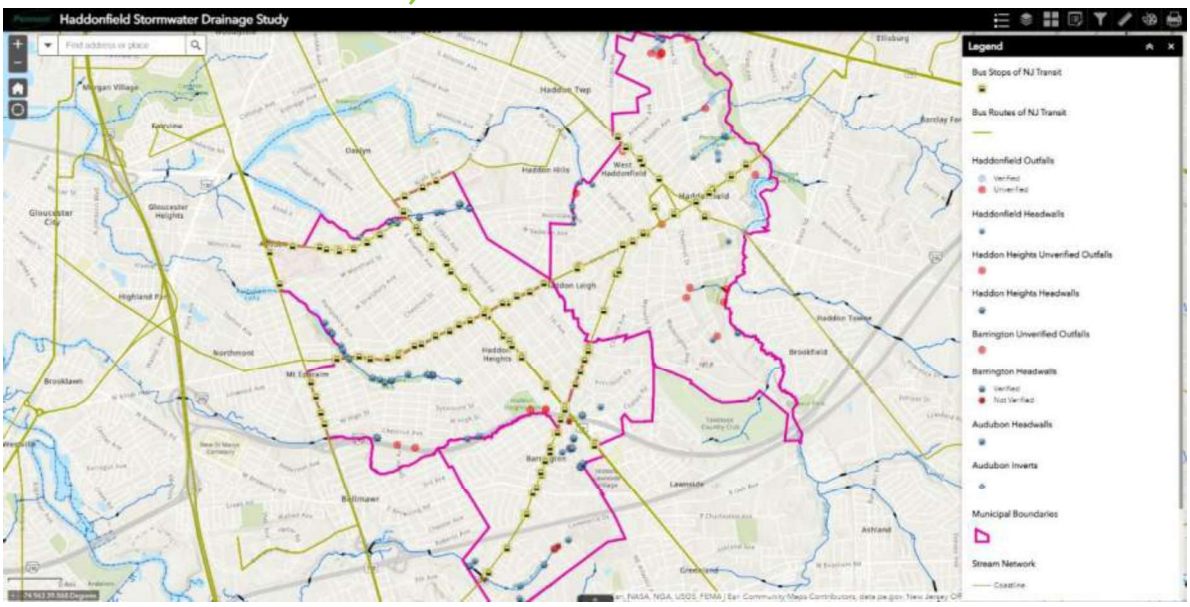
STORMWATER DRAINAGE STUDY AND GREEN INFRASTRUCTURE PLAN FOR HADDONFIELD, AUDUBON, BARRINGTON, AND HADDON HEIGHTS

CAMDEN COUNTY, NJ



Submitted To:

Borough of Haddonfield
Attn: Sharon McCullough
Borough Administrator
242 Kings Highway E
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Senior Engineer
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HDDBH 21001
July 2022

STORMWATER DRAINAGE STUDY AND GREEN INFRASTRUCTURE PLAN FOR

BARRINGTON BOROUGH

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1. EXECUTIVE SUMMARY

Pennoni Associates, Inc. (Pennoni) has completed our stormwater drainage study and Green Infrastructure plan for the four (4) boroughs. The purpose of our study was to perform a regional stormwater drainage study and provide a green infrastructure plan for the Haddonfield, Audubon, Barrington and Haddon Heights service area. This includes a review of urban flooding in the 10.757 square-mile study area, mapping of drainage areas, and recommending appropriate green infrastructure to mitigate flooding, particularly as it affects major roadways and NJ Transit Bus Routes.

The goals of this study are as follows:

1. **Develop a comprehensive overview of the drainage impacts in each borough.**
   a. We spoke with personnel from the boroughs and reviewed previously submitted reports, including the most recent Draft County Hazard Mitigation Plan to gain understanding of the flooding issues facing each borough.
   b. We inventoried the drainage systems in each borough and developed a GIS data base with user-friendly search tools to access collected data including pipe, inlet and outfall locations, field notes, photographs, and more. In all, we inventoried 1,853 inlets, 556 manholes, 139 outfalls, and almost 40 miles of pipe.
   c. The GIS Dashboard allows users to identify inventoried system information within the view screen, which can be used to generate reports, and used in the future to generate work orders.
   d. Each borough can now become licensed to operate and maintain the ESRI-based data platforms.

2. **Provide a list of potential improvement projects to mitigate flooding and prepare for more intense storm events.**
   a. We developed recommendations for potential projects in each area of concern and provided a budget estimate for the primary recommendation.

3. **Develop performance standards for potential Green Infrastructure improvements.**
   a. We have provided performance standards that can be used to develop local ordinances for improvements during development, redevelopment, and local improvement projects.

4. **Identify Green Infrastructure candidate projects.**
   a. We developed conceptual projects that the boroughs can utilize to take advantage of opportunities to develop/improve green areas and replace pervious areas with porous solutions.

5. **Prepare cost estimates for the recommended solutions.**
   a. We reviewed improvement options for each area of concern, then selected a primary recommendation, and developed a budget estimate for the primary recommendation.

6. **Present the Steering Committee findings and recommendations to each governing body.**
   a. This report and the GIS are now available for viewing and access at this location:
      i. GIS mapping application for the Haddonfield Stormwater Drainage Study - https://gis.pennoni.com/portal/apps/webappviewer/index.html?id=f33ca5a314754748acd3de24384609e6
      ii. Link to Overall Report- 21001-STORMWATER

2. INTRODUCTION

2.1. LOCATIONS

Barrington, NJ is one of the boroughs within the area of interest and sits at an average elevation of 65 ft. The Borough drains toward Beaver Brook, I-295, and the NJ Turnpike.

Barrington Borough zoning consists primarily of residential zones with commercial districts centered around Clements Bridge and White Horse Pike and manufacturing districts in the southwestern and southeastern portions of the borough. Barrington Borough houses two parks with wooded areas around Beaver Brook, I-295, and NJ Turnpike.

Barrington Borough has approximately 25.57 miles of roadways, of which 17.95 miles are maintained by the Borough. The remaining mileage consists of various Camden County roads, I-295 and the New Jersey Turnpike. Exit 29 from I-295 connects with US Route 30 and US Route 41. The NJ Bus Route #455 and NJ Bus Route #403 run through the Borough with 18 stops along US Route 41 and 2 stops along US Route 30.

2.2. INFORMATION REFERENCED

We reviewed previously prepared reports provided by the Borough (Barrington) including:

- Barrington Drainage Analysis notes 11/30/21.
- NJDEP 2020 Stormwater Annual Report and Certification.
- Draft Camden County Hazard Mitigation Plan (undated).

3. PHASE 1 - MAPPING

Access to the GIS is available through the following links and includes a dashboard to easily isolate each borough. The dashboard allows each borough to easily inventory mapped stormwater drainage system assets, both borough-wide and on targeted areas within the GIS field view.

The GIS dashboard for GIS mapping analysis is located at:
https://gis.pennoni.com/portal/apps/dashboards/1acafc61cee14d939d680971cbc767cd
The online GIS mapping application for the Haddonfield Stormwater Drainage Study is located at https://gis.pennoni.com/portal/apps/webappviewer/index.html?id=f33ca5a314754748acd3de24384609e6

Borough	Miles of Drainage Pipe	Number of Structures	Number of Outfalls	Number of Detention Facilities
Barrington	8.2	Manholes – 125 Inlets - 425	29	N/A

Borough	Open Space Area (Acres)	Potential Increase to Non-Impervious Coverage	Number of Drainage Areas
Barrington	3.7	---	13

4. PHASE 2 – FLOOD MITIGATION ANALYSES

One of the first lines of defense against flooding is enforcing the Borough's flood damage prevention ordinance to minimize flood-related losses. (Appendix C)

We contacted Barrington Borough's professionals including the Borough Engineer, Office of Emergency Management (OEM), and department of Public Works (DPW) staff to collect existing data and reports pertaining to the existing drainage systems and concerns.

Barrington Borough was included in a Hazard Mitigation Action Plan update put together by Camden County in accordance with the Disaster Mitigation Act of 2000. This report provided data concerning the Borough's risk and vulnerability, the different capabilities used in the Borough and an action plan to be implemented to achieve a more resilient community. Data from historical natural hazard events including storms/flooding were provided and locations of recurring flooding areas were provided. The current solution for the continual flooding consists of annual monitoring for more frequent or severe flooding in the known problem areas and to develop engineering solutions accordingly. The listed areas of recurring flooding are as listed below and have been included in mapping.

- East Williams at Clements Bridge Rd.
- 3rd Ave.
- Austin Ave. and US 295
- Tavistock Blvd.
- Avon Rd. and Princeton Rd.
- Erie Ave.
- Barrington Ave.
- Page Ave.
- Chesterfield Rd.
- Nassau Dr.

East Williams Avenue and Clements Bridge Road

This location has a 67.11 acre drainage area (BAR-00) and is subject to ponding in the intersection of E. Williams Avenue and Clients Bridge Road. The intersection receives runoff from the cartway from the overpass and Moore Avenue intersection. The intersection drains toward the NJ Turnpike and Wilmont Avenue. There is a Type A inlet that discharges toward the NJ Turnpike at the dead end of E. Williams Avenue. We could not confirm the outfall location because the system drains into the existing NJ Turnpike drainage system and information regarding that system was not received.

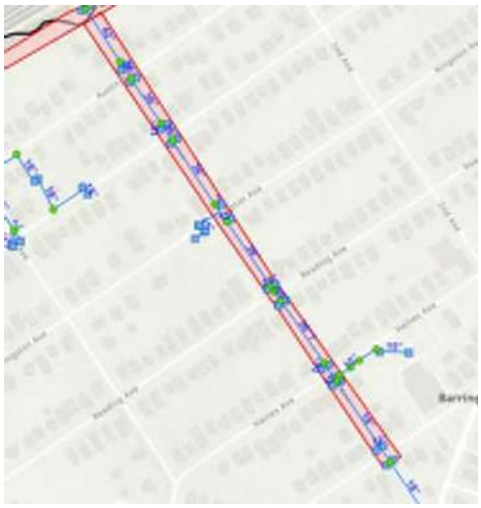
The NJ Transit Bus Route in the vicinity is Route #455, includes two bus stops (#14904, #14917), and has been affected by high-intensity storm events. It is unknown if NJ Turnpike is affected.

Alternative mitigation options that were considered include:

1. Install inlets and drainage pipe at intersection of Clements Bridge Road to mitigate ponding and connect to existing drainage system on Williams Avenue near the NJ Turnpike discharge.

2. Advise DVRPC that this problem area is within NJ Turnpike jurisdiction and may be alleviated by improving drainage facilities within their jurisdiction.
3. Install green infrastructure to areas upstream of flooding area to mitigate stormwater runoff and reduce impact on downstream areas that are at capacity. Focus efforts within drainage area BAR-00.

3rd Avenue



This location has a 105.31 Acre drainage area (BAR – 05) including the cartway from Clements Bridge Road to I-295. We could not confirm the outfall location because the system drains into the existing I-295 drainage system and information regarding that system was not received. The low elevation at the ditch of I-295 appears to be the cause of flooding that occurs during normal or high-intensity storm events (based on oral history from Borough personnel) and backs the existing drainage system up to Trenton Avenue. The outfall to the I-295 drainage ditch appears to be a choke point of a 42" to a 24" to an 18" pipe that may not be in the Borough's jurisdiction.

The NJ Transit Bus Route in the vicinity is Route #455, includes a bus stop (#14195), and has been affected by high-intensity storm events. I-295 does not appear to be affected.

Alternative mitigation options that were considered include:

1. Advise DVRPC that this problem area is within NJDOT jurisdiction and may be alleviated by improving drainage facilities within I-295 jurisdiction.
2. Installing green infrastructure to areas upstream of flooding area to mitigate stormwater runoff and reduce impact on downstream areas that are at capacity. Focus efforts within drainage area BAR-05 as identified on the GIS.

Austin Avenue and US 295

This location has a 105.31 Acre drainage area (BAR – 05) along the I-295 with low elevations that are subject to flooding during normal or high-intensity storm events. Drainage ditch is within the I-295 ROW and Borough drainage structures discharge to the area. Major low spot is located behind the properties 421- 427 Austin Avenue.

There are no NJ Transit Bus Routes in the vicinity and major roadways (I-295) do not appear to be affected.

Alternative mitigation options that were considered include:

1. Installing drainage structures and pipe in area of flooding. – The main area and issue of flooding is due to drainage issues outside of the Borough's jurisdiction and is due to the elevation of I-295. Install piping from 5th Avenue to Little Timber Creek (in Haddon Heights).
2. Advise DVRPC that this problem area is within NJDOT jurisdiction and may be alleviated by improving drainage facilities within I-295 jurisdiction.
3. Installing green infrastructure to areas upstream of flooding area to mitigate stormwater runoff and reduce impact on downstream areas that are at capacity. Focus efforts within drainage area BAR-05 and BAR-05.1.
4. Property acquisition along drainage ditch to mitigate flood damage.
5. Coordinate with NJDOT (I-295) and/or the New Jersey Turnpike Authority (Turnpike) to make improvements to their drainage systems that account for incoming municipal flows.

Tavistock Boulevard

This location has a 183 Acre drainage area (BAR-01) along the cartway with low elevations that are subject to flooding during normal or high-intensity storm events. I-295 contributes to flooding due to grading and low point at intersection of Tavistock and Nassau Drive. Existing ditch that system discharges to is within I-295 ROW.

There are no NJ Transit Bus Routes in the vicinity and major roadways (I-295 and Route 30) do not appear to be affected.

Alternative mitigation options that were considered include:

1. Property acquisition near ditch to mitigate flooding and generate green space.
2. Advise DVRPC to assist in coordinating with NJDOT (I-295) and/or the New Jersey Turnpike Authority (Turnpike) to make improvements to their drainage systems to account for incoming municipal flows.

Avon Road and Princeton Road

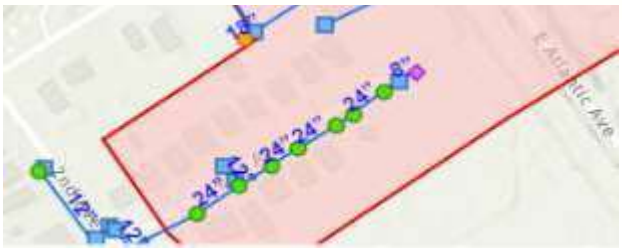
This location is subject to flooding during normal or high-intensity storm events. There is a choke point in the existing drainage of 24" to 18" at the intersection of Avon and Princeton. There is existing 18" clay pipe in the problem area that may require replacement due to deterioration.

There are no NJ Transit Bus Routes in the vicinity and major roadways (Highland Ave) do not appear to be affected.

Alternative mitigation options that were considered include:

1. Upsize undersized pipes and eliminate choke points in Avon Road. Replace pipes composed of outdated materials.
2. Installing green infrastructure to areas upstream of flooding area to mitigate stormwater runoff and reduce impact on downstream areas that are at capacity. Focus efforts within drainage area BAR-01.

Erie Avenue



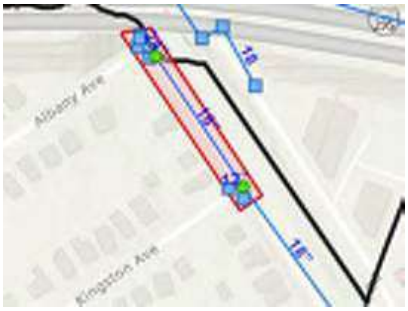
This location has a 58.40 Acre drainage area (BAR – 04) along the Atlantic Avenue railroad with low elevations that are subject to flooding during normal or high-intensity storm events. The railroad appears to trap the water in the natural low spot at the end of Erie Avenue. There appears to be a dead end in the existing drainage system. The existing data does not show where flow might discharge to at the end of Erie Avenue.

There are no NJ Transit Bus Routes in the vicinity and major roadways do not appear to be affected.

Alternative mitigation options that were considered include:

1. Installing green infrastructure to areas upstream of flooding area to mitigate stormwater runoff and reduce impact on downstream areas that are at capacity. Focus efforts within drainage area BAR-04.

Barrington Avenue



This location has a 105.31 Acre drainage area (BAR – 05) along the cartway with a low spot at Albany Avenue and Barrington Avenue that is subject to flooding during high-intensity storm events. The Haddon Heights 90" drainage pipe also drains towards the inlets in this low spot and to the ditch along I-295. The existing drainage in Barrington Avenue is 18" to 24" diameter pipe.

There are no NJ Transit Bus Routes in the vicinity and I-295 does not appear to be affected.

Alternative mitigation options that were considered include:

1. Remove and replace existing pipe that is composed of clay and other outdated materials to prevent decomposition of the pipe and upsize existing drainage pipe sizes.

Page Avenue

This location has a 58.95 Acre drainage area (BAR – 03) along exit 29A on the northbound side of I-295 with low elevations that are subject to flooding during normal or high-intensity storm events.

There are no NJ Transit Bus Routes in the vicinity and the major roadways (I-295 and Route 30) do not appear to be affected.

Alternative mitigation options that were considered include:

1. Installing green infrastructure to areas upstream of flooding area to mitigate stormwater runoff and reduce impact on downstream areas that are at capacity. Focus efforts within drainage area BAR-03.

Chesterfield Road

This location has a 183.08 Acre drainage area (BAR-01) is subject to flooding during high-intensity storm events. The area is localized low spot with flat grading and inlets are present at the lowest area to capture stormwater runoff. The existing Type E inlet receives runoff from the apartment complex along Princeton Road. The existing piping system is connected to the Tavistock Boulevard and will be affected by the flooding of the system downstream. Apartment complex has redirected some roof runoff away from Type E inlet. There also appears to be a sewer pipe running through the Type E inlet located at 939 Chesterfield Road that is leaking into the storm pipe.

There are no NJ Transit Bus Routes in the vicinity and major roadways do not appear to be affected.

Alternative mitigation options that were considered include:

1. Investigate presence of sewer pipe in Type E inlet and correct any intersection and leakage.
2. Upsize any undersized pipes to update drainage facilities to reflect climate changes.
3. Implement green infrastructure and underground storage solutions in the lowest area to mitigate flooding and encourage infiltration.
4. Installing green infrastructure to areas upstream of flooding area to mitigate stormwater runoff and reduce impact on downstream areas that are at capacity. Focus efforts within drainage area BAR-01.

Nassau Drive

This location has a 183.08 acre drainage area (BAR-01) and is subject to flooding during high-intensity storm events. The area is localized low spot with flat grading and inlets are present at the lowest area to capture stormwater runoff. The existing piping system is connected to the Tavistock Boulevard and will be affected by the flooding of the system downstream.

There are no NJ Transit Bus Routes in the vicinity and major roadways do not appear to be affected.

Alternative mitigation options that were considered include:

1. Upsize any undersized pipes to update drainage facilities to reflect climate changes.
2. Installing green infrastructure to areas upstream of flooding area to mitigate stormwater runoff and reduce impact on downstream areas that are at capacity. Focus efforts within drainage area BAR-01.

5. PHASE 3 - GREEN INFRASTRUCTURE ANALYSIS

We would encourage the Borough to adopt a Green Infrastructure ordinance that could contain performance standards as enumerated here.

Municipalities have the ability to incorporate green infrastructure on a neighborhood scale to reduce runoff, relieve overburdened storm drains, and enhance the beauty of the town. One neighborhood wide technique is to incorporate green infrastructure measures such as pervious pavement, street trees, or bioretention basins into the street layout through traffic calming features like curb bump outs, green stormwater practices in rights-of-way and permeable sidewalks. A municipal facility can utilize cisterns to reduce its potable water use runoff impacts during small storm events.

Barrington Borough consists of approximately 75% residential zones and has many privately owned properties. A long-term option will be to acquire properties to generate more green space and infrastructure throughout the Borough first focusing on problem areas and moving upstream.

Most of Barrington's problem areas are located in well developed areas with little or no open space available to help mitigate flooding and reduce stormwater runoff impacts. We have developed several approaches that can be used individually or together to help maximize runoff storage as follows:

- Install drainage stone pits in grass strips wherever possible. If drainage inlets are located nearby, connect to them by installing perforated underdrain pipe from within the drainage stone to the inlet.
- Install drainage stone layers under pavement wherever possible. This can be completed by constructing underdrain trenches or as an additional layer of the pavement profile when fully reconstructing streets. If drainage inlets are located nearby, connect to them by installing perforated underdrain pipe from within the drainage stone to the inlet.
- Install street trees that consume higher amounts of water, including:
    - Red Maple
    - Common Alder (Alnus)
    - American Sycamore
    - Sweetgum
    - River Birch
    - Pin Oak
    - Swamp White Oak
    - Bald Cypress (native to mid-west US)
- Remove sidewalks where possible and replace them with underdrains or stone pits and grass. Streets with sidewalks on both sides may provide options to eliminate one.
- Reduce pavement widths where possible and replace them with underdrains or stone pits and grass.
- Replace parking lot spaces with porous concrete and improved drainage.
- Acquire properties near problem areas for conversion to open space or stormwater detention.

We have provided construction details that can be used for future projects. (Appendix B)

6. RECOMMENDATIONS AND COST ESTIMATES

6.1. Cost Estimates

We have developed cost estimates for the first recommendation for each problem area. Detailed estimates are in Appendix A. We offer the following breakdown:

Problem Area	Estimated Cost	Type of Improvement (Green/ Drainage/Both)
East Williams at Clements Bridge Road	**$349,250**	**Drainage**
3rd Ave		
Austin Ave and US 295	**$1,606,000**	**Drainage**
Tavistock Blvd		
Avon Rd. and Princeton Rd.		
Erie Ave		
Barrington Ave		
Page Ave		
Chesterfield Rd		
Nassau Dr		

6.2. Green Infrastructure Solutions

We recommend incorporating Green Infrastructure measures such as pervious pavement, street trees, and bioretention basins into street improvement projects through traffic calming features like curb bump outs, green stormwater practices in rights-of-way and permeable sidewalks. A municipal facility can utilize cisterns to reduce its potable water use runoff impacts during small storm events.

- Recommended Action:
  Replacing sidewalks with stone drainage pits, underdrain pipe, and grass restoration:
  Estimated Cost:
  $300 per linear foot.

- Recommended Action:
  Install grass bump-outs at intersections to increase pervious area:
  Estimated Cost:
  $20,000 per bump-out

- Recommended Action:
  Replacing asphalt pavement with pervious pavement and stone subbase/
  Estimated Cost:
  $100 per square yard with a 10,000 square yard minimum.
- Recommended Action:
  Reduce 40-foot wide streets to 32-feet wide and install pervious pavement or grass to increase pervious area.

Estimated Cost:
$100 per square yard with a 10,000 square yard minimum.

- Recommended Action:
  Install street trees that consume high amounts of water.
  Estimated Cost:
  $1,000 per tree

- Recommended Action:
  Install bio-retention systems where possible.
  Estimated Cost:
  $300 per cubic yard ($5,000 per 10' x 10' x 5' pit)

6.3. Funding Solutions

The programs listed here represent an initial scan of funding sources for green infrastructure and drainage improvements throughout the Borough. These will require further vetting as additional information is collected on each funder's mission and priorities and as additional detail is compiled regarding the projects.

- Capital Budget
  - Actively budgeting for green infrastructure improvements throughout the Borough and to supplement other roadway improvement projects.
- NJDOT Local Aid Infrastructure Fund
  - Funding to address emergencies and regional needs throughout the state. Approved at the discretion of the commissioner.
  - Funding Estimate: TBD, subject to appropriation
  - Funding Cycle: Rolling deadline
  - Website: https://njdotlocalaidrc.com/state-funded-programs/local-aid-infrastructure
- NJ i-bank CWSRF
  - Funding to improve water quality.
  - Funding Estimate: Low interest loans, principal forgiveness
  - Funding Cycle: Rolling
  - Website: https://nj.gov/dep/wiip/water-bank.html
- NJDEP Lakes Stormwater Improvement
  - Funding for planning and/or implementation to improve stormwater management and control nonpoint source pollution and nutrients in lakes to improve water quality and improve recreational access.
  - Funding Estimate: (total available statewide): Water quality planning - $2M, stormwater management - $3M; management & restoration - $3M
  - Funding Cycle: May
  - Website: https://www.nj.gov/dep/wlm/grants/lakestormwater.html
- NJ Water Quality Restoration
  - Grants to reduce water quality impairment through implementation of nonpoint source (NPS) pollution control projects. Regions funded on rotating basis.
  - Funding Estimate: $TBD
  - Funding Cycle: February
  - Website: https://www.state.nj.us/dep/wms/bears/2020-2022grants.htm#/

- Sustainable Jersey PSEG Foundation
  - Funding for infrastructure implementation, stormwater management, floodplain restoration, other sustainability projects.
  - Funding Estimate: $10,000
  - Funding Cycle: October
  - Website: https://www.sustainablejersey.com/grants/
- USDA Water & Waste Disposal Loan & Grant Program NJ
  - Funding for improvements to WTF/WWTF and stormwater, population <10,000.
  - Funding Estimate: Low interest loans based on project need and median household income
  - Funding Cycle: Rolling
  - Website: https://www.rd.usda.gov/programs-services/water-environmental-programs/water-waste-disposal-loan-grant-program/nj
- FEMA Flood Mitigation Assistance (FMA)
  - Program to reduce or eliminate the risk of repetitive flood damage to buildings and structures insured under the National Flood Insurance Program.
  - Funding Estimate (based on 2020 grant): Maximum $600,000 for Project Scoping; $30,000,000 per community flood mitigation project; $25,000 for local flood hazard mitigation planning; cost share 25%
  - Funding Cycle: Fall deadline (applying as subapplicant via DE Department of Emergency Management)
  - Website: https://www.fema.gov/grants/mitigation/floods
- FEMA Building Resilient Infrastructure & Communities (BRIC)
  - Provides funding for cost-effective means to reduce damage and risk prior to disaster striking. Emphasizing partnership, resiliency, green infrastructure.
  - Funding Estimate: Varies (up to $600,000 per state); cost share 25%, 10% for small and impoverished communities
  - Funding Cycle: Fall deadline (applying as subapplicant via DE Department of Emergency Management)
  - Website: https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities
- FEMA Hazard Mitigation Grant Program (HMGP)
  - Program to reduce community vulnerability to disasters. Requires disaster declaration.
  - Funding Estimate (based on 2020 grant): Maximum $600,000 for Project Scoping; $30,000,000 per community flood mitigation project; $25,000 for local flood hazard mitigation planning; cost share 25%
  - Funding Cycle: Varies
  - Website: https://www.fema.gov/grants/mitigation/floods
- NJDOT TA Set-Aside
  - Funding to support surface transportation projects encouraging non-automotive transportation.
  - Funding Estimate: Minimum award $350,000, max award $1.5M, no match required. Total available statewide $25.2M (funding double through federal infrastructure bill).
  - Funding Cycle: November 3
  - Website: https://www.njdotlocalaidrc.com/federally-funded-programs/transportation-alternatives

7. RECOMMENDATIONS FOR FURTHER SERVICES

Based on similar experience, Pennoni is able to advise on policy matters, including adherence to the requirements and regulations of NJDEP, FEMA, NJOEM, County and local OEM's, US Army Corps of Engineers, and DVRPC.

Pennoni's Funding Solutions services are available to help mitigate funding challenges through identification of additional grant dollars or other sources.

8. LIMITATIONS

This work has been done in accordance with our authorized scope of work and in accordance with generally accepted professional practice in the fields of geotechnical and foundation engineering. This warranty is in lieu of all other warranties either express or implied. Our conclusions and recommendations are based on the data revealed by the data revealed by this exploration. We are not responsible for any conclusions or opinions drawn from the data included herein, other than those specifically stated, nor are the recommendations presented in this report intended for direct use as construction specifications. This report is intended for use with regard to the specific project described herein; any changes in loads, structures, or locations should be brought to our attention so that we may determine how they may affect our conclusions. An attempt has been made to provide for normal contingencies, but the possibility remains that unexpected conditions may be encountered during construction. If this should occur, or if additional or contradictory data are revealed in the future, we should be notified so that modifications to this report can be made, if necessary. If we do not review relevant construction documents and witness the relevant construction operations, then we cannot be responsible for any problems that may result from misinterpretation or misunderstanding of this report or failure to comply with our recommendations.

APPENDICES

APPENDIX A – Budget Estimates

- East Williams Avenue and Clements Bridge Road
- Austin Avenue

BARRINGTON BOROUGH
EAST WILLIAMS AVENUE AND CLEMENTS BRIDGE ROAD DRAINAGE MITIGATION
ENGINEER'S ESTIMATE OF PROBABLE COSTS

	BID ITEM			Engineer's Estimate	
Item #	**Description**	**Quantity**		**Unit Price**	**Total**
1	Initial Test Pitting with HMA Restoration	1	LS	$15,000.00	$15,000.00
2	Mobilization and Demobilization	1	LS	$15,000.00	$15,000.00
3	Trench Repair (Backfill, 6" Thick DGA, 4" Thick HMA 19M 64 Base Course)	500	SY	$75.00	$37,500.00
4	Water Service Relocation (If and Where Directed)	5	UN	$2,500.00	$12,500.00
5	Vertical Concrete Curb Restoration	500	LF	$45.00	$22,500.00
6	Install New Inlet at Clements Bridge Road	4	LF	$5,000.00	$20,000.00
7	Install New Drainage Pipe	600	LF	$300.00	$180,000.00
8	Connect to Existing Structure	1	UN	$5,000.00	$5,000.00
9	Allowance for Asphalt price Adjustment for Hot Mix Asphalt, If Needed	1	LS	$5,000.00	$5,000.00
10	Allowance for Fuel Price Adjustment for Hot Mix Asphalt, If Needed	1	LS	$5,000.00	$5,000.00
				TOTAL	**$317,500.00**
				CONTINGENCY	**$31,750.00**
				CONSTRUCTION ESTIMATE TOTAL	**$349,250.00**

Scope of Work

Install drainage inlets at Clements Bridge Road and install drainage pipe on East Williams Avenue to connect to existing drainage system near NJTP.

BARRINGTON BOROUGH
AUSTIN AVENUE DRAINAGE MITIGATION
ENGINEER'S ESTIMATE OF PROBABLE COSTS

BID ITEM				Engineer's Estimate	
Item #	**Description**	**Quantity**		**Unit Price**	**Total**
1	Mobilization and Demobilization	1	LS	$15,000.00	$15,000.00
2	Site Clearing	1.50	AC	$100,000.00	$150,000.00
3	Underground Detention Pipes (24" HDPE or larger)	4,000	LF	$300.00	$1,200,000.00
4	Install New Discharge to Little Timber Creek	1	UN	$20,000.00	$20,000.00
5	Grass Restorations	1.50	AC	$10,000.00	$15,000.00
6	Replacement Trees	200	UN	$300.00	$60,000.00
				TOTAL	**$1,460,000.00**
				CONTINGENCY	**$146,000.00**
				CONSTRUCTION ESTIMATE TOTAL	**$1,606,000.00**

Scope of Work

Install drainage inlets and piping in the flooding areas between Austin Avenue and Rt 295. Continue piping parallel with Rt 295 from 5th Avenue, across the municipal boundary into Haddon Heights, and install a new discharge to Little Timber Creek.

APPENDIX B – Green Infrastructure Details

- System Placement
  - General Considerations
  - Offsets
  - Pedestrian and Vehicular Access
  - Greening
  - Grading and Elevations
- System Function
  - Infiltration Systems
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- Inlets
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- Monitoring
  - Observation Wells
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- Construction Drawings
  - Stormwater Tree Trench Cross Section
  - Stormwater Tree
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  - Stormwater Bump out (mid-block)
  - Permeable Pavement
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  - Standard Inlet with Underdrain Connection
  - Slow-Release Orifice
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  - Utility Manhole in Permeable Paving
  - Frame and Casting Support in Permeable Paving
  - Tree Planting
  - Tree Pit in Stormwater Trench
  - Stone Pit
  - Underdrain Trench- Pervious Pavement

3.3 Design Technical Requirements & Guidelines

To provide clarity on design direction, this section divides content into requirements and guidelines.

- **Requirements**: Instructions that must be followed for all GSI designs.
- **Guidelines**: Instructions that should generally be followed, but may allow for exceptions. Exceptions are determined on a case-by-case basis and should be discussed with the PWD project manager. Guidelines should still generally be followed and may be enforced strictly by PWD.

There may be additional limitations beyond those mentioned in this manual. Some constraints may be modified in certain circumstances, at the direction of the PWD project manager.

Note on Separate Sewer Areas: The guidelines presented herein are intended for projects within areas of Philadelphia served by combined sewers. When working in separate sewer areas, more specific requirements, or deviations from these requirements, will be provided by the PWD project manager.

Note on Innovation: It is not uncommon in PWD's experience that GSI projects need to move beyond standard design requirements and guidelines to create unique solutions to match unique challenges. As such, PWD expects and encourages innovation in the course of designing GSI. PWD's general direction, when innovation appears to be called for, is for the consultant to work with the PWD project manager to evaluate options and proceed in general accordance with the information listed in section ***3.3 Design Technical Requirements & Guidelines***.

3.3.1 System Placement

Note: Designers should reference planning notes and checklists when finalizing system placement. Designers should have a full understanding of the planning process before starting design work. This section should be utilized by planners during the feasibility phase to site initial system footprints. Preliminary SMP type is selected during planning stage and refined with information in design. PWD project manager will provide more information about SMP selection as needed.

General Considerations

Guidelines

3.3.1.1 The number of individual systems should be minimized to reduce cost and future maintenance requirements.

3.3.1.2 Systems should be located directly upstream from existing inlets whenever possible to maximize drainage areas and allow for a convenient underdrain connection to an existing inlet.

3.3.1.3 Systems should be located to maximize opportunities for infiltration and minimize the need for use of impermeable geomembrane liners.

3.3.1.4 Infiltration/storage trench footprints should be designed as simple shapes. Complex configurations are difficult for construction. Surface SMP layouts can be more complex than subsurface trenches in order to tie into the existing site.

Offsets

Guidelines

3.3.1.5 System footprints should be located to maintain the general ROW offsets shown in ***Table 1*** below. PWD project manager can provide more information if needed.

Table 1: *ROW Offsets*

ROW OFFSETS	OFFSET	NOTES
Property line	5-foot horizontal	For work located on or adjacent to a City-owned property (e.g. park), closer offsets and storage spanning the ROW-parcel boundary may be permitted.
Existing buildings, retaining walls, bridge support structures, or comparable	Bearing plane	Engineer should evaluate the appropriate offset considering the foundation, structure, condition, etc. See ***Figure 26.***
Vacant lots	See PWD's most current version of the *GSI Adjacent to Vacant Lots Guidance*.	
Signalized intersections	See PWD's most current version of the *Streets Design Guidance for GSI Projects*.	
Cartway systems	For systems completely in the cartway, recommend minimum 3-feet from existing curbline.	Recommended to avoid triggering curb restoration.
	Storage should typically take up 40% or less of the cartway width. Where possible, storage should not extend further than the width of the parking or bike lane.	Recommended to avoid triggering full width repaving, improve constructibility, and allow room for other utilities.
Existing fences	Project specific. 2-foot horizontal offset preferred to avoid impacts.	If impacts are unavoidable, PWD will need to conduct outreach to property owners early in design.
Floodplain	Systems should not be placed in the 100-year floodplain.	

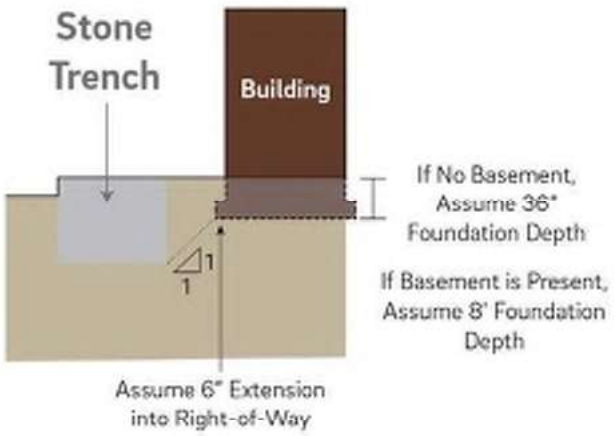


Figure 26: *System offset from building bearing plan.*

3.3.1.6 Systems should be located to maintain the infrastructure offsets shown in ***Table 2*** below. All offsets specified are from the **outer edge of utility lines**. Horizontal offsets generally refer to system footprints and pipes running parallel. Vertical offsets generally refer to pipe crossings. There may be cases where the benefit of moving a utility outweighs the costs and complexities of such an impact. These instances should be discussed early with the PWD project manager. PWD project manager can provide more information if needed.

Table 2: *Infrastructure Offsets*

INFRASTRUCTURE	OFFSET	NOTES
Sewer mains	2V:1H zone of influence	Closer offsets may be considered on a case-by-case basis for larger relief sewers. Not applicable to pipe crossings.
Sewer laterals	5-foot horizontal, 12-18-inches vertical	
Water mains	3-foot horizontal for newer mains (ductile iron), 5-foot horizontal for older mains (cast iron)	
Large utilities	10-feet horizontal, 18-inches vertical	Includes water transmission mains, high pressure gas mains, large PECO conduits. No pipe crossings underneath. Extra precautions may be required, discuss early with PWD project manager.
Sinclair Refinery Lines	2-foot horizontal and vertical	Ductile iron crossings not permitted within 5-foot offset, plastic pipe to be used in this vicinity. Crossing under pipelines preferred.
Utility lines, service lines (not otherwise specified above)	3-feet horizontal, 12-18-inches vertical	Preferable for pipe crossings to go over existing utilities, rather than under. Coordination with utilities required where offsets cannot be achieved.
Existing inlets	5-feet horizontal	Closer offsets may be considered on a case-by-case basis and should be discussed with the PWD project manager.
Telephone poles, utility poles, D-poles, or comparable	5-foot horizontal	
Traffic lights, C-Posts, or comparable	3-foot horizontal	

3.3.1.7 The functional details in section ***3.3.12 Typical Details*** should be referenced for appropriate placement of PWD's most common SMP types. These details show the acceptable offsets for specific SMP types from driveways, poles, parking, curblines, etc. and should be used in conjunction with the general guidance below when determining the feasibility of system locations during the planning and design phases.

Pedestrian and Vehicular Access

Guidelines

3.3.1.8 Maintenance access should be considered early in the design process and must be reviewed and approved by PWD. Vehicular access for trucks and entry permissions (easements) must be provided for off-street sites. PWD project manager will coordinate the acquisition of appropriate easements.

a. Access must allow for maintenance trucks measuring eight (8) feet wide and thirty-five (35) feet long, with a twelve (12) foot vertical clearance. Driving surfaces must be generally 12-feet wide and support trucks weighing 68,000 pounds when fully loaded.

b. Consider location of maintenance truck when locating sump components such as inlets, water level control structures, cleanouts, domed risers, maintenance ports, etc. Maintenance ports must be accessible by vactor hose and clear of obstacles. Consider that vactor truck booms typically extend to a maximum of 30 feet and features that need this type of cleaning should ideally be located within this distance of the vehicular maintenance access location. Obstacles such as fences, wide footways, adjacent mature trees, and/or utility lines should also be evaluated when placing these maintenance features.

3.3.1.9 For vegetated systems, vehicular and pedestrian movement across a site should be considered during planning. If there is a potential for impact or trampling, area protection features such as fencing, boulders, or a shrub border should be considered during design. For further guidance, refer to Chapter 2 of the ***3.3.13 Landscape Design Guidebook***.

a. Consider the circulation of systems (either formal or informal) and how pedestrian movement will interact with the SMP. Note site uses, adjacent access points, and where and how human interactions (i.e. dog walking, recreational activities, etc) are likely to occur with the SMP and design accordingly. In particular, if a surface SMP is located within a school yard, recreation space, or on a slope, then area protection should be included around the perimeter or accessible side of the SMP.

b. For area protection requirements around Green Street systems, see the most current version of *Streets Design Guidance for GSI Projects* (request from PWD project manager).

Figure 27: *Images showing protection features that work well with adjacent vehicular and/or pedestrian circulation. From left to right: fence, boulders, shrub border.*

Greening

Guidelines

3.3.1.10 Existing trees in good condition are to be preserved, particularly mature trees of desirable species. Existing trees that are removed typically require replacement either in the same location or elsewhere within the project. Designers should consult with the PWD project manager regarding PWD's policies on tree preservation. If impacts to trees are proposed, PWD will need to conduct outreach to the property owner early in design. See ***3.3.13 Landscape Design Guidebook*** for more information on appropriate excavation offsets from existing trees.

3.3.1.11 Locate systems to maximize the potential for new tree plantings and canopy tree species. For tree placement and spacing requirements, reference ***3.3.13 Landscape Design Guidebook***.

Figure 28: *Examples of tree preservation.*

Grading and Elevations

Guidelines

3.3.1.12 When grading surface systems, designer should minimize the amount of excavation where possible by working with existing contours to reduce overall system depth.

Note: Keep in mind that fine grading at the outer extents of a system's footprint can make a system feel more naturally integrated into the site and prevent future erosion or conveyance concerns without requiring additional excavation.

3.3.1.13 Designs should consider minimum and maximum depths of excavation due to surface elevation changes over the length of systems. Projects should evaluate the potential costs and greened acre benefit when determining whether to design systems that would require sheeting and shoring. Systems should generally fit between two 2-foot topographic contour lines.

a. A tiered approach to system design may also be considered to reduce excavation depths.

b. If feasible, allow space for sloped excavation and/or benching for easier construction.

3.3.1.14 Gradual side slopes of 1V:5H for graded surface SMPs are preferred where feasible. A maximum side slope of 1V:3H should not be exceeded. Less steep slopes are preferred, where possible, and where adjacent to pedestrian areas.

3.3.1.15 Ponding depths for surface SMPs should consider pedestrian traffic, partner preferences, area protection, and site-specific conditions. The PWD project manager can provide guidance on appropriate depths on a project-by-project basis.

3.3.1.16 If a surface SMP is adjacent to paving without curbing (e.g. a rain garden on a lot adjacent to a sidewalk), the first 12-18 inches of graded slope should be maintained as a flat grade to prevent undermining of the adjacent paving. If substantial flow from an adjacent surface is sloped towards a system, refer to *3.3.1.17* for further guidance on redirecting flow or stabilization measures.

3.3.1.17 If a surface SMP is receiving surface slow from adjacent surfaces, redirect flow via curbing, edging, or earthen berms to protect the slope from erosion. If not possible, stabilize slopes with various erosion control techniques, including robust planting, gradual slopes, erosion matting or other stabilization products. Refer to Chapter 2 of ***3.3.13 Landscape Design Guidebook*** for further guidance.

3.3.2 System Function

GSI system function can be categorized into the following types: infiltration, detention/slow-release, and disconnection.

Note: Some guidance presented in the Infiltration section is relevant for systems that are not fully lined with an impermeable geomembrane liner, even those designed for detention/slow-release.

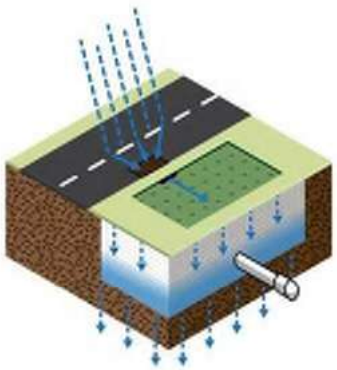


Figure 31: *Infiltration*

Infiltration

Infiltration systems are designed to infiltrate stormwater into the existing subgrade, as shown in ***Figure 31***. The first priority for all projects is infiltration as it removes volume from the combined sewer system and provides the maximum water quality benefits. Systems should be designed to maximize opportunities for infiltration.

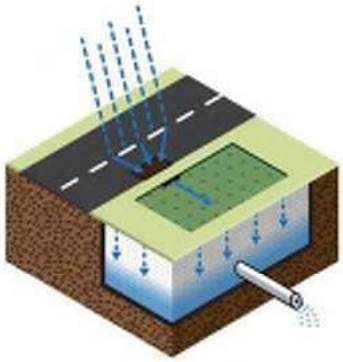


Figure 32: *Detention/slow-release*

Detention/slow-release

Detention/slow-release systems are designed to capture, detain, and treat stormwater and then slowly release it at a controlled rate to the sewer, as shown in ***Figure 32***. If systems are not wrapped in an impermeable geomembrane liner, then some infiltration may still occur.

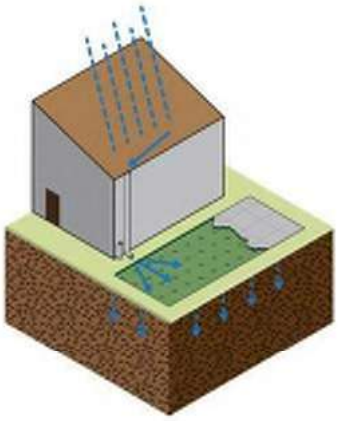


Figure 33: *Disconnection*

Disconnection

Disconnection is designed to divert impervious areas from the stormwater collection system, as shown in ***Figure 33***. Depaving is the most typical form of disconnection in PWD GSI projects. Disconnection may also be used to categorize re-routing inlets to the separate or non-contributing sewer system.

Infiltration Systems

Guidelines

3.3.2.1 If measured infiltration rates are found to be greater than or equal to 0.25 inches per hour, then the system should be designed for infiltration.

a. Where measured infiltration rates are less than 0.25 inches per hour, but soil profiles show layers of greater permeability beneath the impermeable layer, infiltration columns or over-excavation and soil replacement should be considered to promote infiltration. The PWD project manager can provide guidance on a project-by-project basis.

b. Soils with highly variable infiltration rates or with infiltration rates in excess of 10 inches per hour may require over-excavation and soil replacement, amendment, reinforcement, or an impermeable geomembrane liner.

3.3.2.2 Where there is more than one infiltration test for a given system, the infiltration rate should be calculated using the geometric mean. See ***3.3.11 Geotechnical Testing Guidelines*** for more information on obtaining infiltration rates.

3.3.2.3 Infiltration loading ratios (contributing impervious drainage area to infiltration area) should be minimized as feasible.

Table 3: *Maximum Loading Ratio for Subsurface and Surface Systems*

SYSTEM TYPE	MAXIMUM LOADING RATIO
Subsurface Systems	10:1
Surface Systems	25:1

a. These loading ratio maximums are guidance for stabilized drainage areas. Designs should consider the amount of sediment loading expected, factoring in ground cover and land use.

b. Higher loading ratios may be evaluated on a case by case basis in consideration of the geotechnical conditions and at the approval of the PWD project manager. Additional pretreatment should be considered for systems with higher loading ratios.

c. Loading ratios for the total contributing drainage area, which includes pervious and impervious contributing areas, should be designed to consider overall site conditions.

d. Runoff that has been filtered through the surface should not be counted towards the subsurface loading ratio.

3.3.2.4 For surface features, it is recommended that ponding areas drain completely in less than 24 hours. Drain down time for infiltration systems should be calculated using the following equation. Model calculations, where available, may be used in lieu of the equation below.

$$t = \frac{\left(\frac{V}{A_i}\right)}{i} * 12$$

Where:

t = Time (hrs)

V = Storage Volume (cf)

A_i = Infiltration Footprint (sf)

i = Infiltration Rate (in/hr)

Note: The guidance below is relevant for any systems that are not fully lined with impermeable geomembrane liner, even those designed for detention/slow-release.

3.3.2.5 Typically at least 10 feet of separation should be maintained between infiltrating systems and buildings or structures.

a. Review boring log(s) in the vicinity of the proposed system to identity whether there are seams, soil conditions, changes in stratigraphy, and/or limiting layers above the estimated depth of the building that would promote lateral movement of water into a building's basement. In the presence of those conditions, additional lining will be required as noted in *3.3.2.7*.

b. If the system is within the area defined by a 1:1 projection from the bottom of a building or structure, then the part of the system storage in that area should be lined with an impermeable geomembrane. See ***Figure 34***.

c. Where information on the building structure is not available and a system is located closer than 10 feet to a building, the bottom and sides of the system should be lined with an impermeable geomembrane to a minimum distance of 10 feet from the building and the geomembrane should be extended along the infiltration/storage side of the trench at least 15 feet beyond the end of the building. See ***Figure 34***.

- If the trench ends before reaching the end of the building, the geomembrane should cover the end of the trench as well.
- If there is a trench break and the next segment is at least 10 feet from the building, the partial lining does not need to continue to the next trench segment.

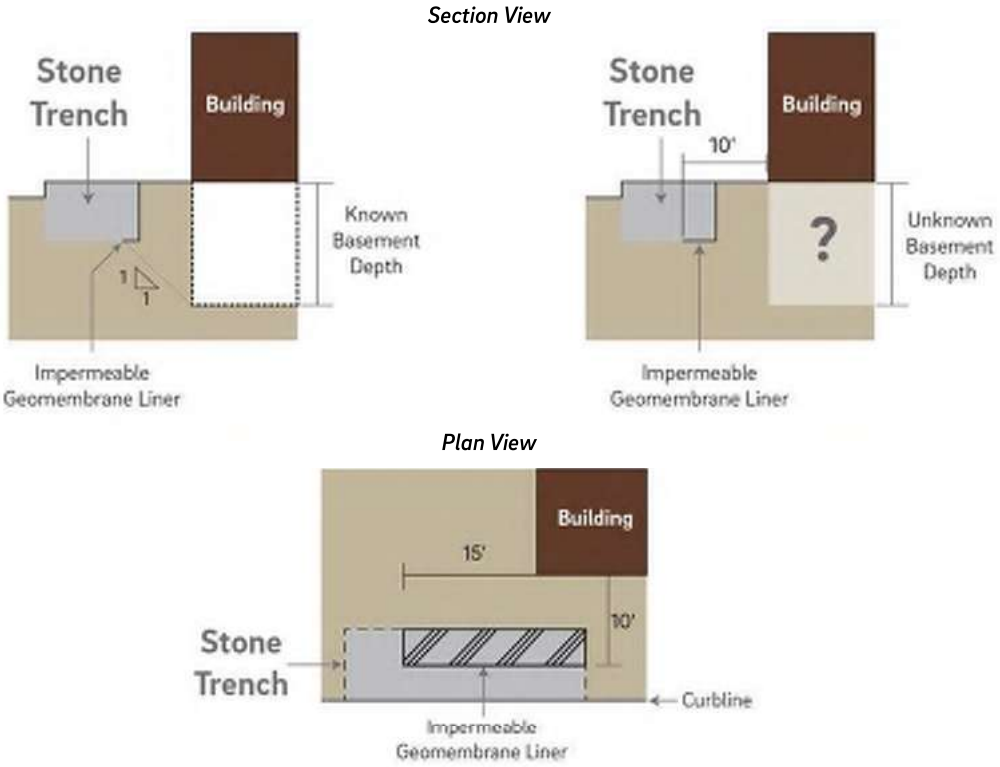


Figure 34: *Extent of impermeable geomembrane liner for trenches near buildings.*

3.3.2.6 Systems should maintain adequate separation to minimize infiltration into nearby sewer infrastructure, including sewer mains, active and inactive laterals (including stubbed laterals and slants), and/or sewer-connected inlets.

a. Review boring log(s) in the vicinity of the proposed system to identity whether there are seams, soil conditions, changes in stratigraphy, and/or limiting layers above the sewer cradle that would promote lateral movement of water into the sewer. In the presence of those conditions, additional lining will be required as noted in *3.3.2.7*.

b. If the system is within the area defined by a 1V:1H projection from the bottom of the sewer cradle to the top of the provided storage, then the part of the system storage in that area should be wrapped with an impermeable geomembrane liner. See ***Figure 35***.

c. Partial lining at active and inactive laterals, including stubbed laterals, should extend along the bottom and sides of the trench within a 1V:4H projection from the assumed invert of the lateral or a minimum distance of 1'-6". PWD project manager will provide guidance on lining standards near any stubbed laterals to be abandoned.

d. When lining of the trench with impermeable geomembrane is required due to proximity to sewer infrastructure, the geomembrane should cover the ends of the trench as well.

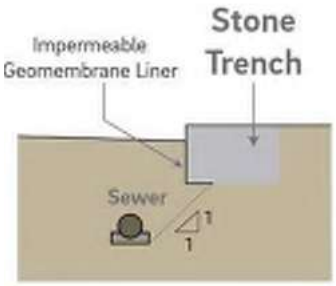


Figure 35: *Impermeable geomembrane liner offset near sewers.*

3.3.2.7 Additional impermeable geomembrane lining near sensitive structures such as basements or sewers should be included in the following scenarios:

a. Where there is evidence of loose fill or miscellaneous fill with debris; limiting layers such as fine-grained silt or clay layers beneath granular sand layers; or dense, micaceous, horizontally bedded soils; additional lining should be included.

- If this material is observed in the upper stratum from the surface to one foot above the bottom of the system, lining of the sides of the system is sufficient.
- If the material is observed anywhere within the zone from one foot above the bottom of the system to the invert of the sewer or basement, the system should be fully lined.

b. Additional impermeable geomembrane lining should be considered where the water table is less than 15 feet below grade, particularly for systems with higher loading ratios (>20:1).

3.3.2.8 Where not in the vicinity of sensitive structures such as basements or sewers, the bottom elevation of an infiltrating system should be a minimum of two (2) feet above any infiltration-limiting layer, such as bedrock or seasonal high groundwater. See *PA BMP Manual* for more information.

3.3.2.9 A six (6) inch sand layer is generally preferred as media separation between the bottom of stone storage and the subgrade for infiltrating systems. Geotextile should be used along the sides and top of the system and tucked six (6) inches under the bottom of the stone layer. See ***3.3.12 Typical Details*** for the Stormwater Trench Cross Section functional detail, which includes additional guidance on sand and geomembrane liner configurations.

Detention/Slow-Release Systems

Requirements

3.3.2.10 Detention/slow-release systems must be designed to release at a maximum rate of 0.05 cfs per acre of contributing impervious drainage area. Release rates should be rounded to the nearest hundredth.

3.3.2.11 Slow-release rates and orifice sizing should be calculated using the orifice equation.

$$Q = C_d A_o \sqrt{2gh}$$

Where:

Q = Peak Release Rate

C_d = Discharge Coefficient = 0.62

A_o = Area of Orifice (ft^2) = $\pi * r^2$

g = Gravity (ft/s^2) = 32.2

h = Slow-Release Hydraulic Head (ft)

3.3.2.12 For constructibility, orifice diameters must be sized for common drill bits (must be a multiple of 1/8 inch).

3.3.2.13 Orifice diameters must not be less than 0.5 inches to minimize the potential for clogging.

Guidelines

Note: For systems that are not fully lined with impermeable geomembrane liner, see additional guidance on previous pages. This guidance is relevant even for detention/slow-release systems.

3.3.2.14 If design infiltration rates are found to be less than 0.25 inches per hour, or if the system is fully or mostly lined, the system should be designed for detention/slow-release.

3.3.2.15 Systems may also be lined and designed for detention/slow-release if geotechnical findings or contamination issues make infiltration inadvisable.

3.3.2.16 Detention/slow-release systems should route ground-level runoff through a PWD-approved pollutant reducing SMP where possible and cost-effective. Pollutant reducing SMPs include basins, planters, rain gardens, bumpouts, green gutters, stormwater trees, or other SMPs that route runoff through a soil profile or other equivalent porous media.

3.3.2.17 Model calculations may be used in lieu of the equations shown at the discretion of the PWD project manager.

3.3.2.18 For surface features, it is recommended that ponding areas drain completely in less than 24 hours. Drain down time for detention/slow-release systems with a uniform horizontal cross section should be calculated using the following equation. This equation was derived from the submerged orifice discharge formula and modified to account for volume draining through a porous media, as is typical in PWD GSI systems. The detailed derivation of this equation is available upon request from the PWD project manager.

$$t = \frac{2V}{C_d A_o \sqrt{2gh} * 3600}$$

Where:

t = Time (hrs)

V = Storage Volume (ft^3)

h = Slow-Release Hydraulic Head (ft)

C_d = Discharge Coefficient = 0.62

A_o = Area of Orifice (ft^2) = $\pi * r^2$

g = Gravity (ft/s^2) = 32.2

3.3.2.19 Drain down time for detention/slow-release systems with a varying cross-sectional area, such as rain gardens, bumpouts, and planters, should be calculated using the following equation. For the purposes of this calculation, each layer that has a constant cross-sectional area will be defined as a "drainage layer". PWD project manager can provide more information on the derivation of this equation upon request.

$$t = \frac{2V}{C_d A_o \sqrt{2g} * 3600} \left[A_1\varphi_1(\sqrt{h_1} - \sqrt{h_2}) + A_2\varphi_2(\sqrt{h_2} - \sqrt{h_3}) + A_n\varphi_n(\sqrt{h_n} - \sqrt{h_{n+1}})\ldots\right]$$

Where:

t = Drain down time from the top of storage to the orifice elevation (hr)

C_d = Orifice discharge coefficient

A_o = Area of the orifice (ft^2)

g = Acceleration due to gravity (32.2 ft/s^2)

A_n = Cross-sectional area of specified drainage layer (ft^2)

φ_n = Effective porosity of specified drainage layer

h_n = Head above the orifice at top and/or bottom of specified drainage layer (ft)

3.3.2.20 The effective porosity is defined as the pore volume divided by the total volume in the drainage layer, depending on the type and amount of storage media. To calculate effective porosity, calculate the pore storage volume in each drainage layer. The effective porosity calculation for DL_1 is:

$$\varphi_1 = \frac{V_{storage\ 1\text{-}2}}{A_1(h_2 - h_2)}$$

Where:

φ_1 = Effective porosity in drainage layer 1

$V_{storage\ 1\text{-}2}$ = Pore storage volume in drainage layer 1 between h_1 and h_2, including ponding volume and volume in the soil pores along the pond side slopes

A_1 = Cross-sectional area of drainage layer 1

h_1 = Head above the orifice at the top of drainage layer 1

h_2 = Head above the orifice at the bottom of drainage layer 1

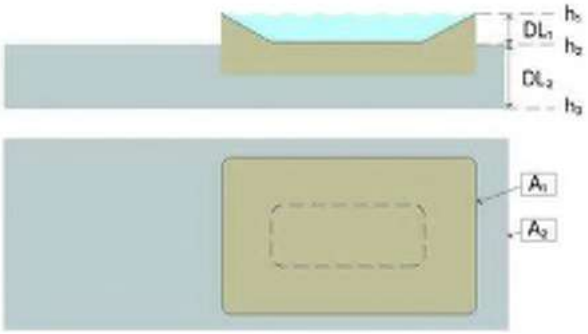


Figure 36: *Hypothetic cross-section and plan view of system with multiple drainage layers with ponding (blue), soil (brown), and gravel (gray).*

Disconnection

Requirements

3.3.2.21 Disconnection is typically comprised of depaving or modifying impervious areas such that they are routed to pervious areas. Depaving systems should meet the following criteria:

a. The flow path over the contributing impervious surface must not be more than 75 feet.

b. The length of overland flow over the pervious area must be equal to or greater than the contributing length.

c. The overland flow must be non-concentrated sheet flow over a vegetated area.

d. The soil of the pervious area must not be designated as a hydrologic soil group "D" as defined by the Natural Resources Conservation Service, United States Department of Agriculture (NRCS, USDA).

e. The slope of the overland flow path of the pervious area and the contributing impervious area must be five (5) percent or less.

f. No more than 1,000 square feet of contributing impervious area can be discharged at a concentrated, discrete point.

g. Disconnection is not designed with storage or with underdrains. If either storage or underdrains are included, then it is categorized as a detention/slow-release or infiltration system.

3.3.2.22 Disconnection may also be used to categorize the re-routing of existing inlets, or the addition of new inlets, to convey runoff that would have gone to the combined sewer system to the separate or non-contributing sewer system.

3.3.3 System Sizing

The primary reporting metric of PWD GSI is the Greened Acre (GA). GA's are an expression of the volume of stormwater, in acre-inches, managed by GSI. It is calculated using the following equation:

*GA = IC * Wd* Where:

IC (acres) = the impervious cover (formerly tributary to the combined sewer system) utilizing green stormwater infrastructure. This quantity can include the area of stormwater management feature itself, plus the area that drains to it.

Wd (inches) = the depth of water over the IC that can be physically managed in a facility.

General Considerations

Requirements

3.3.3.1 Systems must, at minimum, provide static storage for one (1) inch of runoff from the existing directly connected impervious drainage area.

3.3.3.2 Storage provided above the SMP overflow elevation cannot be included.

3.3.3.3 Storage below the orifice should be counted towards the storage volume for detention/slow-release systems that are not completely lined with an impermeable liner.

3.3.3.4 When calculating storage, the following void percentages will be used:

Table 4: *Void Percentages for Storage Calculations*

STORAGE MEDIA	VOID SPACE	NOTES
Open graded aggregate	40%	Frequently referred to as "stone"
Soil storage	20%	Soil storage up to a depth of three (3) feet can be counted in surface systems, such as bumpouts and planters.
		Soil within a tree pit should be considered storage.
Sand	30%	
Pipes embedded in systems	92%	Assumes outside diameter of pipe.
Modular storage products	Product-specific	

3.3.3.5 All systems must safely convey or bypass runoff from the 10-year design storm. This conveyance can include bypass as long as the runoff can be safely treated downstream. This check is typically conducted for off-street systems or where on-street systems propose changes to the existing inlet infrastructure.

3.3.3.6 Systems must be designed to not create any erosive conditions, either internally or at any outfall location.

3.3.3.7 Separate storage calculations must be completed for each individual system.

Guidelines

3.3.3.8 Where feasible and cost-effective, systems should provide static storage for up to 1.5 inches of runoff from the existing directly connected impervious drainage area. Storage should not exceed a volume equivalent to two (2) inches of runoff, unless otherwise approved by PWD where future connections to the GSI system are anticipated.

3.3.3.9 In order to be cost-effective, systems should manage a minimum drainage area of 8,000 SF. Individual drainage areas to each inlet should be no less than 5,000 SF. If an individual drainage area is less than 5,000 SF and adjacent to the area of system excavation, smaller drainage area thresholds may be considered.

3.3.3.10 Under current policy, only drainage areas in the right-of-way, from alleys, or on public lands should be counted for sizing considerations. Alleys with significant drainage contributing to the right-of-way that can be verified and mapped may be included in sizing, though right-of-way drainage should be prioritized in system sizing since it is a more stable land area. Designers should consider the actual topography, land use types, and discuss potential issues with the PWD project manager.

3.3.3.11 Within the right-of-way, grass strips or other highly compacted areas should be considered impervious unless modified with soil improvements as part of the proposed work.

3.3.3.12 Clean-washed stone used as sidewalk or street sub-base can be included in storage calculations where elevations allow.

3.3.3.13 Modular storage may be considered, where determined cost-effective, for sites that have constrained storage opportunities.

3.3.4 Direct Discharge

Direct discharge GSI systems collect runoff from existing combined sewer areas and DO NOT overflow back to the combined sewer. They may overflow back to a receiving waterbody or redirect runoff from the combined sewer to a separate sewer. Note that this section focuses on GSI systems, and does not cover sewer separation.

Requirements

3.3.4.1 Combined sewer greened acres are calculated as the equivalent of 2.0 inches per acre of contributing impervious drainage area being directly discharged when the other requirements listed in this section are met. Note that the greened acre value does not represent resultant load reductions to the separate storm sewer system (MS4) or direct discharges to waterbodies.

3.3.4.2 Any direct discharge systems may be designed with dynamic routing, making sure that the 1.7-inch, 24-hour NRCS Type II design storm is managed.

3.3.4.3 Any portion of managed runoff that is not infiltrated must be routed through a pollutant reducing SMP.

3.3.4.4 Systems discharging to the Delaware and Schuylkill watersheds do not have to meet release rate requirements. In other watersheds, the effect on the receiving water body must be evaluated by comparing outfall discharge to stream flow for the 1-year, 24-hour storm using USGS equations or survey/rain gauge data.

Figure 37: *Images showing types of energy dissipation at stream outfalls.*

Guidelines

3.3.4.5 Where there are concerns of damage to overflow points (outfalls, level spreaders, etc.) from large storms, upstream flow control should be used to route higher flows to the combined sewer.

3.3.4.6 The following should be considered when designing a stream outfall:

a. Ensure that outfall pipe elevation is not blocked by stream flow during rain events.

b. Consider fencing and maintenance access.

3.3.4.7 The following energy dissipation options should be considered for stream outfalls:

a. Armored or grass-lined channel

b. Step Pools

c. Pre-formed scour holes below outfall

3.3.4.8 The following energy dissipation design tools from FHWA's Hydraulic Engineering Circular (HEC) should be used for stream outfalls:

a. HEC 11 (riprap)

b. HEC 14 (energy dissipators)

c. HEC 15 (flexible linings)

3.3.4.9 The following should be considered when designing a level spreader:

a. *PA BMP Manual* may be used as design guidance.

b. Location in constructed fill should be avoided where possible.

c. Erosion control/slope stabilization must be considered in design.

d. Maintenance truck access must be provided.

3.3.5 System & SMP Structure

PWD uses a unique methodology to categorize and track GSI. Projects are composed of systems and systems are made up of SMPs. Projects are grouped into packages for design and construction, identified by a PWD work number.

A **project package** is a grouping of projects that are designed and constructed together. Identified by a PWD work number.

A **project** is a site where GSI is proposed. Identified by a GreenIT Project ID.

A **system** is one or more SMPs that function as a unit to manage a given drainage area. An example of a system is a planter above an infiltration trench; the two function together as one system, with runoff flowing from the planter to the subsurface storage below. SMPs within a system are connected either by pipes or by subsurface storage.

SMPs are assets that compose a GSI system. SMPs have unique operations requirements and so are maintained on an individual basis. Examples of SMPs include planters, bumpouts, and tree trenches. Definitions of SMP types can be found in the *PWD GSI Design Report Definitions*. See ***3.3.14 Metrics Reporting***.

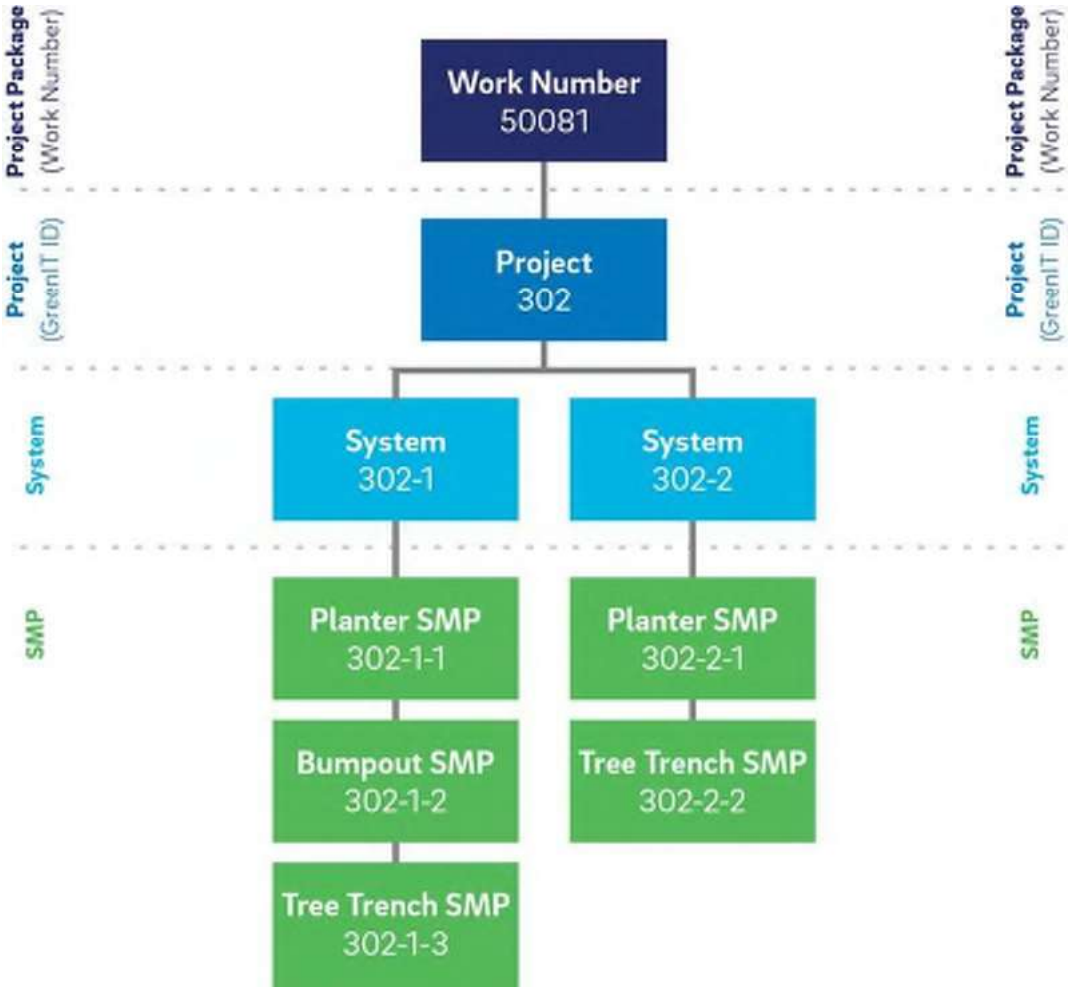


Figure 38: *This diagram illustrates the relationship between a project package (identified by a work number), and the projects, systems, and SMPs it may contain.*

Requirements

System & SMP Numbering

The system and SMP numbering begins on the design plans and in the design metrics report and is ultimately carried over to PWD's GIS asset tracking system and green metrics tracking database, GreenIT, creating a link between GreenIT and PWD's GIS system. To develop the numbering, the PWD project manager communicates the Project ID to the design consultant at the start of the project. Using the Project ID as the root of the numbering, the design consultant develops the system and SMP numbers and adds the numbers to the design plans, design report, cost estimate, and calculations. The Design Consultant is responsible for ensuring that the numbering matches between the plans and the report throughout the design phase. For more information, refer to the ***3.3.10 Survey & Drawing Standards***.

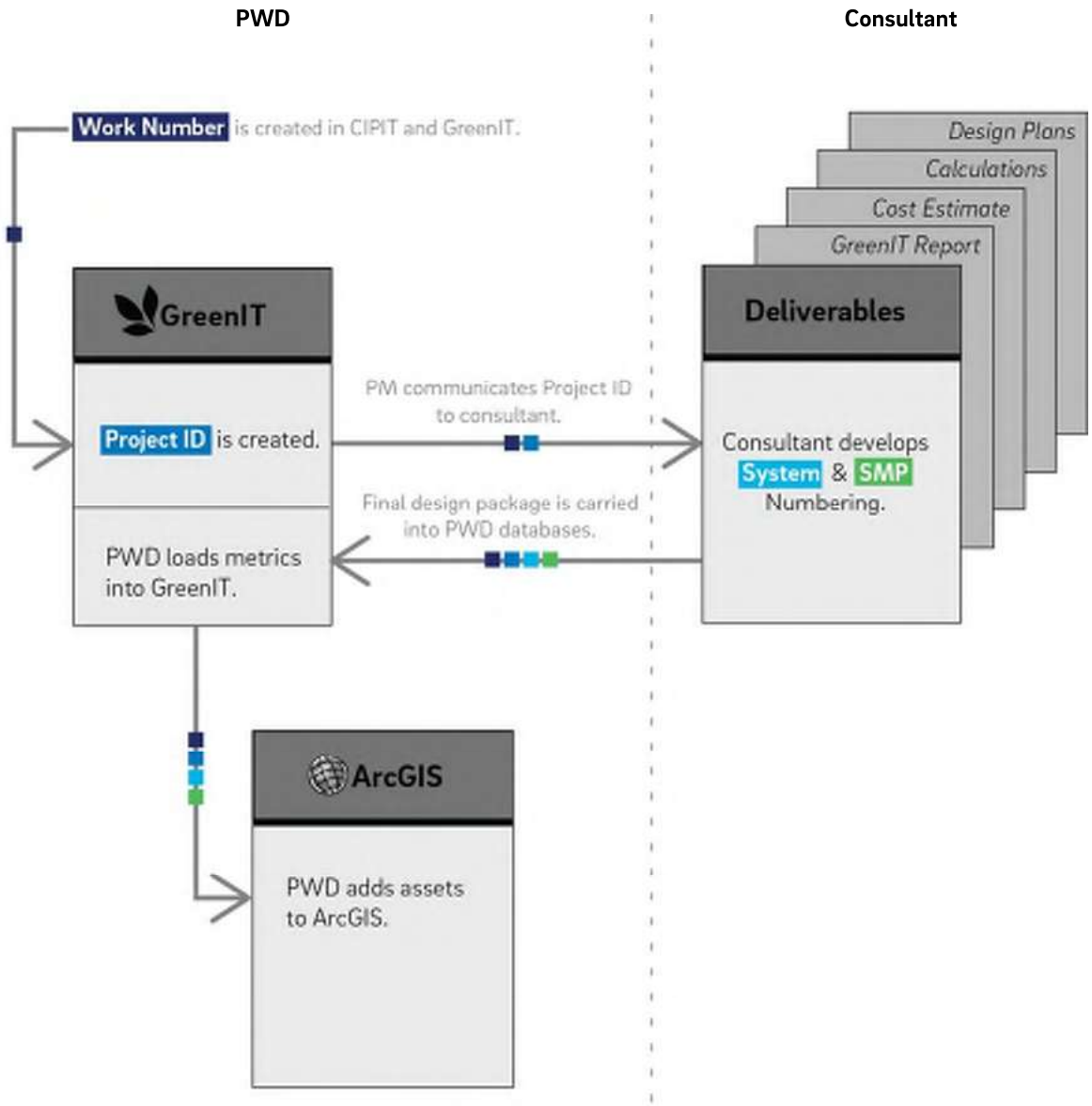


Figure 39: *This diagram illustrates the relationship between the PWD GIS system and design plans, GreenIT report, cost estimate, and calculations to share data on project and system numbers.*

SMP Rules

The following rules describe how individual SMPs are defined. These rules are based on maintenance requirements, often depending on the presence of piping or the distinction between surface features (typically rain gardens, bumpouts, and planters) and subsurface storage.

3.3.5.1 Each surface feature should be counted as a separate SMP.

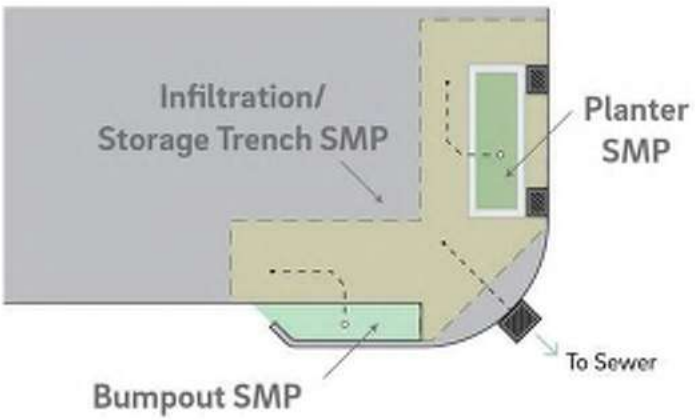


Figure 40: *Example of two (2) separate surface SMPs with a typical underlying subsurface SMP.*

3.3.5.2 When there is NO maintenance access to subsurface storage below a surface SMP, the subsurface storage should be counted as part of the surface SMP.

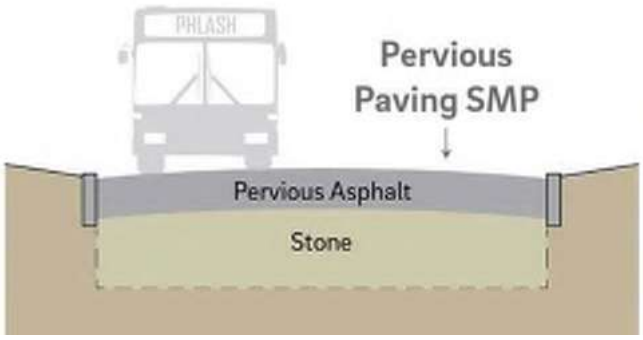


Figure 41: *Example of a surface SMP including stone storage.*

3.3.5.3 When there IS maintenance access to subsurface storage below a surface SMP, the subsurface storage should be counted as a separate SMP.

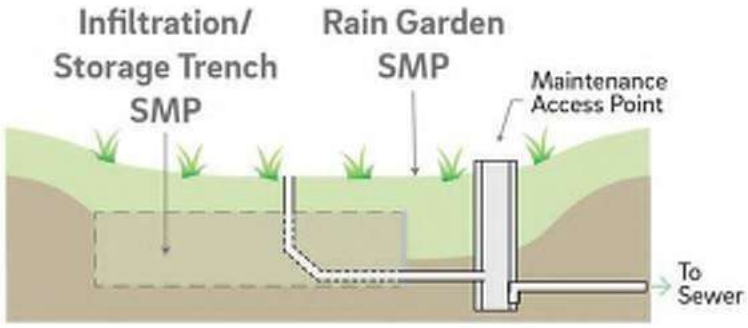


Figure 42: *Example of a surface SMP over a separate subsurface SMP with maintenance access.*

3.3.5.4 Any subsurface feature with an open pipe (no orifice) between sections should be counted as one (1) SMP. New SMPs should not be created due to breaks in actual trench work or for sections of trench that are located on a different block. If part of a system's trench work includes trees but another part does not, the SMP is still coded as a tree trench.

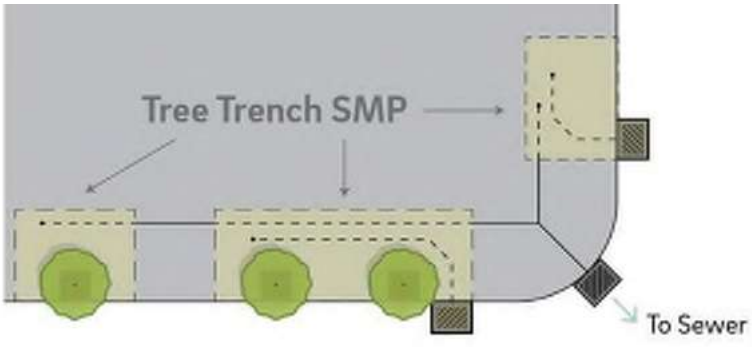


Figure 43: *Example of a tree trench SMP with separate hydraulically connected sections.*

3.3.5.5 When sections of a subsurface feature are separated by an orifice (in a water level control structure for example), each section should be counted as a separate SMP.

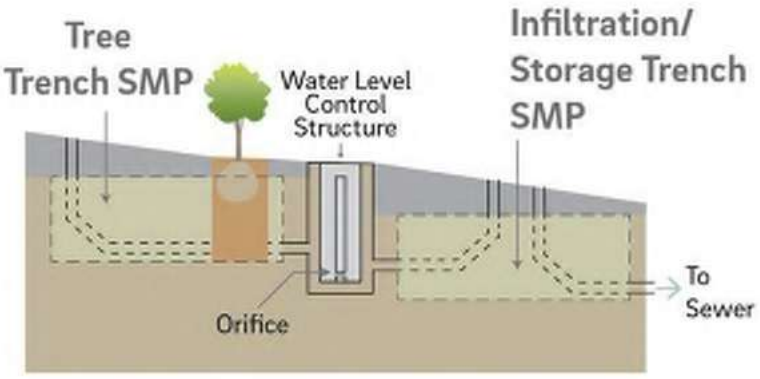


Figure 44: *Example of two (2) separate SMPs, a tree trench and infiltration trench.*

3.3.6 Inlets

Inlets are entry points for stormwater runoff to enter GSI systems. PWD GSI projects typically utilize green inlets, dual catch basins, curb cuts, and trench drains as inlet structures.

Figure 45: *Images showing the various types of inlets to convey runoff to GSI systems. From left to right: a green highway grate inlet, a green city inlet, a curb cut with wheel guard and energy dissipator, and a trench drain.*

Inlet Capacity

Requirements

3.3.6.1 Drainage area, defined as the measure of surface area upon which runoff converges to a single low point, must be determined for each inlet and system.

3.3.6.2 Separate capacity calculations must be completed for each individual routing component and when considering removing non-green inlets.

Exception: Inlet capacity calculations are not required when using a PWD standard inlet following the inlet size requirements of the *PWD Water & Sewer Design Manual*

3.3.6.3 Required inlet capacity must be designed using the Rational Method, which utilizes the following equation:

$$Q = CiA$$

Where:

Q = Peak Runoff Rate (cfs)

C = Runoff Coefficient

i = Average Rainfall Intensity (in/hr)

A = Drainage Area (acre)

3.3.6.4 The average peak 1-year, 15-minute intensity from the 24 rain gage network in Philadelphia is 2.5 inches per hour.

3.3.6.5 Grated inlets must utilize a clogging reduction factor of 0.5 (assuming only half of the opening is available for conveyance of stormwater to the GSI system). This factor must be applied to the unclogged inlet capacity of the inlet and the resulting clogged interception capacity compared to the design intensity flow rate.

Guidelines

3.3.6.6 PWD uses a typical trench drain detail that establishes a 4.5 foot curb opening length. Trench drains can be used without needing to do independent curb opening length calculations where the drainage area is less than 15,000 SF and the longitudinal slope is less than 6%.

3.3.6.7 Where curb opening lengths need to be sized, follow the methods described in the *FHWA Hydraulic Engineering Circular No. 22 (HEC-22)*. However, different coefficients should be used in the curb opening length equation (see below) to better represent PWD inlets. The basis for these modifications are presented in the *"Hydraulic Efficiency of Street Inlets Common to UDFCD Region" technical memorandum* (see equation 3 for CDOT type R inlets).

Where: L_T = Curb opening length required to intercept 100% of gutter flow (ft)

N = 0.38

Q = Peak Runoff Rate (cfs)

a = 0.51 (acre)

S_L = Longitudinal Slope

b = 0.06

n = Manning's Roughness Coefficient

S_e = Equivalent Transverse Street Slope

c = 0.46

Inlet Selection

The following guidelines are used to determine inlet selection. More information about standard inlet design, typical placement locations, inlet photos, and preferred sewer connection types can be found in the *PWD Water & Sewer Design Manual*.

Requirements

3.3.6.8 For systems in the right-of-way, all sewer-connected inlets should conform to the types and locations specified in the *PWD Water & Sewer Design Manual*. See Appendix 5A.

Guidelines

3.3.6.9 Green inlets (inlets that convey runoff to GSI systems) are typically placed 5-feet upstream of existing sewer-connected inlets.

3.3.6.10 The PWD Standard Green Highway Grate Inlet is preferred for conveying street runoff to a subsurface system. A green city inlet may be used when there is a conflict in the cartway.

3.3.6.11 For off-street applications or surface systems, other inlet selection, such as shallow green city inlets or trench drains, may be considered at the advisement of the PWD project manager.

3.3.6.12 Dual catch basin inlets should only be considered where other inlet types are infeasible due to space constraints. Dual catch basin inlets connect to both the GSI system and to the sewer, diverting flow over an overflow weir. When using dual catch basin inlets, designers should keep in mind that the top of storage elevation for the GSI system cannot be higher than the elevation of the top of the dual catch basin weir. When these inlets are proposed at a low point, designers should also evaluate the risk of surface flooding because dual catch basin pretreatment adds difficulty to maintaining the inlet in flooded conditions.

3.3.6.13 Trench drains may be used to convey runoff to surface features in some scenarios, though a shallow inlet is preferred.

a. PWD uses a typical trench drain detail that establishes width and curb opening length. See ***3.3.12 Typical Details***.

b. Do not install trench drains longer than 20 feet.

c. Avoid grade changes of trench drain grate.

d. Trench drain lengths should be in two (2) foot increments to avoid cutting grate castings.

3.3.6.14 Energy dissipation should be included at all inflow points to all surface features to minimize erosion.

3.3.6.15 All green inlets should have permanent inlet protection included for pretreatment. The PWD Master Green Specifications includes the requirements for standard pretreatment provisions.

Inlet Replacement

The following guidelines must be used to determine inlet replacement. More information about standard inlet replacement, typical placement locations, inlet photos, and preferred sewer connection types can be found in the *PWD Water & Sewer Design Manual*.

Requirements

3.3.6.16 If underdrain connections to the existing inlet are being made, the considerations below must be used to determine if the existing inlet should be replaced.

3.3.6.17 Replace all No. 1, No. 2, No. 3, or No. 4 old City inlets. Inlet pipe diameter for existing No. 3 and No. 4 City inlets is 12 inches and 8 inches respectively, and therefore should be reconstructed with 15 inch diameter VCP the full length back to the sewer. Exceptions made for sewers less than 15 inches in diameter.

3.3.6.18 Any inlet that has a brick inlet box must be replaced, regardless of whether the inlet has a newer top style. Type of inlet box is determined during survey by visual inspection.

3.3.6.19 Replace all inlets in poor condition or inlets with a history of problems. PWD project manager can provide inlet history report.

Guidelines

3.3.6.20 If underdrain connections are not being made to the existing inlet and the surrounding footway/paving is not being replaced, inlets may not need to be replaced.

3.3.6.21 If inlet replacement is required, the PWD project manager can provide guidance on whether designs should propose new sewer connections or reconnections to the existing lateral.

3.3.6.22 Designs that propose to abandon existing inlets to increase the drainage area directed to a system should be discussed with the PWD project manager. Inlet removal requires review by PWD Collectors Systems and Water/Sewer Design Utility Engineering.

3.3.7 Piping

General Considerations

Requirements

3.3.7.1 Acceptable pipe materials for GSI distribution and underdrain pipes are:

a. HDPE - perforated or solid, located outside cartway

b. Ductile Iron - solid, located in cartway and perpendicular to curb

c. PP - perforated or solid, located in cartway and parallel to curb

d. PVC - solid, located outside cartway

3.3.7.2 Distribution and underdrain pipes must not be less than eight (8) inches in diameter.

3.3.7.3 Cleanouts must be included, at minimum, every 75 feet and at the end of all pipes.

3.3.7.4 Cleanouts should be located upstream of complicated bends and evenly spaced along straight pipe runs.

3.3.7.5 All intermediate (mid-run) cleanouts and domed riser connections must be oriented downstream to direct all CCTV inspections towards an inlet.

3.3.7.6 Every run of pipe must be accessible from at least two (2) points, such as a cleanout and an inlet connection.

3.3.7.7 All pipes must have a structure to which they can be flushed. Typically, flushing can occur back to an inlet.

a. If pipes do not connect to an inlet, then a sump or other point where debris can be flushed to and removed should be provided. Flushing points are, at a minimum, sumped two (2) feet by two (2) feet concrete structures.

b. If trash and debris will be removed through a PVC catch basin or domed riser, then the structure must be sumped with a minimum diameter of 12 inches and pipe inverts must be no more than four (4) feet below the rim for accessibility.

3.3.7.8 The maximum allowable pipe bend is 45 degrees.

3.3.7.9 Boot seals must be included at any point where a pipe penetrates an impermeable geomembrane liner. This includes utility crossings, distribution pipes, and underdrain pipes.

3.3.7.10 Anti-seep collars should be used in order to prevent water from traveling along the outside of pipes and impacting sensitive structures/utilities or short-circuiting back to sewer. Place anti-seep collars on all pipes entering or exiting GSI storage media when sides are not lined with impermeable geomembrane liner and water should be prevented from traveling along pipe. Anti-seep collar should be placed offset from system where space allows to increase effectiveness.

3.3.7.11 For off-street projects, the condition and capacity of the existing drainage structures (inlets and pipes) must be evaluated when considering whether to reuse as overflow or distribution structures.

Guidelines

3.3.7.12 Cleanouts should not be located in driveways or in the cartway whenever possible. This allows for easier maintenance access.

3.3.7.13 Where possible, cleanouts should not be located in vegetated areas.

3.3.7.14 Cleanouts should be located to provide minimum 6-inches clearance from edge of frame or concrete collar to nearby site features (curbing, tree pits, sidewalk edge, etc.).

3.3.7.15 Pipe bends, both vertical and horizontal, should be avoided whenever possible. Straight pipes are easier and less time consuming to maintain than pipes with bends.

3.3.7.16 Wye fittings should generally be avoided. If used, they must be placed within 18" of inlets so cleaning hoses can be directed along specific pipe runs.

3.3.7.17 Solid pipes should extend 1-2 feet into systems to allow space for the solid to perforated pipe transition.

3.3.7.18 Minimum cover over pipes in the right-of-way or in vehicular paths should be two (2) feet, unless alternative design is approved by the PWD project manager.

3.3.7.19 Green inlets, where appropriate, may be connected in series by a distribution pipe. The distribution pipe between inlets should generally have a minimum slope of 0.5% towards the inlet most adjacent to the system so that runoff is directed towards the GSI.

3.3.7.20 Inlet and outlet pipes that daylight to the surface should be protected from entry with removable, hydraulically-efficient bars or grates if they present a safety hazard. This protection should be included when the pipe diameter is 8-inches or greater and when the pipe length or configuration does not allow daylight to be seen from end to end.

3.3.7.21 In order to avoid root intrusion, pipes should not run underneath tree pits. Avoid close horizontal proximity as well.

3.3.7.22 Flexible coupling must be used when connecting ductile iron to thermoplastic (HDPE and PP) pipes.

Figure 46: *Images showing the various types of piping used in PWD's GSI systems. From top left to bottom right: HDPE, PVC, VCP, RCP, ductile iron.*

Underdrains

Requirements

3.3.7.23 To protect underdrains from sedimentation and trash, underdrain pipes should not have an open connection to any surface features; i.e. underdrain pipes should end in cleanouts and never in domed risers.

Guidelines

3.3.7.24 Regardless of whether a system is designed for infiltration or for detention/slow-release, underdrains should be considered for all systems (not applicable to disconnection systems). This allows for conversion to a detention/slow-release system if the system fails to infiltrate due to clogging.

3.3.7.25 Underdrains should extend inside the system for a minimum length of 20 feet. Lined surface systems should include more extensive underdrains to ensure full draindown of ponded and soil storage.

3.3.7.26 Underdrains should connect perpendicularly to the adjacent existing inlet or a sewer connected control structure. The underdrain should terminate either in a solid cap or orifice depending on whether the system is designed for infiltration or detention/slow-release.

> Exception: If it is not possible or advisable to connect the underdrain to an adjacent existing inlet, then the underdrain should extend for a minimum of five (5) feet outside of the system and be capped. This allows for future access to the underdrain without disruption of the system should the system need to be converted to detention/slow-release.

3.3.7.27 Provide, at minimum, a seven and a half (7 ½) inch offset between the invert of the underdrain pipe and the invert of the outlet pipe to the sewer. See section ***3.3.12 Typical Details*** for the Standard Inlet with Underdrain Connection detail.

3.3.7.28 When a trench is broken into multiple segments, the underdrain should be extended through subsequent trench sections to ensure that the full trench has the ability to drain down.

3.3.7.29 Underdrains should be sumped to increase storage capacity in systems fully lined with an impermeable geomembrane liner.

GSI Sewers

A GSI sewer is a stormwater conduit designed to convey drainage from multiple city blocks to a Centralized GSI Facility. Designers should follow the general requirements for stormwater conduits in the *PWD Water & Sewer Design Manual* except where they differ with the language below.

Requirements

3.3.7.30 GSI sewers should be able to flow at full capacity (maximum flow entering inlet laterals) without overflowing manholes. Hydraulic grade line (HGL) must remain below rims of manholes.

3.3.7.31 GSI sewers should be designed with a minimum velocity of two (2) feet per second. Designs should attempt to maintain velocity without sacrificing GSI system depth.

3.3.7.32 Acceptable pipe materials for main sewer stem and inlet connections are:

a. Reinforced concrete – minimum 15 inch diameter, should be built with a continuous concrete cradle

b. Ductile iron – for diameters less than 15-inches and shallow covers less than two (2) feet, diameters 12-inches and greater should be built with a continuous concrete cradle

c. HDPE/PP – outside of cartway at depths two (2) feet or greater

d. VCP – used only for tight inlet connections where numerous bends are required

3.3.7.33 If the proposed GSI sewers modify existing sewersheds, designs must confirm that the existing sewer has capacity for the potential increased flow. The PWD design project manager will coordinate internally with PWD's Hydraulic & Hydrologic (H&H) Modeling Group.

3.3.7.34 Borings, as noted in the *PWD Water & Sewer Design Manual*, are required where the bearing capacity is unknown.

Guidelines

3.3.7.35 GSI sewers do not typically require capacity for high intensity storms if GSI sewer inlets can overflow to existing sewer inlets. The flow rate of runoff that enters a GSI sewer should be limited through pipe sizing or orifices on laterals.

3.3.7.36 If an inlet lateral is in the vicinity of a manhole, it is preferred to connect directly to the manhole rather than to the sewer.

3.3.7.37 A manhole is needed at the upstream end of a pipe run if the run is 300 feet or longer. Shorter pipe runs may end in an inlet.

3.3.7.38 Where possible, avoid placing manholes in the middle of intersections or the driving lanes of busy roads.

3.3.7.39 Runoff from large storms should be allowed to bypass the GSI system and flow to the existing sewer.

3.3.7.40 Consider the location of residential sewer, water, and gas laterals in design.

3.3.7.41 GSI sewers should be located within the street, at minimum five (5) feet from the curbline, to minimize the need for curb, sidewalk, and ADA ramp replacement.

3.3.7.42 GSI sewer alignments are preferred to run parallel along streets and not at angles.

3.3.7.43 Stacking GSI sewers on top of existing sewers may be considered based on the condition of the existing sewer or if sewer lining/reconstruction is included in project scope. Early discussion with the PWD project manager about this is encouraged.

Figure 47: *Examples of GSI sewers during construction. From left to right, top to bottom: Ferko Playground, Wissinoming Park, Lanier Playground.*

3.3.8 Monitoring

Observation Wells

Requirements

3.3.8.1 A minimum of one (1) observation well is required for each GSI system, including systems that are fully lined with an impermeable geomembrane liner.

3.3.8.2 The placement of the first observation well should not exceed a distance of more than 50-feet from the primary inflow structure to the subsurface. For larger systems, additional observation wells are required so that any part of the system footprint is within a 100-foot radius of at least one observation well.

Guidelines

3.3.8.3 For trenches that are broken into 2 to 4 sections, one observation well is recommended in the first section and one in the last section. For trenches broken into more than 5 sections, one observation well is recommended in the first section, one in the middle section, and one in the last section.

3.3.8.4 Observation wells should not be located in driveways. If possible, avoid placing in the cartway as well. This allows for easier monitoring access.

3.3.8.5 Where possible, observation wells and maintenance ports should not be located in vegetated areas.

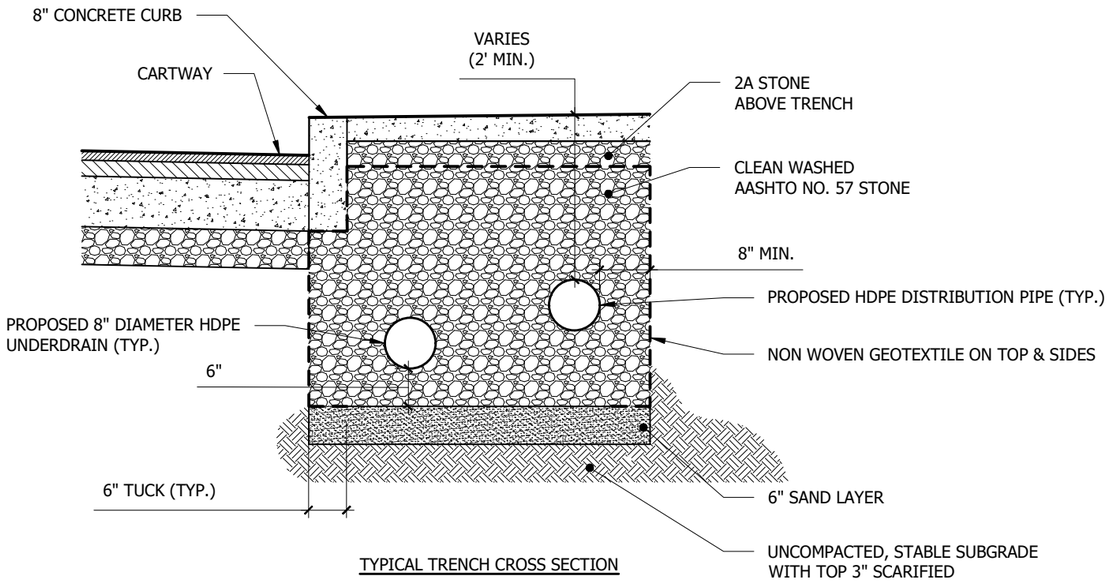
3.3.8.6 Observation wells should be located to provide minimum 6-inches clearance from edge of frame or concrete collar to nearby site features (curbing, tree pits, sidewalk edge, etc.).

Groundwater Monitoring Wells

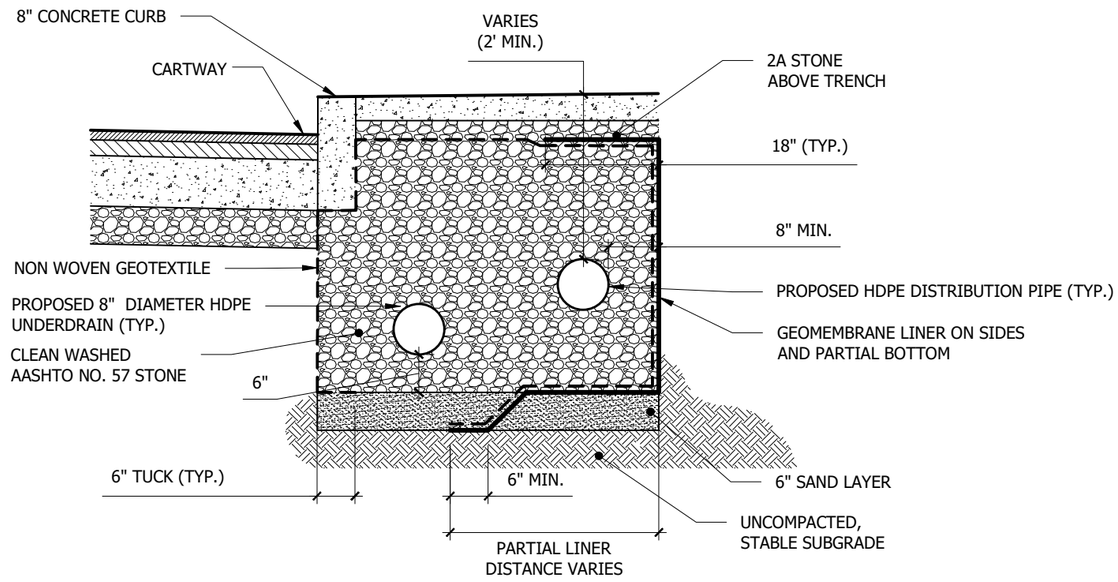
Requirements

3.3.8.7 Groundwater monitoring wells must be installed on the proposed site for Centralized GSI Facility projects. The wells are to be monitored by PWD for a full year prior to design of Centralized GSI Facility projects to evaluate the seasonally high groundwater levels and provide data for design phase groundwater mounding analyses.

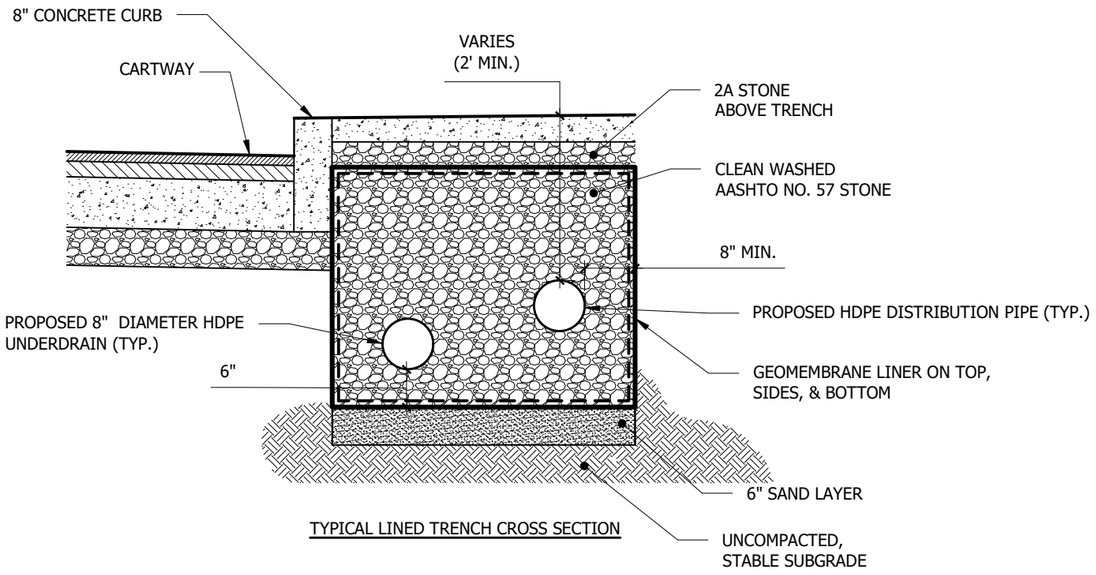
Original Details from: https://water.phila.gov/pool/files/gsi-typical-details.pdf



TYPICAL TRENCH CROSS SECTION



TYPICAL PARTIALLY LINED TRENCH CROSS SECTION



TYPICAL LINED TRENCH CROSS SECTION

NOTES TO DESIGNER:

1. THE CROSS SECTIONS ABOVE ARE INTENDED AS AN EXAMPLE AND CAN BE MODIFIED AND USED FOR SECTIONS ON PLANS.
2. AVOID PLACING GEOMEMBRANE LINER UNDER CURB IF POSSIBLE. WHEN GEOMEMBRANE LINER IS PLACED UNDER CURB, INCLUDE THE FOLLOWING CALLOUT: "DO NOT PUNCTURE GEOMEMBRANE LINER WITH CURB FORM PINS"

SEE DECEMBER 2020 ADDENDUM FOR UPDATE

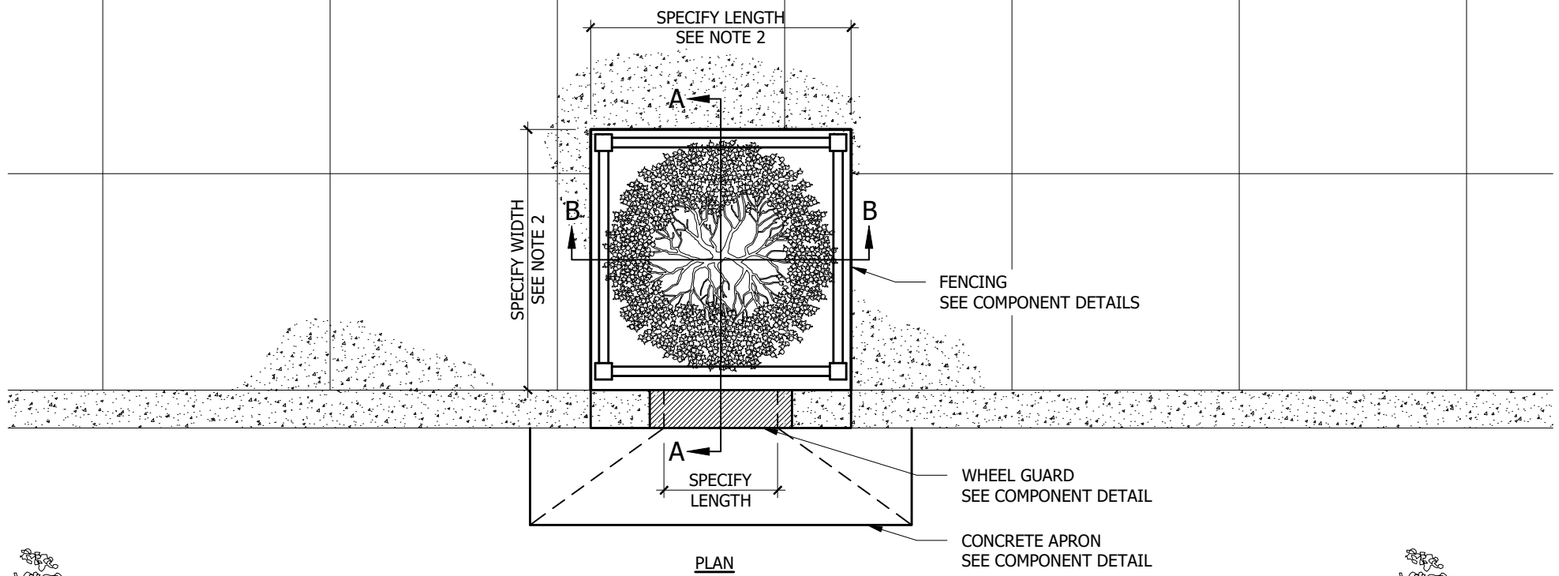
Modified by Pennoni Associates for Stormwater Drainage Study- Green Infrastructure Details

STORMWATER TREE TRENCH CROSS SECTION

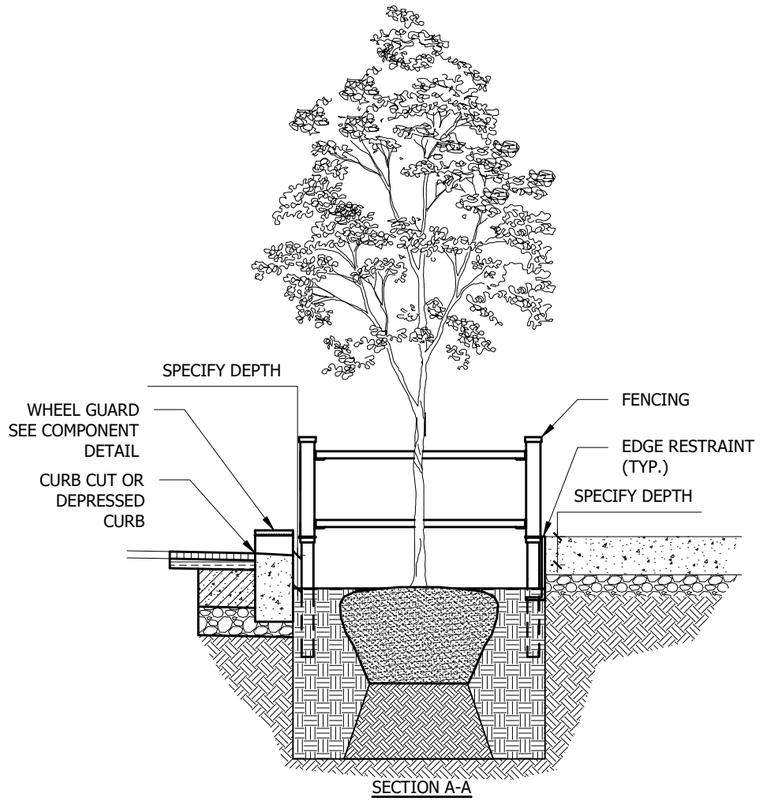
SCALE: N.T.S.

VS.	DATE	INITIALS	REASON
1	06/09/2017	MJD	ADDED PARTIALLY LINED TRENCH SECTION
2	06/01/2018	MJD/DJM	CONVERTED TO FUNCTIONAL DETAIL, ADDED GEOTEXTILE AND SAND TO PROTECT GEOMEMBRANE LINER

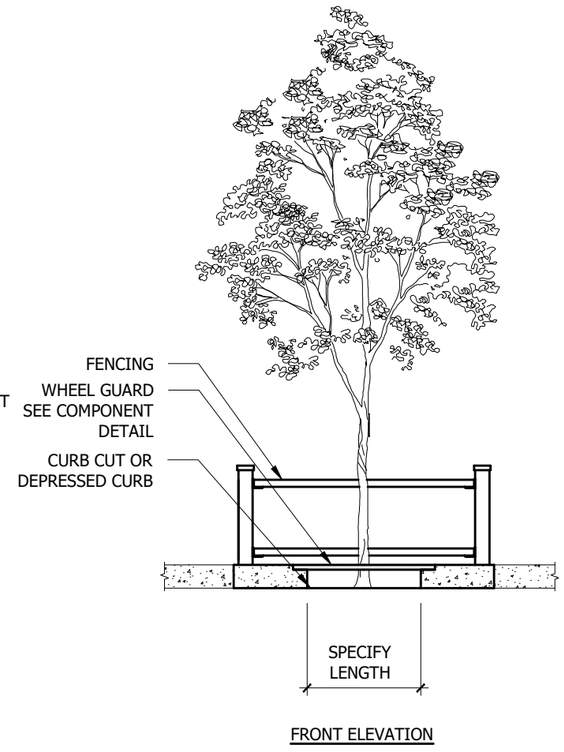
DRAWING NUMBER: F-2



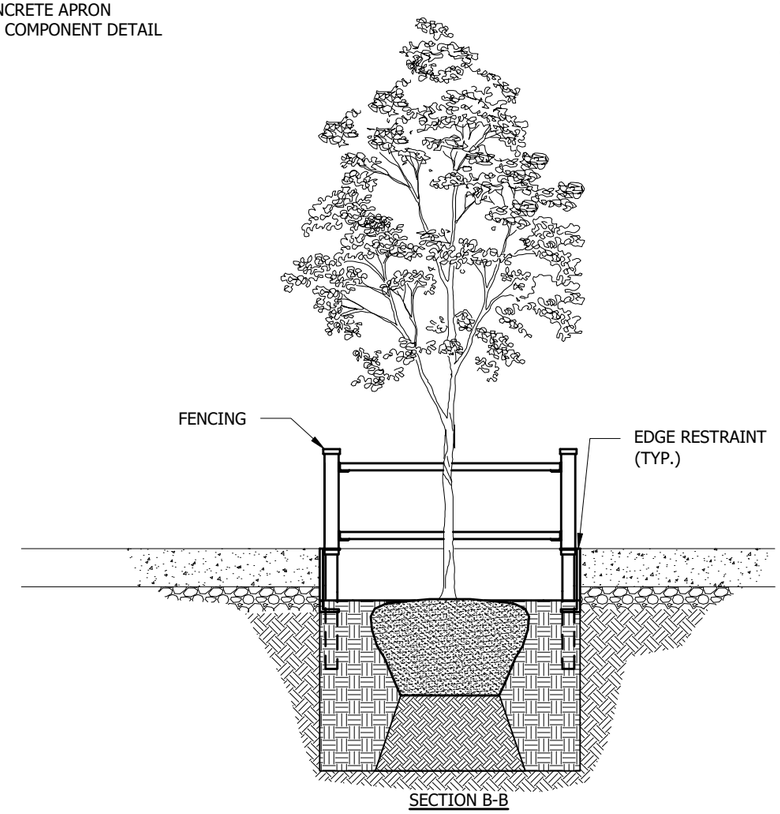
PLAN



SECTION A-A



FRONT ELEVATION



SECTION B-B

NOTES TO DESIGNER:

1. THIS DESIGN DETAIL SHOULD BE ADAPTED TO THE SPECIFIC ENGINEERED DESIGN OF A RESPECTIVE INSTALLATION.

2. THE MINIMUM TREE PIT DIMENSION FOR TREE PITS IS 4-FEET BY 4-FEET (3-FEET BY 5-FEET CAN BE USED IN AREAS WHERE SIDEWALK WIDTH OR ADA ACCESS IS A CONSTRAINT). LARGER TREE PIT AREAS ARE PREFERRED FOR THE HEALTH OF THE TREE AND IN CONSIDERATION OF ACHIEVING THE APPROPRIATE LOADING RATIO, AND SHOULD BE USED IF SPACE IS AVAILABLE. TREE PIT MAY ALSO BE RECTANGULAR IN SHAPE.

3. DESIGN SHOULD INCLUDE LOCATION AND SPECIES SELECTION OF TREE. NOTE, HOWEVER, THAT LOCATIONS AND SPECIES OF ALL TREES ARE REVIEWED AND APPROVED BY PP&R. PP&R CAN ALSO SELECT TREE SPECIES, IF REQUESTED.

4. ALTHOUGH SURFACE IS SHOWN AS CONCRETE SIDEWALK, STORMWATER TREES CAN BE CONSTRUCTED ADJACENT TO VARIOUS SURFACES INCLUDING GRASS STRIPS, PAVERS, AND OTHER MATERIALS..

5. DESIGNER MUST ENSURE THE PLANTING MEDIA SURFACE IS SET AT AN ELEVATION TO PREVENT EXPOSURE OF THE SIDEWALK'S AGGREGATE SUBBASE. IF DEPTH OF THE PLANTING MEDIA SURFACE WILL CAUSE THIS MATERIAL TO BE EXPOSED, DESIGNER SHOULD DESIGN A SYSTEM TO PREVENT THIS MATERIAL FROM SLOUGHING INTO THE TREE PIT.

6. THE PONDING DEPTH OF WATER IN THE STORMWATER TREE IS CORRELATED TO A VARIETY OF SITE SPECIFIC FACTORS SUCH AS SURROUNDING GRADES, OFFSETS BETWEEN STORMWATER TREE ENTRANCE ELEVATIONS AND TOP OF PLANTING MEDIA, OFFSETS BETWEEN STORMWATER TREE ENTRANCE AND OVERFLOW ELEVATIONS, DESIRED FREEBOARD, AND THE DESIGN DEPTH OF THE STORMWATER TREE. THE DESIGNER SHOULD EVALUATE SITE SPECIFIC CONDITIONS SUCH AS THOSE MENTIONED IN ORDER TO ACHIEVE A TYPICAL PONDING DEPTH OF 6" AND TO MAXIMIZE PONDING DEPTH TO THE EXTENT POSSIBLE.

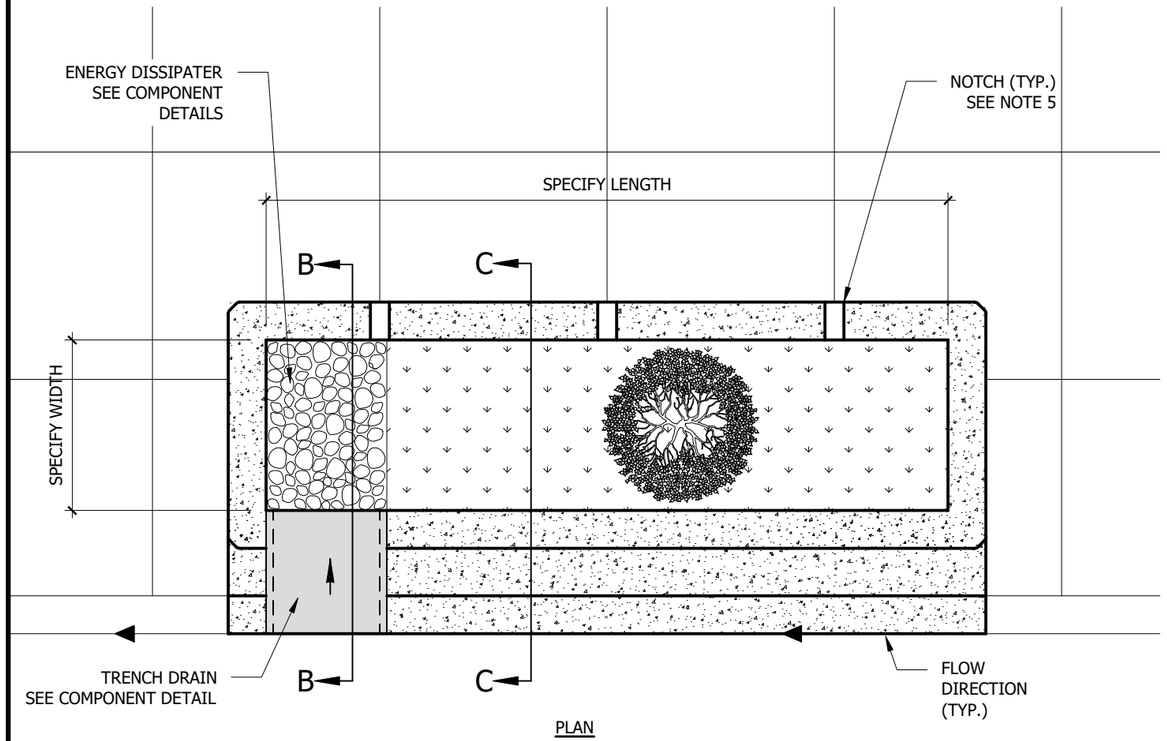
Modified by Pennoni Associates for Stormwater Drainage Study- Green Infrastructure Details

STORMWATER TREE

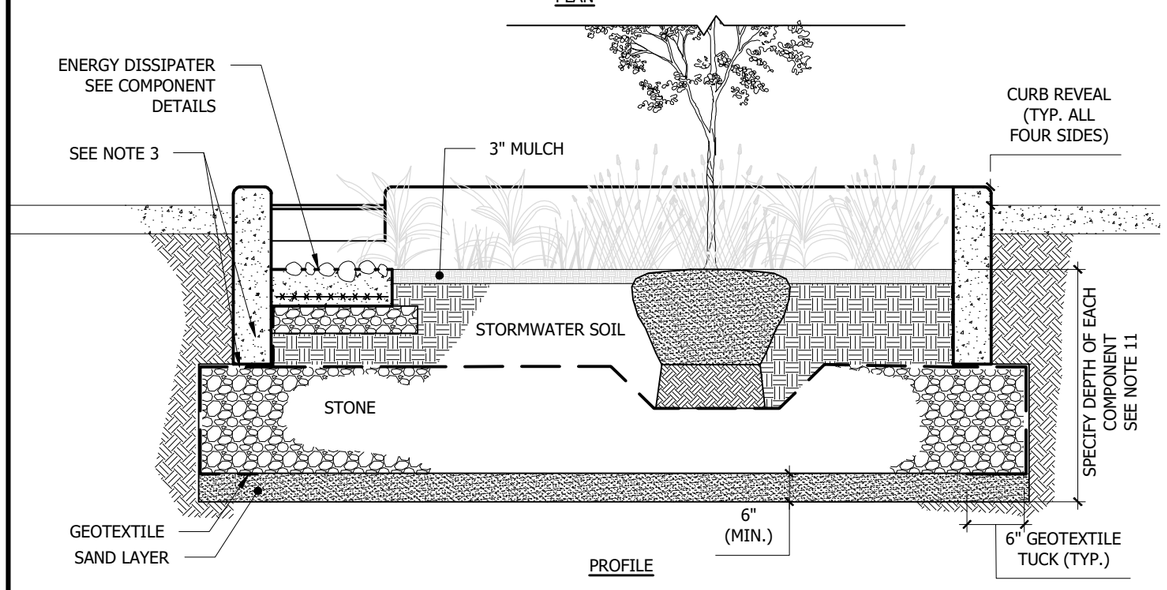
VS.	DATE	INITIALS	REASON
1	09/01/2016		

SCALE: N.T.S.

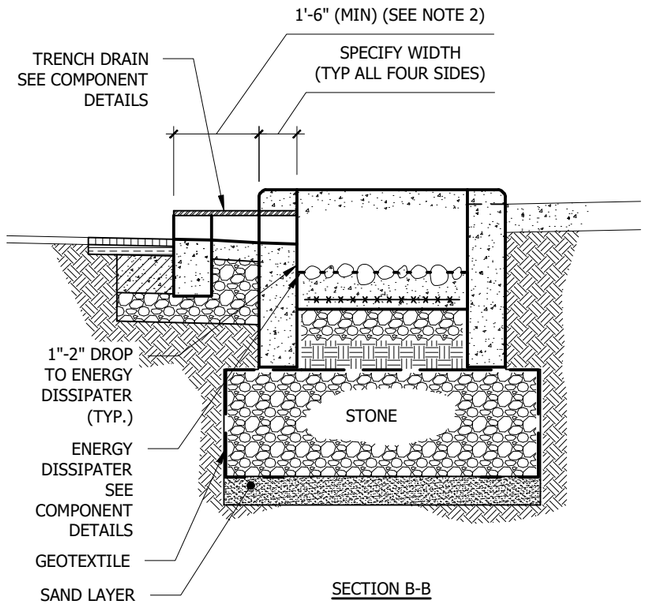
DRAWING NUMBER: F-3



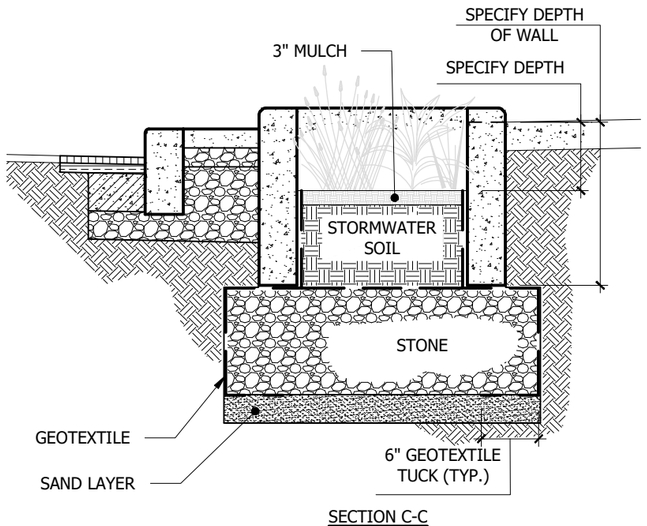
PLAN



PROFILE



SECTION B-B



SECTION C-C

NOTES TO DESIGNER:

1. THIS DESIGN DETAIL SHOULD BE ADAPTED TO THE SPECIFIC ENGINEERED DESIGN OF A RESPECTIVE INSTALLATION.
2. THE MINIMUM DISTANCE FROM FACE OF CURB IS 18" ALONG STREETS THAT ALLOW ON-STREET PARKING AND/OR LOADING. THERE IS NO MINIMUM DISTANCE WHERE PARKING AND/OR LOADING ARE PROHIBITED.
3. STORMWATER PLANTER WALLS MAY BE PRECAST OR CAST-IN-PLACE CONCRETE. FOR ANY STRUCTURAL COMPONENTS, INCLUDING BUT NOT LIMITED TO PLANTER WALLS, STRUCTURAL DESIGN MUST BE PREPARED BY THE DESIGNER. AT A MINIMUM, DESIGNER SHOULD CONSIDER PLANTER WALL DEPTH, FOOTER/FOUNDATION FOR WALLS, CONCRETE MIX, CONCRETE STRENGTH, REINFORCING STEEL DESIGN (AS REQUIRED), JOINT PLACEMENT AND DESIGN, AND DESIGN LOAD CONDITION.
4. DESIGNER SHOULD BE AWARE THAT PROPERLY ALIGNING THE INVERT OF TRENCH DRAIN WITH OPENING THROUGH PLANTER WALL CAN BE CHALLENGING WHEN PRECAST CONSTRUCTION IS USED.
5. NOTCHES IN THE PLANTER WALL SHOULD BE SIZED AND SPACED AS REQUIRED TO PREVENT PONDING ON THE SIDEWALK ADJACENT TO THE PLANTER. IT IS RECOMMENDED THAT NOTCHES BE CAST-IN-PLACE RATHER THAN SAW-CUT.
6. ALL EXPOSED CONCRETE EDGES SHALL BE BEVELED.
7. DESIGNER SHOULD EVALUATE WHETHER TOP OF CURB REVEAL SHOULD FOLLOW SLOPE OF SURROUNDING GRADES OR BE LEVEL BASED ON DESIRED APPEARANCE AND SITE CONDITIONS.
8. THE LOWEST PLANTING MEDIA SURFACE IN STORMWATER PLANTERS SHOULD BE LEVEL ALONG THE ALIGNMENT OF THE STREET. A MILD SLOPE NO GREATER THAN 1 PERCENT IS ACCEPTABLE BUT A LEVEL SURFACE IS RECOMMENDED. IF SURROUNDING SLOPES ARE STEEP, IMPERMEABLE BARRIERS SUCH AS SURFACE CHECK DAMS CAN HELP MAINTAIN A LEVEL SURFACE. NOTE THIS DOES NOT APPLY TO THE CROSS-GRADING, IF USED, FROM THE PERIMETER OF THE PLANTER DOWN TO THE LOWEST PLANTING MEDIA SURFACE.
9. DESIGNER SHOULD CONSIDER THE HEIGHT OF VEGETATION BOTH AT INSTALLATION AND ANTICIPATED MATURITY. BOTH HEIGHTS SHOULD BE CONSIDERED IN THE CONTEXT OF THE STORMWATER PLANTER'S PLAN DIMENSIONS, DEPTH, AND SURROUNDING AREA PROTECTION AND VEGETATION SELECTED ACCORDINGLY. IT HAS BEEN FOUND THAT IF A PLANTER IS DEEP AND/OR HAS HIGH AREA PROTECTION, VERY LOW VEGETATION AT INSTALLATION TENDS TO GIVE A STORMWATER PLANTER AN EXCESSIVELY DEEP APPEARANCE. NOTE THAT WITH THE EXCEPTION OF TREES, MAXIMUM VEGETATION HEIGHT AT MATURITY SHOULD BE NO GREATER THAN 36-INCHES ABOVE THE SURROUNDING SIDEWALK ELEVATION. ALSO, PLANT SELECTION AND PLACEMENT SHOULD BE DONE TO PREVENT ENCROACHMENT OF PLANTS OUTSIDE OF THE LIMITS OF THE STORMWATER PLANTER AND IN CONSIDERATION OF MAINTAINING ADEQUATE SIGHT LINES BASED ON THE PLACEMENT OF THE STORMWATER PLANTER.
10. THE PONDING DEPTH OF WATER IN THE STORMWATER PLANTER IS CORRELATED TO A VARIETY OF SITE SPECIFIC FACTORS SUCH AS SURROUNDING GRADES, OFFSETS BETWEEN STORMWATER ENTRANCE ELEVATIONS AND TOP OF PLANTING MEDIA, OFFSETS BETWEEN STORMWATER ENTRANCE AND OVERFLOW ELEVATIONS, DESIRED FREEBOARD, THE VEGETATION SELECTED FOR THE STORMWATER PLANTER, AND THE DESIGN DEPTH OF THE STORMWATER PLANTER. THE DESIGNER SHOULD EVALUATE SITE SPECIFIC CONDITIONS SUCH AS THOSE MENTIONED IN ORDER TO ACHIEVE A TYPICAL PONDING DEPTH OF 6" AND TO MAXIMIZE PONDING DEPTH TO THE EXTENT POSSIBLE.
11. MINIMUM SOIL DEPTH SHALL BE APPROPRIATE FOR THE VEGETATION PLANTED AND NO LESS THAN 2 FEET, OR 3 FEET WHERE TREES ARE PRESENT.
12. FENCING IS TYPICALLY INCLUDED AROUND STORMWATER PLANTERS. DESIGNERS SHOULD REFER TO COMPONENT DETAILS.
12. DOMED RISERS MAY BE USED AS NEEDED TO ALLOW SUBSURFACE STONE STORAGE TO FILL BEFORE SYSTEM OVERFLOWS.
13. UNDERDRAINS, WHILE NOT SHOWN, ARE TYPICALLY INSTALLED EXCEPT UNDER CERTAIN CIRCUMSTANCES

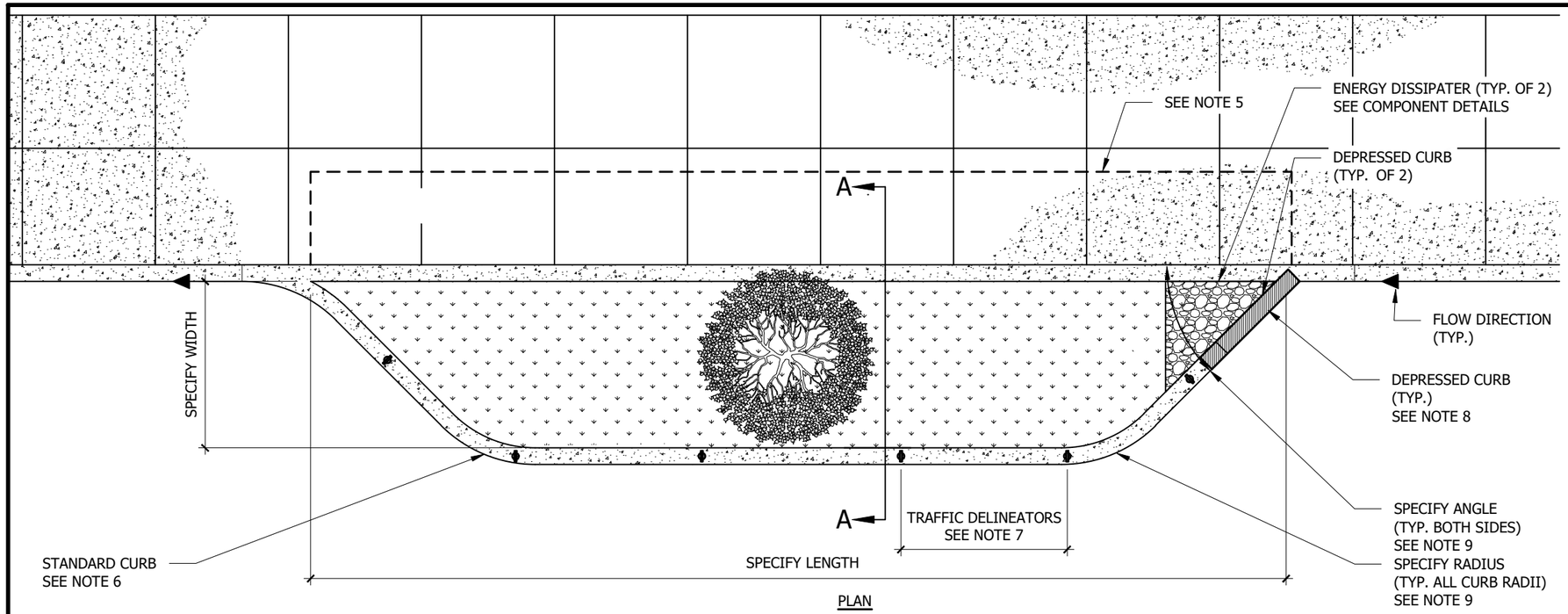
Modified by Pennoni Associates for Stormwater Drainage Study- Green Infrastructure Details

STORMWATER PLANTER

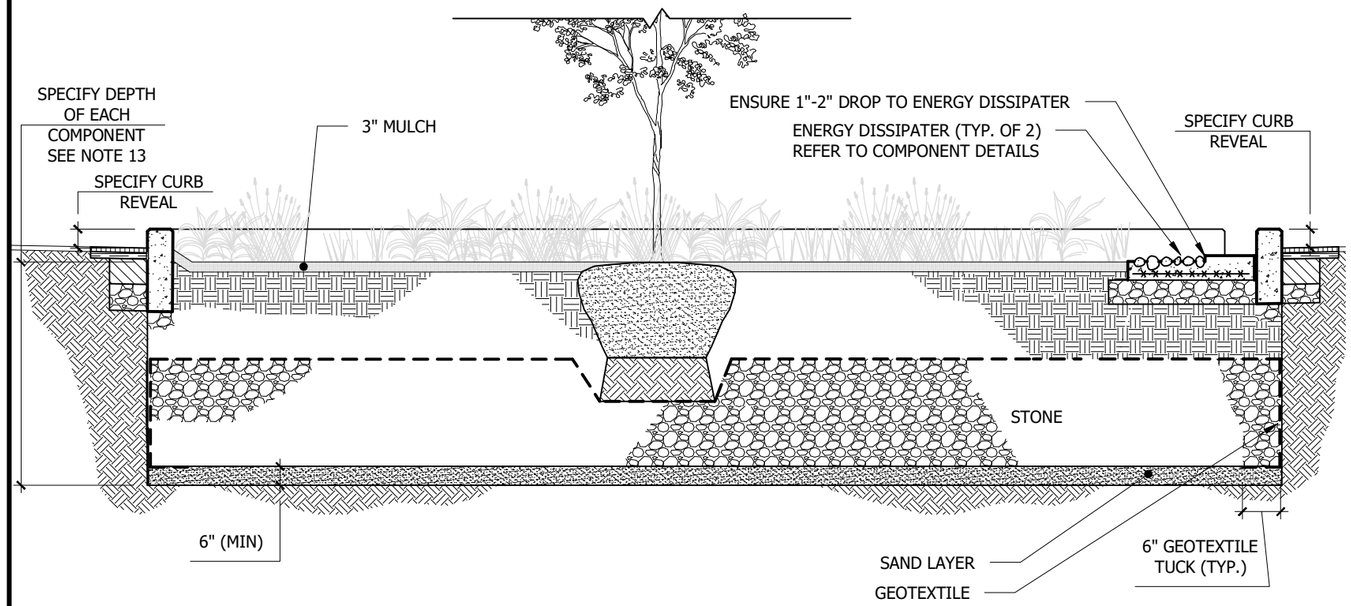
SCALE: N.T.S.

VS.	DATE	INITIALS	REASON
1	09/01/2016		
2	06/01/2018	ANJ	ADDED MULCH LAYER

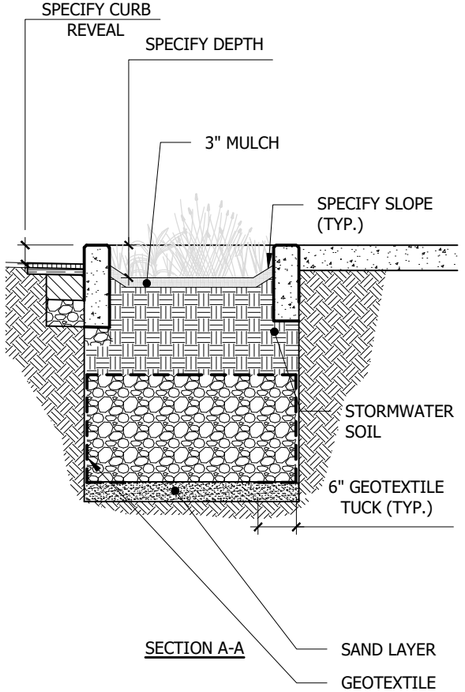
DRAWING NUMBER: F-5



PLAN



PROFILE



SECTION A-A

NOTES TO DESIGNER:

1. THIS DESIGN DETAIL SHOULD BE ADAPTED TO THE SPECIFIC ENGINEERED DESIGN OF A RESPECTIVE INSTALLATION.
2. THE LOWEST PLANTING MEDIA SURFACE IN STORMWATER BUMPOUTS SHOULD BE LEVEL ALONG THE ALIGNMENT OF THE STREET. A MILD SLOPE NO GREATER THAN 1 PERCENT IS ACCEPTABLE BUT A LEVEL SURFACE IS RECOMMENDED. IF SURROUNDING SLOPES ARE STEEP, IMPERMEABLE BARRIERS SUCH AS SURFACE CHECK DAMS CAN HELP MAINTAIN A LEVEL SURFACE. NOTE THIS DOES NOT APPLY TO THE CROSS-GRADING, IF USED, FROM THE PERIMETER OF THE BUMPOUT DOWN TO THE LOWEST PLANTING MEDIA SURFACE.
3. DESIGNER SHOULD CONSIDER THE HEIGHT OF VEGETATION BOTH AT INSTALLATION AND ANTICIPATED MATURITY. BOTH HEIGHTS SHOULD BE CONSIDERED IN THE CONTEXT OF THE STORMWATER BUMPOUT'S PLAN DIMENSIONS, DEPTH, AND SURROUNDING AREA PROTECTION AND VEGETATION SELECTED ACCORDINGLY. NOTE THAT WITH THE EXCEPTION OF TREES, MAXIMUM VEGETATION HEIGHT AT MATURITY SHOULD BE NO GREATER THAN 36-INCHES ABOVE THE SURROUNDING SIDEWALK ELEVATION. ALSO, PLANT SELECTION AND PLACEMENT SHOULD BE DONE TO PREVENT ENCROACHMENT OF PLANTS OUTSIDE OF THE LIMITS OF THE STORMWATER BUMPOUT AND IN CONSIDERATION OF MAINTAINING ADEQUATE SIGHT LINES BASED ON THE PLACEMENT OF THE STORMWATER BUMPOUT.
4. THE PONDING DEPTH OF WATER IN THE STORMWATER BUMPOUTS IS CORRELATED TO A VARIETY OF SITE SPECIFIC FACTORS SUCH AS SURROUNDING GRADES, OFFSETS BETWEEN STORMWATER ENTRANCE ELEVATIONS AND TOP OF PLANTING MEDIA, OFFSETS BETWEEN STORMWATER ENTRANCE AND OVERFLOW ELEVATIONS, DESIRED FREEBOARD, THE VEGETATION SELECTED FOR THE STORMWATER BUMPOUT, AND THE DESIGN DEPTH OF THE STORMWATER BUMPOUT. THE DESIGNER SHOULD EVALUATE SITE SPECIFIC CONDITIONS SUCH AS THOSE MENTIONED IN ORDER TO ACHIEVE A MINIMUM PONDING DEPTH OF 6" AND TO MAXIMIZE PONDING DEPTH TO THE EXTENT POSSIBLE.
5. ALTHOUGH NOT SHOWN, EXTENDING THE VEGETATED AREA INTO THE LIMITS OF THE SIDEWALK IS PERMITTED. HOWEVER, ANY REQUIREMENTS/GUIDELINES FOR OTHER SMPS LOCATED IN THE SIDEWALK, SUCH AS STORMWATER PLANTERS, WOULD APPLY.
6. CURBS AROUND STORMWATER BUMPOUTS ON CITY STREETS WILL FOLLOW THE SAME REQUIREMENTS AS NORMAL CURBS AND SHALL BE WITHIN A HEIGHT RANGE OF 4" TO 8". DESIGNER WILL SELECT A HEIGHT WITHIN THAT RANGE BASED ON APPLICABLE SITE CONDITIONS AND THE CURB HEIGHT SHALL BE CONSISTENT ALONG THE LENGTH OF THE BUMPOUT.
7. DELINEATORS SHOULD BE PLACED ALONG BUMPOUT CURB. PLACEMENT SHOWN HERE IS EXAMPLE ONLY AND PLACEMENT AND SPACING SHOULD BE DETERMINED ON A PER PROJECT BASIS
8. OPENING SIZE AND PLACEMENT TO BE DETERMINED BY DESIGNER. OPENINGS ALONG OUTSIDE EDGE OF BUMPOUT, IF USED, MUST INCLUDE A WHEEL GUARD.
9. DESIGNER SHOULD DETERMINE THE APPROPRIATE GEOMETRY FOR BUMPOUTS BASED ON GOOD ENGINEERING PRACTICE, JUDGMENT OF THE SITE, AND INFORMATION IN PWD'S BUMPOUT DESIGN GUIDANCE DOCUMENT.
10. MINIMUM SOIL DEPTH SHALL BE APPROPRIATE FOR THE VEGETATION PLANTED AND NO LESS THAN 2 FEET, OR 3 FEET WHERE TREES ARE PLANTED.
12. DOMED RISERS MAY BE USED AS NEEDED TO ALLOW SUBSURFACE STONE STORAGE TO FILL BEFORE SYSTEM OVERFLOWS.
13. UNDERDRAINS, WHILE NOT SHOWN, ARE TYPICALLY INSTALLED EXCEPT UNDER CERTAIN CIRCUMSTANCES

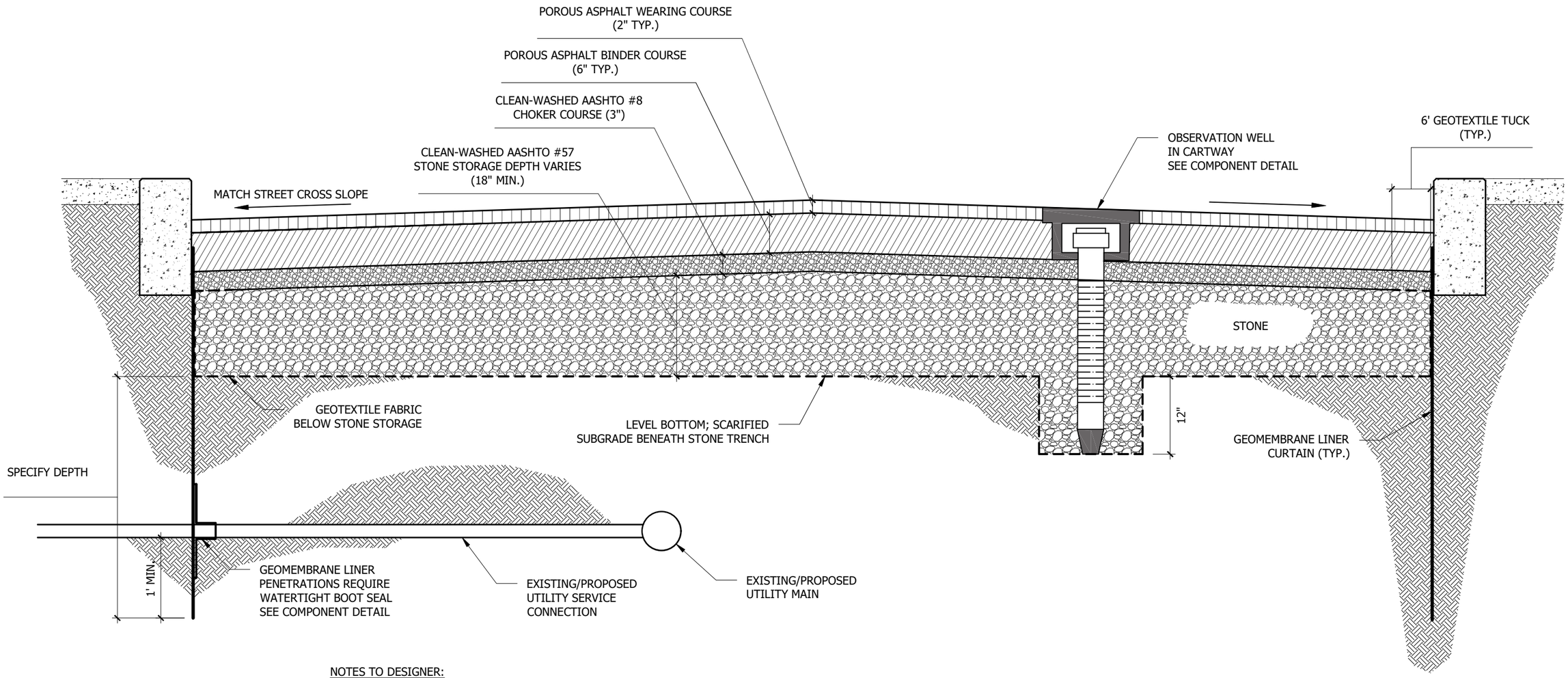
Modified by Pennoni Associates for Stormwater Drainage Study- Green Infrastructure Details

STORMWATER BUMPOUT (MID-BLOCK)

SCALE: N.T.S.

VS.	DATE	INITIALS	REASON
1	09/01/2016		
1	06/01/2018	ANJ	ADDED MULCH LAYER, ADDED REFERENCE TO BUMPOUT GUIDANCE DOCUMENT

DRAWING NUMBER: F-7



NOTES TO DESIGNER:

1. THIS DESIGN DETAIL SHOULD BE ADAPTED TO THE SPECIFIC ENGINEERED DESIGN AND ITS RESPECTIVE INSTALLATION.
2. ALL EDGES BETWEEN NEW AND EXISTING ASPHALT PAVEMENT SHALL BE SEALED WITH HOT ASPHALT CEMENT. ALSO, JOINTS BETWEEN UTILITY FRAMES FOR MANHOLES AND INLETS OR OTHER UTILITY OWNED STRUCTURES AND PERMEABLE ASPHALT WEARING COURSE SHALL BE SEALED WITH HOT ASPHALT CEMENT FOR A DISTANCE OF 6-INCHES FROM THE EDGE OF THE FRAME.
3. PERMEABLE PAVEMENT SHALL INCLUDE CHECK DAMS AS NEEDED TO ACCOMMODATE STREET SLOPE (SEE COMPONENT DETAIL).
4. PERMEABLE PAVEMENT SHALL NOT BE USED IN AREAS WHERE LONGITUDINAL SLOPE IS GREATER THAN 5%.
5. SPECIFY GEOMEMBRANE LINER CURTAIN DEPTH TO PREVENT INFILTRATION INTO BASEMENTS OF ADJACENT BUILDINGS.

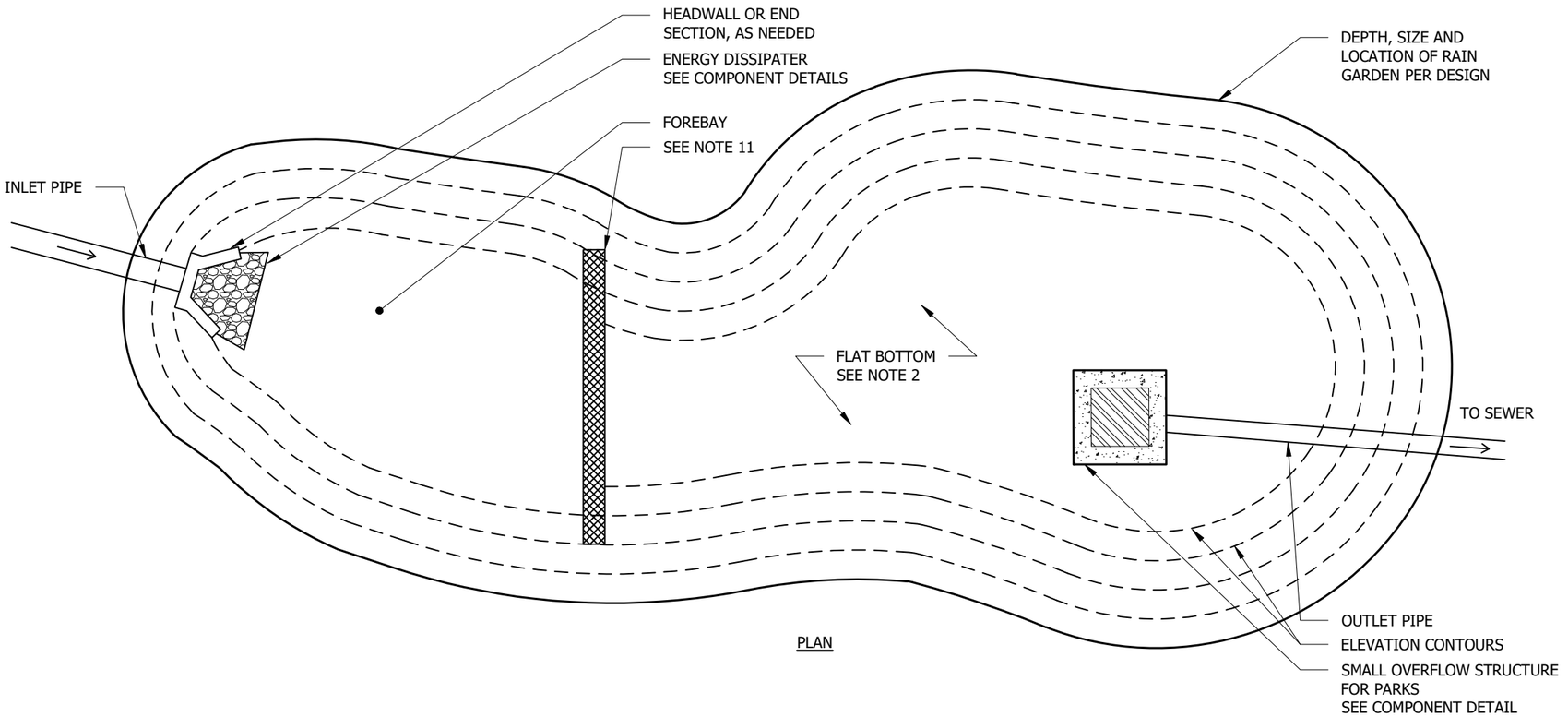
Modified by Pennoni Associates for Stormwater Drainage Study- Green Infrastructure Details

PERMEABLE PAVEMENT

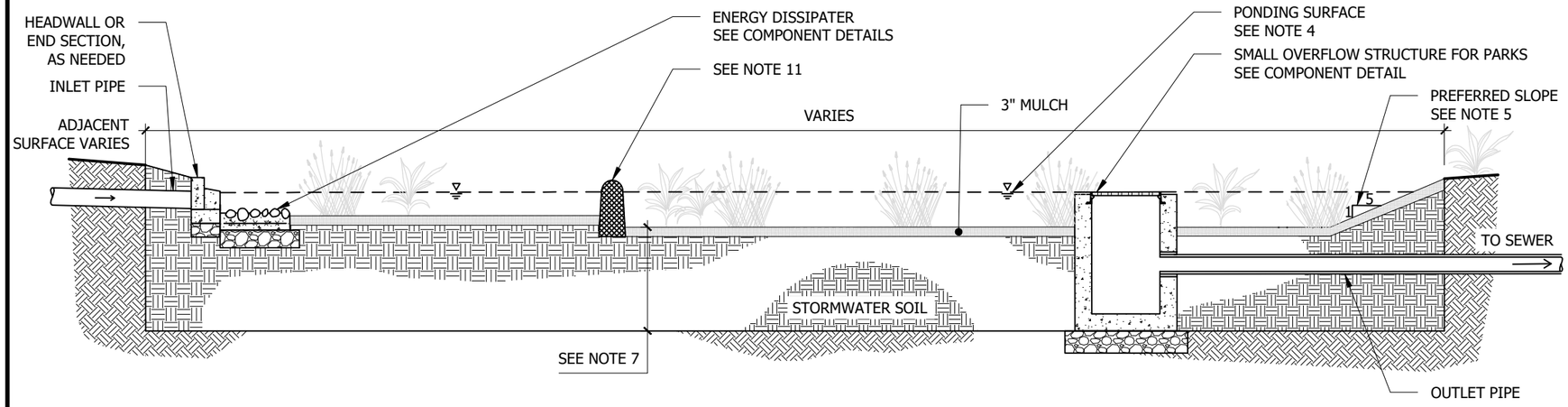
SCALE: N.T.S.

DRAWING NUMBER: F-9

VS.	DATE	INITIALS	REASON
1	09/01/2016		
2	06/01/2018	ANJ/DJM	REMOVED PAVER AND CONC. EXAMPLES AND SAND LAYER, ADDED GEOTEXTILE, GEOMEMBRANE, AND OBS. WELL



PLAN



PROFILE

NOTES TO DESIGNER:

1. THIS DESIGN DETAIL SHOULD BE ADAPTED TO THE SPECIFIC ENGINEERED DESIGN OF A RESPECTIVE INSTALLATION.
2. THE LOWEST PLANTING MEDIA SURFACE IN THE RAIN GARDEN SHOULD BE LEVEL. A MILD SLOPE NO GREATER THAN 1 PERCENT IS ACCEPTABLE BUT A LEVEL SURFACE IS RECOMMENDED. IF SURROUNDING SLOPES ARE STEEP, IMPERMEABLE BARRIERS SUCH AS SURFACE CHECK DAMS CAN HELP MAINTAIN A LEVEL SURFACE. NOTE THIS DOES NOT APPLY TO THE CROSS-GRADING, IF USED, FROM THE PERIMETER OF THE RAIN GARDEN DOWN TO THE LOWEST PLANTING MEDIA SURFACE.
3. DESIGNER SHOULD CONSIDER THE HEIGHT OF VEGETATION BOTH AT INSTALLATION AND ANTICIPATED MATURITY. BOTH HEIGHTS SHOULD BE CONSIDERED IN THE CONTEXT OF THE RAIN GARDEN'S PLAN DIMENSIONS, DEPTH, AND SURROUNDING AREA PROTECTION AND VEGETATION SELECTED ACCORDINGLY. NOTE THAT WITH THE EXCEPTION OF TREES, MAXIMUM VEGETATION HEIGHT AT MATURITY SHOULD BE NO GREATER THAN 36-INCHES ABOVE THE SURROUNDING SIDEWALK ELEVATION IF IN THE RIGHT-OF-WAY. ALSO, PLANT SELECTION AND PLACEMENT SHOULD BE DONE TO PREVENT ENCROACHMENT OF PLANTS OUTSIDE OF THE LIMITS OF THE RAIN GARDEN AND IN CONSIDERATION OF MAINTAINING ADEQUATE SIGHT LINES BASED ON THE PLACEMENT OF THE RAIN GARDEN IF IN THE RIGHT-OF-WAY.
4. THE PONDING DEPTH OF WATER IN THE RAIN GARDEN IS CORRELATED TO A VARIETY OF SITE SPECIFIC FACTORS SUCH AS SURROUNDING GRADES, OFFSETS BETWEEN STORMWATER ENTRANCE ELEVATIONS AND TOP OF PLANTING MEDIA, OFFSETS BETWEEN STORMWATER ENTRANCE AND OVERFLOW ELEVATIONS, DESIRED FREEBOARD, THE VEGETATION SELECTED FOR THE RAIN GARDEN, AND THE DESIGN DEPTH OF THE RAIN GARDEN. THE DESIGNER SHOULD EVALUATE SITE SPECIFIC CONDITIONS IN ORDER TO ACHIEVE A MINIMUM PONDING DEPTH OF 6" AND TO MAXIMIZE PONDING DEPTH TO THE EXTENT POSSIBLE.
5. STEEPER SIDE SLOPES MAY BE ALLOWED ON A PROJECT-SPECIFIC BASIS.
6. CONSIDER CURB REVEAL, FENCING, EDGING, OR OTHER PROTECTIVE BARRIER WHEN RAIN GARDEN IS DIRECTLY ADJACENT TO PEDESTRIAN PATHS OR RIGHT-OF-WAY SIDEWALK AREAS.
7. MINIMUM SOIL DEPTH SHALL BE APPROPRIATE FOR THE VEGETATION PLANTED AND NO LESS THAN 2 FEET, OR 3 FEET WHERE TREES ARE PLANTED.
8. STONE CHIMNEYS AND/OR INFILTRATION COLUMNS SHALL BE CONSIDERED AS NEEDED TO ENHANCE INFILTRATION.
9. UNDERDRAINS, WHILE NOT SHOWN, ARE TYPICALLY INSTALLED EXCEPT UNDER CERTAIN CIRCUMSTANCES
10. PROPOSED GRADING SHALL INCORPORATE EXISTING CONTOURS TO THE EXTENT FEASIBLE, AND THE DESIGN SHALL MITIGATE STEEP CHANGES IN ELEVATION.
11. DESIGNER SHOULD CONSIDER BARRIER/WEIR SYSTEM TO FORM FOREBAY AREA. THIS MAY ALSO BE ACHIEVED WITH GRADING.
12. DOMED RISERS MAY BE USED AS NEEDED TO ALLOW SUBSURFACE STONE STORAGE TO FILL BEFORE SYSTEM OVERFLOWS IN CASE STORMWATER SOIL DOES NOT INFILTRATE HIGH INTENSITY STORMS FAST ENOUGH.

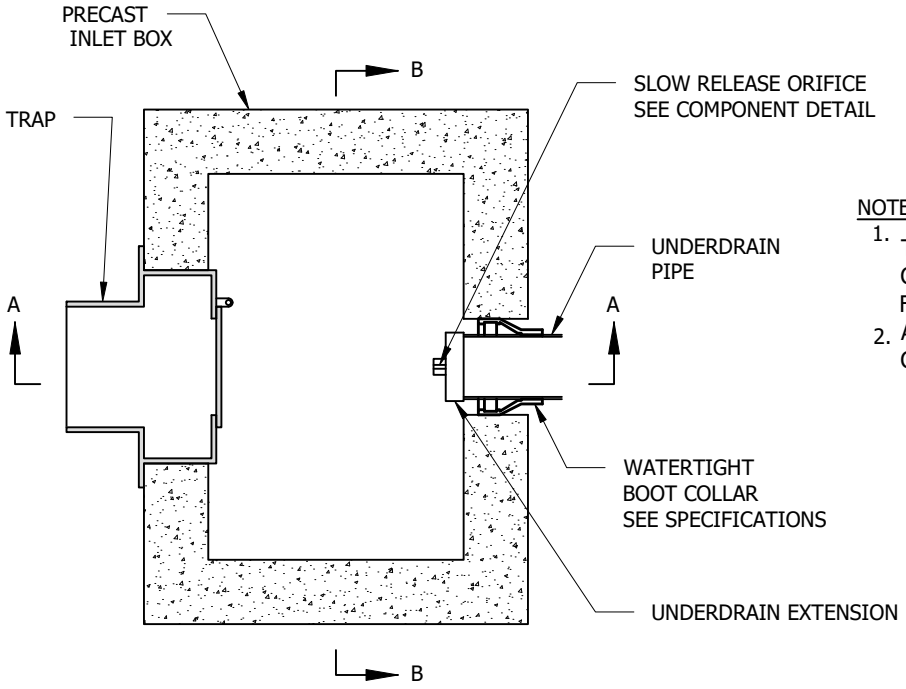
Modified by Pennoni Associates for Stormwater Drainage Study- Green Infrastructure Details

RAIN GARDEN

VS.	DATE	INITIALS	REASON
1	09/01/2016		
2	06/01/2018	ANJ	ADDED MULCH LAYER

SCALE: N.T.S.

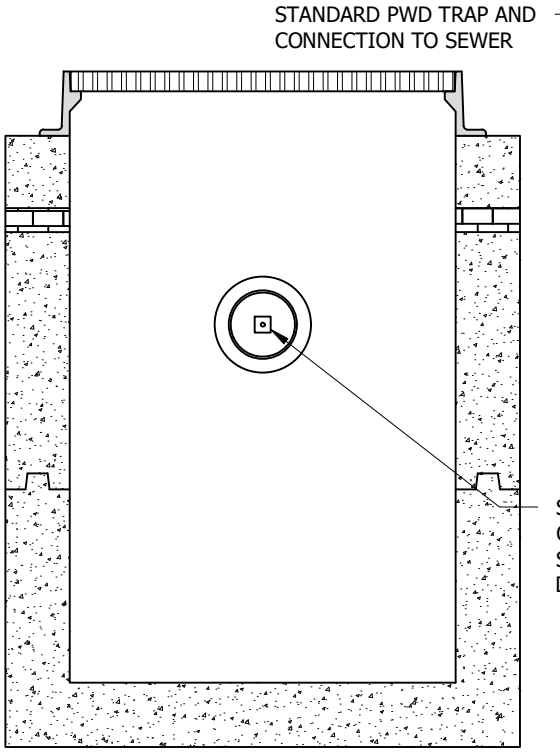
DRAWING NUMBER: F-10



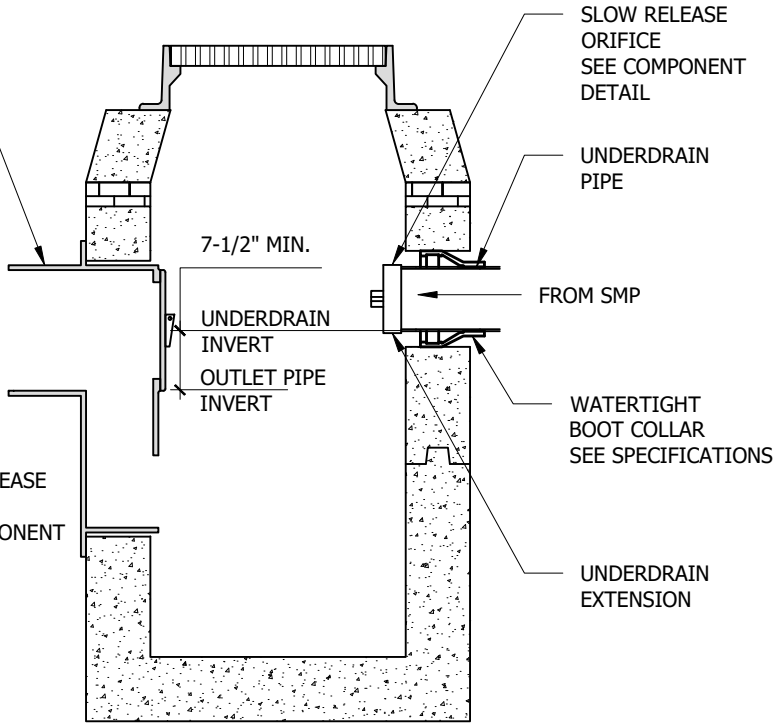
PLAN

NOTES:

1. TOTAL EXTENSION OF UNDERDRAIN AND CAP ASSEMBLY INTO INLET TO BE 2" FROM INLET WALL TO END OF CAP.
2. ALL JOINTS, ADJUSTMENTS, AND PIPE CONNECTIONS MUST BE WATERTIGHT.



SECTION B-B



SECTION A-A

Modified by Pennoni Associates for Stormwater Drainage Study- Green Infrastructure Details

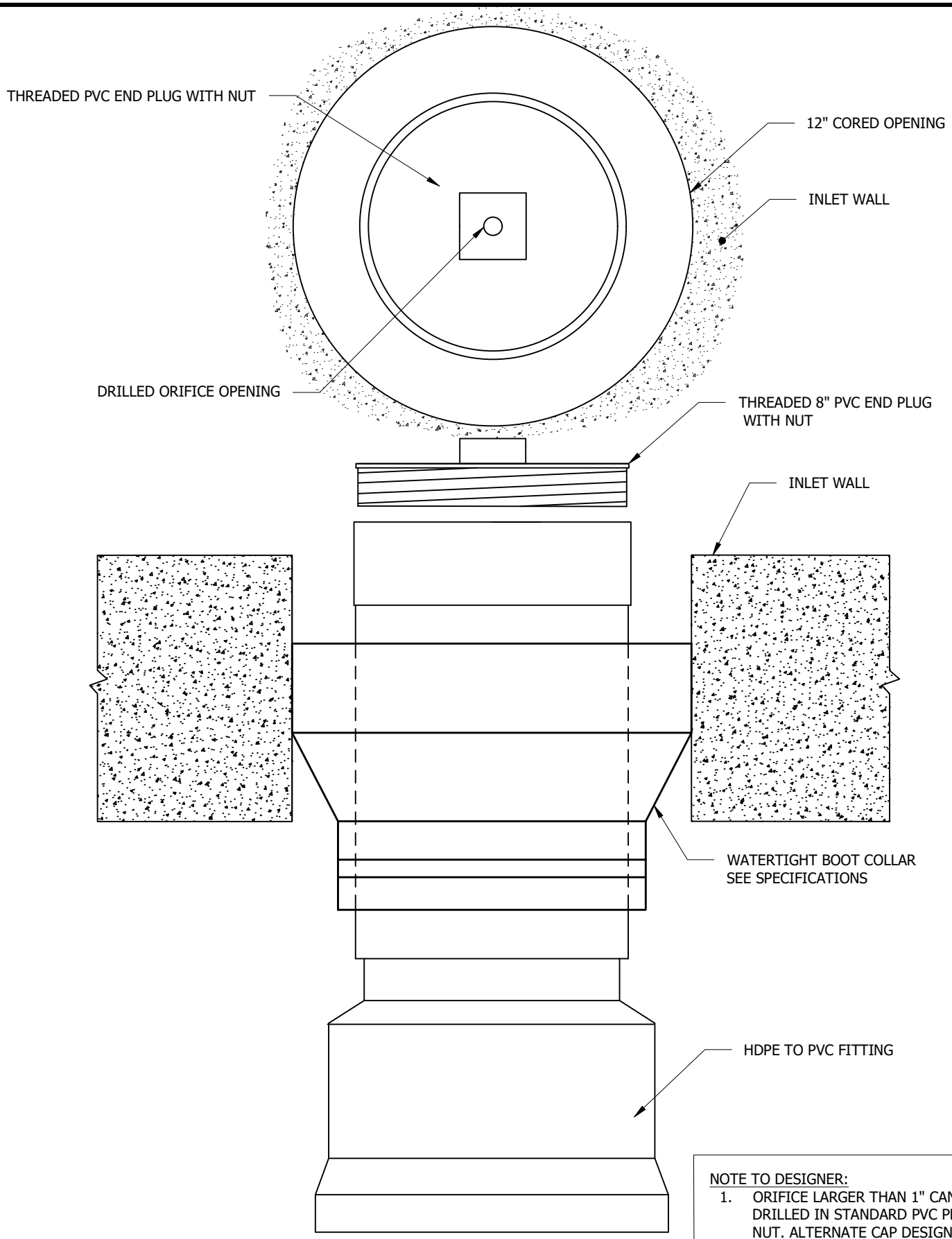
STANDARD INLET WITH UNDERDRAIN CONNECTION

SCALE: N.T.S.

VS.	DATE	INITIALS	REASON
1	09/01/2016	ANJ/DJM	
2	06/01/2018	ANJ	UPDATED PVC PLUG, ADDED BOOT COLLAR

DRAWING NUMBER:

C-7



NOTE TO DESIGNER:

1. ORIFICE LARGER THAN 1" CANNOT BE DRILLED IN STANDARD PVC PLUG NUT. ALTERNATE CAP DESIGN NEEDED IN THIS INSTANCE.

Modified by Pennoni Associates for Stormwater Drainage Study- Green Infrastructure Details

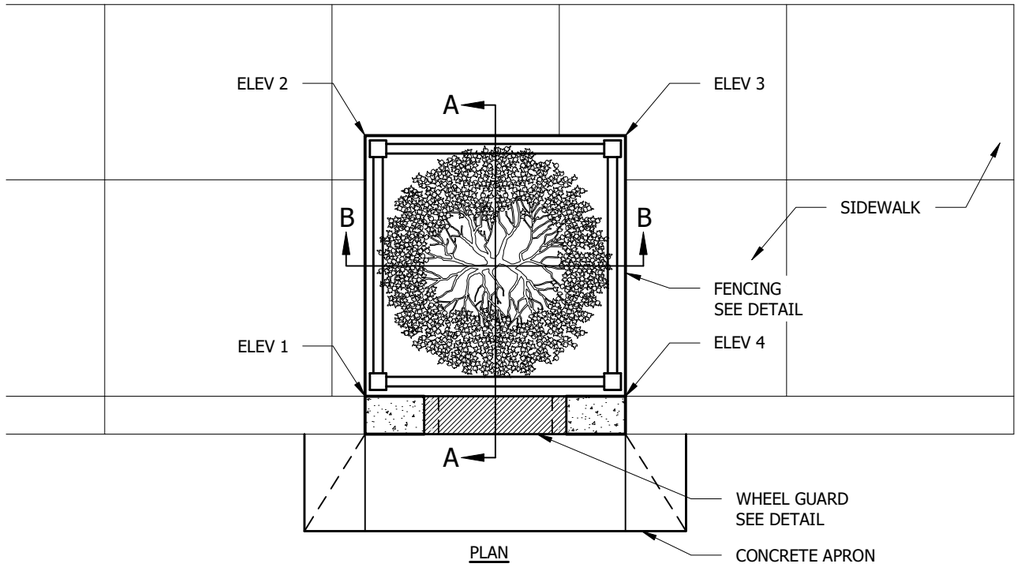
SLOW RELEASE ORIFICE

SCALE: N.T.S.

VS.	DATE	INITIALS	REASON
1	09/01/2016	ANJ/DJM	
2	06/01/2018	ANJ/DJM	UPDATED PVC PLUG, ADDED BOOT COLLAR

DRAWING NUMBER:

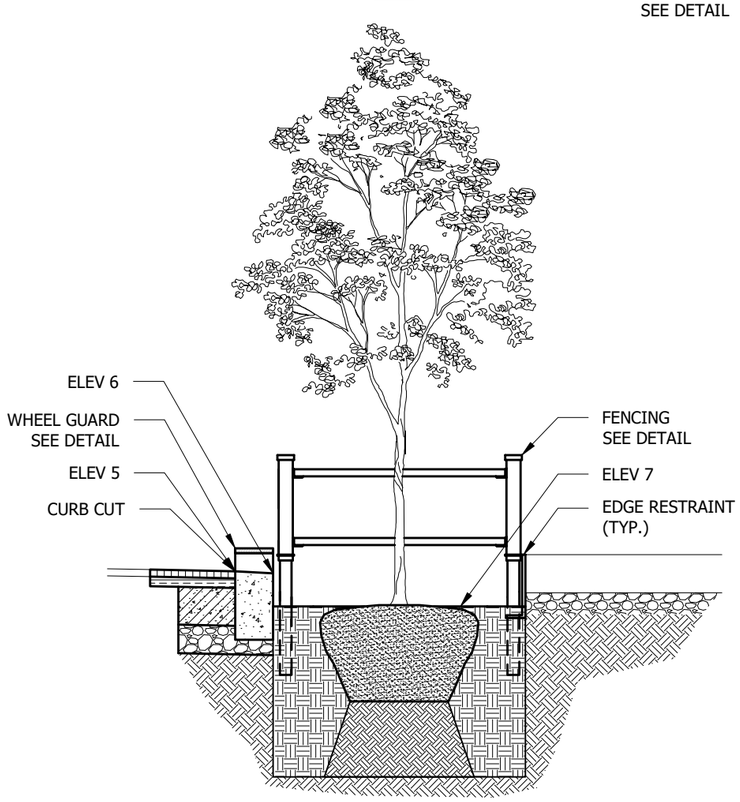
C-8



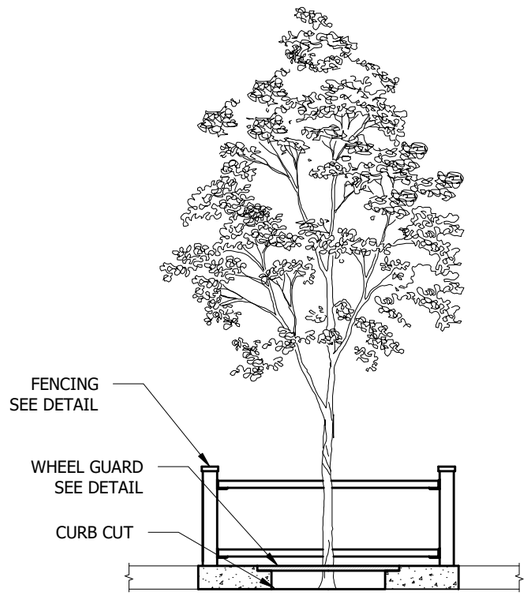
PLAN

	ADJACENT PAVEMENT ELEVATIONS				CURB CUT ELEVATION		SOIL ELEVATION	TREE PIT LENGTH	TREE PIT WIDTH	CURB CUT LENGTH	SOIL DEPTH
TREE NO.	ELEV 1 (FT)	ELEV 2 (FT)	ELEV 3 (FT)	ELEV 4 (FT)	ELEV 5 (FT)	ELEV 6 (FT)	ELEV 7 (FT)	L_1 (FT)	W_1 (FT)	L_2 (FT)	D_1 (FT)

NOTE:
1. GRADE SOIL TO ENSURE SIDEWALK SUBGRADE IS NOT EXPOSED (ALL SIDES).

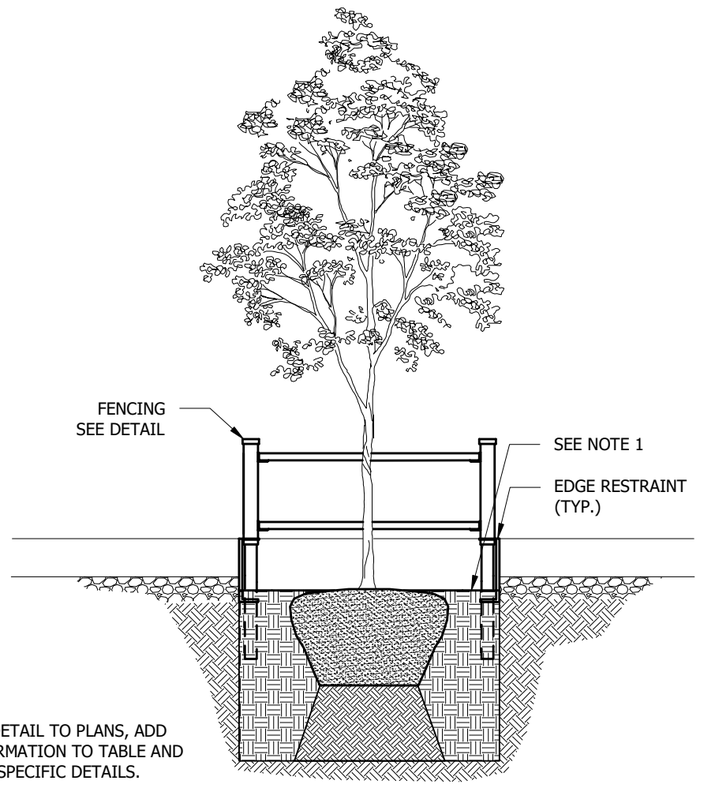


SECTION A-A



FRONT ELEVATION

NOTE TO DESIGNER:
1. IN ORDER TO ADD THIS DETAIL TO PLANS, ADD PERTINENT DESIGN INFORMATION TO TABLE AND UPDATE REFERENCES TO SPECIFIC DETAILS.



SECTION B-B

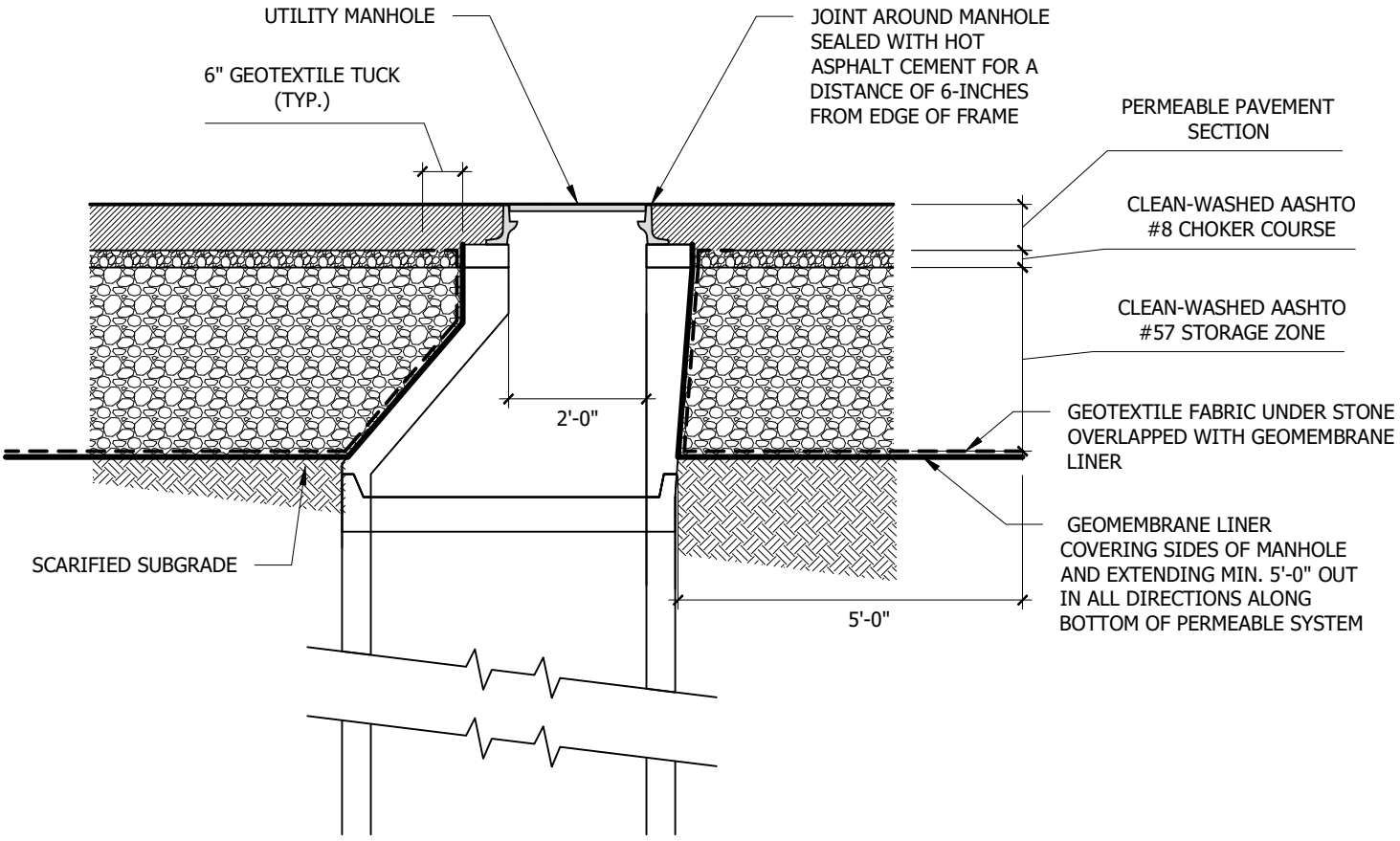
Modified by Pennoni Associates for Stormwater Drainage Study- Green Infrastructure Details

DROP-IN STORMWATER TREE

SCALE: N.T.S.

VS.	DATE	INITIALS	REASON
1	09/01/2016		

DRAWING NUMBER: C-27



Modified by Pennoni Associates for Stormwater Drainage Study- Green Infrastructure Details

UTILITY MANHOLE IN PERMEABLE PAVING

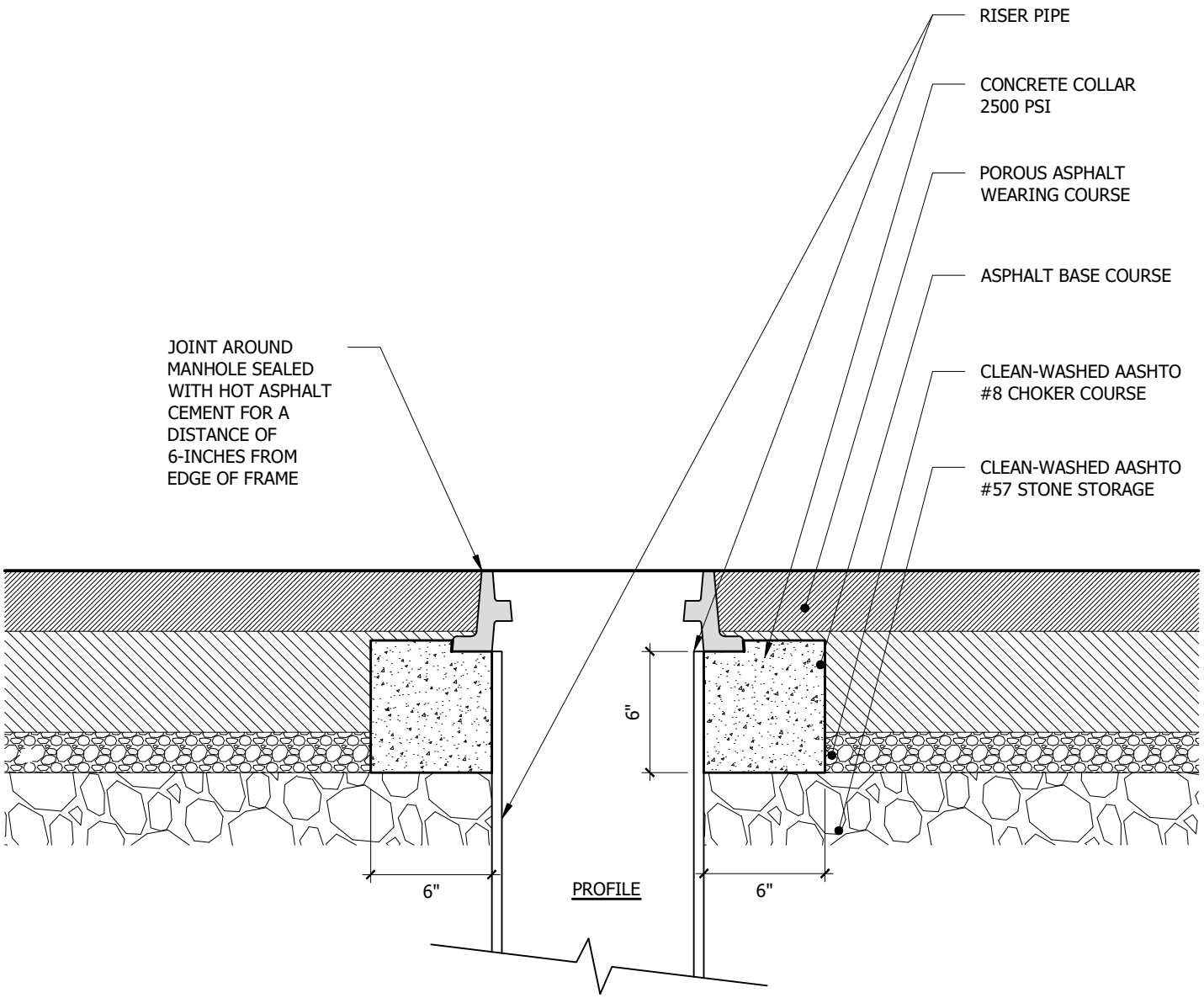
SCALE: N.T.S.

VS.	DATE	INITIALS	REASON
1	09/01/2016		
2	06/01/2018	ANJ	REMOVED SAND LAYER, ADDED JOINT SEAL NOTE

DRAWING NUMBER:

C-30

NOTES:
1. TO BE USED ON WATER VALVES, OBSERVATION WELLS, CLEANOUTS, GAS VALVES LOCATED IN POROUS PAVING



PROFILE

Modified by Pennoni Associates for Stormwater Drainage Study- Green Infrastructure Details

FRAME & CASTING SUPPORT IN PERMEABLE PAVING

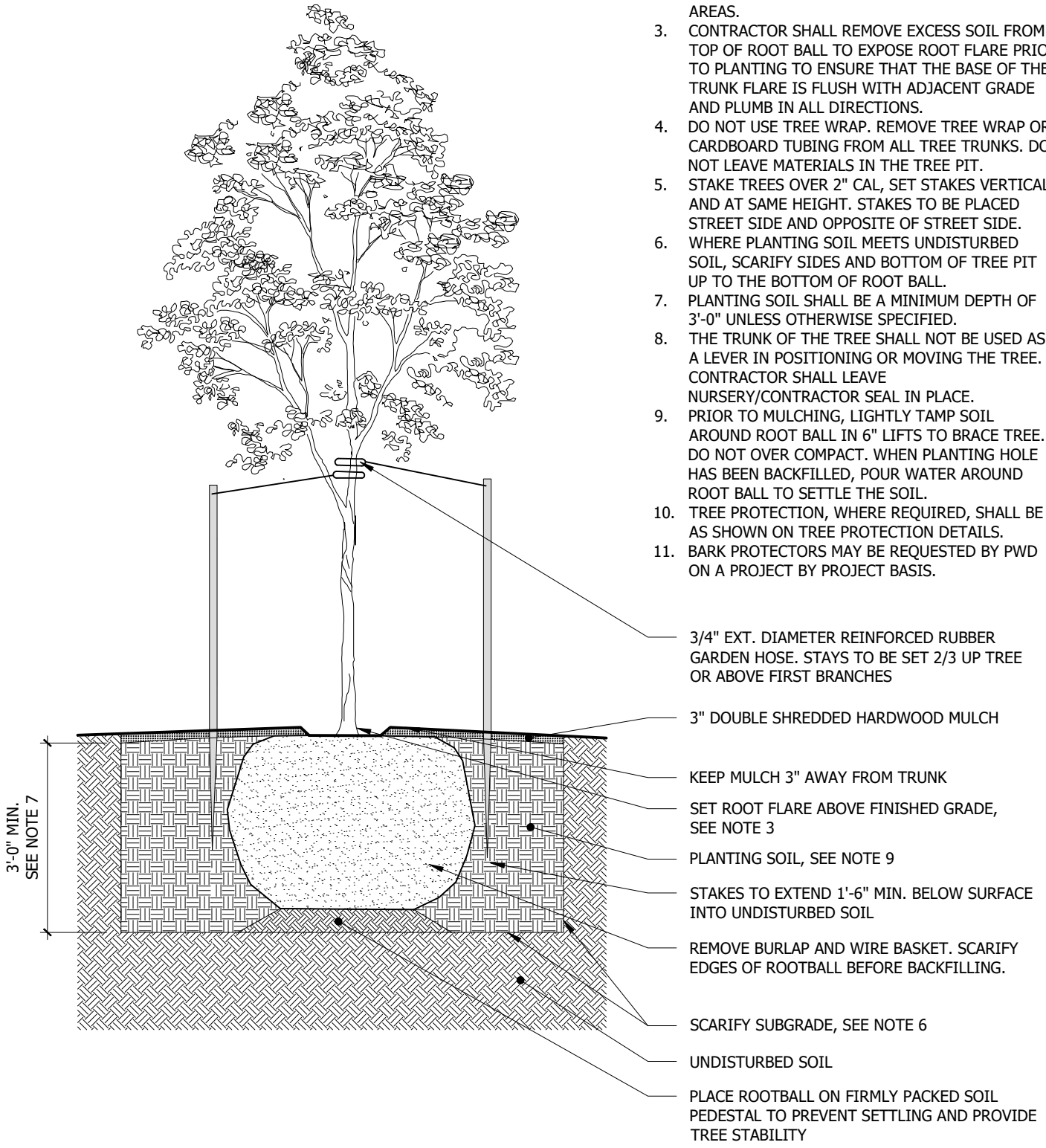
SCALE: N.T.S.

VS.	DATE	INITIALS	REASON
1	09/01/2016		
2	06/01/2018	DJM	ADDED JOINT SEAL NOTE

DRAWING NUMBER:
C-31

NOTES:

1. DO NOT HEAVILY PRUNE THE TREE AT PLANTING. PRUNE ONLY TO REMOVE CO-DOMINANT LEADERS, DEAD, AND BROKEN BRANCHES. PRUNE WITH A CLEAN CUT PER ANSI A300 & ISA (2008) STANDARDS. DO NOT CUT TREE'S CENTRAL LEADER.
2. SET PLANTS PLUMB AND FACE TO GIVE THE BEST APPEARANCE OR RELATIONSHIP TO ADJACENT AREAS.
3. CONTRACTOR SHALL REMOVE EXCESS SOIL FROM TOP OF ROOT BALL TO EXPOSE ROOT FLARE PRIOR TO PLANTING TO ENSURE THAT THE BASE OF THE TRUNK FLARE IS FLUSH WITH ADJACENT GRADE AND PLUMB IN ALL DIRECTIONS.
4. DO NOT USE TREE WRAP. REMOVE TREE WRAP OR CARDBOARD TUBING FROM ALL TREE TRUNKS. DO NOT LEAVE MATERIALS IN THE TREE PIT.
5. STAKE TREES OVER 2" CAL, SET STAKES VERTICAL AND AT SAME HEIGHT. STAKES TO BE PLACED STREET SIDE AND OPPOSITE OF STREET SIDE.
6. WHERE PLANTING SOIL MEETS UNDISTURBED SOIL, SCARIFY SIDES AND BOTTOM OF TREE PIT UP TO THE BOTTOM OF ROOT BALL.
7. PLANTING SOIL SHALL BE A MINIMUM DEPTH OF 3'-0" UNLESS OTHERWISE SPECIFIED.
8. THE TRUNK OF THE TREE SHALL NOT BE USED AS A LEVER IN POSITIONING OR MOVING THE TREE. CONTRACTOR SHALL LEAVE NURSERY/CONTRACTOR SEAL IN PLACE.
9. PRIOR TO MULCHING, LIGHTLY TAMP SOIL AROUND ROOT BALL IN 6" LIFTS TO BRACE TREE. DO NOT OVER COMPACT. WHEN PLANTING HOLE HAS BEEN BACKFILLED, POUR WATER AROUND ROOT BALL TO SETTLE THE SOIL.
10. TREE PROTECTION, WHERE REQUIRED, SHALL BE AS SHOWN ON TREE PROTECTION DETAILS.
11. BARK PROTECTORS MAY BE REQUESTED BY PWD ON A PROJECT BY PROJECT BASIS.



Modified by Pennoni Associates for Stormwater Drainage Study- Green Infrastructure Details

TREE PLANTING

SCALE: N.T.S.

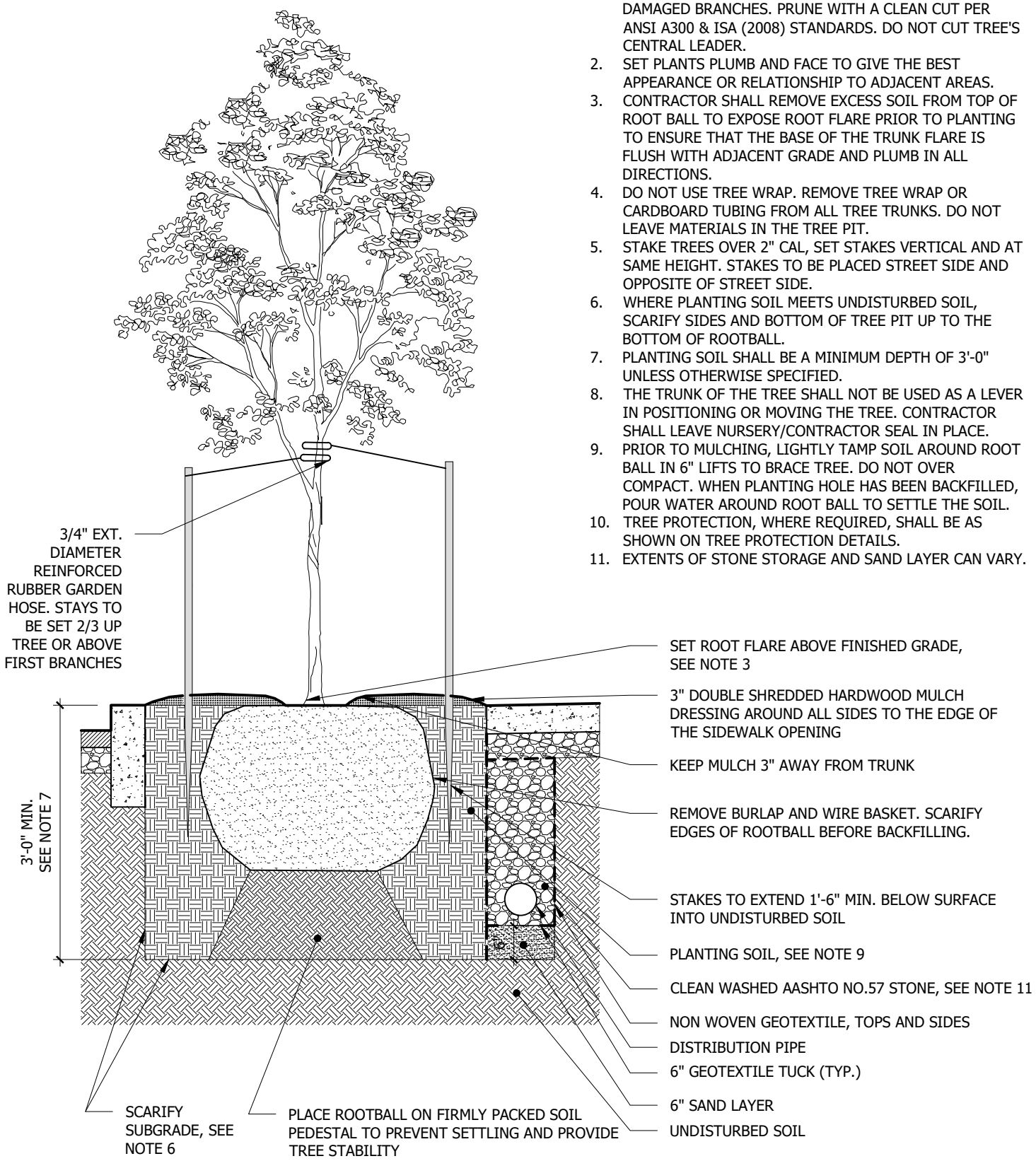
VS.	DATE	INITIALS	REASON
1	09/01/2016		
2	06/01/2018	TJL	ADDED BARK PROTECTORS NOTE

DRAWING NUMBER:

C-38

NOTES:

1. DO NOT HEAVILY PRUNE THE TREE AT PLANTING. PRUNE ONLY CO-DOMINANT LEADERS, BROKEN, DEAD OR DAMAGED BRANCHES. PRUNE WITH A CLEAN CUT PER ANSI A300 & ISA (2008) STANDARDS. DO NOT CUT TREE'S CENTRAL LEADER.
2. SET PLANTS PLUMB AND FACE TO GIVE THE BEST APPEARANCE OR RELATIONSHIP TO ADJACENT AREAS.
3. CONTRACTOR SHALL REMOVE EXCESS SOIL FROM TOP OF ROOT BALL TO EXPOSE ROOT FLARE PRIOR TO PLANTING TO ENSURE THAT THE BASE OF THE TRUNK FLARE IS FLUSH WITH ADJACENT GRADE AND PLUMB IN ALL DIRECTIONS.
4. DO NOT USE TREE WRAP. REMOVE TREE WRAP OR CARDBOARD TUBING FROM ALL TREE TRUNKS. DO NOT LEAVE MATERIALS IN THE TREE PIT.
5. STAKE TREES OVER 2" CAL, SET STAKES VERTICAL AND AT SAME HEIGHT. STAKES TO BE PLACED STREET SIDE AND OPPOSITE OF STREET SIDE.
6. WHERE PLANTING SOIL MEETS UNDISTURBED SOIL, SCARIFY SIDES AND BOTTOM OF TREE PIT UP TO THE BOTTOM OF ROOTBALL.
7. PLANTING SOIL SHALL BE A MINIMUM DEPTH OF 3'-0" UNLESS OTHERWISE SPECIFIED.
8. THE TRUNK OF THE TREE SHALL NOT BE USED AS A LEVER IN POSITIONING OR MOVING THE TREE. CONTRACTOR SHALL LEAVE NURSERY/CONTRACTOR SEAL IN PLACE.
9. PRIOR TO MULCHING, LIGHTLY TAMP SOIL AROUND ROOT BALL IN 6" LIFTS TO BRACE TREE. DO NOT OVER COMPACT. WHEN PLANTING HOLE HAS BEEN BACKFILLED, POUR WATER AROUND ROOT BALL TO SETTLE THE SOIL.
10. TREE PROTECTION, WHERE REQUIRED, SHALL BE AS SHOWN ON TREE PROTECTION DETAILS.
11. EXTENTS OF STONE STORAGE AND SAND LAYER CAN VARY.



Modified by Pennoni Associates for Stormwater Drainage Study- Green Infrastructure Details

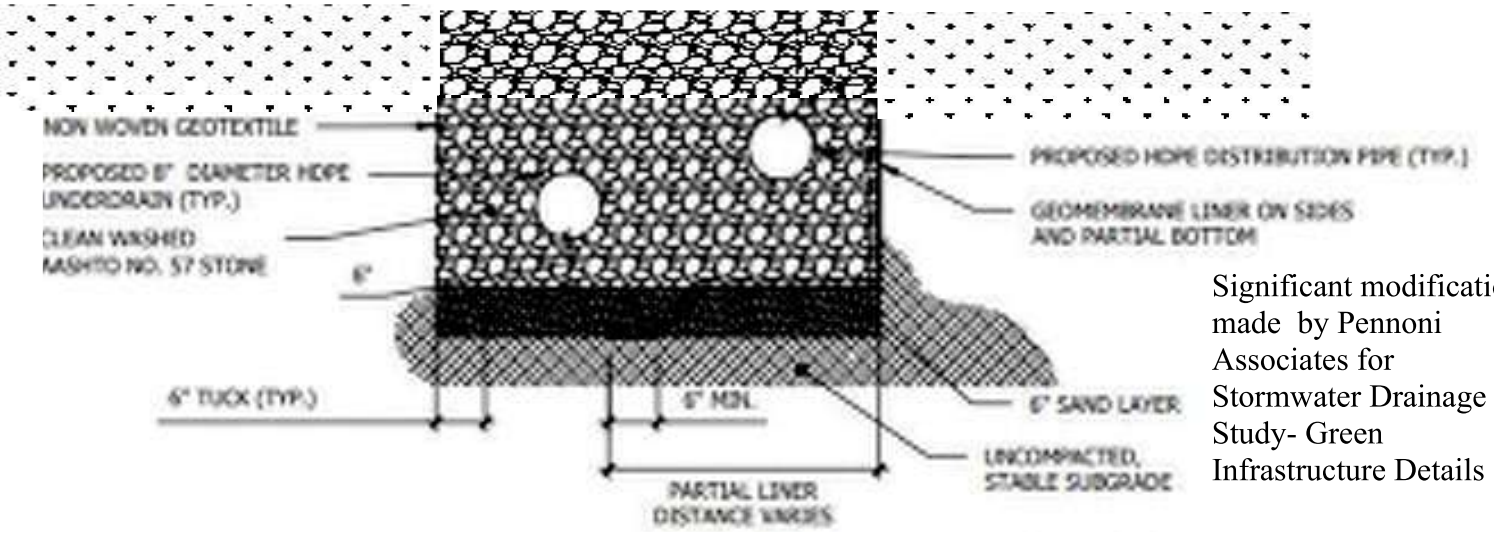
TREE PIT IN STORMWATER TRENCH

SCALE: N.T.S.

VS.	DATE	INITIALS	REASON
1	09/01/2016		

DRAWING NUMBER: C-39

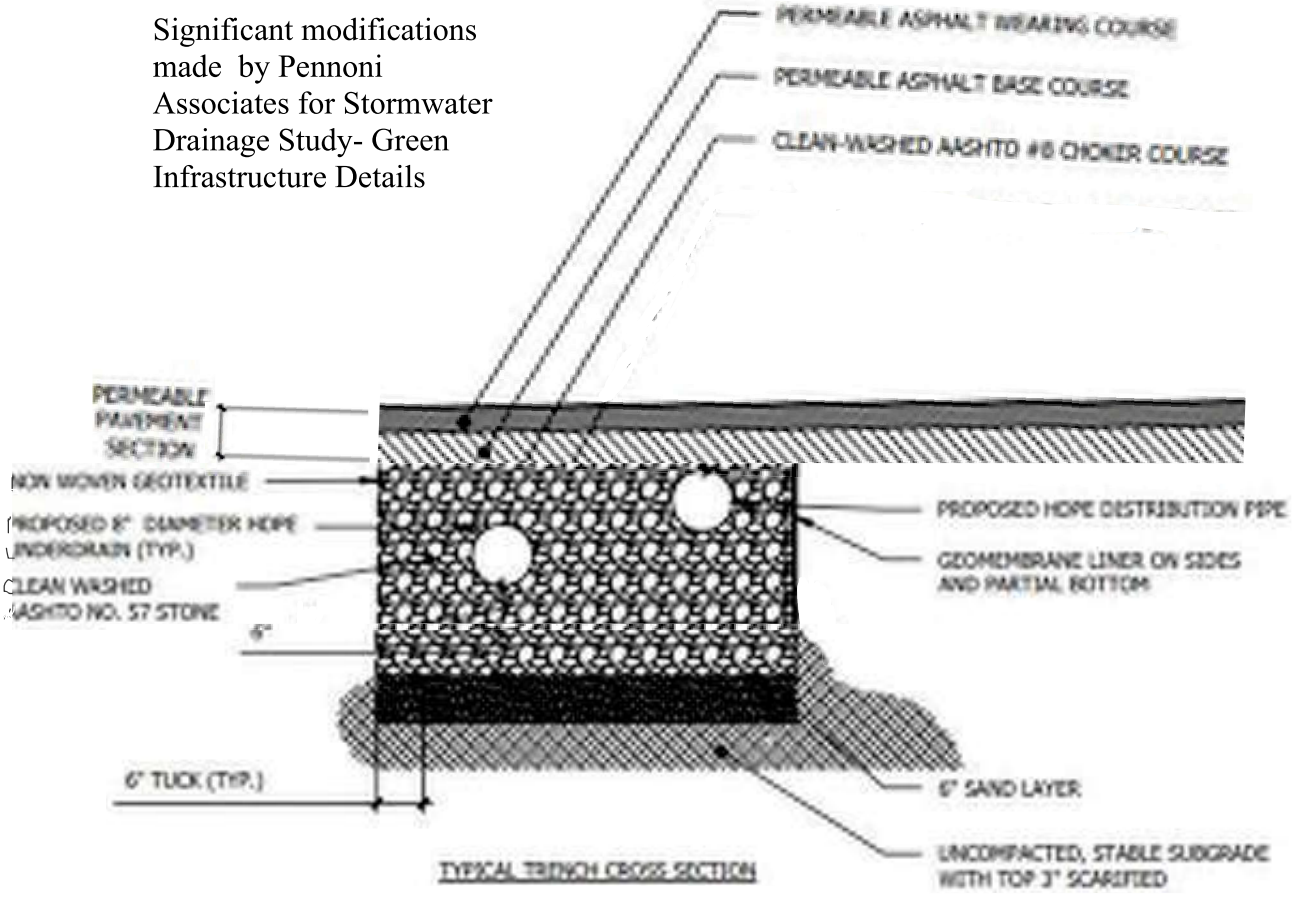
STONE PIT



Significant modifications made by Pennoni Associates for Stormwater Drainage Study- Green Infrastructure Details

UNDERDRAIN TRENCH- PERVIOUS PAVEMENT

Significant modifications made by Pennoni Associates for Stormwater Drainage Study- Green Infrastructure Details



APPENDIX C – Ordinances

- Flood Damage Prevention Ordinance
- Required (NJDEP) Green Infrastructure Elements for Development and Redevelopment

Borough of Barrington, NJ
Thursday, May 5, 2022

Chapter 60. Flood Damage Prevention

[HISTORY: Adopted by the Mayor and Council of the Borough of Barrington 7-12-2016 by Ord. No. 1059. Amendments noted where applicable.]

Article I. Statutory Authorization, Findings of Fact, Purpose and Objectives

§ 60-1. Statutory authorization.

The Legislature of the State of New Jersey has, in N.J.S.A. 40:48-1 et seq., delegated the responsibility to local governmental units to adopt regulations designed to promote public health, safety, and general welfare of its citizenry.

§ 60-2. Findings of fact.

A. The flood hazard areas of the Borough of Barrington are subject to periodic inundation which results in loss of life and property, health and safety hazards, disruption of commerce and governmental services, extraordinary public expenditures for flood protection and relief, and impairment of the tax base, all of which adversely affect the public health, safety, and general welfare.

B. These flood losses are caused by the cumulative effect of obstructions in areas of special flood hazard which increase flood heights and velocities and, when inadequately anchored, cause damage in other areas. Uses that are inadequately floodproofed, elevated or otherwise protected from flood damage also contribute to the flood loss.

§ 60-3. Purpose.

It is the purpose of this chapter to promote the public health, safety, and general welfare, and to minimize public and private losses due to flood conditions in specific areas by provisions designed:

A. To protect human life and health;

B. To minimize expenditure of public money for costly flood-control projects;

C. To minimize the need for rescue and relief efforts associated with flooding and generally undertaken at the expense of the general public;

D. To minimize prolonged business interruptions;

E. To minimize damage to public facilities and utilities such as water and gas mains, electric, telephone and sewer lines, streets, and bridges located in areas of special flood hazard;

F. To help maintain a stable tax base by providing for the second use and development of areas of special flood hazard so as to minimize future flood blight areas;

G. To ensure that potential buyers are notified that property is in an area of special flood hazard; and

H. To ensure that those who occupy the areas of special flood hazard assume responsibility for their actions.

§ 60-4. Methods of reducing flood losses.

In order to accomplish its purposes, this chapter includes methods and provisions for:

A. Restricting or prohibiting uses which are dangerous to health, safety, and property due to water or erosion hazards, or which result in damaging increases in erosion or in flood heights or velocities;

B. Requiring that uses vulnerable to floods, including facilities which serve such uses, be protected against flood damage at the time of initial construction;

C. Controlling the alteration of natural floodplains, stream channels, and natural protective barriers, which help accommodate or channel floodwaters;

D. Controlling filling, grading, dredging, and other development which may increase flood damage; and

E. Preventing or regulating the construction of flood barriers which will unnaturally divert floodwaters or which may increase flood hazards in other areas.

Article II. Terminology

§ 60-5. Definitions.

Unless specifically defined below, words or phrases used in this chapter shall be interpreted so as to give them the meaning they have in common usage and to give this chapter its most reasonable application. As used in this chapter, the following terms shall have the meanings indicated:

AH ZONE
Areas subject to inundation by 1% annual chance shallow flooding (usually areas of ponding) where average depths are between one and three feet. Base flood elevations (BFEs) derived from detailed hydraulic analyses are shown in this zone.

AO ZONE
Areas subject to inundation by 1% annual chance shallow flooding (usually sheet flow on sloping terrain) where average depths are between one foot and three feet.

APPEAL
A request for a review of the Borough Engineer's interpretation of any provision of this chapter or a request for a variance.

AREA OF SHALLOW FLOODING
A designated AO, AH, or VO Zone on a community's Digital Flood Insurance Rate Map (DFIRM) with a 1% annual or greater chance of flooding to an average depth of one foot to three feet where a clearly defined channel does not exist, where the path of flooding is unpredictable and where velocity flow may be evident. Such flooding is characterized by ponding or sheet flow.

AREA OF SPECIAL FLOOD HAZARD
Land in the floodplain within a community subject to a 1% or greater chance of flooding in any given year. It is shown on the FIRM as Zone V, VE, V1-30, A, AO, A1-A30, AE, A99, or AH.

BASE FLOOD

A flood having a 1% chance of being equaled or exceeded in any given year.

BASEMENT

Any area of the building having its floor subgrade (below ground level) on all sides.

BREAKAWAY WALL

A wall that is not part of the structural support of the building and is intended through its design and construction to collapse under specific lateral loading forces without causing damage to the elevated portion of the building or supporting foundation system.

DEVELOPMENT

Any man-made change to improved or unimproved real estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation or drilling operations, or storage of equipment or materials located within the area of special flood hazard.

DIGITAL FLOOD INSURANCE RATE MAP (DFIRM)

The official map on which the Federal Insurance Administration has delineated both the areas of special flood hazard and the risk premium zones applicable to the community.

ELEVATED BUILDING

A nonbasement building built in the case of a building in an area of special flood hazard to have the top of the elevated floor elevated above the ground level by means of piling, columns (posts and piers), or shear walls parallel to the flow of the water, and adequately anchored so as not to impair the structural integrity of the building during a flood up to the magnitude of the base flood. In an area of special flood hazard, "elevated building" also includes a building elevated by means of fill or solid foundation perimeter walls with openings sufficient to facilitate the unimpeded movement of floodwaters.

EXISTING MANUFACTURED HOME PARK OR SUBDIVISION

A manufactured home park or subdivision for which the construction of facilities for servicing the lots on which the manufactured homes are to be affixed (including, at a minimum, the installation of utilities, the construction of streets, and either final site grading or the pouring of concrete pads) is completed before the effective date of the floodplain management regulations adopted by a community.

FLOOD INSURANCE RATE MAP (FIRM)

The official map on which the Federal Insurance Administration has delineated both the areas of special flood hazard and the risk premium zones applicable to the community.

FLOOD INSURANCE STUDY (FIS)

The official report in which the Federal Insurance Administration has provided flood profiles, as well as the Flood Insurance Rate Map(s) and the water surface elevation of the base flood.

FLOOD or FLOODING

A general and temporary condition of partial or complete inundation of normally dry land areas from:

A. The overflow of inland or tidal waters; and/or

B. The unusual and rapid accumulation or runoff of surface waters from any source.

FLOODPLAIN MANAGEMENT REGULATIONS

Zoning ordinances, subdivision regulations, building codes, health regulations, special purpose ordinances (such as a floodplain ordinance, grading ordinance and erosion control ordinance) and other applications of police power. The term describes such state or local regulations, in any combination thereof, which provide standards for the purpose of flood damage prevention and reduction.

FLOODPROOFING

Any combination of structural and nonstructural additions, changes, or adjustments to structures which reduce or eliminate flood damage to real estate or improved real property, water and sanitary facilities, structures and their contents.

HIGHEST ADJACENT GRADE

The highest natural elevation of the ground surface prior to construction next to the proposed or existing walls of a structure.

HISTORIC STRUCTURE

Any structure that is:

A. Listed individually in the National Register of Historic Places (a listing maintained by the Department of the Interior) or preliminarily determined by the Secretary of the Interior as meeting the requirements for individual listing on the National Register;

B. Certified or preliminarily determined by the Secretary of the Interior as contributing to the historical significance of a registered historic district or a district preliminarily determined by the Secretary to qualify as a registered historic district;

C. Individually listed on a state inventory of historic places in states with historic preservation programs which have been approved by the Secretary of the Interior; or

D. Individually listed on a local inventory of historic places in communities with historic preservation programs that have been certified either:

(1) By an approved state program as determined by the Secretary of the Interior; or

(2) Directly by the Secretary of the Interior in states without approved programs.

LOWEST FLOOR

The lowest floor of the lowest enclosed area (including basement). An unfinished or flood-resistant enclosure, usable solely for the parking of vehicles, building access or storage, in an area other than a basement is not considered a building's lowest floor, provided that such enclosure is not built so as to render the structure in violation of other applicable nonelevation design requirements of 44 CFR 60.3.

MANUFACTURED HOME

A structure, transportable in one or more sections, which is built on a permanent chassis and is designed for use with or without a permanent foundation when attached to the required utilities. The term "manufactured home" does not include a recreational vehicle.

MANUFACTURED HOME PARK or MANUFACTURED HOME SUBDIVISION

A parcel (or contiguous parcels) of land divided into two or more manufactured home lots for rent or sale.

NEW CONSTRUCTION

Structures for which the start of construction commenced on or after the effective date of a floodplain regulation adopted by a community and includes any subsequent improvements to such structures.

NEW MANUFACTURED HOME PARK OR SUBDIVISION

A manufactured home park or subdivision for which the construction of facilities for servicing the lots on which the manufactured homes are to be affixed (including, at a minimum, the installation of utilities, the construction of streets, and either final site grading or the pouring of concrete pads) is completed on or after the effective date of the floodplain management regulations adopted by the municipality.

RECREATIONAL VEHICLE

A vehicle which is:

A. Built on a single chassis;

B. Four hundred square feet or less when measured at the longest horizontal projections;

C. Designed to be self-propelled or permanently towable by a light-duty truck; and

D. Designed primarily not for use as a permanent dwelling but as temporary living quarters for recreational, camping, travel, or seasonal use.

START OF CONSTRUCTION

A. For other than new construction or substantial improvements under the Coastal Barrier Resources Act (P.L. No. 97-348),[1] includes substantial improvements and means the date the building permit was issued, provided the actual start of construction, repair, reconstruction, rehabilitation, addition, placement, or other improvement was within 180 days of the permit date. The actual start means either the first placement of permanent construction of a structure on a site, such as the pouring of a slab or footings, the installation of piles, the construction of columns, or any work beyond the stage of excavation, or the placement of a manufactured home on a foundation.

B. Permanent construction does not include land preparation, such as clearing, grading and filling, nor does it include the installation of streets and/or walkways, nor does it include excavation for a basement, footings or piers, or foundations or the erection of temporary forms, nor does it include the installation on the property of accessory buildings, such as garages or sheds not occupied as dwelling units or not part of the main structure. For a substantial improvement, the actual start of construction means the first alteration of any wall, ceiling, floor, or other structural part of a building, whether or not that alteration affects the external dimensions of the building.

STRUCTURE

A walled and roofed building, a manufactured home, or a gas or liquid storage tank that is principally aboveground.

SUBSTANTIAL DAMAGE

Damage of any origin sustained by a structure whereby the cost of restoring the structure to its before-damaged condition would equal or exceed 50% of the market value of the structure before the damage occurred.

SUBSTANTIAL IMPROVEMENT

Any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50% of the market value of the structure before the start of construction of the improvement. This term includes structures which have incurred substantial damage, regardless of the actual repair work performed. The term does not, however, include either:

A. Any project for improvement of a structure to correct existing violations of state or local health, sanitary or safety code specifications which have been identified by the local Code Enforcement Officer and which are the minimum necessary to assure safe living conditions; or

B. Any alteration of a historic structure, provided that the alteration will not preclude the structure's continued designation as a historic structure.

VARIANCE

A grant of relief from the requirements of this chapter that permits construction in a manner that would otherwise be prohibited by this chapter.

VIOLATION

The failure of a structure or other development to be fully compliant with this chapter. A new or substantially improved structure or other development without the elevation certificate, other certifications, or other evidence of compliance required in 44 CFR 60.3(b)(5), (c)(4), (c)(10), (e)(2), (e)(4), or (e)(5) is presumed to be in violation until such time as that documentation is provided.

[1] *Editor's Note: See 16 U.S.C. § 3501 et seq.*

Article III. General Provisions

§ 60-6. Lands to which chapter applies.

This chapter shall apply to all areas of special flood hazard within the jurisdiction of the Borough of Barrington, County of Camden, New Jersey.

§ 60-7. Basis for establishing the areas of special flood hazard.

A. The areas of special flood hazard for the Borough of Barrington, County of Camden, New Jersey, Community Panel Nos. 34007C0043E, 34007C0102F and 34007C0106E, dated August 17, 2016, are identified and defined on the following documents prepared by the Federal Emergency Management Agency:

(1) A scientific and engineering report "Flood Insurance Study, Camden County, New Jersey (All Jurisdictions)," dated August 17, 2016.

(2) "Flood Insurance Rate Map for Camden County, New Jersey (All Jurisdictions)" as shown on index and panel(s), whose effective date is August 17, 2016.

B. The above documents are hereby adopted and declared to be a part of this chapter. The Flood Insurance Study, maps and advisory documents are on file at 229 Trenton Avenue, Barrington, New Jersey 08007.

§ 60-8. Violations and penalties.

No structure or land shall hereafter be constructed, relocated, extended, converted, or altered without full compliance with the terms of this chapter and other applicable regulations. Violation of the provisions of this chapter by failure to comply with any of its requirements (including violations of conditions and safeguards established in connection with conditions) shall constitute a misdemeanor. Any person who violates this chapter or fails to comply with any of its requirements shall upon conviction thereof be fined not more than $2,000 or imprisoned for not more than 90 days, or both, for each violation and, in addition, shall pay all costs and expenses involved in the case. Nothing herein contained shall prevent the Borough of Barrington from taking such other lawful action as is necessary to prevent or remedy any violation.

§ 60-9. Abrogation and greater restrictions.

This chapter is not intended to repeal, abrogate, or impair any existing easements, covenants, or deed restrictions. However, where this chapter and other ordinance, easement, covenant, or deed restriction conflict or overlap, whichever imposes the more stringent restrictions shall prevail.

§ 60-10. Interpretation.

In the interpretation and application of this chapter, all provisions shall be:

A. Considered as minimum requirements;

B. Liberally construed in favor of the governing body; and

C. Deemed neither to limit nor repeal any other powers granted under state statutes.

§ 60-11. Warning and disclaimer of liability.

A. The degree of flood protection required by this chapter is considered reasonable for regulatory purposes and is based on scientific and engineering considerations. Larger floods can and will occur on rare occasions. Flood heights may be increased by man-made or natural causes. This chapter does not imply that land outside the area of special flood hazard or uses permitted within such areas will be free from flooding or flood damages.

B. This chapter shall not create liability on the part of the Borough of Barrington, any officer or employee thereof or the Federal Insurance Administration for any flood damages that result from reliance on this chapter or any administrative decision lawfully made thereunder.

Article IV. Administration

§ 60-12. Establishment of development permit.

A development permit shall be obtained before construction or development begins, including placement of manufactured homes, to determine whether such construction or development is in a floodplain. Application for a development permit shall be made on forms furnished by the Borough Engineer and may include, but not be limited to, plans in duplicate drawn to scale showing the nature, location, dimensions, and elevations of the area in question, existing or proposed structures, fill, storage of materials, drainage facilities, and the location of the foregoing. Specifically, the following information is required:

A. Elevation in relation to mean sea level of the lowest floor (including basement) of all structures.

B. Elevation in relation to mean sea level to which any structure has been floodproofed.

C. Description of the extent to which any watercourse will be altered or relocated as a result of proposed development.

§ 60-13. Designation of local administrator.

The Borough Engineer is hereby appointed to administer and implement this chapter by granting or denying development permit applications in accordance with its provisions.

§ 60-14. Duties and responsibilities of administrator.

Duties of the Borough Engineer shall include, but not be limited to:

A. Permit review.

(1) Review all development permits to determine that the permit requirements of this chapter have been satisfied; and

(2) Review all development permits to determine that all necessary permits have been obtained from those federal, state or local governmental agencies from which prior approval is required.

B. Use of other base flood and floodway data. The Borough Engineer shall obtain, review, and reasonably utilize any base flood elevation and floodway data available from a federal, state or other source in order to administer § **60-16**, General standards.

C. Information to be obtained and maintained.

(1) Obtain and record the actual elevation (in relation to mean sea level) of the lowest floor (including basement) of all new or substantially improved structures, and whether or not the structure contains a basement.

(2) Maintain for public inspection all records pertaining to the provisions of this chapter.

D. Alteration of watercourses.

(1) Notify adjacent communities and the New Jersey Department of Environmental Protection, Dam Safety and Flood Control Section and the Land Use Regulation Program, prior to any alteration or relocation of a watercourse and submit evidence of such notification to the Federal Insurance Administration.

(2) Require that maintenance is provided within the altered or relocated portion of said watercourse so the flood-carrying capacity is not diminished.

E. Substantial damage review.

(1) After an event resulting in building damages, assess the damage to structures due to flood and nonflood causes.

(2) Record and maintain the flood and nonflood damage of substantial damage structures and provide a letter of substantial damage determination to the owner and the New Jersey Department of Environmental Protection, Dam Safety and Flood Control Section.

F. Interpretation of FIRM boundaries. Make interpretations, where needed, as to the exact location of the boundaries of the areas of special flood hazard (for example, where there appears to be a conflict between a mapped boundary and actual field conditions). The person contesting the location of the boundary shall be given a reasonable opportunity to appeal the interpretation as provided in § **60-15**, Variance procedure.

§ 60-15. Variance procedure.

A. Appeal board.

(1) The Planning Board as established by the Borough of Barrington shall hear and decide appeals and requests for variances from the requirements of this chapter.

(2) The Planning Board shall hear and decide appeals when it is alleged there is an error in any requirement, decision, or determination made by the Borough Engineer in the enforcement or administration of this chapter.

(3) Those aggrieved by the decision of the Planning Board, or any taxpayer, may appeal such decision to the Superior Court of New Jersey, Law Division, Camden County, as provided by statute.

(4) In passing upon such applications, the Planning Board shall consider all technical evaluations, all relevant factors, standards specified in other sections of this chapter, and:

(a) The danger that materials may be swept onto other lands to the injury of others;

(b) The danger to life and property due to flooding or erosion damage;

(c) The susceptibility of the proposed facility and its contents to flood damage and the effect of such damage on the individual owner;

(d) The importance of the services provided by the proposed facility to the community;

(e) The necessity to the facility of a waterfront location, where applicable;

(f) The availability of alternative locations for the proposed use which are not subject to flooding or erosion damage;

(g) The compatibility of the proposed use with existing and anticipated development;

(h) The relationship of the proposed use to the comprehensive plan and floodplain management program of that area;

(i) The safety of access to the property in times of flood for ordinary and emergency vehicles;

(j) The expected heights, velocity, duration, rate of rise, and sediment transport of the floodwaters and the effects of wave action, if applicable, expected at the site; and

(k) The costs of providing governmental services during and after flood conditions, including maintenance and repair of public utilities and facilities, such as sewer, gas, electrical and water systems, and streets and bridges.

(5) Upon consideration of the factors of § **60-15A(4)** and the purposes of this chapter, the Planning Board may attach such conditions to the granting of variances as it deems necessary to further the purposes of this chapter.

(6) The Borough Engineer shall maintain the records of all appeal actions, including technical information, and report any variances to the Federal Insurance Administration upon request.

B. Conditions for variances.

(1) Generally, variances may be issued for new construction and substantial improvements to be erected on a lot of 1/2 acre or less in size contiguous to and surrounded by lots with existing structures constructed below the base flood level, provided § **60-15A(4)(a)** through **(k)** have been fully considered. As the lot size increases beyond the 1/2 acre, the technical justification required for issuing the variance increases.

(2) Variances may be issued for the repair or rehabilitation of historic structures upon a determination that the proposed repair or rehabilitation will not preclude the structure's continued designation as a historic structure and the variance is the minimum necessary to preserve the historic character and design of the structure.

(3) Variances shall only be issued upon a determination that the variance is the minimum necessary, considering the flood hazard, to afford relief.

(4) Variances shall only be issued upon:

(a) A showing of good and sufficient cause;

(b) A determination that failure to grant the variance would result in exceptional hardship to the applicant; and

(c) A determination that the granting of a variance will not result in increased flood heights, additional threats to public safety, or extraordinary public expense; create nuisances; cause fraud on or victimization of the public as identified in § **60-15A(4)**; or conflict with existing local laws or ordinances.

(5) Any applicant to whom a variance is granted shall be given written notice that the structure will be permitted to be built and that the cost of flood insurance will be commensurate with the increased risk resulting from the reduced lowest floor elevation.

Article V. Provisions for Flood Hazard Reduction

§ 60-16. General standards.

In all areas of special flood hazard, compliance with the applicable requirements of the Uniform Construction Code (N.J.A.C. 5:23) and the following standards, whichever is more restrictive, is required:

A. Anchoring.

(1) All new construction and substantial improvements shall be anchored to prevent flotation, collapse, or lateral movement of the structure.

(2) All manufactured homes shall be anchored to resist flotation, collapse or lateral movement. Methods of anchoring may include, but are not to be limited to, use of over-the-top or frame ties to ground anchors. This requirement is in addition to applicable state and local anchoring requirements for resisting wind forces.

B. Construction materials and methods.

(1) All new construction and substantial improvements shall be constructed with materials and utility equipment resistant to flood damage.

(2) All new construction and substantial improvements shall be constructed using methods and practices that minimize flood damage.

C. Utilities.

(1) All new and replacement water supply systems shall be designed to minimize or eliminate infiltration of floodwaters into the system;

(2) New and replacement sanitary sewage systems shall be designed to minimize or eliminate infiltration of floodwaters into the systems and discharge from the systems into floodwaters;

(3) On-site waste disposal systems shall be located to avoid impairment to them or contamination from them during flooding; and

(4) For all new construction and substantial improvements the electrical, heating, ventilation, plumbing and air-conditioning equipment and other service facilities shall be designed and/or located so as to prevent water from entering or accumulating within the components during conditions of flooding.

D. Subdivision proposals.

(1) All subdivision proposals and other proposed new development shall be consistent with the need to minimize flood damage;

(2) All subdivision proposals and other proposed new development shall have public utilities and facilities such as sewer, gas, electrical, and water systems located and constructed to minimize flood damage;

(3) All subdivision proposals and other proposed new development shall have adequate drainage provided to reduce exposure to flood damage; and

(4) Base flood elevation data shall be provided for subdivision proposals and other proposed new development which contain at least 50 lots or five acres (whichever is less).

E. Enclosure openings. All new construction and substantial improvements having fully enclosed areas below the lowest floor that are usable solely for parking of vehicles, building access or storage in an area other than a basement and which are subject to flooding shall be designed to automatically equalize hydrostatic flood forces on exterior walls by allowing for the entry and exit of floodwaters. Designs for meeting this requirement must either be certified by a registered professional engineer or architect or must meet or exceed the following minimum criteria:

(1) A minimum of two openings in at least two exterior walls of each enclosed area having a total net area of not less than one square inch for every square foot of enclosed area subject to flooding shall be provided

(2) The bottom of all openings shall be no higher than one foot above grade.

(3) Openings may be equipped with screens, louvers, or other covering or devices provided that they permit the automatic entry and exit of floodwaters.

F. Manufactured homes.

(1) Manufactured homes shall be anchored in accordance with § **60-16A(2)**.

(2) All manufactured homes to be placed or substantially improved within an area of special flood hazard shall:

(a) Be consistent with the need to minimize flood damage.

(b) Be constructed to minimize flood damage.

(c) Have adequate drainage provided to reduce exposure to flood damage.

Article VI. Severability

§ 60-17. Severability.

If any section, subsection, paragraph, sentence, clause, or phrase of this chapter shall be declared invalid for any reason whatsoever, such a decision shall not affect the remaining portions of the chapter, which shall remain in full force and effect, and for this purpose the provisions of this chapter are hereby declared to be severable.

Article VII. Enactment

§ 60-18. Effective date.

This chapter shall be effective on August 1, 2016, and shall remain in force until modified, amended or rescinded by Borough of Barrington of Camden County, New Jersey.

O. Green Infrastructure Standards

1. This subsection specified the types of green infrastructure BMPs that may be used to satisfy the groundwater recharge, stormwater runoff quality, and stormwater runoff quantity standards.
2. To satisfy the groundwater recharge and stormwater runoff quality standards at Section IV.P and Q, the design engineer shall utilize green infrastructure BMPs identified in Table 1 at Section IV.F. and/or an alternative stormwater management measure approved in accordance with Section IV.G. The following green infrastructure BMPs are subject to the following maximum contributory drainage area limitations:

Best Management Practice	**Maximum Contributory Drainage Area**
Dry Well	1 acre
Manufactured Treatment Device	2.5 acres
Pervious Pavement Systems	Area of additional inflow cannot exceed three times the area occupied by the BMP
Small-scale Bioretention Systems	2.5 acres
Small-scale Infiltration Basin	2.5 acres
Small-scale Sand Filter	2.5 acres

3. To satisfy the stormwater runoff quantity standards at Section IV.R, the design engineer shall utilize BMPs from Table 1 or from Table 2 and/or an alternative stormwater management measure approved in accordance with Section IV.G.
4. If a variance in accordance with N.J.A.C. 7:8-4.6 or a waiver from strict compliance in accordance with Section IV.D is granted from the requirements of this subsection, then BMPs from Table 1, 2, or 3, and/or an alternative stormwater management measure approved in accordance with Section IV.G may be used to meet the groundwater recharge, stormwater runoff quality, and stormwater runoff quantity standards at Section IV.P, Q and R.
5. For separate or combined storm sewer improvement projects, such as sewer separation, undertaken by a government agency or public utility (for example, a sewerage company), the requirements of this subsection shall only apply to areas owned in fee simple by the government agency or utility, and areas within a right-of-way or easement held or controlled by the government agency or utility; the entity shall not be required to obtain additional property or property rights to fully satisfy the requirements of this subsection. Regardless of the amount of area of a separate or combined storm sewer improvement project subject to the green infrastructure requirements of this subsection, each project shall fully comply with the applicable groundwater recharge, stormwater runoff quality control, and stormwater runoff quantity standards at Section IV.P, Q and R, unless the project is granted a waiver from strict compliance in accordance with Section IV.D.

P. Groundwater Recharge Standards

1. This subsection contains the minimum design and performance standards for groundwater recharge as follows:
2. The design engineer shall, using the assumptions and factors for stormwater runoff and groundwater recharge calculations at Section V, either:
    i. Demonstrate through hydrologic and hydraulic analysis that the site and its stormwater management measures maintain 100 percent o the average annual pre-construction groundwater recharge volume for the site; or
    ii. Demonstrate through hydrologic and hydraulic analysis that the increase of stormwater runoff volume from pre-construction to post-construction for the 2-year storm is infiltrated.
3. This groundwater recharge requirement does not apply to projects within the "urban redevelopment area," or to projects subject to 4 below.
4. The following types of stormwater shall not be recharged:
    i. Stormwater from areas of high pollutant loading. High pollutant loading areas are areas in industrial and commercial developments where solvents and/or petroleum products are loaded/unloaded, stored, or applied, areas where pesticides are loaded/unloaded or stored; areas where hazardous materials are expected to be present in greater than "reportable quantities" as defined by the United States Environmental Protection Agency (EPA) at 40 CFR 302.4; areas where recharge would be inconsistent with Department approved remedial action work plan or landfill closure plan and areas with high risks for spills of toxic materials, such as gas stations and vehicle maintenance facilities; and
    ii. Industrial stormwater exposed to "source material." "Source material" means any material(s) or machinery, located at an industrial facility, that is directly or indirectly related to process, manufacturing or other industrial activities, which could be a source of pollutants in any industrial stormwater discharge to groundwater. Source materials include, but are not limited to, raw materials; intermediate products; final products; waste materials; by-products; industrial machinery and fuels, and lubricants, solvents, and detergents that are related to process, manufacturing, or other industrial activities that are exposed to stormwater.