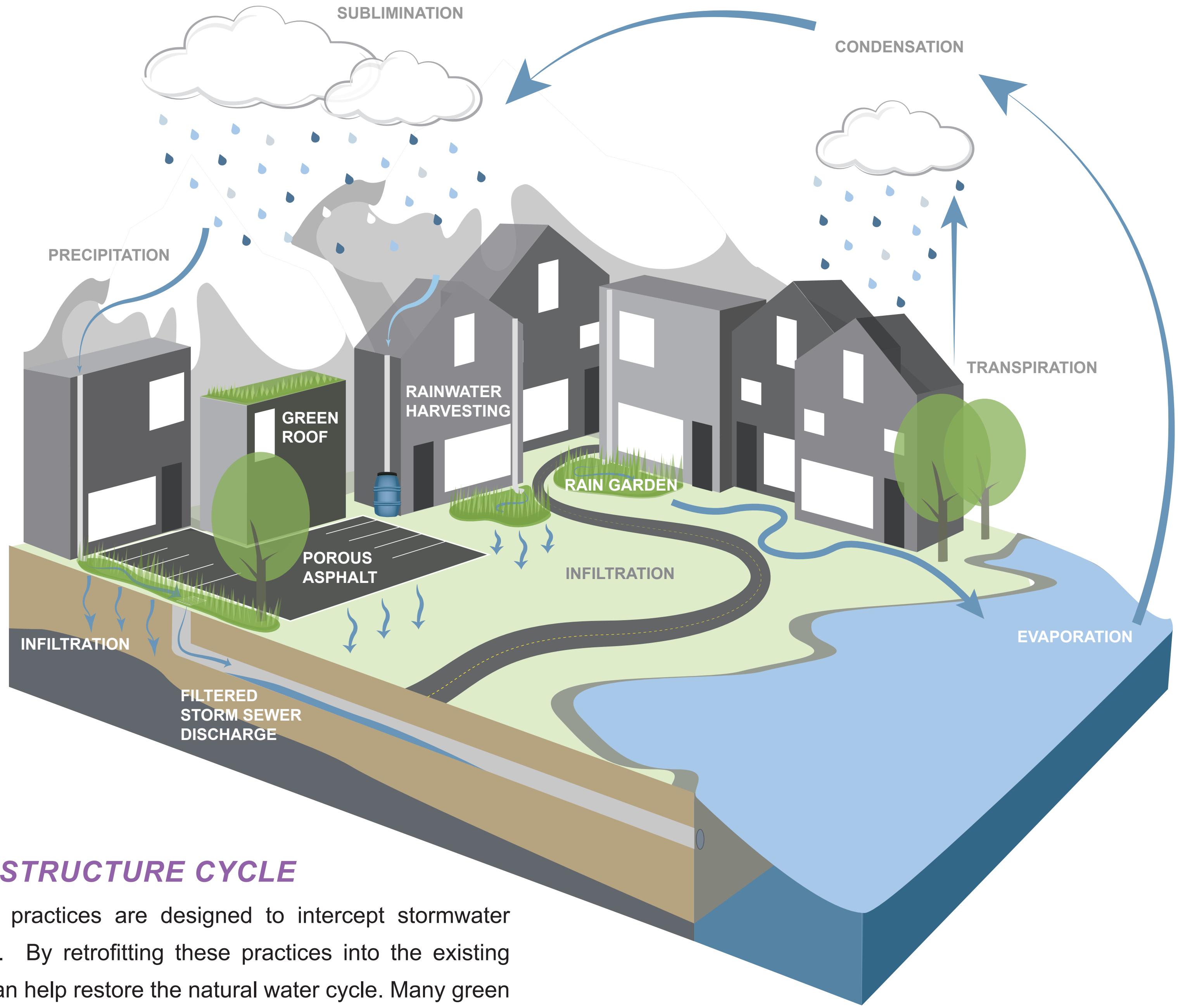
WATER CYCLE

The natural water cycle is a balanced movement of water from varying states (solid, liquid, gas).



URBAN WATER CYCLE

Impervious surfaces have decreased the amount of infiltration and transpiration that takes place throughout the natural water cycle.

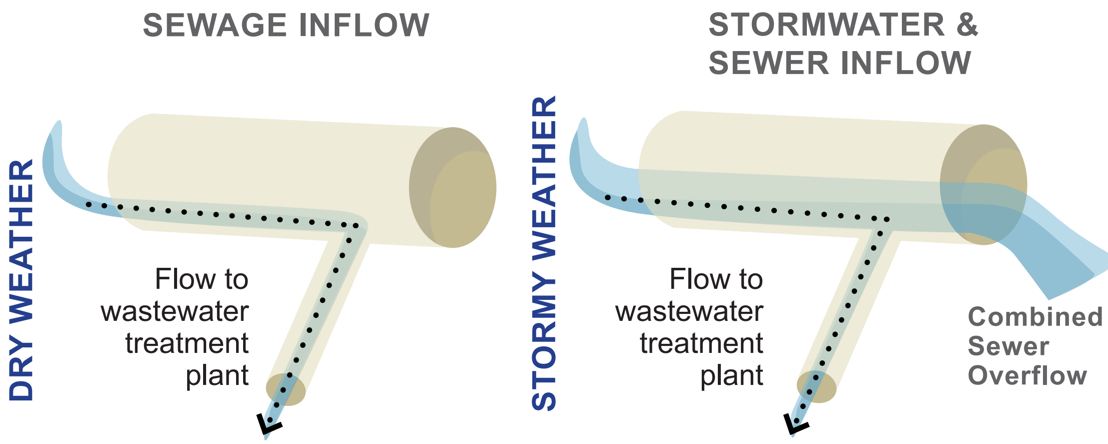


GREEN INFRASTRUCTURE CYCLE

Green infrastructure practices are designed to intercept stormwater runoff at the source. By retrofitting these practices into the existing development, they can help restore the natural water cycle. Many green infrastructure practices incorporate vegetation to help treat runoff and promote infiltration and transpiration.

COMBINED SEWER OVERFLOW COMMUNITIES

The first combined sewer systems were designed to convey untreated wastewater, stormwater, and industrial waste to local waterways to protect human health and prevent disease by draining the street gutter of this material. As we began worrying about the health of our waterways, the combined sewer systems were diverted to wastewater treatment plants instead of discharging directly into the rivers. Since it was cost prohibitive for these wastewater treatment plants to be designed to treat all the combined sewer overflow during heavy rainfall events, engineers designed discharge points where combined sewer systems could overflow into local waterways (i.e., combined sewer overflow (CSO)).



This figure shows the CSO system in both dry and wet weather. In dry weather (left) sewage is held in the pipes and flows to the treatment plant. In wet weather (right) the combination of stormwater and sewage exceeds the capacity of the system and overflows into local waterways.

In New Jersey, there are approximately 212 active CSOs throughout 21 communities in eight counties. These discharge points are located in older, urban areas along tidal portions of the Delaware River in Camden, Gloucester, and Mercer counties, the tidal portion of the Raritan River in the City of Perth Amboy, and throughout the New Jersey/New York harbor complex. Untreated discharges from these systems impact 25 waterbodies in 10 watersheds. These CSOs are known to contain pathogens (disease causing organisms), floatable debris, toxic metals, settleable solids, toxic organic chemicals, nutrients, and organic contaminants. Overflow events degrade water quality and adversely impact aquatic animals, plants, and human health. In the New Jersey/New York harbor estuary complex alone, CSOs contribute 89% of the pathogenic indicator organisms.[4]

Today, the United States Environmental Protection Agency (EPA) is responsible for enforcing the Clean Water Act to address CSO issues throughout the country. The New Jersey Department of Environmental Protection (NJDEP), working with EPA, has issued individual New Jersey Discharge Pollution Elimination System (NJDPES) permits for all New Jersey CSO permittees, which requires these permittees to develop a long-term control plan that, once implemented, will bring the CSO discharges into full compliance with the Clean Water Act.

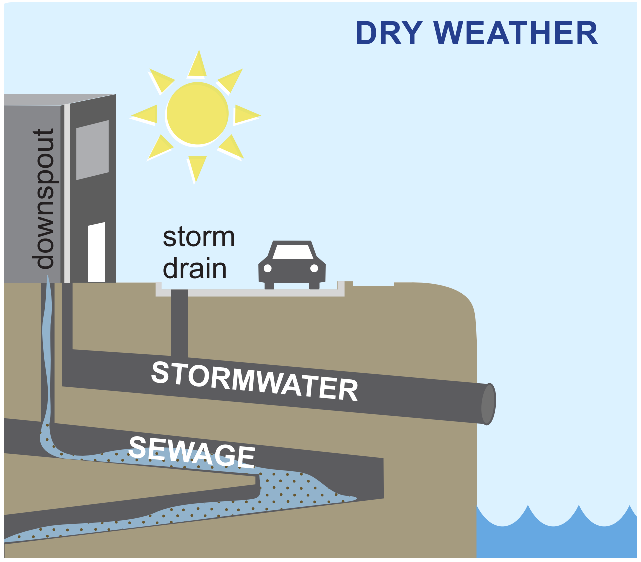
Although New Jersey is implementing a state-wide CSO control program to bring combined sewer systems into compliance with the water quality based provisions of the Clean Water Act, communities with CSO systems continue to struggle to better manage the systems, reduce overflows, and upgrade failing infrastructure. The financial investment needed for these "grey infrastructure" upgrades is tremendous. New and larger systems of pipes, catch basins, and treatment facilities are extremely costly.

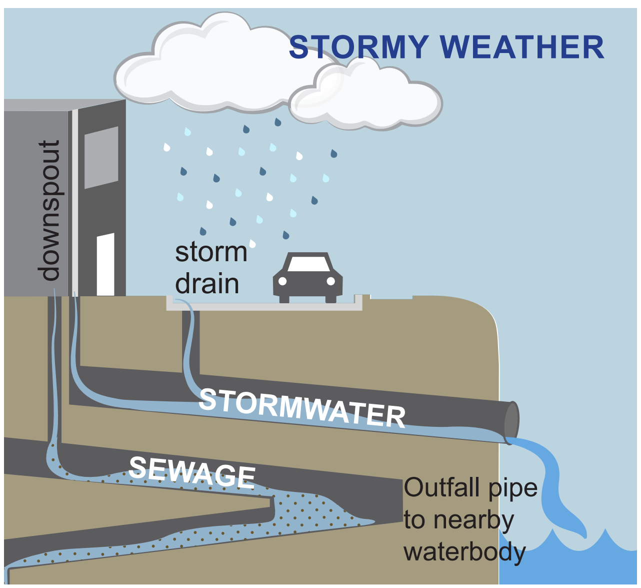
Although grey infrastructure improvements seem inevitable, using green infrastructure systems in CSO communities are proving to be both cost-effective and environmentally beneficial throughout the country. These programs integrate water resource management with community and environmental enhancement to reduce stormwater runoff volumes to combined sewer systems.

[4] New Jersey Department of Environmental Protection Agency (NJDEP). 2016. CSO Basics. http://www.nj.gov/dep/dwq/cso-basics.htm

PERMITTEE	COUNTY	CSOs
Bayonne Municipal Utilities Authority	Hudson	30
Camden City	Camden	22
Camden County Municipal Utilities Authority	Camden	1
East Newark Boro	Hudson	1
Elizabeth City	Union	29
Fort Lee Boro	Bergen	2
Gloucester City	Camden	7
Hackensack City	Bergen	2
Harrison Town	Hudson	7
Jersey City Municipal Utilities Authority	Hudson	21
Kearny Town	Hudson	5
NBMUA Woodcliff STP (North Bergen)	Hudson	1
Newark City	Essex	18
North Bergen Municipal Utilities Authority	Hudson	9
North Hudson Sewerage Authority (Hoboken and Weehawken)	Hudson	8
North Hudson Sewerage Authority (West New York)	Hudson	2
Paterson City	Passaic	23
Perth Amboy City	Middlesex	16
Ridgefield Park Village	Bergen	6
Town of Guttenberg	Hudson	1
Trenton Sewer Utility	Mercer	1
TOTAL		212

The NJDEP requires that CSO permittees evaluate the use of green infrastructure as part of their long-term control plan.





Referenced from USEPA

MUNICIPAL SEPARATE STORMWATER SEWER SYSTEM COMMUNITIES

While managing stormwater with green infrastructure has become a high priority in CSO communities, it is equally important in MS4 (municipal separate storm sewer system) communities. The EPA has determined that MS4 systems can be regulated under the Clean Water Act. EPA's Stormwater Phase II Final Rule is "intended to further reduce adverse impacts to water quality and aquatic habitat by instituting the use of controls on the unregulated sources of stormwater discharges that have the greatest likelihood of causing continued environmental degradation."[5] Due to these Phase II regulations, NJDEP issued MS4 permits to all 565 municipalities in New Jersey. These permits require municipalities to develop, implement, and enforce a stormwater program that "shall be designed to reduce the discharge of pollutants from the municipality's small MS4 to the maximum extent practicable to protect water quality."[6] While these MS4 permits do not specifically require that green infrastructure be used to manage stormwater from uncontrolled sources, green infrastructure would be a cost effective way to reduce pollutants entering local waterways.

Even though the regulatory requirements do not specifically require municipalities to retrofit existing development with green infrastructure, there has been a strong need for municipalities to become more resilient to the changing climate. While recent hurricanes, superstorms, and nor'easters have severely impacted many New Jersey residents, localized flooding causes a more regular disruption in the lives of New Jersey residents. By retrofitting existing development with green infrastructure, these localized flooding events can be reduced or eliminated.

[5] United States Environmental Protection Agency (USEPA). 2005. Stormwater Phase II Final Rule, An Overview. EPA833-F-00-001. http:// www3.epa.gov/npdes/pubs/fact1-0.pdf
[6] New Jersey Department of Environmental Protection (NJDEP). 2005. Tier A Municipal Stormwater General Permit (NJ0141852) Major Modification. http://www.nj.gov/dep/dwq/pdf/final_tier_a_permit.pdf

While New Jersey has strict regulations requiring stormwater management for new development, an effort needs to be made to retrofit existing development with stormwater management using green infrastructure. The green infrastructure practices outlined in this manual can be designed to capture, treat, infiltrate, and/or store the increasing runoff from future storms. With proper planning, design, and construction, these green infrastructure practices can provide quality of life benefits and climate resiliency to communities throughout the state.

THE GREEN SOLUTION

CHAPTER 2

WHAT IS GREEN INFRASTRUCTURE?

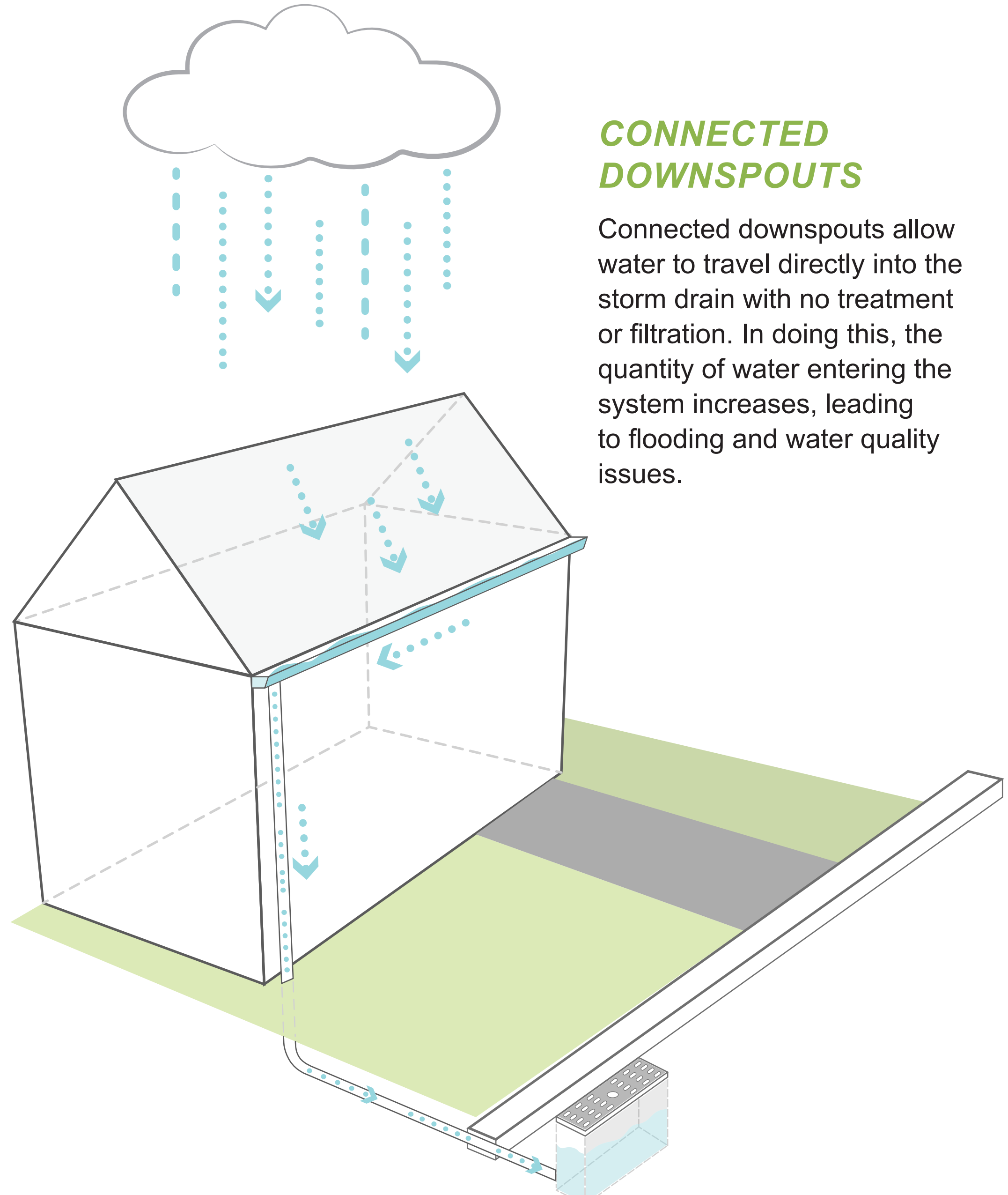
Green infrastructure is an approach to stormwater management that is cost-effective, sustainable, and environmentally friendly. Green infrastructure practices capture, filter, absorb, and/or reuse stormwater to help restore the natural water cycle. When used as components of a stormwater management system, green infrastructure practices such as bioretention, green roofs, pervious pavement, rain gardens, and vegetated swales can produce a variety of environmental benefits. In addition to effectively retaining and infiltrating runoff, these practices can help filter air pollutants, reduce energy demands, mitigate urban heat islands, and sequester carbon while also providing communities with aesthetic and natural resource benefits.[7]

[7] United States Environmental Protection Agency (USEPA). 2015. Benefits of Green Infrastructure. http://www.epa.gov/green-infrastructure/benefits-green-infrastructure

SIMPLE DISCONNECTION

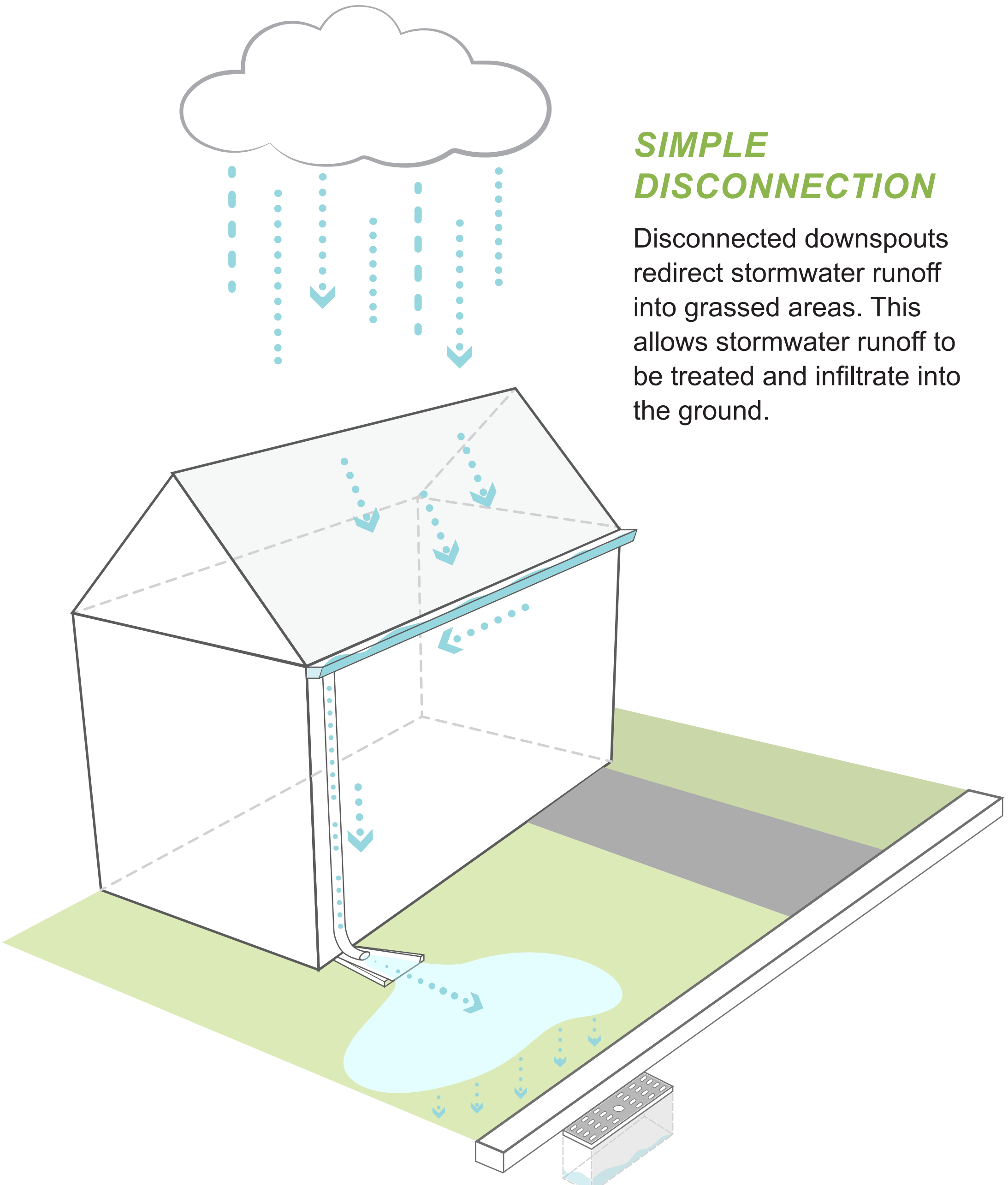
Many of the impervious surfaces across New Jersey are directly connected to sewer systems or local waterways. For example, the rainfall that lands on the rooftops of buildings is piped directly to the sewer system or to the street where it ultimately flows into the sewer system. Another example is when stormwater runoff from parking lots is captured in catch basins and piped directly to streams. In these examples, stormwater runoff does not have the opportunity to be treated or to infiltrate. In these examples, stormwater is transported very quickly from impervious surfaces to sewer systems and to local streams, causing CSOs, localized flooding, and/or high stream flows that can result in stream bank erosion.

Many of these connected impervious surfaces can be disconnected. This is the main objective of green infrastructure, namely to capture stormwater runoff before it enters the sewer system or local waterways. Rooftop runoff can



CONNECTED DOWNSPOUTS

Connected downspouts allow water to travel directly into the storm drain with no treatment or filtration. In doing this, the quantity of water entering the system increases, leading to flooding and water quality issues.



SIMPLE DISCONNECTION

Disconnected downspouts redirect stormwater runoff into grassed areas. This allows stormwater runoff to be treated and infiltrate into the ground.

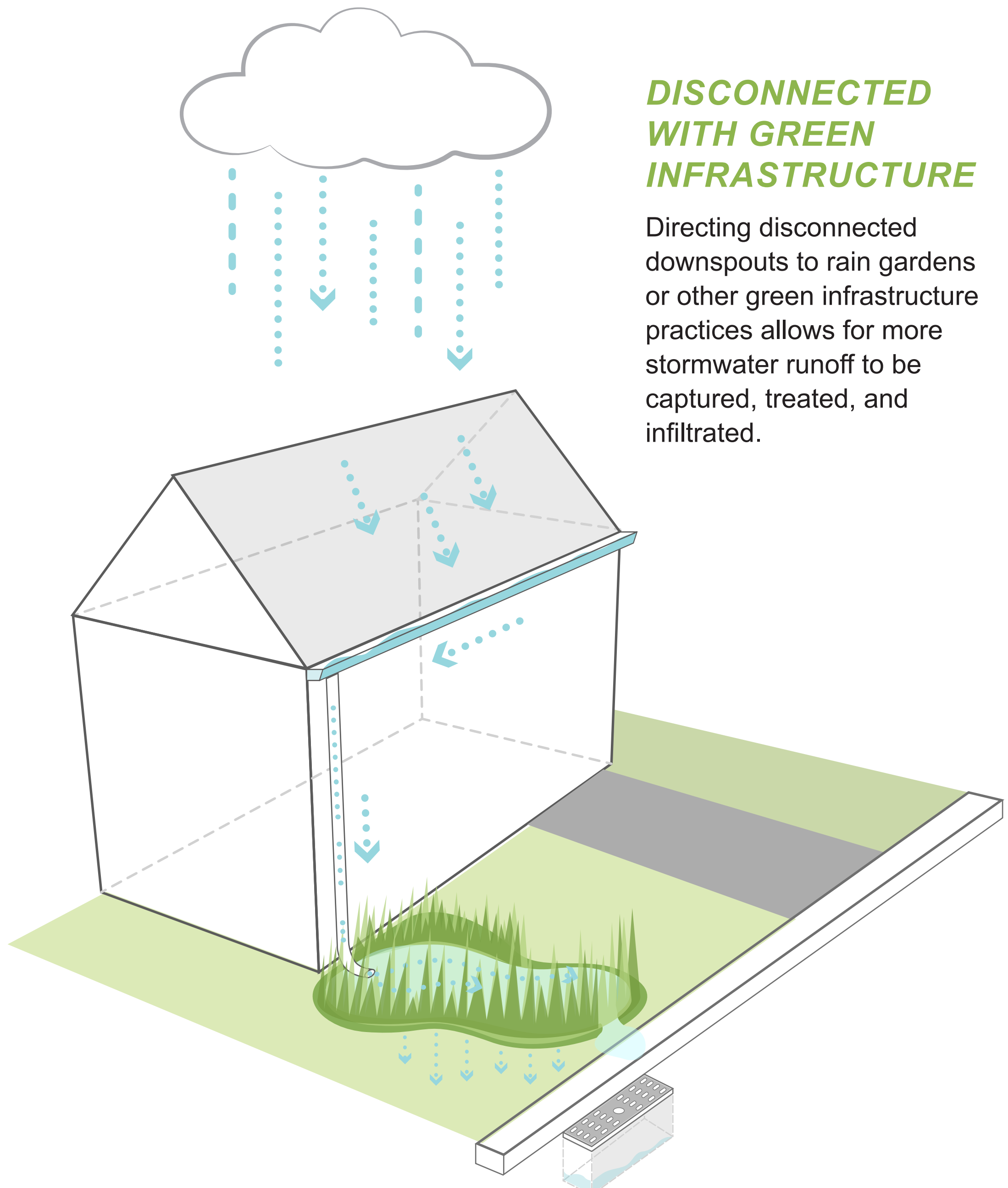
be diverted to pervious lawn areas for treatment and infiltration. Parking lots can be designed so stormwater can flow onto adjacent pervious surfaces as sheet flow. These pervious surfaces provide opportunities for filtering and infiltration of stormwater runoff.

When a connected impervious surface is disconnected so that stormwater flows onto a pervious surface such as a lawn area, it is called "simple disconnection." Simple disconnection is often the least expensive option for treating stormwater runoff. Lawn areas usually can absorb the first inch of runoff from these impervious surfaces, provided sufficient lawn area is available. Other means of disconnection involve diverting a connected impervious surface to a green infrastructure practice such as a rain garden or bioretention system. These types of green infrastructure practices can be designed to capture larger runoff volumes than simple disconnection to a lawn area.

One of the most common ways to disconnect an impervious surface is to install a bioretention system/rain garden. A rain garden can be easily designed to manage stormwater runoff from a rainfall event of several inches and complement existing landscaping. These systems are often inexpensive to build.

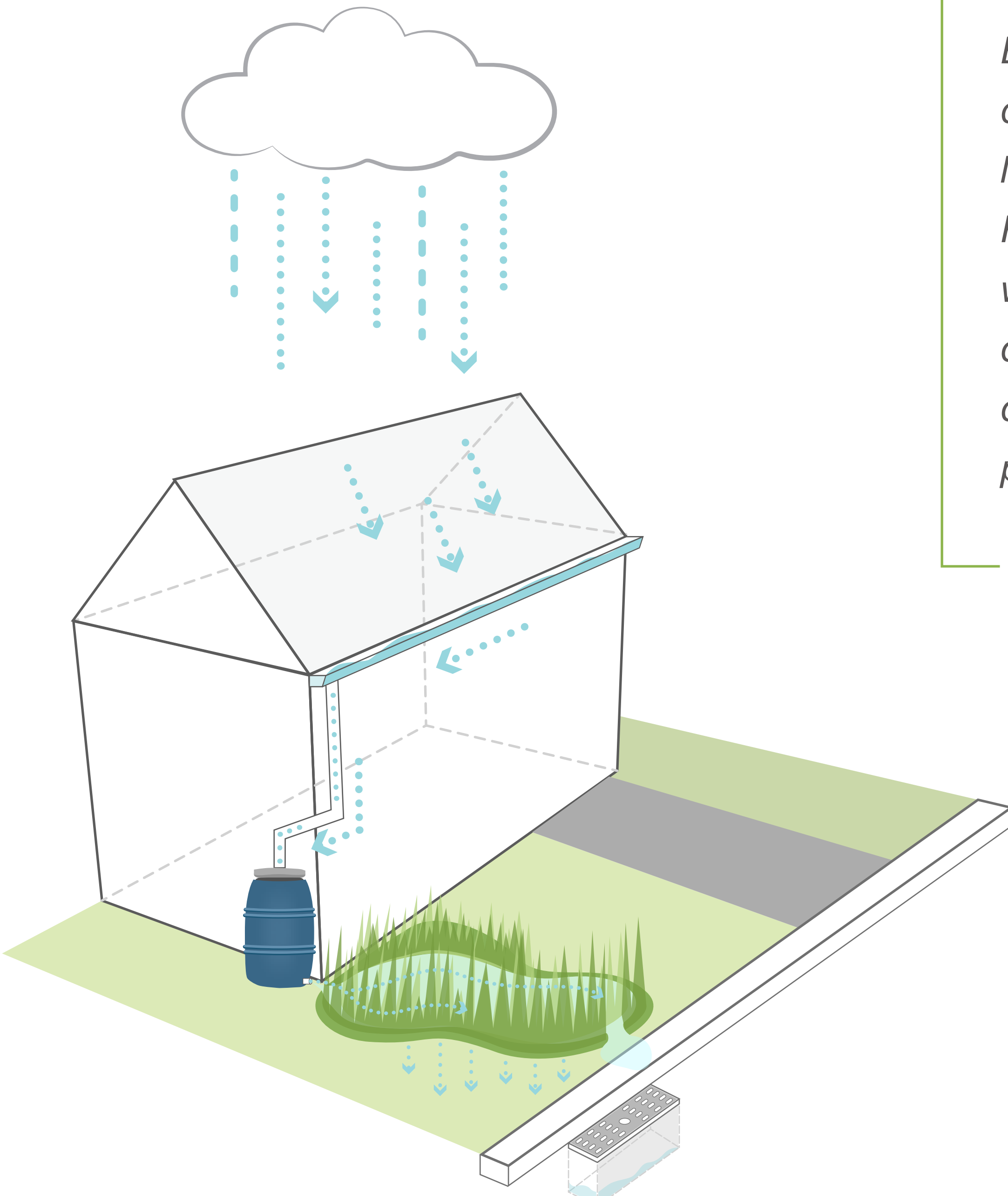
Many homes and businesses that install cisterns or rain barrels also build rain gardens to manage the overflow from these rainwater harvesting systems. A rain barrel alone can only manage the first 50 to 100 gallons of stormwater but when coupled with a rain garden, thousands of gallons of stormwater runoff per storm event can be captured, treated, and infiltrated.

Disconnection
When stormwater runoff flows from an impervious surface onto a pervious surface or into a green infrastructure practice prior to entering a local waterway or a sewer system, the impervious surface is considered "disconnected."



DISCONNECTED WITH GREEN INFRASTRUCTURE

Directing disconnected downspouts to rain gardens or other green infrastructure practices allows for more stormwater runoff to be captured, treated, and infiltrated.



Every drop of rain that leaves a directly connected roof ends up in local waterways without treatment. Runoff carries pollutants to local waterways, degrading water quality and causing flooding. By disconnecting downspouts, less polluted stormwater will flow directly

DISCONNECTION WITH GREEN INFRASTRUCTURE SYSTEMS

Disconnected downspouts redirect stormwater runoff onto planted areas. This allows stormwater runoff to be treated and infiltrate into the ground.

GREEN INFRASTRUCTURE PRACTICES

When managing stormwater with green infrastructure practices, the overall goal is to disconnect impervious surfaces that are connected (i.e., drain directly to sewer systems or local waterways). Green infrastructure practices can be designed to capture and infiltrate stormwater. These practices tend to filter water using soil, as in the case of bioretention, or using stone, as in the case of porous asphalt. In areas where infiltration is not possible, these green infrastructure practices also can be used as a detention system to store runoff and slowly release it after the storm event. Some green infrastructure practices are used to harvest stormwater runoff for non-potable water usage such as watering gardens. Other green infrastructure practices, like bioswales, are designed to move water from one location to another while filtering pollutants.

The following pages describe some green infrastructure practices that have been proven to be successful in New Jersey. These practices include:

- Bioretention & rain gardens
- Bioswales
- Downspout planters
- Stormwater planters
- Cisterns & rain barrels
- Permeable pavements
- Tree filter boxes


BEFORE


AFTER A RAINGARDEN IS BUILT


BEFORE


AFTER A CISTERN IS INSTALLED

CASE STUDIES:

LOCATION: Hamilton, NJ
This residential rain garden is 150 square feet and six (6) inches deep. It was designed to capture the rainwater from the roof of this home.

LOCATION: Camden, NJ
This rain garden is one in a system that is designed to capture stormwater run-off from the adjacent roadway. Once one garden fills up, the overflow is piped to adjacent rain gardens.

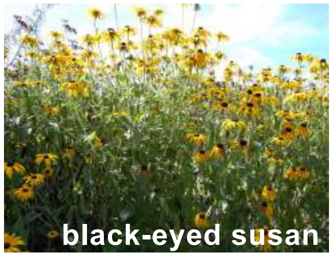
BIORETENTION & RAIN GARDEN SYSTEMS

INFILTRATION AND STORAGE

A rain garden, or bioretention system, is a landscaped, shallow depression that captures, filters, and infiltrates stormwater runoff. The rain garden removes nonpoint source pollutants from stormwater runoff while recharging groundwater. A rain garden serves as a functional system to capture, filter, and infiltrate stormwater runoff at the source, while being aesthetically pleasing. Rain gardens are an important tool for communities and neighborhoods to create diverse, attractive landscapes while protecting the health of the natural environment. Rain gardens can also be installed in areas that do not infiltrate by incorporating an underdrain system.

Rain gardens can be implemented throughout communities to begin the process of re-establishing the natural function of the land. Rain gardens offer one of the quickest and easiest methods to reduce runoff and help protect our water resources. Beyond the aesthetic and ecological benefits, rain gardens encourage environmental stewardship and community pride.

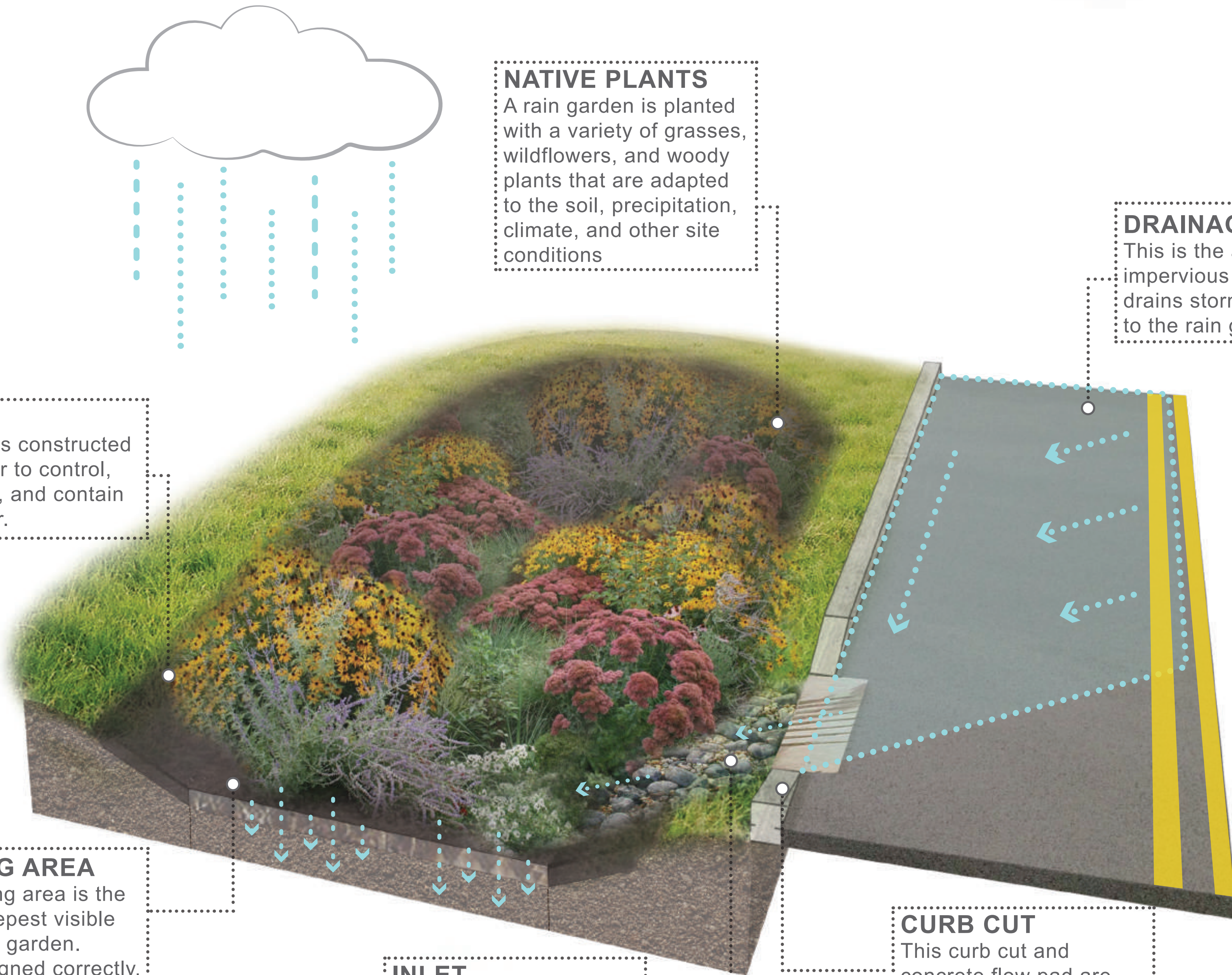
SOME RECOMMENDED VEGETATION:



APPLICATION/SUITABILITY:

These systems are best applied in areas:

- with good soil for infiltration
- that are low lying
- that are adjacent to a roadway
- that are near a downspout



NATIVE PLANTS
A rain garden is planted with a variety of grasses, wildflowers, and woody plants that are adapted to the soil, precipitation, climate, and other site conditions

DRAINAGE AREA
This is the area of impervious surface that drains stormwater runoff to the rain garden.

BERM
The berm is constructed as a barrier to control, slow down, and contain stormwater.

PONDING AREA
The ponding area is the lowest, deepest visible area of the garden. When designed correctly, this area should drain within 24 hours.

INLET
This is the area where stormwater enters. The inlet is often lined with stone to slow water flow and prevent erosion.

CURB CUT
This curb cut and concrete flow pad are designed to help redirect stormwater runoff to the rain garden system and out of the storm drain.

CASE STUDIES:

LOCATION: Troy Hills, NJ
This bioswale was installed at a public works department. It captures water from the parking lot while treating and moving it toward the stream.

LOCATION: Parsippany, NJ
This bioswale was installed at St. Gregory's Church. The bioswale was designed to capture water from the parking lot and move it toward the forest area on the south end of the site.

BIOSWALE

CONVEYANCE AND INFILTRATION

Bioswales are landscape features that convey stormwater from one location to another while removing pollutants and allowing water to infiltrate. Bioswales are often designed for larger scale sites where water needs time to move and slowly infiltrate into the groundwater.

Much like rain garden systems, bioswales can also be designed with an underdrain pipe that allows excess water to discharge to the nearest catch basin or existing stormwater system.

SOME RECOMMENDED VEGETATION:

APPLICATION/SUITABILITY:

These systems are best applied in areas:

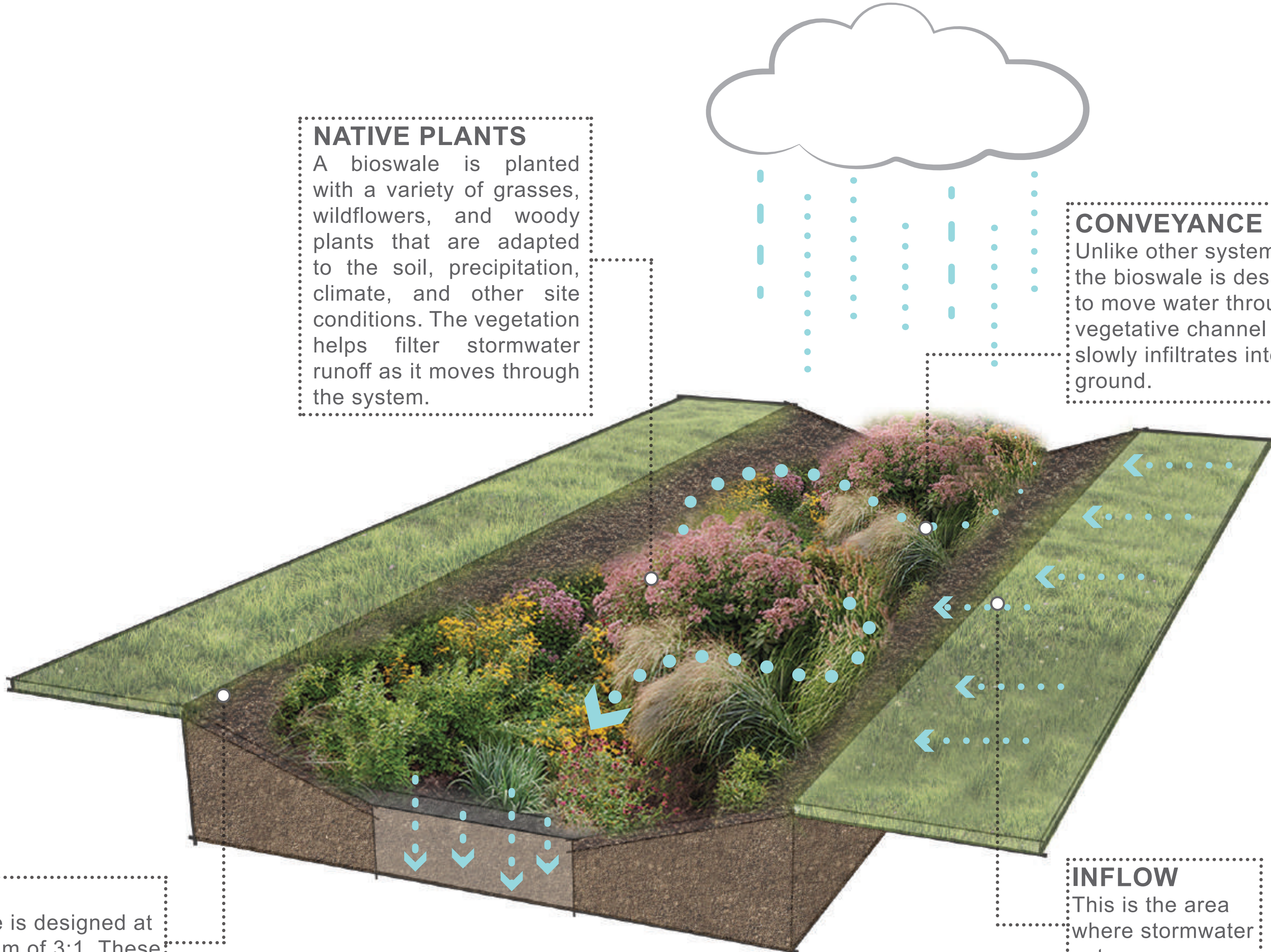
- with good soil for infiltration
- that are low lying
- that are adjacent to a roadway or parking area

NATIVE PLANTS

A bioswale is planted with a variety of grasses, wildflowers, and woody plants that are adapted to the soil, precipitation, climate, and other site conditions. The vegetation helps filter stormwater runoff as it moves through the system.

CONVEYANCE

Unlike other systems, the bioswale is designed to move water through a vegetative channel as it slowly infiltrates into the ground.



SLOPE

The slope is designed at a maximum of 3:1. These slopes often require erosion control materials for stabilization.

INFLOW

This is the area where stormwater enters.

CASE STUDIES:

LOCATION: Camden, NJ
Downspout planters are installed at the end of a downspout to capture, store, and slowly discharge stormwater back to the nearest sewer system.

LOCATION: Camden, NJ
This downspout planter was designed as part of a system of multiple downspout planters that capture water from one downspout and discharge the overflow to the adjacent boxes.

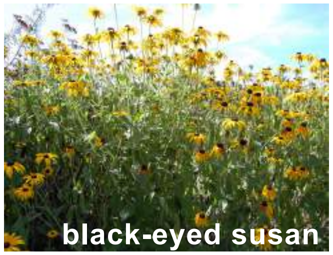
DOWNSPOUT PLANTER

STORAGE

Downspout planter boxes are wooden or concrete boxes with plants installed at the base of the downspout that provide an opportunity to beneficially reuse rooftop runoff. Although small, these systems have some capacity to store rooftop runoff during rainfall events and release it slowly back into the system through an overflow.

Most often, downspout planter boxes are a reliable green infrastructure practice used to provide some rainfall storage and aesthetic value for property.

SOME RECOMMENDED VEGETATION:



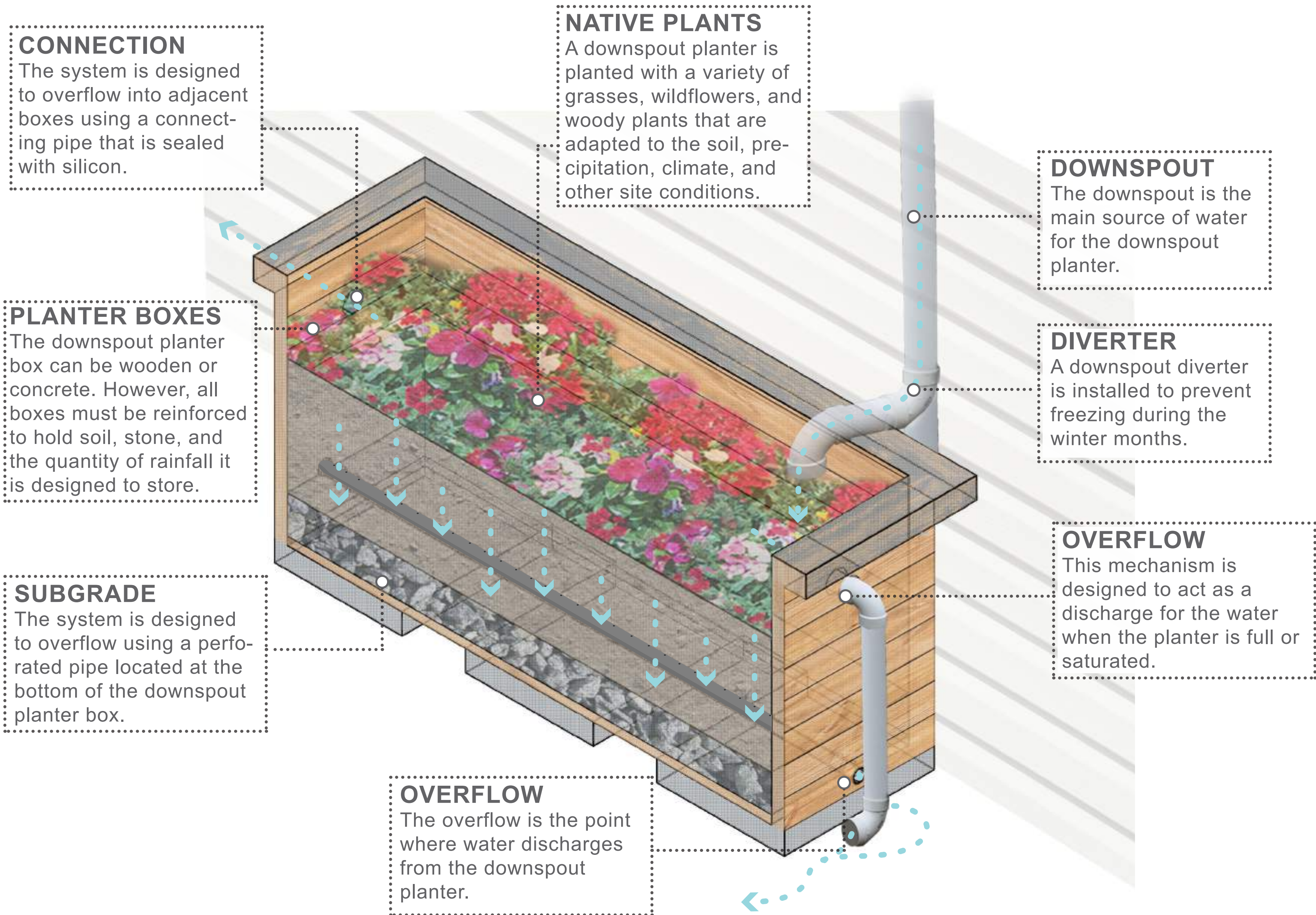
APPLICATION/SUITABILITY:

These systems are best applied in areas:

- near buildings with external downspouts
- areas near buildings with level ground
- areas that will not negatively impact pedestrian circulation

SYSTEM OPPORTUNITIES:

Downspout planters are best suited for systems when paired with more downspout planters. The storage capacity of a downspout planter can be increased by building multiple boxes connected by an underdrain pipe.


CONNECTION
The system is designed to overflow into adjacent boxes using a connecting pipe that is sealed with silicon.
NATIVE PLANTS
A downspout planter is planted with a variety of grasses, wildflowers, and woody plants that are adapted to the soil, precipitation, climate, and other site conditions.
DOWNSPOUT
The downspout is the main source of water for the downspout planter.
PLANTER BOXES
The downspout planter box can be wooden or concrete. However, all boxes must be reinforced to hold soil, stone, and the quantity of rainfall it is designed to store.
DIVERTER
A downspout diverter is installed to prevent freezing during the winter months.
OVERFLOW
This mechanism is designed to act as a discharge for the water when the planter is full or saturated.
SUBGRADE
The system is designed to overflow using a perforated pipe located at the bottom of the downspout planter box.
OVERFLOW
The overflow is the point where water discharges from the downspout planter.

CASE STUDIES:

LOCATION: Camden, NJ
This stormwater planter was designed as part of a system. Both the stormwater planter and the pervious concrete collect stormwater runoff from the adjacent streetscape.

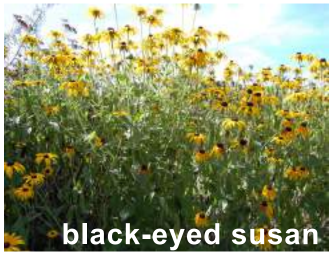
LOCATION: Camden, NJ
This stormwater planter was designed to capture stormwater runoff from the street in front of the Brimm School in Camden, New Jersey.

STORMWATER PLANTER

STORAGE AND INFILTRATION

Stormwater planters are vegetated structures that are built into the sidewalk to intercept stormwater runoff from the roadway or sidewalk. Stormwater planters, like rain gardens, are a type of bioretention system. This means many of these planters are designed to allow the water to infiltrate into the ground. However, some are designed simply to filter the water and convey it back into the stormwater sewer system via an underdrain system.

SOME RECOMMENDED VEGETATION:



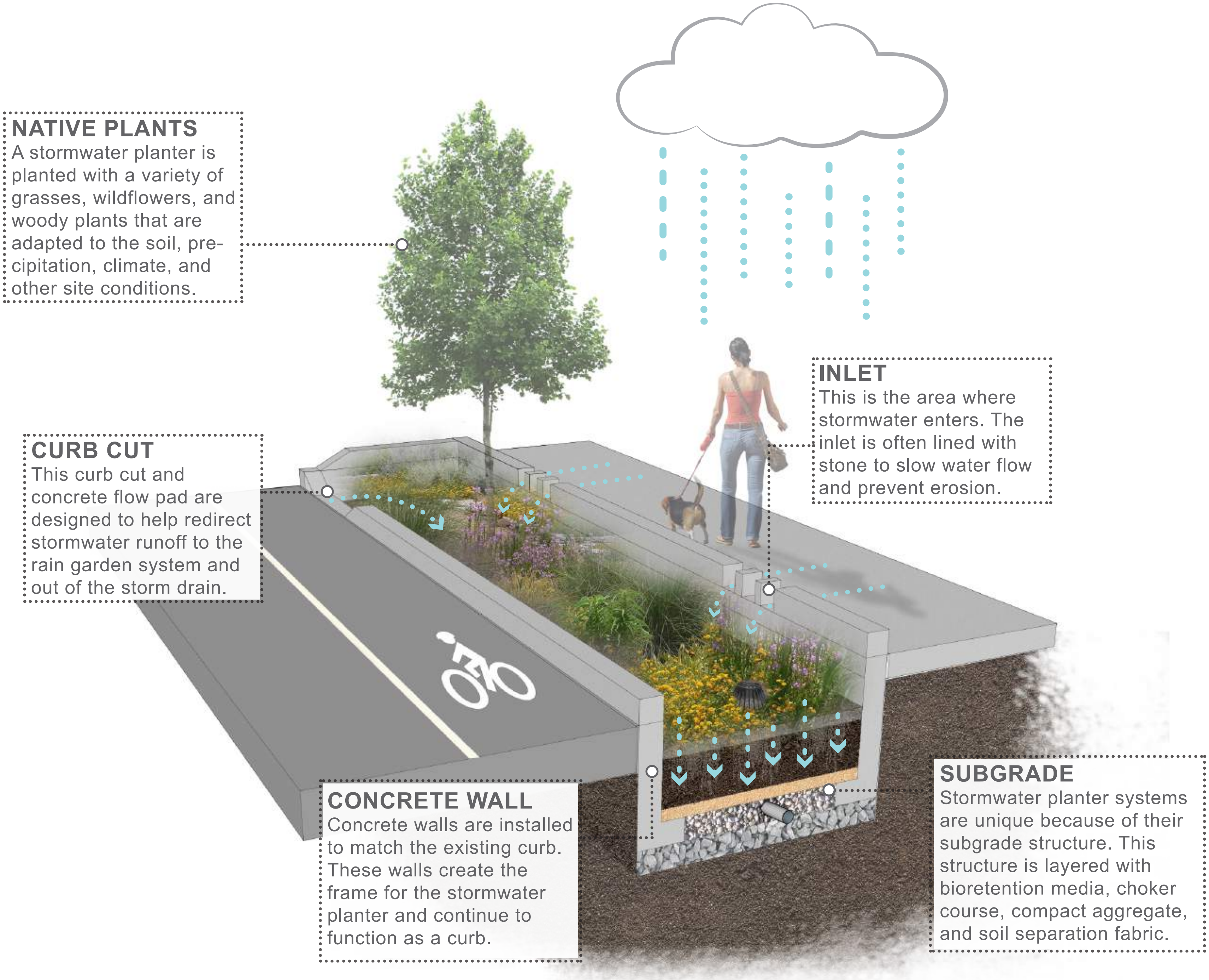
APPLICATION/SUITABILITY:

These systems are best applied in areas:

- with good soil for infiltration
- that are low lying
- that are adjacent to a roadway

SYSTEM OPPORTUNITIES:

Stormwater planters are often paired with other green infrastructure practices to enhance their effectiveness. By pairing the stormwater planter with permeable pavements, the storage capacity can be increased significantly.


NATIVE PLANTS
A stormwater planter is planted with a variety of grasses, wildflowers, and woody plants that are adapted to the soil, precipitation, climate, and other site conditions.
CURB CUT
This curb cut and concrete flow pad are designed to help redirect stormwater runoff to the rain garden system and out of the storm drain.
INLET
This is the area where stormwater enters. The inlet is often lined with stone to slow water flow and prevent erosion.
CONCRETE WALL
Concrete walls are installed to match the existing curb. These walls create the frame for the stormwater planter and continue to function as a curb.
SUBGRADE
Stormwater planter systems are unique because of their subgrade structure. This structure is layered with bioretention media, choker course, compact aggregate, and soil separation fabric.

CASE STUDIES:

LOCATION: Camden, NJ
This cistern was installed in a community garden. With the lack of an existing structure to harvest water, a shade structure was built to capture rainfall and harvest it in the cistern.

LOCATION: Clark, NJ
This cistern was installed at a public works department. The rainwater is harvested from the rooftop of the building and used as part of a "green car wash" system that uses rainwater.

CISTERNS & RAIN BARRELS

RAINWATER HARVESTING

These systems capture rainwater, mainly from rooftops, in cisterns or rain barrels. The water can then be used for watering gardens, washing vehicles, or for other non-potable uses.

Rainwater harvesting systems come in all shapes and sizes. These systems are good for harvesting rainwater in the spring, summer, and fall but must be winterized during the colder months. Cisterns are winterized, and then their water source is redirected from the cistern back to the original discharge area.

CISTERN/RAIN BARREL TYPES:


tank


slimline


rain barrels

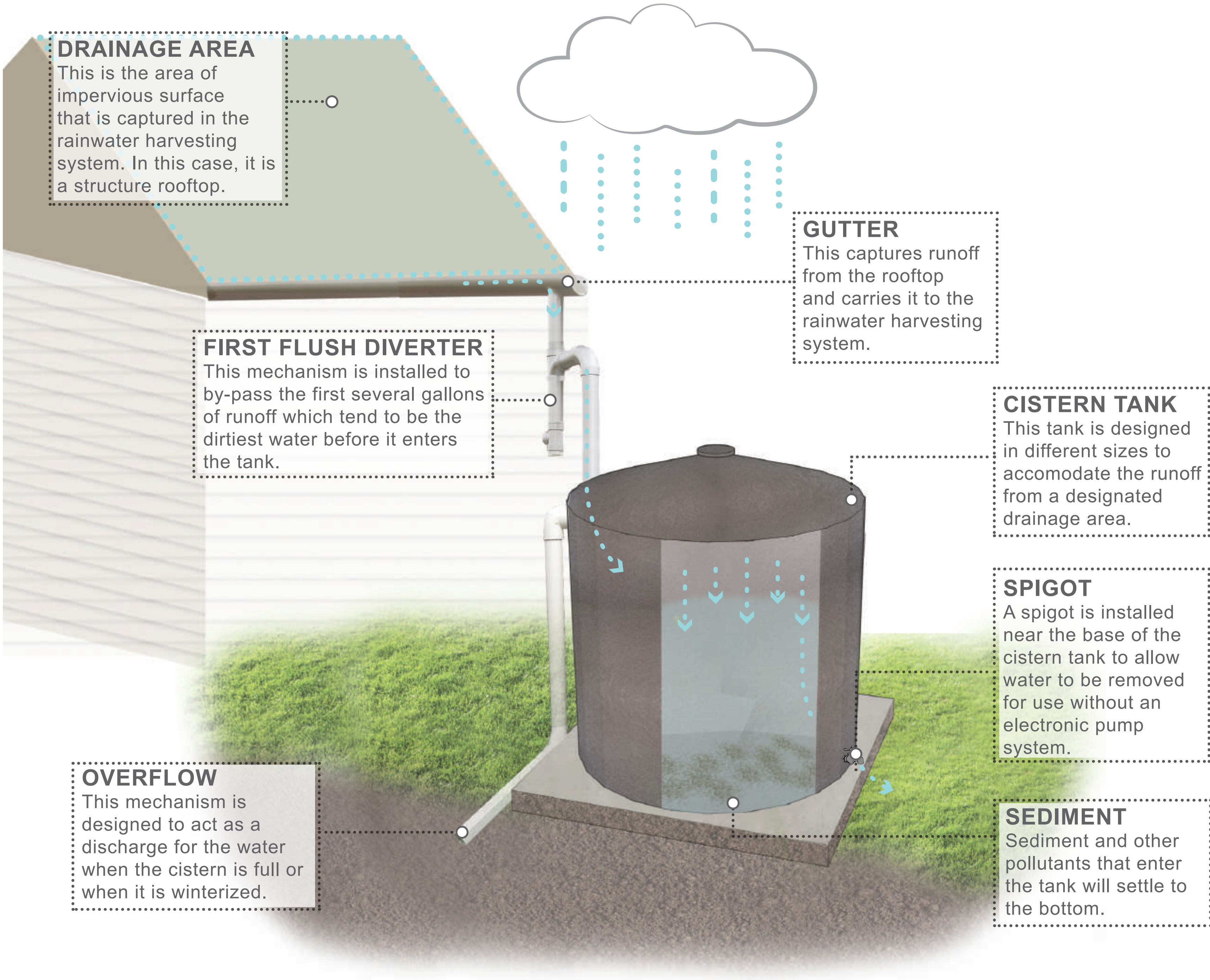
APPLICATION/SUITABILITY:

These systems are best applied in areas:

- with existing buildings
- that need irrigation
- with exterior downspouts
- that need vehicles washed
- with single family households

SYSTEM OPPORTUNITIES:

Cisterns and rain barrels are often paired with other green infrastructure practices to increase their storage capacity or efficiency. Most commonly, cistern or rain barrel systems are paired with a vegetative system (e.g., rain garden, bioswale, stormwater planter) to capture the overflow from the system when it has reached its full capacity.


DRAINAGE AREA
This is the area of impervious surface that is captured in the rainwater harvesting system. In this case, it is a structure rooftop.
GUTTER
This captures runoff from the rooftop and carries it to the rainwater harvesting system.
FIRST FLUSH DIVERTER
This mechanism is installed to by-pass the first several gallons of runoff which tend to be the dirtiest water before it enters the tank.
CISTERN TANK
This tank is designed in different sizes to accomodate the runoff from a designated drainage area.
SPIGOT
A spigot is installed near the base of the cistern tank to allow water to be removed for use without an electronic pump system.
OVERFLOW
This mechanism is designed to act as a discharge for the water when the cistern is full or when it is winterized.
SEDIMENT
Sediment and other pollutants that enter the tank will settle to the bottom.

CASE STUDIES:

LOCATION: Clark, NJ
Porous asphalt was used in the parking spaces of this parking lot. It is common to use conventional asphalt in the cartways and porous asphalt in the parking spots. This reduces wear on the porous asphalt.

LOCATION: Camden, NJ
Pervious concrete is often used in conjunction with an additional green infrastructure practice because it can capture water, store it, and divert it to an infiltration system.

PERMEABLE PAVEMENTS
STORAGE AND INFILTRATION

These surfaces include pervious concrete, porous asphalt, interlocking concrete pavers, and grid pavers. Pervious concrete and porous asphalt are the most common of these permeable surfaces. They are similar to regular concrete and asphalt but without the fine materials. This allows water to quickly pass through the material into an underlying layered system of stone that holds the water, allowing it to infiltrate into the underlying uncompacted soil. They have an underlying stone layer to store stormwater runoff and allow it to slowly seep into the ground.

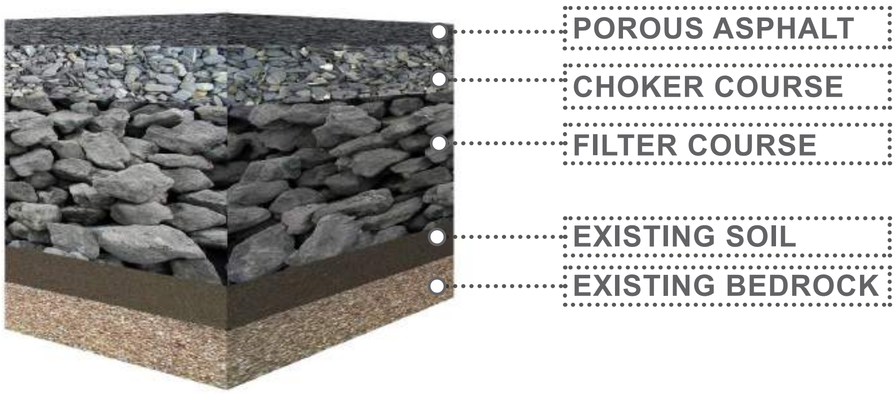
By installing an underdrain system, these systems can be used in areas where infiltration is limited. The permeable pavement system will still filter pollutants and provide storage but will not infiltrate the runoff.

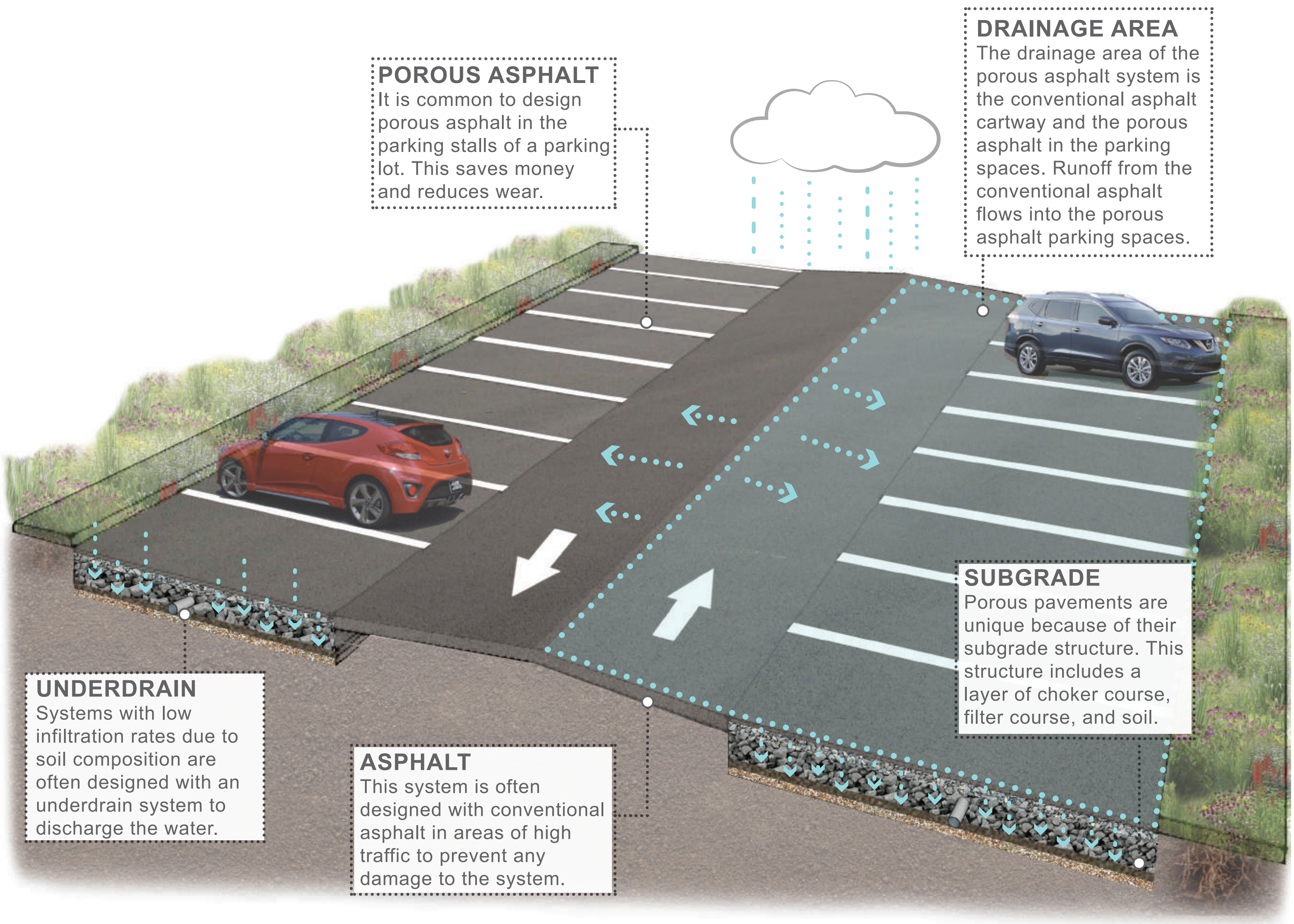
APPLICATION/SUITABILITY:

These systems are best applied in areas:

- with existing pavement
- that need to increase stormwater storage
- that experience vehicular traffic
- with single family households
- that are flat or nearly level

TYPICAL POROUS ASPHALT SUBGRADE: *CROSS-SECTION*




POROUS ASPHALT
It is common to design porous asphalt in the parking stalls of a parking lot. This saves money and reduces wear.
DRAINAGE AREA
The drainage area of the porous asphalt system is the conventional asphalt cartway and the porous asphalt in the parking spaces. Runoff from the conventional asphalt flows into the porous asphalt parking spaces.
SUBGRADE
Porous pavements are unique because of their subgrade structure. This structure includes a layer of choker course, filter course, and soil.
UNDERDRAIN
Systems with low infiltration rates due to soil composition are often designed with an underdrain system to discharge the water.
ASPHALT
This system is often designed with conventional asphalt in areas of high traffic to prevent any damage to the system.

CASE STUDIES:

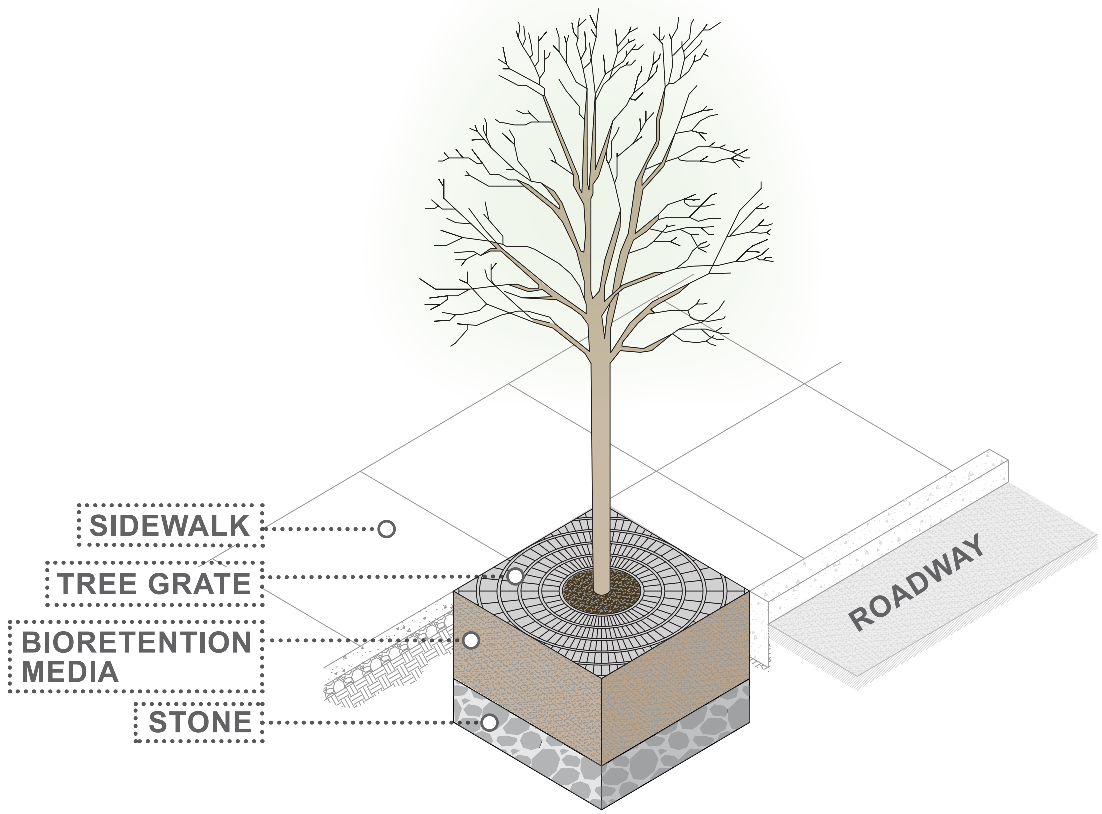
LOCATION: Parsippany, NJ
This enhanced tree pit is located at the Parsippany-Troy Hills Municipal Court parking lot. The tree pit collects and filters water from the existing parking lot.

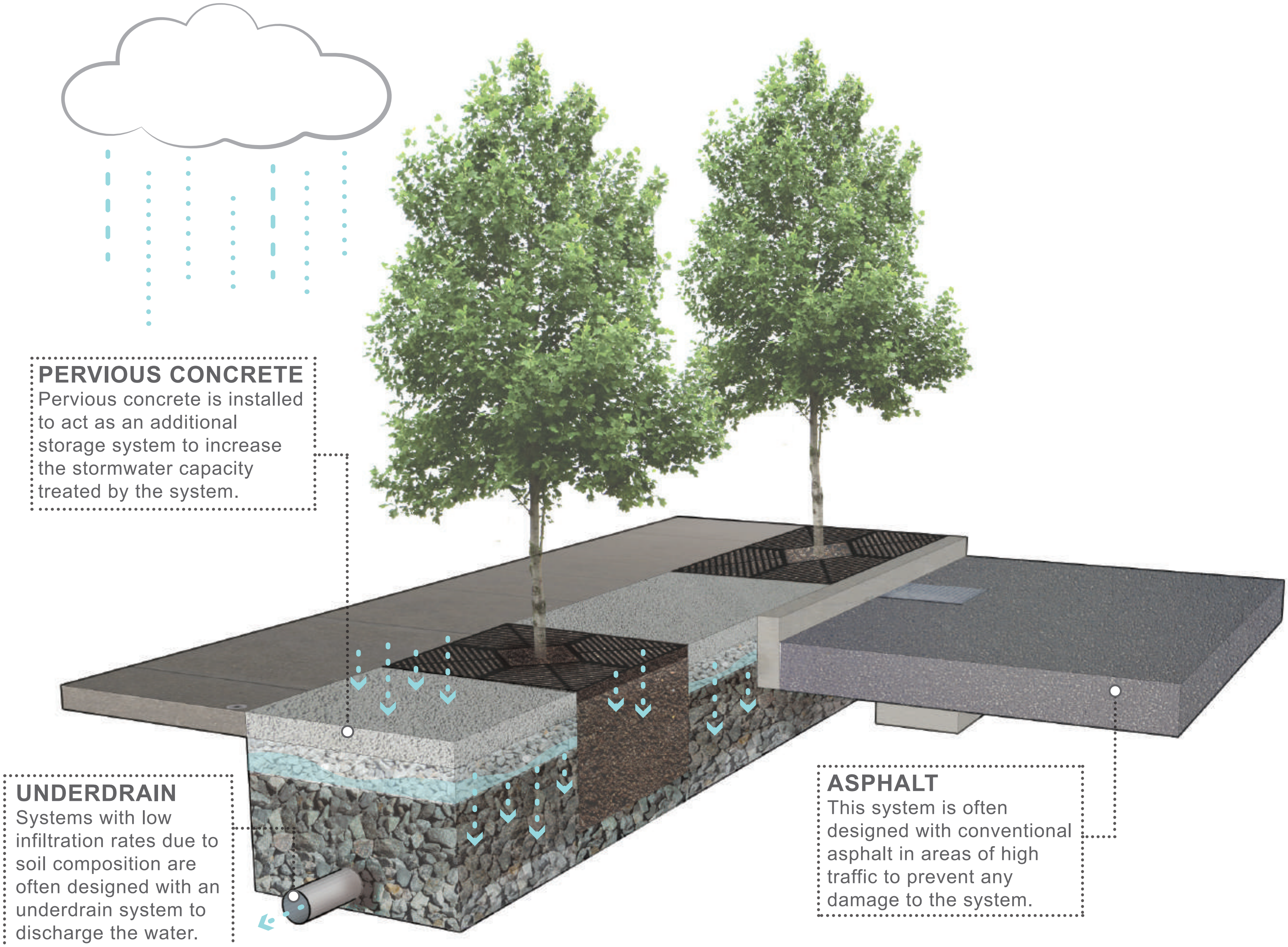
TREE FILTER BOX

STORAGE AND INFILTRATION

Tree filter boxes can be pre-manufactured concrete boxes or enhanced tree pits that contain a special soil mix and are planted with a tree or shrub. They filter stormwater runoff but provide little storage capacity. They are typically designed to quickly filter stormwater and then discharge it to the local sewer system.

Often tree filter boxes are incorporated into streetscape systems that include an underlying stormwater system which connects several boxes (as shown on page 37). This is also coupled with pervious concrete to increase the storage capacity for rainwater in the system.





PERVIOUS CONCRETE
Pervious concrete is installed to act as an additional storage system to increase the stormwater capacity treated by the system.
UNDERDRAIN
Systems with low infiltration rates due to soil composition are often designed with an underdrain system to discharge the water.
ASPHALT
This system is often designed with conventional asphalt in areas of high traffic to prevent any damage to the system.

GREEN INFRASTRUCTURE SYSTEMS

Existing development frequently requires several green infrastructure practices to be installed to adequately address the stormwater runoff for the site. As discussed earlier in this chapter, pervious concrete can be combined with tree filter boxes (see page 37) or enhanced tree pits. Cisterns or rain barrels are regularly combined with rain gardens. The next chapter will discuss how to evaluate a site for green infrastructure opportunities. While each site is unique, many will require more than one green infrastructure practice to disconnect all the impervious surfaces. For some sites, it may not be practical to disconnect all of the impervious surfaces. For other sites, green infrastructure could be used to disconnect offsite impervious surfaces like adjacent roads, sidewalks, or buildings.

The images to the right offer examples of green infrastructure system design. The photo in the top left corner shows a paved parking lot at the Samuel E. Shull Middle School in Perth Amboy. The site currently serves as a paved play space for students. By re-envisioning the space as a depaved community garden area with rainwater harvesting and permeable surfaces, it eliminates the impervious surface and stormwater runoff while providing a new outdoor garden space for students. The photo in the bottom left corner shows a Department of Public Works building in Gloucester City. The project disconnects the rooftop by capturing stormwater runoff in a large tank cistern. The cistern then overflows to a nearby rain garden that also collects stormwater runoff from the roof.

Designing green infrastructure practices in systems allows for more impervious cover to be disconnected and often improves the overall design of the project. These renderings provide only two small examples of opportunities for designing green infrastructure systems.


BEFORE


AFTER


BEFORE


AFTER

DESIGN FOR THE FUTURE

GREEN INFRASTRUCTURE DESIGN PROCESS

Green infrastructure practices are often sited, designed, and implemented to retrofit areas that have been developed without sufficient stormwater management. This chapter will present processes to identify opportunities throughout a community and to develop a site specific design. If a community is hoping to reduce localized flooding, increase climate resilience, reduce the occurrence of CSOs, and/or improve the overall health of local waterways, green infrastructure needs to be installed wherever an opportunity exists.

As mentioned in Chapter 1, the primary cause of the pollution, flooding, and erosion problems is the quantity of impervious surfaces that drain directly to local waterways. New Jersey is one of the most developed states in the country. Currently, the state has the highest percent of impervious cover in the country at 12.1% of its total area.[8] Many of these impervious surfaces are directly connected to local waterways (i.e., every drop of rain that lands on

[8] Arnold, C.L. Jr and C.J. Gibbons. 1996. Impervious Surface Coverage The Emergence of a Key Environmental Indicator. *Journal of the American Planning Association* 62(2): 243-258.

these impervious surfaces ends up in a local river, lake, or bay without any chance of being treated or soaking into the ground). Green infrastructure can be designed to retrofit these areas with better stormwater management to repair our waterways, reduce flooding, and stop erosion.

The literature suggests a link between impervious cover and stream ecosystem impairment starting at approximately 10% impervious surface cover.[9] Impervious cover may be linked to the quality of lakes, reservoirs, estuaries, and aquifers,[10] and the amount of impervious cover in a watershed can be used to project the current and future quality of streams. Based on the scientific literature, Caraco et al. classified urbanizing streams into the following three categories: sensitive streams, impacted streams, and non-supporting streams. Sensitive streams typically have a watershed impervious cover area of 0-10%. Impacted streams have a watershed impervious cover area ranging from 11-25% and typically show clear signs of degradation from urbanization. Non-supporting streams have a watershed impervious cover area of greater than 25%; at this high level of impervious cover, streams are simply conduits for stormwater flow and no longer support a diverse stream community.[11]

The first step to remediating these conditions is to retrofit impervious surfaces in developed areas with green infrastructure. This next chapter will outline the design process for green infrastructure practices. All green infrastructure practices should be designed by a professional engineer and/or a licensed landscape architect in accordance with state requirements. This section is intended to provide guidance to design professionals based on the experience of the RCE Water Resources Program.

[9] May, C.W., R.R. Horner, J.R. Karr, B.W. Mar, E.G. Welch. 1997. Effects of Urbanization on Small Streams in the Puget Sound Lowland Ecoregion. *Watershed Protection Techniques* 2(4): 483-493.
[10] Schueler, T. 1994. The Importance of Imperviousness. *Watershed Protection Techniques* 1(3): 100-111.
[11] Caraco, D.,R. Claytor, P. Hinkle, H. Kwon, T. Schueler, C. Swann, S. Vysotsky, and J. Zielinski. 1998. Rapid Watershed Planning Handbook. A Comprehensive Guide for Managing Urbanizing Watersheds. Prepared by Center For Watershed Protection, Ellicott City, MD. Prepared for U.S. Environmental Protection Agency, Office of Wetlands, Oceans and Watersheds and Region V.

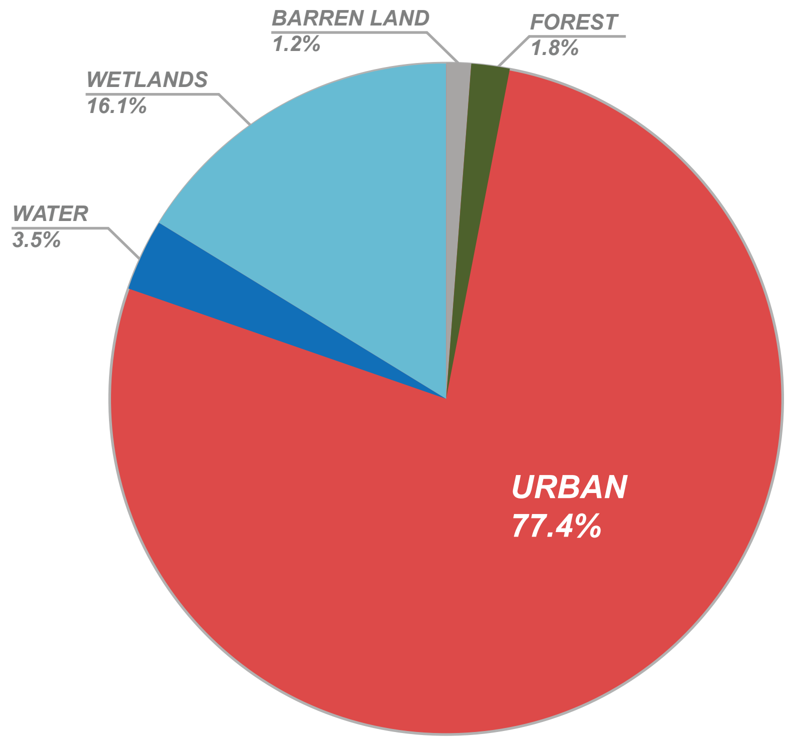
THE DESIGN PROCESS

1. ASSESS EXISTING STORMWATER ISSUES
2. IDENTIFY SITE OPPORTUNITIES
3. EVALUATE GREEN INFRASTRUCTURE FEASIBILITY
4. DESIGN GREEN INFRASTRUCTURE PRACTICE

① *ASSESS EXISTING STORMWATER MANAGEMENT*

The first step to reducing the impacts of impervious surfaces is to conduct an impervious cover assessment. An impervious cover assessment is designed to help communities better understand the effect impervious cover has on local waterways. This assessment can be completed on a variety of scales: an individual lot, municipality, or watershed. Impervious surfaces need to be identified for stormwater management.

The NJDEP 2007 land use/land cover geographical information system (GIS) data layer categorizes the state into many unique land use areas and assigns a percent impervious cover for each delineated area. These impervious cover values are used to estimate the impervious cover for a specified community. Once estimated, the level of impervious cover is compared to literature values to determine if local waterbodies are classified as sensitive, impacted, or non-supporting.



This pie chart illustrates the land use of Manville, New Jersey. Using the NJDEP 2007 land use/land cover data, impervious cover percentages are specified based on land use.

Subwatershed	Total Area		Land Area		Water Area		Impervious Cover		
	(ac)	(mi²)	(ac)	(mi²)	(ac)	(mi²)	(ac)	(mi²)	(%)
Millstone River	267.6	0.42	252.6	0.39	15.0	0.02	55.4	0.09	21.9%
Lower Raritan River	727.3	1.14	696.3	1.09	31.0	0.05	264.3	0.41	38.0%
Royce Brook	572.7	0.89	564.0	0.88	8.72	0.01	194.3	0.30	34.5%
Total	1,567.6	2.45	1,512.9	2.36	54.7	0.09	514.0	0.80	34.0%

Using the subwatersheds of Manville as a scale of measurement, percentages of impervious cover are calculated for each subwatershed in Manville.

Subwatershed	Total Run-off Volume for 1.25” NJ Water Quality Storm (MGal)	Total Runoff Volume for NJ Annual Rainfall of 44” (MGal)	Total Runoff Volume for 2-Year Design Storm (3.3”) (MGal)	Total Runoff Volume for 10-year Design Storm (5.0”) (MGal)	Total Runoff Volume for 100-Year Design Storm (8.2”) (MGal)
Millstone River	1.9	66.2	5.0	7.5	12.3
Lower Raritan River	9.0	315.8	23.7	35.9	58.8
Royce Brook	6.6	232.1	17.4	26.4	43.3
Total	17.4	614.1	46.1	69.8	114.4

Runoff volumes from impervious surfaces are calculated by subwatershed. In both tables the following abbreviations are as follows: ac = acres, mi^2 = square miles, MGal = millions of gallons.

The next step is to set a reduction goal for impervious area in each subwatershed. Based upon the RCE Water Resources Program’s experience, a 10% reduction is achievable in most areas throughout the state. While it may be difficult to eliminate paved areas or replace all of them with pervious pavement, it is relatively easy to identify these impervious surfaces and disconnect at least 10% of the paved area using green infrastructure practices.

② IDENTIFY SITE OPPORTUNITIES

To address the impact of stormwater runoff from impervious surfaces, the second step is to identify site opportunities within a municipality for eliminating, reducing, and disconnecting directly connected impervious surfaces.

ELIMINATION OF IMPERVIOUS SURFACES

One method to reduce impervious cover is to "depave." Depaving is the act of removing paved impervious surfaces and replacing them with pervious soil and vegetation that will allow for the infiltration of rainwater. Depaving leads to the re-establishment of natural areas that will help reduce flooding, increase wildlife habitat, and positively enhance water quality as well as beautify neighborhoods. Depaving also can bring communitites together around a shared vision to work together to reconnect their neighborhood to the natural environment.

REDUCE OR CONVERT IMPERVIOUS SURFACES

There may be surfaces that are required to be hardened, such as roadways or parking lots, but could be made smaller and still be functional. A parking lot that has two-way cartways could be converted to one-way cartways. There also are permeable paving materials such as porous asphalt, pervious concrete, or permeable paving stones that could be substituted for impermeable paving materials.

IMPERVIOUS COVER DISCONNECTION

By redirecting runoff from paving and rooftops to pervious areas in the landscape, the amount of directly connected impervious area in a drainage area can be greatly reduced. There are many cost-effective ways to disconnect impervious surfaces from local waterways. See Chapter 2 for detailed information regarding green infrastructure practices that can be designed to disconnect impervious surfaces from local waterways.

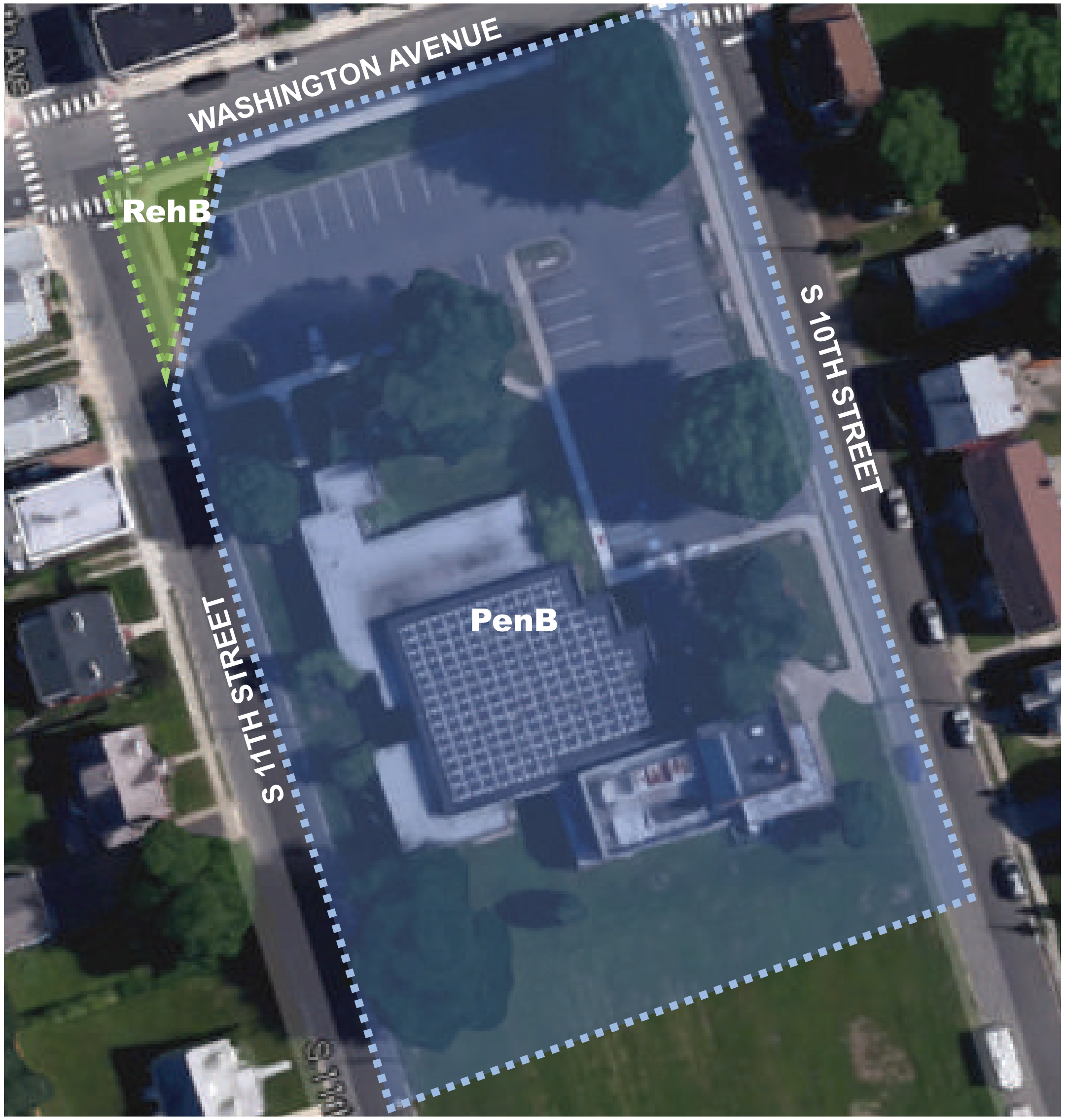
A collection of sites are identified in each municipality based on site visibility, feasibility, cost-effectiveness, and potential partnerships. The RCE Water Resources Program uses a “look here first” method to identify the most accessible and visible sites. These sites include: schools, churches, libraries, municipal buildings, public works, firehouses, post offices, fraternal/social organization lodges such as the Elks or Moose, and parks/recreational fields. These sites often have large amounts of impervious cover and typically are relatively easy to engage in implementing green infrastructure practices. Sites are selected based on their feasibility or the probability of getting the project in the ground. This criteria is based on property ownership and ability to do maintenance. In addition, potential partnerships related to the site help in making a project feasible.

③ EVALUATE GREEN INFRASTRUCTURE FEASIBILITY

After the sites are identified, each site is individually evaluated for green infrastructure projects. Initially, aerial imagery is assessed to identify potential impervious areas to eliminate, reduce, or disconnect. Next, a soil assessment is conducted to determine the soil type at the site. Site visits are conducted at each of these potential project sites to determine available options to reduce or disconnect impervious surfaces from draining directly to the local waterway or storm sewer system. During the site visit, appropriate green infrastructure practices for the site are determined. Sites with existing stormwater management practices are not considered for evaluation in favor of sites with no stormwater management.

SOIL ASSESSMENT

Prior to conducting a site visit, preliminary soil assessments should be conducted to determine soil suitability for green infrastructure practices. The US Department of Agriculture Natural Resources Conservation Service (USDA NRCS) web soil survey is a good tool for



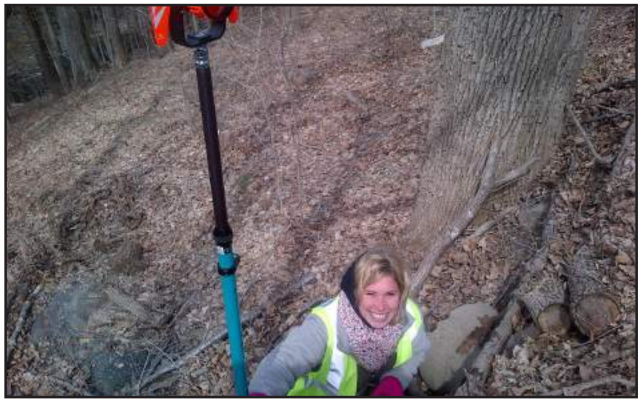
This aerial photograph shows the different types of soil (i.e., RehB - Reaville, PenB - Penn) located at the site based on the NRCS web soil survey.

these assessments. The assessment indicates the types of soils present on the site and the properties associated with each classification. This will further indicate which locations have soils most suitable for various green infrastructure practices.

As shown in the aerial photograph to the left, the predominate soil on the site is Penn silt loam (PenB). This soil has a hydrologic soil group classification of “C.” Other important soil properties and qualities are:

- Slope: 2 to 6 percent
- Depth to restrictive feature: 20 to 39 inches to lithic bedrock
- Natural drainage class: Well drained
- Runoff class: Very low
- Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 6.00 in/hr)
- Depth to water table: More than 80 inches
- Frequency of flooding: None
- Frequency of ponding: None
- Available water storage in profile: Low (about 4.5 inches)

Based on this analysis, infiltration-type green infrastructure practices are appropriate for the site. The important factors are depth of restrictive feature (i.e., bedrock), depth to groundwater (i.e., depth to water table), and infiltration rate (i.e., capacity of the most limiting layer to transmit water). It is important to note that a site specific soil investigation should be conducted prior to completing the final design of the green infrastructure practice to confirm the infiltration rate and depth to groundwater.



SITE ASSESSMENT

The next step is to conduct a site visit. The site assessment evaluates each property for green infrastructure opportunities to manage on-site stormwater and adjacent roadway runoff. Overall, there are a number of general observations that assist in identifying these opportunities. A complete site assessment checklist is provided in Appendix A.

1. **Identify stormwater flow pattern.** Knowing the sources of stormwater and flow direction are important for selecting and locating types of green infrastructure practices. Green infrastructure practices should be located to intercept stormwater at its source. It is often easier to retrofit a site with green infrastructure practices when focusing on source controls. This requires designing smaller systems that can be contained in the space available with minimal site disruption. An alternative is to locate a practice at the lowest point of the site to capture all the runoff from the site. This results in one large practice instead of several smaller ones and is often unachievable due to a lack of available space for the practice.
2. **Understand the slope.** Knowing the slope of the site helps with understanding the flow direction as well as selecting suitable green infrastructure practices. Some green infrastructure practices are not suitable for steep areas while others require a minimum slope to drain properly.
3. **Identify the amount of impervious cover.** The area of impervious cover determines the size of the green infrastructure practice as well as how much stormwater runoff it will treat. If evaluating a streetscape, determine the area available for potential green infrastructure practices by measuring building setback distances from the street and curb as well as the width of existing sidewalks.
4. **Evaluate impervious cover.** If the impervious cover is in disrepair, then there is a higher potential that it can be cost-effectively removed or replaced with

a green infrastructure practice. If impervious areas are directly connected, there may be an opportunity to redirect stormwater into a green infrastructure practice.

5. **Identify opportunities for disconnection.** These opportunities include downspouts or paved areas that slope to lawn areas. Identifying opportunities where stormwater can be managed at the surface as opposed to the subsurface provides the greatest potential for cost-effective management.

6. **Locate stormwater catch basins in and around the site and/or streetscape.** Stormwater runoff flows to catch basins. There are often opportunities to intercept runoff before it reaches the catch basin and divert it to a green infrastructure practice. The depth and condition of these catch basins can also provide important information to designers.

7. **Identify areas of flooding or stormwater ponding.** If water is ponding on the site or flooding the street or intersection, there could be too much stormwater runoff or poorly maintained infrastructure. In these cases, green infrastructure practices can help address the problem. If ponding is due to a high water table and the area is continually wet, then green infrastructure may be less suitable.

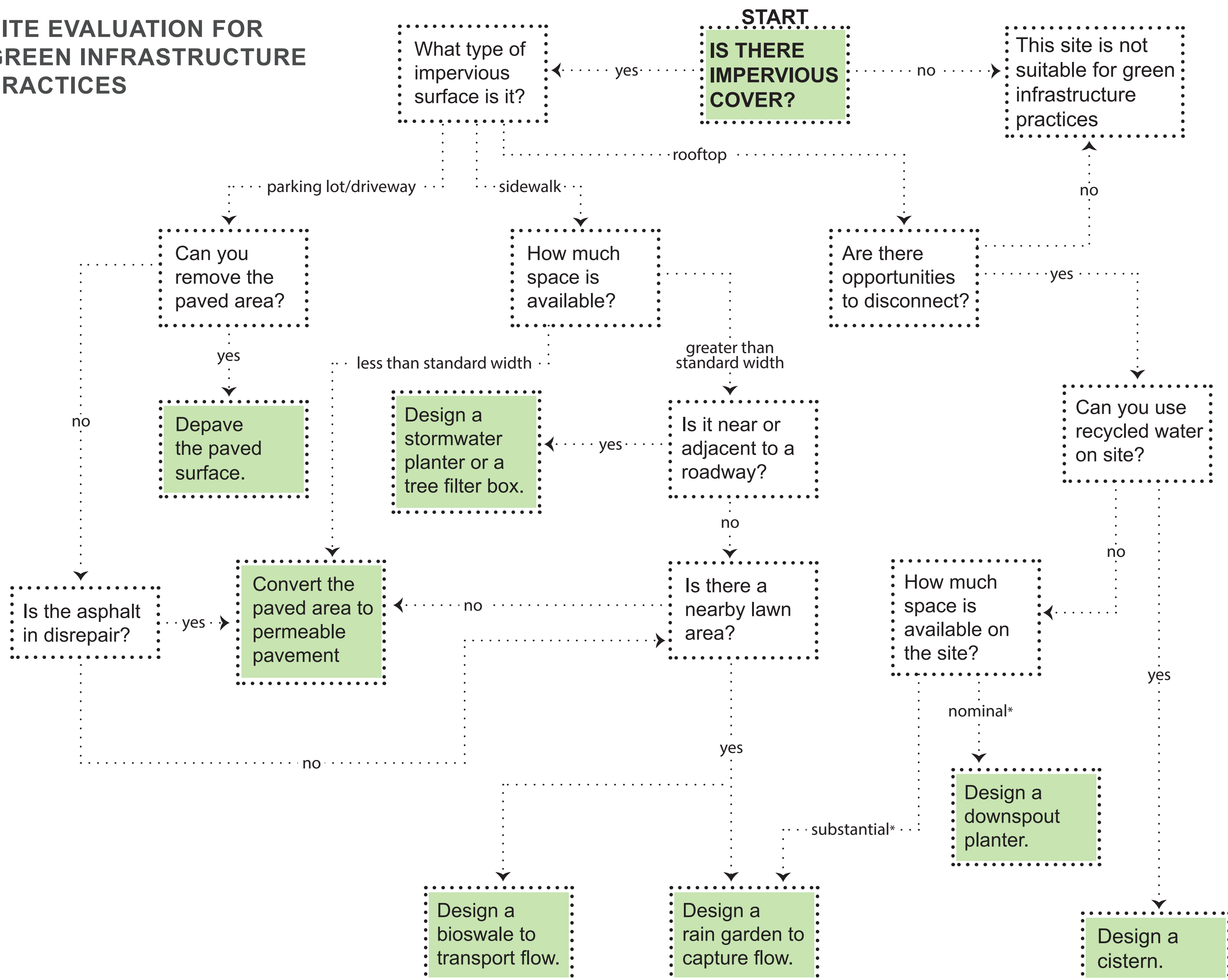
8. **Identify and evaluate existing trees or landscaping features.** Landscape features may be providing stormwater benefits and could be enhanced or integrated into a green infrastructure design. Determining the type of plants appropriate for the site will help ensure that any green infrastructure practices that include plantings (such as a rain garden, tree trench, or a stormwater planter) will be successful in that environment.

9. **Determine the location of existing utilities.** This is important for green infrastructure practice installation. If there are underground utilities, green infrastructure practices must be designed to avoid conflicts with these utilities.

10. **Identify streetscape conditions.** Designing green infrastructure in the streetscape can often be used for traffic calming or pedestrian safety improvements. If an intersection or streetscape is heavily used by pedestrians, shortening crosswalks using curb extensions or other landscape strategies can make it safer.

In addition to the general observations listed above, there are some observations that are specific to different green infrastructure practices. These observations are listed in the appendix as part of the site assessment checklist. For specific green infrastructure practice opportunities, the figure to the right can help answer key questions to help identify which green infrastructure practices are most feasible for the site.

SITE EVALUATION FOR GREEN INFRASTRUCTURE PRACTICES



*Typically the size of a rain garden needs to be 10%-20% of the total drainage area

4 DESIGN GREEN INFRASTRUCTURE PRACTICE

After identifying sites for green infrastructure implementation, the next step is to design the green infrastructure practices. The design of green infrastructure practices is determined by the green infrastructure type, the total drainage area, and site specific observations or constraints. Green Infrastructure practices should be designed with the guidance of a professional engineer and/or licensed landscape architect. Successful projects will require that multiple site constraints and opportunities be carefully considered and integrated into a final functional plan. The following design guidance is intended to provide design professionals with a basic understanding of the design approach needed to successfully plan a green infrastructure project in New Jersey.

Typically, green infrastructure practices in New Jersey are designed to manage the water quality storm (1.25 inches of rainwater over two-hours). The RCE Water Resources Program has been designing green infrastructure practices to manage the two-year design storm. This makes the system slightly larger to withstand the more intense storms that will result from climate change.

The two-year design storm rainfall totals vary based on county and range from 3.2 to 3.5 inches of rainfall over 24-hours. The USDA NRCS methodology is used to calculate stormwater runoff from the site. This methodology is fully described in Technical Release 55 – Urban Hydrology for Small Watersheds (TR-55). There are many software packages readily available that use the NRCS methodology to calculate runoff volumes.

CALCULATING A DRAINAGE AREA

The starting point for sizing any green infrastructure practice is to determine the drainage area. A drainage area is determined by site observations (including site slope and catch basin location) and contour data. Designing green infrastructure at a site almost always requires conducting a survey to determine surface elevations, flow direction, and drainage area. Even if topography data is available, a field investigation is important to verify existing site conditions.

DESIGNING BIORETENTION SYSTEMS & RAIN GARDENS

When designing a bioretention system or rain garden, a good approximation of the storage volume necessary to manage the two-year design storm is to calculate the runoff volume of 1.5 inches of runoff from the drainage area. For example, the runoff volume from a 1,000 square foot driveway for 1.5 inches of rain (0.125 feet of rain) would be 125 cubic feet of water. This means the approximate size of a bioretention system should be 125 square feet at a depth of one foot or 250 square feet at a depth of six inches (0.5 feet).

SURFACE AREA OF DRAINAGE AREA * DEPTH OF RAINFALL = APPROXIMATED RUNOFF VOLUME

1,000 SF * 0.125 F = 125 CF

The next step is to use hydrologic modeling software to simulate the green infrastructure practice during the two-year design storm. The runoff hydrograph for a 1,000 square foot driveway is shown in Figure 1.

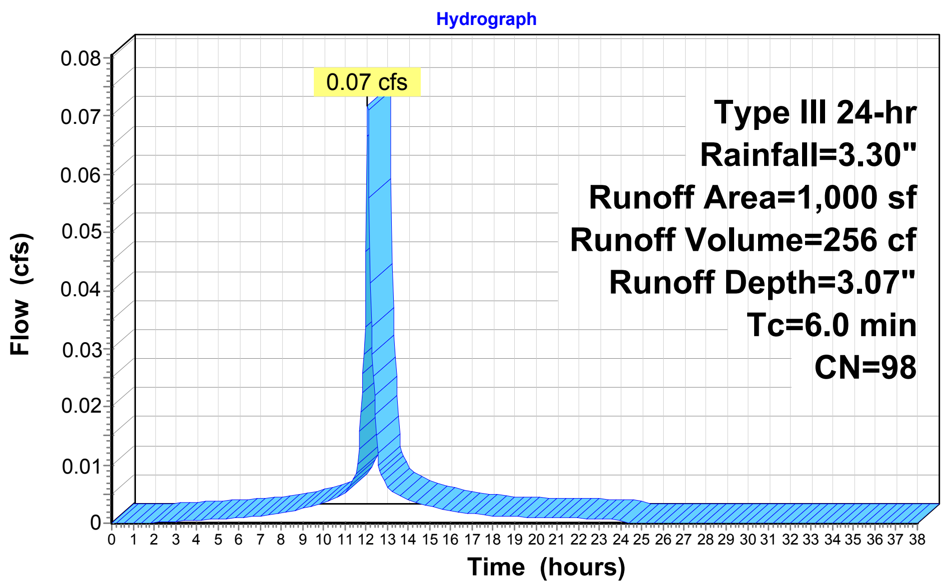


Figure 1: Stormwater runoff hydrograph from a 1,000 square foot driveway for the two-year design storm

The total runoff volume is 256 cubic feet (cf) from the site with a peak runoff rate of 0.07 cubic feet per second (cfs). A bioretention system, or rain garden, can be designed to manage this amount of runoff. Using the estimation described above, the rain garden would need to be approximately 250 square feet in size. It is important to note, a rain garden does not only capture the runoff from the driveway, but also from the garden itself. The runoff hydrograph was recalculated using the new drainage area of 1,250 square feet. This hydrograph is shown in Figure 2.

DRAINAGE AREA + BIORETENTION AREA = TOTAL DRAINAGE AREA

(TOTAL DRAINAGE AREA)* DEPTH OF RAINFALL = TOTAL RUNOFF VOLUME

1,250 SF * 0.125 F = 157 CF

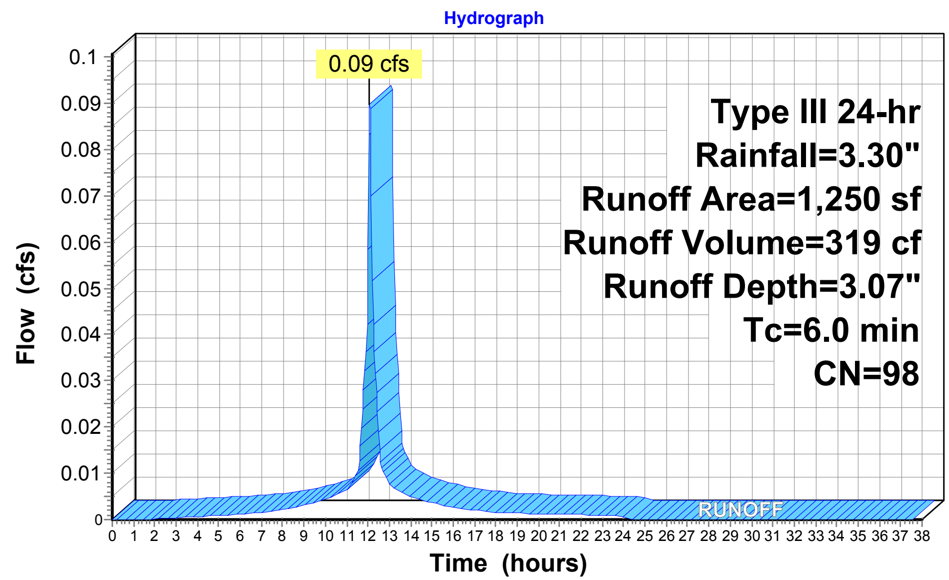


Figure 2: Stormwater runoff hydrograph from a 1,250 square foot total drainage area for the two-year design storm

For modeling purposes, the infiltration rate for the rain garden was assumed to be 0.5 inches per hour. When modeling green infrastructure practices, the infiltration rate used in the model should be half of the infiltration rate measured in the field. For example, if you measure an infiltration rate of one inch per hour, the rate used in the model should be 0.5 inches per hour. If the measured infiltration rate is less than one inch per hour, an underdrain system should be installed to ensure the system drains within 72 hours after the storm. An underdrain is a perforated pipe located about one foot below the base of the rain garden. This allows water to discharge from the garden to a nearby overflow point without flooding the area for an extended period of time. Figure 3 shows the hydrograph of the routing of the driveway runoff through the rain garden.

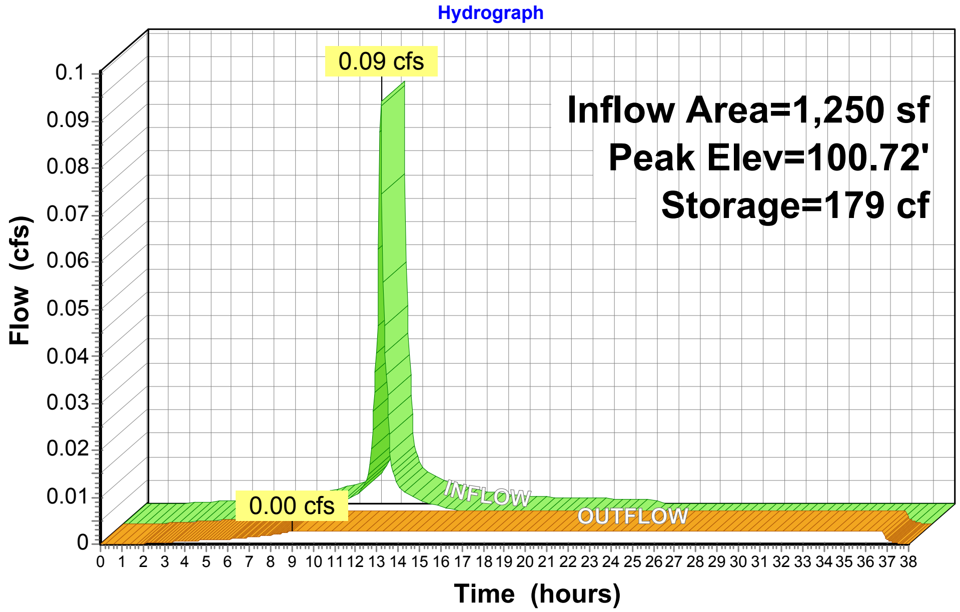


Figure 3: Routing summary of a bioretention system/rain garden for managing driveway runoff

Figure 4 shows the summary of these routing calculations. The rain garden was designed to have a bottom elevation of 100 feet and a ponding depth of 1.0 foot. The summary shows that the maximum water surface elevation in the rain garden is 100.72 (i.e., water depth of 0.72 feet). To reduce this water depth, the size of the rain garden would have to be enlarged beyond 250 square feet. The garden would have to be 350 square feet in size to keep the maximum water depth to 0.5 feet for a drainage area of 1,350 square feet (1,000 square feet of driveway and 350 square feet of rain garden) with an infiltration rate of 0.5 inches per hour.

Summary for Bioretention (Rain Garden)

Inflow Area = 1,250 sf,100.00% Impervious, Inflow Depth = 3.07"
Inflow = 0.09 cfs @ 12.09 hrs, Volume= 319 cf
Outflow = 0.00 cfs @ 9.05 hrs, Volume= 319 cf, Atten= 97%, Lag= 0.0 min
Discarded = 0.00 cfs @ 9.05 hrs, Volume= 319 cf

Routing by Stor-Ind method, Time Span= 0.00-38.00 hrs, dt= 0.05 hrs
Peak Elev= 100.72' @ 15.71 hrs Surf.Area= 250 sf Storage= 179 cf

Plug-Flow detention time= 539.3 min calculated for 319 cf (100% of inflow)
Center-of-Mass det. time= 539.3 min (1,295.0 - 755.8)

Volume	Invert	Avail.Storage	Storage Description
#1	100.00'	250 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
100.00	250	0	0
101.00	250	250	250

Device	Routing	Invert	Outlet Devices
#1	Discarded	100.00'	**0.500 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.00 cfs @ 9.05 hrs HW=100.01' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.00 cfs)

Figure 4: Routing summary of a bioretention system managing driveway runoff

While the RCE Water Resources Program recommends designing bioretention systems/ rain gardens to manage the two-year design storm, there may be times when this is not practical and the system only can be designed to manage the water quality storm (WQS) of 1.25 inches of rain over two-hours. For a bioretention system with an infiltration rate of 0.5 inches per hour, the table below can be used to determine the maximum volume of runoff captured per storm and the total annual runoff volume captured. The total annual runoff volume captured is based upon the drainage area and the annual rainfall (44 inches). It is assumed that a system designed to manage the WQS can capture 90% of the annual rainfall, and a system that is designed to manage the two-year design storm can capture

95% of the annual rainfall. The table was created for a drainage area of 1,000 square feet, which includes the surface area of the bioretention system. The values provided in this table can be used to estimate gallons of runoff captured for larger drainage areas. For example, 643 gallons of runoff would be captured for the WQS from a 1,000 square foot drainage area. If the drainage area was 10,000 square feet, 6,430 gallons of runoff would be captured for the WQS.

Green Infrastructure Practice	Design Storm	Maximum Volume Captured per Storm per 1,000 sq. ft. of Drainage Area (gallons)*	Total Annual Runoff Volume Captured per 1,000 sq.ft. of Drainage Area (gallons)*
Bioretention Systems/ Rain Gardens	WQS	643	24,684
Bioretention Systems/ Rain Gardens	2-YR	1,915	26,055

* This drainage area includes the surface area of the bioretention system

DESIGNING BIOSWALES

A bioswale is designed the same way as a bioretention system/rain garden except that additional calculations have to be performed to ensure that the peak flow during the two-year design storm can travel through the bioswale without causing erosion or scouring. The velocity of the stormwater traveling through the bioswale should not exceed the allowable erosive velocity for the soil texture and plant material in the bioswale. For a bioswale, maximum velocity shall be based on the 10-year frequency storm, unless a larger storm event is to be conveyed for reasons of safety and compatibility with other stormwater management measures.

DESIGNING DOWNSPOUT PLANTERS

Downspout planters are modeled as bioretention systems with an infiltration rate of 5.0 inches per hour to be conservative. Infiltration measurements conducted by Rawls et al. (1998) showed the sandy compost mixture to have an infiltration rate of 7.16 inches per hour.[12] Much like smaller rainwater harvesting systems, these planter boxes can quickly fill and overflow during frequent rainfall events. The design of these systems needs to include an underdrain piping system to slowly drain and release captured water and a downspout diverter to divert flow during winter months. A stable foundation is required, and overflow from these boxes needs to be directed away from nearby structures.

DESIGNING STORMWATER PLANTERS

Since stormwater planters are a type of bioretention system, they are designed in a similar fashion. The standard size of a stormwater planter is 4 feet by 20 feet or 80 square feet. These systems are designed to be incorporated into the sidewalk area. For the 80 square foot planter, the table below provides the maximum drainage area the planter can manage for the WQS and the two-year design storm assuming an infiltration rate of 0.5 inches per hour. The table provides the maximum volume of runoff captured per storm and the total annual runoff volume captured. The maximum volume of runoff captured per storm is greater for the two-year design storm than the WQS. The annual runoff captured for the two-year design storm is less than the WQS because the drainage area for the two-year storm is much smaller, and the annual runoff volume captured is based on the drainage area. Similar to the table provided for bioretention systems, the values in this table can be used to estimate the runoff volume capture for larger drainage areas.

Green Infrastructure Practice	Design Storm	Maximum Drainage Area that Stormwater Planter can Manage (sq.ft)**	Maximum Volume Captured in 80 sq.ft. Stormwater Planter per Storm (gallon)**	Total Annual Runoff Volume Captured in 80 sq.ft. Stormwater Planter (gallons)**
Stormwater Planter	WQS	525	337	12,959
Stormwater Planter	2-year	310	591	8,077

* This drainage area includes the surface area of the stormwater planter

[12] Rawls, W. J., D. Gimenez, and R. Grossman. 1998. Use of Soil Texture, Bulk Density, and Slope of the Water Retention Curve to Predict Saturated Hydraulic Conductivity. *Transactions of the ASAE* 41.4: 983-88.

DESIGNING PERMEABLE PAVEMENT

Unlike bioretention systems, permeable pavements store stormwater runoff volumes beneath the surface in a stone reservoir. Considering the void space of the stone reservoir is 35%, approximately three gallons of stone is needed to store one gallon of water. Since water passes very quickly through the permeable surface, the constraining factor is the infiltration rate of the underlying soil. Consider a 40,000 square foot parking lot as shown to the right. The runoff hydrograph for a 40,000 square foot parking lot is shown in Figure 5.

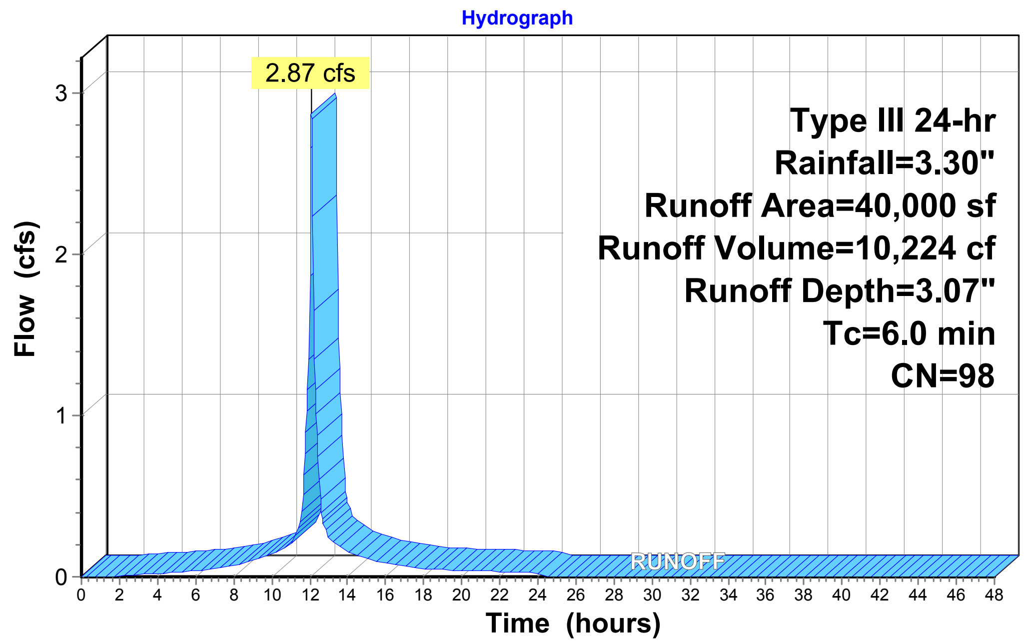
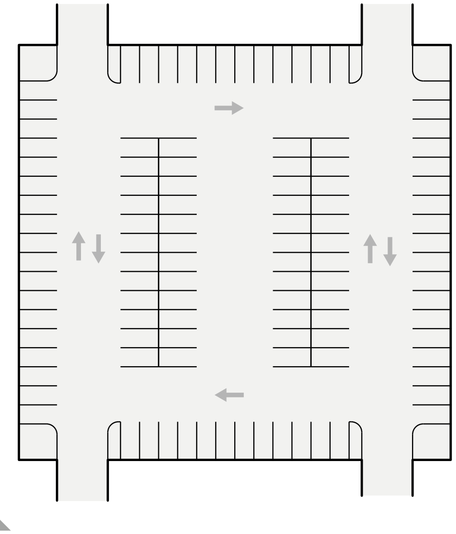


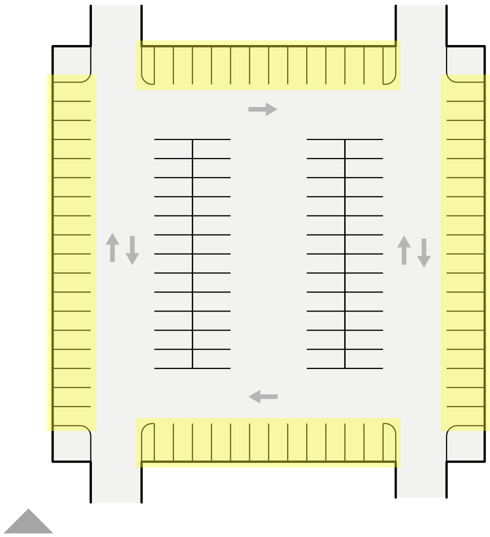
Figure 5: Stormwater runoff hydrograph from a 40,000 square foot driveway for the two-year design storm

Typically, permeable pavements such as porous asphalt are not used in the cartways, only in the parking spaces. One way to treat the stormwater runoff in this parking lot is to install a two-foot porous asphalt system in the perimeter parking spaces as shown on page 64. The porous asphalt system would have a 1.75-foot stone reservoir to hold the stormwater runoff while it infiltrates into the underlying soil. In this example, the infiltration rate for



This is an example of a 40,000 square foot parking lot.

porous asphalt is assumed to be 0.5 inches per hour for modeling purposes. It is important to accurately determine the infiltration rate of the soil beneath the porous asphalt system. If the infiltration rate is less than one inch per hour, an underdrain system should be installed to ensure the system drains within 72 hours after the storm. Figure 6 shows the hydrographs for inflow and discharge of the parking lot runoff through the porous asphalt system. Figure 7 shows a summary of these routing calculations. The porous asphalt system was designed to have a bottom elevation of 100.0 feet. The summary shows that the maximum water surface elevation in the stone reservoir is 101.50 feet (i.e., water depth of 1.5 feet, or 18 inches).



This is an example of a 40,000 square foot parking lot designed with porous asphalt in only the perimeter parking area as indicated by the yellow highlighted areas; a porous asphalt system includes the asphalt paving and the underlying stone reservoir.

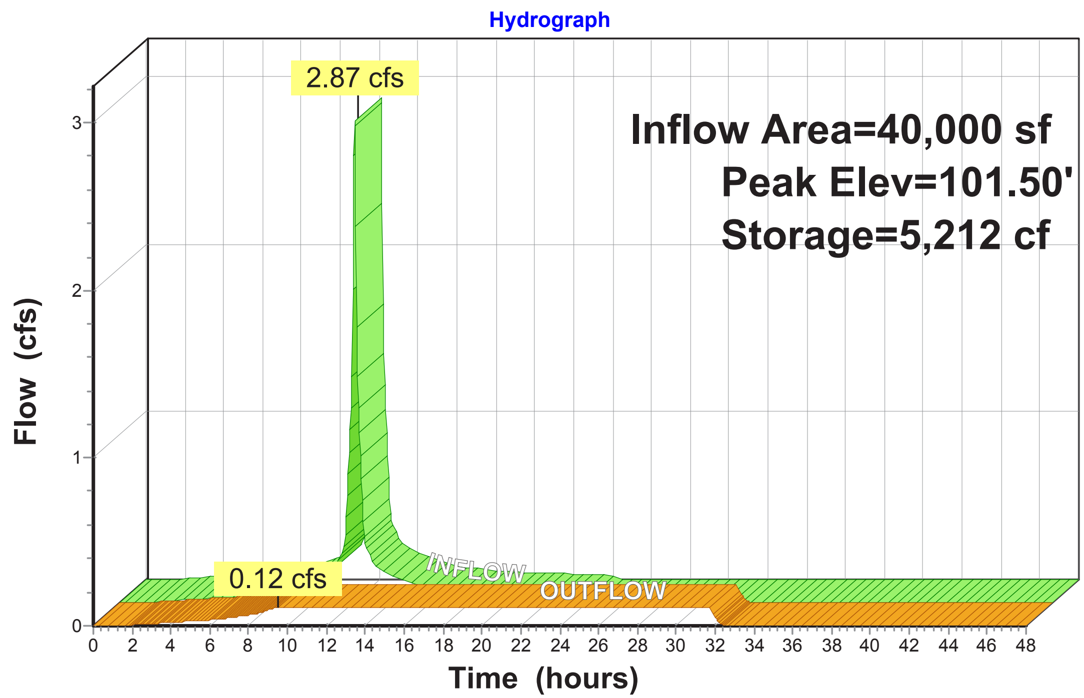


Figure 6: Routing of the two-year design storm through a two-foot porous asphalt system that has an infiltration rate of 0.5 inches per hour

Summary for Porous Asphalt: Option 1

Inflow Area = 40,000 sf,100.00% Impervious, Inflow Depth = 3.07"
Inflow = 2.87 cfs @ 12.09 hrs, Volume= 10,224 cf
Outflow = 0.11 cfs @ 9.55 hrs, Volume= 10,224 cf, Atten= 96%, Lag= 0.0 min
Discarded = 0.11 cfs @ 9.55 hrs, Volume= 10,224 cf

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 101.50' @ 15.06 hrs Surf.Area= 9,950 sf Storage= 5,212 cf

Plug-Flow detention time= 388.6 min calculated for 10,224 cf (100% of inflow)
Center-of-Mass det. time= 388.7 min (1,144.5 - 755.8)

Volume	Invert	Avail.Storage	Storage Description
#1	100.00	6,468 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

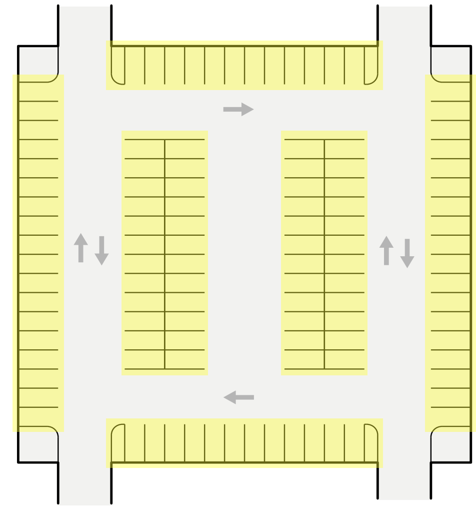
Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
100.00	9,950	0.0	0	0
101.75	9,950	35.0	6,094	6,094
101.83	9,950	15.0	119	6,214
102.00	9,950	15.0	254	6,468

Device	Routing	Invert	Outlet Devices
#1	Discarded	100.00'	**0.500 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.12 cfs @ 9.60 hrs HW=100.02' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.12 cfs)

Figure 7: Routing summary of a two-foot porous asphalt system for managing driveway runoff

A second option would be to pave all the parking spaces with a one-foot porous asphalt system, which includes a 0.75-foot stone reservoir for storage. Assuming the same drainage area and hydrology in Figure 5, Figure 8 shows the hydrographs of the routing of the parking lot runoff through the porous asphalt system. Figure 9 shows the summary of these routing calculations. The porous asphalt system was designed to have a bottom elevation of 100.0 feet. The summary shows that the maximum water surface elevation in the stone reservoir is 100.66 feet (i.e., water depth of 0.66 feet or 8 inches).



This is an example of a 40,000 square foot parking lot designed with porous asphalt in all of the parking spots as indicated by the yellow highlighted areas. The porous asphalt system includes paving materials and an underlying stone reservoir.

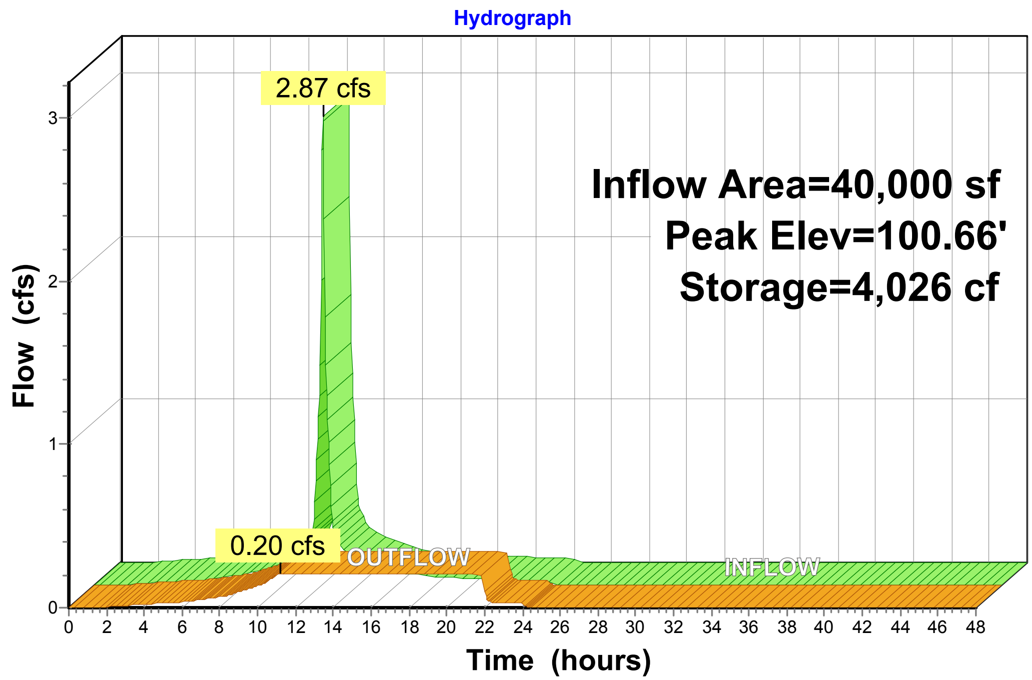


Figure 8: Routing of the two-year design storm through a one-foot porous asphalt system that has an infiltration rate of 0.5 inches per hour

Summary for Porous Asphalt: Option 2

Inflow Area = 40,000 sf,100.00% Impervious, Inflow Depth = 3.07"
Inflow = 2.87 cfs @ 12.09 hrs, Volume= 10,224 cf
Outflow = 0.20 cfs @ 11.05 hrs, Volume= 10,224 cf, Atten= 93%, Lag= 0.0 min
Discarded = 0.20 cfs @ 11.05 hrs, Volume= 10,224 cf

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 100.66' @ 13.36 hrs Surf.Area= 17,500 sf Storage= 4,026 cf

Plug-Flow detention time= 152.6 min calculated for 10,213 cf (100% of inflow)
Center-of-Mass det. time= 152.4 min (908.2 - 755.8)

Volume	Invert	Avail.Storage	Storage Description
#1	100.00	5,250 cf	**Custom Stage Data (Prismatic)**

Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
100.00	17,500	0.0	0	0
100.75	17,500	35.0	4,594	4,594
100.83	17,500	15.0	210	4,804
101.00	17,500	15.0	446	5,250

Device	Routing	Invert	Outlet Devices
#1	Discarded	100.00'	**0.500 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.20 cfs @ 11.05 hrs HW=100.01' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.20 cfs)

Figure 9: Routing summary of a one-foot porous asphalt system for managing driveway runoff

Based upon the modeling, both designs will manage the runoff from the two-year design storm. Other site conditions may make one system more desirable than another. For example, if the seasonal high water table (SHWT) is high, the one-foot system may be more desirable. If the parking lot needs to remain in use during construction, the two-foot system will allow for the systematic replacement of the perimeter parking while leaving the remainder of the parking lot undisturbed.

Green Infrastructure Practice	Design Storm	Area of Permeable Pavement Needed to Treat Design Storm	Depth of Stone Reservoir under Permeable Pavement (inches)	Maximum Runoff Volume Captured per Storm per 40,000 sq. ft. of Drainage Area (gallons)	Total Annual Runoff Volume Captured per Storm per 40,000 sq. ft. of Drainage Area (gallons)
Permeable Pavements	WQS	9,950	10	25,799	987,360
Permeable Pavements	WQS	17,500	5	25,799	987,360
Permeable Pavements	2-year	9,950	18	76,476	1,042,213
Permeable Pavements	2-year	17,500	8	76,476	1,042,213

Drainage Area (square feet)	Cistern Sizes (gallons)
100	150 - 200
500	750 - 800
1,000	1,500 - 1,750
2,000	3,000 - 3,250
5,000	7,500 - 8,000
10,000	15,000 - 17,000

Sizing details for cistern tanks based on drainage area

DESIGNING CISTERNS

Storage tanks and barrels for rainwater harvesting systems range in size from 50 gallons to over 5,000 gallons. Barrels and tanks can store rainwater from roofs for a variety of non-potable uses. Smaller storage systems under 300 gallons can be installed near a variety of downspouts and will quickly fill during rain events. The size and shape of smaller systems should be determined based on available space and the amount of water that will be typically used every one to two weeks.

Larger systems, greater than 300 gallons, should be sized based on the available roof top drainage area. Systems should be designed to fill to capacity within three to four weeks given an average rainfall of 3-3.5 inches per month. To calculate the volume of water available for capture, assume that for every 1,000 square feet of roof, approximately 600 gallons will be generated during a one-inch rainfall event. Additionally, not every drop of rain can be captured and stored in the tank. Conservatively, factor that 75% of the runoff from the rooftop can efficiently be captured and stored. The basic formula for calculating the potential rain that can be captured in a rainwater harvesting system is:

$$\frac{\text{CATCHMENT AREA} * \text{INCHES OF RAIN} * 600 \text{ GALLONS} * 0.75}{1{,}000 \text{ SQUARE FEET}}$$

Select an appropriate cistern tank size based on the amount of rainfall that can be captured in three to four weeks (tank filled to capacity from 3-3.5 inches of rainfall). It is also important to ensure that regular use of the stored water will empty at least 50% of the stored rainwater every one to two weeks.

Important considerations when designing a rainwater harvesting system also include available space for the storage tank, suitable foundation for supporting the storage tank, and security of the system. Finally, larger tanks can be as high as 8-12 feet. Often, rooftops may not be high enough to effectively drain runoff into larger, taller tanks.

All rainwater harvesting systems need to be designed with a first flush diverter and a way to divert flow during winter months. During winter months, the tank and all plumbing pipes and fittings must be completely drained, and the rooftop runoff must be diverted from the system. Water freezing in any part of the system can cause significant damage. Designing simple ways to divert flow, drain pipes, and clean out filters is important for making these systems efficient and effective. Finally, overflow and diverted runoff during winter months must be directed away from the system and any nearby structures to prevent damage.

PLANNING & LAND DEVELOPMENT

This manual outlines a range of green infrastructure practices that can be adapted for use in New Jersey communities. Each community should evaluate which practices best fit into their neighborhoods by understanding which can be maintained by the community, are cost-effective, and are able to address the community's water quality and flooding issues. Green infrastructure is not a "one-size fits all" program, but a unique application of a range of tools specifically selected for each community.

To begin planning a green infrastructure program, communities need to prepare a feasibility study that evaluates multiple green infrastructure demonstration practices. The feasibility study expands on the work completed through the impervious cover assessment (ICA) and the impervious cover reduction action plan (RAP) to propose an implementation strategy for completing priority projects. Through the feasibility planning process, a range of priority green infrastructure practices can be considered by the community.

The feasibility study is intended to be used as a guide for a community to better understand the benefits of green infrastructure and identify specific practices for early implementation. The study focuses on implementation opportunities that retrofit green infrastructure into existing sites, not the substantial effort needed to integrate green infrastructure into future redevelopment projects.

FEASIBILITY STUDY

The feasibility study starts with the assessment of existing stormwater management as previously discussed. The assessment includes information on:

- Water and sewer infrastructure
- Drainage patterns and topography
- Impervious cover and land use
- Soil type

This assessment is used to prepare base maps specific to a community and to better understand the source of stormwater runoff contributing to combined sewer overflows and flooding. These base maps can be used to complete a detailed analysis of target neighborhoods to understand stormwater runoff patterns, recognize limitations of existing infrastructure, consider community character, and identify opportunities for green infrastructure.

Using the assessment, community leaders can begin discussions with residents to understand neighborhood-specific issues related to flooding and infrastructure needs. These discussions should include clearly documenting each neighborhood's unique character and identity. Efforts need to be made to complete a thorough evaluation of each neighborhood. Site visits are needed to identify opportunities. Visits should include sites identified in the impervious cover reduction action plan and additional opportunities recommended by local residents. Site evaluations include photos, field surveys, measurements, and interviews with neighborhood leaders and residents. This results in a list of green infrastructure opportunities that can then be reviewed, considered, and prioritized by a community.

The feasibility study should summarize green infrastructure opportunities and provide recommendations for appropriate practices that will:

- Improve the function of existing infrastructure
- Reduce impacts of stormwater runoff
- Improve the quality of life for local residents

With a completed feasibility study, a community can then develop an implementation strategy that identifies the potential costs and benefits of proposed green infrastructure practices. Once specific recommendations have been endorsed, community leaders can estimate the costs to implement green infrastructure. Costs can be evaluated as stand-alone projects or as part of larger capital infrastructure improvement projects. Additionally, community leaders can begin to consider integrating green infrastructure requirements into local ordinances and master plans.

Lastly, a community should work with infrastructure managers and those responsible for developing long-term control plans to quantify the stormwater management benefits of recommended green infrastructure practices. This final step is important for justifying the ongoing investment in green infrastructure as a community looks to comply with regulatory requirements to protect water quality.

COMMUNITY ENGAGEMENT & EDUCATION

In MS4 and CSO municipalities, community engagement and education is key to promoting the adoption of green infrastructure. Local community leaders and residents play an important role in identifying water resources problems such as areas that regularly flood where sewers back up and places where sediment is washing into sewers or directly into waterways. Once engaged and educated, these same people can become advocates for green infrastructure and encourage the municipality, businesses, schools, and residents to install green infrastructure practices to address site-specific issues on their property, thereby helping improve the overall well-being of the community. Communities can become engaged through the creation of local groups that focus on stormwater issues such as municipal action teams or community action teams. Programming that targets specific audiences can also be used to engage residents. Some of these programs could provide incentives for residents to install green infrastructure.

MUNICIPAL ACTION TEAMS

Municipal action teams foster community engagement and serve as advocates for green infrastructure in their city. These local leadership teams can be stand-alone organizations or a subset of an environmental commission or Sustainable Jersey Green Team. Municipal action teams can be developed in MS4 communities to combat flooding, improve water quality, and/or promote climate resiliency. In CSO communities, the municipal action team can be the advocates for green infrastructure to reduce the occurrences of CSOs. Since the CSO regulations now require utility authorities to engage the community, the municipal action team can help the utility authority satisfy this requirement.

A municipal action team can be established to bring together local governments, utility authorities, and community organizations. Together these groups work to set an agenda for a community-based green infrastructure initiative. The goal of this action team is to foster collaboration and collective action that helps the municipality speak with a common voice to achieve a common goal. Members of the municipal action team work together to perform the following objectives:

- Define the need and opportunities for green infrastructure
- Educate residents and community leaders
- Identify and prioritize opportunities for green infrastructure
- Address permit and long-term control plan requirements
- Leverage funding to design and implement demonstration projects

With a variety of organizations, a range of funding opportunities can be pursued by multiple team members to increase the community's sense of ownership and move a municipality collectively toward adopting a green infrastructure program. This work will help communities address their water resources problems and reduce localize flooding, protect water quality, and improve residents' quality of life.

CITIZEN ACTION TEAMS

Citizen action teams are a group of empowered residents that work together to install multiple green infrastructure practices throughout their community. The concept behind citizen action teams is that to have a real positive effect on reducing flooding, improving water quality, enhancing climate resiliency, or reducing the occurrences of CSOs, green infrastructure practices must be installed everywhere. The citizen action teams can work closely with the municipal action team. The municipal action team provides leadership, and the citizen action team provides "boots-on-the-ground" to implement practices.

EDUCATIONAL PROGRAMMING & WORKSHOPS

BUILD A RAIN BARREL

With the *Build a Rain Barrel* workshop, community members participate in a short presentation on stormwater management and water conservation and then learn how to build their own rain barrel. Workshop participants work with trained experts to convert 55 gallon plastic food-grade drums into rain barrels. They are quickly able to take an active role in recycling rainwater by installing a rain barrel at their home. Harvesting rainwater has many benefits including saving water, saving money, and preventing basement flooding. By collecting rainwater, homeowners are helping to reduce flooding and pollution in local waterways. When rainwater flows across hard surfaces like rooftops, driveways, roadways, parking lots, and compacted lawns, it carries pollution to our local waterways. Harvesting rainwater in a rain barrel is just one of the ways homeowners can capture rainwater draining from their property to help reduce neighborhood flooding problems.

STORMWATER IN YOUR SCHOOLYARD

The *Stormwater Management in Your Schoolyard* program provides educational lectures, hands-on activities, and community-level outreach for students on the topics of water quality issues and stormwater management practices. Program objectives include the exploration of various aspects of the natural environment on school grounds, the detailed documentation of findings related to these explorations, and the communication of these findings to the school community. As part of this program, several New Jersey State Core Curriculum Content Standards for science (5.1, 5.3, and 5.4), 21st-century life and careers (9.1, 9.3, and 9.4), and social studies (6.3) are addressed. Every school is unique in its need for stormwater management, so each school's *Stormwater Management in Your Schoolyard* program can be delivered in a variety of ways. This program can be tailored for grades K-8 or 9-12 and can be offered to meet a variety of schedules.

RAIN BARREL AND RAIN GARDEN REBATE PROGRAM

Rain Barrel Rebate and *Rain Garden Rebate* programs provide a financial incentive to property owners to install a rain barrel or a rain garden. These programs have been successfully piloted in New Jersey. Homeowners purchase rain barrels from a local hardware store, install the barrels, and apply for a rebate. The organization that is running the program confirms that the barrel has been installed and provides a rebate to the property owner. The rain garden rebate program is a little more complicated. An educational session is held to explain to the property owner what a rain garden is and why they should want one. Then the property owner is invited to a technical session where they have a one-on-one consultation with an engineer and landscape architect who work with the property owner to design a rain garden specifically for their property. Once the garden is installed by the property owner, it is inspected, and a rebate is provided.

TECHNICAL NEEDS

CHAPTER 4

GREEN INFRASTRUCTURE CONSTRUCTION

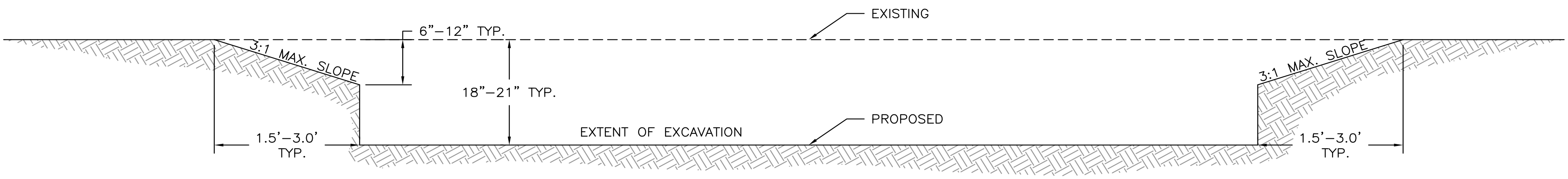
The RCE Water Resources Program has been designing and building green infrastructure practices throughout New Jersey. As part of this process, we have assembled a collection of construction specifications and details which are presented in this chapter. Many of these details have been included on engineering plans, submitted to NJDEP, and approved by NJDEP as part of New Jersey Environmental Infrastructure Trust loan applications. These construction documents are intended to provide green infrastructure designers in New Jersey guidance on some of the designs that have been constructed in the state.

TECHNICAL DETAILS FOR CONSTRUCTION

All details have been made available for download at water.rutgers.edu

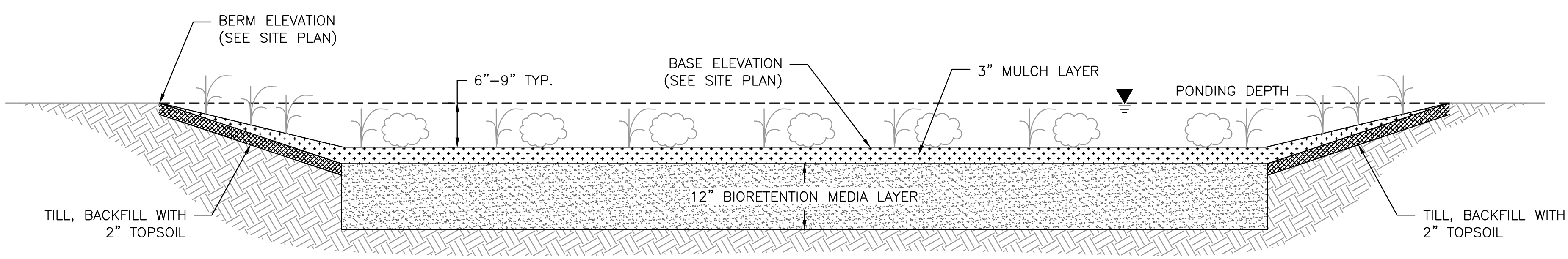
1.0 BIORETENTION

Landscaped feature designed to capture, treat, and infiltrate stormwater



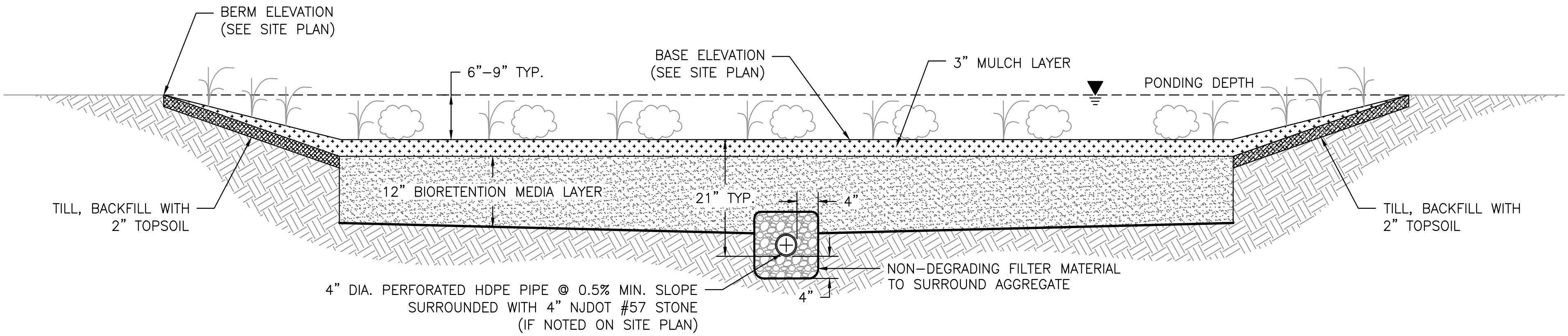
1.1 RAIN GARDEN EXCAVATION SECTION

This detail is necessary for all design plans that specify a rain garden. Depth of rain garden assumes 3" of mulch, 3" to 9" of storage above the mulch, and 12" of soil replacement with bioretention media. *Note: bioretention media may not be necessary if existing soils have appropriate infiltration capabilities*



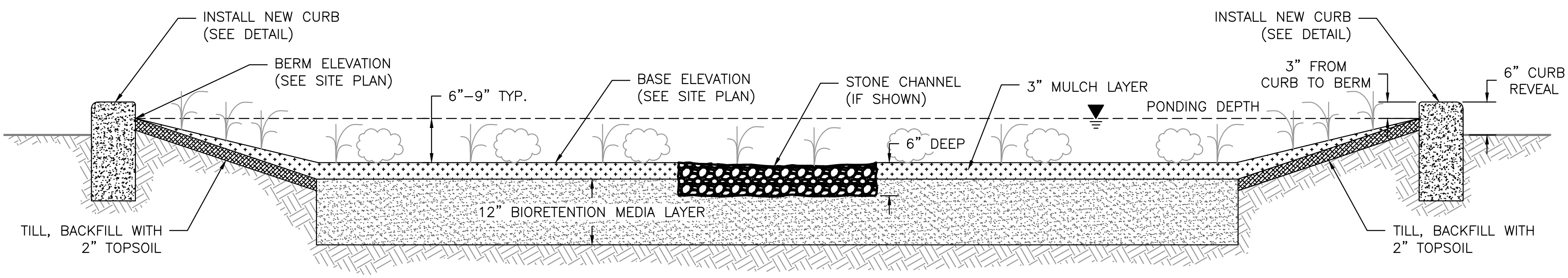
1.2 RAIN GARDEN SECTION

see detail ***1.3 RAIN GARDEN CROSS SECTION W. UNDERDRAIN PIPE*** for designs in high clay content soils
see detail ***1.7 INLET PROTECTION CROSS SECTION*** for water flow entrance
see detail ***1.10 ROCK-LINED OVERFLOW*** for water to overflow from the system



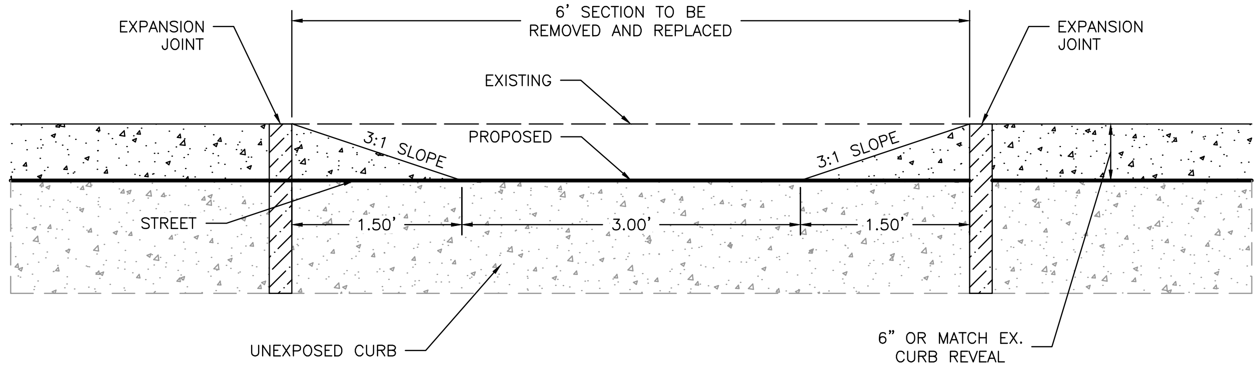
1.3 RAIN GARDEN EXCAVATION SECTION

see detail ***1.7 INLET PROTECTION CROSS SECTION*** for water flow entrance
see detail ***1.11 DRAINTECH OUTLET*** for water to overflow from the system



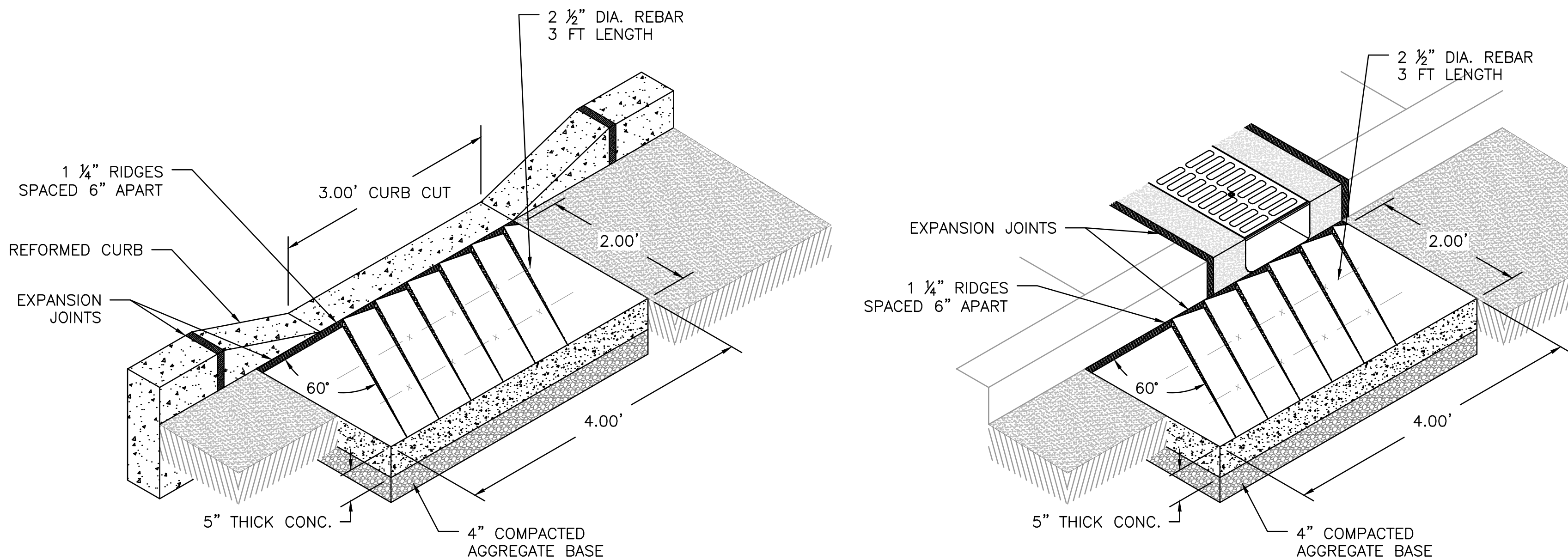
1.4 RAIN GARDEN SECTION

see detail ***1.3 RAIN GARDEN CROSS SECTION W. UNDERDRAIN PIPE*** for designs in high clay content soils
see detail ***1.7 INLET PROTECTION CROSS SECTION*** for water flow entrance
see detail ***1.8 STONE-LINED CHANNEL CROSS SECTION*** , if shown
see detail ***1.10 ROCK-LINED OVERFLOW*** for water to overflow from the system



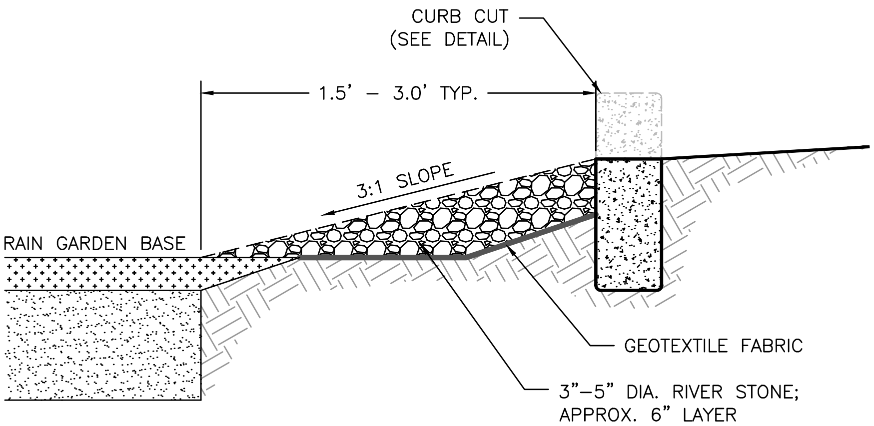
1.5 CURB CUT CROSS SECTION

see detail ***1.6 CONCRETE FLOW PAD*** for all designs using a curb cut that is roadside
see detail ***1.7 INLET/OUTLET CURB CUT PROTECTION*** for designs using a curb cut

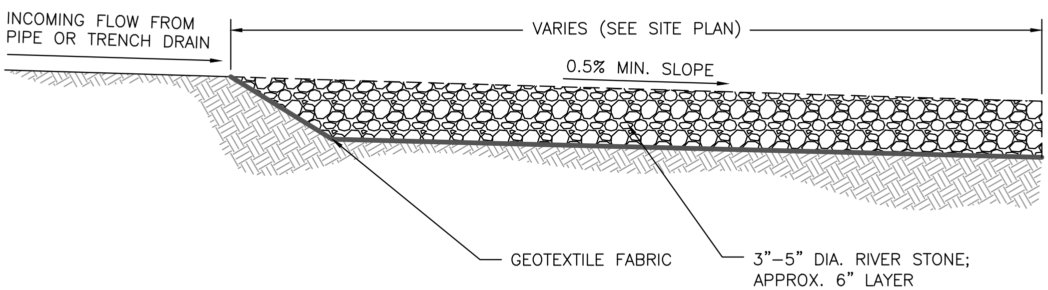


1.6 CONCRETE FLOW PAD

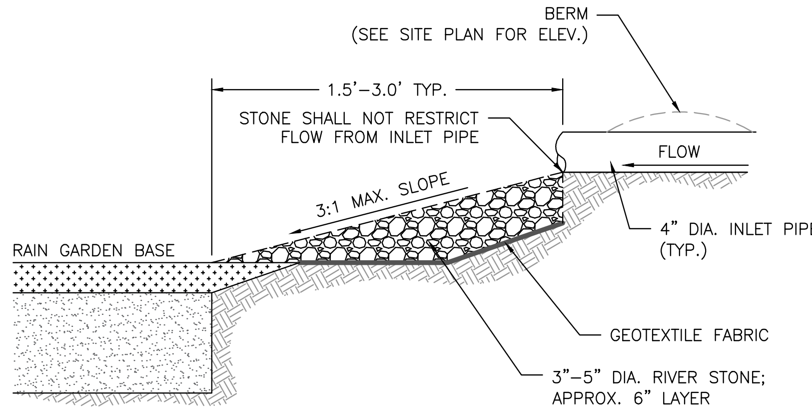
see detail ***1.13 SAWCUT EXISTING SLAB TRENCH DRAIN INSTALLATION*** for designs using a trench drain
see detail ***1.14 TRENCH DRAIN BAR SCREEN*** for designs using a trench drain
see detail ***1.15 TRENCH DRAIN PLAN VIEW*** for designs using a trench drain



1.7 INLET/OUTLET CURB CUT PROTECTION

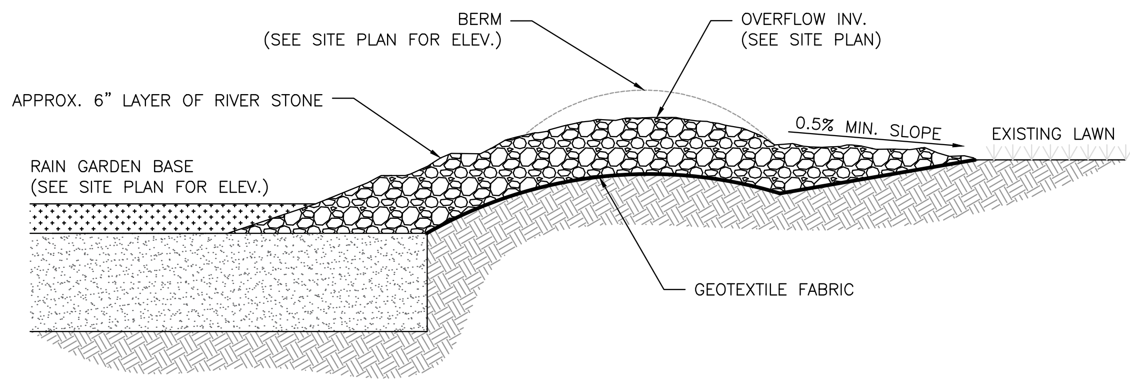


1.8 STONE-LINED CHANNEL

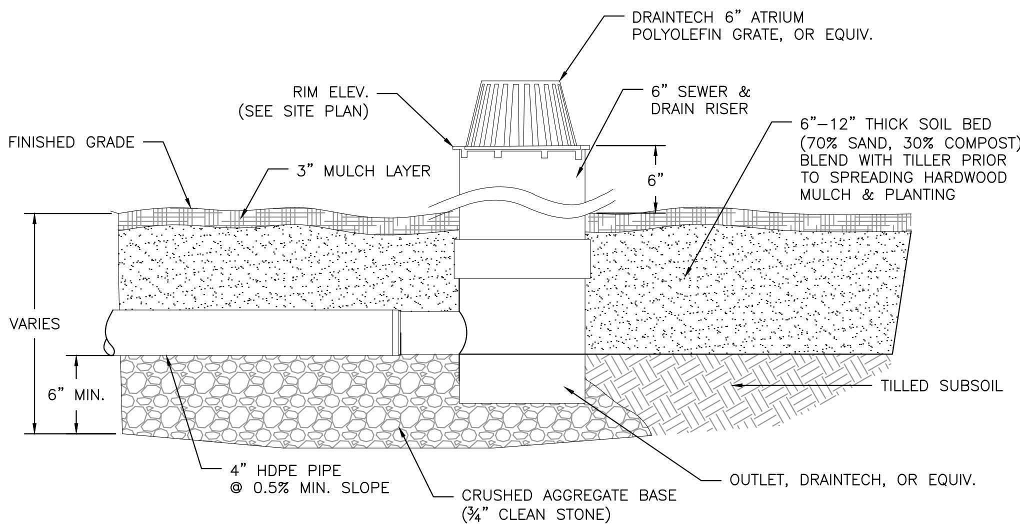


1.9 INLET PROTECTION CROSS SECTION

see detail ***1.3 RAIN GARDEN CROSS SECTION W. UNDERDRAIN PIPE*** for designs in high clay content soils
see detail ***1.7 INLET PROTECT CROSS SECTION*** for water flow entrance
see detail ***1.8 ROCK-LINED OVERFLOW*** for water to overflow from the system

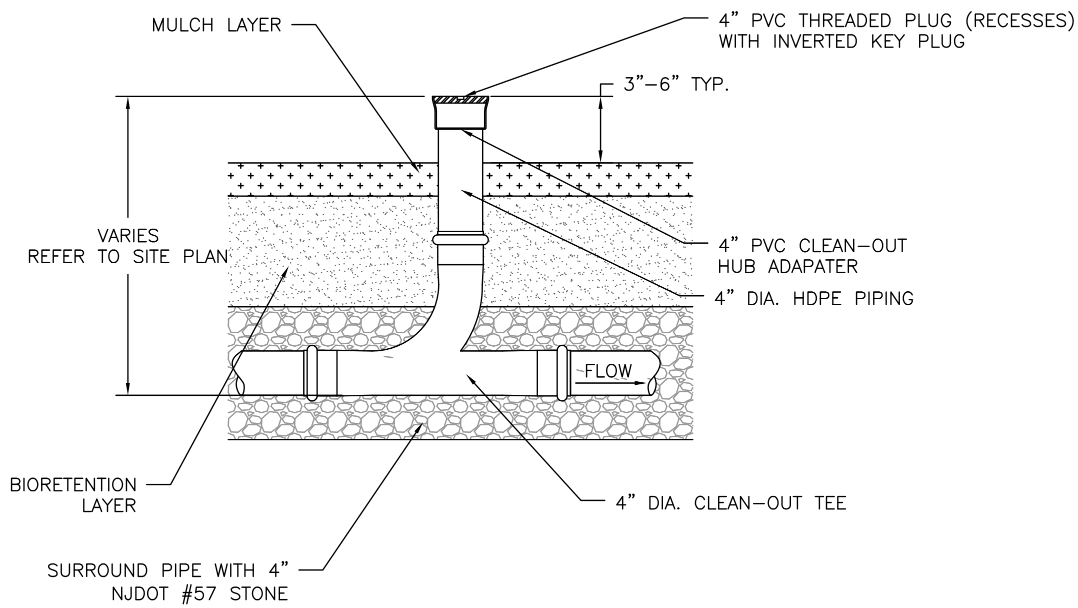


1.10 ROCK-LINED OVERFLOW

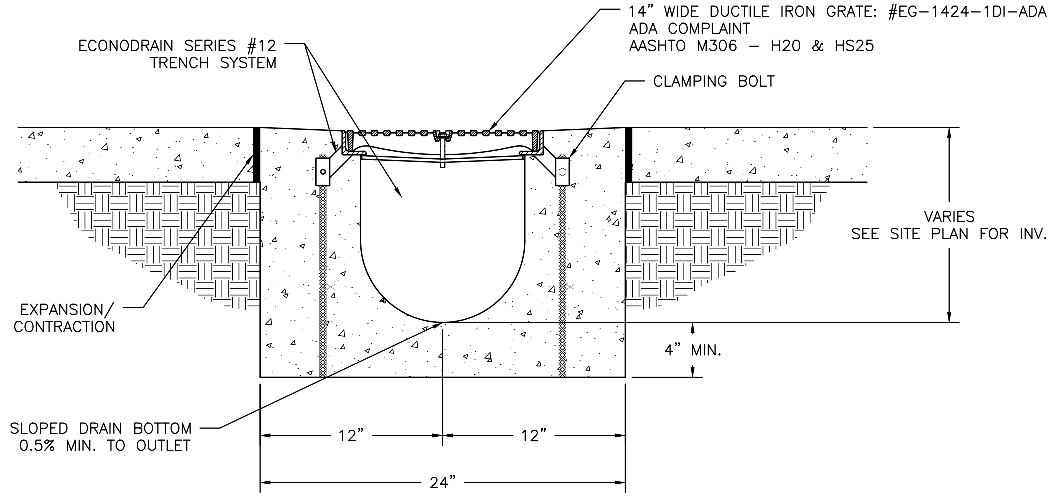


1.11 DRAINTECH OUTLET

see detail ***1.3 RAIN GARDEN CROSS SECTION W. UNDERDRAIN PIPE*** for designs in high clay content soils

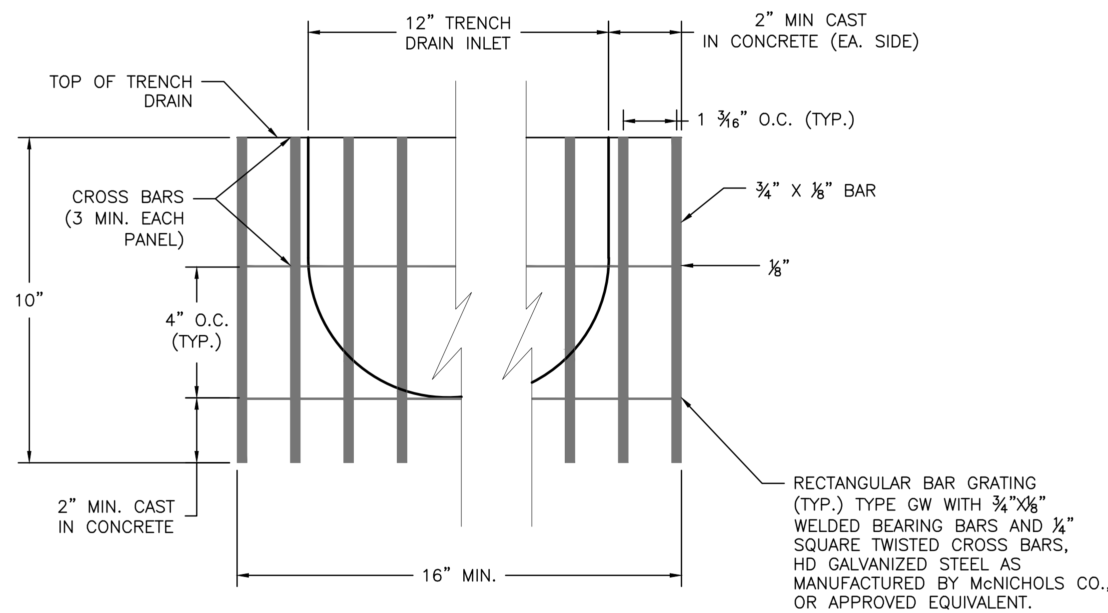


1.12 RAIN GARDEN CLEANOUT

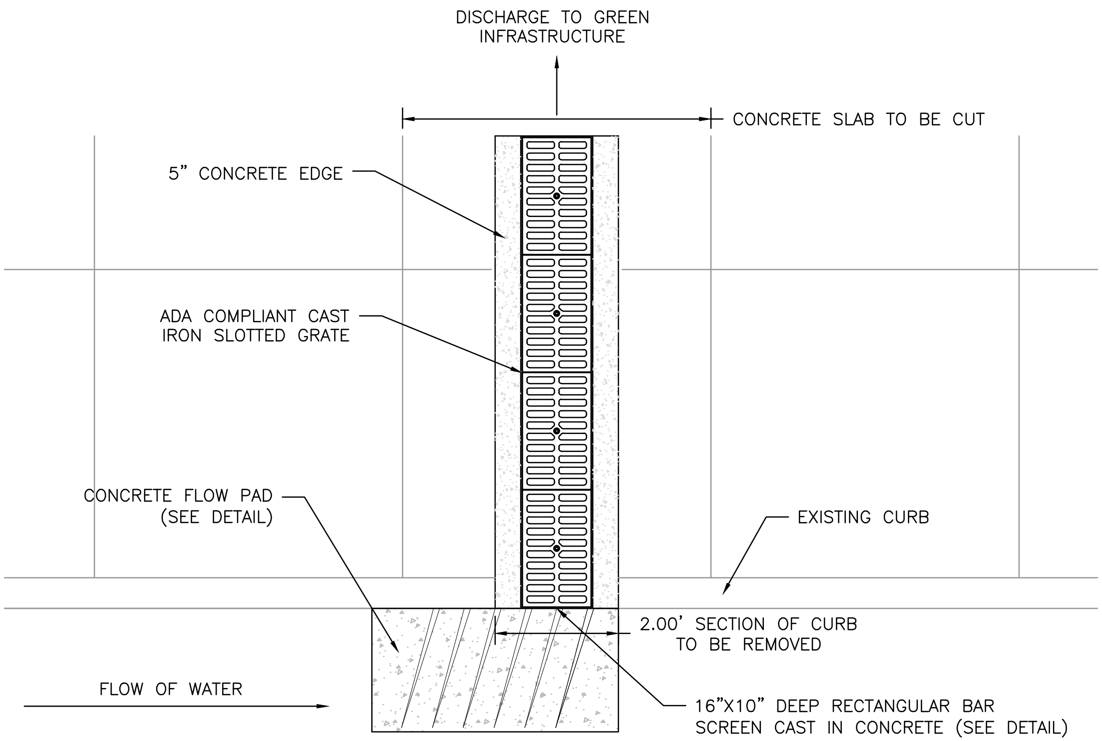


1.13 SAWCUT EXISTING SLAB TRENCH DRAIN INSTALLATION

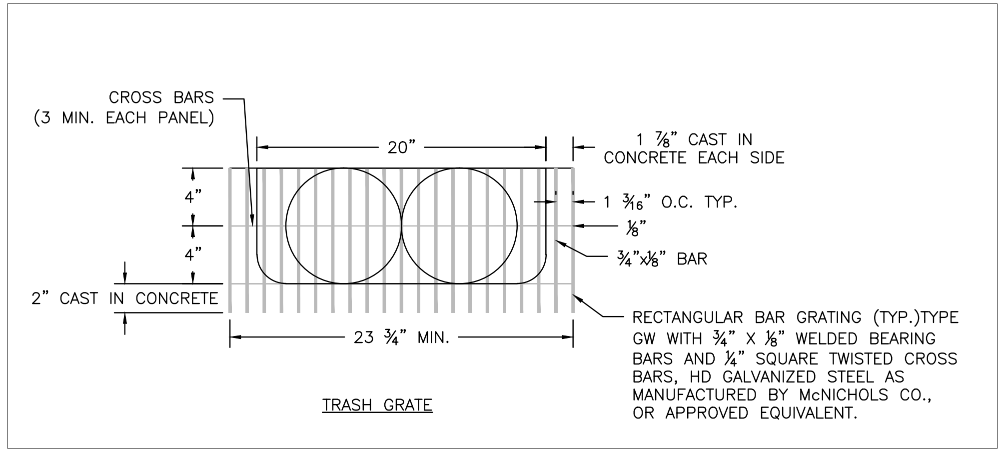
see detail ***1.14 TRENCH DRAIN BAR SCREEN*** for screen installation
see detail ***1.14 TRENCH DRAIN PLAN VIEW*** for proper installation and location

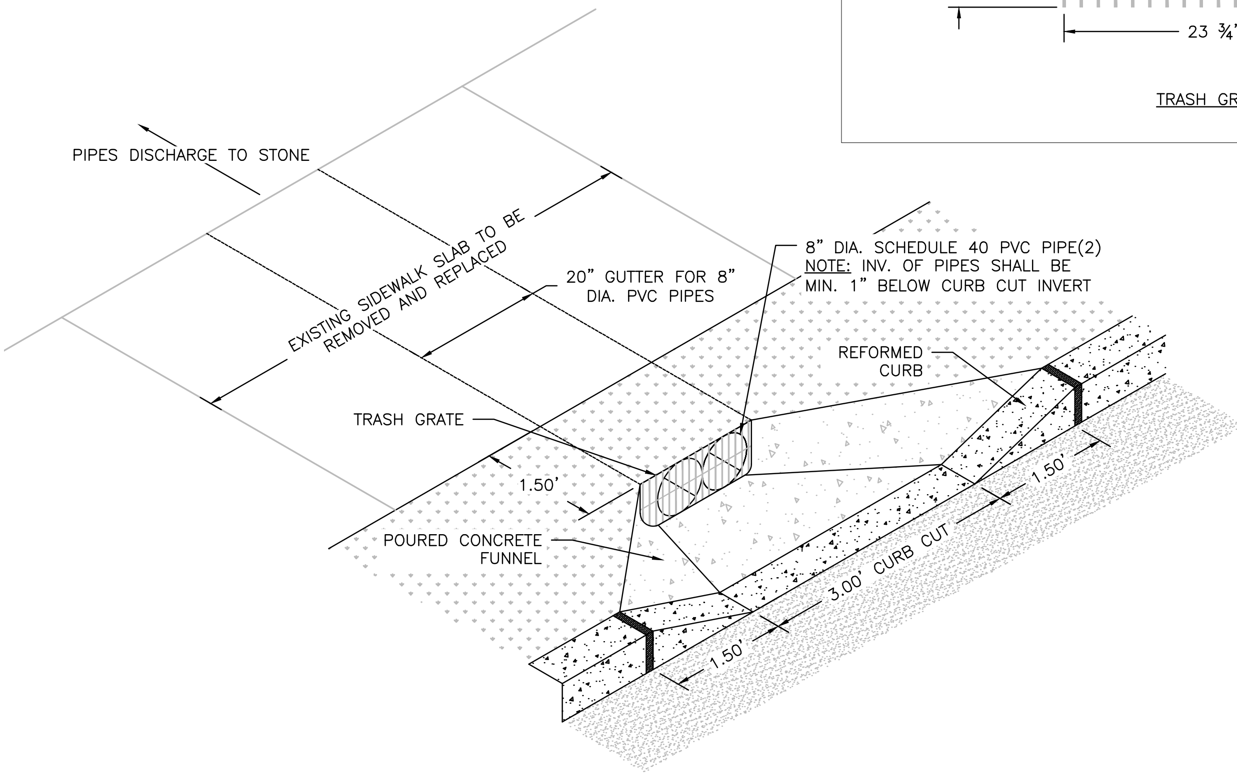


1.14 TRENCH DRAIN BAR SCREEN



1.15 TRENCH DRAIN PLAN VIEW





1.16 CURB CUT AND CONCRETE FUNNEL

1.17 BIORETENTION - GENERAL SPECIFICATIONS

CONSTRUCTION NOTES

1. The contractor shall verify all information prior to excavation including elevations and locations of existing utilities.
2. The contractor shall notify the engineer immediately if any field conditions differ materially from those represented on these drawings and the specifications or if, in the contractor's opinion, said conditions conflict with the designs shown hereon.
3. The engineer shall inspect all planting bed areas before mulching to insure that adequate drainage exists. If any areas to be mulched show evidence of poor drainage, the contractor shall take corrective action.
4. The contractor shall avoid disturbing all existing trees. Any disturbance to trees or tree roots must be coordinated with the property owner.
5. Dimensions and shape will vary, refer to site plan.
6. River stone protection dimensions are typical and may vary per site. Consult the engineer and site plan for dimensions on a per site basis.
7. River stone protection shall slope to rain garden base.
8. Refer to site plan to determine outlet type (rock-lined overflow or draintech riser).
9. Refer to site plan for all elevations and inverts.
10. The contractor shall excavate 12 inches lower than the base elevation shown on the site plans. The slopes of the rain garden shall be at a 2:1 maximum.
11. The subgrade of the rain garden shall be level to ensure proper drainage. The contractor shall obtain engineer approval prior to backfilling with 12 inches of bioretention media.
12. The contractor shall install overflow if specified in site plans prior to backfilling with bioretention media.
13. The bioretention layer shall be level to ensure proper drainage. The contractor shall obtain engineer approval prior to spreading mulch and planting.
14. Inlet and outlet protection shall be underlain with geotextile fabric.
15. Inlets and outlets shall not inhibit the flow of water from the street. The river stone shall be placed below the bottom of the pipe.
16. The contractor shall till the berm section and backfill with topsoil.
17. All disturbed areas exclusive of rain garden and sloped berm shall be restored to original conditions by contractor.
18. The contractor shall have a pre-construction meeting with the project engineer prior to any work on site.

SPECIFICATIONS

1. Max cover over top of pipe is 4 feet. Contact ADS (pipe manufacturer) if otherwise greater.
2. The approval of materials and mixing of sand, compost, and soil shall be done under the supervision of the project engineer/ landscape architect. Bioretention media shall consist of 70% sand and 30% compost mixture.
3. Sand shall at the minimum conform to the sieve analysis for concrete aggregate sand (ASTM c-33). USGA tee/green sieve gradation mix is preferable where available.
4. Underlying soils shall be tilled/scarified prior to spreading/mixing of bioretention media.
5. All bioretention media shall be placed from the sides of the facilities, and in no event shall any tracked or wheeled equipment be permitted to cross the rain garden.
6. Rain garden shall be constructed to dimensions indicated on the site plan.
7. 3-5-inch diameter washed river stone shall be used for stone

channel and inlet/outlet protection.

8. Non-dyed, triple-shredded hardwood mulch shall be used.
9. Planting of rain garden and sloped berm shall be completed as indicated on the site plan.
10. The contractor shall perform all work in conformance with the NJDOT Standard Specifications for Road and Bridge Construction, 2007 or latest version.

1.18 TRENCH DRAIN AND CURB CUT - GENERAL SPECIFICATIONS

CONSTRUCTION NOTES

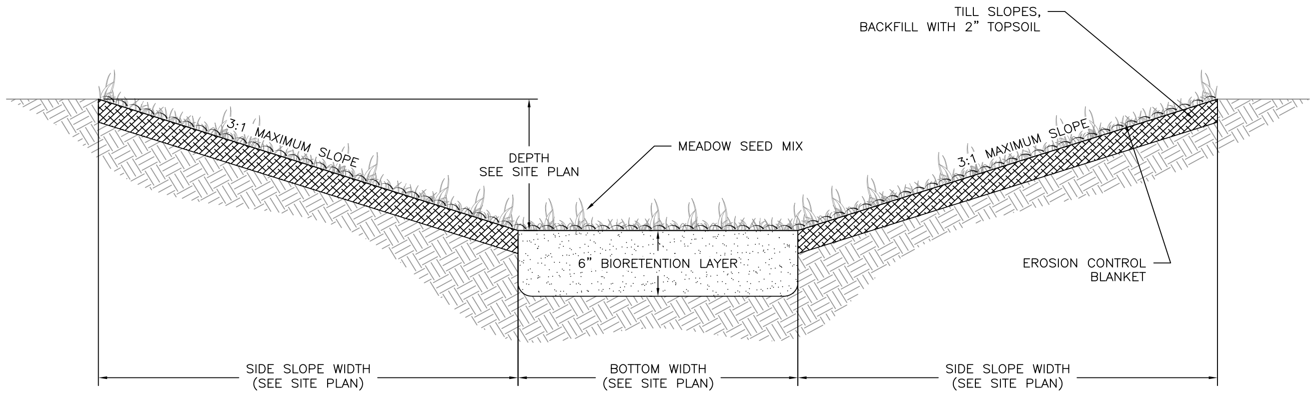
1. The contractor shall verify all information prior to excavation including elevations and locations of existing utilities.
2. The contractor shall notify the engineer immediately if any field conditions differ materially from those represented on these drawings and the specifications or if, in the contractor's opinion, said conditions conflict with the designs shown hereon.
3. The contractor shall avoid disturbing all existing trees. Any disturbance to trees or tree roots must be coordinated with the property owner.
4. Inlet and outlet protection shall be underlain with geotextile fabric.
5. Inlet and outlet curb cuts shall not inhibit the flow of water from the street. The curb cut shall be slightly lower than the road. The concrete slab shall be placed just below the bottom of the curb cut.
6. The contractor shall sawcut, remove, and replace a 6-foot section of curb for the concrete funnel. The entire curb shall be reinstalled with a 3-foot depressed section flush with the pavement and adjoining 18-inch 3:1 sloped sections.
7. The contractor shall pour the concrete flow pad as shown with 60° ridges. The ridges shall be 1 1/4 inches in height.
8. All areas exclusive from the trench drain and/or curb cut shall be restored to original conditions.
9. The contractor shall have a pre-construction meeting with the engineer prior to any work on-site.

SPECIFICATIONS

1. Trench drain shall be Econodrain® Series #12 as manufactured by Econodrain®, or approved equivalent.
2. The grate for the trench drain shall be cast iron ADA grate part number EG-1424-2 CI-ADA with locking fasteners, or equal.
3. End cap cutouts are to be removed upon approval.
4. Stone for protection shall be 3-5-inch diameter washed river stone.
5. The contract shall be performed in conformance with the NJDOT Standard Specifications for Road and Bridge Construction, 2007 or latest version.
6. The contractor shall only use concrete with 4,500 psi strength.

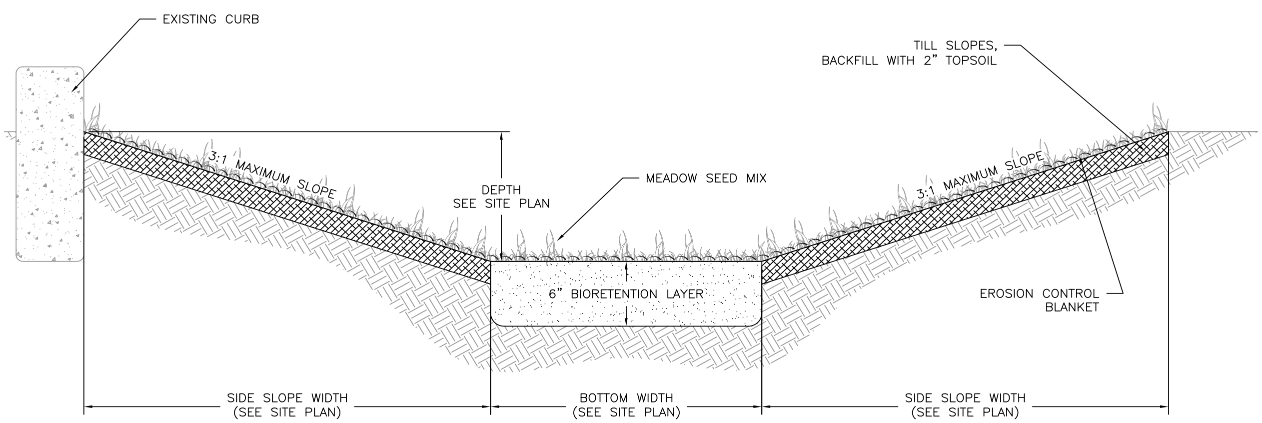
2.0 BIOSWALE

Landscaped features that convey stormwater from one location to another while removing pollutants and providing water an opportunity to infiltrate

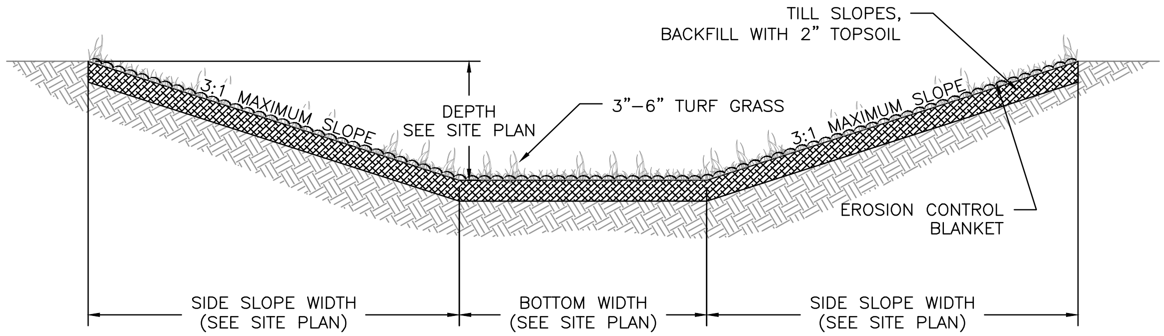


2.1 BIOSWALE CROSS-SECTION

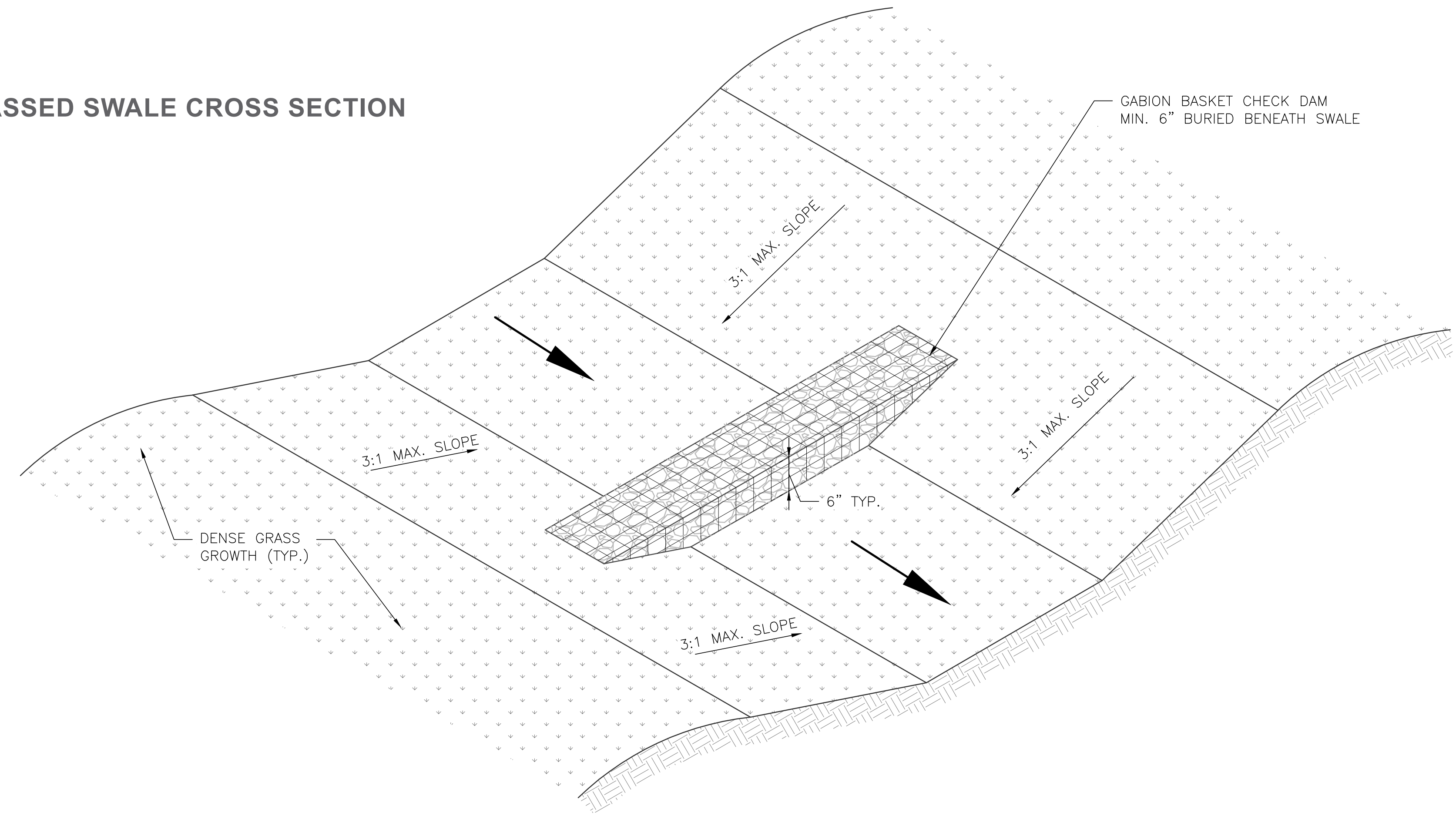
see detail ***2.2 CURB SIDE BIOSWALE CROSS SECTION*** for designs adjacent to curbs
see detail ***2.3 GRASSED SWALE CROSS SECTION*** for designs with only turfgrass



2.2 CURBED BIOSWALE CROSS SECTION



2.3 GRASSED SWALE CROSS SECTION



2.4 CHECK DAM ISOMETRIC

This detail is necessary for all swale designs with a slope greater than 8%.

2.5 BIOSWALE - GENERAL SPECIFICATIONS

CONSTRUCTION NOTES

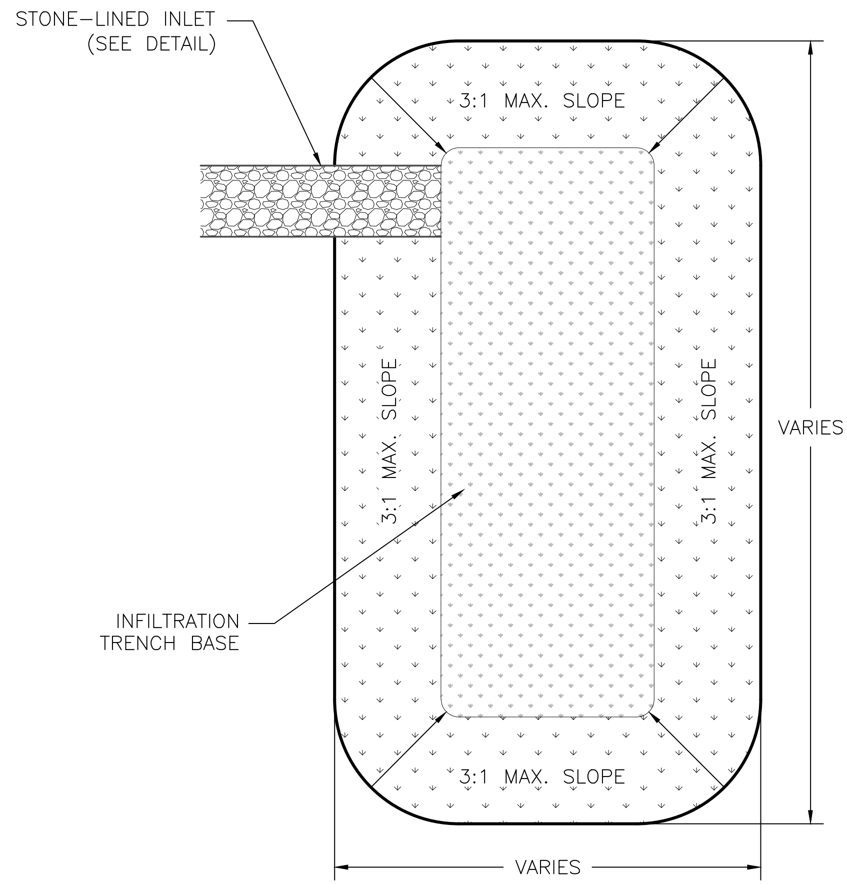
1. The contractor shall verify all information prior to excavation including elevations and locations of existing utilities.
2. The contractor shall notify the engineer immediately if any field conditions differ materially from those represented on these drawings and the specifications or if, in the contractor's opinion, said conditions conflict with the designs shown hereon.
3. The engineer shall inspect all planting bed/seeding areas before planting/seeding to insure that adequate drainage exists for bioswales. If any areas to be planted/seeded show evidence of poor drainage, the contractor shall take corrective action.
4. The contractor shall have all utilities marked before any excavation. If any utilities interfere with the project, the contractor shall notify the engineer.
5. The contractor shall avoid over-compacting the existing materials to avoid poor infiltration.
6. The contractor shall verify that the swale will capture stormwater runoff from the desired drainage area.
7. The contractor shall establish all elevations and lines as shown on the site plan for review by the engineer prior to construction.
8. The contractor shall verify that the subgrade is consistent with line, grade, and elevations as indicated on the site plan. Any areas showing erosion or potential ponding shall be regraded before subbase installation.
9. Immediately after the subgrade is approved by the engineer, the contractor shall begin subbase construction which includes all materials below the swale base and above the native subgrade.
10. Prior to backfilling the bioswale with bioretention media, the contractor shall scarify native soil to promote infiltration into the underlying subgrade.
11. The bioretention media layer shall be installed evenly over the native subgrade.
12. The bioswale shall have an infiltration of at least 5-30 ft/day or 50% of the hydraulic conductivity (D2434).
13. The contractor shall install a gabion basket check dam (if specified) as shown on site plans. A minimum of six inches of the basket shall be buried.
14. The contractor shall install erosion control blanket along the base and side slopes of the newly constructed swale for stabilization.

SPECIFICATIONS

1. The bioretention layer shall be comprised of 70% sand and 30% compost mixture.
2. Inlet protection for the swale shall be comprised of 3-5-inch diameter washed river stone. Stone shall be placed on geotextile fabric.
3. The gabion basket check dam shall be dura-weld galvanized and PVC coated baskets. Baskets are typically 6'x3'x1'; refer to site plan for basket size.
4. Gabion stone shall be 4-10-inch diameter washed.
5. The swale shall be seeded with contractor turf mix unless specified otherwise on plans.

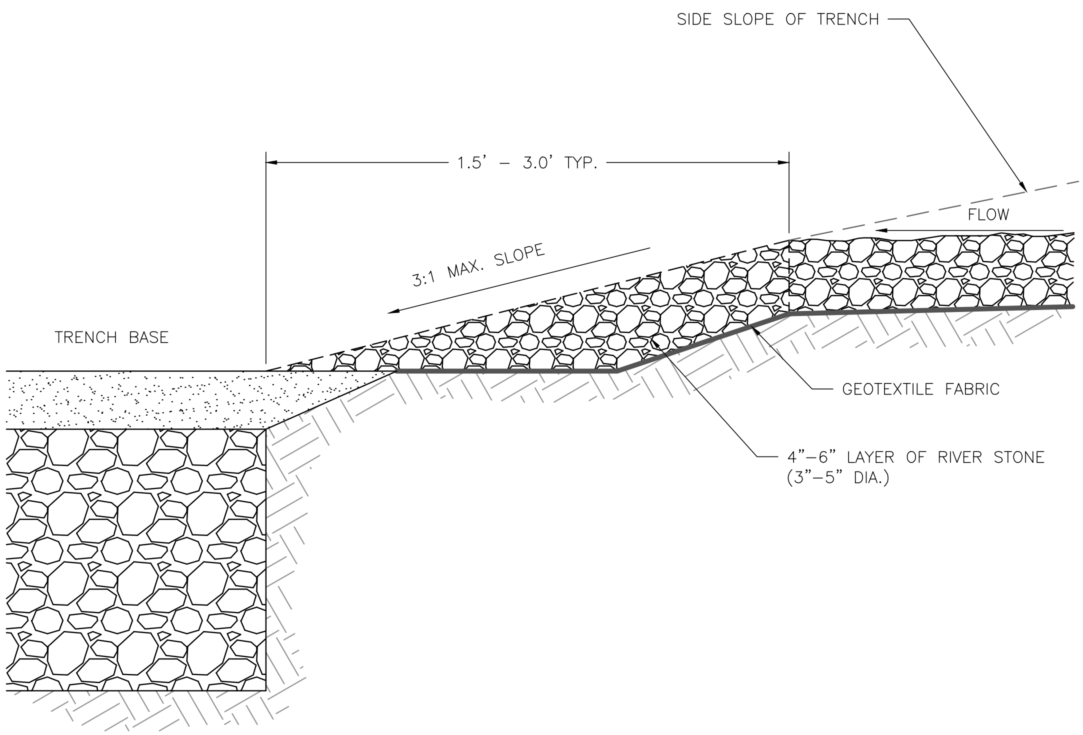
3.0 INFILTRATION TRENCH

Landscaped feature that stores stormwater allowing it to slowly infiltrate into the ground

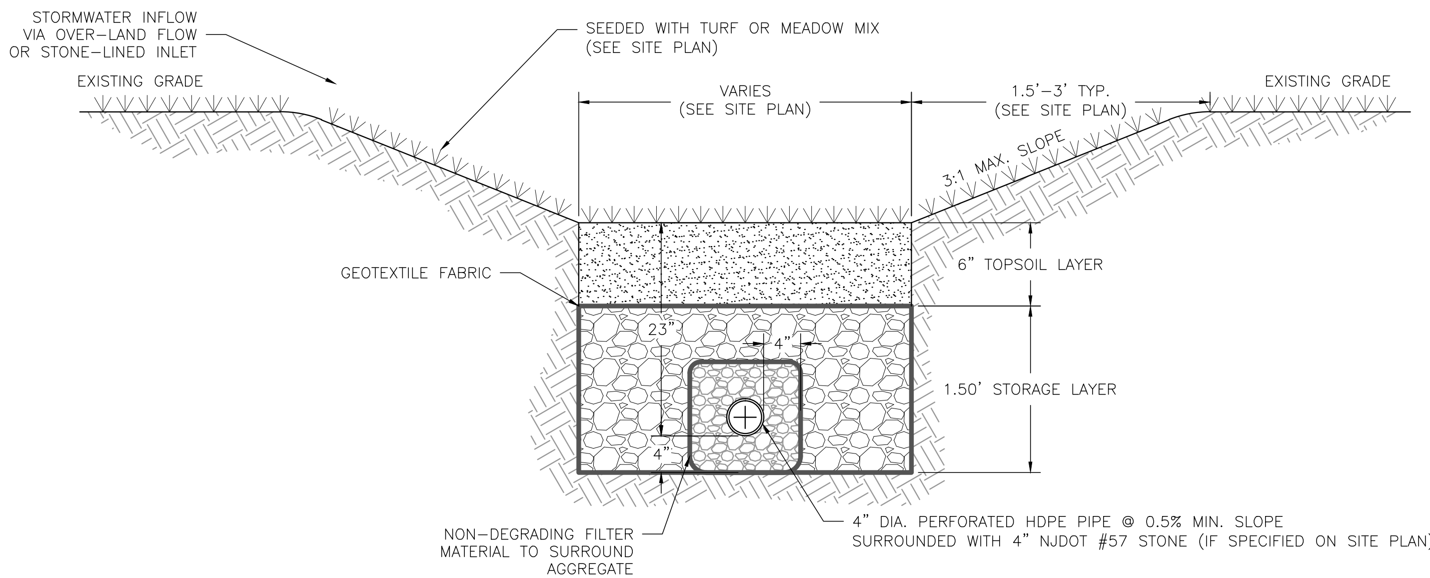


3.1 INFILTRATION TRENCH PLAN VIEW

see detail ***3.2 STONE LINED CHANNEL FOR INFILTRATION TRENCH*** for water flow entry

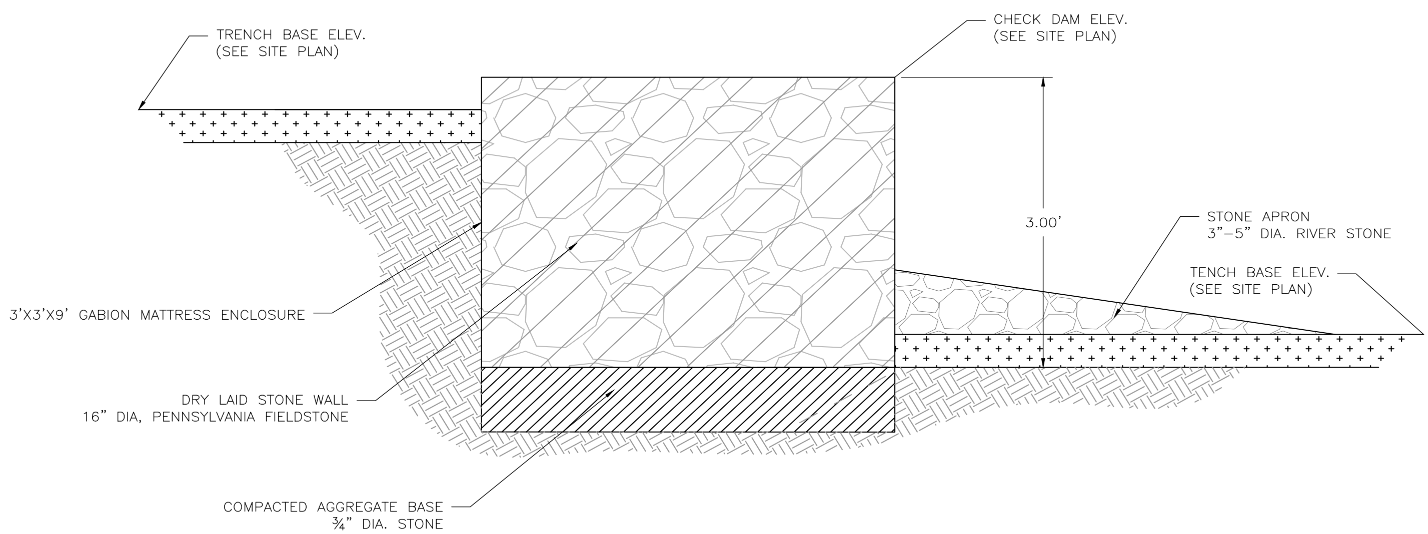


3.2 STONE LINED INLET FOR INFILTRATION TRENCH



3.3 INFILTRATION TRENCH CROSS SECTION

see detail ***1.12 RAIN GARDEN CLEANOUT*** for designs using an underdrain pipe



3.4 GABION STONE CHECK DAM

This detail is necessary for all infiltration trench designs with a slope greater than 10%.

3.5 INFILTRATION TRENCH - GENERAL SPECIFICATIONS

CONSTRUCTION NOTES

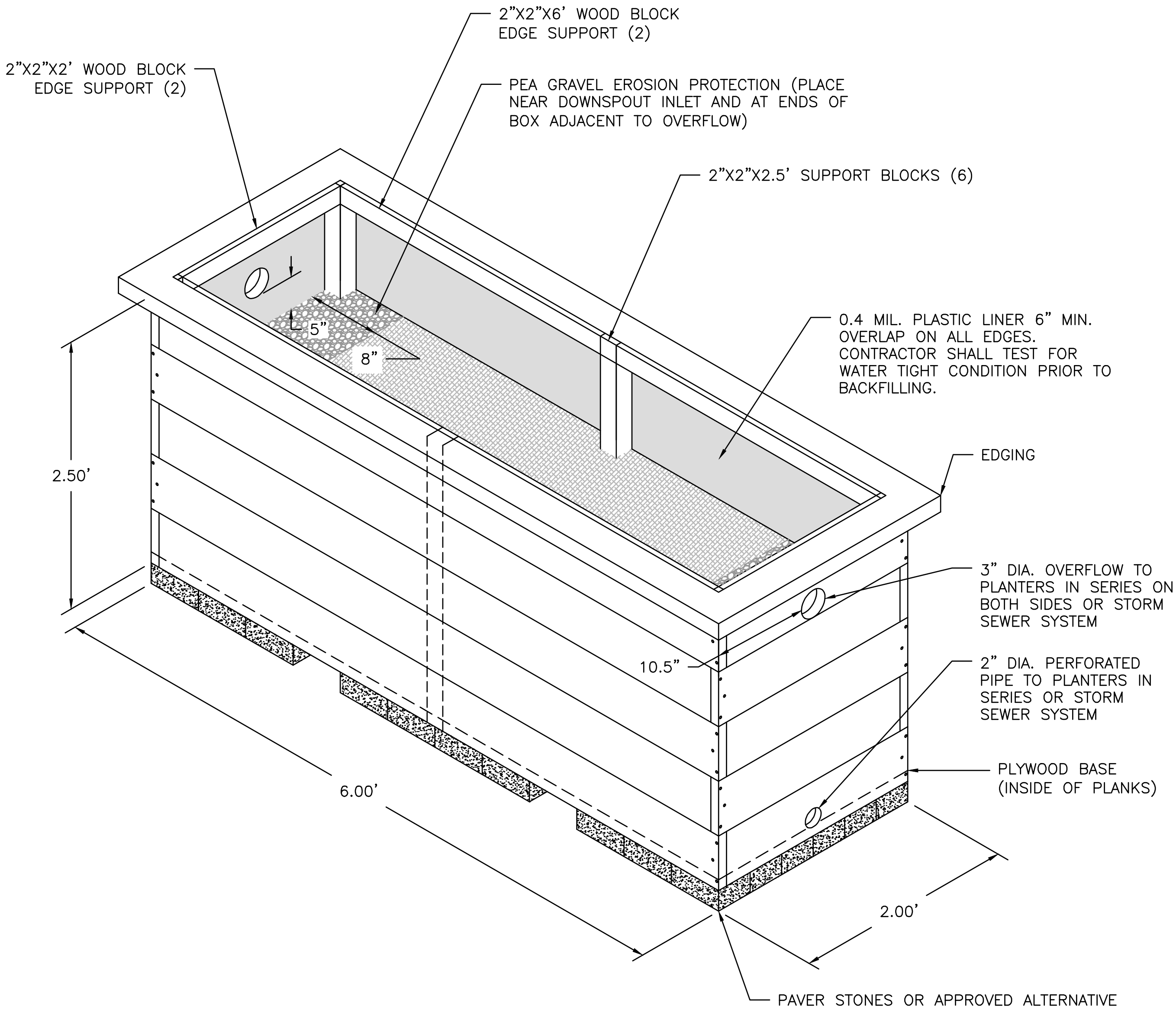
1. The contractor shall verify all information prior to excavation including elevations and locations of existing utilities.
2. The contractor shall notify the engineer immediately if any field conditions differ materially from those represented on these drawings and the specifications or if, in the contractor's opinion, said conditions conflict with the designs shown hereon.
3. The engineer shall inspect all planting bed areas before planting to insure that adequate drainage exists. If any areas to be planted show evidence of poor drainage, the contractor shall take corrective action.
4. The contractor shall have all utilities marked before any excavation. If any utilities interfere with the project, the contractor shall notify the engineer.
5. The contractor shall be responsible for disposal of any excess materials.
6. The contractor shall avoid over compacting existing soils to avoid poor infiltration.
7. The infiltration trench base shall be slightly lower than the roadway to ensure flow into the strip.
8. The contractor shall establish all elevations and lines as shown in the site plan for review by the engineer before any construction begins.
9. The contractor shall verify that the subgrade is consistent with line, grade, and elevations as indicated in the site plan. Any areas showing erosion or potential ponding shall be regraded before subbase installation.
10. Immediately after the subgrade is approved by the engineer, the contractor shall begin subbase construction which includes all materials below the pavement and above the existing subgrade.
11. The contractor shall place geotextile fabric in compliance with manufacturer's specifications. All adjacent fabric shall be overlapped by at least 16 inches. The fabric shall be secured at least four feet outside of the excavated base. The entire pit perimeter shall be lined with geotextile fabric.
12. The stone storage layer (No. 57) shall be installed evenly over the existing subgrade and permeable fabric. Storage layer aggregate shall be installed to a maximum of 95% standard proctor compaction. Permeable soil separation fabric shall be installed on top of the storage layer prior to installing the bioretention media.
13. The bioretention media layer shall be installed evenly over the storage layer and fabric.
14. The infiltration rate shall be at least 5-30 ft/day or 50% of the hydraulic conductivity (D2434).
15. After subbase aggregate installation, the geotextile fabric shall be folded back along all bed edges. The fabric shall remain secure until adjacent soils establish vegetation. Any necessary measures shall be taken to prevent sediment from washing into beds.

SPECIFICATIONS

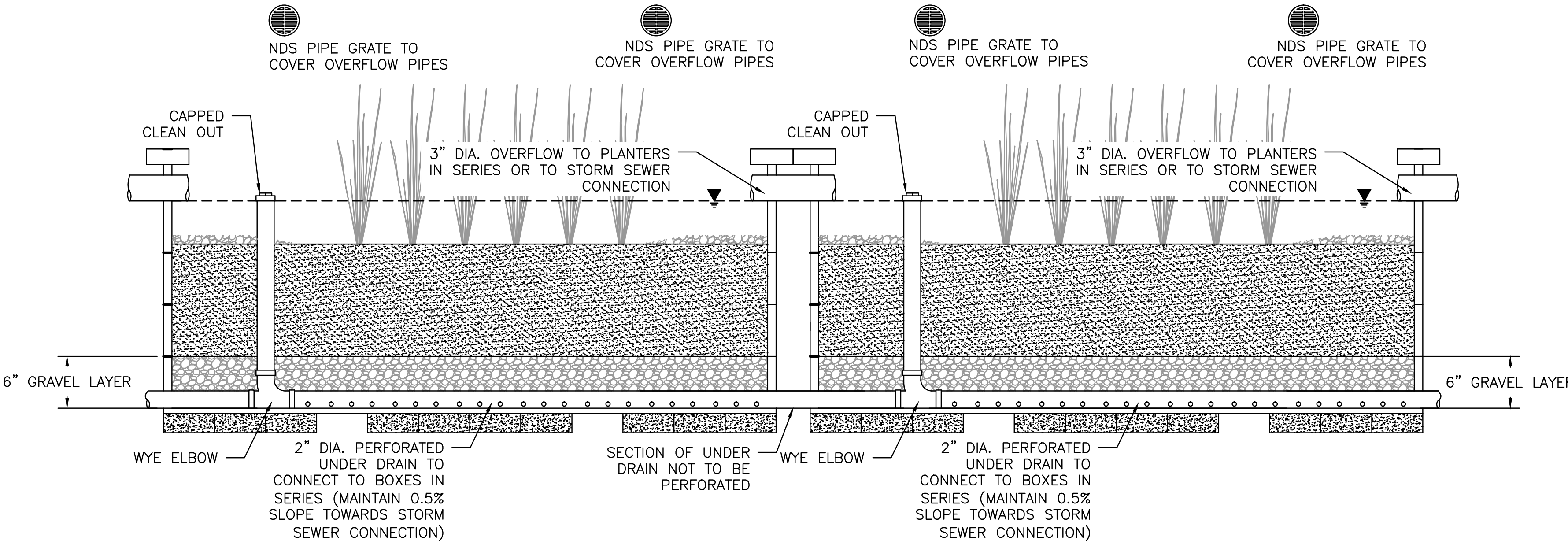
1. The bioretention layer shall be comprised of 70% sand and 30% compost mixture.
2. Inlet protection for the swale shall be comprised of 3-5-inch diameter river stone. Stone shall be underlain with geotextile fabric.
3. The gabion basket check dam shall be dura-weld galvanized and PVC coated baskets. Baskets are typically 6'x3'x1'; refer to the site plan for basket size.
4. Gabion stone shall be 4-10-inch diameter washed.
5. The swale shall be seeded with contractor turf mix unless specified otherwise on plans.

4.0 DOWNSPOUT PLANTER

Wooden boxes with plants installed at the base of the downspout that provide an opportunity to beneficially reuse rooftop runoff

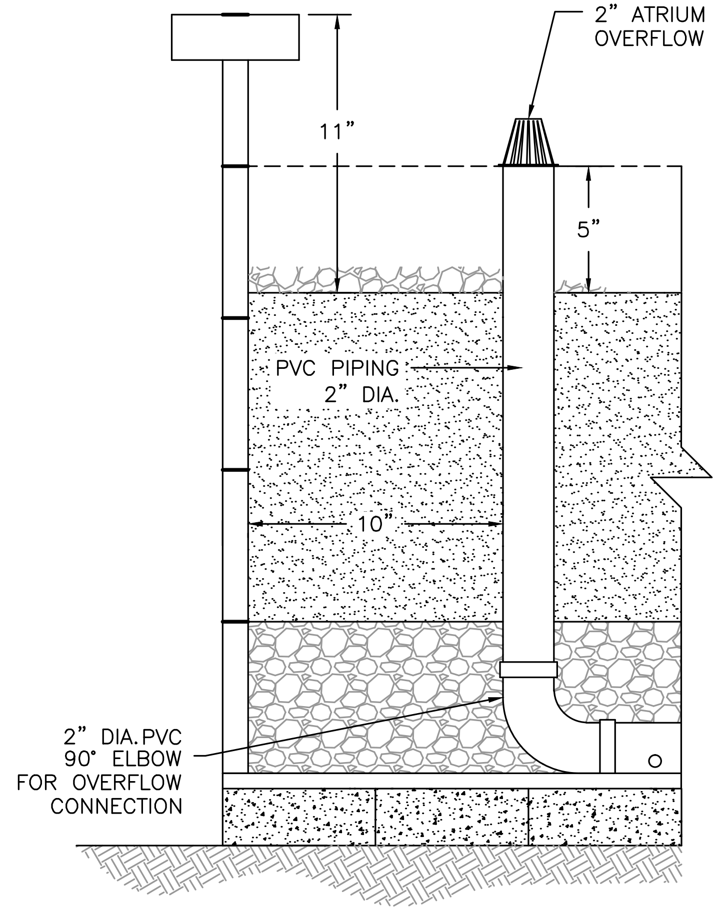


4.1 DOWNSPOUT PLANTER ISOMETRIC

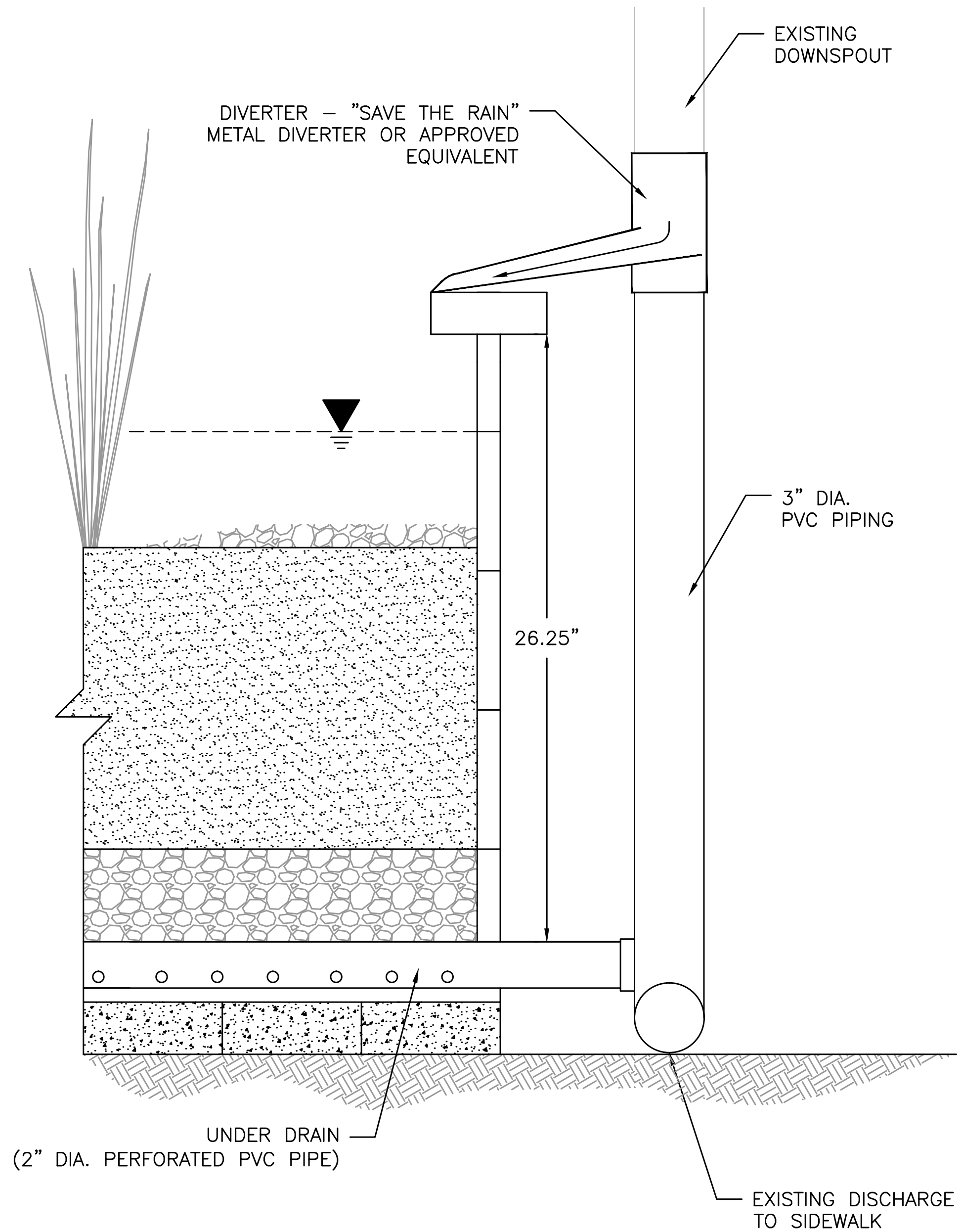


4.2 DOWNSPOUT PLANTER CROSS SECTION

see detail ***4.3 OVERFLOW CONNECTION CROSS SECTION & 4.4 UNDERDRAIN CONNECTION CROSS SECTION*** for detailed view of overflow and underdrain mechanisms



4.3 OVERFLOW CONNECTION CROSS SECTION



4.4 UNDERDRAIN CONNECTION CROSS SECTION

4.5 DOWNSPOUT PLANTER BOX - GENERAL SPECIFICATIONS

CONSTRUCTION NOTES

1. The planter box shall be built according to the dimensions in detail 4.1 and as indicated on the plans.
2. An existing downspout shall be modified to enter the 1st planter box in series. The downspout shall be fitted with a diverter allowing flow to be directed to the box or existing storm sewer connection.
3. Planter boxes in series shall be placed flush against each other as shown in the site plan.
4. The contractor shall discuss any modifications with the engineer and property owner before action is taken.
5. The paver stone base or approved alternative shall be positioned prior to any other construction.
6. The planter box shall be built as shown in detail 4.1. Supports shall be used on the inside of the box as shown.
7. The contractor shall position and level the planter box and then install waterproof liner prior to backfilling with materials.
8. All overflow piping shall be comprised of 3-inch diameter PVC piping. Overflow pipes shall be placed as shown and connected to planter boxes in series. Ends that are positioned inside the planter shall be capped with a PVC pipe grate. See specification items #12 and #13.
9. The underdrain pipe shall be a 2-inch perforated PVC pipe.
10. All pipes shall be fitted and secured with adhesive that is in conformance with local plumbing codes.
11. The existing downspout shall be directed into the first planter box in series.
12. The last box in series (farthest from downspout) shall have a 2-inch atrium grate for overflow. The overflow shall discharge to the existing storm sewer connection.
13. The contractor shall place and compact each aggregate and soil layer once the planter box is constructed.
14. Planter boxes connected in series shall have the overflow and underdrain connect throughout the entire system.

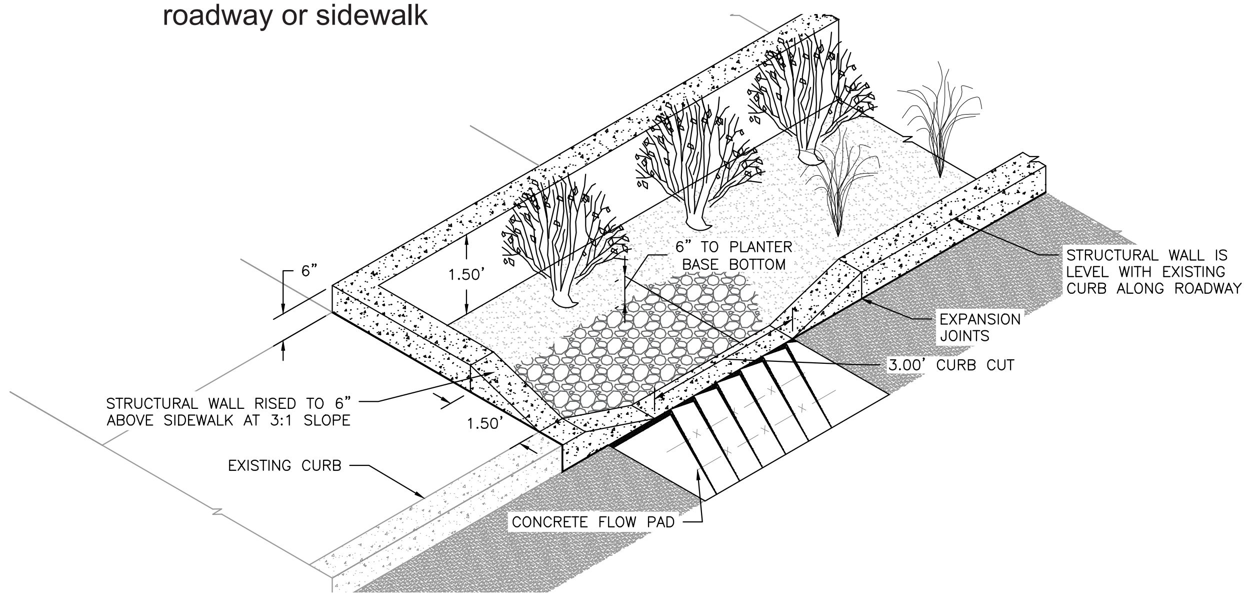
SPECIFICATIONS

1. The planter boxes shall be level when installed.
2. Prior to installation, the contractor shall provide engineer shop drawings of downspout connections and piping.
3. The gravel layer shall be comprised of No. 57 washed stone.
4. The sandy compost mix shall be comprised of 85% washed sand and 15% compost.
5. The diverter shall be ‘Save the Rain’ metal diverter or approved equivalent.
6. All PVC piping shall be schedule 40.
7. The erosion protection shall be comprised of 3-5-inch diameter washed river stone.
8. The plants shall be specified by the planting schedule.
9. All wood material is to be 2-inch dimensional lumber (2”x4”, 2”x6”, and/or 2”x8”) and pressure treated for use in exterior applications.
10. The planter base shall be pressure treated or marine grade plywood suitable for use in exterior applications.
11. All connecting screws and hardware are to be galvanized or coated and approved for exterior use with treated lumber.
12. The overflow pipe grates shall be NDS 3-inch structural-foam polyolefin grate model #16 or equivalent.
13. The overflow atrium shall be NDS 2-inch atrium grate, part #270 or approved equivalent.
14. Upon engineers request, the paver stone base may be replaced with 4’x4’ pressure treated wood blocking or concrete formed pad.

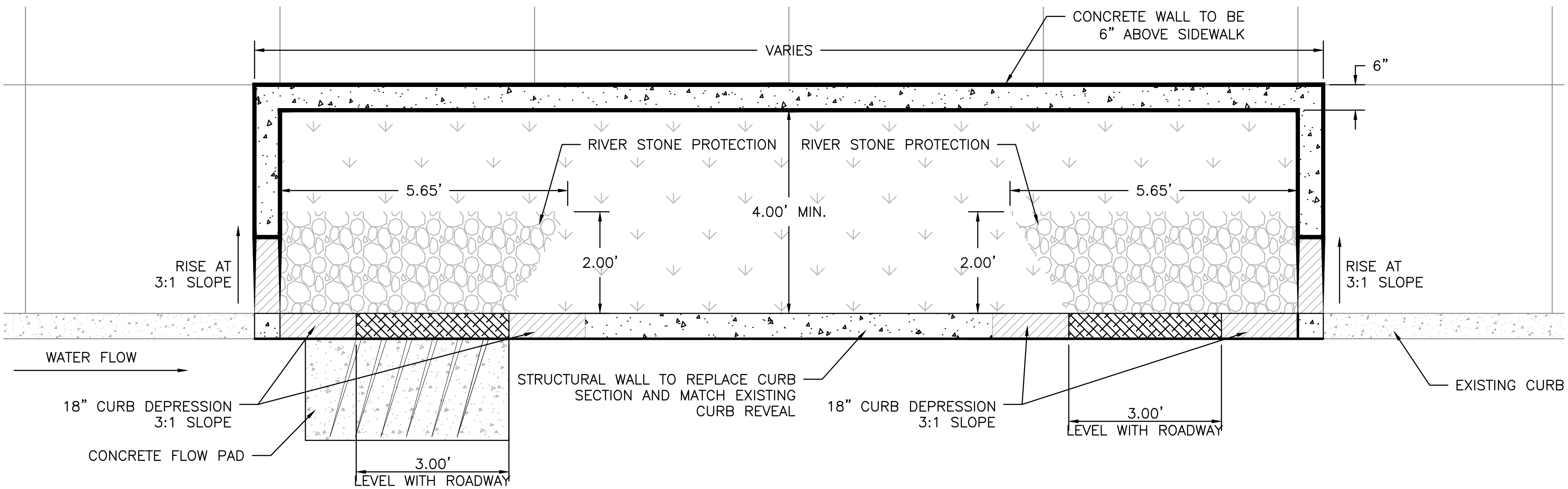
15. The underdrain pipe (2-inch diameter) shall have holes drilled manually by the contractor. The perforations shall not by made in the sections of the underdrain that are exposed between planter boxes as shown in detail. Perforation hole size shall be 3/8”; hole spacing shall be 5”(±1/8”); number of rows shall be 2 @ 120° (±5°).

5.0 STORMWATER PLANTER

Structures that are built into the sidewalk used to intercept stormwater runoff from the roadway or sidewalk

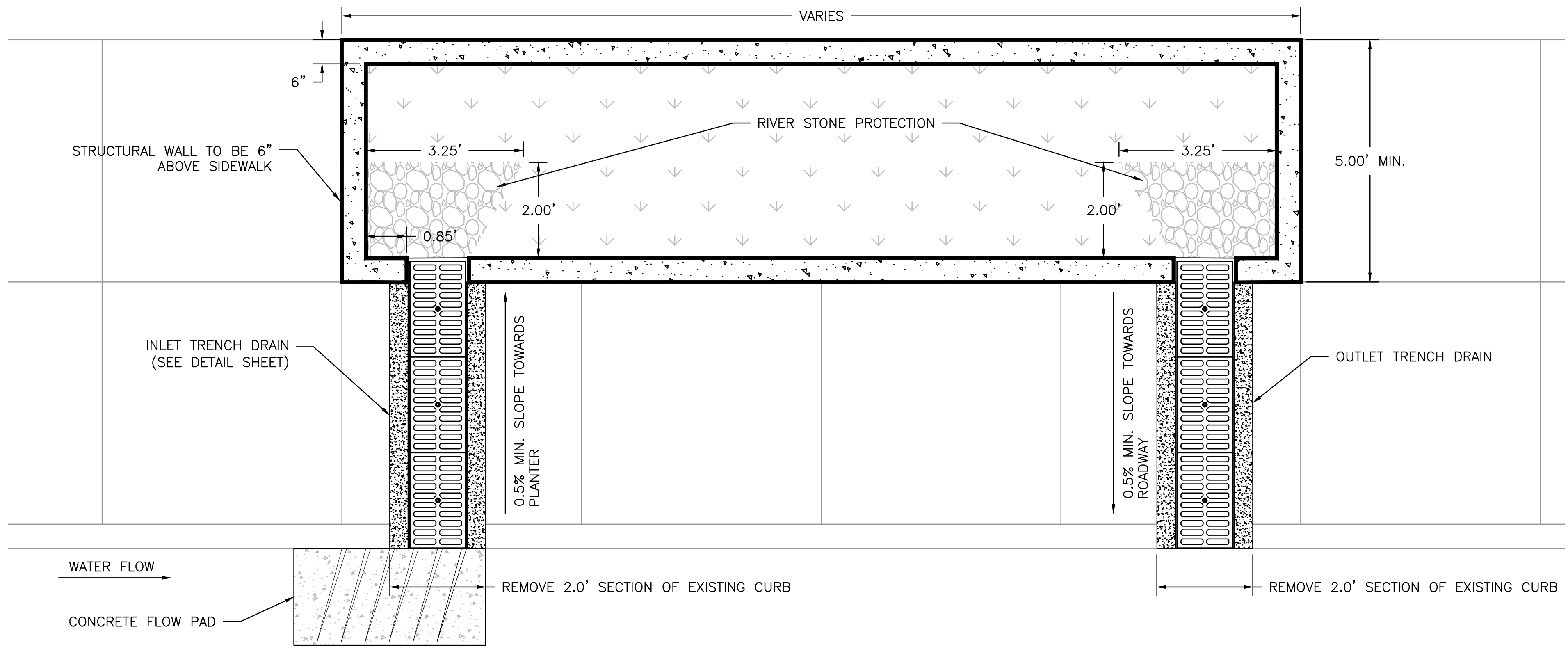


5.1 STORMWATER PLANTER ISOMETRIC



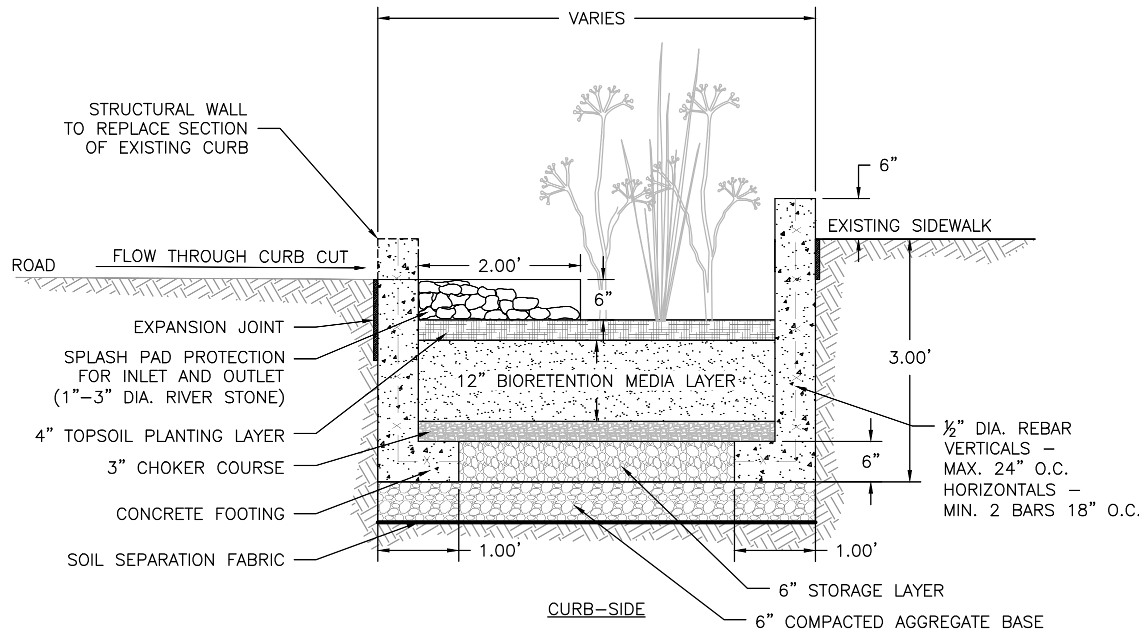
5.2 CURB SIDE STORMWATER PLANTER

see detail ***5.3 STORMWATER PLANTER*** for designs that are not adjacent to the curb



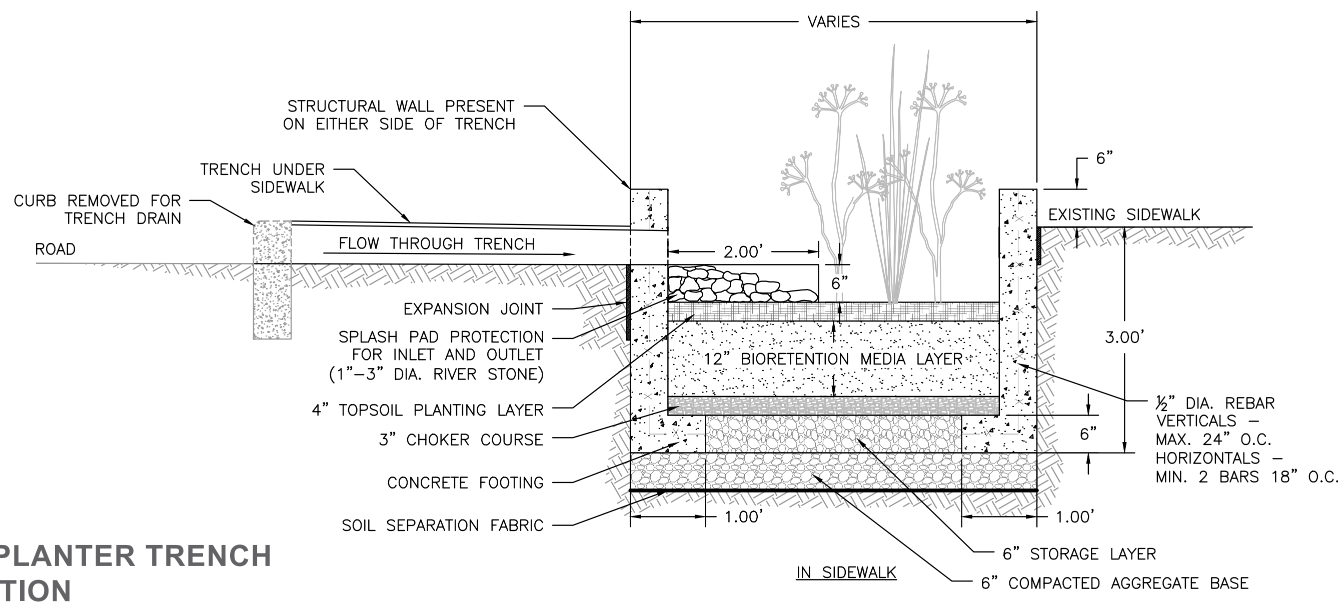
5.3 STORMWATER PLANTER

see detail ***5.2 CURBSIDE STORMWATER PLANTER*** for designs that are adjacent to the curb
see detail ***1.13 SAWCUT EXISTING SLAB TRENCH DRAIN INSTALLATION,1.14 TRENCH DRAIN BAR SCREEN,*** and ***1.15 TRENCH DRAIN PLAN VIEW*** for additional views of trench drain installation



5.4 STORMWATER PLANTER CROSS SECTION

see detail ***5.2 CURBSIDE STORMWATER PLANTER*** for additional views of installation



5.5 STORMWATER PLANTER TRENCH DRAIN CROSS SECTION

5.6 STORMWATER PLANTER - GENERAL SPECIFICATIONS

CONSTRUCTION NOTES

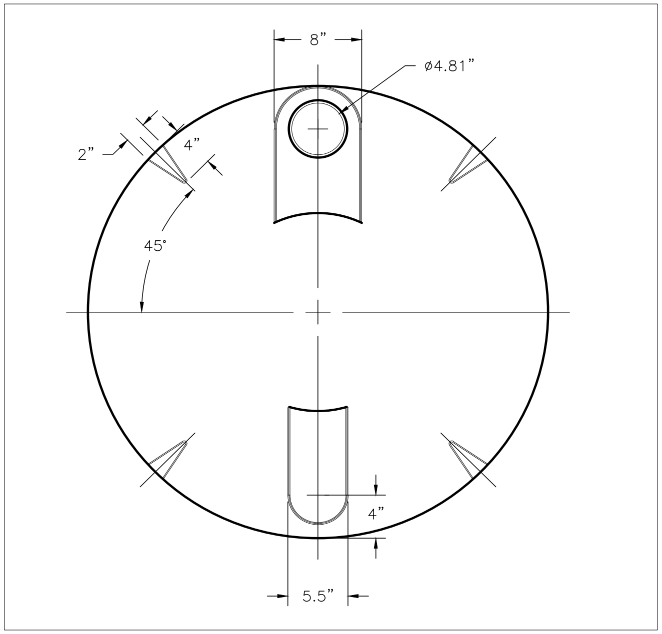
1. The contractor shall verify all information prior to excavation including elevations and locations of existing utilities.
2. The contractor shall notify the engineer immediately if any field conditions differ materially from those represented on these drawings and the specifications or if, in the contractor's opinion, said conditions conflict with the designs shown hereon.
3. The structural wall shall be 6 inches above sidewalk as a safety precaution. For a curb-side planter, the structural wall adjacent to the roadway shall be level with the existing curb. The rise of the structural wall shall have a 3:1 slope as shown in detail 5.4.
4. The grate or lid must be installed prior to backfilling.
5. Sand shall at the minimum conform to the sieve analysis for concrete aggregate sand (ASTM c-33). USGA tee/green sieve gradation mix is preferable where available.
6. The approval of materials and mixing of sand, compost, and soil shall be done under the supervision of the project engineer/ landscape architect.
7. Underlying soils shall be tilled/scarified prior to spreading/mixing of bioretention media.
8. The stormwater planter shall be staked out and approved by the engineer prior to installation.
9. The separation fabric shall be installed prior to backfilling the stormwater planter.
10. All bioretention media shall be placed from the sides of the facilities, and in no event shall any tracked or wheeled equipment be permitted to cross the planter base.
11. All areas exclusive from the stormwater planter and trench drain shall be restored to original conditions.

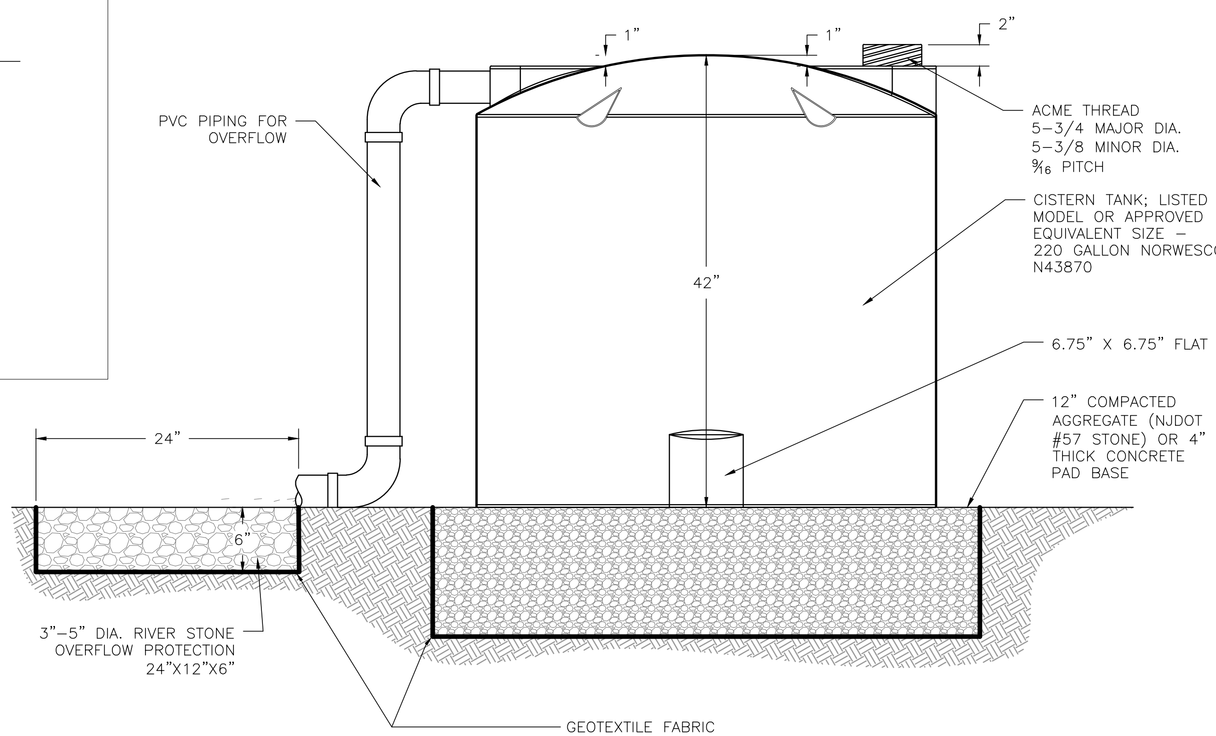
SPECIFICATIONS

1. Bioretention media shall be comprised of 70% sand and 30% compost mixture.
2. The choker course shall be comprised of 3/8" pea gravel.
3. The storage layer and compacted aggregate layer shall be comprised of DOT No. 57 washed stone.
4. Refer to the site plan for dimensions and the planting plan.
5. The structural wall shall be a deep concrete curb in conformance with the NJDOT Standard Specifications for Road and Bridge Construction, 2007 or latest version.
6. The contractor shall only use concrete with 4,500 psi strength.

6.0 CISTERN

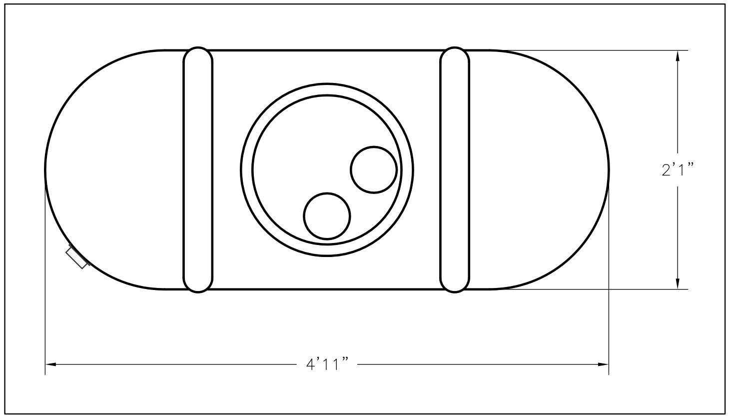
Systems designed to capture rainwater, mainly from rooftops, in cisterns or rain barrels

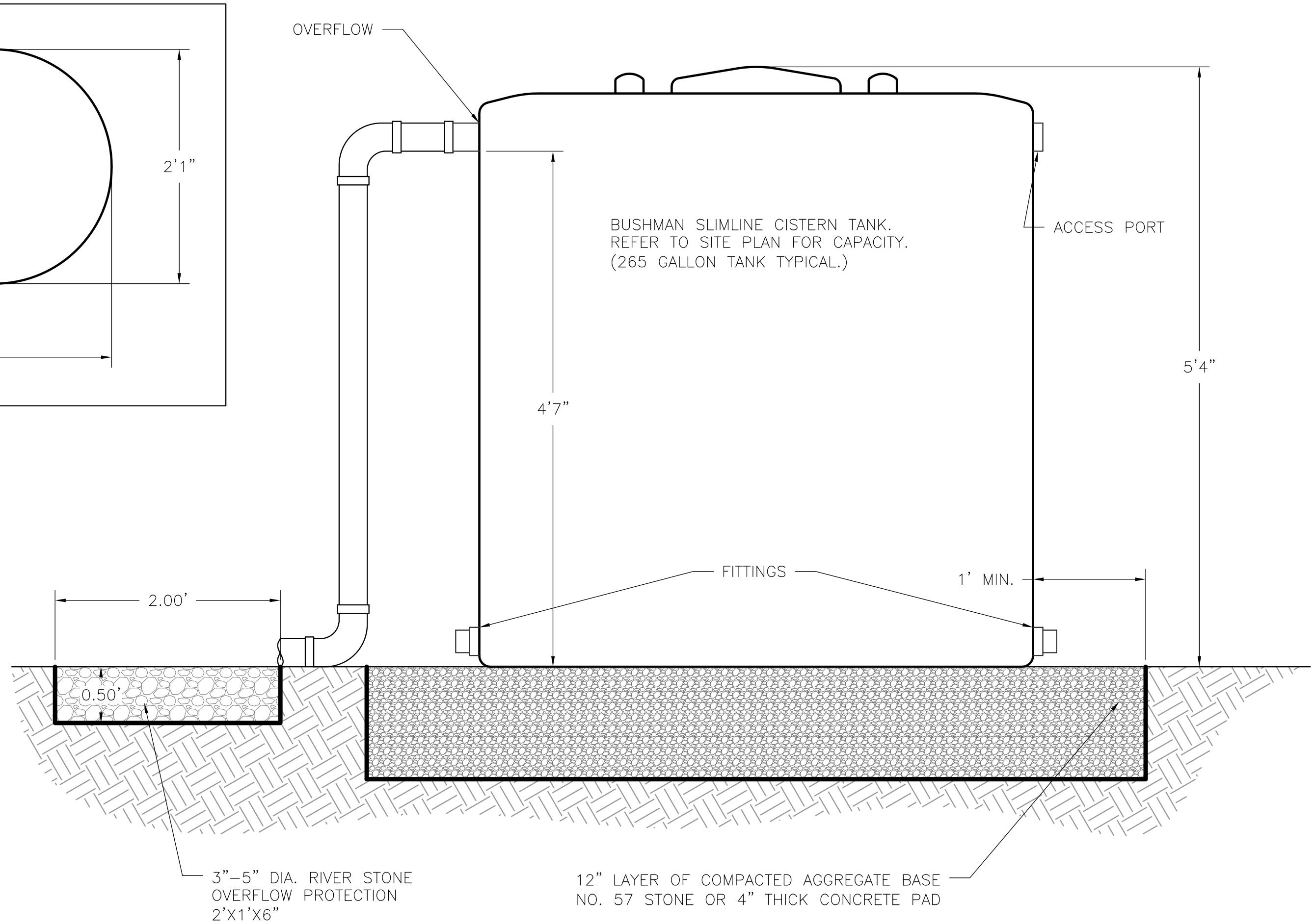




6.1 CISTERN TANK (gal. sizes vary)

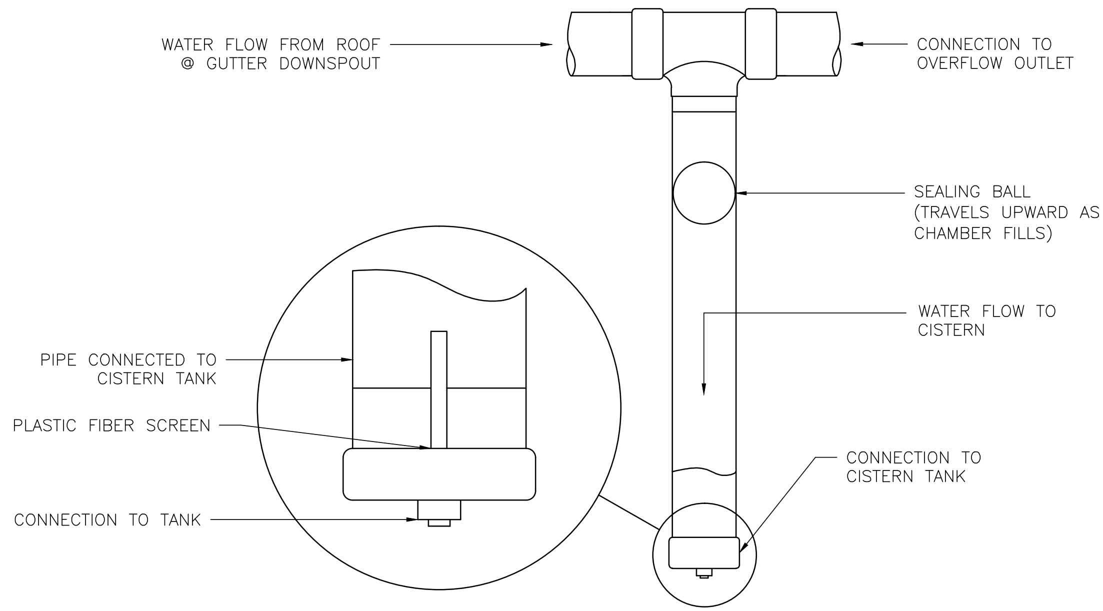
see detail ***6.3 FIRST FLUSH DIVERTER*** for designs that will be used in community gardens
see detail ***6.4 CISTERN DIVERTER*** for designs that will be winterized



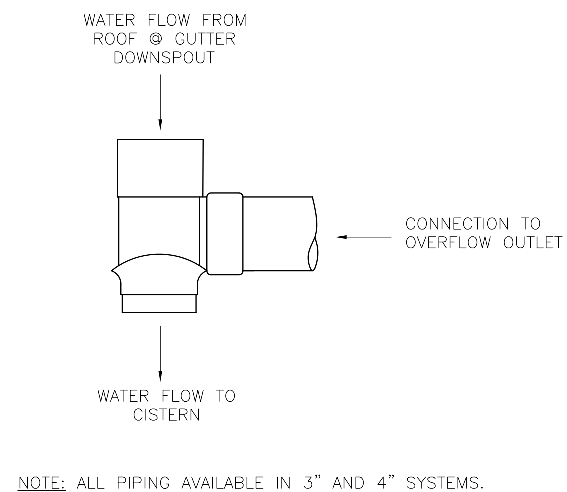


6.2 BUSHMAN SLIMLINE CISTERN (gal. sizes vary)

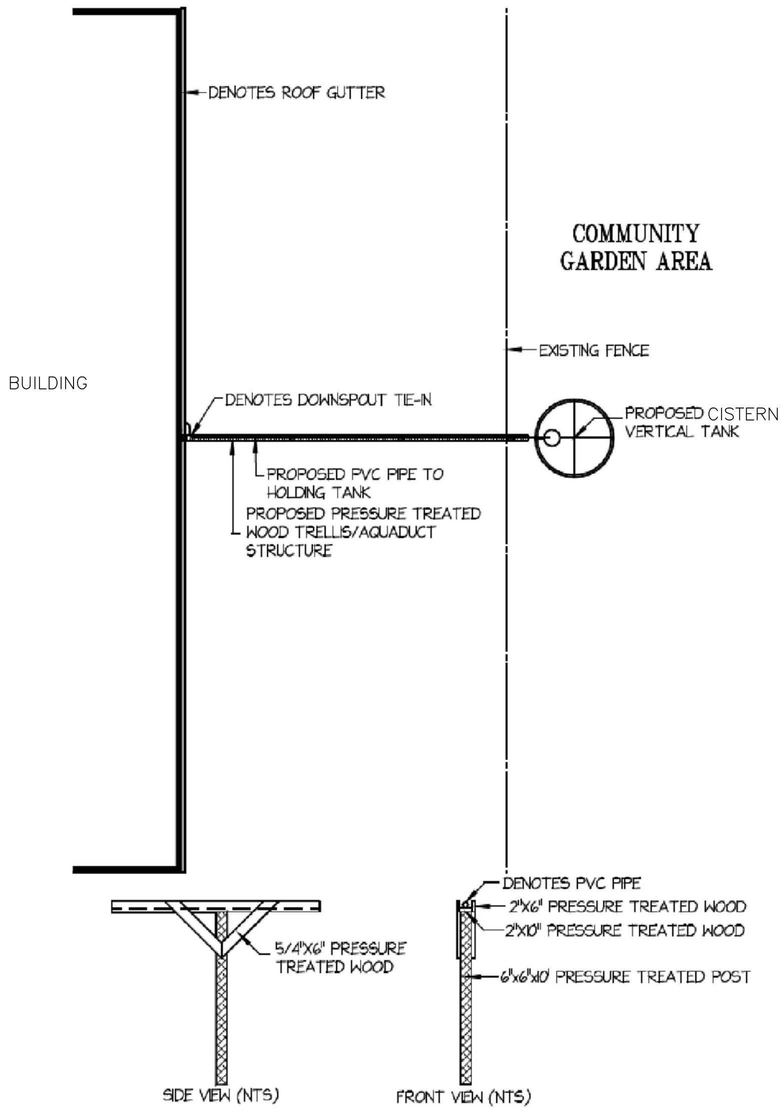
see detail ***6.3 FIRST FLUSH DIVERTER*** for designs that will be used in community gardens
see detail ***6.4 CISTERN DIVERTER*** for designs that will be winterized



6.3 FIRST FLUSH DIVERTER



6.4 Y-SHAPED CISTERN DIVERTER



6.5 TRELLIS

This detail is used for designs that collect rooftop runoff but are not adjacent to the roof.

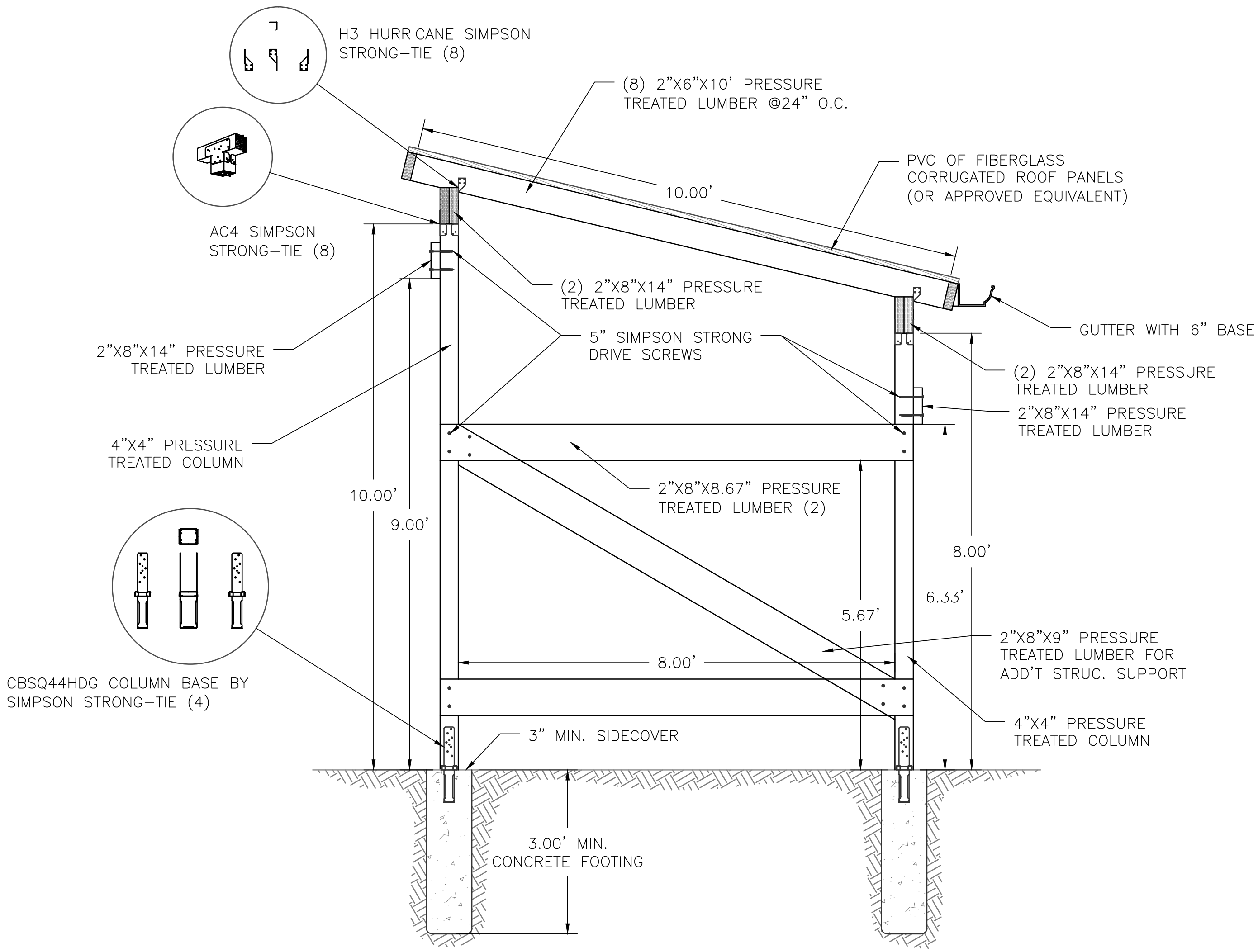
6.6 CISTERN - GENERAL SPECIFICATIONS

CONSTRUCTION NOTES

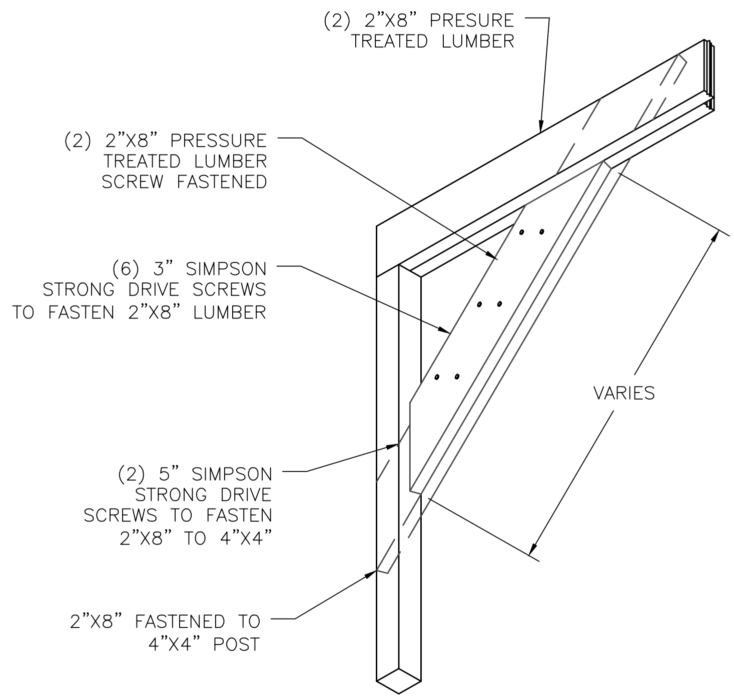
1. The contractor shall verify all information prior to installation including elevations and locations of existing utilities.
2. The contractor shall notify the engineer immediately if any field conditions differ materially from those represented on these drawings and the specifications or if, in the contractor's opinion, said conditions conflict with the designs shown hereon.
3. The contractor shall have a pre-construction meeting with the engineer prior to any work on site.
4. The contractor shall avoid disturbing the existing area. Any disturbance to sidewalks or landscaped vegetation and trees must be coordinated with the property owner.
5. The contractor shall use PVC piping for connection from roof to cistern.
6. All pipes used for connection from rooftop to cistern shall be clear of any clogs or obstructions. All pipes shall be fitted and secured with adhesive in conformance with local plumbing codes.
7. The contractor shall provide a crushed aggregate base or concrete slab with 4,500 psi strength to support the cistern as indicated on the plan.
8. The overflow from the cistern shall connect to the nearest storm sewer catch basin inlet.
9. The contractor shall not make any modifications at the site until consulting with the engineer.
10. The contractor is required to submit shop drawings of all materials and construction methods to the engineer for review and approval prior to purchase and installation.
11. All systems shall be tested by the engineer for leaks and water tight fittings prior to acceptance and payment.
12. The contractor shall use Simpson Strong Ties in connectors for the shade structure.
13. The contractor shall use pressure treated lumber.
14. The contractor shall install concrete footings with a minimum 3-foot depth.
15. The contractor shall not make any modifications at the site until consulting with the engineer.
16. The contractor is required to submit shop drawings of all materials and construction methods to the engineer for review and approval prior to purchase and installation of the gutter.

SPECIFICATION

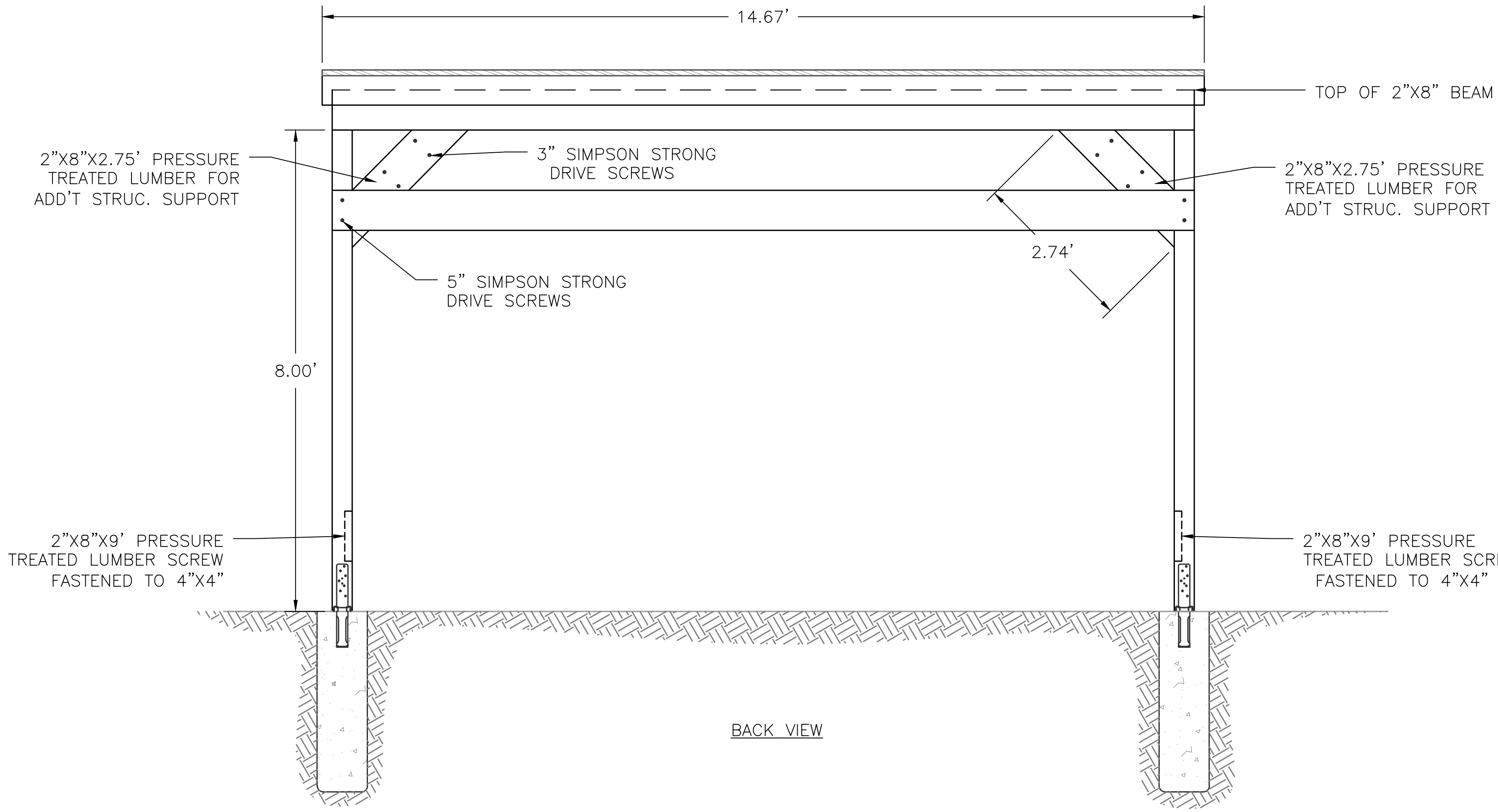
1. Crushed aggregate base shall be comprised of DOT No. 57 stone. The alternative concrete pad shall be concrete with 4,500 psi strength.
2. The cistern shall be 220 gallon Norwesco n43870, 130 Gal. Bushman Slimline BSLT130, Bushman Slimline BSLT265e, or approved equivalent.
3. All disturbed areas exclusive of the cistern shall be restored to original conditions by the contractor.
4. The contractor shall provide shop drawings of downspout connections to the cistern for engineers approval prior to installation.
5. The diverter filter box shall be a Rainharvesting® first flush downspout diverter (product code: wdds9x) or equivalent.
6. Overflow shall discharge to a lawn area unless specified otherwise. Stone protection comprised of 3-5-inch diameter washed river stone shall be installed as shown in the detail.



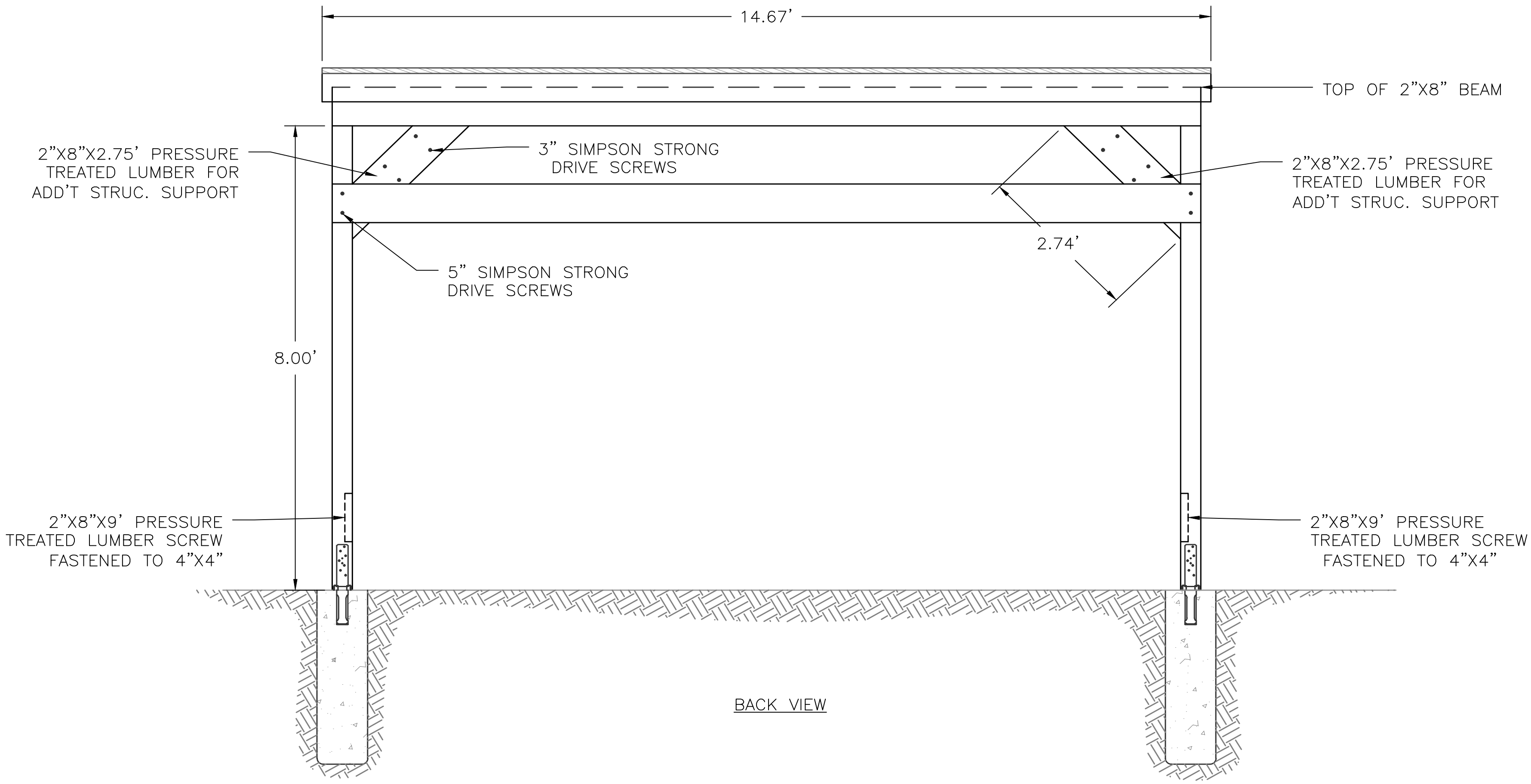
6.7 SHADE STRUCTURE SIDE VIEW see detail ***6.9 SHADE STRUCTURE FRONT VIEW*** and ***6.10 SHADE STRUCTURE BACK VIEW*** for additional views of installation
see detail ***6.8 CORNER DETAIL*** and ***6.11 ROOF DETAIL*** for additional details



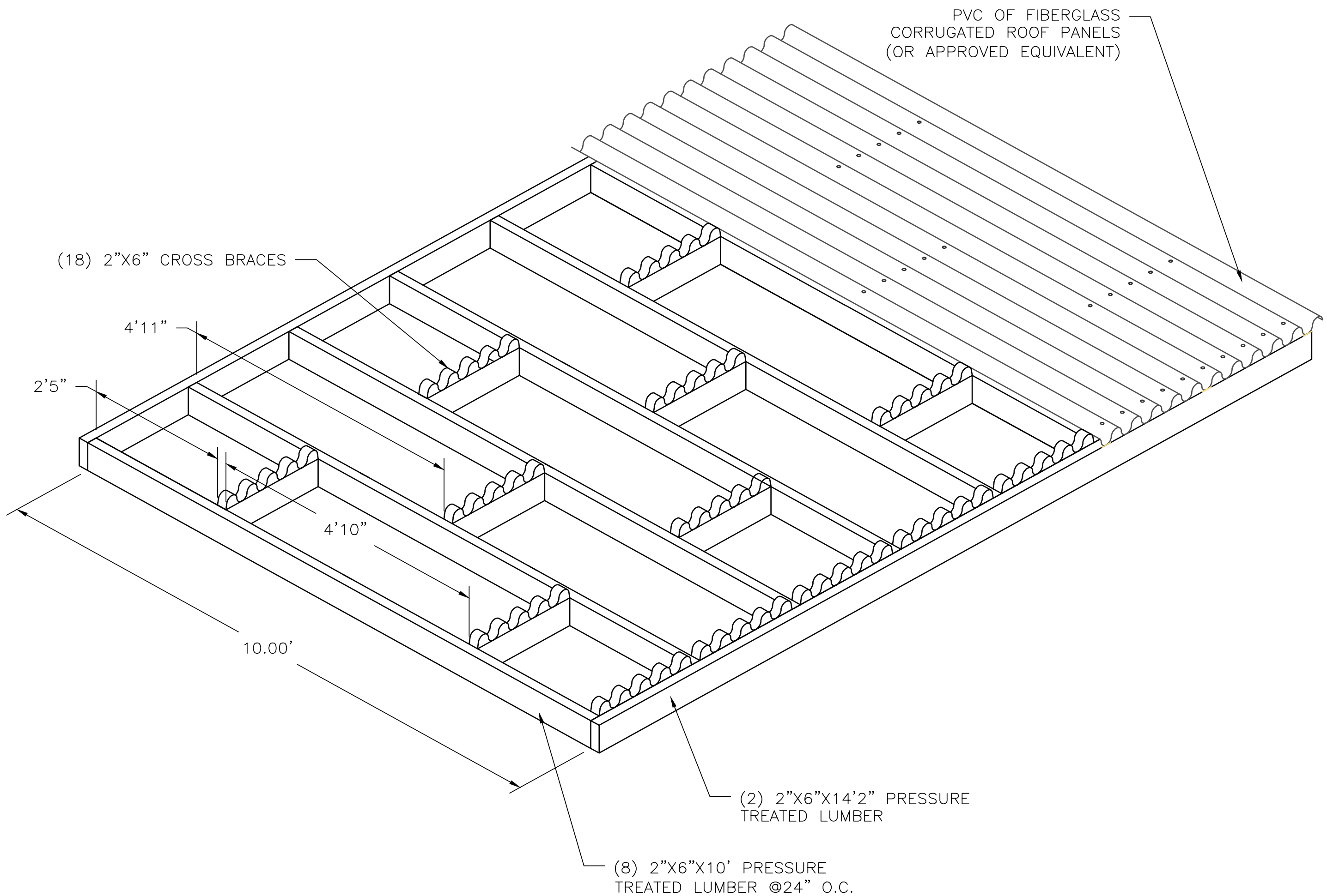
6.8 SHADE STRUCTURE CORNER DETAIL



6.9 SHADE STRUCTURE FRONT VIEW



6.10 SHADE STRUCTURE BACK VIEW



6.11 SHADE STRUCTURE ROOF DETAIL

6.12 SHADE STRUCTURE - GENERAL SPECIFICATIONS

CONSTRUCTION NOTES

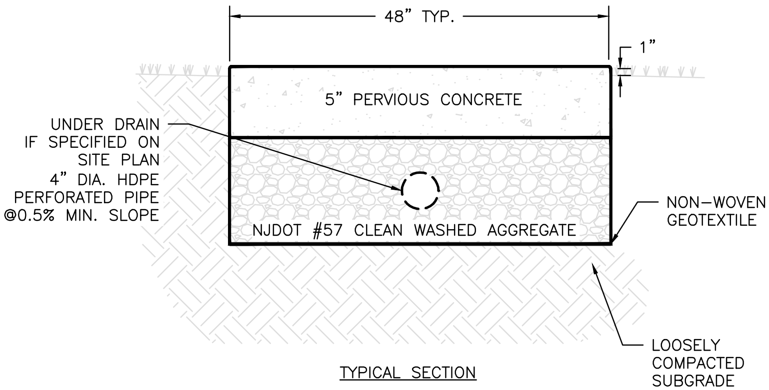
1. The contractor shall verify all information prior to installation including elevations and locations of existing utilities.
2. The contractor shall notify the engineer immediately if any field conditions differ materially from those represented on these drawings and the specifications or if, in the contractor's opinion, said conditions conflict with the designs shown hereon.
3. The contractor shall have a pre-construction meeting with the engineer prior to any work on site.
4. The contractor shall minimize disturbance during construction. Any disturbance to sidewalks or landscaped vegetation and trees must be coordinated with the property owner.
5. The contractor shall use PVC piping for the connection from the roof to the cistern.
6. All pipes used for connection from the shade structure to the cistern shall be clear of any clogs or obstructions. All pipes shall be fitted and secured with adhesive in conformance with local plumbing codes.
7. The overflow from the cistern shall connect to the nearest storm sewer catch basin inlet.
8. The contractor shall not make any modifications at the site until consulting with the engineer.
9. The contractor is required to submit shop drawings of all materials and construction methods to the engineer for review and approval prior to installation.

SPECIFICATIONS

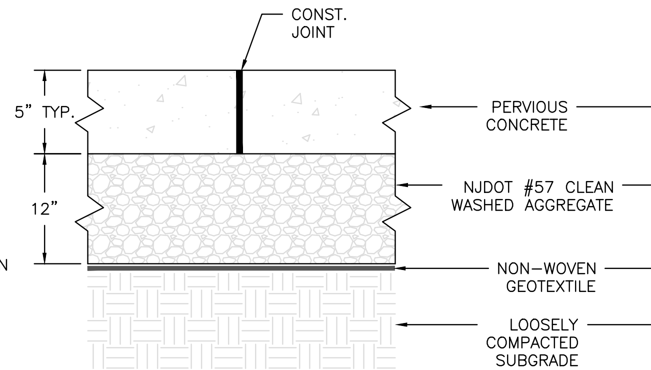
1. The contractor shall use Simpson Strong Tie in connectors and strong drive screws for the shade structure.
2. The contractor shall use pressure treated lumber.
3. The contractor shall install concrete footings with a minimum 3-foot depth.
4. The roof panels shall be corrugated PVC or fiberglass panels.
5. The gutter shall have a 6-inch base.
6. The contractor shall only use concrete with 4,500 psi strength.
7. All disturbed areas exclusive of the shade structure shall be restored to original conditions by the contractor.

7.0 PERMEABLE PAVEMENT

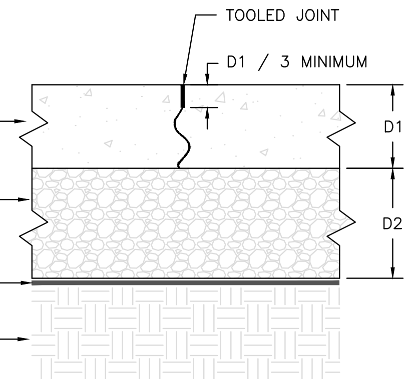
Surfaces that are hard and support vehicle traffic but also allow water to infiltrate through the surface



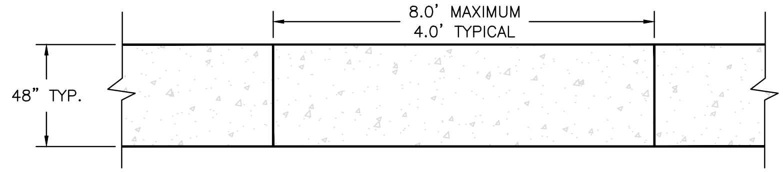
TYPICAL SECTION



PERVIOUS CONSTRUCTION JOINT



PERVIOUS CONTRACTION JOINT



JOINT SPACING – PLAN VIEW

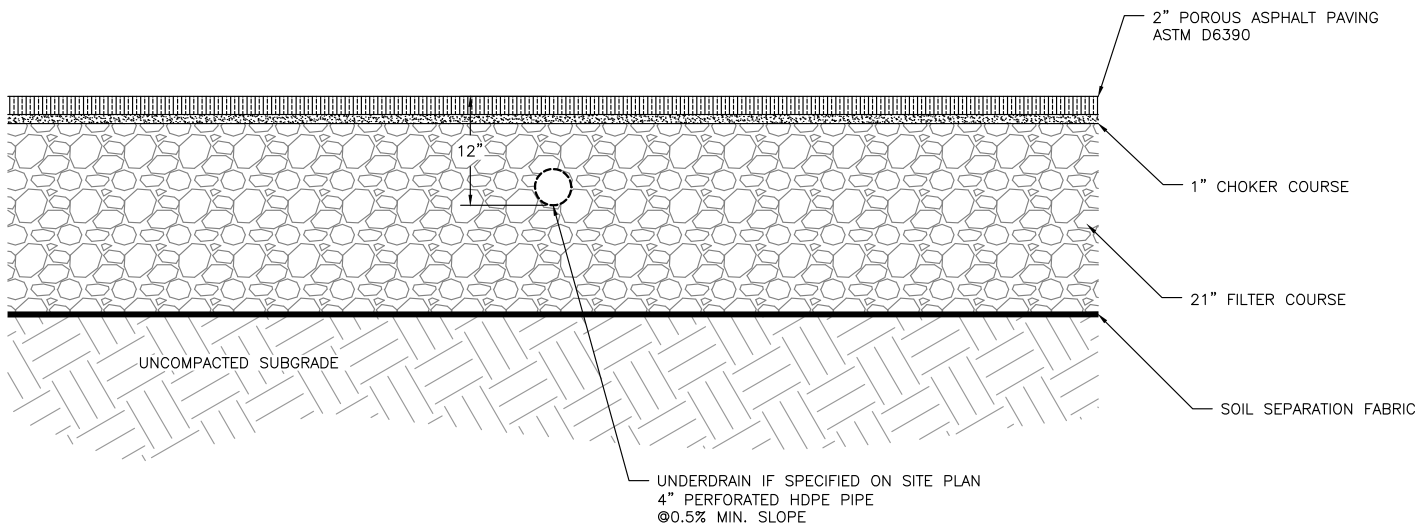
NOTES:
1. PERVIOUS CONCRETE MUST BE SUPPLIED AND INSTALLED BY NRMCA CERTIFIED PRODUCERS AND CONTRACTORS.
2. JOINT TO BE CUT IN FRESH PAVEMENT WITH A PERVIOUS CONCRETE JOINT TOOL ONLY.
3. PERVIOUS CONCRETE MUST BE COVERED WITH 6 MIL. PLASTIC, SECURELY FASTENED, FOR SEVEN (7) DAYS.
4. EXPANSION JOINTS TO BE PLACED EVERY THIRD JOINT OR 20 FEET (WHICHEVER IS LESS) AND AT EACH DRIVEWAY CUT AS PER THE DETAIL AND SPECIFICATIONS. A FULL-DEPTH SAWCUT CAN BE USED IN LIEU OF EXPANSION JOINTS.

INSTALLATION

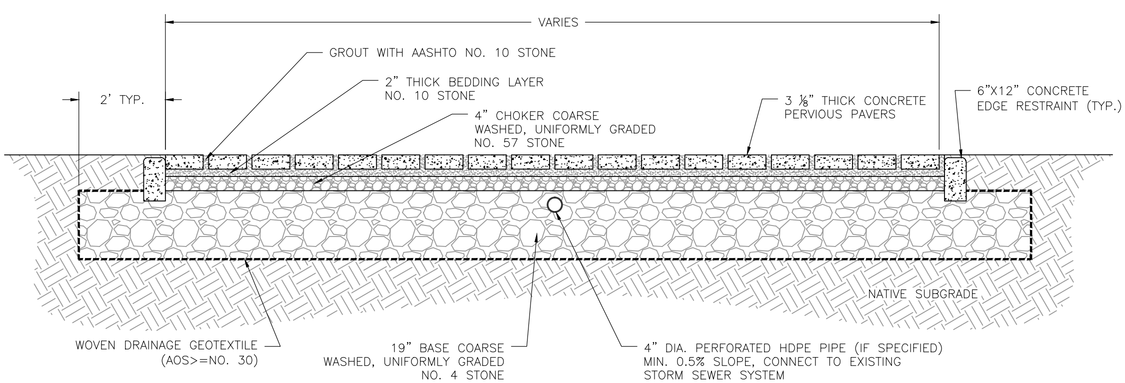
JOINT CUTTING

CURING

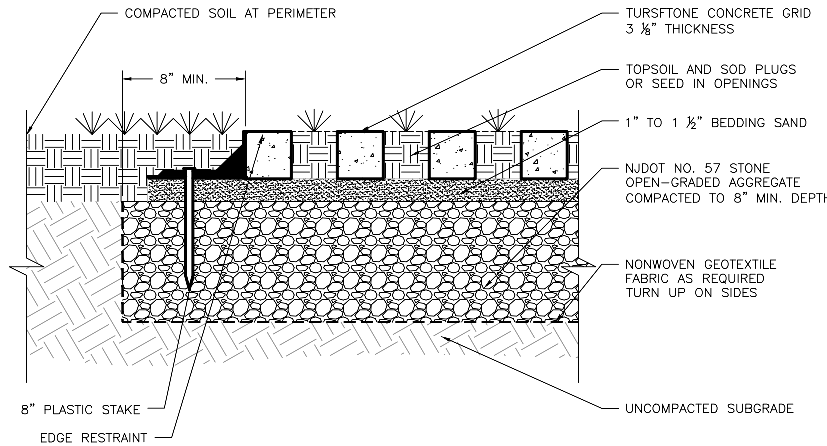
7.1 PERVIOUS CONCRETE CROSS SECTION



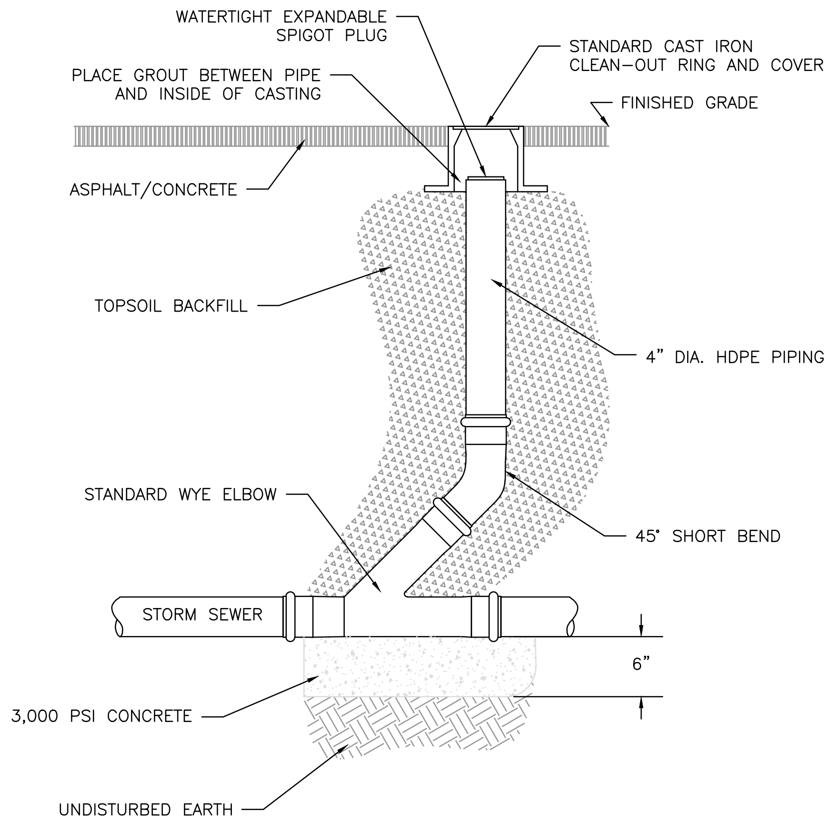
7.2 POROUS ASPHALT CROSS SECTION



7.3 INTERLOCKING PAVERS CROSS SECTION



7.4 GRASS PAVERS CROSS SECTION



7.5 PERMEABLE PAVEMENTS CLEANOUT

ASPHALT AND SUB-BASE MATERIALS				
PROPOSED ELEVATION	LAYER	DEPTH	PROPERTIES	STONE
100.00	POROUS ASPHALT	0'-2"	SEE SPECIFICATIONS	-
99.83	CHOKER COURSE	0'-3"	SAND	BC SAND
99.75	FILTER COURSE	2'-0"	WASHED CRUSHED STONE	AASHTO No. 57
98.00	SOIL SEPARATION FABRIC	2'-0"	NON-WOVEN GEOTEXTILE	-

7.6 POROUS ASPHALT MATERIALS TABLE

TABLE 901.03-1 STANDARD SIZES OF COARSE AGGREGATE																
		AMOUNTS FINER THAN EACH LABORATORY SIEVE, % BY WEIGHT														
No.	NOMINAL SIZE	4"	3 ½"	3"	2 ½"	2"	1 ½"	1"	3/4"	1/2"	3/8"	No. 4	No. 8	No. 16	No. 50	No. 100
1	3 ½" - 1 ½"	100	90-100		25-60		0-15		0-5							
2	2 ½" - 1 ½"			100	90-100	35 -70	0-15		0-5							
3	2" - 1"				100	90-100	35-70	0-15		0-5						
4	1 ½" - ¾"					100	90-100	20-55	0-15		0-5					
5	1" - ½"						100	90-100	20-55	0-10	0-5					
57	1"-No. 4						100	95- 100		25-60		0-10	0-5			
67	¾" - No. 4							100	90-100		20-55	0-10	0-5			
7	½" - No. 4								100	90-100	40-70	0-15	0-5			
8	⅜" - No. 8									100	85-100	10-30	0-10	0-5		
9	No. 4 - No. 16										100	85-100	10-40	0-10	0-5	
10	No. 4 - No. 200										100	85-100				10-30

7.7 NJDOT STANDARD SPECIFICATION FOR AGGREGATE

7.8 PERMEABLE PAVEMENTS - GENERAL SPECIFICATIONS

CONSTRUCTION NOTES

1. The contractor shall verify all information prior to excavation including elevations and locations of existing utilities.
2. The contractor shall notify the engineer immediately if any field conditions differ materially from those represented on these drawings and the specifications or if, in the contractor's opinion, said conditions conflict with the designs shown hereon.
3. The contractor shall have a pre-construction meeting with the engineer prior to any work on site.
4. The contractor shall avoid over compacting the existing materials to avoid poor infiltration.
5. The contractor shall establish all elevations and lines as shown in the site plan for review by the engineer before any construction begins.
6. The contractor shall verify that the subgrade is consistent with line, grade, and elevations as indicated in the site plan. Any areas showing erosion or potential ponding shall be regraded before subbase installation.
7. Immediately after the subgrade is approved by the engineer, the contractor shall begin subbase construction which includes all materials below the pavement and above the existing subgrade.
8. The contractor shall place geotextile fabric in conformance with manufacturer's specifications. All adjacent fabric shall be overlapped by at least 16 inches. The fabric shall be secured at least four feet outside of the excavated base.
9. The filter course aggregate shall be installed in 8-inch maximum lifts and compacted to a maximum of 95% standard proctor (ASTM d698/AASHTO t99).
10. The choker course shall be installed evenly over the filter course; the contractor shall notify the engineer for approval. The choker base shall be at least four inches thick. The choker, gravel, and stone base aggregate shall be installed to a maximum of 95% standard proctor compaction.
11. The infiltration rate shall be at least 5-30 ft/day or 50% of the hydraulic conductivity (D2434).
12. Subbase courses densities shall be approved by the engineer; rolling and shaping shall resume until densities are acceptable. Water shall be poured over subbbase course materials during compaction.
13. The contractor shall perform all rolling and shaping from the low side to the high side until each layer conforms to grade as indicated and layers are smooth.
14. After subbase aggregate installation, the geotextile fabric shall be folded back along all bed edges. The fabric shall remain secure until adjacent soils establish vegetation. Any necessary measures shall be taken to prevent sediment from washing into beds.
15. The asphalt and concrete mixing plant, hauling and placing equipment, and installation shall be in conformance with National Asphalt Pavement Association's *Porous Asphalt Pavements for Stormwater Management* (NAPA IS-131) and the NJDOT Standard Specifications for Road and Bridge Construction, 2007 or latest version.

SPECIFICATIONS

1. The contract shall be performed in conformance with the NJDOT Standard Specifications for Road and Bridge Construction, 2007 or latest version.

2. Finished pavements shall show no marks from rollers and be free from low lying spots subject to puddle formation. The entire surface shall drain properly. All elevations must be within 0.1 feet.
3. All work must meet the standards of the engineer before payment. Additional work and testing will be necessary if standards are not met.
4. The thickness of No. 57 aggregate is 12 inches under pervious concrete sidewalks.
5. Porous asphalt mix design criteria:

Sieve size (inch/mm)	percent passing (%)
0.75/19	100
0.50/12.5	85-100
0.375/9.5	55-75
No.4/4.75	10-25
No.8/2.36	5-10
No.200/0.075 (#200)	2-4

Binder content (AASHTO t164)	6-6.5%
Binder performance grade	64-22
Fiber content by total mixture mass	0.3%
Cellulose or 0.4% Mineral	
Rubber solids (SBR) content by weight of the bitumen	1.5-3%
Air void content (ASTMd6752/ASSHTO t275)	16.0-22.0%
Draindown (ASTM d6390)* < 0.%	

Retained tensile strength (AASHTO 283)** > 80%

Cantabro abrasion test engaed samples (ASTM d7064-04) < 20%

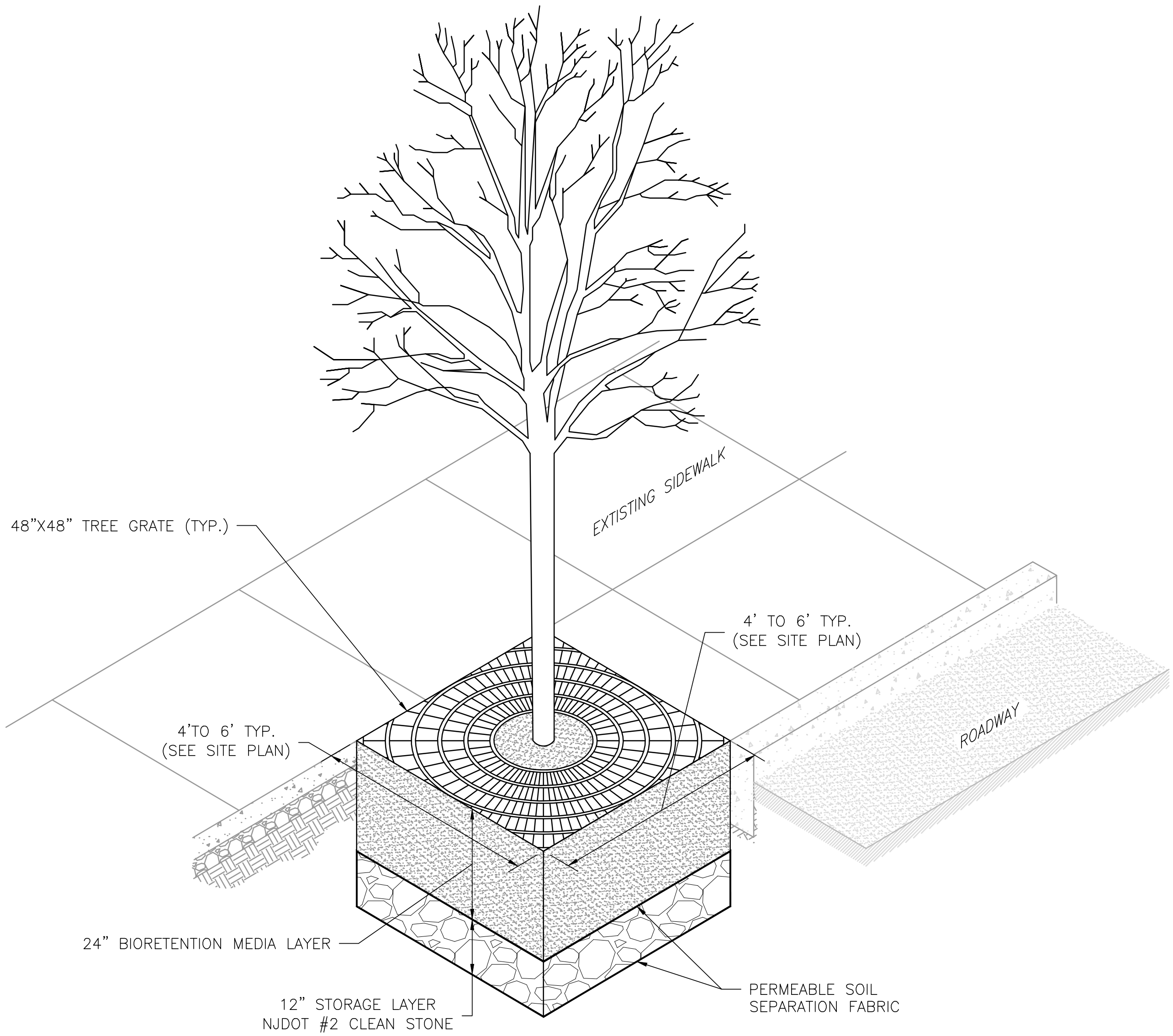
Cantabro abrasion test on 7 day aged samples < 30%

*Cellulose or mineral fibers may be used to reduce draindown.

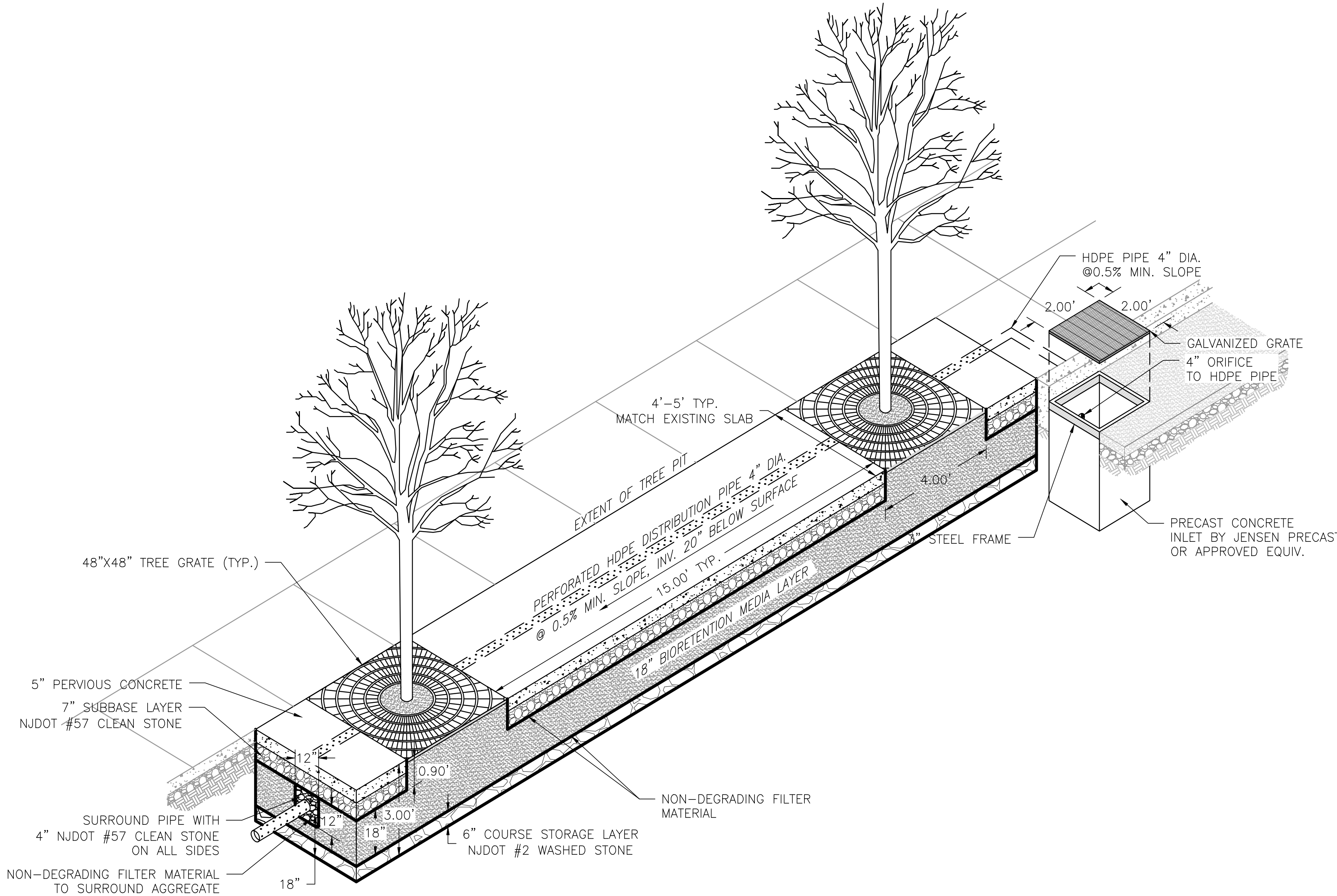
**If the RTS (retained tensile strength) values fall below 80% when tested per NAPA IS-131 (with a single freeze thaw cycle rather than 5), then in step 4, the contractor shall employ an antistrip additive, such as hydrated lime (ASTM c977) or a fatty amine, to raise the RTS value above 80%.

8.0 ENHANCED TREE PIT

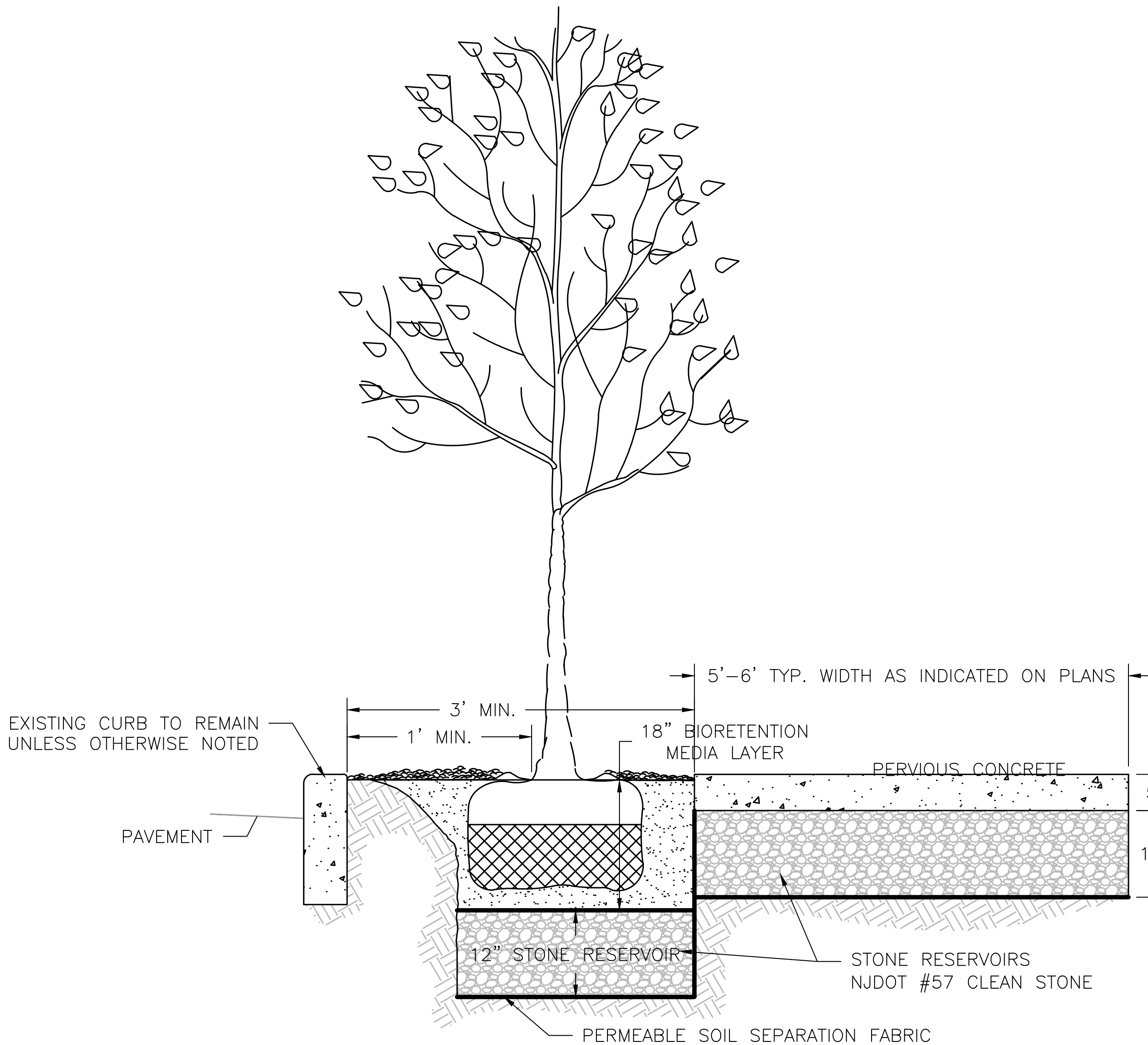
Pre-manufactured concrete boxes that contain a special soil mix and are planted with a tree or shrub



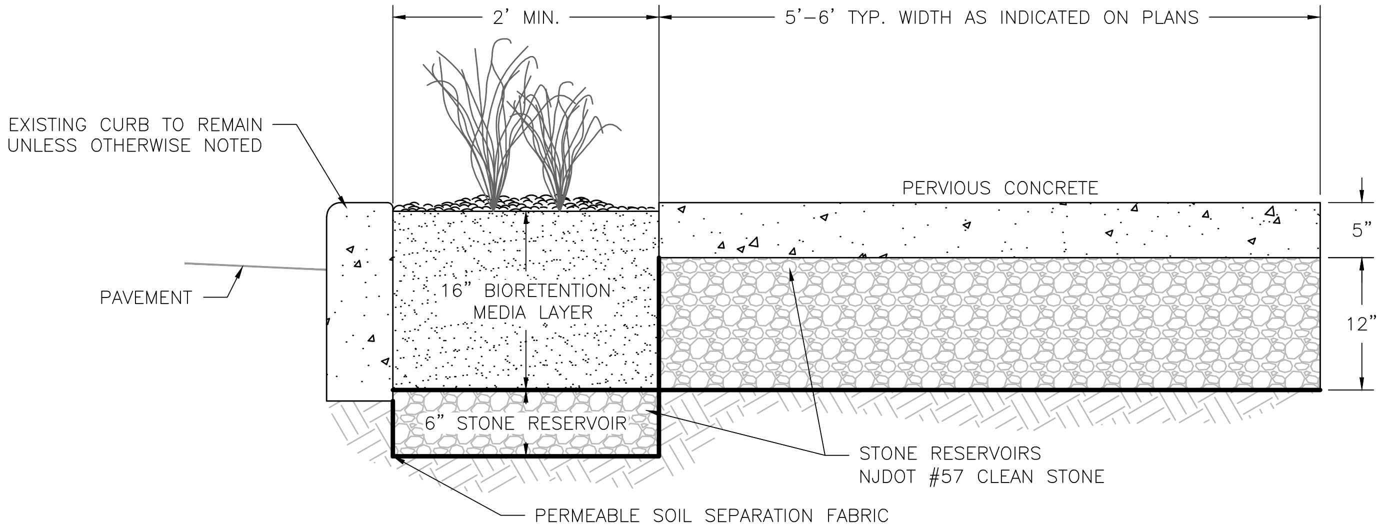
8.1 ENHANCED TREE PIT ISOMETRIC



8.2 CONTINUOUS TREE PIT ISOMETRIC



8.3 STREET TREE PLANTING AND PERVIOUS CONCRETE STRIP



8.4 GRASS PLANTING AND PERVIOUS CONCRETE STRIP

8.5 ENHANCED TREE PIT - GENERAL SPECIFICATIONS

CONSTRUCTION NOTES

1. The contractor shall verify all information prior to excavation including elevations and locations of existing utilities.
2. The contractor shall notify the engineer immediately if any field conditions differ materially from those represented on these drawings and the specifications or if, in the contractor's opinion, said conditions conflict with the designs shown herein.
3. The engineer shall inspect all planting bed areas before planting to insure that adequate drainage exists. If any areas to be planted show evidence of poor drainage, the contractor shall take corrective action.
4. The contractor shall have all utilities marked before any excavation. If any utilities interfere with the project, the contractor shall notify the engineer.
5. The entire continuous tree pit and/or enhanced tree pit shall be excavated, the contractor shall dispose of any excess materials.
6. The contractor shall avoid over compacting the existing soils to avoid poor infiltration.
7. The contractor shall establish all elevations and lines as shown in the site plan for review by the engineer prior to construction.
8. The contractor shall verify that the subgrade is consistent with line, grade, and elevations as indicated in the site plan. Any areas showing erosion or potential ponding shall be regraded before subbase installation.
9. Immediately after the subgrade is approved by the engineer, the contractor shall begin subbase construction which includes all materials below the pavement and above the existing subgrade.
10. The contractor shall place geotextile fabric in compliance with manufacturer's specification. All adjacent fabric shall be overlapped by at least 16 inches. The fabric shall be secured at least four feet outside of the excavated base. The entire pit perimeter shall be lined with geotextile fabric.
11. The storage layer (No. 2) Shall be installed evenly over the existing subbgrade and permeable fabric. The storage layer aggregate shall be installed to a maximum of 95% standard proctor compaction. Permeable soil separation fabric shall be installed on top of storage layer prior to installing bioretention media.
12. The bioretention media layer shall be installed evenly over the storage layer and fabric.
13. The infiltration rate shall be at least 5-30 ft/day or 50% of the hydraulic conductivity (D2434).
14. After the subbase aggregate installation, the geotextile fabric shall be folded back along all bed edges. The fabric shall remain secure until adjacent soils establish vegetation. Any necessary measures shall be taken to prevent sediment from washing into beds.
15. Concrete shall be installed in conformance with NJDOT Standard Specifications for Road and Bridge Construction, 2007 or latest version.

SPECIFICATIONS

1. The tree gates shall be the retrofit collection grates (r-9002) from NEENAH foundry. Grates shall be 48 inches on each side with a 16-inch diameter expandable tree opening or approved alternative for continuous tree pit. For the enhanced tree pit, the grate shall be 48 - 72 inches on each side with a 16-inch diameter expandable tree opening or approved alternative. See site plan for grate dimensions for enhanced tree pits.
2. The bioretention layer shall be comprised of 70% sand and 30% compost mixture.
3. The coarse storage layer shall be comprised of No. 2 washed stone. The layer shall be compacted multiple times. All other storage layers shall be comprised of No. 57 washed stone.

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Green Infrastructure
Site Assessment Instructions

GENERAL OVERVIEW

1) Prior to going into the field, map potential sites in the target neighborhood that will be assessed for green infrastructure concepts. Include sites such as schools, libraries, parks, community centers, community gardens, and other public areas.

2) Compile the selected sites into a document, with addresses and aerial images. If possible include lot and block numbers and contour lines on the image.

3) Conduct field visits to assess the sites. Bring copies of the images for all participants as well as copies of the Green Infrastructure Site Assessment Checklist.

4) Follow the Green Infrastructure Site Assessment Checklist while looking at each site. Be sure to make notes on the printed maps/aerial photos and take digital photographs of each site. There should be general site photographs as well as more detailed photographs of potential stormwater BMP locations.

5) After initial assessments, narrow down the list of potential sites and prioritize the most likely and most cost-effective sites to recommend for green infrastructure concepts.

OBSERVATIONS

General Observations:

1) The sources of stormwater and flow direction are important to the assessment as they inform initial decisions for selecting and locating green infrastructure practices. Green infrastructure practices must be located to intercept stormwater but should not be at

the lowest point of the site where water is currently ponding. The location of existing storm drains need to be identified, and sources of sediment are significant as it could impact the function of green infrastructure practices.

2) The slope of the site helps to understand the flow direction as well as selecting suitable green infrastructure practices; some green infrastructure practices are not suitable for steep areas while others require a minimum slope to drain properly.
3) The amount of impervious cover on the site allows for the determination of the size of green infrastructure practices as well as how much stormwater runoff it will treat. If evaluating a streetscape, determine the area available for potential green infrastructure practices by measuring building setback distances from the street and curb as well as the width of existing sidewalks.
4) If the impervious cover is in disrepair, then there is a higher potential that it can be cost-effectively removed or replaced with a green infrastructure practice.
5) If impervious areas are directly connected, it could allow for an opportunity to redirect stormwater into a green infrastructure practice; these are prime opportunities for green infrastructure.
6) If there are opportunities for disconnection, such as downspouts or intercepting runoff, the installation of a green infrastructure practice could be easier and potentially more cost-effective. Identifying opportunities where this can be done at the surface as opposed to subsurface installations provides the greatest potential for cost-effective management.
7) Locate all stormwater catch basin inlets in and around the site and/or streetscape. This is important to determine where green infrastructure practices can most effectively be located. The depth and condition of these catch basins can also provide important information for designers.
8) If water is ponding on the site or flooding the street or intersection, there could be too much stormwater runoff or poorly maintained infrastructure. In these cases, green infrastructure practices can help address the problem. If ponding is due to a high water table and the area is continually wet, then green infrastructure may be less suitable.
9) Existing trees or landscaping may be providing stormwater benefits. It should be evaluated and, if possible, integrated into the green infrastructure design. Determining the type of plants appropriate for the site will help ensure that any green infrastructure practices, including plantings (such as a rain garden, tree trench, or a stormwater planter), will be successful in that environment.

10) Determining the location of existing utilities is important for green infrastructure practice installation. If there are any underground utilities, placement considerations must be evaluated to avoid conflicts or other impacts with utilities. Moving utility poles can also be cost prohibitive.
11) Green infrastructure can often be used as part of traffic calming or pedestrian safety improvement projects. If an intersection or streetscape is heavily used by pedestrians, shortening crosswalks using curb extensions or other landscape strategies can make it safer. Keep in mind these changes will also impact available parking, bus access, and circulation.

Rain Gardens

1) Access to an exterior downspout (rather than interior) allows for easier installation of a rain garden.
2) Unpaved areas are easier and more cost-effective locations to implement a rain garden than areas that require depaving.
3) If the area is above ponding or flooding, then it is an opportune location to capture, filter, and infiltrate stormwater runoff.

Rainwater Harvesting

1) A nearby building is necessary to connect a rainwater harvesting system to; if downspouts are visible, then they will be easier to divert to a rainwater harvesting system.
2) If a community garden is in the vicinity, there is a readily available use for the harvested water.

Tree Pits, Trenches, and Streetscape Strategies

1) If there is runoff flowing across existing sidewalks or along the curb, it may be redirected into one of these practices to disconnect the stormwater runoff from flowing into the storm sewer.

2) Existing trees, landscaping, and areas of grass or turf can provide ideal locations to install a green infrastructure practice.
3) If water is flowing along the curb, it is most cost-effective if it can be redirected into a surface planter or tree pit. Make note if areas adjacent to the street are significantly higher and would prevent water from flowing onto the surface.

Porous Pavement

1) If the existing use of the site requires impervious/paved areas, alternative pervious pavements may be an appropriate replacement option. If areas are lightly used, but paving of some sort is still required, pervious pavement may be an appropriate option.
2) If the current impervious surface is in disrepair and replacement is likely in the near future, it may be more cost-effective to replace it with porous pavement.

Curb Extensions and Stormwater Planters

1) These practices work well in areas where pedestrian crosswalks need to be shortened. They can be integrated into traffic calming or pedestrian safety projects cost-effectively.
2) The intersection or streetscape needs to be located such that stormwater is flowing into the area and can be intercepted prior to entering the existing storm sewer. Ideal locations will not be at the “top of the hill” but also not at the “bottom of the hill” that is frequently flooded.

Rutgers New Jersey Agricultural Experiment Station

Green Infrastructure
Site Assessment Checklist

GENERAL INFORMATION		Site ID:
Name person(s) completing assessment:		Date:
Location Address and Cross Streets:	Neighborhood:	
Name of Nearest Waterway:	Property Owner / Tax Parcel ID/Street Segment:	
Contact Information:		

SITE DESCRIPTION
Description of site and relative visibility to the public (public or private property, lot size, current use, streetscape, etc):

OBSERVATIONS	NOTES/REMARKS
1) What is the source of stormwater runoff and where does it flow (on map or aerial photo indicate water flow direction and existing storm drains)? Is there a noticeable source or deposit of sediment?	
2) What is the direction and relative slope of the site and/or street? (indicate on map or aerial photo)	
3) Where on the site are impervious areas and estimate area in square feet (i.e., rooftops, parking lots, sidewalks)? For streetscapes, what is the building setback and/or sidewalk width?	
4) Do paved areas appear to be in poor condition (cracks, settling, vegetation growth, etc.) or do they appear newly paved or reconstructed?	
5) Does stormwater runoff from impervious areas flow directly to the sewer system (such as roof runoff directed into a storm drain)?	
6) Are there opportunities to redirect and disconnect runoff (downspouts, grassed areas, tree pits, curb extensions)?	

7) How many stormwater catch basins are visible? Note location on maps and general condition, i.e., clogged, functioning, shallow (< 3 ft), or deep (>3 ft)?	
8) Is there evidence of ponding water at the site or flooding in streets or intersections? (indicate reason; i.e., due to clogged drains, high water table, etc.)	
9) Are there mature trees/vegetation at the site? What types of plants would be appropriate at the site (sun or shade tolerant, height or site line restrictions)?	
10) Where are utilities on the site or in the right of way that could conflict with construction (sewer pipes, utility poles, water, gas, etc.)?	
11) Does pedestrian safety need to be addressed? Will parking or bus stops be impacted by construction?	

Choose suggested BMPs or indicate other. Include site photos and a description of recommended BMP location.			
RAIN GARDENS	YES	NO	COMMENTS
1) Are there visible, exterior downspouts on any buildings?			
2) Are there unpaved areas suitable for landscaping?			
3) Is the site subject to ponding or flooding?			
RAINWATER HARVESTING	YES	NO	COMMENTS
1) Are there nearby buildings with visible exterior downspouts?			
2) Is there a community garden nearby or other use for collected rainwater?			
TREE PITS, TRENCHES, AND STREETSCAPE STRATEGIES	YES	NO	COMMENTS
1) Does stormwater flow across sidewalks or along the curb?			
2) Are there existing trees, landscaping or tree pits near the street?			
2) Can water be directed from the street/curb into adjacent areas?			
POROUS PAVEMENT	YES	NO	COMMENTS
1) Are there large areas of pavement on the site and are any paved areas not heavily used (i.e., fire lane, overflow)?			
2) Are existing impervious areas in poor condition and in need of replacement?			
CURB EXTENSIONS AND STORMWATER PLANTERS	YES	NO	COMMENTS
1) Is this a heavily used pedestrian crossing? Are there pedestrian crosswalks that would be safer if			

shortened?			
2) Is the intersection or street at a location where stormwater can be collected before it enters a storm drain?			
OTHER STRATEGIES	**YES**	**NO**	**COMMENTS**

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RUTGERS COOPERATIVE EXTENSION WATER RESOURCES PROGRAM

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