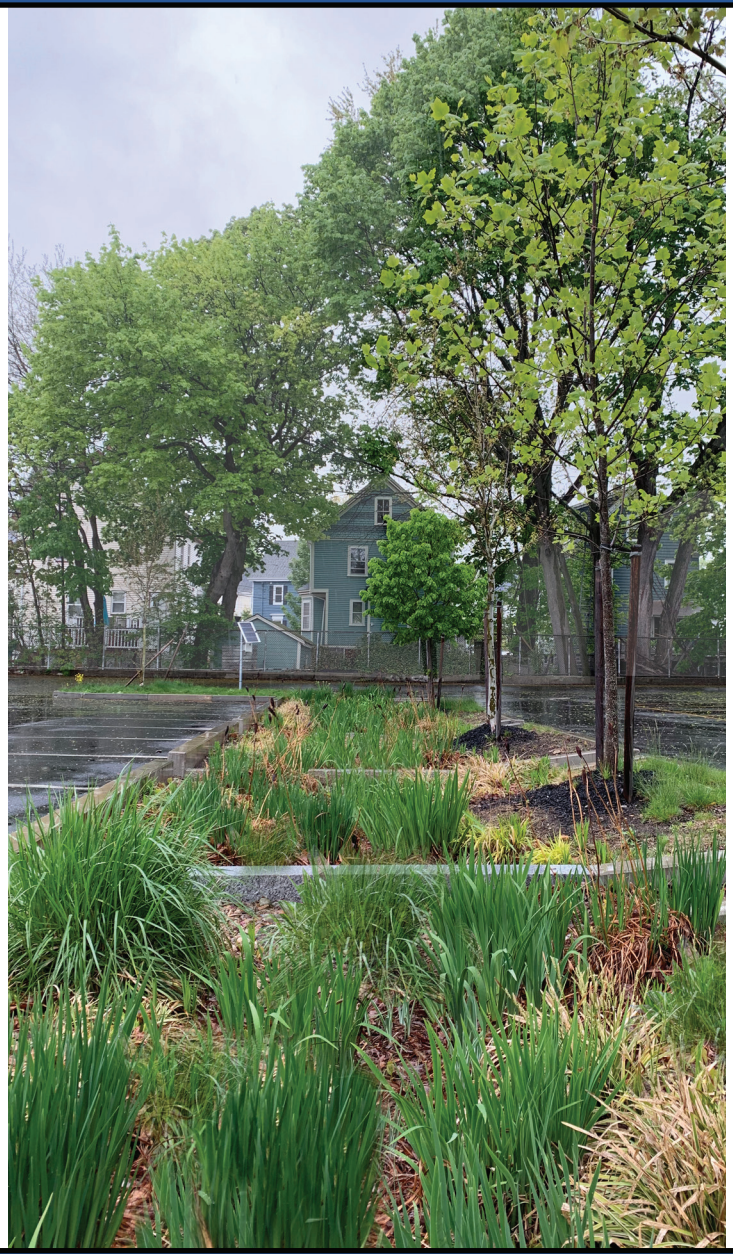
STORMWATER TREE TRENCH
DESIGN OPTIONS GUIDE

December, 2021



Providence Stormwater Innovation Center

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SNEP NETWORK

Horsley Witten Group

Southeast New England Program (SNEP) Network

The SNEP Network is a project of the New England Environmental Finance Center and is funded by the U.S. Environmental Protection Agency's Southeast New England Program.

About

The Southeast New England Program Network is a collaborative group of 16 partner organizations with expertise in financing and implementing stormwater and watershed management efforts. The mission of the SNEP Network is to empower communities to achieve healthy watersheds, sustainable financing and long-term climate resilience through management of stormwater and restoration projects. A project of the New England Environmental Finance Center, The Network provides free training and technical assistance to strengthen the capacity of municipalities, organizations, and tribes within Rhode Island and Southeastern Massachusetts.

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PURPOSE

INTRODUCTION

A Stormwater Tree Trench (Tree Trench) is a type of Green Stormwater Infrastructure (GSI) technique which uses a nature based approach to filter and infiltrate stormwater. The Stormwater Tree Trench Design Guide (the Guide) was developed as a companion to existing design manuals to help municipalities design and maintain greener, healthier, and more resilient tree trenches. The Guide is a tool to assist with the design process given specific stormwater objectives, site context, aesthetics, tree health, and maintenance capabilities. It is not intended to be prescriptive or one-size-fits-all, but rather to encourage a creative, multi-functional design approach specific to each project's needs, goals, and budget.

Guidance pertaining to regulatory requirements, sizing criteria, and construction details specific to the practice are not included in this Guide. Refer to the Rhode Island Stormwater Design and Installation Standards Manual, the Rhode Island Department of Transportation Linear Stormwater Manual, as well as other regulatory documents and resources for specific design and maintenance requirements. Registered professionals knowledgeable in the design and installation of GSI, landscape design, and tree health should be consulted to ensure all goals, objectives, and requirements are met.

HOW DOES IT WORK?

Tree Trenches are designed to mimic nature and use the natural filtration properties of soil and plants to remove pollutants from stormwater runoff. All GSI, including Stormwater Tree Trenches, rely on the following five basic steps and the associated components to function properly.

1. **Collect**
2. **Capture**
3. **Move**
4. **Filter and/or Infiltrate**
5. **Overflow**

These components will be referenced throughout this Guide. If one of these steps does not function properly, the entire system could be compromised and the GSI practice itself could contribute to more frequent maintenance burden, unhealthy trees, and localized flooding, possibly requiring costly repairs.

A Tree Trench can include variations of different GSI practices designed to filter or infiltrate stormwater as well as add trees to the landscape, such as an Infiltration Gutter, Bioretention Curb Inlet Planter, Bioretention Swale, Biostrip, Tree Filter, Tree Filter with Storage, Enhanced Tree Trench, Tree Trench, and Tree Pit Filter. For the purposes of this Guide, we have simplified the practices into two basic types:

- **Surface Tree Trench** - provides stormwater filtration through an amended soil media and in some applications infiltration through the subsoils.

- **Subsurface Tree Trench** - provides stormwater storage in a gravel bed and infiltrates stormwater through the subsoils.

PURPOSE

HOW TO USE THIS GUIDE

The Guide provides a basic understanding of the different components of a Tree Trench and information to assist design decisions specific to each project's location and objectives. The Guide starts with an initial introduction to **Trees and Good Practices** and is then divided into two sections which provides more detailed design information on the two Tree Trench types.
Under each type are the following three subsections:

Components

This section describes the five basic components for each tree trench type: Collect, Capture, Move, Filter or Infiltrate. The design and location of each component may vary depending on specific site constraints and design choices.

Design Matrix

Understanding the various options available for each component is important to selecting the one that best fits a specific application and context. The Design Matrix lists the advantages, limitations, uses, and general maintenance for each design option.

Typical Layout

Typical tree trench layout options are provided for each tree trench type to illustrate how the components fit together and their adaptability to various conditions. These layouts are not intended to be the only options. Layout variations can be developed to create a unique tree trench that fits a sites specific needs.

Subsurface stormwater tree trench

TREE BENEFITS

Healthy and mature trees provide a wide array of health, safety, environmental, and economic benefits within our communities. The design of these practices should take into consideration the growth and health of the tree to maximize these long-term benefits. Trees intercept rainfall, "absorb" stormwater runoff, filter pollutants, and provide water storage, thereby acting as a GSI system unto themselves. They also provide the following additional benefits beyond stormwater management:

- Add shade and urban tree canopy
- Mitigate the urban heat island effect
- Absorb carbon dioxide from the air and release oxygen
- Remove various pollutants from the atmosphere through absorption and adhesion
- Create context and frame views
- Provide a physical and visual connection to nature
- Create and enhance habitat
- Provide traffic calming benefit within streetscapes, and increase pedestrian comfort
- Improve property values

SITE CONTEXT

Considering the benefits trees provide, a tree trench should be carefully designed to create an environment where trees will thrive. This requires careful review of the intended location to determine if the site conditions are appropriate. When starting the design process it is important to review the project area and consider the following questions:

1. Is there enough room for the tree roots?
2. Is there enough room for the tree canopy?
3. Are there any site constraints that will affect tree growth?
4. Will the tree need to be removed or replaced?

Roots

Tree trenches should be designed to include adequate root space for trees to grow to full maturity and ensure longevity. The exact volume varies per tree species. According to the National Association of City Transportation Officials (NACTO) Urban Street Stormwater Guide, a minimum cubic footage can be determined by tree canopy:

- 10' Canopy = 120 CF
- 20' Canopy = 500 CF
- 30' Canopy = 1000 CF

The first few inches of soil depth are the most important for the root system and should be prioritized. Most roots typically do not utilize soil beyond a 4-foot depth, therefore volume below this depth need not be considered.

To reach the recommended minimum sizes a linear tree trench will frequently be close to the length of the tree canopy, depending on it's width. For subsurface practices, the opening in the surrounding hardscape should be at least 6' by 4' wide.

The growing form of the root system should also be considered. There are generally three types of root forms, tap root, heart root, and flat root. The root system may vary depending on site constraints, but generally some of the species for these types are:

- **Tap root:** hickory, walnut, butternut, white oak, hornbeam
- **Heart root:** red oak, honey locust, basswood, sycamore, pines
- **Flat root:** birch, fir, spruce, sugar maple, cottonwood, silver maple, hackberry.

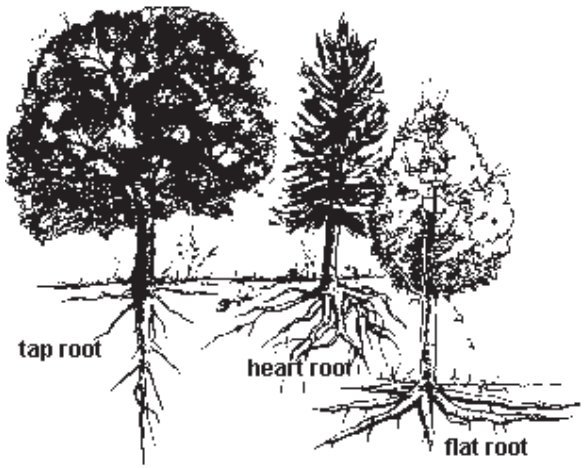


Image and species per root provided by Iowa State University Forestry Extension.

In general, trees that are tap or heart rooted have less expansive root zones and are best for tree trenches with hardscape, and are less likely to clog up practices.

Root options

If site constraints do not allow for the proposed root system area/volume, consider expanding the available root zone area with one of the following options:

- Reducing the amount of surrounding hardscape,
- Connecting to adjacent open spaces or
- Utilizing structural soil or tree cell products under paved surfaces. (These are propriety products, and several resources are available for their design and installation.)

Depending on the site-specific constraints and design, it may make sense to locate the tree outside of the inundation/ponding area so the roots may take advantage of the excess water and growing space but reduce the stress of continual inundation, as demonstrated in the Typical Layout section.

Canopy Space

Consider the size of the canopy from when the tree is planted to full growth. Are there structures or overhead utilities in the immediate area that the canopy might grow into? Is there an adjacent walkway or roadway that may be affected by lower branches? Selecting the right tree for the location will help prevent future harm to the branches.

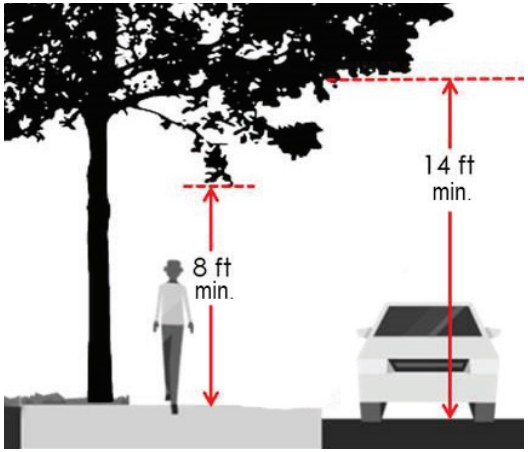


Image by City of Shoreline Washington. shoelinewa.gov

Site Constraints

Consider existing or proposed site conditions that may affect tree health such as the following:

- Targeted stormwater pollutants or receiving water impairments
- Roadway maintenance (salt & snow storage)
- Underground infrastructure
- Depth to groundwater
- Stored stormwater drawdown time
- Circulation – pedestrian and vehicular
- Contamination of soil or groundwater from previous land uses

SELECTING SPECIES

Along with the site constraints listed above typical restrictions for plant selection should be taken into consideration such as sun/shade tolerance, soil pH, drought/urban stress tolerance, etc. Additionally, tree selection should maximize benefits for the surrounding environment such as shade, human health benefits, traffic calming, and wildlife habitat.

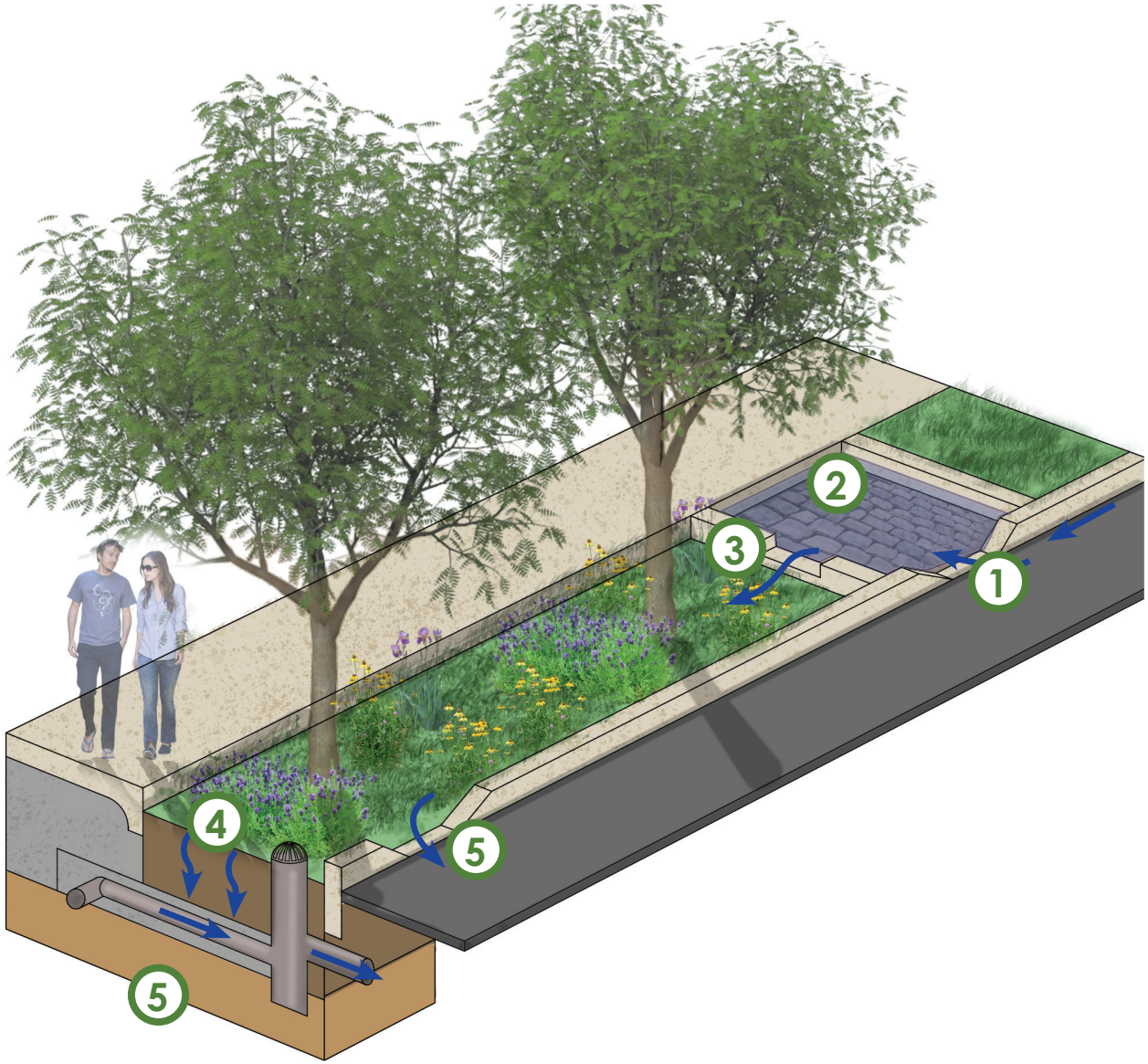
Many resources are available to help select tree species that are appropriate for a specific site. Some of the available sources include:

- The Climate and Health Species list for Rhode Island Urban Trees
- Rhode Island Stormwater Design and Installation Standards Manual (RIDEM & CRMC)
- RIDOT Linear Stormwater Manual
- EPA Stormwater Trees Technical Memorandum

The multi-functional benefits of planting and protecting trees should not be overlooked. Opportunities to preserve and enhance the urban tree canopy should be identified early during the site analysis and design process.

SURFACE TREE TRENCH

COMPONENTS



1 COLLECT
Stormwater runoff enters the treatment system through an inlet.

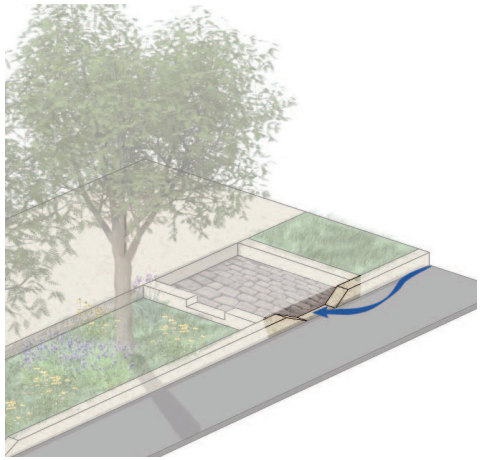
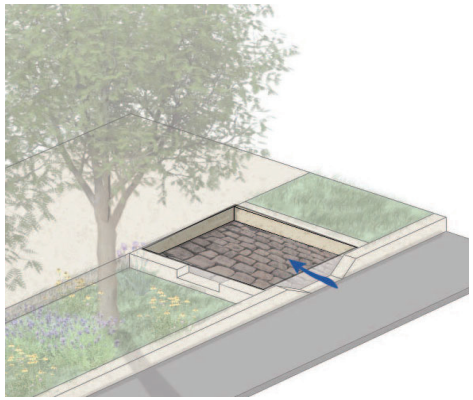
2 CAPTURE
The collected runoff is directed to a sediment forebay, that slows the water down with a check dam, allowing debris and sediment to settle out.

3 MOVE
The runoff then overflows into the filter area.

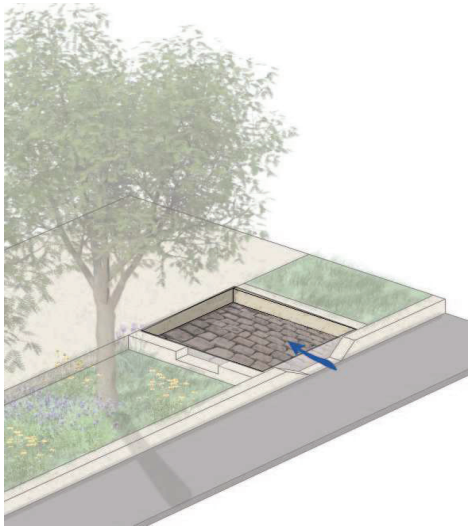
4 FILTER
The runoff is filtered through manufactured soil and root zones to remove pollutants and provide watering.

5 OVERFLOW
The filtered stormwater exits the system through subsurface infiltration providing groundwater recharge or via the outlet structure for larger storm events.

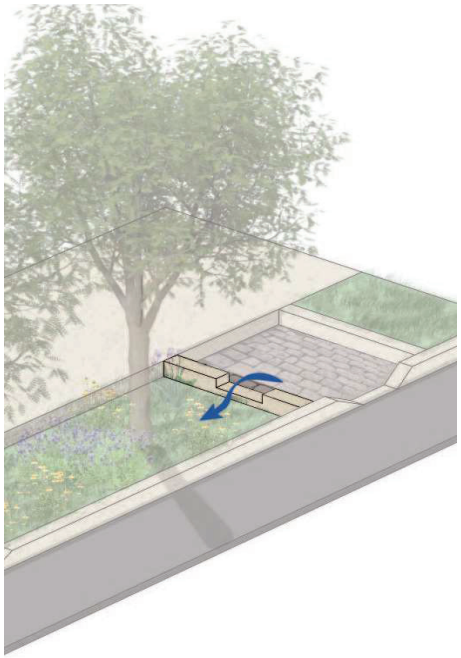
DESIGN MATRIX

		ADVANTAGES	LIMITATIONS	USE	CONSTRUCTION & MAINTENANCE
1. COLLECT (Inlet)					
 **Considerations:** • Design inlet location to ensure proper drainage direction. If placed along a gutter line utilize micro grading to create a low point and direct water into inlet.	a. Curb Cut				
		• Cost: Inexpensive • Clean and simple design • Easy to retrofit • Difficult to clog • Can be taken off line in the winter if desired • Easily maintained	• Perpendicular to gutter line and prone to water bypassing • May require gutter line regrading • Can be damaged from plowing • Can be clogged by snow/ice during the winter	• Streetscape. • Parking lots. • Road medians. • Best located at road sag / low points	• Monitor for debris and clogging • Monitor for rainwater by-passes • Requires low point is set 1" lower than gutter line • Shovel in winter
	b. Trench Inlet				
		• Surface flow option where curb & sidewalks exist • Accommodates pedestrians • Can be used as a design element • Many grate pattern options • Can be taken off line in the winter if desired	• Cost: Expensive • Prone to more frequent clogging • Grate needs to be removed & heavy for cleaning • Difficult to build on an angle • See also Curb Cut above	• Areas with sidewalk crossings (Streetscape / Parking lots)	• Monitor for debris and clogging • Open grate to remove debris from under
	c. Paver Flume				
		• Cost: Moderate • Efficient at intercepting water • Can be angled • Adaptable to many uses • Difficult to clog • Easily maintained	• Requires more repaving • Can be clogged by snow/ice during the winter • Difficult to take offline • Utilitarian aesthetic	• Open spaces • Natural edge • Parking lot • Road medians	• Monitor for debris and clogging
2. CAPTURE (Sediment Forebay)					
	a. Vegetated				
		• Cost: Inexpensive • Soft aesthetic that blends in with natural setting • Additional treatment with vegetation • Can be mowable • Infrequent cleaning	• Requires digging up vegetation and replanting to remove sediment • Will clog over time • Can become unsightly/weedy	• Open spaces • Naturalistic areas • (Best for areas with low anticipated sediment loading)	• Vegetation management • Monitor soil for clogging or puddles. If standing water is observed remove and replace top 3" of soil and replant.
	b. Landscape Stone (hand placed)				
		• Cost: Inexpensive • Easy install • Material readily available • Well-drained	• Sediment trapped between stone is very difficult to maintain • More expensive maintenance over life of practice • Can become weedy & unsightly	• Not recommended	• Monitor for clogging. Once stone is filled with debris remove, clean and replace.

DESIGN MATRIX

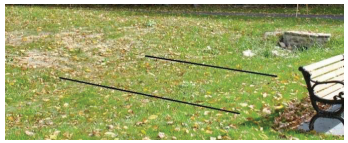
		ADVANTAGES	LIMITATIONS	USE	CONSTRUCTION & MAINTENANCE
2. CAPTURE (Sediment Forebay) - continued					
	c. Permeable Pavers				
		• Easy maintenance (shovel) • Provides a visual indicator/hard surface for cleaning • Many design options available • Porous voids can be planted • Provides a nice design aesthetic	• Moderate to expensive • Requires frequent cleaning to prevent clogging • Void spaces may become difficult to clean over time	• Streetscape • Parking lots • Open spaces • Naturalistic areas (depending on the product)	• Shovel and remove sediment build up in forebay • If standing water is observed over an extended period, power wash to clean out sediment build up, or pull up, clean and reinstall.
	d. Cobbles or Landscape Stone (mortared)				
		• Easy maintenance (shovel) • Provides a visual indicator/hard surface for cleaning • Great design element and aesthetics	• Cost: Expensive • Holds water for extended periods • Mortared joints may retain sediment over time and become harder to clean • Weir design needs to account for drainage	• Urban streetscape • Historic areas	• Shovel and remove sediment build up in forebay
	e. Concrete with Opening				
		• Very easy maintenance (shovel) • Provides a visual indicator/smooth surface for cleaning • Stamping options • Opening in concrete provides a planting opportunity	• Cost: Moderate to Expensive • Can hold water for extended periods • Requires a porous opening to allow for drainage • Opening is prone to clogging and requires replacing soil/plants • Utilitarian aesthetic	• Urban streetscape • Parking lot	• Shovel and remove sediment build up in forebay • If excessive puddling occurs and opening is clogged remove and replace top 3" of soil in opening and replant.
Considerations: • Design to avoid standing water over an extended period of time with permeable surface or other option. This can be achieved through a permeable ground plain when there is adequate ground water separation or seepage through the weir (3. Move). • The depth and size of the forebay is determined be determined by the amount of water collected, sediment loading and regulatory requirements.	f. Impermeable Pavers (With Opening)				
		• Easy maintenance (shovel) • Provides a visual indicator/hard surface for cleaning • Great design element and aesthetics • Incorporates plants	• Cost: Expensive • Planted porous opening prone to clogging • Can holds water for extended periods • Mortared joints may retain sediment over time	• Urban streetscape • Historic areas	• Shovel and remove sediment build up in forebay • If excessive puddling occurs and opening is clogged remove and replace top 3" of soil in opening and replant.

DESIGN MATRIX

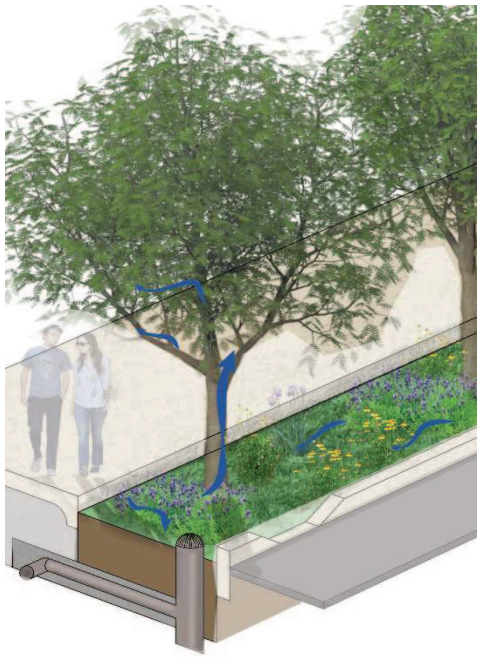


Considerations:

• When impermeable weirs are selected, adequate drainage in sediment forebay such as permeable surface, needs to be provided for draw down.

	ADVANTAGES	LIMITATIONS	USE	CONSTRUCTION & MAINTENANCE
3. MOVE (Weir/check dam)				
a. Stone				
	• Cost: Inexpensive • Re-use of materials on site • Natural aesthetic • Permeable	• Sediment may migrate through the gaps • Requires a skilled contractor to install correctly • May need to be mortared or variation in stone size to prevent excessive weeping • Suitable for natural settings	• Open spaces and naturalistic areas with space available	• Monitor for clogging. Once stone is filled with debris remove, clean and replace.
b. Earthen, Vegetated				
	• Cost: Inexpensive • Natural aesthetic	• Requires more space • Prone to erosion • Can settle over time • Can become unsightly • Can be damaged during maintenance • Permeable	• Limited to open spaces and naturalistic areas with space available	• Vegetation management (cutting / weed whacking) • Monitor for erosion
c. Curbing				
	• Multiple design options (granite, reclaimed granite, concrete) • Space efficient • Highly durable/functional • Formal aesthetic	• Cost: Expensive • Impermeable	• Streetscape • Parking lot • Open spaces	• Minimal
e. Wooden Log or Compost Sock				
	• Cost: Inexpensive • Reclaimed/sustainable material • Naturalistic aesthetic • Can incorporate vegetation into sock	• Moderate to low durability • Likely to break down over time and will need to be replaced • Hardwoods preferred • Limited applications/site specific	• Open space • Naturalistic areas • Educational site • Nature play	• Replace log/sock when it starts to decompose. Depending on material / species this may be frequent
f. Metal Edging				
	• Very space efficient • Unique design element • Industrial aesthetics • Costs: Moderate	• Can be dangerous/sharp edges	• Urban spaces • Small areas that requires maximizing space	• Minimal
g. Recycled Plastic Board				
	• Space efficiency • Recycled material • Color options	• Cost: Moderate to expensive • Plastic is not a sustainable material • Flexible • Durability	• Urban spaces • Small areas that requires maximizing space	• Minimal
h. Gabion Basket with Stone				
	• Cost: Inexpensive • Unique design element • Permeable	• Sediment may migrate through the gaps • May require replaced every few years if there is excessive sediment build up • May catch additional debris and garbage	• Building environments or park settings	• Monitor for clogging. Once stone is filled with debris remove, clean and replace.

DESIGN MATRIX



Considerations:

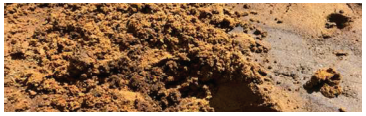
• The size and the ponding depth of tree trench is determined by local regulatory requirements and contributing drainage area.

• Filter components required are determined by specific site constraints such as available space, seasonal groundwater table, and local regulations.

• The location of vegetation should be selected to provide the best opportunity for long term growth and accessible maintenance.

• Provide additional space for roots in highly impervious / urban areas, through the use of structural soil, continuous openings in paved surfaces, and structural cells.

• The size of vegetation selected should be based on site constraints including adjacent utilities, need for an underdrain and space for canopy.

	ADVANTAGES	LIMITATIONS	USE	CONSTRUCTION & MAINTENANCE
4. FILTER (Treatment)				
a. Soil Media				
	• Allows for plant growth • Existing, amended soils can be used to reduce costs • Can be amended for targeted pollutant removal	• May need to be replaced	• All locations	• Monitor soil for clogging. If clogging occurs, aerate or remove top few inches and replace
b. Soil Amendments				
	• Increases pollutant removal • Target specific nutrients or pollutants • can target specific nutrient of pollutant removal	• Additional cost • May require replacement • requires identification of amendments specific to pollutant removal • Amendments may need to be added and mixed on site	• Sites located with areas with specific targeted pollutant removal requirements (TMDLs)	• Monitor soil for clogging. If clogging occurs, aerate or remove top few inches and replace.
e. Tree				
 Image Credit: Plantplaces.com	• Canopy provides shade & habitat • Aesthetics, improves built environments & fits in natural areas • Transpiration • Uptakes water	• Tree selection is limited due to water inundations • Roots may cause clogging of underdrains	• The size of vegetation selected should be based on site constraints including adjacent utilities, need for an underdrain and space	• Vegetation management including pruning and monitoring health
d. Groundcover (Native Grasses / Perennials)				
	• Adds biodiversity and habitat • Plant roots can improve filtering and infiltration • Additional transpiration • Urban wild aesthetic	• Adds additional landscape maintenance • Can be perceived as messy or "unkept" • Vegetation management requires plant species knowledge	• Naturalistic areas • Park settings • Streetscape • Parking lots	• Vegetation management including weeding, cutting and replanting as needed.
e. Groundcover (Turf)				
 Image Credit: NJ Developers Guide	• Mowable • Potential usable space	• Moderate maintenance • Less biodiversity • Can be come worn down/unsightly	• Boulevards • Open spaces	• Vegetation management including weeding, cutting and replanting as needed.
f. Lined				
	• Provides flexibility in areas where infiltration is not possible	• Additional costs • More complicated design and install • Underdrain required and connected to the existing drainage system • Limits plant selection	• High water table • Contaminated soil site • Close to building foundations (liner along sidewalls only)	• None
g. Gravel Storage (Under Media)				
	• Can increase storage / infiltration capacities • Holds water for additional root uptake	• Additional cost • Located below the tree roots and unmaintainable if clogged	• Areas where additional stormwater storage and infiltration is desired	• Monitor system to ensure stone isn't clogged. Following maintenance requirements for 2.Capture is important for underground storage

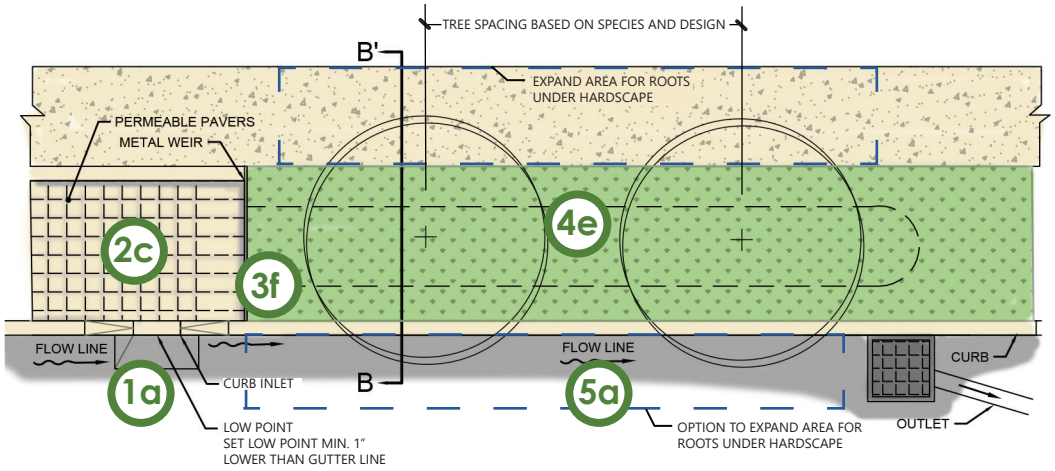
DESIGN MATRIX

		ADVANTAGES	LIMITATIONS	USE	CONSTRUCTION & MAINTENANCE
5. OVERFLOW (Exit / Outlet)					
	a. No Outlet (stormwater stays in the gutter line when full)				
		• Cost: Inexpensive • Clean and simple design • Easy retrofit • Offline • Easily maintained	• Suitable as a gutter line retrofit only • The inlet needs to be the low point and water will not overtop in other locations • Cannot be located at the "end of the line"	• Roads • Parking lots (edge)	• Monitor to ensure there is no clogging
	b. Second Curb Cut				
		• Cost: Inexpensive • Clean and simple design • Easy to retrofit • Easily maintained	• May require gutter line regrading • Damage from plowing • Clogged by snow/ice during the winter	• Streetscape • Parking lots • Road medians	• Monitor to ensure there is no clogging
	c. Overflow Structure				
		• Provides overflow into additional subsurface gravel storage bed • Provides direct discharge to an existing drainage network • Provides an outlet for underdrains	• Cost: More Expensive • Additional work required within the road • Additional structure and pipes to maintain	• Where additional stormwater volumes are required • Areas with an existing drainage system	• Monitor inlet to make sure there is no clogging. Clean excess debris as needed.
	d. Underdrain				
		• Ensures proper drainage with poor soils and liners • Reduces the time standing water is observed	• Cost: More expensive • Requires an overflow structure and connection to an existing drainage system • Additional maintenance	• Poor soils • Lined trench • Where standing water is a concern	• Check annually through cleanout to ensure no clogging has occurred. Clean as needed.
	e. Emergency Overflow / Level Spreader				
		• Provides overflow for large storms if not discharging to the gutter line or drainage system • Used to disperse water from large storms off-site for online systems	• Only required for online systems • Requires a safe off site location to direct water	• Limited sites • Open spaces with offsite discharge locations (ponds, rivers, etc.) • Trenches designed to handle large storms	• Monitor for erosion

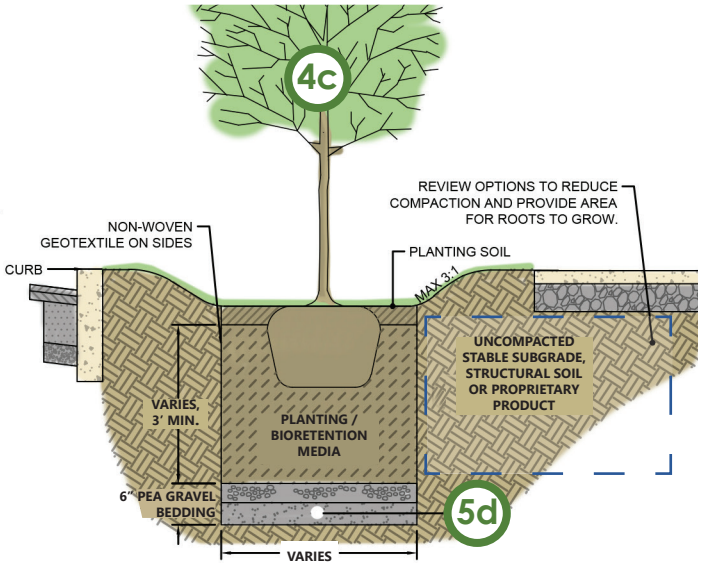
Considerations:

• The outlet locations needs to be the low point and water will not overtop in other locations.

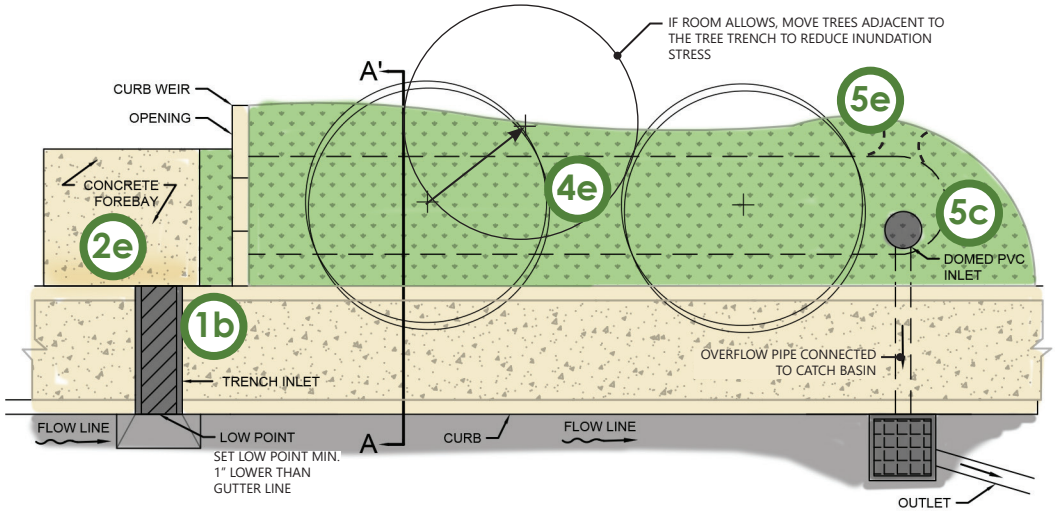
TYPICAL LAYOUT



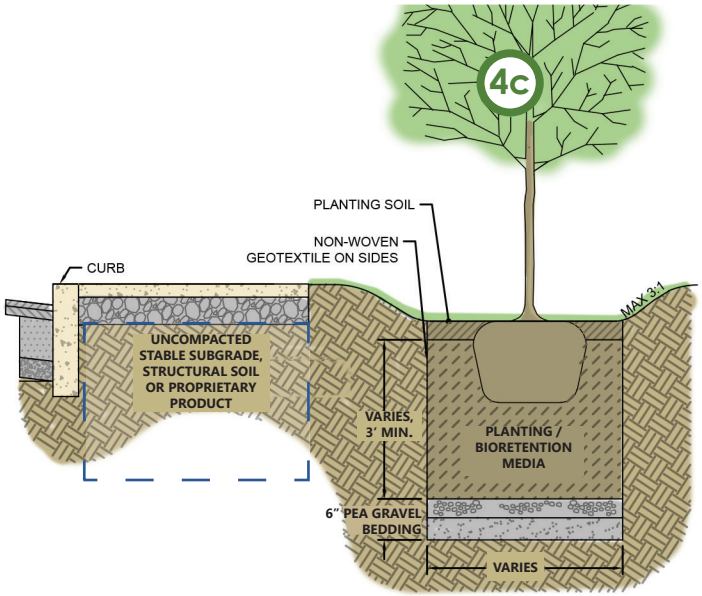
TREE LAWN
(Between road and sidewalk)
NOT TO SCALE



SECTION B-B'
NOT TO SCALE

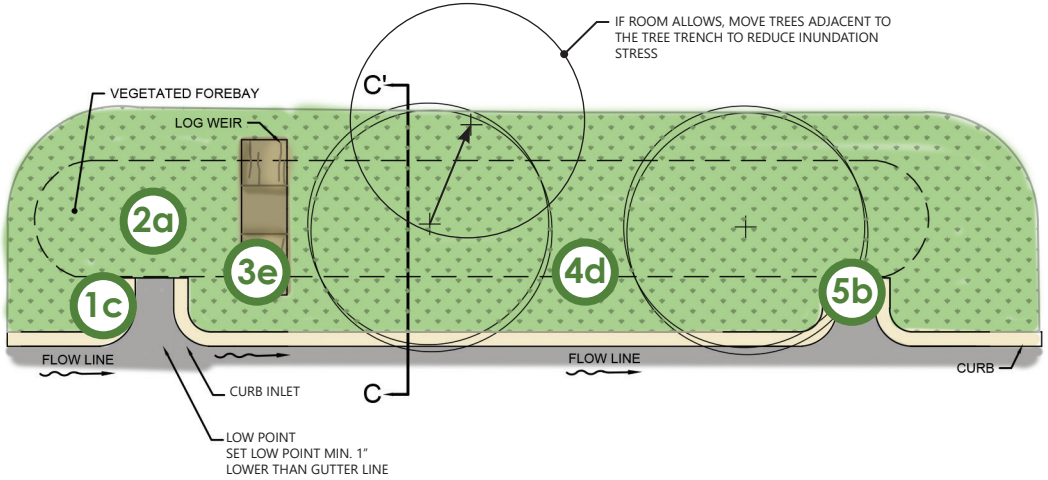


BACK OF SIDEWALK
NOT TO SCALE

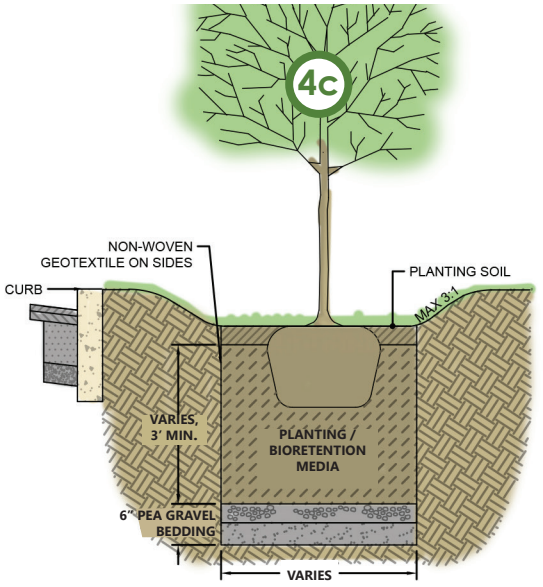


SECTION A-A'
NOT TO SCALE

TYPICAL LAYOUT



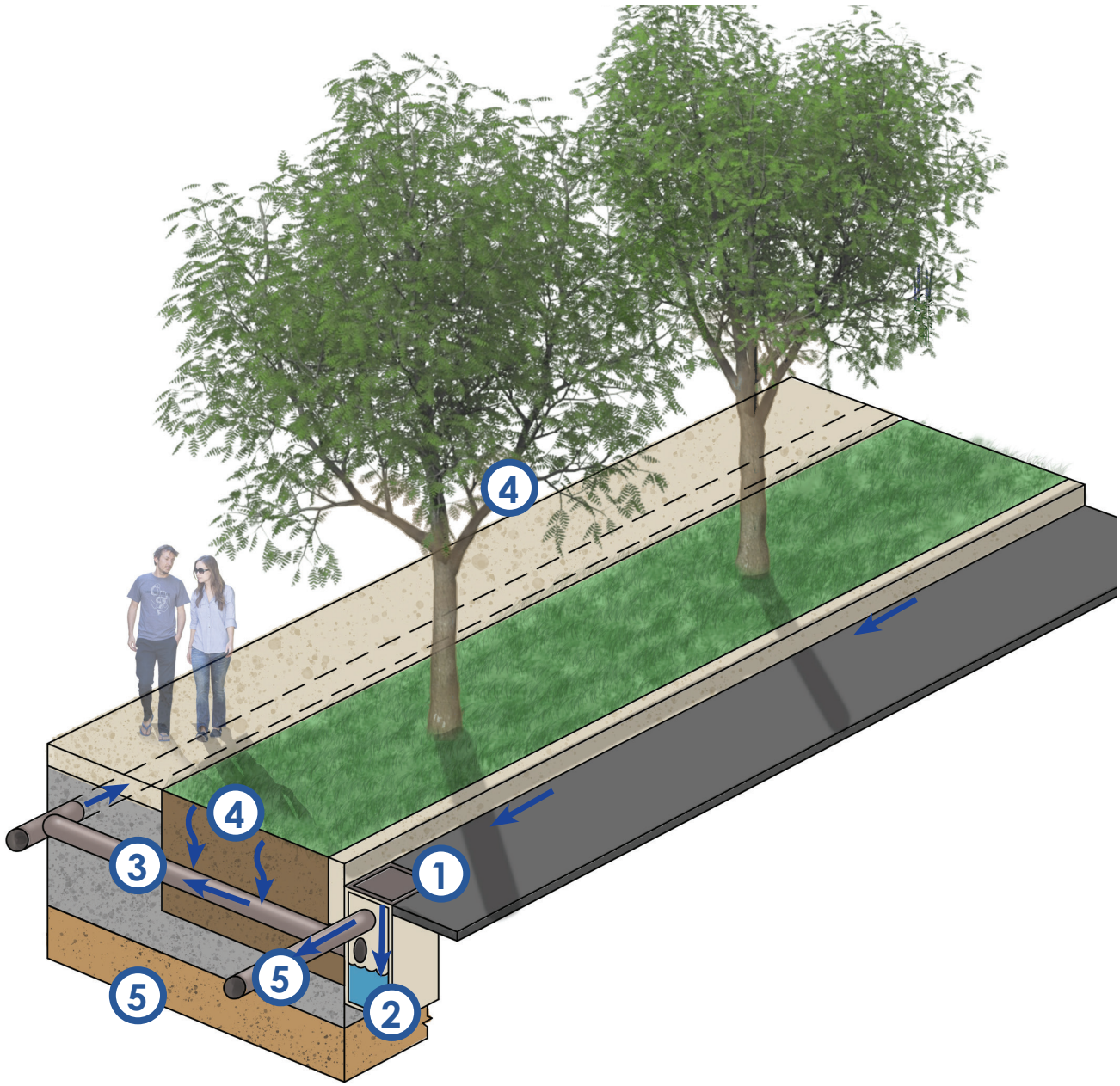
OPEN - NO SIDEWALK
NOT TO SCALE



SECTION C-C'
NOT TO SCALE

SUBSURFACE TREE TRENCH

COMPONENTS



1 **COLLECT**
Stormwater runoff enters the treatment system through an inlet.

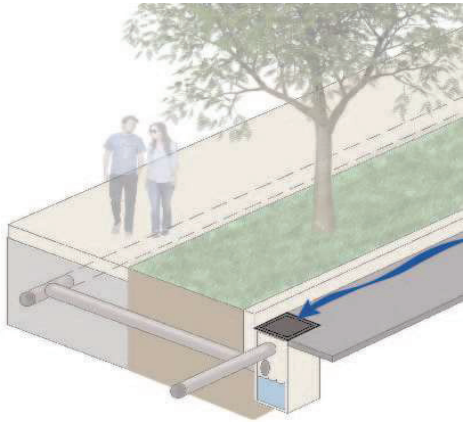
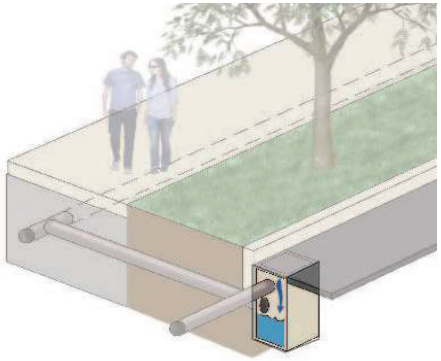
2 **CAPTURE**
The collected runoff is directed to a deep sump and pipe hood, that will allow debris and sediment to settle out.

3 **MOVE**
The runoff then overflows into a distribution pipe that moves the runoff to the main filter area.

4 **FILTER**
The runoff is filtered through a gravel storage area that allows for tree root uptake and infiltration into the subsoils.

5 **OVERFLOW**
The stormwater exits the system through subsurface infiltration providing groundwater recharge or via the outlet structure for v storm events.

DESIGN MATRIX

		ADVANTAGES	LIMITATIONS	USE	CONSTRUCTION & MAINTENANCE
1. COLLECT (Inlet)					
 **Considerations:** • Set grate 1" lower than gutter line to minimize runoff by-pass.	a. Catch Basin with Grate (concrete)				
		• Municipalities are familiar with maintenance • Can provide outlet overflow (see exit) • Insert can be used at the grate to capture additional sediment	• Cost: Expensive • Typically includes a connection to the existing drainage system • Maintenance often neglected • Typically needs to meet municipal standards	• Existing catch basin retrofit • Larger roadway drainage projects	• Typical catch basin maintenance
	b. Curb inlet with Structure				
		• Minimal work in the roadway • Insert can be used at the grate to capture additional sediment • Diameter can vary • Polyethylene drain basins can be used	• Cost: Moderate to expensive • Additional maintenance for sediment forebay depending on material selected	• Retrofits / streetscape improvements - no roadway work • Space available in the ROW	• Monitor inlet to make sure there is no clogging
2. CAPTURE (Deep Sump)					
 **Considerations:** • Inlet set a minimum of 3" above forebay to allow for sediment accumulation. • Use permeable pavers in forebay to allow for easier maintenance and avoid standing water.	a. Deep Sump				
		• Cost: Inexpensive • Municipalities familiar with maintenance • Less frequent maintenance • Sediment not seen	• Requires a vactor truck or clamshell for cleaning • Sediment captured below grade maintenance not visible - often neglected	• Existing catch basin retrofit • Larger roadway drainage projects	• Clean out sump with vacuum truck • Clean out inlet insert sack if utilized
	b. Sediment Forebay Permeable Pavers				
		• Captures sediment at the surface and below grade	• Cost: Moderate to expensive • More frequent maintenance is required • Additional maintenance for sediment forebay depending on material selected	• Retrofits / streetscape improvements - no roadway work • Space available in the ROW	• Shovel and remove sediment build up in forebay • Clean out sump with vacuum truck • Clean out catch basin insert if utilized

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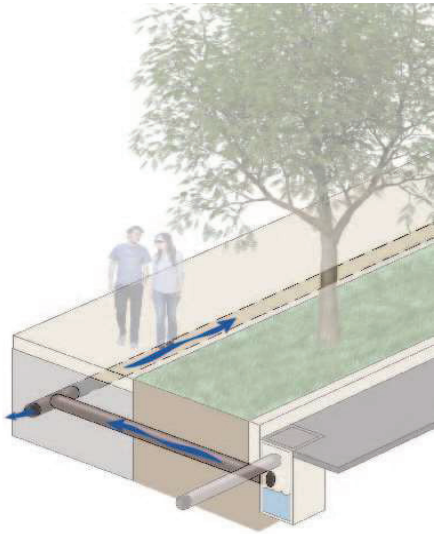
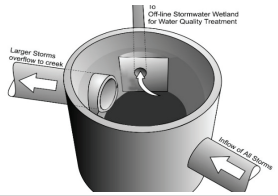
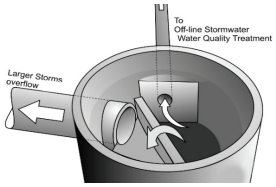
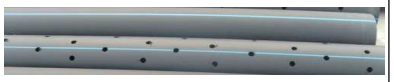
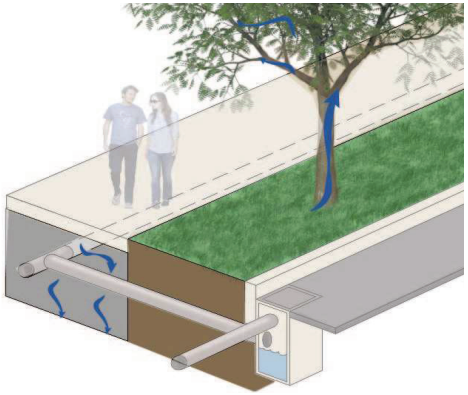
3. MOVE (pipes)					
	Pipe Inverts (in structure)				
		• Cost: Inexpensive • Simple design if connection to existing drainage is not required • Easy retrofit of an existing structure if inverts work • Easy maintenance combined with Deep Sump	• Requires a high existing invert connection to existing drainage	• Locations where existing inverts are high or connection to an existing drainage system is not required.	• Standard catch basin maintenance
	b. Weir Plate (in structure)				
		• Versatile • Adaptable to all existing drainage inverts	• Cost: Moderate to expensive • More complicated • Maintenance access is difficult • Prone to clogging • May require a catch basin and manhole with a weir	• Locations where existing inverts are too low and not compatible	• Monitor to ensure no clogging has occurred
	c. Perforated Distribution Pipe				
		• Required for all applications	• Required for all applications	• Required for all applications	• Check annually through cleanout to ensure no clogging has occurred, or that tree roots have not entered the pipe. Clean as needed.
4. FILTER (Treatment)					
	a. Subsoils (well to moderately drained)				
		• Cost: Inexpensive • Drains water quickly • Provides filtration and infiltration	• Sandy/gravelly soils may drain to quickly. • More infiltration than filtration. • Limits water available for tree root uptake	• Locations with well drained soils.	• Not applicable
	b. Subsoils (moderately to poorly drained)				
		• Retains water longer for tree root uptake.	• May not drain quickly and tree roots will remain saturated • More complex design, underdrains required for poorly drained soils	• Locations with moderately drained to poorly drained soils (only with underdrains)	• Not applicable
Considerations for soil amendments: • Amendments added to the soil are considered after testing to existing media is completed. • Over dig poor soils if well drained soils are available at greater depth.	c. Soil Amendments				
		• Increases pollutant removal. • Targets specific nutrients or pollutants. • slows down infiltration rate for excessively well drained soils.	• Additional cost • Amendments may cause clogging • Need to identify amendments specific to targeted pollutant removal • Soil cannot be replaced	• Locations with specific targeted pollutant removal requirements (TMDLs). • Excessively well drained soils.	• Not applicable

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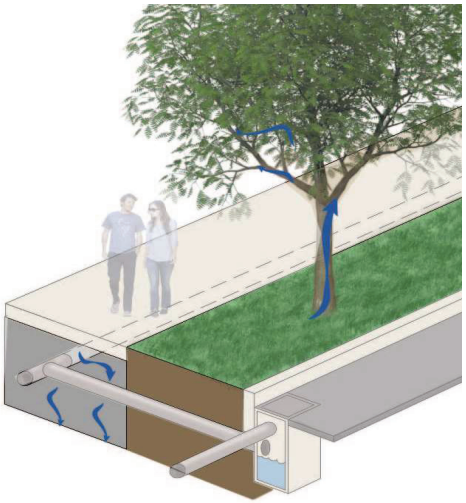

Considerations:

- The size of the tree trench is determined by local regulatory requirements and contributing drainage area.
- Filter components required are determined by specific site constraints such as available space, seasonal groundwater table, and local regulations.
- The location of vegetation should be selected to provide the best opportunity for long term growth and accessible maintenance.
- Provide additional space for roots in highly impervious / urban areas, through the use of structural soil, continuous openings in paved surfaces, and structural cells.
- The size of vegetation selected should be based on site constraints including adjacent utilities, need for an underdrain and space for canopy.
- Geotextiles or liners are utilized only when needed for specific site constraints. Avoid using geotextiles in between material layers to prevent clogging.

	ADVANTAGES	LIMITATIONS	USE	CONSTRUCTION & MAINTENANCE
4. FILTER (Continued)				
d. Tree				
 Image Credit: Plantplaces.com	• Canopy provides shade & habitat • Aesthetics, improves built environments & fits in natural areas • Transpiration • Uptakes water	• Tree selection is limited due to gravel and water in the root zone • Roots may cause clogging over time	• All sites (tree size and selection will vary by site).	• Vegetation management
e. Groundcover (Native Grasses / Perennials)				
	• Adds biodiversity and habitat • Plant roots can improve filtering and infiltration • Additional transpiration • Urban wild aesthetic	• Additional (higher) maintenance • Can be perceived as messy or "unkept" • Vegetation management requires plant species knowledge	• Naturalistic areas • Park settings • Streetscapes • Parking lots	• Vegetation management, weeding
f. Groundcover (Turf)				
	• Mowable • Potential usable space • Can be come worn down/unsightly	• Moderate maintenance • Less biodiversity	• Boulevards • Open spaces	• Mowing or weed trimming as needed
g. Groundcover (Permeable Pavers)				
	• Low maintenance • Provides a hardscape with surface infiltration for tree roots • Urban aesthetic • Adaptable to hardscape	• Cost: Expensive • Less green	• Streetscape • Urban plaza	• Annual sweeping
h. Gravel Stone				
	• Provides greater storage/infiltration volume.	• Requires a commitment to regular maintenance at Capture to prevent clogging. • Infiltration capacity may diminish over time.	• Required for all applications	• See collect, capture and move
i. Lined				
	• Provides flexibility in areas where infiltration is not possible	• Additional costs • More complicated design and install • Underdrain required and connected to the existing drainage system • Limits plant selection	• High water table • Contaminated soil site • Close to building foundations (liner along sidewalls only)	• None

DESIGN MATRIX

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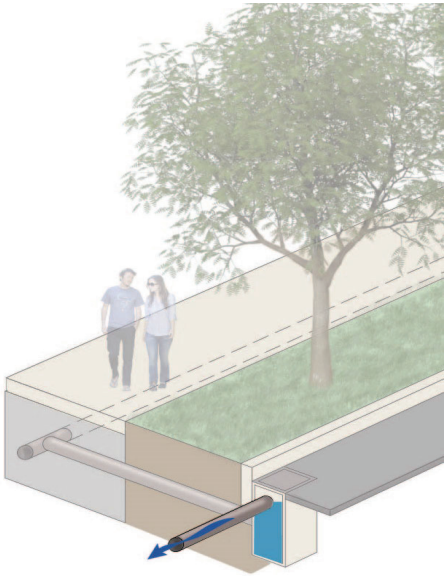
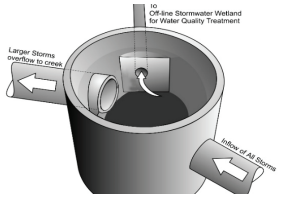
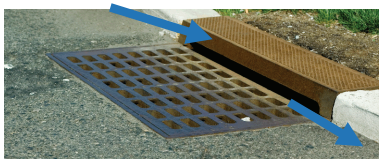
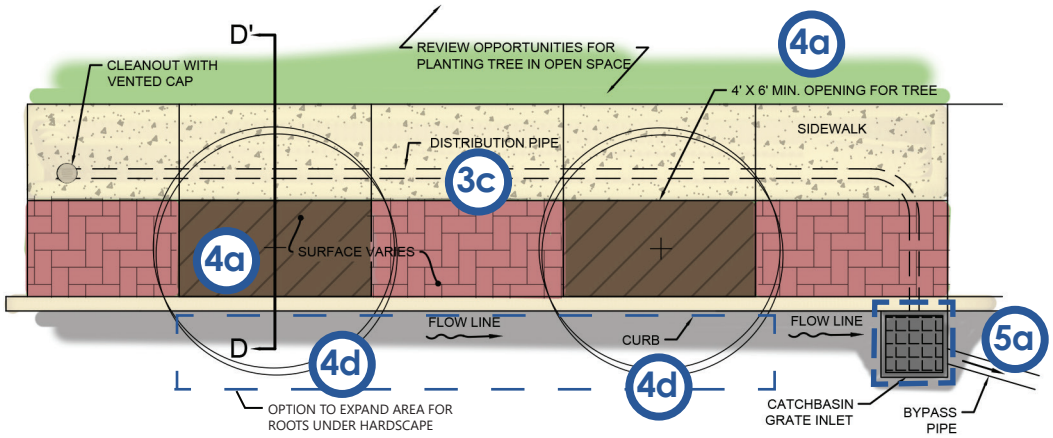
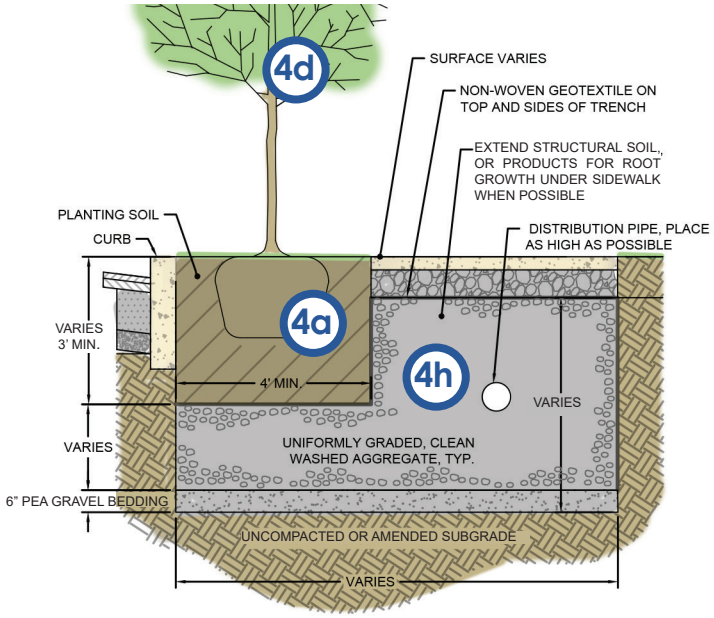
5. OVERFLOW (Exit / Outlet)					
 **Considerations:** A pea stone bed underlines the entire tree trench.	a. Pipe overflow at the catch basin				
		• Cost: Inexpensive • Easy retrofit of an existing structure if inverts work • Catch basin drains quickly after rain	• Maintenance not visible - often neglected • Requires connection to the existing drainage system • If clogged, special equipment is required	• Locations where existing inverts are high or connection to an existing drainage system is not required.	• Monitor to ensure no clogging has occurred
	b. Overtops Catch basin (not connected to drainage system)				
	 Image Credit: Tekportal.net, Liberal Dictionary	• Cost: Inexpensive • Simple design • Easy installation • Does not require connection to the existing drainage system	• Catch basin will hold water until the tree trench drains.	• Locations with well drained soils	• Monitor to ensure no clogging has occurred
	c. Underdrain				
		• Allows for proper draining and required with liners and poorly drained subsoils	• Costs: Expensive • Complicated design and installation • Requires an overflow structure and connection to an existing drainage system • Additional maintenance	• Locations with poorly drained soils or trench that needs to be lined	• Check annually through cleanout to ensure no clogging has occurred, or that tree roots have not entered the pipe. Clean as needed.

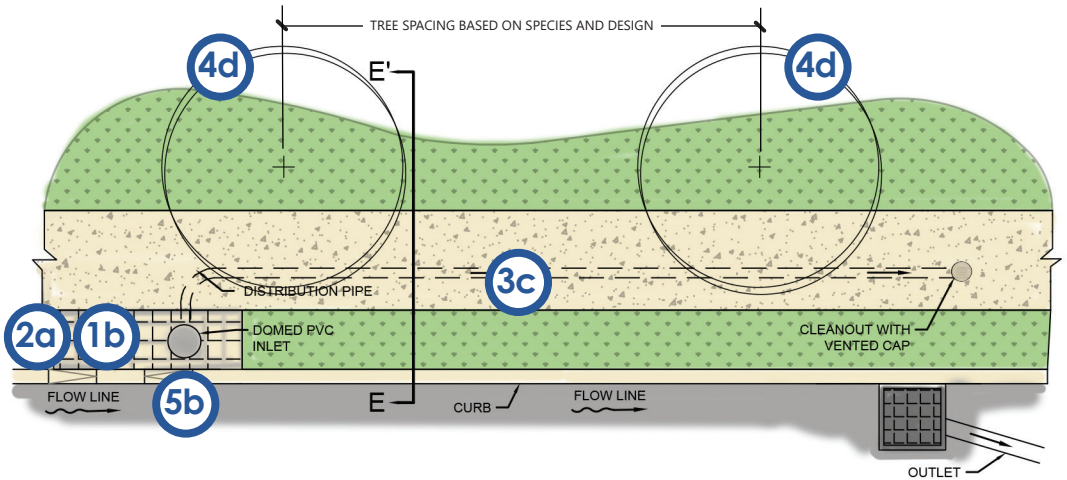
TYPICAL LAYOUT



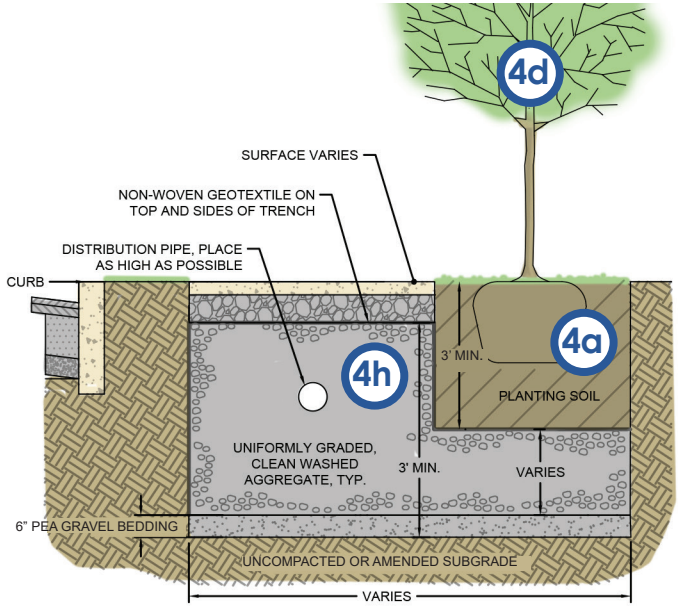
TREE WELL
NOT TO SCALE



SECTION D-D'
NOT TO SCALE



BEHIND SIDEWALK
NOT TO SCALE



SECTION E-E'
NOT TO SCALE