RUTGERS
THE STATE UNIVERSITY
OF NEW JERSEY

Designing and Implementing Green Infrastructure

Christopher C. Obropta, Ph.D., P.E.

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Bioretention Systems/Rain Gardens



Landscaped, shallow depression that captures, filters, and infiltrates stormwater runoff.

Bioretention Systems / Rain Gardens

How it works:

These systems capture, filter, and infiltrate stormwater runoff using soils and plant material. They are designed to capture the first few inches of rainfall from rooftops, parking areas, and streets.

Benefits:

Removes nonpoint source pollutants from stormwater runoff while recharging groundwater

Restore/"mimic" predevelopment site hydrology

- Infiltration
- Evapotranspiration

Improve water quality

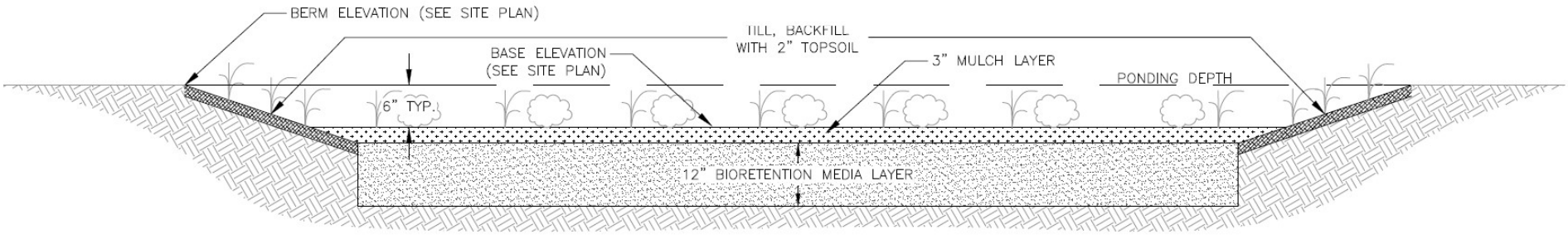
- Sedimentation, filtration, & plant uptake
- Microbial Activity

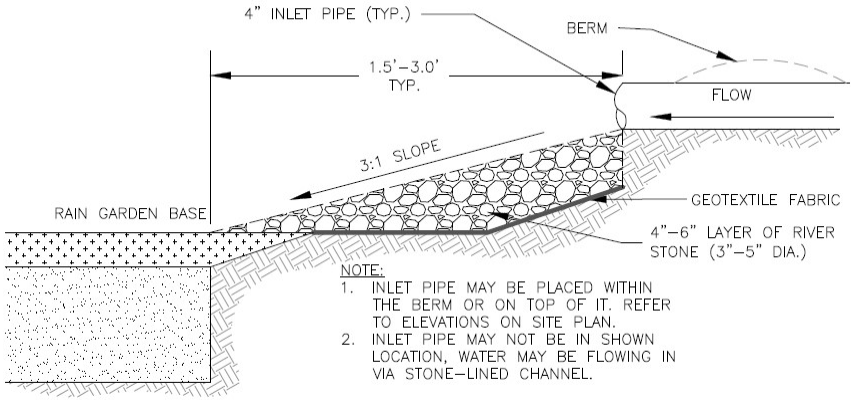
Add aesthetic value

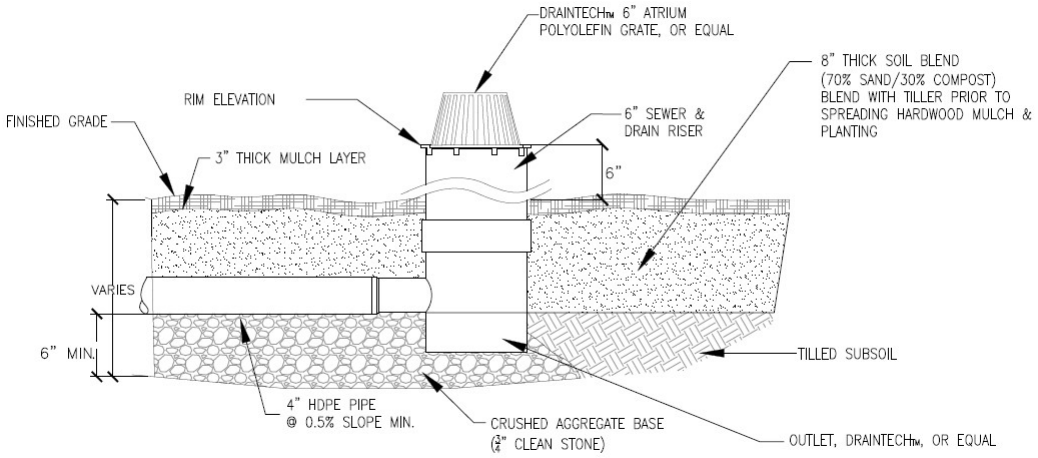
- Plant selection

Vegetative System

Bioretention Systems / Rain Gardens







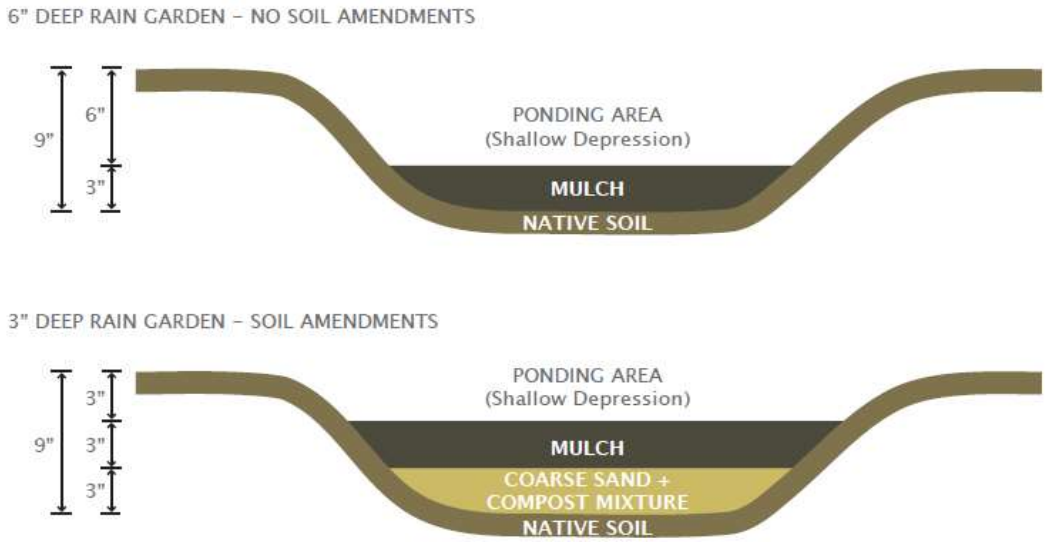
Vegetative System

Design Parameters for Retrotting with Bioretention System/Rain Garden:

- Close to the source of runoff
- Flat bottom with stable inflow and overflow
- Captures, treats, and infiltrates at least the water quality storm (1.25 inches over two-hours)
- Can be designed for the two-year design storm (3.3 inches of rain over 24-hours)
- Minimum infiltration rate of 0.5 inches per hour and maximum infiltration rate of 10 inches per hour
- If infiltration rate unknown or less than 0.5 inches per hour, design with underdrain and test at time of construction
- Amend soil with coarse sand and/or compost if necessary
- Include rain garden as part of drainage area

Design Criteria

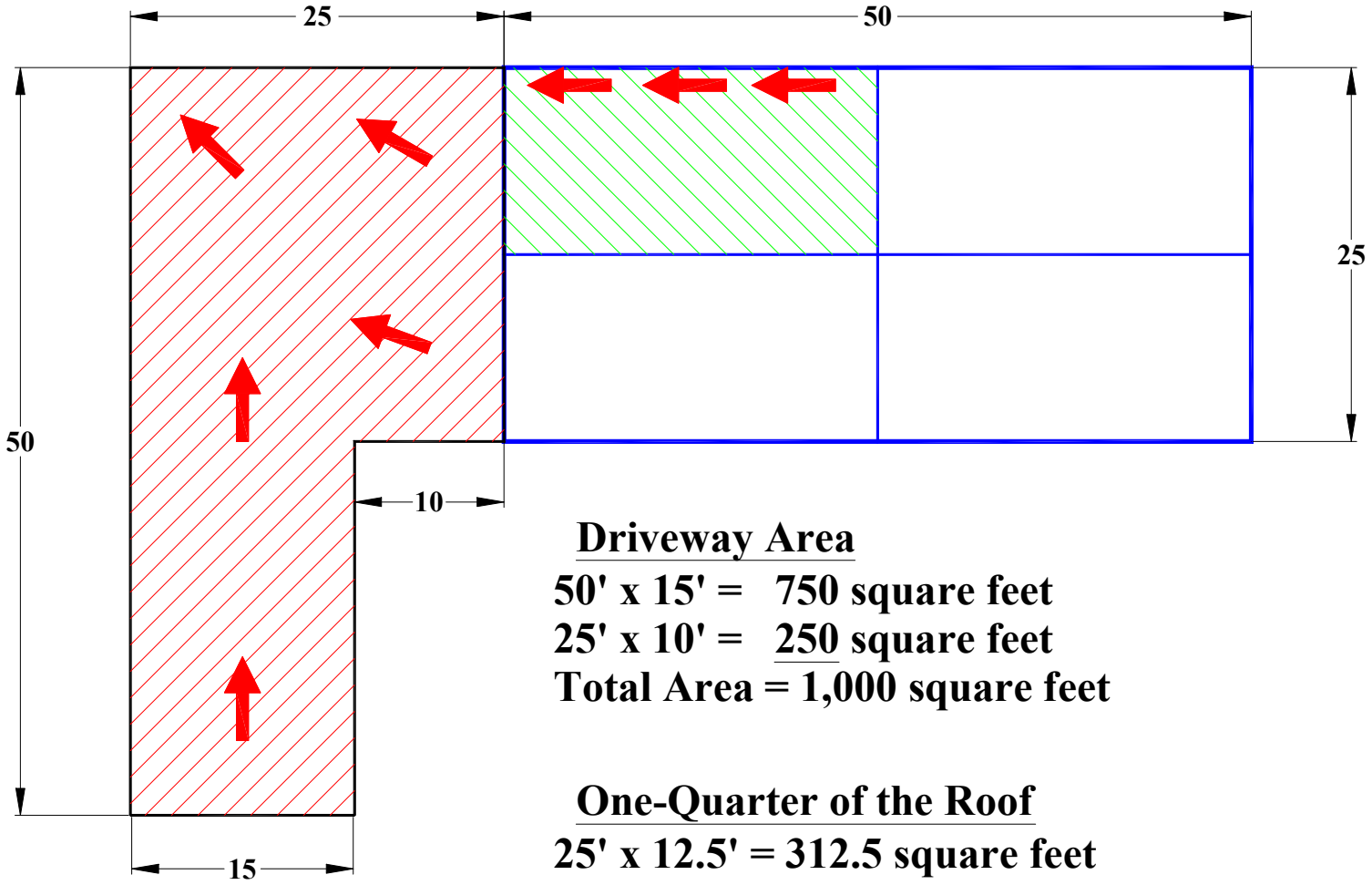
- The size of the rain garden is a function of volume of runoff to be treated and recharged.
- Typically, a rain garden is sized to handle the water quality storm r the two-year design storm (3.3 inches of rain over 24 hours)
- Rain garden range from 75 to 2,500 square feet



Design Problem

How big does a rain garden need to be to treat the stormwater runoff from my driveway?

Design Problem



Driveway Area

50' x 15' = 750 square feet
25' x 10' = 250 square feet
Total Area = 1,000 square feet

One-Quarter of the Roof

25' x 12.5' = 312.5 square feet

Design Problem: Approximate the size

- Drainage Area = 1,000 square feet
- 1.5 inches of rain = 0.125 feet of rain
- 1,000 sq. ft. x 0.125 ft. = 125 cubic feet of water for the design storm
- Let's design a rain garden that is 6 inches deep

Answer:

10 ft wide x 25 ft long = 250 square feet

Now let's get a better estimate

The new drainage is 1,250 square feet (1,000 sq.ft. of driveway + 250 sq.ft. of rain garden)

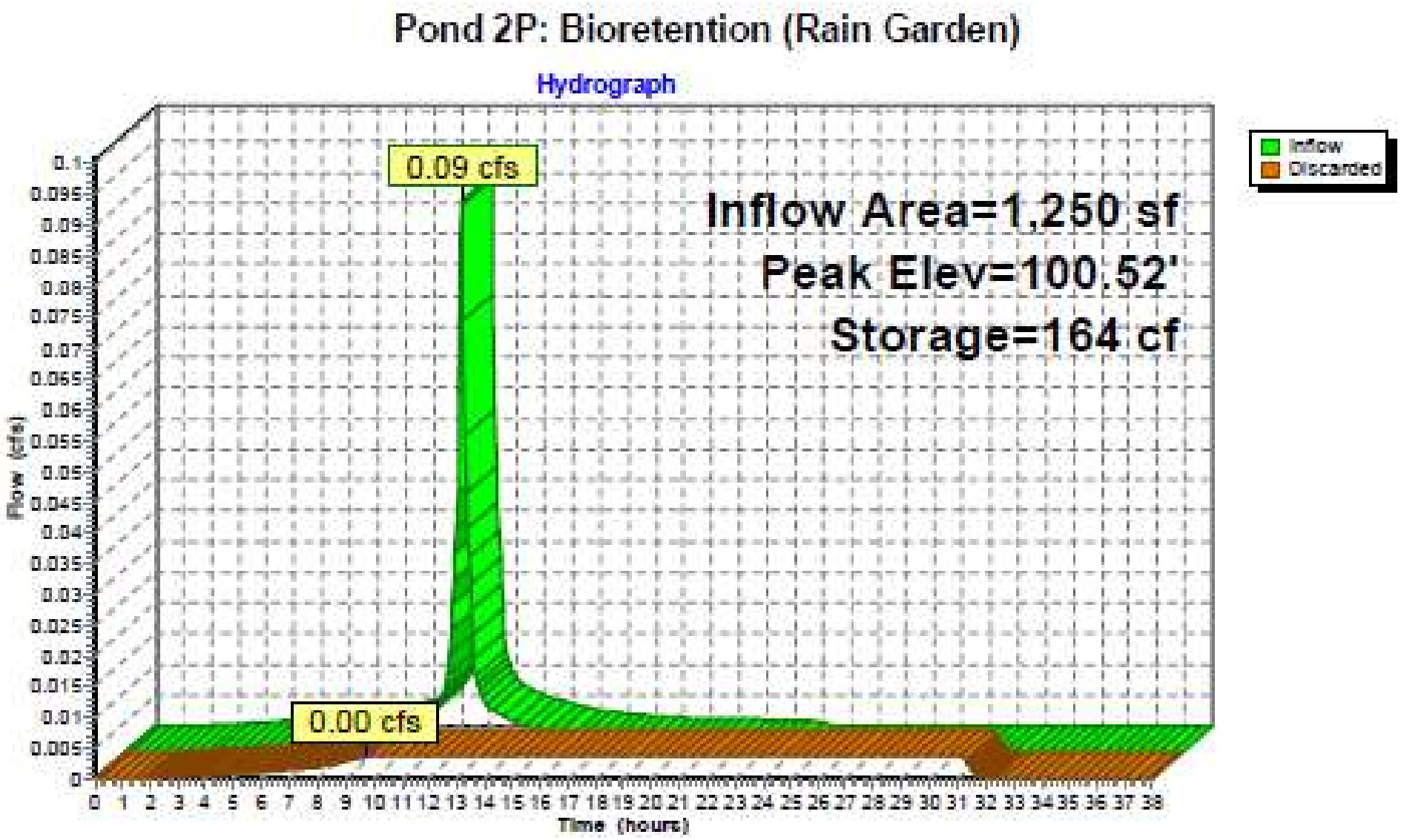
Design Problem

- Drainage Area = 1,250 square feet
- 1.5 inches of rain = 0.125 feet of rain
- 1,250 sq. ft. x 0.125 ft. = 156 cubic feet of water for the design storm
- Let's design a rain garden that is 6 inches deep

Answer:

10 ft wide x 31.2 ft long = 312 square feet

Use a hydrologic model to determine the actual size



How much water does this treat?

- 95% of rainfall events are less than 3.3”
- New Jersey has approx. 44” of rain per year
- The rain garden will treat and recharge:

  0.95 x 44” = 41.8”/year = 3.5 ft/year
- The drainage area is 1,312 square feet
- Total volume treated and recharged by the rain garden is 1,312 sq. ft. x 3.5 ft. = 4,592 cubic feet, which is 34,350 gallons per year
- **Build 30 of these and we have treated and recharged over 1,000,000 gallons of water per year!**

RUTGERS Water Resources Program

Rain garden at Catto School in Camden, NJ

Vegetative System




Rain garden installation at Ferry Avenue Library in Camden, NJ

Vegetative System

Rain garden at Waterfront South Park in Camden, NJ

Vegetative System

Stormwater Planters

Vegetated structures that are built into the sidewalk to intercept stormwater runoff from the roadway or sidewalk.

Stormwater Planters

How it works:

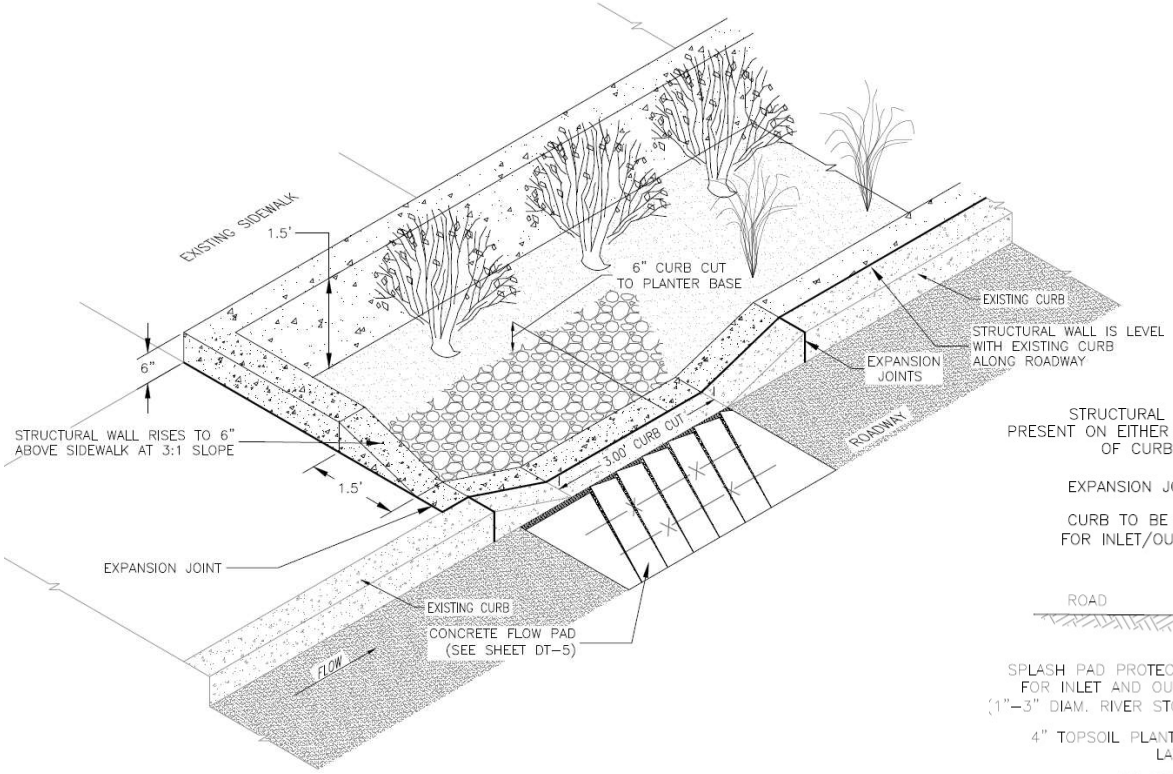
- It is a structural bioretention system that is installed in a sidewalk
- Contains a layer of stone that is topped with bioretention media and plants or trees
- Captures stormwater runoff from the roadway and sidewalk
- Once the system fills up, runoff flows back into the street or into an overflow drain which connects to the sewer system

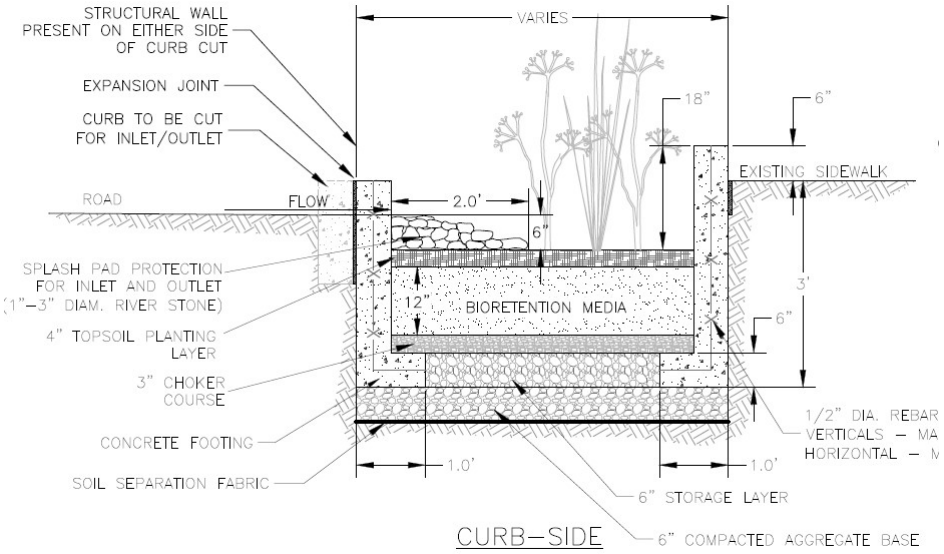
Benefits:

- Allows water to infiltrate into the ground

Stormwater Planters

Typically, 4 feet wide by 20 feet long





Vegetative System

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Water Resources Program

Stormwater Planter at the Brimm School in Camden, NJ

Vegetative System

Stormwater Planters at Community Garden in Camden, NJ

Vegetative System

Typical Planter

- 4 foot wide by 20 feet long x 6 inches deep = 40 cubic feet of storage
- For infiltration rate of 0.5 inches/hour, can manage 240 square feet of pavement for two-year design storm
- For infiltration rate of 1.0 inches/hour, can manage 320 square feet of pavement for two-year design storm
- For infiltration rate of 0.5 inches/hour, can manage 450 square feet of pavement for water quality design storm
- For infiltration rate of 1.0 inches/hour, can manage 500 square feet of pavement for water quality design storm
- Planters can be designed in series to overflow to each other
- Planters can be designed to feed underground stone storage detention

Rainwater Harvesting Systems: Cisterns/Rain Barrels

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

Rainwater Harvesting Sytems

How it works:

- Capture, diversion, and storage of rainwater

Benefits:

- Eliminates need for complex and costly distribution systems
- Provides additional water source
- Landscape irrigation
- Reduces flow to stormwater drains
- Reduces non-point source pollution
- Delays expansion of existing water treatment plants
- Reduces consumers' utility bills

Harvesting System

Sizing

- The rule of thumb is 600 gallons of water per inch of rain per thousand square feet of catchment area.
- Not all the rain that falls can actually be collected. Efficiency is usually presumed to be 75% depending on system design and capacity.

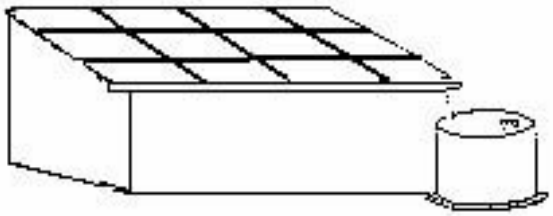
Sizing Formula

Here is the basic formula for calculating the potential amount that can be collected:

$$\frac{\textit{(Catchment area) x (inches of rain) x (600 gallons) x (.75)}}{\textit{1000 square feet}}$$

Design Example

The sample roof shown below has a catchment area that is 40 feet wide and 30 feet long. Hence, it has a 1,200 square feet roof (40 feet wide x 30 feet long). Assume that it rains 2 inches. We can now plug this information into our general formula (see equation above).



Catchment Area = 1,200 square feet

Amount of Rain = 2 inches

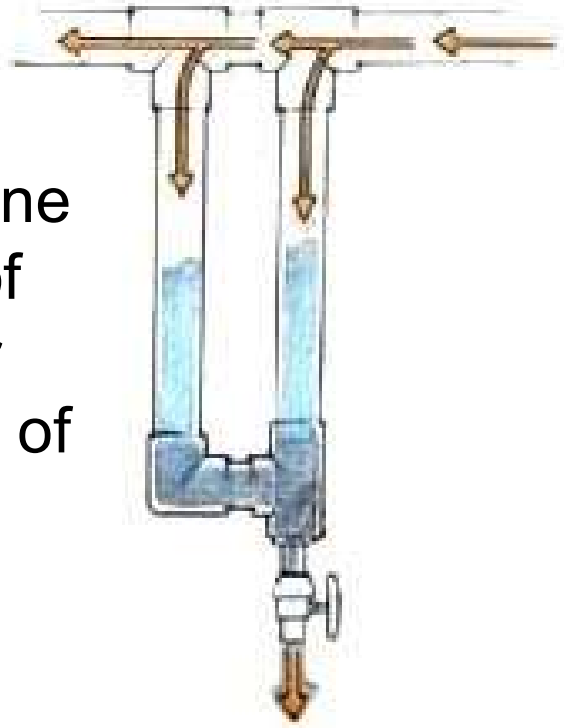
Gallons of water collected per inch of rain per 1000 sq.ft. = 600 gallons

Percent Efficiency = 75% or .75

$$\frac{(1{,}200 \text{ sq.ft.}) \times (2 \text{ inches of rain}) \times (600 \text{ gal}) \times (.75)}{1000 \text{ square feet}} = 1080 \text{ gal}$$

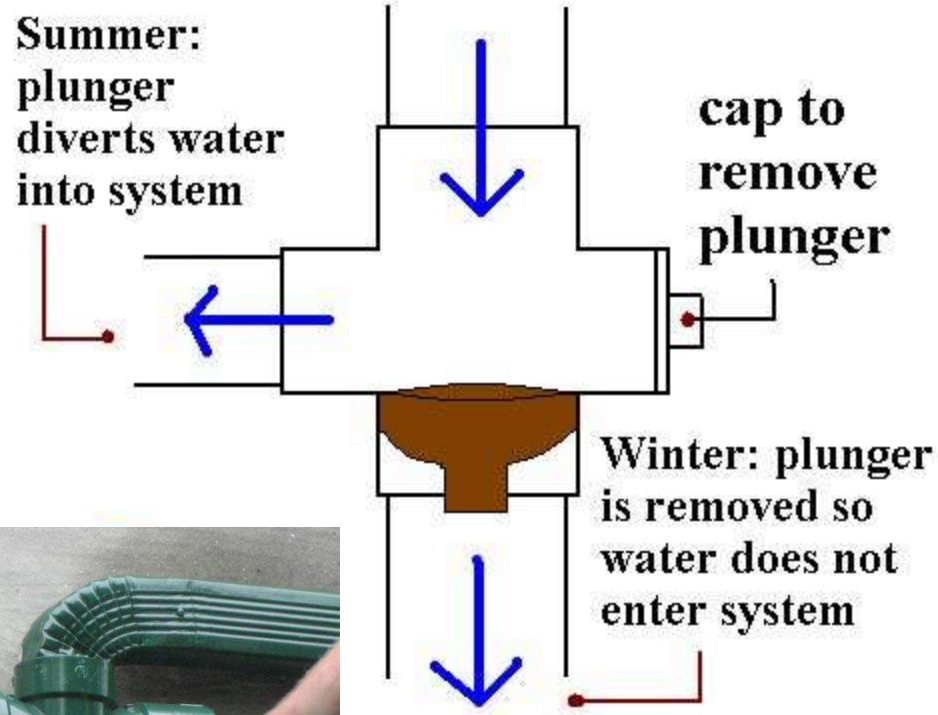
First Flush Diverter or Roof Washer

The rule of thumb is one to two gallons of roof washer capacity for every 100 square feet of catchment area.



- A one foot length of 6 inch diameter PVC pipe holds 1.5 gallons.
- A one foot length of 4 inch diameter PVC pipe holds 0.66 gallons.

Diverting Rainwater to Cistern



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Cistern at the Neighborhood Center in Camden, NJ

Harvesting System

Cistern at St. Bartholomew's Church in Camden, NJ

Harvesting System

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Cistern at Front Street Community Garden in Camden, NJ

Harvesting System

Downspout Planters

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

Downspout Planter: Harvesting System

How it works:

- Constructed boxes placed against buildings
- Contains stone/gravel topped with sandy compost mixture and plants
- Designed with underdrain and overflows
- Disconnects downspouts

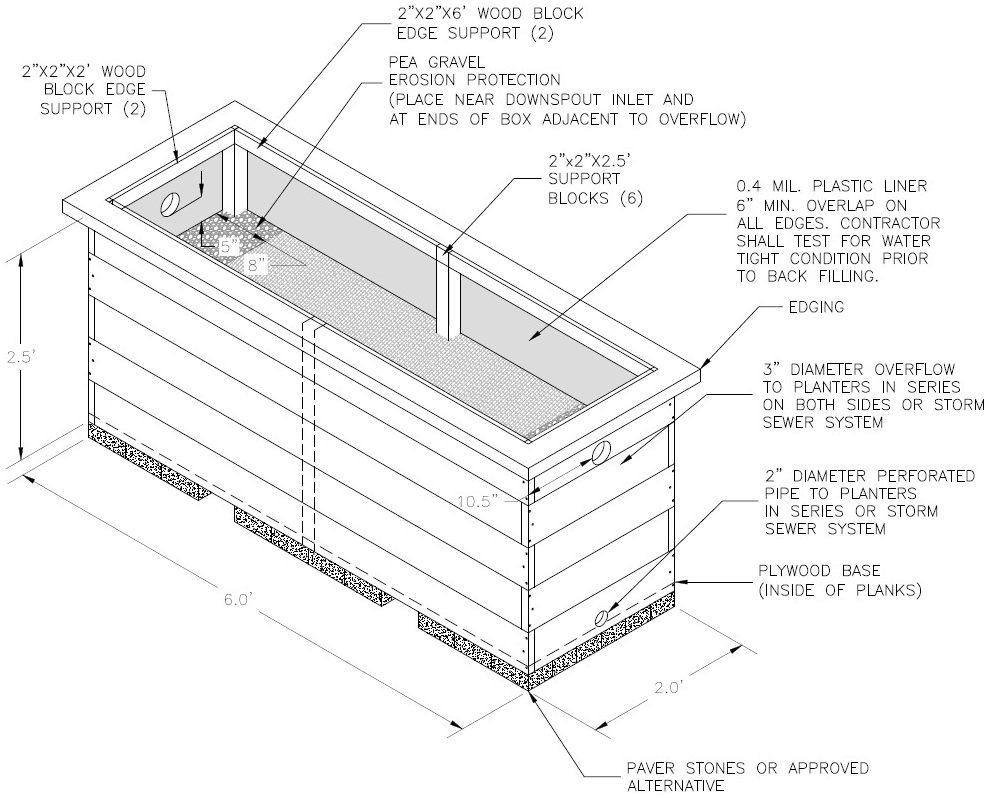
Benefits:

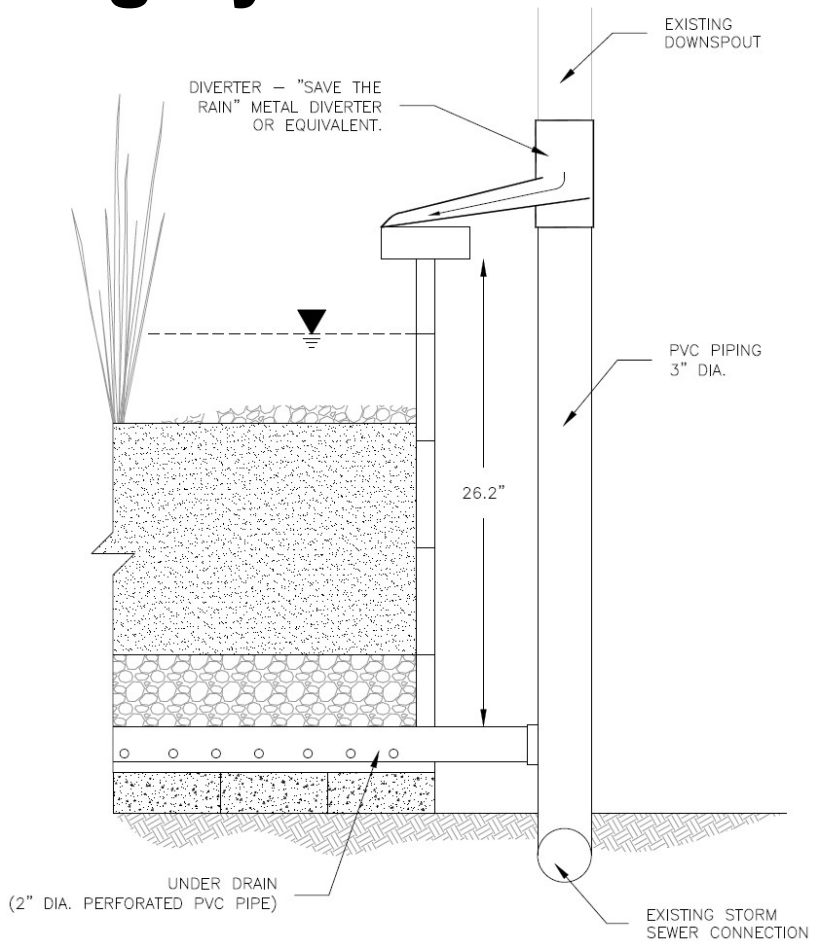
- Aesthetics
- Provide some rainfall storage

Design Parameters for Downspout Planters:

- Planter box must be adequately reinforced to hold soil, stone, and plants
- Limited capacity for stormwater retention – mostly infiltration
- Soil infiltration rate is 5.0 inches per hour
- Underdrains are installed to drain the water after the storm event

Downspout Planter: Harvesting System





Harvesting System

Downspout Planter Boxes at Acelero Learning Center in Camden, NJ

Harvesting System

Downspout Planter Boxes at Davis School in Camden, NJ

Harvesting System

Stormwater Tree Pits/Street Trees



Pre-manufactured concrete boxes or enhanced tree pits that contain a special soil mix and are planted with a tree or shrub. They filter stormwater runoff and provide limited storage capacity.

Storage System

Stormwater Tree Pits/Street Trees

How it works:

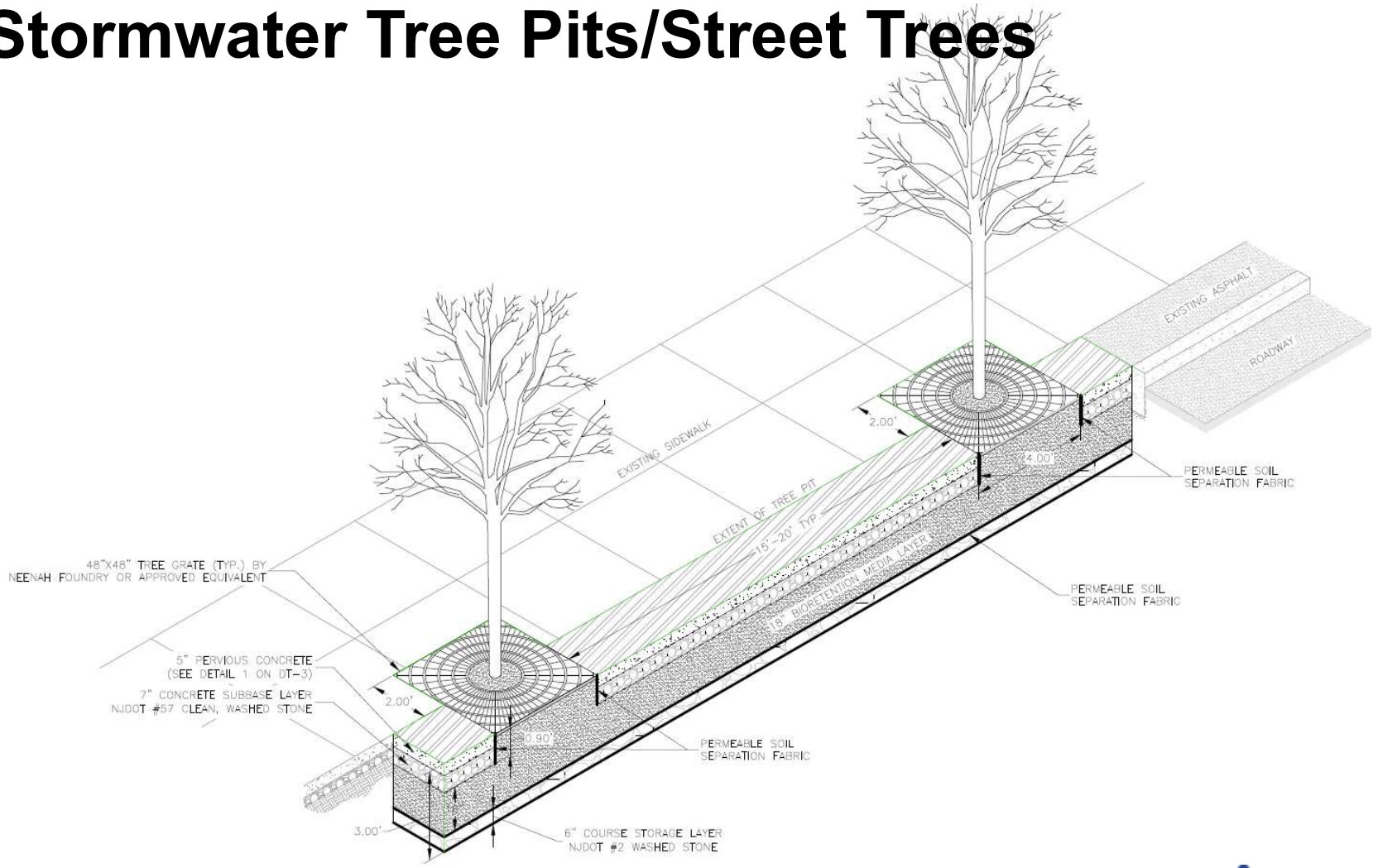
- Pervious concrete is installed to act as an additional storage system to increase the stormwater capacity treated by the system.
- Systems with low infiltration rates due to soil composition are often designed with an underdrain system to discharge the water.
- This system is often designed with conventional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

Benefits:

- Improved aesthetics
- Healthier trees
- Reduced heat island effect

Storage System

Stormwater Tree Pits/Street Trees



Storage System

Pervious Pavements

These surfaces include pervious concrete, porous asphalt, interlocking concrete pavers, and grid pavers. These materials allow water to quickly pass through the material into an underlying layered system of stone that holds the water, allowing it to infiltrate into the underlying uncompacted soil.

Pervious Pavement

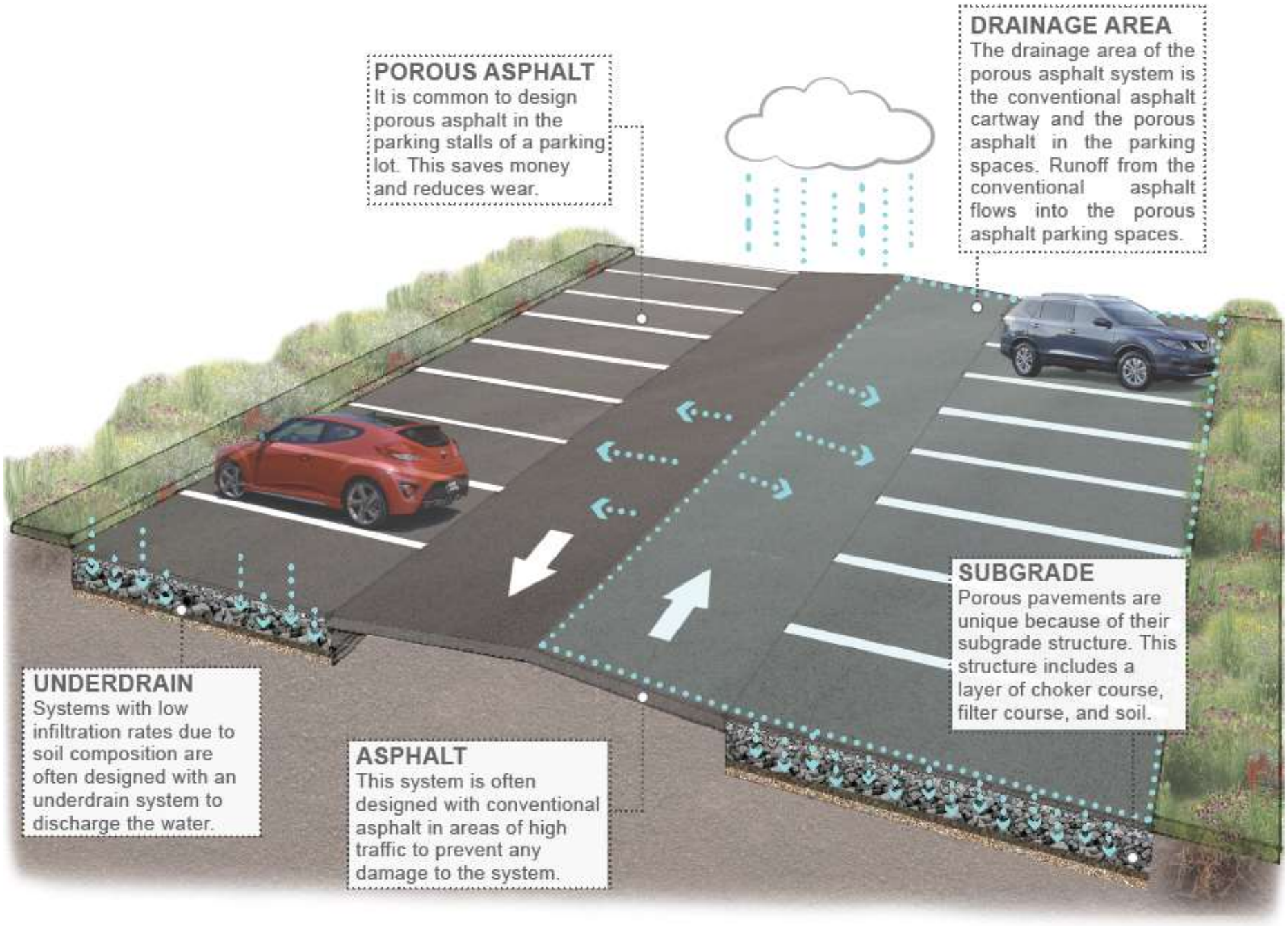
How it works:

- Underlying stone reservoir
- Porous asphalt and pervious concrete are manufactured without "fine" materials to allow infiltration
- Grass pavers are concrete interlocking blocks with open areas
- Ideal application for porous pavement is to treat a low traffic or overflow parking area

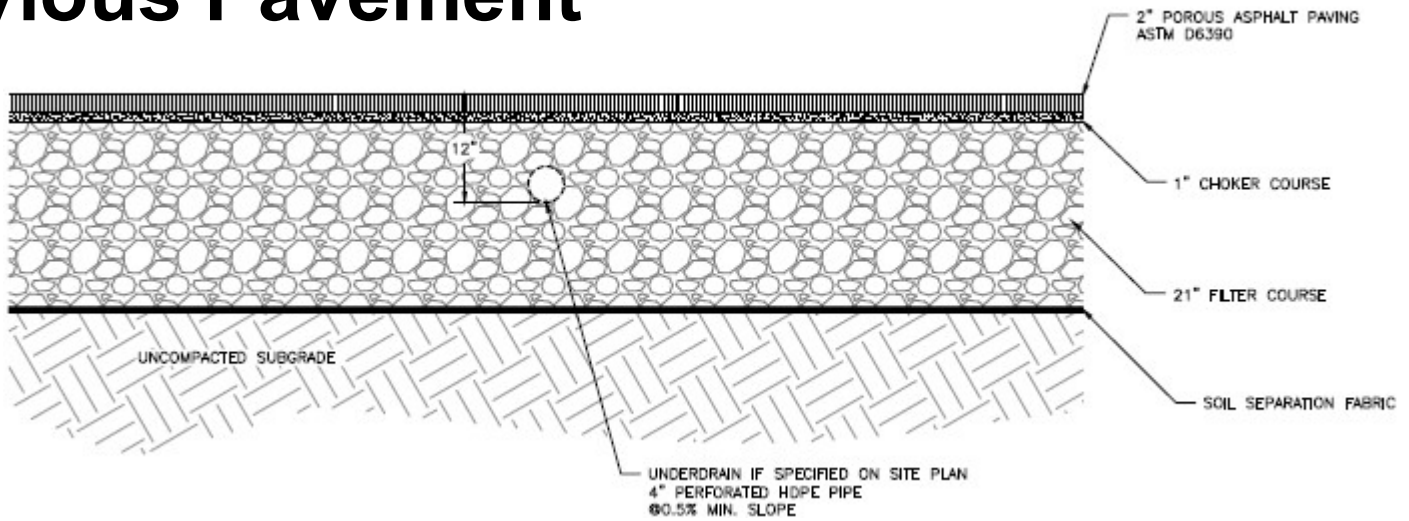
Benefits:

- Manage stormwater runoff, minimize site disturbance, promote groundwater recharge
- Low life cycle costs, alternative to costly traditional stormwater management methods
- Contaminant removal as water moves through layers of system
- Allows runoff to flow through the surface to an underlying storage layer

Storage System


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

Pervious Pavement



Storage System

Porous Pavement (Asphalt) at Yorkship School in Camden, NJ

Storage System

Porous Pavement (Concrete) at Wiggins School in Camden, NJ

Storage System

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Questions?

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