

# Green Infrastructure Toolkit

City of Albany

City of Cohoes

City of Rensselaer

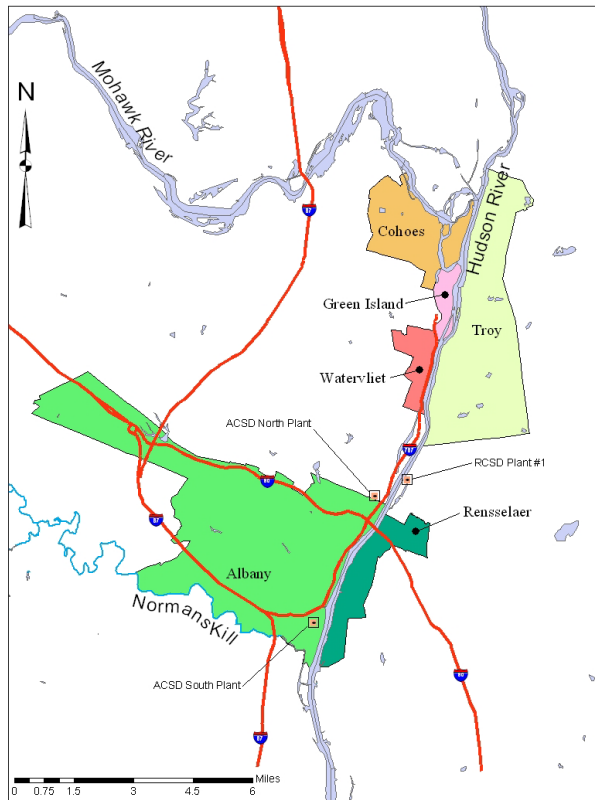
City of Troy

City of Watervliet

Village of Green Island



# Albany Pool Communities



Map of Albany Pool Communities

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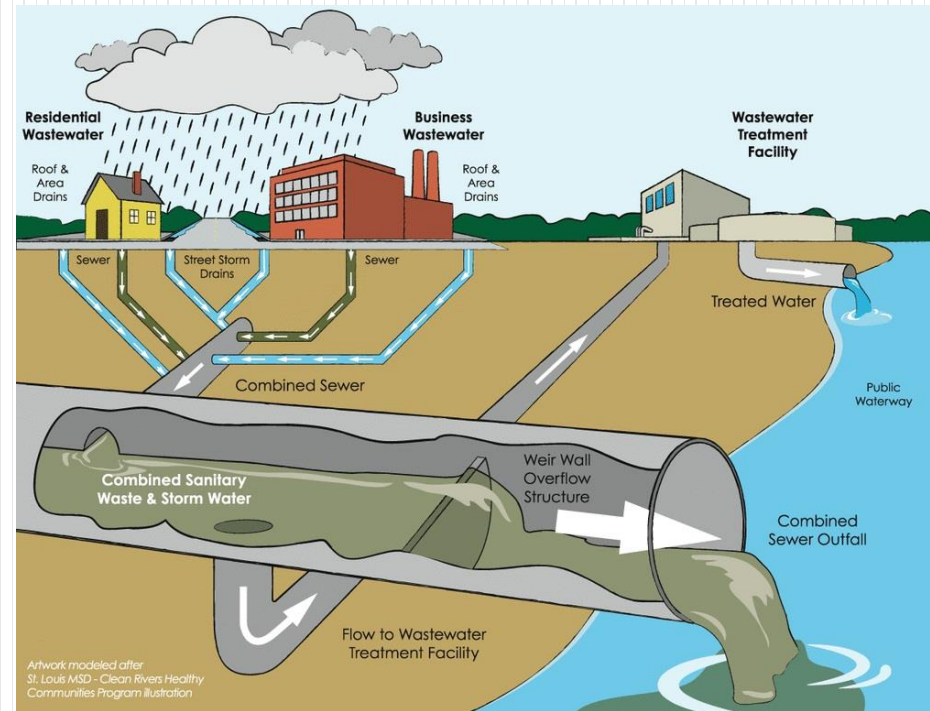
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# Mission Statement

- To provide customizable green alternatives to traditional stormwater management on small sites to promote:
  - greener landscapes
  - reduction of heat island effect
  - removal of stormwater pollutants
  - reduction in the incidences of combined sewer overflows



# Use and Objectives

- This Toolkit is intended for use on non-residential projects that disturb less than or equal to 1 acre.
- The New York State Department of Environmental Conservation (NYSDEC) and the local Municipal Separate Storm Sewer (MS4) requirements apply to projects that disturb more than 1 acre. <http://www.dec.ny.gov/chemical/43150.html>
- This Toolkit is intended to supplement the NYSDEC Stormwater Management Design Manual (Design Manual). Practices and definitions included in the Design Manual are acceptable for use on some smaller sites. <http://www.dec.ny.gov/chemical/29072.html>
- Some of the Design Manual requirements have been relaxed or modified to make green infrastructure (GI) practices easier to adopt for small and challenging sites, particularly urban redevelopment projects.

# Use and Objectives

- The Albany Pool Communities (APC) are comprised of five Cities and one Village, each with their own local land use codes. This GI Toolkit is intended to serve as an aid to wider adoption of GI Infrastructure, but local requirements will continue to remain in effect.
- As a parallel project to this GI Toolkit, the Capital District Regional Planning Commission and Barton & Loguidice have reviewed the APC local laws and guidance documents in an effort to promote green infrastructure. This project included:
  - Research of best practices used in other communities.
  - Identified gaps in the local laws and guidelines.
  - Drafted a model local law for consideration by the Albany Pool Communities
- The City of Albany adopted a Unified Sustainable Development Ordinance (USDO) in May 2017. Of note, this ordinance requires:
  - Projects that disturb more than  $\frac{1}{4}$  acre must comply with the NYSDEC Design Manual.
  - Post development peak runoff must not exceed the existing peak runoff for the 10 year storm event.
  - Properties  $\frac{1}{4}$  acre or smaller must either; detain the first 1 inch of rainfall and direct 100% of the rooftop and 75% of surface stormwater flows to a tree well, drainage swale, raingarden, or underground cistern; or install a green or blue roof.

# Changes from NYS DEC Stormwater Design Manual

- Only Applies to sites 1 acre or less.
- Applies to both new and redevelopment sites.
- Focuses on reduction of the runoff volume (RRv). The RRv calculation is simplified to 1" of rain times the directly connected impervious areas of the site.
- Establishes a hierarchy for GI practice selection:
  - Reduce Impervious areas.
  - Use infiltration practices where feasible.
  - Use Flow through practices only where infiltration is not feasible.
- RRv requirements can be met by reducing the existing impervious area by 15%.
- Increases impervious area reduction credit for tree planting from 100 ft<sup>2</sup> to 150 ft<sup>2</sup>.
- Reduces pretreatment requirements.
- Reduces separation distance to groundwater from 3' to 2'.
- Reduces minimum infiltration rate required for infiltration practices from 0.5"/hour to 0.2"/hour.
- Increases maximum time to drain practices to 3 days.
- Increases allowed ponding depth for bioretention areas from 6" to 1'.
- Requires flow through practices to slowly release the RRv over 72 hours if possible.
- Reduces minimum orifice size to ½" diameter when using underdrains to allow for slower release rates.
- Allows infiltration to area of shallow permeable soils, including fill soils.
- Relaxes requirements for disconnected runoff.



# What are Green Infrastructure Practices?

- As land becomes developed and urbanized, the addition of roofs, streets and other impervious areas increase the volume and rate of stormwater runoff.
- Green Infrastructure (GI) practices are stormwater management features designed to reduce the volume of stormwater runoff (RRv) and reduce the pollutants in stormwater discharges from the site.
- GI practices that reduce impervious areas directly reduces the RRv. For storms of up to 1", most, if not all of the rain that falls on pervious areas is retained with the soils, vegetation or in small depressions. In contrast, almost all of the rain that falls on impervious surfaces results in runoff.
- GI infiltration practices allow stormwater to seep into the ground rather than run off the site and should be the first choice to manage stormwater from impervious surfaces.
- Other GI practices remove pollutants and slow down the rate of discharge through the use of temporary storage.
- Many GI practices use carefully selected plants and soils, configured to help in treatment.

# Other Strategies to Reduce CSOs

- While not the focus of this toolkit, practices which reduce the peak runoff from sites for larger storm events such as the 10 year (Q10) and 100 year (Q100) storms will help reduce the frequency of Combined Sewer Overflows (CSO).
- Peak runoff reduction is typically achieved by providing storage and releasing the stormwater at a controlled (lower) rate than would otherwise occur.
- Stormwater may be stored in a wet or dry pond or in a variety of underground structures including vaults, pipes or chambers.
- Blue roofs provide the storage of stormwater on building roofs.
- Some municipalities, such as Chicago, encourage the storage of up to 12" of stormwater on parking lot surfaces.

# GI Practices

- **Impervious Area Reduction Practices:**
  - Tree Planting
  - Disconnect Impervious Areas
  - Green Roofs
  - Porous Pavement
- **Infiltration Only Practices**
  - Infiltration Basin
  - Infiltration Trenches
  - Infiltration Chambers and Drywells
  - Shallow Soil System
- **Vegetated Swale**
- **Infiltration or Flow Through Practices**
  - Porous Pavement
  - Vegetated Swale
  - Bioretention Practices
    - Rain Gardens
    - Stormwater Planters
    - Bioretention Areas
- **Rainwater Harvesting**
  - Rain Barrels and Cisterns
- **Flow Through Only Practices**
  - Dry Swale

# Additional GI Practices

- The Design Manual discusses several other GI Practices which generally take up more space than is typically available for sites less than 1 acre, but can be used if space permits. Refer to the Design Manual for further information.  
<http://www.dec.ny.gov/chemical/29072.html>
- These practices include:
  - Conservation of Natural Areas.
  - Sheet-flow to Riparian Buffers or Filter Strips.
  - Stream Daylighting.

# Runoff Reduction Sizing

- **Water Quality Volume ( $WQ_v$ )** is the volume of runoff from the site that must be captured and treated to reduce downstream pollution from stormwater.
- The rainfall used to calculate the  $WQ_v$  is based on the 90%, 24 hour rainfall event (only 10% of rainfall events exceed this value).
- **Runoff Reduction Volume ( $RR_v$ )** is the portion of the  $WQ_v$  treated by GI practices. The  $RR_v$  is calculated as follows:

$$RR_v = 1" / 12 \times A_{ic}$$

Where:

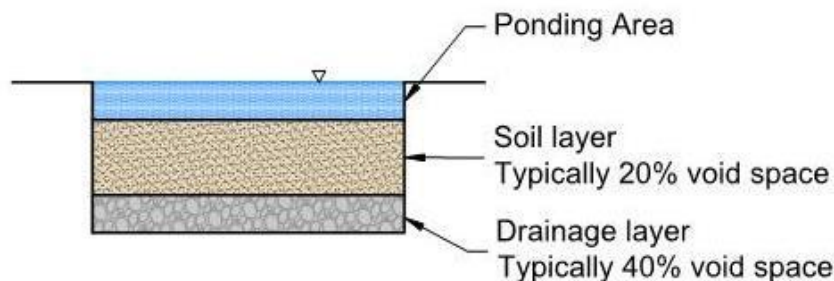
$RR_v$  = is the stormwater volume to be managed through GI.

$A_{ic}$  = Area of directly connected impervious cover (new and/or redeveloped) in square feet.

Runoff of 1" is divided by (12"/1 ft) to obtain the volume in cubic feet.

# Runoff Reduction Volume

- Typically, the required RRv is temporarily stored within the GI Practice.
- The stored volume then infiltrates to the soils below for **infiltration practices**, or flows out through an underdrain for **flow through** practices.
- Depending on the specific configuration of the GI practice, storage is provided in:
  - A ponding area above the practice,
  - Within the void spaces in a soil layer,
  - Within the void spaces in a drainage layer.



# Practice Selection Flow Chart

Let's get started.....

1

- Plan to reduce area of roofs, parking lots and other impervious surfaces.
- Maintain grass areas, buffers, sensitive resources.
- See [Planning Tips](#).

2

- Determine the Runoff Reduction Volume (RRv) for the site.
- The RRv is the amount of stormwater to be collected and managed through green infrastructure practices to reduce pollution and downstream impacts.

3

- Check Soils. If Hydraulic Soil Group (HSG) A or B then maximize use of infiltration practices.
- HSG C or D soils may not be suitable for infiltration. See [Soils and Infiltration Testing](#).

4

- Apply other GI practices to manage the remaining RRv after applying infiltration practices have been utilized to the maximum extent feasible.

# Options to Reduce Impervious Cover

- Before continuing; check that you have looked at the [Planning Tips](#) and see that you have taken every opportunity to reduce the area of impervious cover (Aic).
- There are several other GI practices that provide impervious area reduction:
  - Disconnected Impervious Areas:
    - Rather than discharging directly to a stormwater system, runoff from impervious areas is discharged to pervious areas of the site.
    - Any disconnected impervious areas can be subtracted from the Aic used to calculate the RRv.
  - Tree Plantings
    - Up to 150 square feet per tree can be subtracted from the Aic.
  - Porous Pavement
    - Replace impervious asphalt pavement and concrete with porous alternatives.
  - Green Roof
    - Replace impervious roofs with a green roof system.



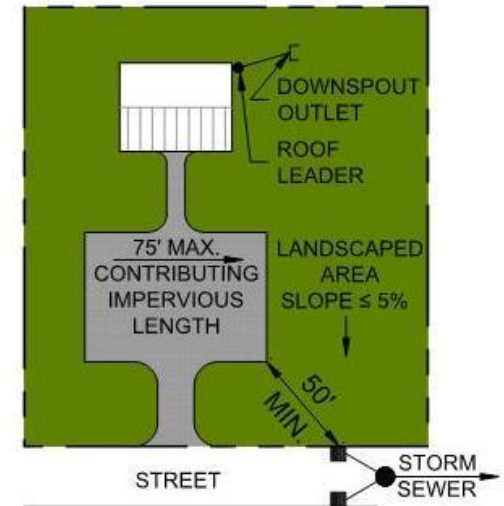
# Impervious Area Reduction

- Reducing the area of impervious cover directly reduces both the volume of runoff and the peak discharge from the site for all storm events.

**For the purposes of this Tool Kit, a project that reduces the impervious cover area by 15% from existing conditions has satisfied the RRv Requirements.**

# Disconnected Runoff

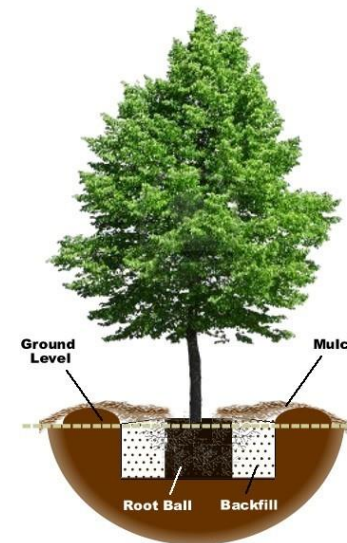
- To count as disconnected runoff:
  - Contributing flow path over impervious area must be  $\leq 75'$ .
  - Disconnected impervious area must be  $\leq 2,000 \text{ ft}^2$ .
  - Provide level spreaders where impervious area is  $> 500 \text{ ft}^2$ .
  - Drain to grass/landscaped area with slope  $\leq 5\%$ .
  - Drainage shall continue across landscape area for a minimum distances of 50'.



- Resources:
  - City of Portland Downspout Disconnection Program:  
<https://www.portlandoregon.gov/bes/54651>

# Tree Planting

- Plant new trees to replace any trees removed by project.
- To receive area reduction credit:
  - Plant new trees within 10' of impervious area.
  - Credit allowed for preserved trees with canopies  $\leq 20'$  from impervious area.
- Subtract the tree area credit from the area of impervious cover as follows:
  - Subtract 150 ft<sup>2</sup> for each tree with a mature canopy diameter of 16'.
  - Subtract  $\frac{1}{2}$  of the canopy area for each tree with mature canopy diameters of  $< 16'$ .
  - Planted trees must be 2" minimum caliper for deciduous and 6' tall for evergreen.



- The City of Albany Street Tree program picks up  $\frac{1}{2}$  the cost of planting trees within the City right of way. See:  
[http://www.albanyny.gov/Libraries/General\\_Services/Tree\\_Planting\\_2017 - 4 page - Updated.sflb.ashx](http://www.albanyny.gov/Libraries/General_Services/Tree_Planting_2017_-_4_page_Updated.sflb.ashx)
- Plant urban tolerant species: <http://www.hort.cornell.edu/uhi/outreach/recurbtrees/>
- For a homeowner's guide to tree planting, see: <http://chesapeakestormwater.net/be-bay-friendly/tree-planting/>

# Porous Pavement

- Under the general term of “Porous Pavement” there are a number of variations depending on function and materials. In all cases, the objective is to provide a GI alternative to traditional asphalt and concrete sidewalks, drives and parking areas.
- Porous surface options:
  - Porous asphalt.
  - Porous concrete.
  - Permeable Pavers – concrete or clay bricks where water flows through the joints.
  - Porous pavers - typically grid of concrete or plastic with grass or stone infill.
  - Pervious pavers – manufactured permeable pavers.

## References:

Porous Asphalt: [http://www.asphaltpavement.org/index.php?option=com\\_content&view=article&id=359&Itemid=863](http://www.asphaltpavement.org/index.php?option=com_content&view=article&id=359&Itemid=863)

Porous Concrete: <http://www.perviouspavement.org/>

University of New Hampshire Stormwater Center: <http://www.unh.edu/unhsc/>

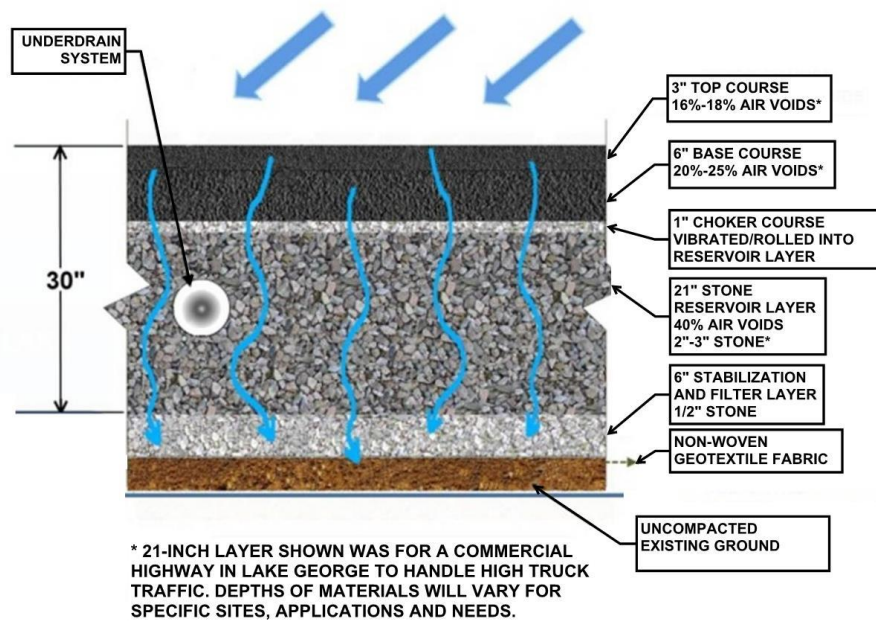
Permeable Pavers: <https://www.icpi.org/paving-systems/permeable-pavers>

# Porous Pavement Sizing

- Stormwater passing through a porous pavement is typically stored in the subbase under the surface.
- In addition to stormwater storage, the subbase must provide a suitable foundation to support traffic or pedestrian loads.
- At a minimum, the storage volume should be sized to store the RRv resulting from rain falling directly on the porous pavement.
- By providing additional storage capacity, the porous pavement areas can handle the RRv from other impervious areas of the site.
- The storage capacity of the subbase is based on the area, depth, and porosity of the subbase. A typical open graded stone subbase will have a porosity of 0.4.
- Where soils are suitable, stormwater temporarily stored in the subbase will infiltrate into the ground. See [Infiltration Practices](#).
- Where soils are less permeable ( $<0.2$ " /hour) underdrains will be required.

# Porous Pavement

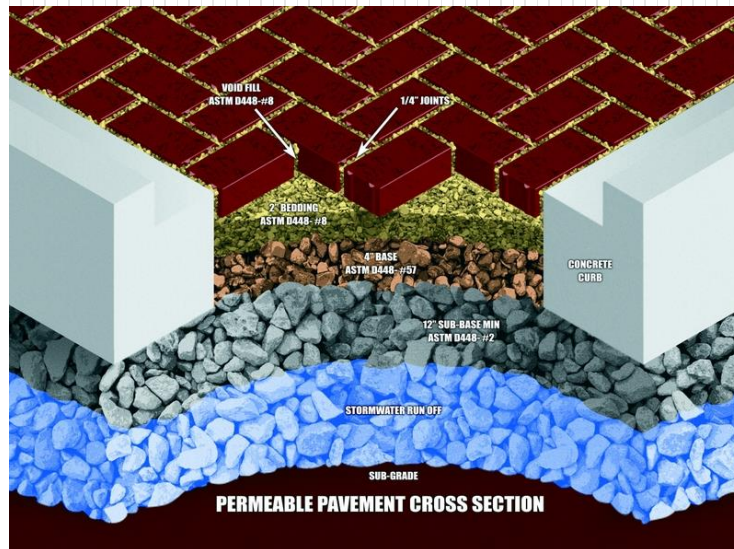
- For traffic areas, a special asphalt mix is used which allows water to seep through the surface.





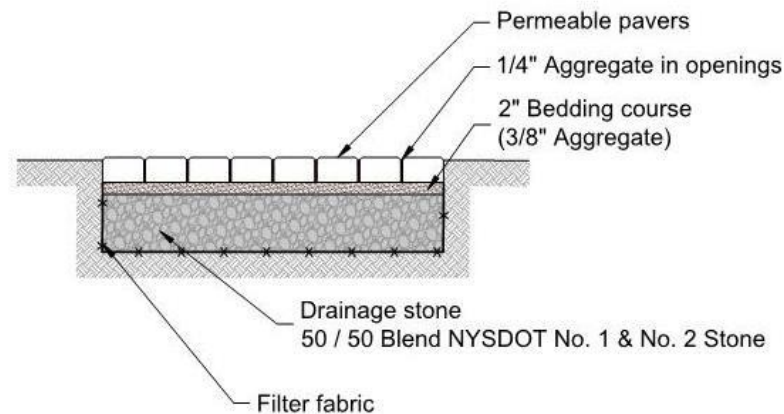
# Porous Pavement

- For low traffic and non traffic areas, porous asphalt or porous concrete can be used as the surface. Alternatively, there are a wide number of manufactured products that can be used including:
  - Stormcrete™.
  - FILTERPAVE ®.
  - KBI Flexi®-Pave.
  - Pavers such as; Unilock ® Belgard ® and EP Henry.
  - Plastic turf or gravel systems such as; Truegrid ®, Invisible Structures, NDS ®.



# Porous Pavement

- Permeable pavers may also be used without providing storage underneath when placed on permeable soils (HSG A or B).
- Plastic reinforced turf systems can be used to provide emergency access. While not suitable for frequent traffic, there are options that can support heavy vehicles, including fire trucks.



- Homeowner's reference for installing permeable pavers:

<http://chesapeakestormwater.net/be-bay-friendly/permeable-hardscapes/>



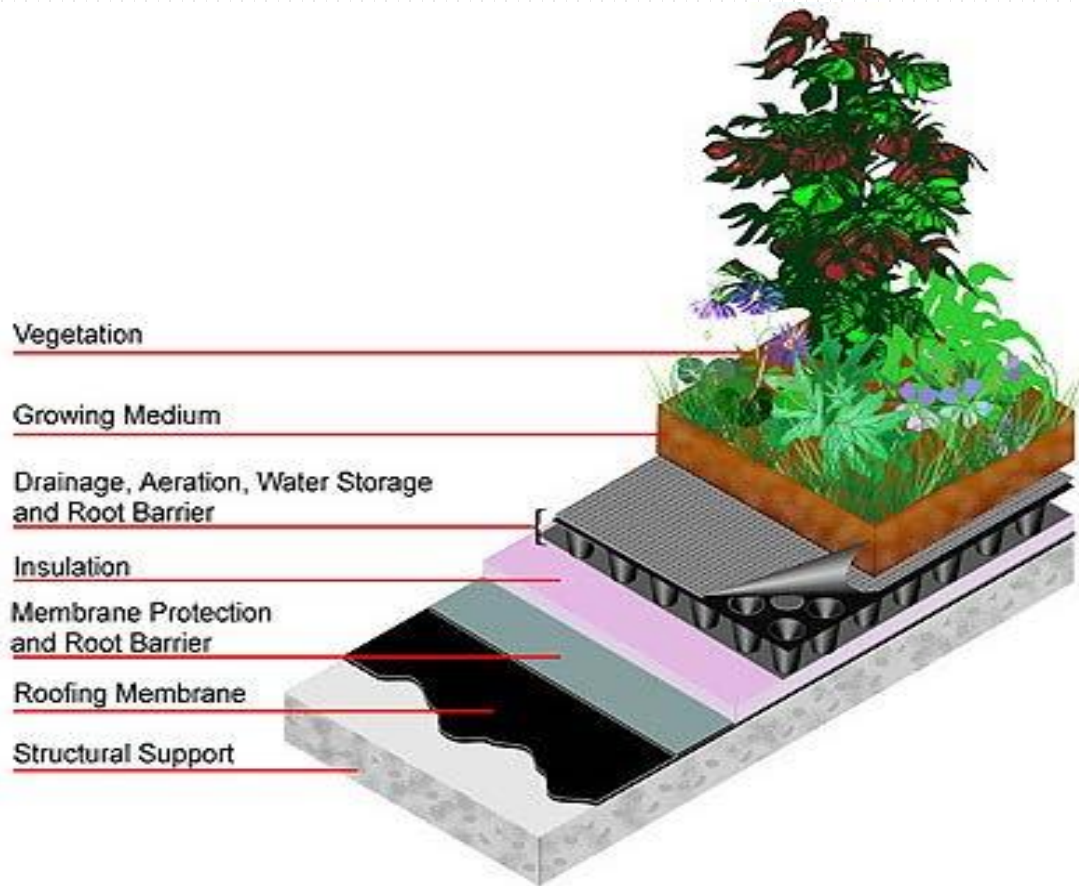
# Green Roof

- Green roofs offer many benefits other than stormwater management including; reducing the urban heat island effect, lowering heating and cooling costs, filtering air borne contaminants, providing fire resistance, providing bird and butterfly habitat, and can be aesthetically pleasing.
- Green roofs are considered pervious and therefore directly reduce the area of impervious cover (Aic) and resulting RRv.
- Additional green roof storage can be provided to treat RRv from adjacent impervious areas.
- Parking garage roofs are an excellent opportunity for the application of green roofs.
- The design of green roofs is integral to the building design and should be done by the design professional. Refer to the Design Manual for additional information.  
[http://www.dec.ny.gov/docs/water\\_pdf/swdm2015chptr05.pdf](http://www.dec.ny.gov/docs/water_pdf/swdm2015chptr05.pdf)

# Green Roof



# Green Roof Detail



# Green Roofs in the Capital Region

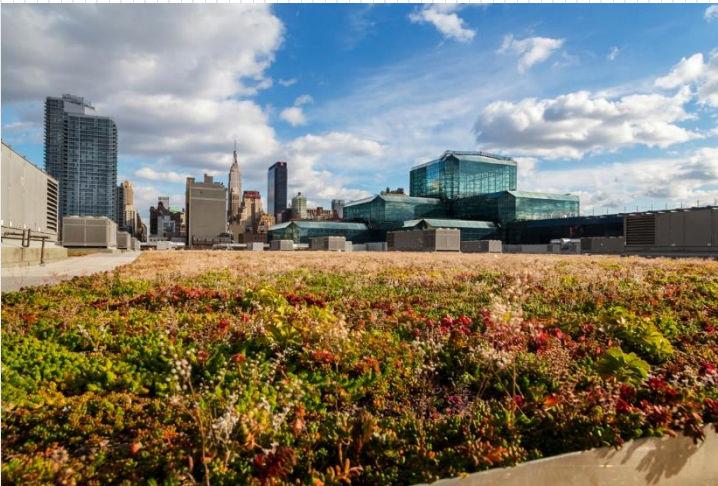
## **Doane Stuart School, Troy, NY**

- 22,000ft<sup>2</sup> multi-use green roof system
- Project design and construction funded through a \$1.4 million EFC GIGP grant
- Stormwater runoff reduction of 50%-90%
- <http://www.doanestuart.org/academics/green-roof-2/>





# National Examples of Green Roofs



## Javits Center, New York City

- 6.75 acre greenroof
- Captures 6.8 million gallons of stormwater per year
- <http://www.nydailynews.com/life-style/big-town/raising-roof-article-1.1975080>



## World Wildlife Federation Building, Washington D.C.

- 28,000ft<sup>2</sup> green roof
- <http://www.greenroofs.com/projects/pview.php?id=1334>

# Green Roof Resources

- <http://www.dec.ny.gov/lands/58930.html#Green>
- <https://www.greenroofs.org/resources/>
- <https://www.wbdg.org/resources/extensive-vegetative-roofs>
- <http://www.greenroofguide.co.uk/design/>
- <https://www.epa.gov/heat-islands/using-green-roofs-reduce-heat-islands>
- <https://www.epa.gov/heat-islands/green-roofs-stormwater-management-and-urban-heat-island-mitigation>

# Infiltration Practices

- After implementing Aic reduction through planning and GI practices which reduce impervious areas, the next step is to maximize RRv reduction through infiltration. Infiltration Practices Include:
  - **Infiltration Basin:** Round or more linear swale, typically grass covered.
  - **Infiltration Trench:** Open graded stone trench with grass or peastone surface.
  - **Infiltration Chambers and Drywells:**
    - Subsurface structure used to increase the available storage volume.
    - Typically concrete or plastic surrounded by sand or stone.
    - Can be traffic rated and installed under parking lots and roads.
  - **Shallow Soil System:** Similar to infiltration trench with a larger area of shallow infiltration stone or permeable soil.

# Infiltration Practices

- In addition to these practices, there are a number of GI practices can be designed as either infiltration systems or flow through systems with underdrains. Use the infiltration type systems whenever possible:
  - Porous Pavement with infiltration
  - Bioretention Area with infiltration
  - Stormwater Planter with infiltration
- Underdrains from Flow Through GI practices can be directed to infiltration practices.
- Design guidance:
  - All infiltration practices require suitable soils with a minimum infiltration rate of 0.2"/hour. (reduced from Design Manual minimum of 0.5"/hour).  
Refer to [Soils and Infiltration Testing](#).
  - Maintain a minimum of 2' separation to groundwater or bedrock. Greater separation distance may be required for “hot spots” , over aquifers, or as required by local requirements.
  - Keep infiltration practices 10' away horizontally from buildings and foundations and 100' from onsite wells.

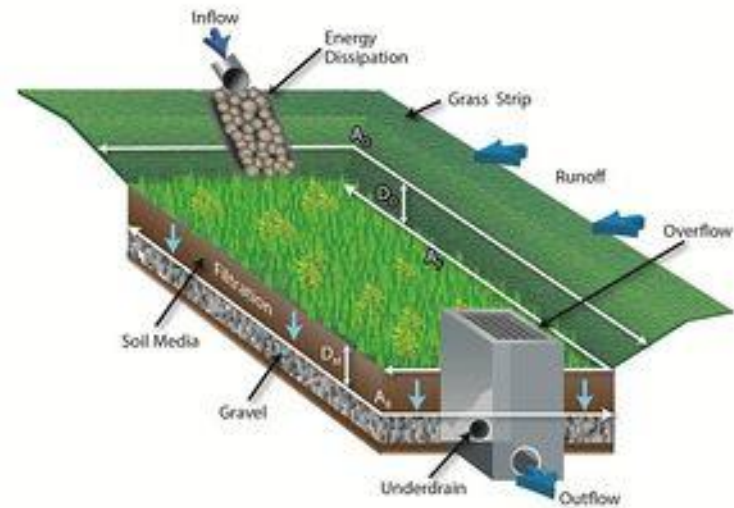
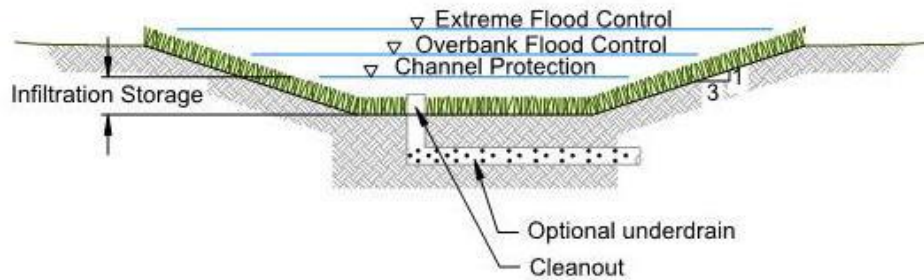


# Infiltration Practices

- Design guidance:
  - Existing soils that will receive infiltration should be protected from over compaction or siltation during construction. De-compaction of previously disturbed soils may be required.
  - A conservative approach is recommended, especially when using soils with lower infiltration rates. Consideration should be given to:
    - Providing overflows and/or underdrains.
    - Applying a safety factor to measured infiltration rates.
    - Oversize the infiltration area provided.
  - Keep ponding depth  $\leq 12"$  and time to drain  $< 3$  days. Ponding and standing water can be a safety and insect breeding concern.
  - Geotextiles are often used to keep adjacent fine soil particles from entering the infiltration practice. Care and judgement should be used however, because excessive fines in the stormwater can plug geotextile surfaces.

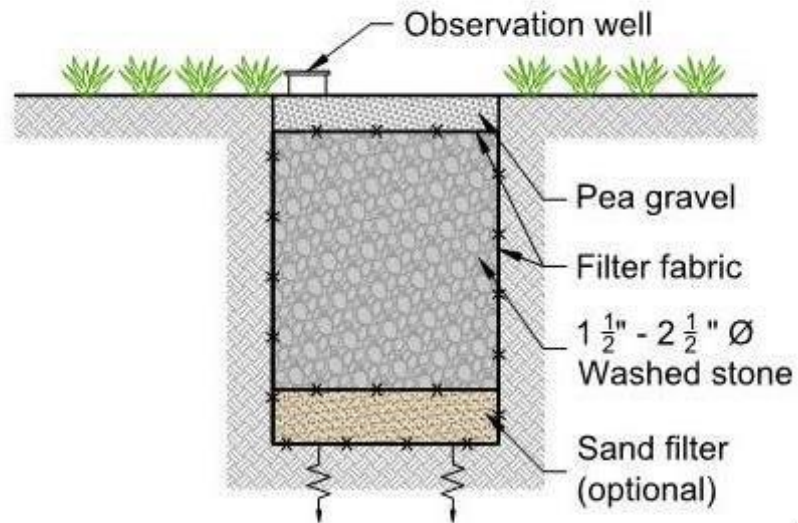
# Infiltration

## INFILTRATION BASIN

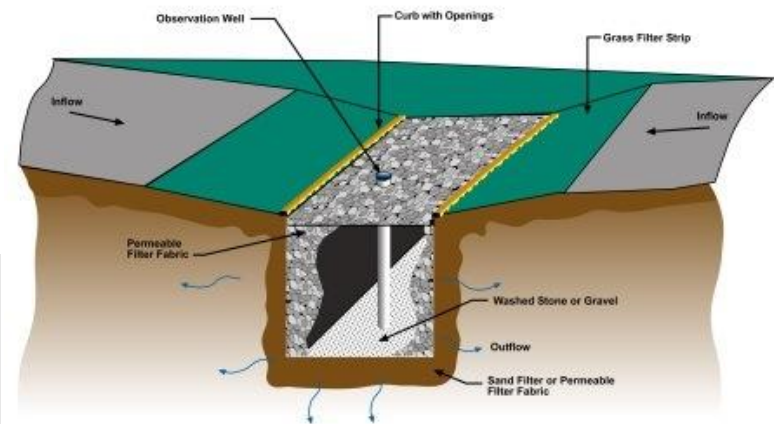


# Infiltration

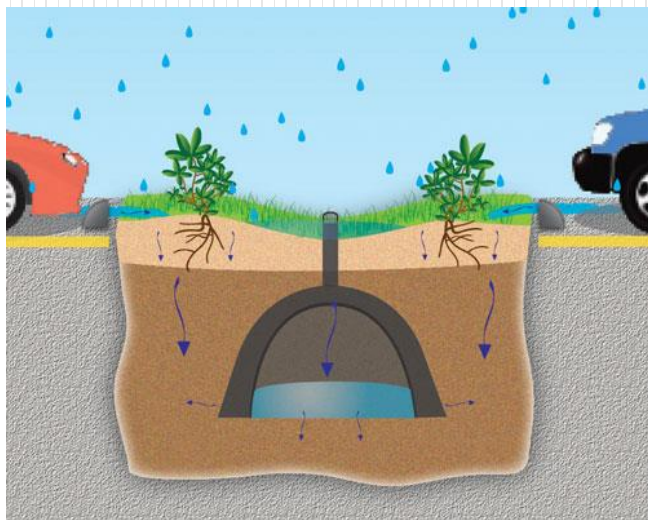
## INFILTRATION TRENCH



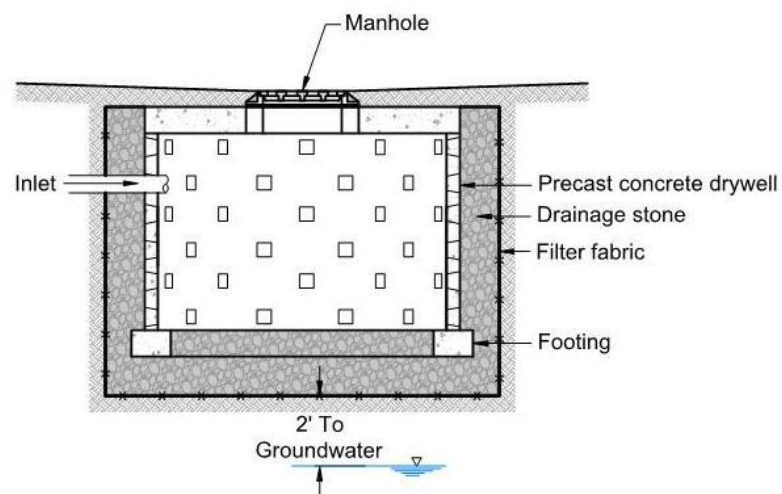
Runoff through undisturbed subsoils with a min. rate of 0.2 in/hr



# Infiltration Chambers & Drywells



Storm Chambers



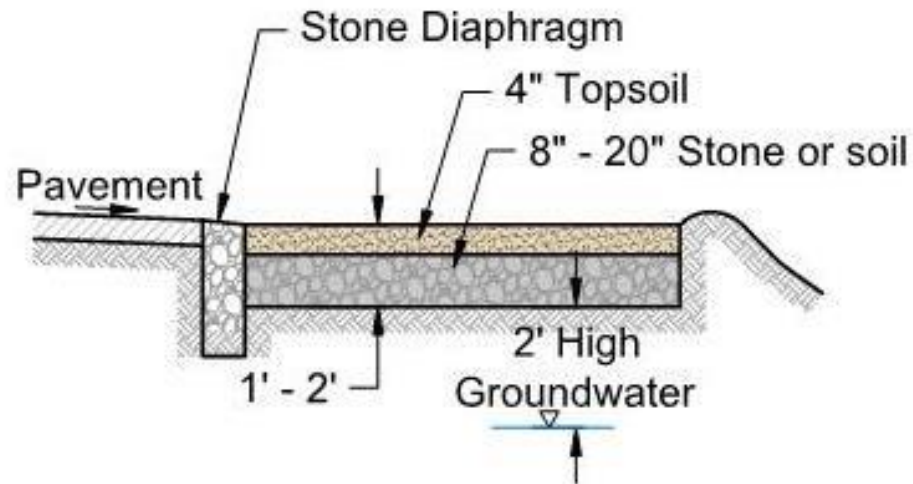
Drywell

# Infiltration Practices

- **Shallow Soil System**

- Stormwater from small impervious areas can be directed to a shallow soil system.
- A shallow soil system consists of a 1' to 2' layer of soil, either native or imported fill. (This is a variance from the Design Manual which does not allow infiltration in fill).
- Existing disturbed soils should be restored (see Design Manual, 5.1.6).
- The upper 4" layer is topsoil to support turf. The soil below can be native permeable soils or imported fill.
- The shallow soil system is designed to store the RRv within the void spaces in the 1' to 2' depth of soil. Porosities will vary from 0.2 for topsoil to 0.4 for drainage stone.
- Underdrains and/or surface overflows will be needed where the underlying soils are poor ( $< 0.2$ " /hour infiltration).

# Shallow Soil System



# Infiltration Sizing Example – Infiltration Trench

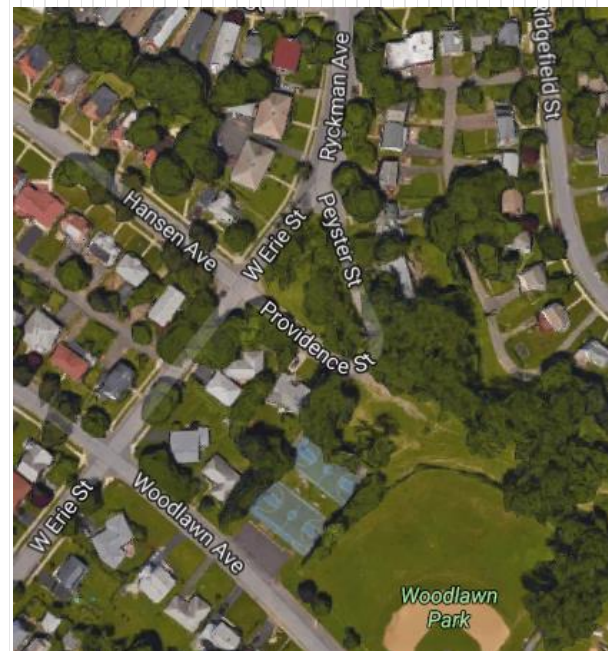
Infiltration Trench			
Infiltration Practices are sized to store the RRv which infiltrates to the soils below.			
Item	Input	Units	Notes
Runoff Reduction Volume, RRv	1000	ft <sup>3</sup>	
Depth of Infiltration Practice, dp	36	inches	
Soil Infiltration Rate, Ir	0.5	"/hr	Minimum of 0.2" /hr
Time to Drain, $t = d/I_r$	72	hours	Maximum 72 hours
Area of Practice, Ap	900	ft <sup>2</sup>	
Porosity of Drainage Stone, nd	0.4		Typically 0.4 for drainage stone
Volume in Practice, $V_p = A_p * d_p / 12 * n_d$	1080	ft <sup>3</sup>	
Volume OK?	OK		If $V_p < RR_v$ increase area or depths

**Note:** Calculations are similar for **drywells and storm chambers**, except that the volume in the practice, includes the open volume in the drywell or storm chambers, plus the volume available in the drainage stone.



# Local Infiltration Project: Ryckman and Hansen Overflow Abatement Project, City of Albany, NY

- The project is located in Woodlawn Park to the Hansen Avenue and Ryckman Avenue intersection in the City of Albany, New York
- To provide abatement of system surcharging and flooding in Hansen Alley, flows collected along Hansen Alley have been diverted to an underground infiltration gallery located in Woodlawn Park. Flow has been diverted through a series of pipes and structures that run south along West Erie Street and then southeast along Woodlawn Avenue. The existing underground detention system in the alley and underground infiltration gallery capture, detain, and infiltrate flows from the Hansen Alley watershed area.
- Abatement of system surcharging and flooding in Ryckman Alley has been achieved through a constructed wetland system south of the Alley consisting of a wet pond, plunge pool, micro-pool and assortment of aquatic plant life. The existing underground detention system and wetland system capture, detain, and mitigate flows from the Ryckman Alley watershed area. Collectively, these practices provide for the storage of over a million gallons.





# Bioretention Practices

- Overview
  - Selected plants & soils used to retain and treat stormwater.
  - Can be infiltration type (preferred) or flow through type.
  - The Design Manual describes bioretention areas, rain gardens and stormwater planters. These are all bioretention practices. The terminology may vary between references.
- Where to use
  - Use for roof runoff, paved plazas or sidewalk areas, parking lot medians and along drives.
- Bioretention – Infiltration Type
  - Use as first choice if soils are suitable (infiltration rate  $> 0.2$  inches/hour).
  - Keep infiltration areas at least 10 feet away from basements.
- Bioretention – Flow Through Type
  - Requires underdrain with discharge to storm system or separate infiltration practice.
  - Provides water quality treatment, temporary storage of the RRv and some reduction in peak runoff when the release rates are controlled.

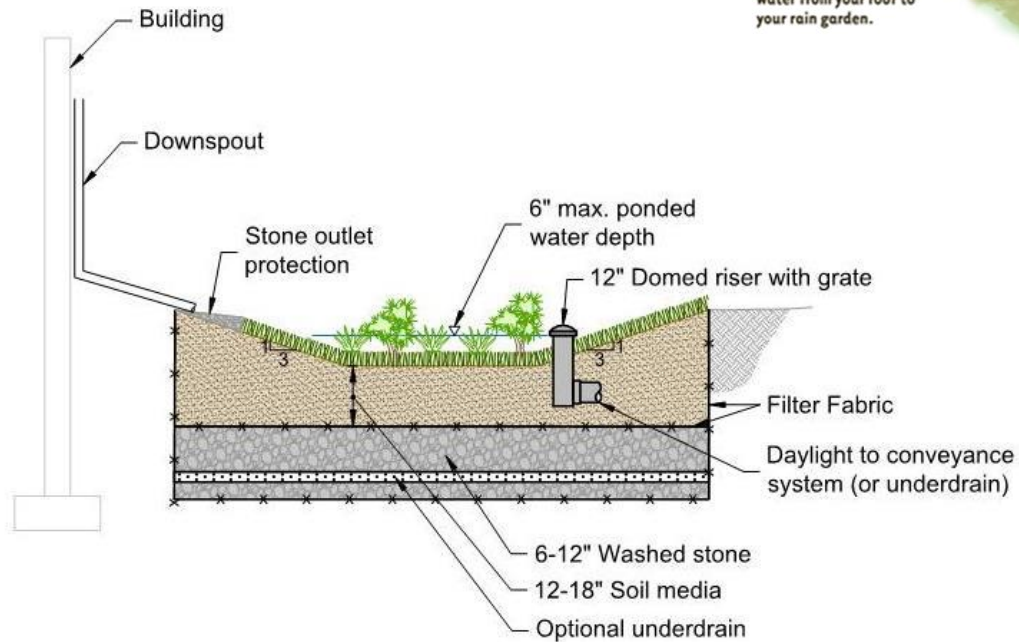
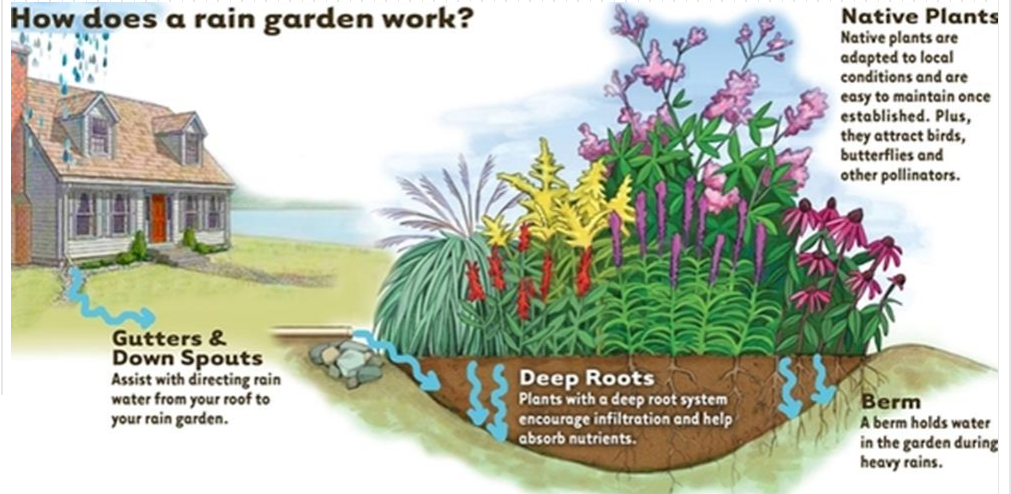
# Rain Gardens

- Shallow depression that collects runoff.
- Used to treat smaller impervious areas - up to 1,000 ft<sup>2</sup>.
- 6" ponding depth, 12" to 18" soil media, 6" to 12" stone storage area under soil media.
- Sized as infiltration practice



# Rain Gardens

## How does a rain garden work?



# Stormwater Planters

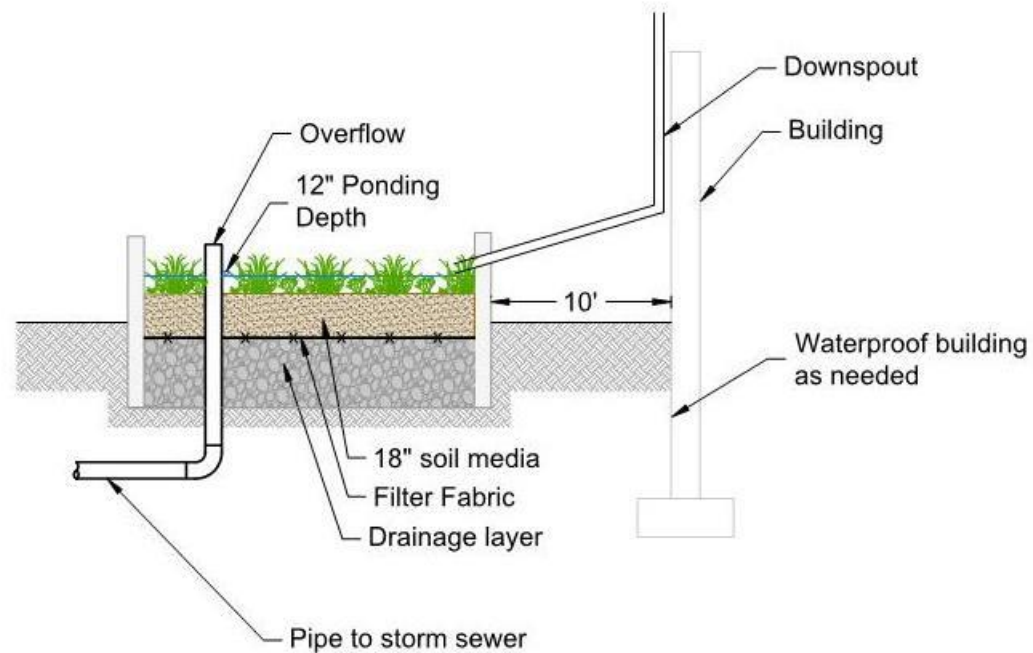
- Above or below grade wood or concrete container with soil media placed in structure.
- Used to treat areas up to 15,000 ft<sup>2</sup>.
- Contained Planters – do not treat adjacent areas. Reduces the impervious area by the area of the contained planter.
- Stormwater Planters – Infiltration is the preferred practice if soils are acceptable.
- Stormwater Planters – Flow Through, use underdrain with discharge.
- Typical construction includes 6" to 12" ponding depth, 18" soil media, 12" stone storage area under soil media.

# Stormwater Planter

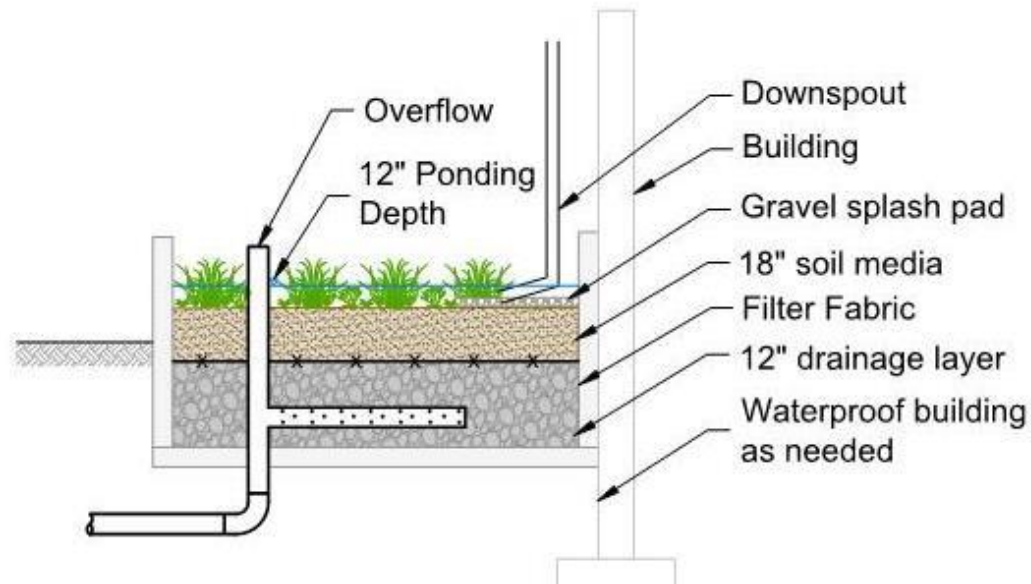




# Stormwater Planter – Infiltration Type



# Stormwater Planter – Flow Through Type



# Bioretention Area

- Unlined or lined with curbing.
- Used to treat areas up to 5 acres.
- Pretreatment is important for larger impervious areas.
- Use Infiltration Type when soils have adequate infiltration.
- Flow Through Type - use underdrain with discharge to storm sewer system.
- Typical construction includes 6" to 12" ponding depth, 2.5' to 4' soil media.



# Bioretention Area



Stormwater curb extension, **HOBOKEN**

# Bioretention Areas - Design Elements

## ● Pretreatment

- Stone or splash block at inlets and roof leaders.
- Stone diaphragm at pavement edges.
- Additional pretreatment for large paved areas:

Grass filter strips

Sediment basins

Proprietary pretreatment devices

See [Pretreatment Guide](#)

## ● Ponding Area above soils

Typically 6" to 12".

Provides temporary stormwater storage.

## ● Plants

- Select for periodic flooding.
- Use native, non-invasive species.
- See [Planting Guide](#)

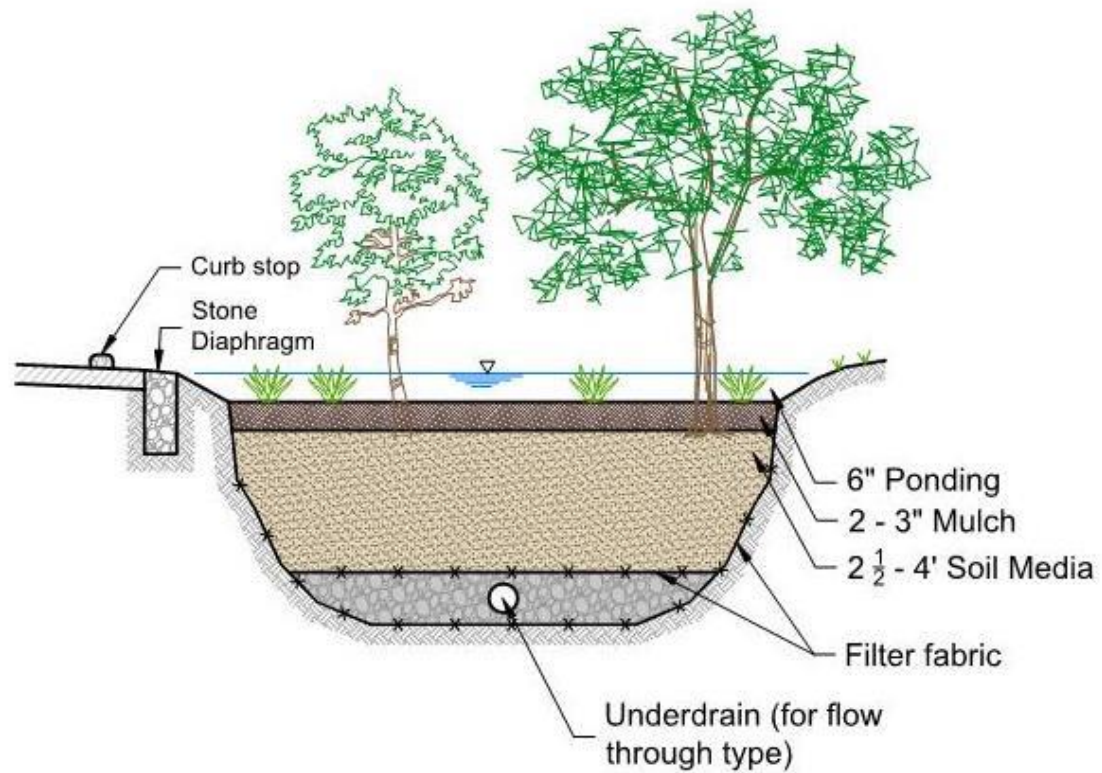
## ● Planting Soils

- 18" minimum. Typically 2.5' to 4'.
- Sandy loam.
- Mulch layer recommended on top.
- See [Bioretention Soils Guide](#).

## ● Drainage Layer and Underdrains

- Drainage Stone under soil media.
- Increases Storage Volume.
- Geotextile for soils separation.
- Infiltration Type – infiltrates to soils below, or;
- Flow Through Type – Underdrain conveys stormwater to outlet or downstream practice.
- Perforated or slotted underdrain pipe, typically 4" or 6" diameter.
- See [Underdrain Guide](#)

# Bioretention Area



# Bioretention Sizing Example – Infiltration

## Bioretention Area - Infiltration

Bioretention area is sized to store the RRv which infiltrates to the soils below.

Volume = Volume Ponding + Volume Soil Media + Volume Drainage Layer

Volume Soil Media = Area x Depth Soil Media x Porosity

Volume Drainage Layer = Area x Depth Drainage Layer x Porosity

Item	Input	Units	Notes
Runoff Reduction Volume, RRv	1000	ft <sup>3</sup>	
Soil Infiltration Rate	0.5	"/hr	Minimum of 0.2"/hr
Bioretention Area Provided, A	600	ft <sup>2</sup>	
Depth of Ponding, dp	1	ft	
Vp = A*dp	600	ft <sup>3</sup>	
Depth Soil Media, ds	2.5	ft	Typically 2.5'-4'
Porosity of Soil Media, ns	0.2		Typically .2-.25
Vsm = A*ds*ns	300	ft <sup>3</sup>	
Depth of Drainage Layer, dl	1	ft	Optional 0.5' to 1' of stone below
Porosity of Drainage layer, nd	0.4		Typically 0.4 for drainage stone
Vdl = A*dl*nd	240	ft <sup>3</sup>	
Volume Provided, Vp=Vp+Vsm+Vdl	1140	ft <sup>3</sup>	
Volume OK?	OK		If Vp<RRv increase area or depths

# Bioretention Sizing Example – Flow Through

Bioretention Area - Flow Through			
Area of practice is sized to store the RRv as ponding above soil media			
Required Area, $A = (RRv)/dp$			
Average height water above bed, $hav_g = dp/2$			
Hydraulic gradient, $i = (ds + hav_g)/ds$			
Flow through filter, $Q = (k)(i)(A)$			
Time to Drain, $t = RRv/Q$			
Item	Input	Units	Notes
Runoff Reduction Volume, RRv	1000	ft <sup>3</sup>	
Depth of Ponding, dp	1	ft	Maximum 1'
Required Area, A =	1000	ft <sup>2</sup>	
Depth Soil Media, ds	2.5	ft	Typically 2.5'-4'
Soil Permeability, k	0.5	ft/day	Typically 0.5 to 2 ft/day
Avg. height water above bed, havg	.5	ft	
Hydraulic gradient, i	1.2		
Flow through Practice, Q	600	ft <sup>3</sup> /day	
Time to Drain, t	1.67	days	Maximum 3 days

# Vegetated Swale

- A vegetated swale is a landscaped trapezoid or parabolic shaped ditch.
- For small sites, vegetated swales without an outlet may be used to satisfy the requirements for disconnection runoff. In these cases, after the required travel length (50'), the swale can overflow to the site or to an off-site storm sewer system.
- Vegetated swales can be used in place of pipes to convey stormwater.
- Requirements:
  - Flow velocity of  $< 1$  ft/sec at a design flow  $< 3$  cfs.
  - Bottom width 2' to 6'.
  - Side Slopes no steeper than 3 horizontal to 1 vertical.
  - Where used for conveyance, size to handle a 10 year storm with flow velocity  $< 5$  ft/sec with a freeboard of  $\geq 6$ ".
  - Maximum slope of 4%.

# Vegetated Swale

- Sizing – refer to Design Manual
  - Calculate the peak 10 year (Q10) and peak water quality flow (Qwqv).
  - Use Manning Equation to calculate flow depths and velocities to verify requirements have been met.
- Provide 4" of topsoil and use a durable seed mix to establish turf. See [Planting Guide](#).
- A RRv Credit shall be applied as follows (based on the soil types):

HSG A or B Soils	20%
HSG C or D Soils	10%

- After subtracting the RRv credit, the remaining RRv should be treated by another GI practice.





# Rainwater Harvesting

- Rainwater harvesting uses rain barrels or cisterns to store rainwater for reuse.
- Reuse options include lawn and landscape irrigation, car washing, flushing toilets, and other non potable water uses.
- This practice directly reduces the RRv by the amount of rain barrel or cistern storage provided.
- Common elements include:
  - Water tight container/structure of suitable materials including concrete, wood, metal and plastic.
  - Secure cover, mosquito/debris screen, inlet screen or filter, overflow pipe, drain valve and tap or pump to withdraw water from storage for reuse.
- The rain barrel or cistern must be actively managed. The collected rainwater must be drained or used between storm events so that the storage volume is available for the next storm.
- The rain barrel or cistern typically must be drained in winter months.



# Rainwater Harvesting – Rain Barrels

- Rain Barrels are typically under 100 gallons in size.
- Typically a rain barrel is placed at each downspout.



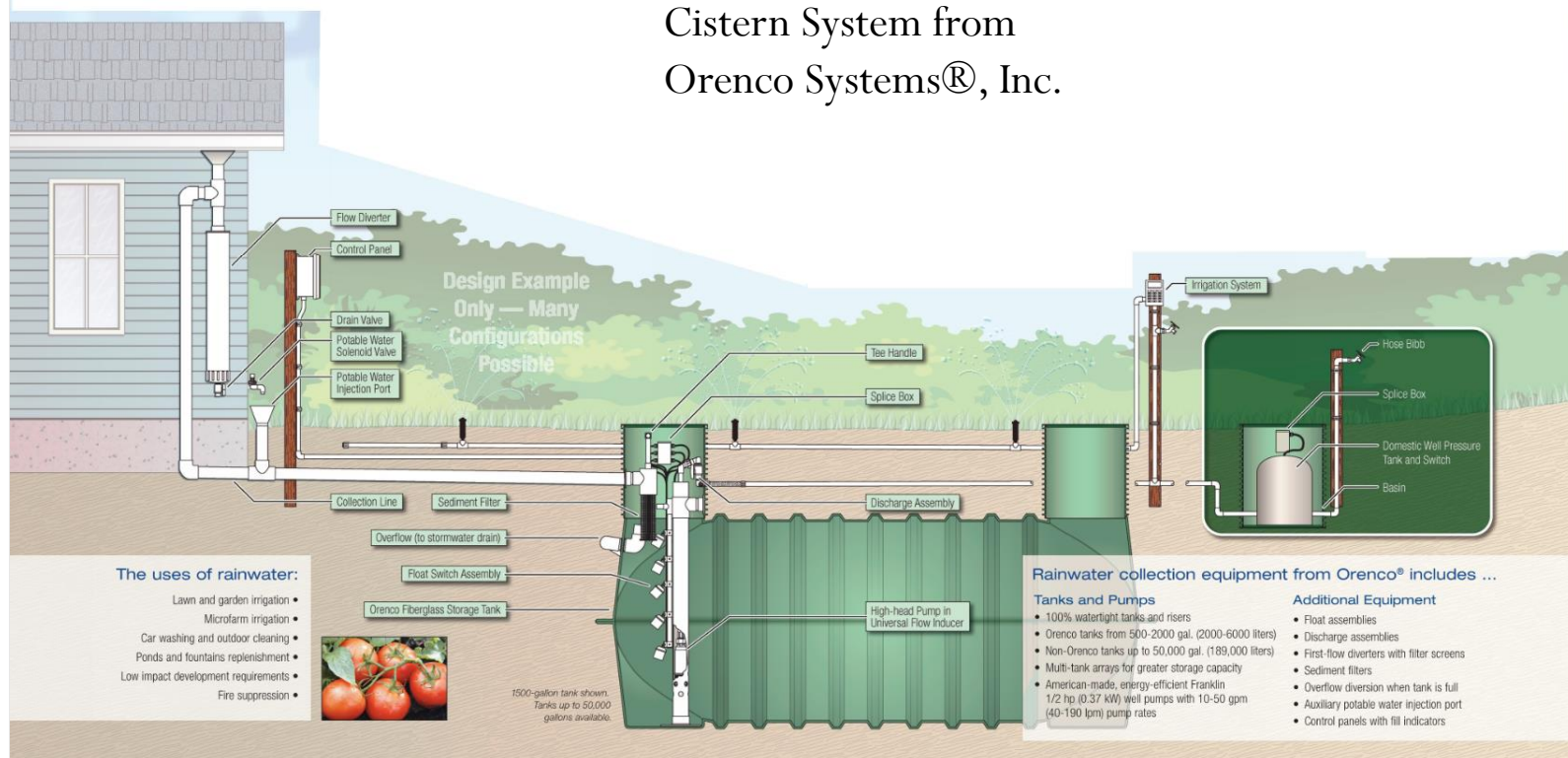
- The Syracuse “Save the Rain” program is a model community project. One of the Save The Rain projects is the distribution of free rain barrels provided by Onondaga County to homeowners in the City of Syracuse. In order to receive a rain barrel, homeowners must attend a brief instructional workshop and sign a Rain Barrel Agreement Form.  
[http://savetherain.us/str\\_project/rain-barrel-program/](http://savetherain.us/str_project/rain-barrel-program/)
- Homeowner’s guide: <http://chesapeakestormwater.net/be-bay-friendly/rainwater-harvesting/> and <http://sfwater.org/index.aspx?page=178>

# Rainwater Harvesting –Cisterns

- Cisterns are larger storage tanks of 100 gallons or more.
- Cisterns can be located above or below ground.
- Traffic rated tanks can be placed under parking areas.
- Precast concrete tanks used for septic systems are an economical choice.
- Reuse of rainwater for flushing of toilets is more complicated but is a good option that provides a year round reuse of rainwater and a potentially large savings on water bills. Plumbing codes must be carefully followed to prevent the potential for cross contamination of the potable water system.
- The Capital Roots project is a great local example. See [Local GI Projects](#)

# Rainwater Harvesting - Cistern

## Example of Complete Cistern System from Orenco Systems®, Inc.



# Capital Roots Cistern

**Capital Roots** in Troy, NY has an insulated cistern that holds 5,200 gallons of stormwater, collected from the rooftop. The water is used year round for flushing toilets and landscaping and has resulted in a 50% reduction in water needs at the facility.

An aerator prevents the cistern from freezing and automatic valve, with a backflow preventer, ensures that there is a back-up municipal water supply on hand in the event of the system runs dry or there is a power outage. After several months of use, the system is reportedly working well with only a few small modifications. Small particles of organic material do collect in the rainwater creating a tan, greyish color.

There was some alarm about the color of water in the toilets, as folks unfamiliar with the rainwater system believed something was amiss with the water supply. Although the discoloration from organic material in the harvested rainwater is normal, the project manager thought this could easily be rectified by posting a sign and switching out the system filter to a smaller micron rating. Only rarely has the cistern ever filled beyond capacity. An overflow is built in and this drains to a bioretention practice.

For more information go to: <http://www.capitalroots.org/>



# Flow Through Practices

- Non infiltrating GI practices reduce the discharge of stormwater pollutants but do not reduce the volume of runoff.
- To minimize peak runoff flow that contributes to CSOs, the RRV is temporarily stored within the GI practice and released over an extended period of time.
- The release rate is controlled by the outlet, typically using small diameter orifices.
- Orifices as small as 0.5" diameter can be used when preceded by an underdrain consisting of perforated or slotted pipe surrounded by drainage stone.
- The targeted release rate of 3 days is waived when an orifice  $< 0.5$ " in diameter would be required, as smaller diameter orifices are prone to clogging.
- Other outlet control options include:
  - Proprietary flow control devices.
  - Pumped discharge (more costly and high O&M).



# Outlet Control For Flow Through Practices

- The release rate is calculated as follows:

$$Q = V/T$$

Where:

$Q$  = release rate flow in cfs

$V$  = Volume stored in practice (RRv)

$T$  = release time. Target = 3 days.

- Using an orifice for outlet control, the release rate or orifice flow is calculated as follows:

$$Q_f = C \times A \times \sqrt{2gh}$$

Where:

$Q_f$  = orifice flow in cfs

$C$  = Orifice Coefficient, typically 0.6

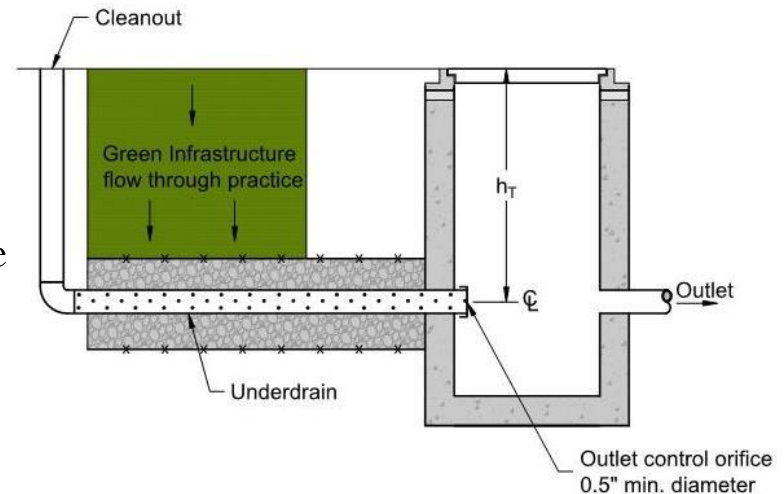
$A$  = area of orifice,  $\text{ft}^2$

$g$  = acceleration constant  $32.2 \text{ ft/s}^2$

$h$  = average head from center of orifice.  $= (h_t - h_0)/2$

$h_t$  = total maximum head (see sketch)

$H_0$  = minimum head (when drained=0) measured from center of orifice.



# Outlet Control For Flow Through Practices

- Example Calculation:

- For a 0.5" diameter orifice (minimum recommended) and a typical average head of 2', the calculated  $Q_f = .00929$  cfs
- For a site with 20,000 ft<sup>2</sup> of impervious cover (Aic):

$$RR_v = 1" / 12 * 20,000 \text{ ft}^2 = 1,667 \text{ ft}^3$$

$$\text{Time to drain, } T = \text{Vol} / Q_f$$

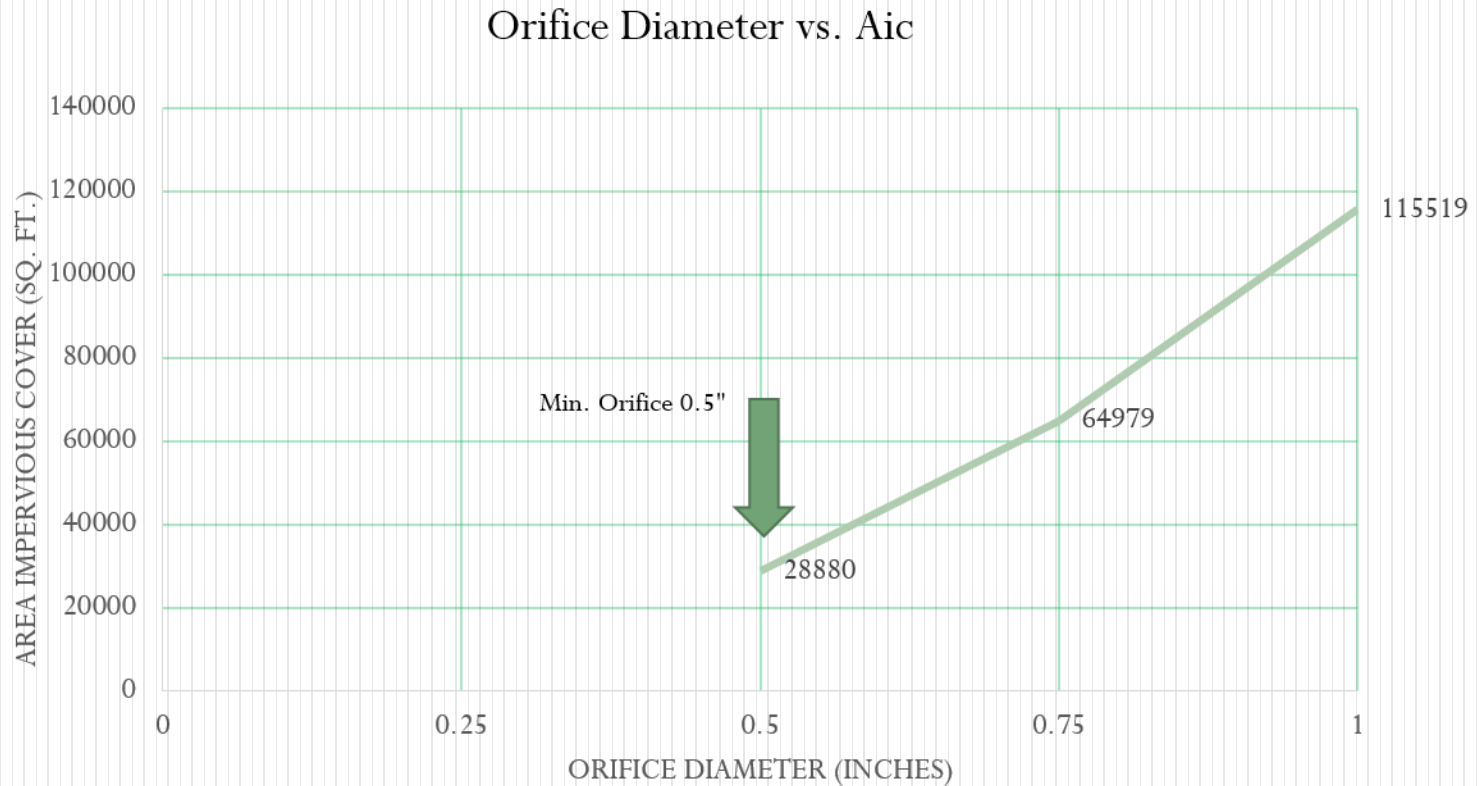
$$T = 1,667 \text{ ft}^3 / .00929 \text{ cfs} / 3,600 \text{ sec/hr} = 50 \text{ hours}$$

This is less than 72 hours but the orifice size can not be less than 0.5" diameter.

- Sites with Aic less than 28,800 ft<sup>2</sup> shall use the minimum size orifice of 0.5" diameter.

**The resulting release time will be less than the targeted 3 days.** See graph next page.

# Orifice Outlet Control





# Outlet Control – Low Flow Devices

Proprietary Low Flow Control Devices  
Reviewed for Use in Philadelphia.

Company	Product
Contech Stormwater Solutions	<a href="#">Vortex Valve</a>
HRD Technologies	<a href="#">Hydro-Brake Optimum Flow Control</a>
Hydro International	<a href="#">Reg-U-Flo</a>
HYNDS Environmental	<a href="#">Hydro-Brake Flow Control Valve</a>
Mosbaek	<a href="#">Cyclone Flow Regulator CEV</a>
Rocla	<a href="#">Hydro-Brake</a>
Veolia	<a href="#">Hydrovex Pond Vortex Flow Regulator</a>

# Flow Through Practices

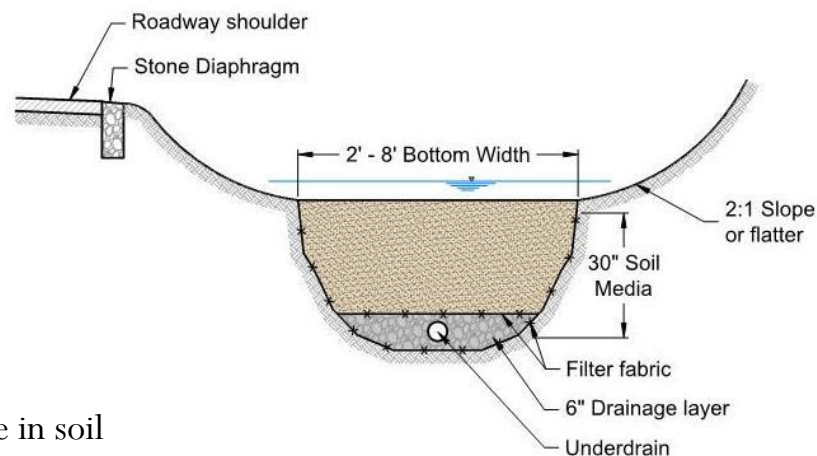
- **Soil based outlet control** can be used as an alternative to conventional flow control devices.
- Soil can be placed over an underdrain (see GI practices with underdrains).
- The flow rate is a function of the depth of the soil layer and the soil's permeability.
- For example, soil medias used for bioretention areas may have a permeability of 0.5 ft/day to 2 ft/day. The desired rate of outflow can be achieved by selecting the appropriate soil and soil depth.

# Open Channel Systems

- Open Channel Systems (dry option)
  - Grass lined channels are used to store the RRv and convey stormwater.
  - Similar to Vegetative Swale.
  - Can be used along the sides of roads.
- Design Elements
  - Bottom width of 2' to 8'.
  - Side slopes no steeper than 2:1 (3:1 preferred).
  - Maximum longitudinal slope 4%.
- Designed as Flow through practice.
  - Permeable soil layer (30") with underdrain .
  - Drain ponded water within 72 hours.
  - RRv is temporarily stored (ponding plus storage in soil media and underdrain).
- RRv Reduction credit is as follows:

HSG A&B	40%
HSG C&D	20%

- After subtracting the RRv credit, the remaining RRv should be treated by another GI practice.
- Wet options also – see Design Manual.



# Planning Tips

- Reduce Building Footprint:
  - Smaller building
  - Additional Stories
- Reduce Driveway Pavement
  - Narrower widths
  - Smaller Turnarounds
  - Fewer entrance/exits
- Reduce Parking
  - Shared Parking
  - Smaller Spaces
  - Reduced Spaces for Motorcycles & Smaller Vehicles
- Preserve Undisturbed & Sensitive Areas
  - Identify and avoid streams, wetlands and wetland buffers
  - Use Compact Site Design

## Resources:

- NYSDEC *Better Site Design*.
- Rhode Island DEM *The Urban Environmental Design Manual*.
- Center for Watershed Protection, *Better Site Design*.
- Maryland DEP, *Low-Impact Development Design Strategies*.

# Planning Tips

- Graphic Information Systems (GIS) is a great tool for planning and more and more data is becoming available.
- For the purposes of site and GI planning, sites of particular interest include:

Source	Data Available
<b>Stormwater Coalition of Albany County</b>	Watershed Maps Other GIS Links
<b>Albany County GIS</b>	Tax Parcel Data Orthoimagery 2' elevation contours FEMA Flood Zones DEC & NWI Wetlands
<b>Rensselaer County GIS</b>	Tax Parcel Data
<b>NYSDEC Environmental Resource Mapper</b>	DEC wetlands Water bodies and classifications Rare plants/animals Significant natural Communities
<b>NRCS – Web Soil Survey</b>	Soils data including HSG information
<b>NYSDEC Stormwater Interactive Map</b>	CSOs MS4s 303(d) Water Bodies
<b>NYSGIS Clearinghouse</b>	Rensselaer County Tax Parcel Data Elevation data – 1 meter DEM, LIDAR data. including 10' elevation data LIDAR elevation data Orthoimagery
<b>FEMA Flood Map Service Center</b>	FEMA Flood Zones

# Planning Guide - GI Banking and Vacant Lots

- The APC has completed a Feasibility Study for a **Green Infrastructure Banking System**.
- Implementation of this program would provide alternatives for difficult sites that are unable to meet stormwater management requirements.
- As part of this effort, CDRPC has identified many vacant lots within the APC.
- The Albany County Land Bank Corp., and the Troy Community Land Bank, acquire vacant, abandon and tax foreclosed lots and sells them to eligible buyers.
- Vacant lots present a great opportunity to implement GI practices that can be incorporated into a GI banking program.
- From a stormwater management perspective, particularly in CSO areas, redevelopment of vacant lots should:
  - Encourage uses that maximize pervious surfaces such as pocket parks and community gardens.
  - Minimize impervious surfaces. Porous pavement options should be used where feasible for redeveloping vacant lots for parking.

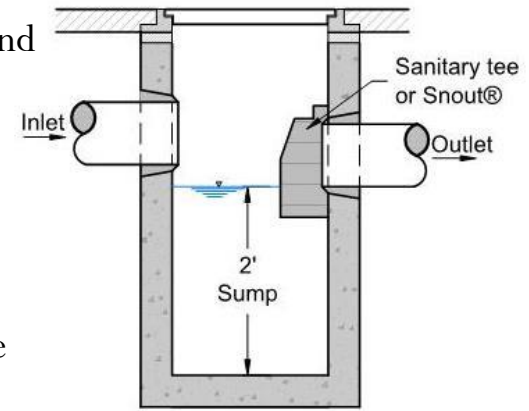
# Planning Guide - GI Banking and Vacant Lots

## Resources for GI on Vacant Lots:

- Ideas for Vacant Land Re-use in Cleveland, Cleveland City Planning Commission.
- Urban Vacant Land Assessment Protocol, 2014 EPA GI Technical Assistance Program, Buffalo Sewer Authority.
- Green pattern Book, Using Vacant Land to Create Greener Neighborhoods in Baltimore, US Forest Service.
- The Greening of Detroit Vacant Land Treatment Guide 2.0, City of Detroit.
- Greening Vacant Lots: Planning and Implementation Strategies, the nature Conservancy NatLab Collaboration

# Pretreatment Guide

- All GI practices should be protected at the inlet from erosive flows. This may include:
  - Drops at curb inlets (6" typical)
  - Stone diaphragms or level spreaders along areas of sheet drainage
  - Splash pads
  - Stone check dams
  - Mulch helps with erosion control and trapping debris in bioretention and other vegetative practices.
  - Sample drawings are available (see [references](#)) for additional pretreatment and inlet options.
- **Catch basin or inlet structures** with deep sumps (2') and outlet protection are a low cost “minimum” measure. The outlet can include a sanitary tee or “snout” to reduce downstream migration of “floatables”. Screen outlets limit carry over of larger debris. For combined sewers, use of products such as Tideflex® check valves can prevent odors and sewer backflows.
- Catch basins should be periodically inspected and sediment removed to ensure that flow is not blocked.





# Pretreatment Guide

- **Pretreatment** is particularly important ahead of infiltration practices. Without pretreatment, migration of fine soils particles wash into and eventually plug the infiltrating surfaces.
- **Sediment basins** are an economical choice but take up space on tight sites.
- **Sediment tanks** can be installed underground.
  - Precast septic tanks are an economical choice. Seamless 1,000 and 1,500 gallon tanks are locally available and can be placed in series if needed.
- **Grass filter strips** with slopes of 2% and lengths of 10' to 25' are effective but may be difficult to fit into small sites.
- **Sand filter** – 6" minimum, can be applied directly above some GI practices such as infiltration trenches or chambers.

# Pretreatment Guide

- **Flow Diversion Structures**

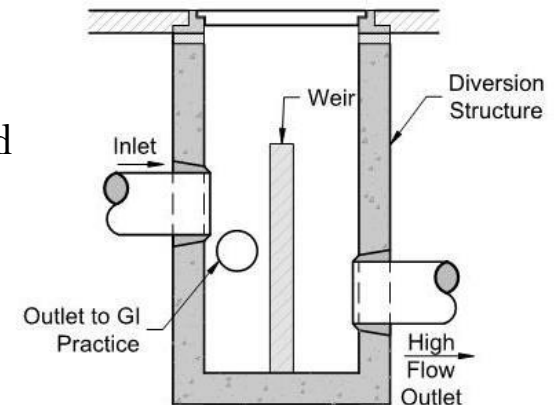
Often it is necessary to divert runoff from larger storm events so that these flows bypass GI practices.

- A typical flow diversion structure is contained in a catch basin or manhole.
- Weirs can be used to split the flows. Low flows are directed to GI practices. Larger flows cause water to spill over the weir and discharge to the high flow outlet.

- **Proprietary pretreatment devices** – manufactured products, typically installed in a catch basin or manhole. See list of New Jersey Verified Products at

<http://www.nj.gov/dep/stormwater/treatment.html>

- May be more costly and require more maintenance than passive measures, but can save space and improve sediment and pollutant removal rates.



# Soils and Infiltration Testing

Consult NRCS Soils Maps (Web Soil Survey) which show the hydraulic soils groups (HSG) for the site.

HSG	Infiltration Rates inches/hour <sup>(1)</sup>	Notes
A	$>1.42$	Best for Infiltration
B	$>.57 \leq 5.67$	Generally ok
C	$>.06 \leq 1.42$	May be ok
D	$<0.14$	Generally not suitable

(1) NRCS Part 730 national Engineering Handbook, table 7-1.

- HSG not available for many urban areas (soils classified Ur – Urban soils).
- Infiltration testing required to verify mapping: [See Design Manual Appendix D.](#)
- Provide a minimum of 2' to bedrock or seasonal high groundwater unless greater separation required by local regulators.
- Soil restoration is important for previously disturbed areas. Till soils to depth of 12". See Design Manual 5.1.6.

# Planting Guide

- **Guide**

- Select plants to handle the anticipated ponding level and frequency of flooding.
- Select local natural species suitable for Plant Hardiness Zone 5b.
- Avoid invasive species and poisonous plants.
- Maintain a mulch layer for moisture retention and soil fertility.
- Water and weed to maintain a healthy cover of plants.
- Replace with new plants as needed to avoid bare spots.

## Resources

- Green Stormwater Infrastructure Landscape Design Guidebook, City of Philadelphia.
- Design Manual, Appendix H, Landscape Guidance/Plant List.
- Plant Materials for Vegetation Management along New York State Roadsides, Cornell Cooperative Extension.

# Bioretention Soils Guide

## Resources

- University of New Hampshire Bioretention Soil Specification  
[https://www.unh.edu/unhsc/sites/default/files/media/unhsc\\_bsm\\_spec\\_10-3-16.pdf](https://www.unh.edu/unhsc/sites/default/files/media/unhsc_bsm_spec_10-3-16.pdf)
  - Design Manual, Appendix H.
- 
- Local organic soils and compost is available from the Albany Recycles Compost Facility and other local landscaping supply businesses.

# Underdrain Guide

- **Geotextile** – used to separate materials and keep fines from moving into openings of courser materials. Typically a non-woven polypropylene geotextile is used for this purpose.
- **Stone envelope** – surrounds the underdrain pipe. Provides additional storage of stormwater in the open spaces between the stones. The stone or gravel material should be fairly uniform in size to provide open spaces for drainage and washed or screened to minimize excessive fine materials. NYSDOT specifications are commonly used. A good specification for drainage stone is a 50%/50% mix of NYSDOT No. 1 and 2 stone (approximately ¼" to 1" in size).
- The Stone should surround the underdrain pipe. Typically 2" below and 4" minimum above the pipe.
- **Underdrain Pipe**
  - Typically PVC or Corrugated Polyethylene Pipe (CPP).
  - Perforated or slotted.
  - Typical sizes used for underdrain applications – 4" diameter to 8" diameter. Larger diameter pipe is less prone to freezing.
  - Cleanouts recommended to allow flushing and cleaning of underdrains.

# Cost of GI Practices

- The most cost effective measure is careful site planning to reduce the amount of impervious surfaces in the project, which directly reduces the RRV requiring treatment.
- A number of GI practices have other benefits which help offset costs.
  - Street trees and vegetated practices improve the aesthetics of a property.
  - Rain barrels and cisterns capture water for reuse and can save on water bills.
  - Plants mitigate climate change impacts by reducing CO<sub>2</sub> emissions.
  - Landscaping and trees reduce urban “heat island” effects.



# Cost of Selected GI Practices

GI Practice	Range - \$/treated ft <sup>3</sup>
Rain Gardens	\$3-\$6
Stormwater Planters	\$21-\$41
Bioretention Areas	\$9-\$46
Infiltration Trench/Drywell	\$12-\$15
Permeable Pavers	\$109-\$164
Rain Barrels	\$7-\$28
Cisterns	\$14-\$26

From: Water Environment Federation (WEF), Green Infrastructure Implementation, 2014. Costs in 2012 dollars.

# Construction Considerations

- Develop and implement an erosion and sediment control plan to protect downstream properties and waterways.
- Proper construction sequencing is critical to make sure the site is stabilized prior to exposing infiltration areas to sediments that can clog these areas.
- Keep heavy equipment off of pervious areas to avoid over compaction.
- Restore Soils in pervious areas – Till to 12" depth See: [Soils and Infiltration Testing](#).

# Maintenance Considerations

- General
  - Check for erosion.
  - Integrity of structures and pipes.
  - Flows maintained as intended, soil/infiltration not clogging.
- Pretreatment
  - Remove debris and accumulated sediments.
- Vegetation
  - Water & fertilizer.
  - Weed.
  - Replant as needed.
- Rain barrels and cisterns
  - Need active management to make sure vessel is emptied in advance of storm events.
- Proprietary systems
  - Generally higher maintenance.
  - May include mechanical components.
  - Consult manufacturer's O&M manuals.

# Maintenance Considerations

- Resources:
  - A good resource for maintenance is the NYSDEC document, Maintenance Guidance for Stormwater Practices, September 2016 (draft):  
[http://www.dec.ny.gov/docs/water\\_pdf/smpmaintguiddraft.pdf](http://www.dec.ny.gov/docs/water_pdf/smpmaintguiddraft.pdf)
- Sample Maintenance Agreements
  - City of Syracuse:  
<http://www.syr.gov.net/uploadedFiles/Departments/Engineering/Content/revised%20model%20maintenance%20agreement%207-15-09.doc>
  - NYSDEC:  
<ftp://ftp.dec.state.ny.us/dow/stormdocuments/Maintenance/Example%20Maintenance%20Agreement.pdf>

# Maintenance Tasks

Maintenance Task	Recommended Frequency	Description
Porous Pavement Vacuuming	Semi-annually (2x/year) for concrete, asphalt and flexible pavement; annually in spring for pavers	Porous pavement surfaces require vacuuming to remove debris that may clog the permeable layers/voids prevent infiltration.
Porous Pavement Power Washing	Once every three years (or as necessary)	Power washing restores permeability and should follow porous pavement vacuuming. Porous pavers should not be power washed.
Porous Paver Maintenance (Restoring Aggregate)	As needed when gravel infill is not within 1/2 inch of the paver surface, immediately following vacuuming	Refilling of voids between pavers with additional aggregate material to replace any material that has been lost by vacuuming and/or due to natural migration, settlement, and erosion.
Winter Maintenance for Porous Pavements	As necessary during Winter	Porous pavement surfaces require modified plowing and salting practices during the winter months when snow is present.
Stormwater Structure Cleaning	Semi-annually (2x/year)	Stormwater Structure Cleaning refers to removing debris or clogged materials and vacuuming the interior of the structure.
Inlet Filter Insert Cleaning or Filter Insert Pouch Replacement	Clean Quarterly (4x/year) until it is determined a particular inlet requires less frequent cleaning; Replace annually	Filter inserts need to be cleaned with an industrial vacuum to remove debris and prevent clogging.

# Maintenance Tasks - Continued

Maintenance Task	Recommended Frequency	Description
Green Roof Maintenance	Spring and Fall, after initial 2-3 year establishment period; must adhere to the project specifications/warranty provisions	Remove debris, weed, prune plants, replenish, fertilize if needed. Follow project specific maintenance plan.
River-stone Edge Maintenance	Annually in Spring	Remove debris, weed, rake, replenish as needed.
Tree General Maintenance, Weeding, Mulching, Soil Amendment	Year 1 is covered by Contractor's maintenance agreement/warranty; weeding occurs 3 times/year; mulching occurs annually in Spring	Tree inspection covers an initial tree health assessment, followed by tree pit weeding and tree pit mulching.
Landscaping Areas General Maintenance, Weeding, Mulching	Inspection: 1x/year; Weeding to occur 3x/year (spring clean-up; Summer maintenance; fall put to bed); Mulching to occur 1x/year in Spring	Landscape inspection covers an initial health assessment of the plantings, followed by trash removal, weeding, and mulching.
Meadow Inspection, Control of Invasive Species	Monitor meadow monthly during growing season for invasive species during first 2 to 3 years	Inspect and monitor the meadow for invasive species.
Tree Watering	Year 1 is covered by Contractor's maintenance agreement/warranty; Year 2: water weekly in the absence of rain; Years 3+: only as necessary in during extended periods of drought.	Tree and landscape watering refers to watering during establishment in Years 1 and 2 and as necessary during extended periods of drought.
Landscape Watering	Year 1 is covered by Contractor's maintenance agreement/warranty; Year 2 and 3: water the first 4-6 weeks of growing season and during extended periods of drought.	Tree and landscape watering refers to watering during establishment in Years 1 and 2 and as necessary during extended periods of drought.

# Maintenance Tasks - Continued

Maintenance Task	Recommended Frequency	Description
Tree Pruning	Year 1 is covered by Contractor's maintenance agreement/warranty; One-time per year in Year 3 (Fall or Spring depending on species); One time per year in years 5, 8, 12, 18, 24, 30, 36, 44, 52, 60	Tree and landscape pruning refers to annual pruning to maintain aesthetics and promote tree vigor.
Landscape Pruning	Year 1 is covered by Contractor's maintenance agreement/warranty; 1x/year beginning in Year 2 depending on plant type	Tree and landscape pruning refers to annual pruning to maintain aesthetics and promote tree vigor.
Meadow Mowing	Year 1: once a month from Apr-Nov; Year 2: Once in Fall; Year 3 and beyond: once every 2 years in Spring	Mowing helps prevent/control woody plant and weed establishment, and helps to disperse seeds of desirable species.
Landscape Replacement (excludes Trees)	Spring and Fall, as a corrective maintenance task that should only be performed on an as needed basis	Replace missing, dead, or diseased shrubs and herbaceous plant material.

# Maintenance Costs

Maintenance Cost Estimates vary widely, and because systematic GI use is relatively new there are limited records of existing programs. Below is an estimate of maintenance costs for a recent Green Infrastructure Project.

GI TYPE	REQUIRED MAINTENANCE	FREQUENCY	ESTIMATED ANNUAL COST (\$)
Porous pavements	Vacuuming of surface Inspection & Cleaning of drainage structures	2 times per year	Avg. \$0.15 / SF
Rain Gardens	Water & Care Establishment Weeding, Pruning, Mulching Inspect & Clean overflow drainage Remove litter, debris, sedimentation	4 times per year (Spring & Fall critical)	Avg. \$0.30 / SF
Bioretention	Water & Care Establishment Weeding, Pruning, Mulching Inspect & Clean overflow drainage Remove litter, debris, sedimentation Erosion Control, stone apron repairs	3 times per year (Spring & Fall critical)	Avg. \$0.75 / SF



# Lessons Learned

Many GI projects are highly specialized and may require deviations from standard construction best practices. GI has a unique set of best practices which are evolving quickly. Additional communication between contractors, municipal staff, and designers can help resolve these differences and build unified project goals.

Key communication and inspections should occur during the following construction activities:

- Erosion and sediment controls - proper installation practices, down gradient perimeter control, checklist conformity.
- Excavation, grading and site preparations – critical staging and phasing of operations, identify infiltration areas, keep water/storage clean and protected, identify stabilization areas, limit compaction as necessary.
- Utility installation and protection – identify utilities to remain and protection measures required, may require careful vacuum excavation to limit disturbances, ensure anti-seepage collars are installed where required, coordination with owners of utilities.

# Lessons Learned - Continued

- Stormwater infrastructure – services kept off line until surface measures in place, proprietary devices functioning and properly installed, elevations are verified for structures and piping inverts.
- Pavement installation – inspections to ensure proper compaction, subbase and storage depths; limit debris and sediment; observe construction traffic, compaction, and protection; direct stormwater to temporary stabilized areas if necessary.
- Finish grading – attention to detail, proper elevations of pavements, curbs, structures, slopes, low points, etc; communicate proper adjustments if necessary; appropriate soil amendments, tilling, decompaction and permeability testing if needed; installation of rock areas, diaphragms, and outlet/ inlet elements.
- Vegetation – proper planting techniques, locations, depths, procedures; ensure adequate water and moisture retention for establishment; inspect for disease, dying or decaying materials; ensure proper placement and type for function of plantings.

# Local GI Projects

## Stormwater Coalition of Albany County September 24, 2013 Green Infrastructure Tour 11:30am to 5:00pm

### Registration and Lunch Cook Park, Village of Colonie, New York



**Stormwater Coalition Green Infrastructure Local Law Advisory Committee (GILLAC)** —planning, registration, lunch coordination, troubleshooting  
**Helping Out For The Day:** Jeremy Cramer, Town of New Scotland; Melissa Ashline-Hell, City of Cohoes; Leslie Lombardo, Albany County; Maryella Davenport, City of Albany; Mike Lyons, Town of Colonie.



**Tour Host (Registration and Lunch):** Village of Colonie, Carl Fleschman and Randy Rivera...waiting for the buses!

### Introductions Green Infrastructure Explained...



Nancy Heinzen  
Stormwater Coalition of Albany County  
Program Coordinator

### Welcome!



Daniel P. McCoy, County Executive, Albany County

### Getting Around—School Buses!



Antoinette Estates



Top of Rapp Road landfill



End of Tour! Cook Park

**Tour Funding:** NYSDEC Environmental Protection Fund Stormwater Implementation Grant (Round 10)  
**Stormwater Coalition of Albany County:** 112 State Street, Room 720, Albany, NY 12203. [www.albanycountystormwater.org](http://www.albanycountystormwater.org)

## Site 1: Rain Garden (Cook Park, Village of Colonie)

**Background:** The purpose of the rain garden is to treat small volumes of stormwater runoff using a conditioned planting soil bed and planting materials to filter runoff stored within a shallow depression. This garden receives runoff from a portion of a parking lot and was built in November, 2011. Albany County Cornell Cooperative Extension Master Gardeners designed the garden; Albany County Soil and Water Conservation District provided labor and planting material, and the Village of Colonie Department of Public Works provided equipment and helped dig the garden. The garden is maintained by the Village of Colonie. The Stormwater Coalition of Albany County monitors rain garden performance and facilitates coordination and training as needed. This is one of eight demonstration rain gardens throughout Albany County. Estimated cost of each demonstration rain garden: \$1,500 (labor, equipment, materials). Plant supplier: Project Natives, Fiddlehead Creek Nursery, Helderberg, splits of plants from other rain gardens. Multiple sources of funding for all eight demonstration rain gardens.



Presenter: Susan Pezzolla,  
Cornell Cooperative Extension  
of Albany County Master Gardeners



Presenter: Randy Rivera, Village of  
Colonie, Stormwater Program  
Coordinator



Rain Garden (November, 2011)



Presenter: Susan Lewis, Albany County Soil and Water Conservation  
District (right of Randy Rivera)



## Site 3: Green Roof (University at Albany-SUNY, Uptown Campus, Liberty Terrace Dorm)

**Background:** This green roof was installed in 2012 and was one of several natural and sustainable elements incorporated into the Liberty Terrace project. This LEED Gold project also includes a ground source heat pump, rain gardens, daylight maximization, and the use of recycled and locally-sourced materials. The roof garden supplier was Carlisle's S & L Roofing and from top to bottom the roof components include: Carlisle's vegetated sedum mats; Carlisle's 2.5" growth media; Carlisle's Miradrain G4; 060 White EPDM; EPDM Bonding; 1/2" securock cover-board; tapered insulation; 725 TR vapor barrier; 702 Primer; 1/2" DENS deck plume; wood deck. Carlisle's pressure sensitive molded walkway pads surround the vegetated area. An authorized contractor installed the green roof.



Presenter: Diana Delp, Registered  
Architect, Project Manager, University  
at Albany-SUNY

Presenter: Peter Spoor, Construction  
Manager, University at Albany-SUNY  
(available for questions)





# Local GI Projects

## Site 2: Porous Pavement, Downspout Disconnect, Soil Restoration, and Reduction of Impervious Cover (Antoinette Estates, Town of Colonie)

**Background:** As originally planned this was a 13 lot residential sub-division resulting in a total disturbance of 4.8 acres. The original Basic SWPPP (Erosion and Sediment Control Plan) included small near-lots and deed restricted areas. After construction commenced, to address changing market conditions, the developer favored larger lots. This resulted in a redesign of the site to include post construction stormwater practices.

Given site opportunities and constraints, various green infrastructure practices were proposed which met the needs of the developer and addressed the Town's interest in testing out and promoting green infrastructure. These practices included porous pavement for both the Town road and individual lot driveways, plus roof top disconnection. While porous asphalt had been used elsewhere in Albany County, this application involved residential, rather than commercial property and a Town road, rather than the more typical parking lot, or foot/bike path. This novel application resulted in heightened oversight of the project and careful attention to all design, construction and maintenance details. A variety of individuals participated in this project and presentation: John Dzialo, Town of Colonie Stormwater Program Coordinator; Dan Hershberg, PE, Stormwater Design Engineer; Anthony Guidarelli, Owner, Guidarelli Construction, Inc.; Bob Higgins, Town of Colonie Stormwater Inspector; Adam Wands, Town of Colonie, Stormwater Inspector.

While this site was primarily an example of porous pavement and downspout disconnection, two other green infrastructure practices were discussed as well, soil decompaction and the reduction of impervious area (i.e. via Town law...reduce street width).



Dan Hershberg, explaining the project. John Dzialo and Anthony Guidarelli available for questions.



John Dzialo, Town of Colonie, Stormwater Program Coordinator

1. What our test pits showed...well drained soils, suitable for porous asphalt.
2. Decompact pavement sub-grade utilizing methods as described in Deep Ripping and Decompaction (April, 2008 NYSDEC) ...VERY IMPORTANT!
3. Maintenance agreements with homeowners—critical. They need to know how to maintain their porous asphalt driveway.



This is the third Tour demonstration of the day. John is spraying about ~200 gallons of water onto the porous asphalt pavement.



After ~30 seconds, this is what it looks like.



Adam Wands and Bob Higgins explaining street width dimensions...this site 32' wide (wing to wing). Town standard had been 36'. Town might consider 28' wing to wing. EPA Water Quality Scorecard recommends 18–22' street width.



Downspout Disconnect—Antoinette Estates

## Site 4: Stream and Habitat Restoration (City of Albany Rapp Road Landfill & Albany Pine Bush Preserve)

**Background:** June, 2009 NYSDEC issued a permit to expand the Rapp Road landfill (23-acre overfill; 15 acre lateral landfill expansion; extend life of landfill by 7 years assuming currently approved maximum daily tipping rates). Permit requires several actions to minimize and mitigate adverse environmental impacts. One action "...the City fully implement an Albany Pine Bush Ecosystem, Habitat Restoration Plan..." Restoration Plan: create ~20 acres of wetlands; 3200 feet of stream, native plant nursery. Phasing: restore ~130 acres of Preserve lands surrounding landfill; test native plant restoration on a closed portion of landfill; restore ~130 acres on the closed landfill

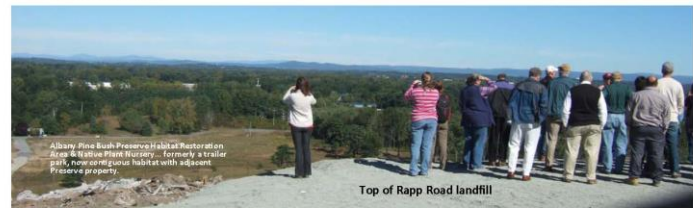


Stream and Habitat Restoration Albany Pine Bush Preserve

### Presenters:

#### Left to Right:

Joe Giebelhaus, City of Albany Landfill, Solid Waste Manager  
Neil Gifford, Albany Pine Bush Preserve Conservation Director



Top of Rapp Road landfill



As the landfill closes, the NYSDEC Permit requires the restoration of closed portions (cap and contour with native sand and plant natives)



# Additional References

## General References that include extensive stormwater tools and resources:

- [US Environmental Protection Agency \(USEPA\)](#)
- [University of New Hampshire Stormwater Center](#)
- [The Center for Watershed Protection](#)
- [Low Impact Development Center](#)
- [The Water Environment Federation](#)
- [National Association of City Transportation Officials, \*Urban Street Stormwater Guide\*.](#)

## New York State Department of Environmental Conservation (NYSDEC)

- [Stormwater Management Design Manual](#)
- [NYS Standards and Specifications for Erosion and Sediment Control \(Blue Book\)](#)
- [Better Site Design](#)

## New York City

- [Guidelines for the Design and Construction of Stormwater Management Systems](#)
- [NYC Green Infrastructure Plan \(Includes GI cost estimates\)](#)
- [NYC Standards for Green Infrastructure \(Includes CAD drawings\)](#)

## City of Chicago

- [Stormwater Management Ordinance Manual](#)
- [Green Alley Handbook](#)

## City of Philadelphia

- [Stormwater management Guidance Manual](#)
- [Green Street Design Manual](#)
- [Green Streets Details \(CAD drawings\)](#)
- [Green Stormwater Infrastructure Standard Details \(CAD Drawings\)](#)
- [Green Stormwater Infrastructure Planning & Design Manual](#)
- [Green Stormwater Infrastructure Landscape Design Guidebook](#)

## City of Portland

- [Stormwater Management Manual](#)
- Presumptive Performance Details (CAD drawings)
- Stormwater Simplified Typical Details (CAD drawings)
- Green Street Typical Details (CAD drawings)

## City of Rochester and Monroe County

- [Green Infrastructure Retrofit Manual](#)

# Glossary

- **Aic** – Area of directly connected impervious cover
- **APC** – Albany Pool Communities
- **CDRPC** – Capital District Regional Planning Commission
- **cfs** – cubic feet per second
- **Design Manual** – New York State Stormwater Design Manual, NYSDEC
- **GI** – Green Infrastructure
- **HSG** – NRCS Hydrologic Soil Group
- **NYSDEC** – New York State Department of Environmental Conservation
- **NRCS** – National Resource Conservation Service
- **RR<sub>v</sub> - Runoff Reduction Volume** – The volume of runoff to be treated by Green Infrastructure practices, equal to 1” of rainfall over the area of impervious surfaces.
- **WQ<sub>v</sub> – Water Quality Volume** – The volume of stormwater to be treated under the Design Manual, equal to the runoff from the 24 hour 90% storm event. Differs from the RR<sub>v</sub> because it is calculated on the total contributing area, which can include both impervious and pervious areas.