

# Green Infrastructure Champion Training: Part 5 *“How To Design and Build a Rain Garden”*”

April 15, 2019  
Rutgers EcoComplex  
Bordentown, NJ



**RUTGERS**  
New Jersey Agricultural  
Experiment Station



# Rutgers Cooperative Extension

Rutgers Cooperative Extension (RCE) helps the diverse population of New Jersey adapt to a rapidly changing society and improves their lives through an educational process that uses science-based knowledge.





# Water Resources Program

Our mission is to identify and address community water resources issues using sustainable and practical science-based solutions.





**Let's Talk  
About Rain**

# What's a 100-year storm?



# How often do we get the 100-year storm?

**Annual probability (%) = 100/recurrence interval (yrs)**

100-year storm =  $100/100 = 1\%$

10-year storm =  $100/10 = 10\%$

2-year storm =  $100/2 = 50\%$



# NEW JERSEY 24 HOUR RAINFALL FREQUENCY DATA

## Rainfall Amounts in Inches

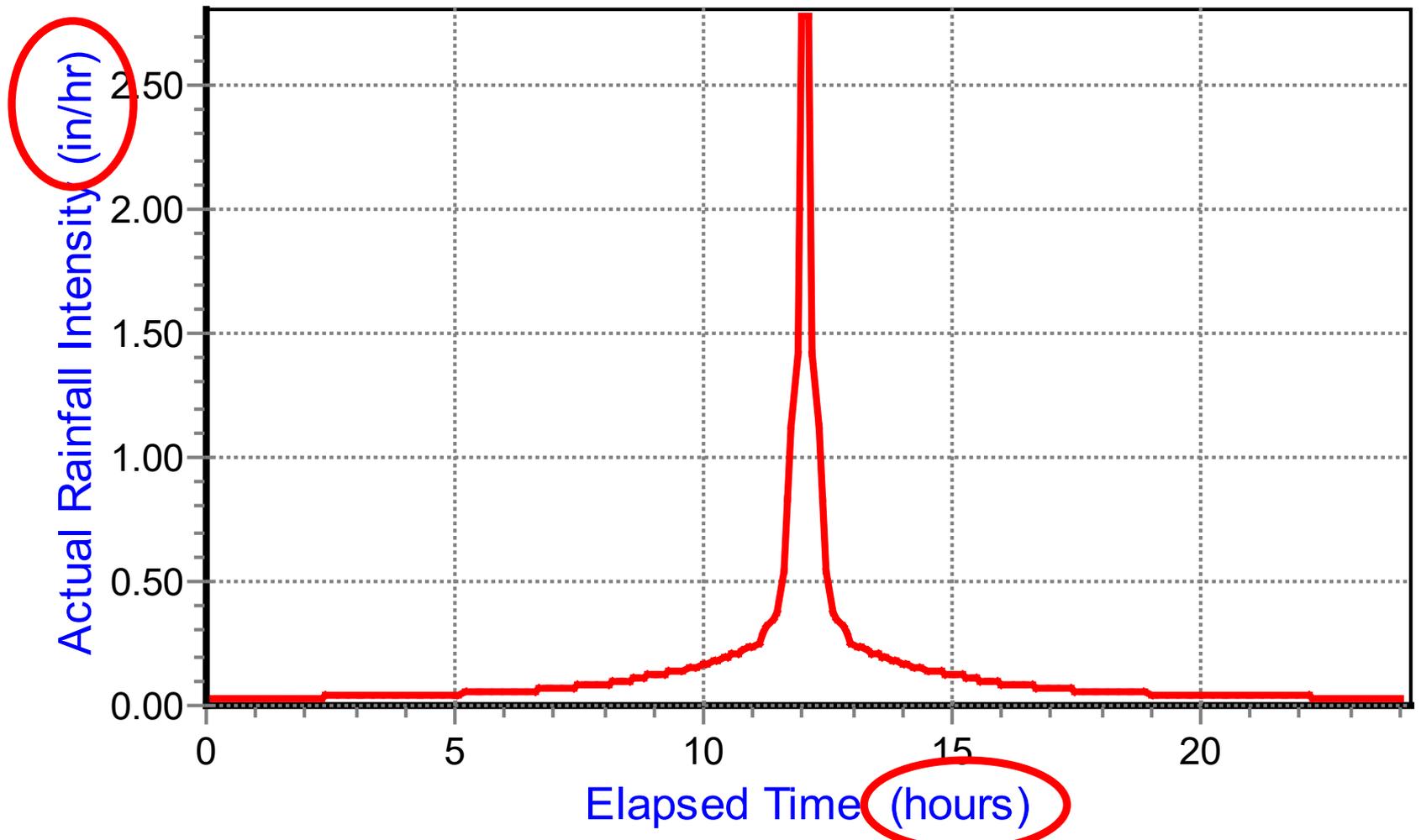
County	1 year	2 year	5 year	10 year	25 year	50 year	100 year
Atlantic	2.8	3.3	4.3	5.2	6.5	7.6	8.9
Bergen	2.8	3.3	4.3	5.1	6.3	7.3	8.4
Burlington	2.8	3.4	4.3	5.2	6.4	7.6	8.8
Camden	2.8	3.3	4.3	5.1	6.3	7.3	8.5
Cape May	2.8	3.3	4.2	5.1	6.4	7.5	8.8
Cumberland	2.8	3.3	4.2	5.1	6.4	7.5	8.8
Essex	2.8	3.4	4.4	5.2	6.4	7.5	8.7
Gloucester	2.8	3.3	4.2	5.0	6.2	7.3	8.5
Hudson	2.7	3.3	4.2	5.0	6.2	7.2	8.3
Hunterdon	2.9	3.4	4.3	5.0	6.1	7.0	8.0
Mercer	2.8	3.3	4.2	5.0	6.2	7.2	8.3
Middlesex	2.8	3.3	4.3	5.1	6.4	7.4	8.6
Monmouth	2.9	3.4	4.4	5.2	6.5	7.7	8.9
Morris	3.0	3.5	4.5	5.2	6.3	7.3	8.3
Ocean	3.0	3.4	4.5	5.4	6.7	7.9	9.2
Passaic	3.0	3.5	4.4	5.3	6.5	7.5	8.7
Salem	2.8	3.3	4.2	5.0	6.2	7.3	8.5
Somerset	2.8	3.3	4.3	5.0	6.2	7.2	8.2
Sussex	2.7	3.2	4.0	4.7	5.7	6.6	7.6
Union	2.8	3.4	4.4	5.2	6.4	7.5	8.7
Warren	2.8	3.3	4.2	4.9	5.9	6.8	7.8



**What is the  
NJ Water  
Quality Storm?**

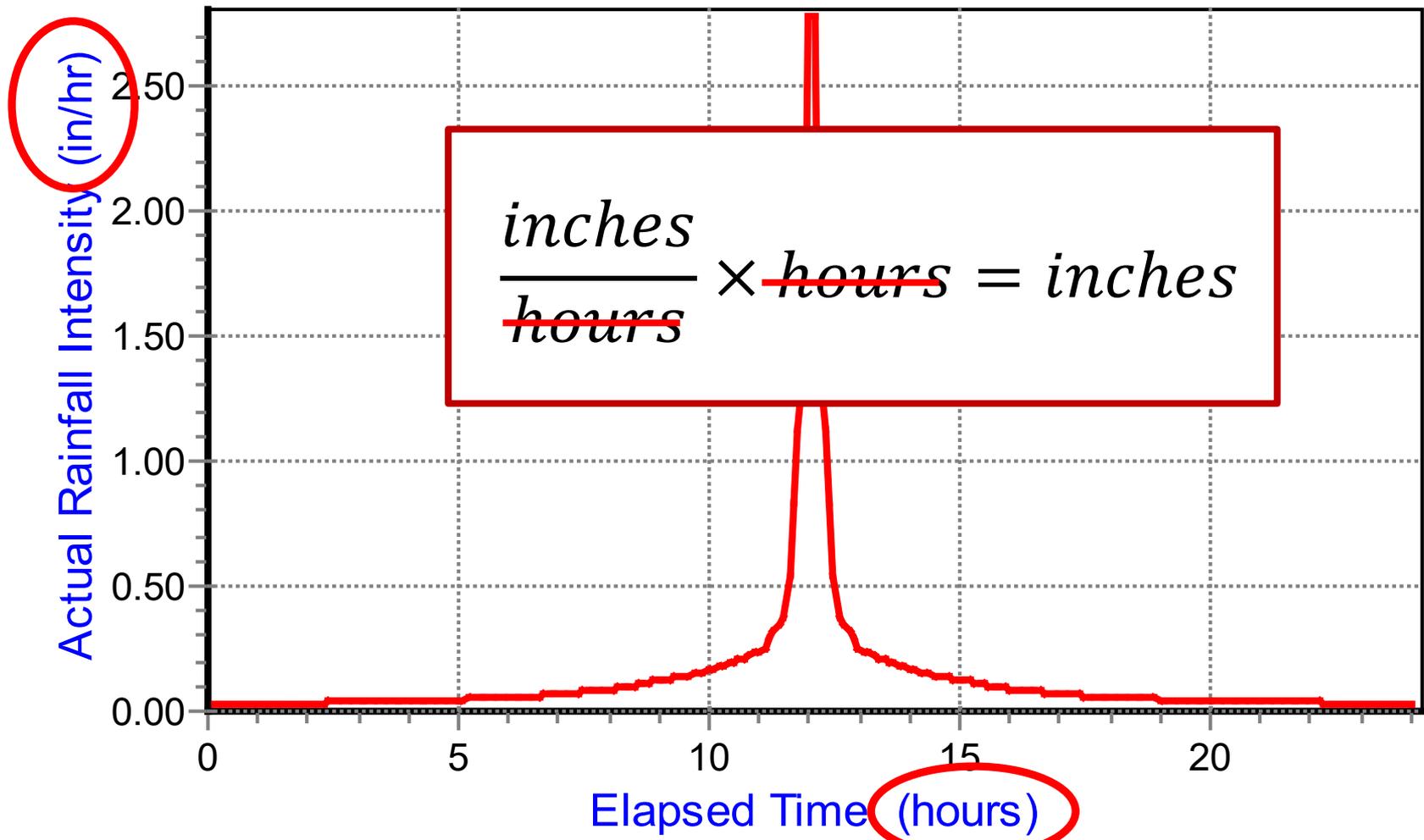
# New Jersey Water Quality Storm = 1.25 inches of rain over two-hours

Rainfall Intensity vs. Time



# New Jersey Water Quality Storm = 1.25 inches of rain over two-hours

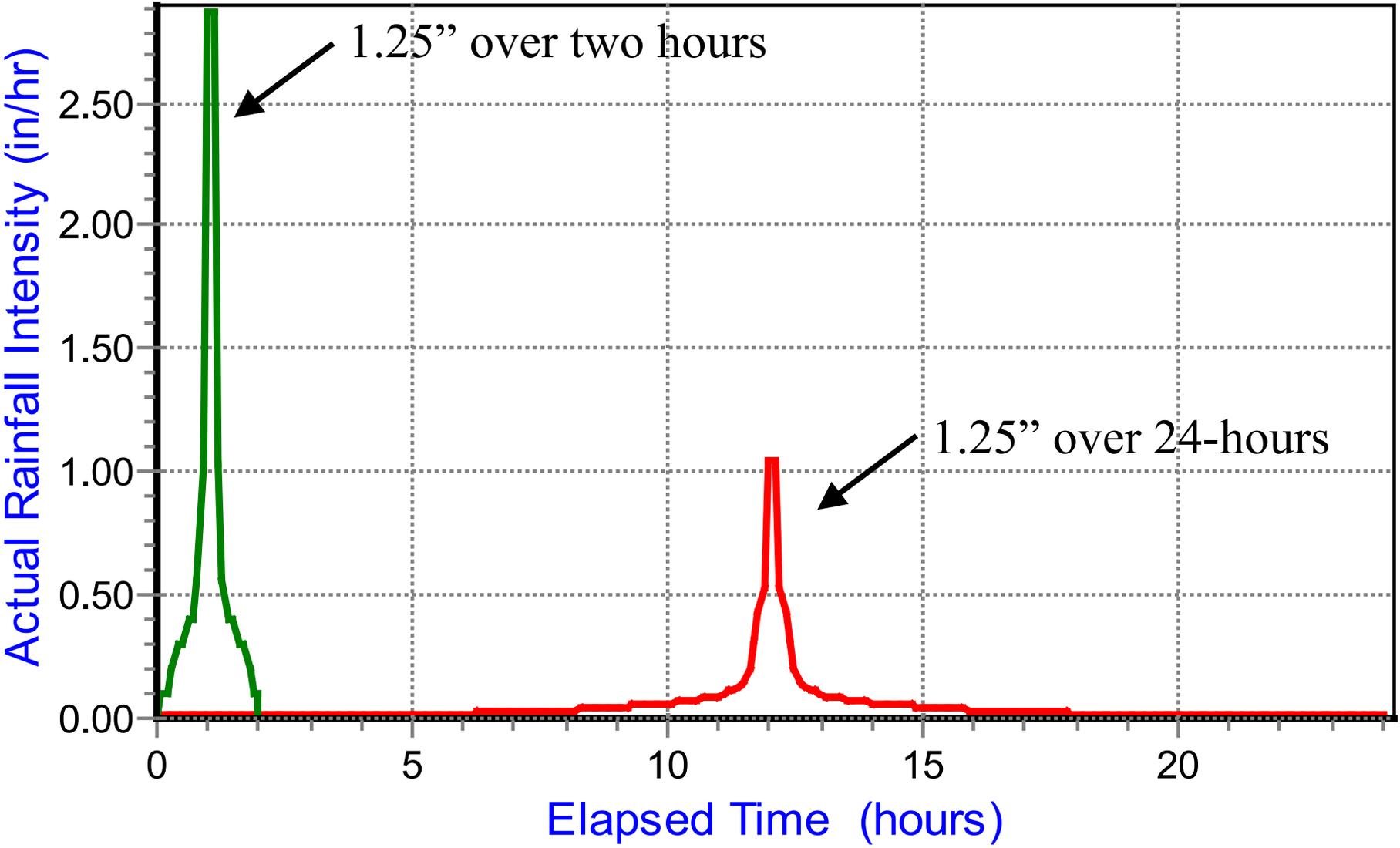
Rainfall Intensity vs. Time



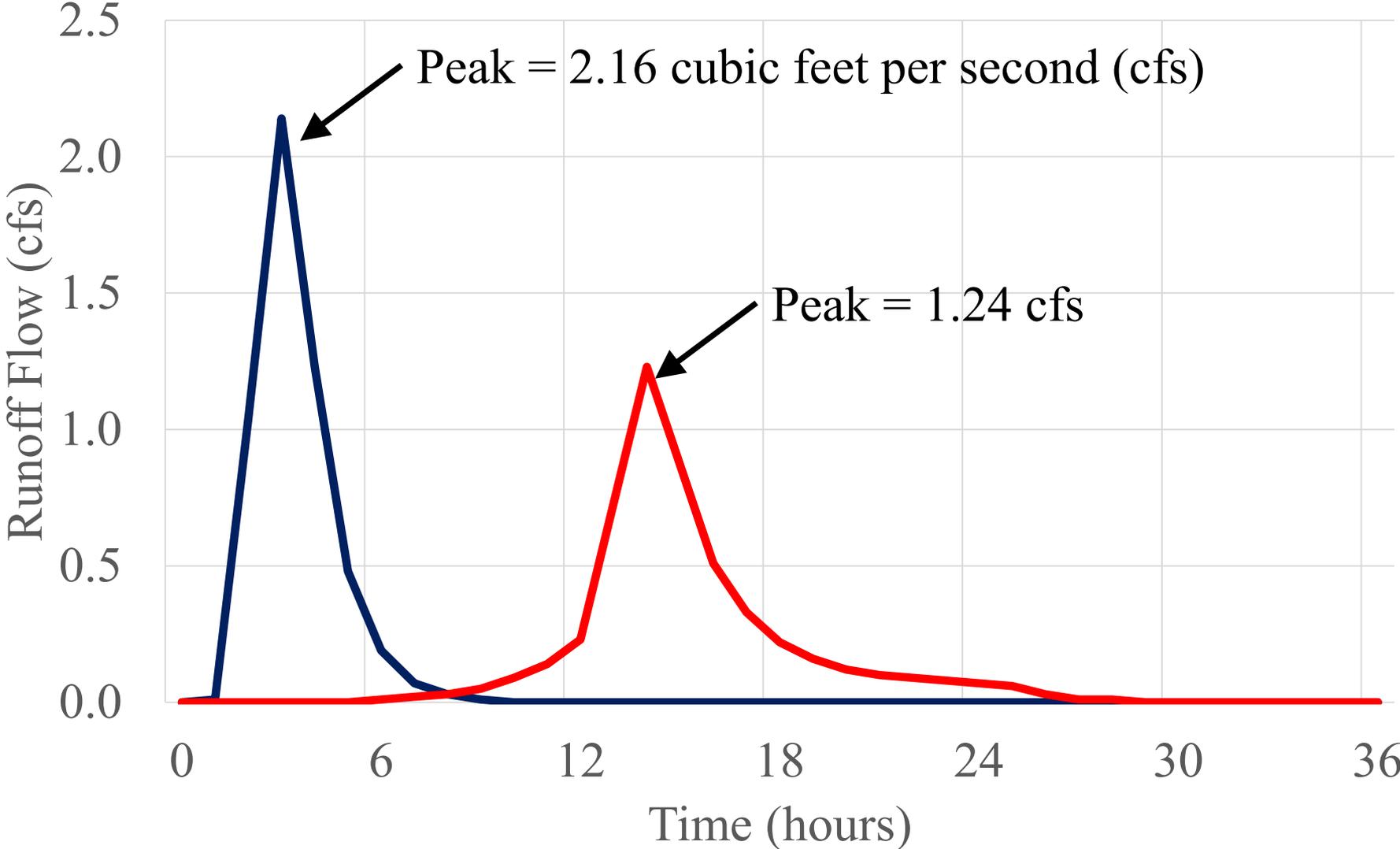
# Characteristics of Rainfall and Drainage Area Can Influence Runoff

#1. High intensity rainfall will generally produce a greater peak discharge than a rainfall that occurs over a longer time period

# Rainfall Intensity vs. Time



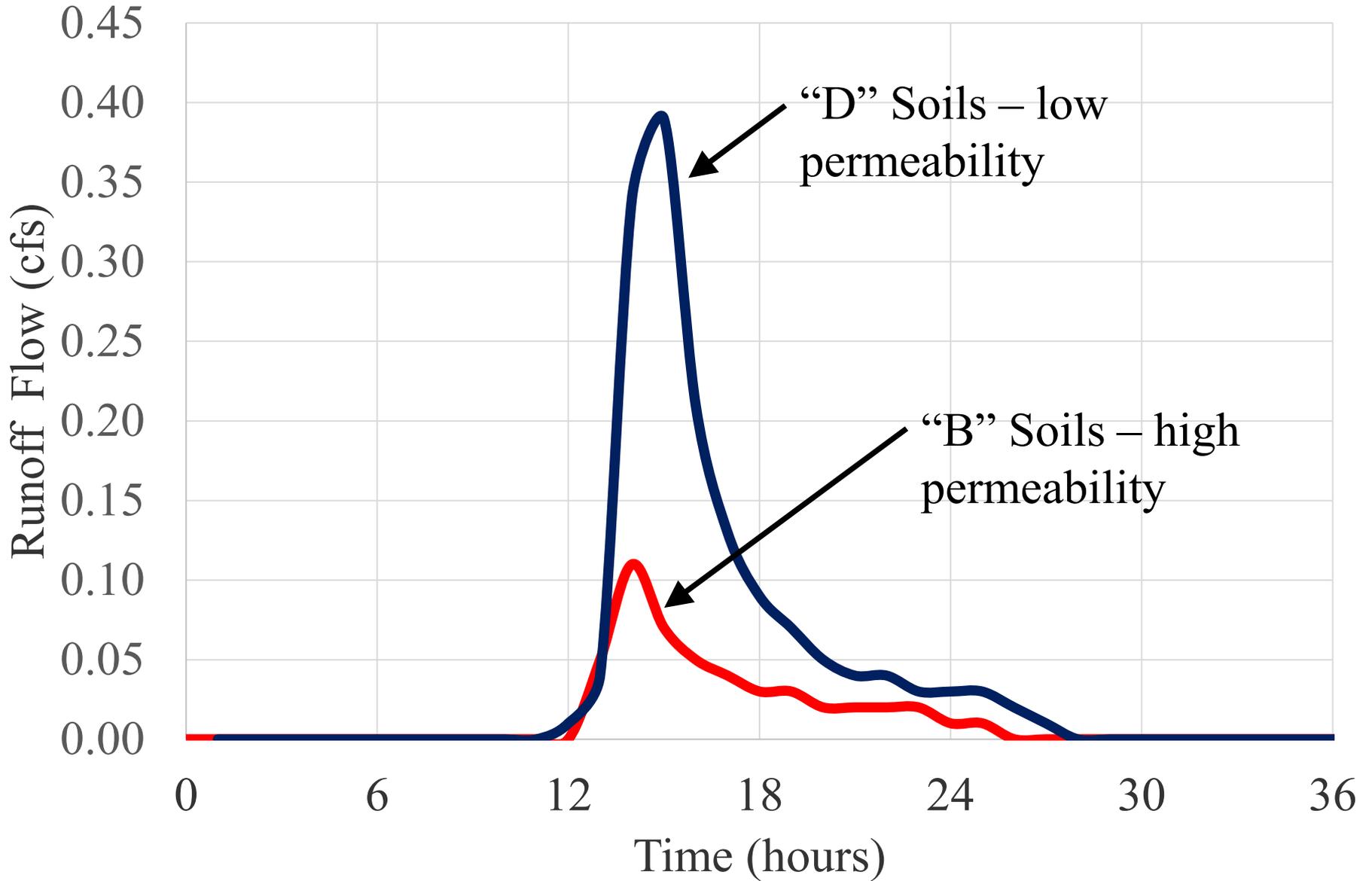
# Hydrographs for a Two-hour vs 24-hour Storm for Parking Lot



# Characteristics of Rainfall and Drainage Area Can Influence Runoff

#2. Highly permeable soils that can rapidly infiltrate rainfall generally produce less runoff volume than soils with more restrictive infiltration

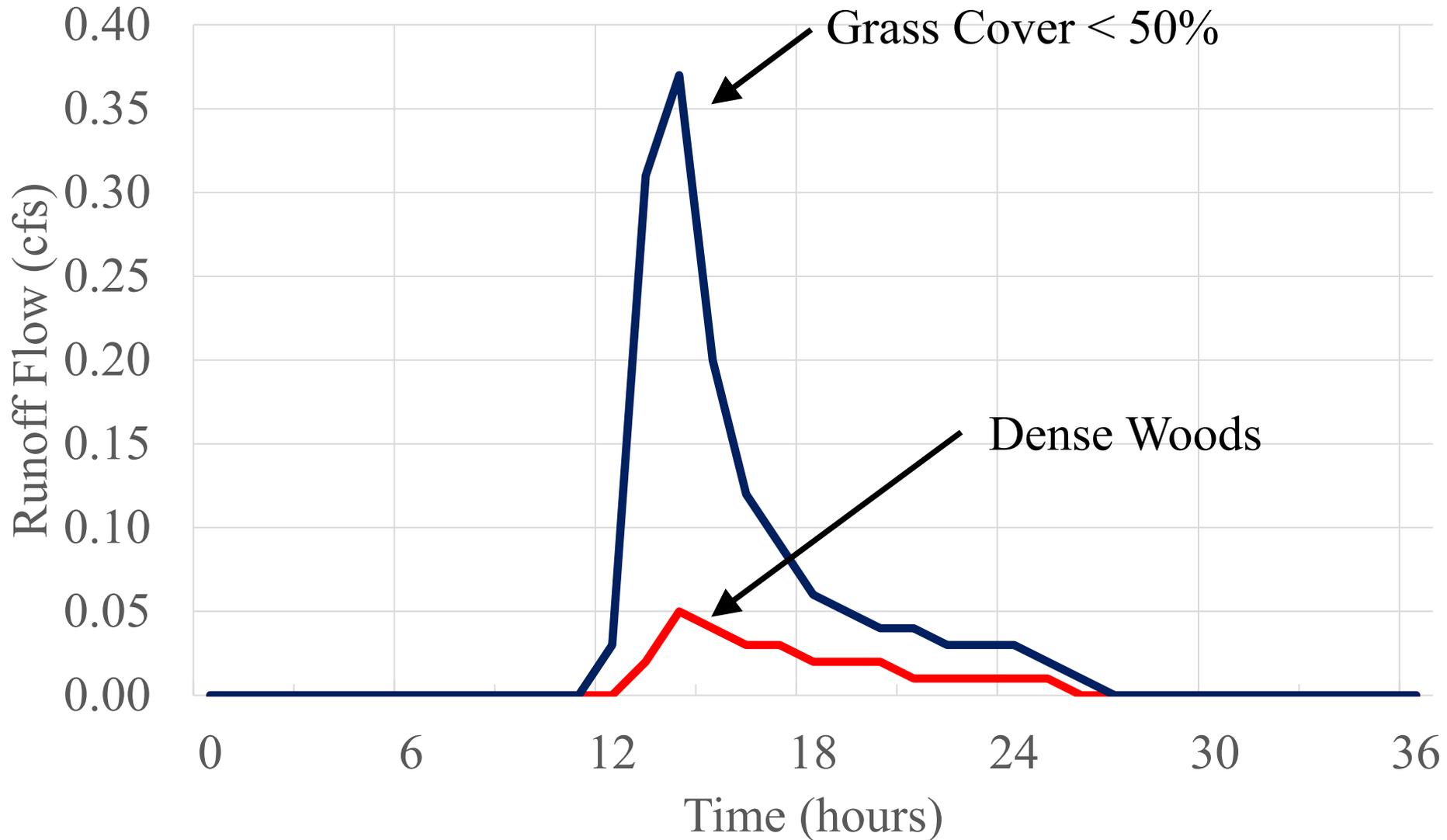
# Hydrographs for Soil Type B vs. Soil Type D



# **Characteristics of Rainfall and Drainage Area Can Influence Runoff**

#3. Dense vegetation such as woodland intercepts and help infiltrates rainfall, thereby reducing runoff volumes and rates

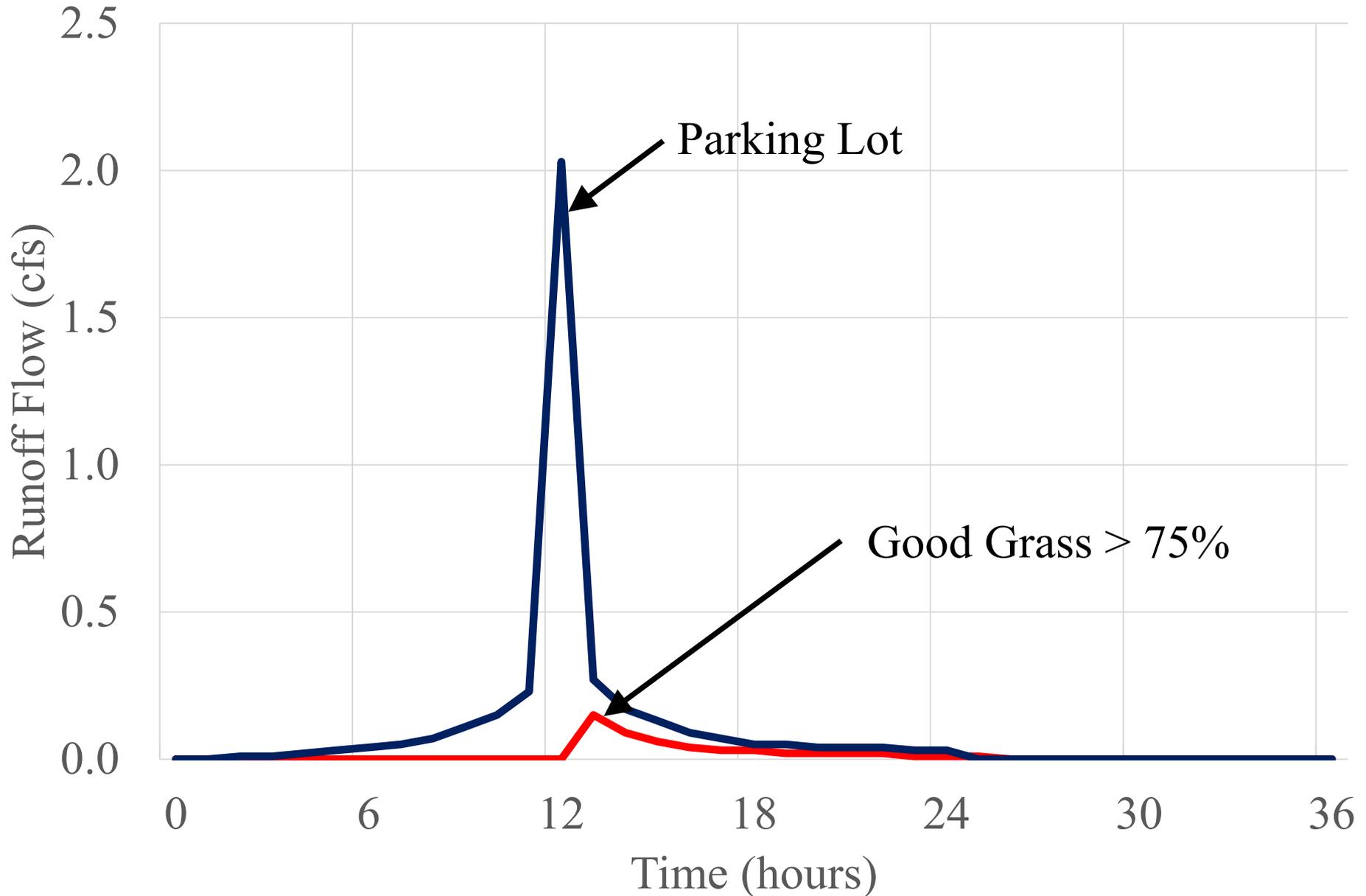
# Hydrographs for Dense Vegetation vs. Less Dense Vegetation



# Characteristics of Rainfall and Drainage Area Can Influence Runoff

#4. Conversely, impervious areas such as roadways and rooftops prevent infiltration and increase runoff volumes and rates

# Hydrographs for Good Grass vs. Parking Lot

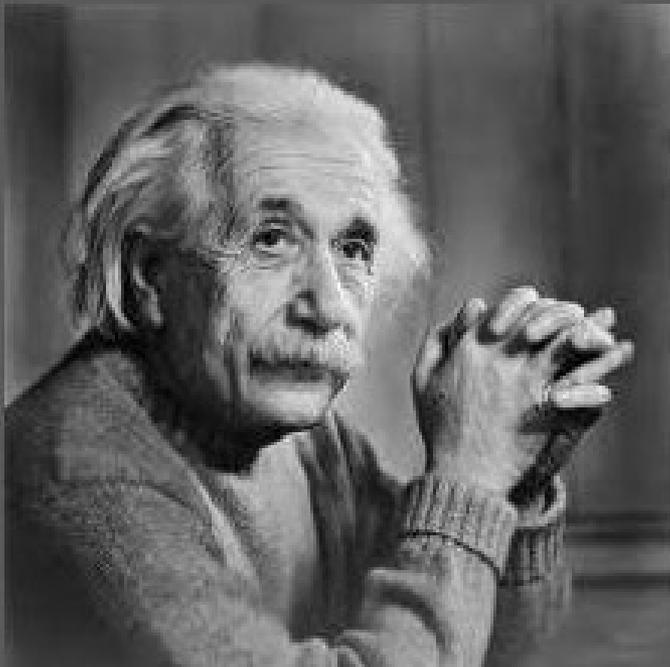


**WHY? WHY? WHY?**

# Fixing the Problem

- Enforcing existing environmental regulations will limit the impact from new development
- The U.S. Farm Bill and Natural Resources Conservation Service (NRCS) will help farmers reduce their environmental impact
- We must focus on retrofit existing development with stormwater management practices

**Albert Einstein** was not a believer in excuses; "Man must cease attributing his problems to his environment, and learn again to exercise his will - his personal responsibility."

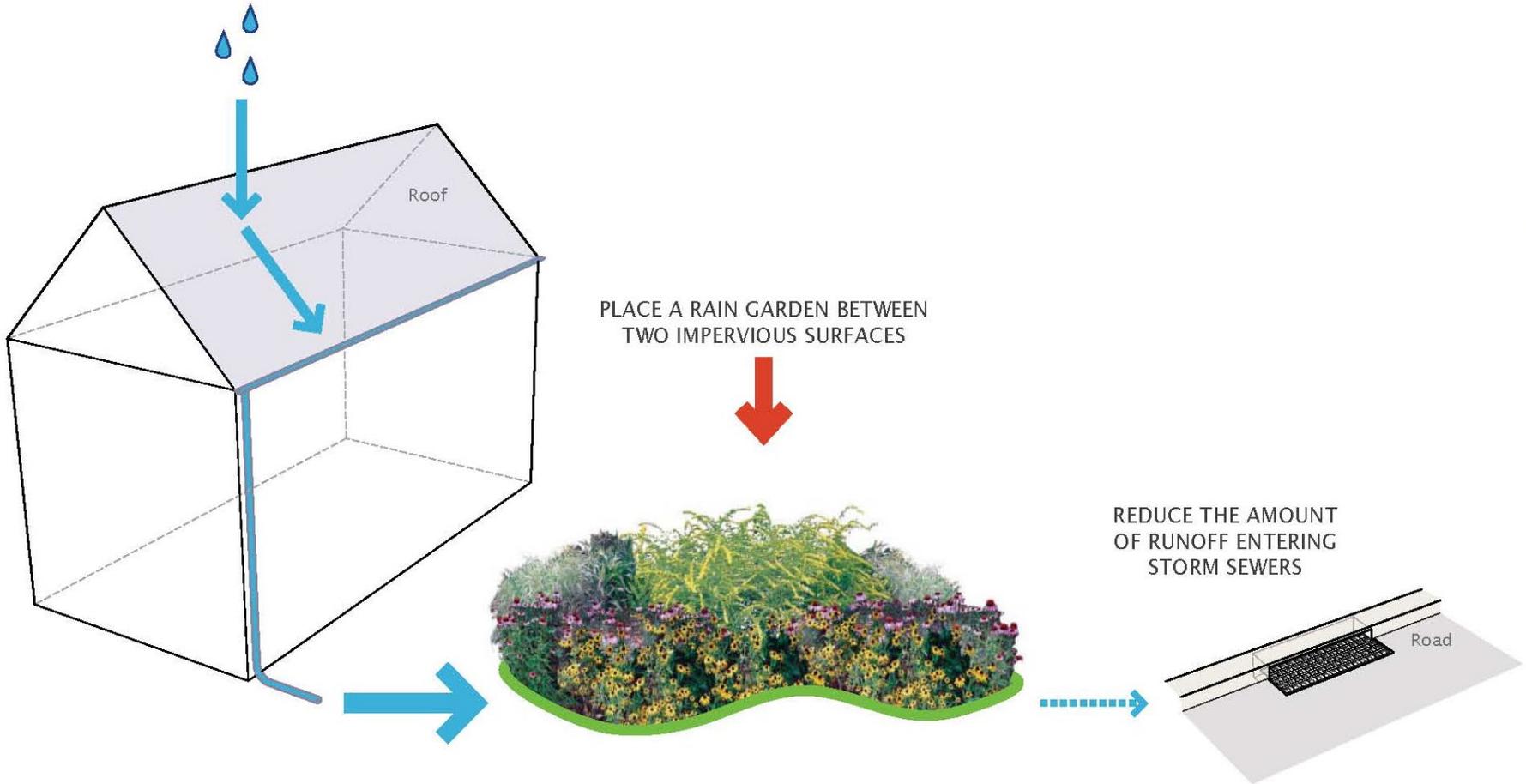


President **Barack Obama** called on all American citizens with; "Change will not come if we wait for some other person or some other time. We are the ones we've been waiting for. We are the change that we seek."

# Connected or Disconnected?



# The Solution...



# Rain Gardens

A rain garden is a landscaped, shallow depression that is designed to capture, treat, and infiltrate stormwater at the source before it becomes runoff.













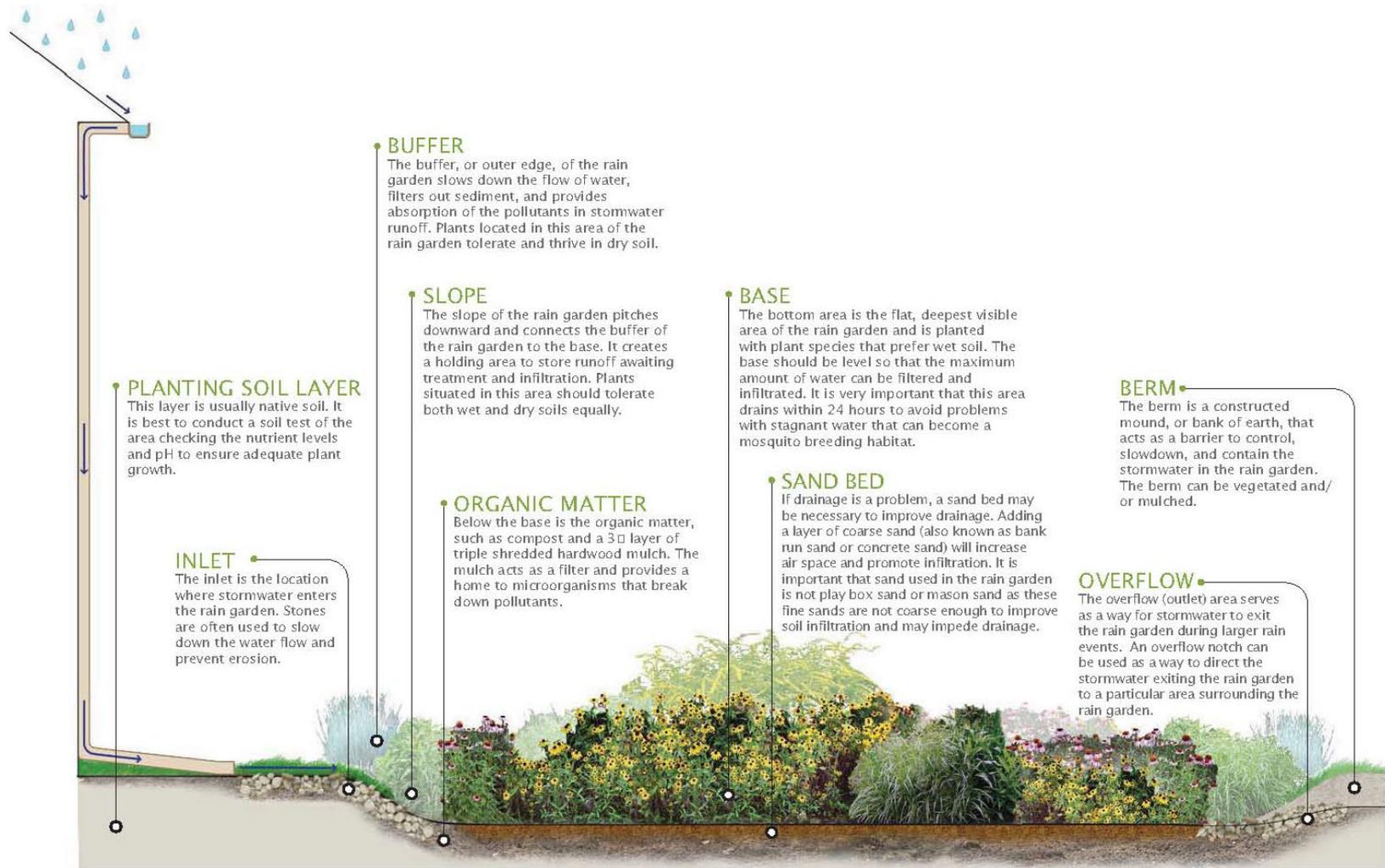
116



Blue Cornflower  
Centaurea cyanus  
Native to Europe  
and Asia  
Grows in open, sunny  
places  
in grassy fields  
and meadows  
in the  
mountain regions  
of Europe  
and Asia  
in the  
mountain regions  
of Europe  
and Asia



# PARTS OF A RAIN GARDEN



# 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.

# Bioretention Systems / Rain Gardens

## Benefits:

Removes nonpoint source pollutants from stormwater runoff while recharging groundwater

Restore/“mimic” predevelopment site hydrology

- Infiltration
- Evapotranspiration

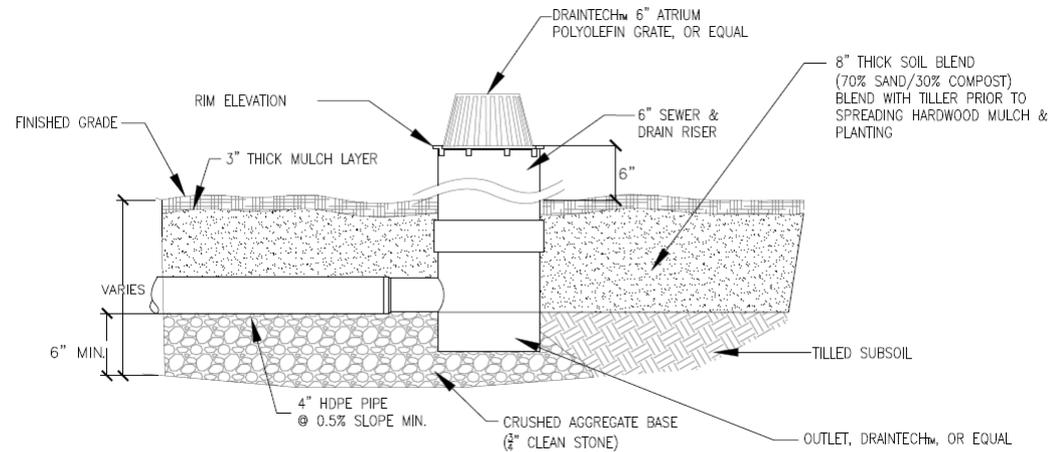
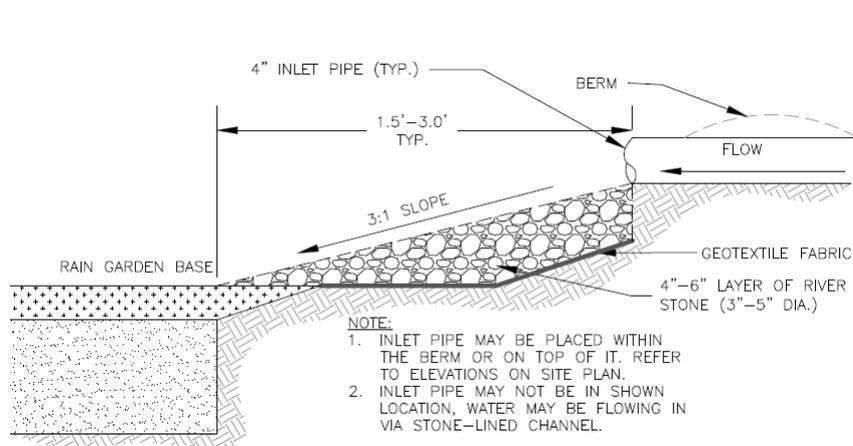
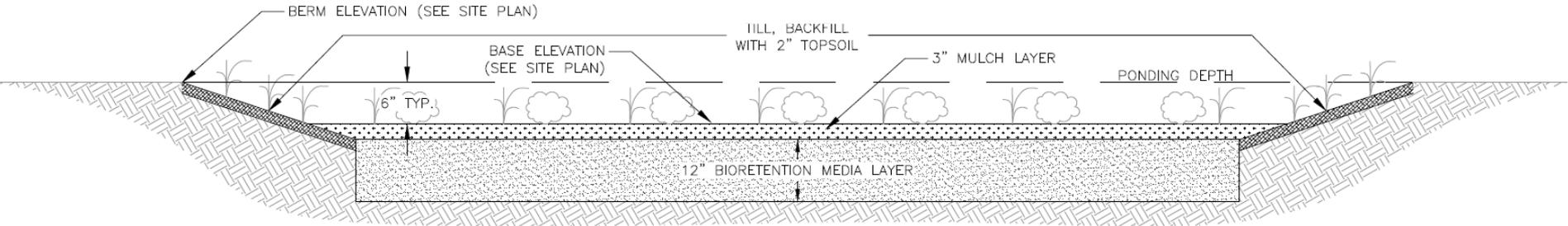
Improve water quality

- Sedimentation, filtration, & plant uptake
- Microbial Activity

Add aesthetic value

- Plant selection

# Bioretention Systems / Rain Gardens



# Design Parameters:

- 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)

# Design Parameters:

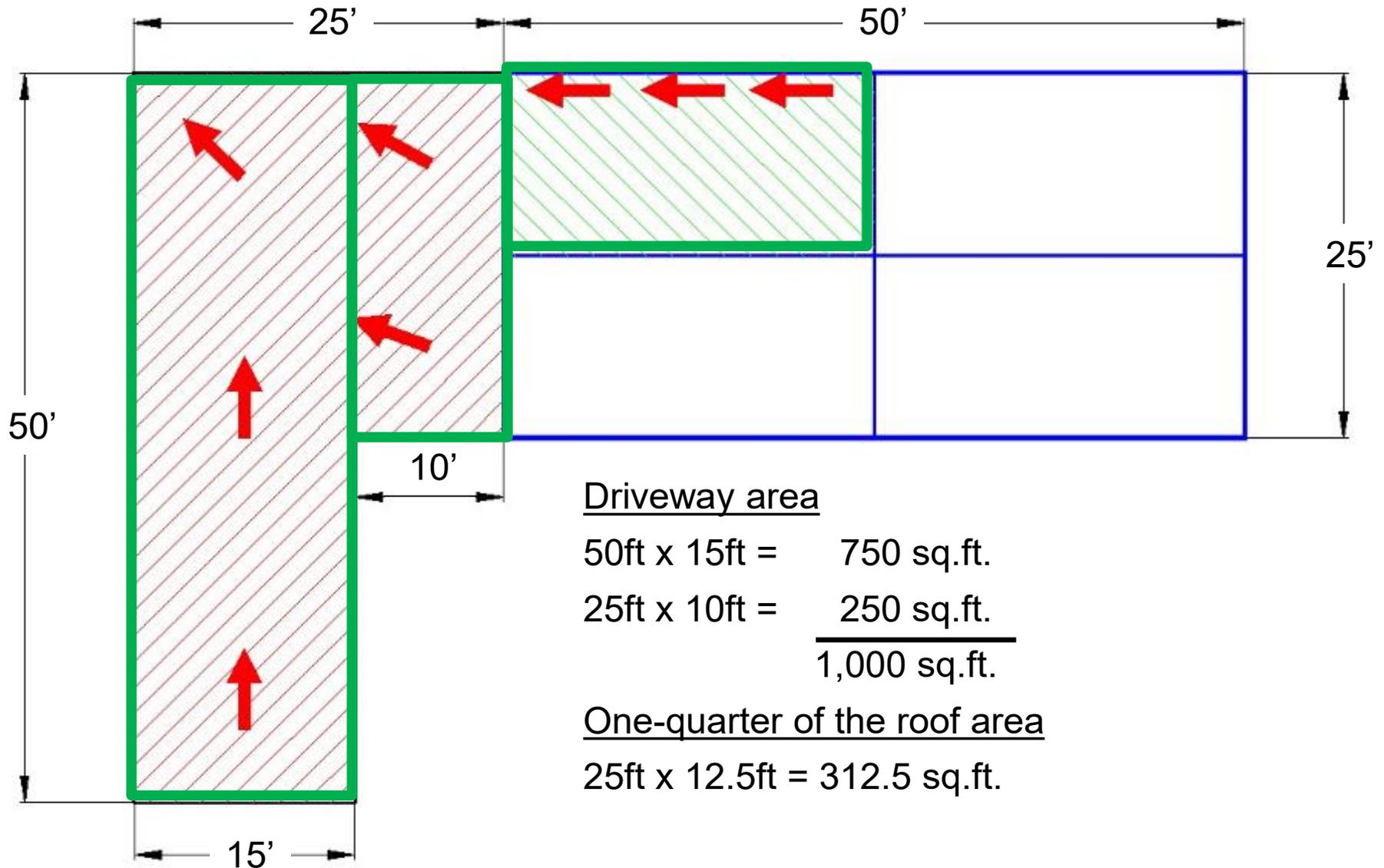
- Minimum infiltration rate of 0.5 inches per hour and maximum infiltration rate of 10 inches per hour
- If infiltration rate unknown or less than 0.5 inches per hour, design with underdrain and test at time of construction
- Amend soil with coarse sand and/or compost if necessary
- Include rain garden as part of drainage area

# Design Problem

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



# Design Example:



## Driveway area

$$50\text{ft} \times 15\text{ft} = 750 \text{ sq.ft.}$$

$$25\text{ft} \times 10\text{ft} = 250 \text{ sq.ft.}$$

$$\underline{1,000 \text{ sq.ft.}}$$

## One-quarter of the roof area

$$25\text{ft} \times 12.5\text{ft} = 312.5 \text{ sq.ft.}$$

# 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 (or 0.5 feet) deep
- 125 cubic feet  $\div$  0.5 feet = 250 square feet

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
- $1,250 \text{ sq. ft.} \times 0.125 \text{ ft.} = 156 \text{ cubic feet of water for the design storm}$
- Let's design a rain garden that is 6 inches (or 0.5 feet) deep
- $156 \text{ cubic feet} \div 0.5 \text{ feet} = 312 \text{ square feet}$

Answer:

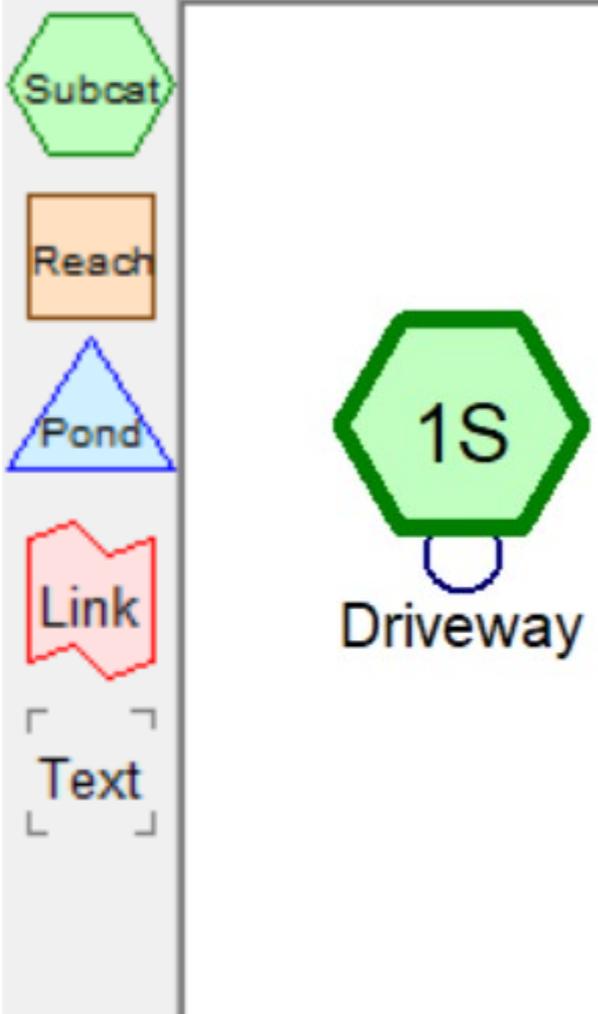
10 ft wide x 31.2 ft long = 312 square feet

# HydroCAD<sup>®</sup>

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<https://hydrocad.net/>



**Edit Subcat 1S - GI\_ChampionsExample**

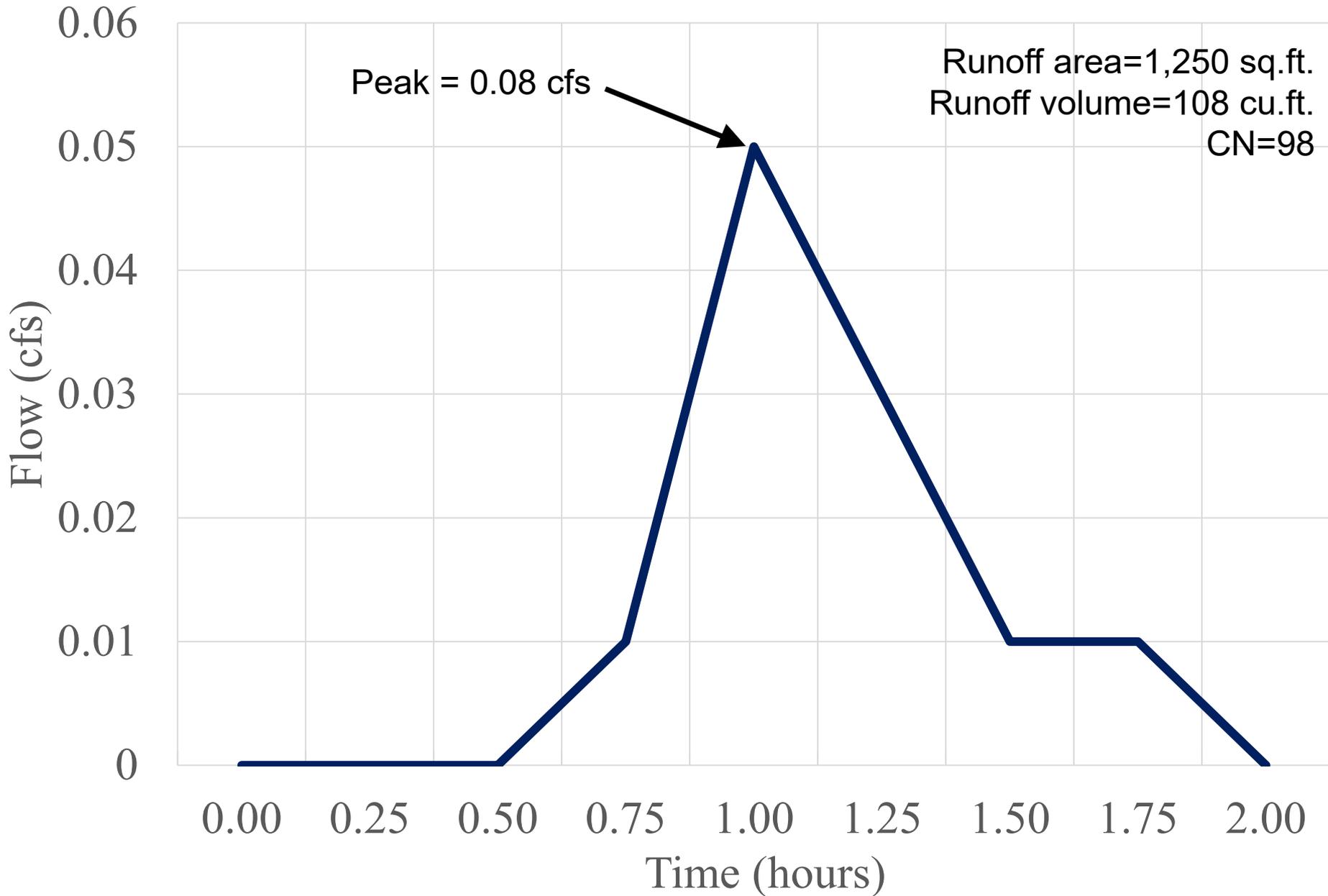
General | **Area** | Tc | Notes

Line	Area (sq-ft)	CN	Description
1	1,250	98	Paved parking, HSG C
2			
3			
4			
5			
6			
7			
8			

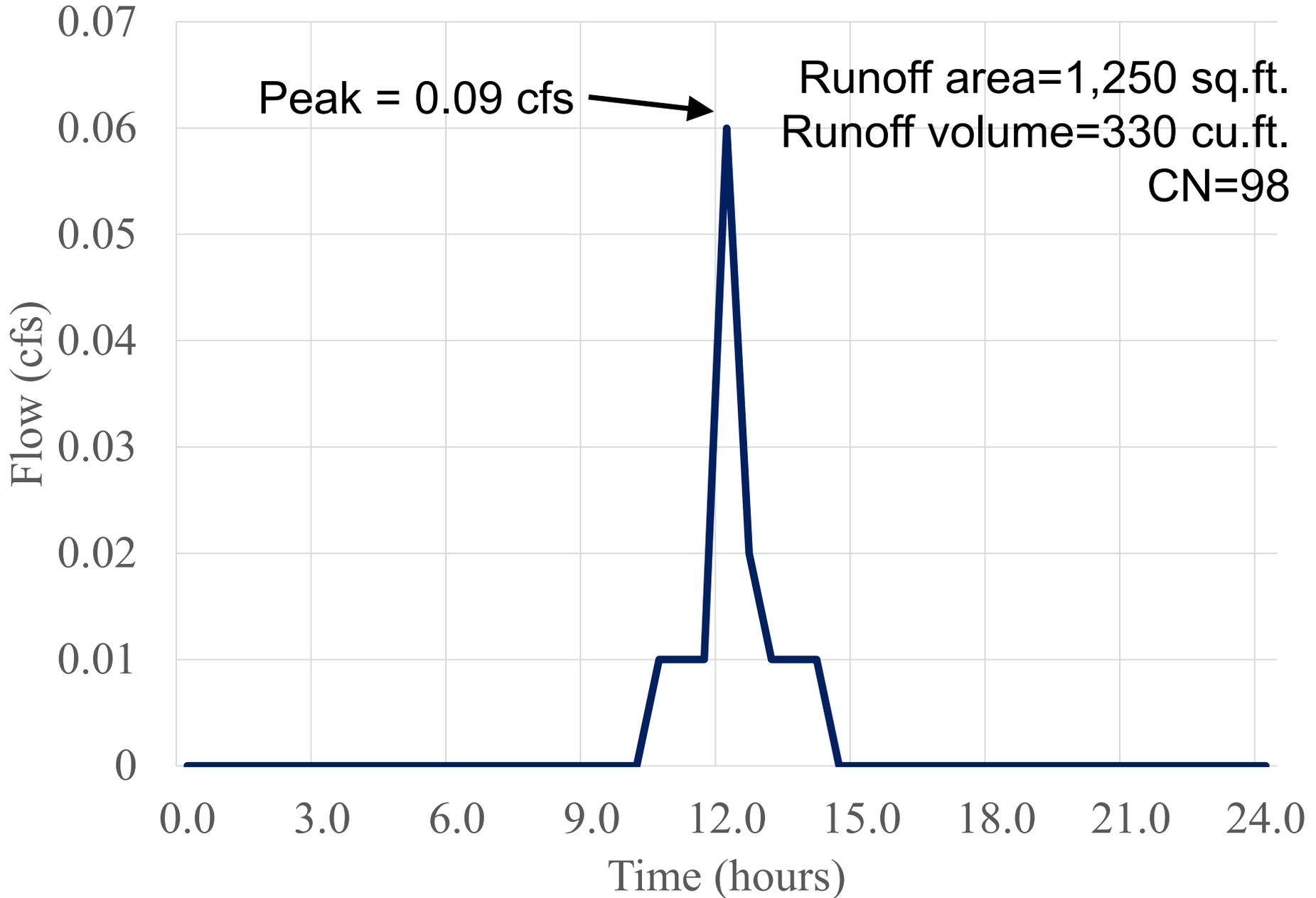
Total Area: (sq-ft)       Weighted CN:      

Large areas       Import areas automatically

# Hydrograph for Driveway for Water Quality Storm

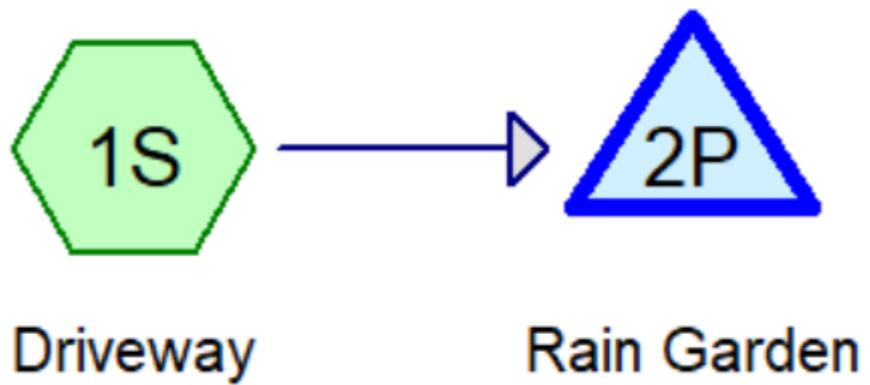


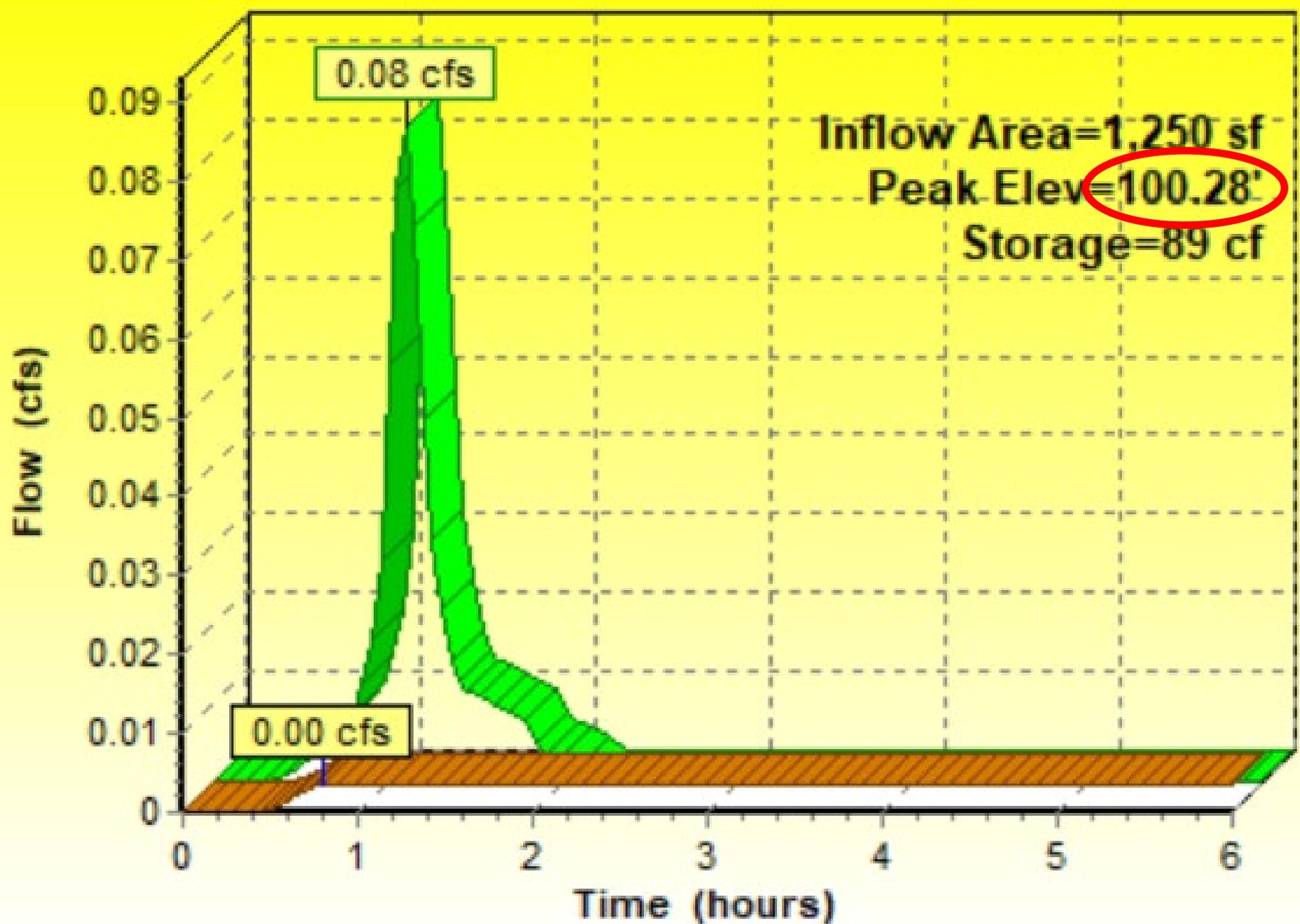
# Hydrograph for Driveway for Two-year Storm

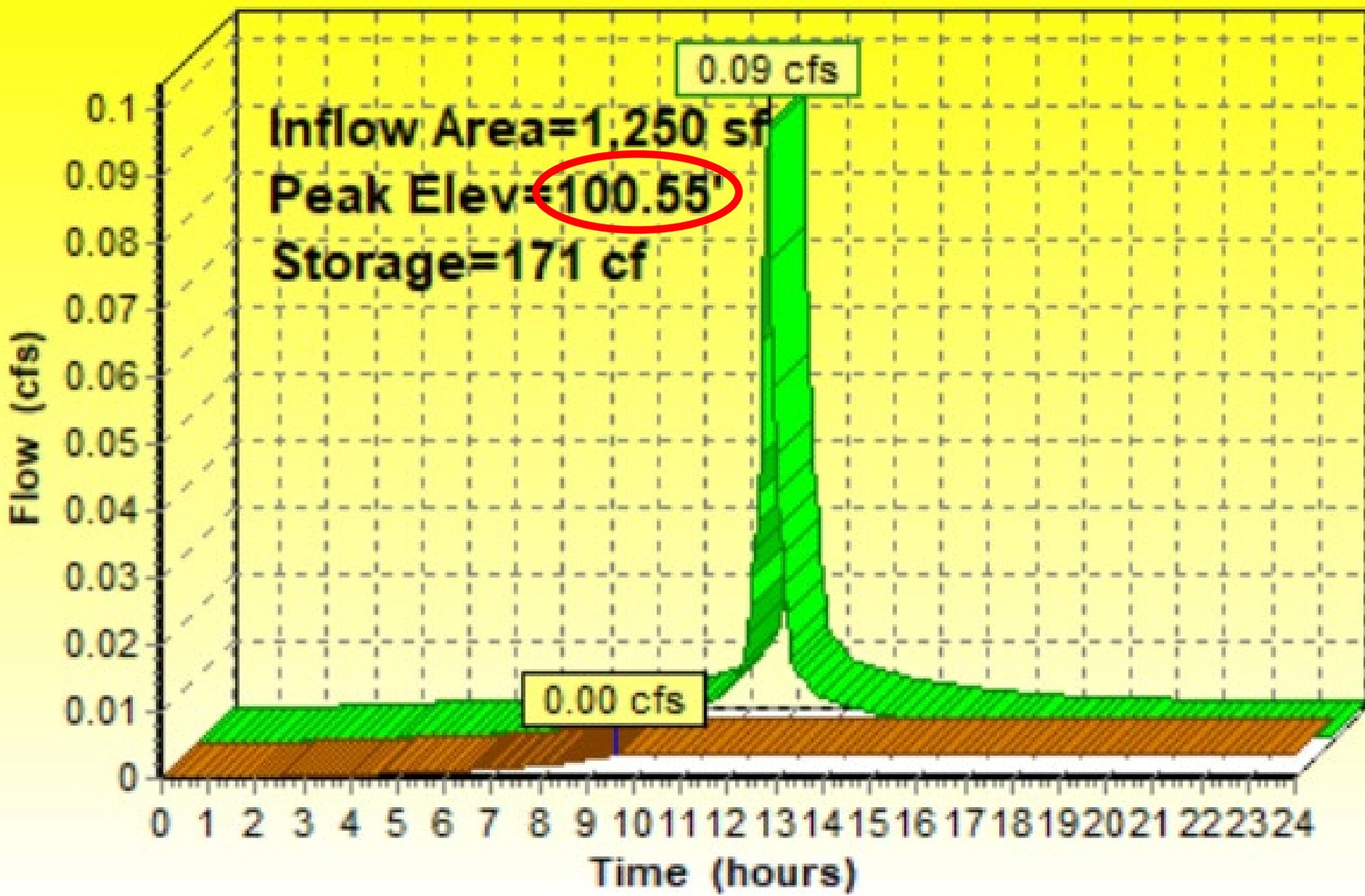




- Subcat
- Reach
- Pond
- Link
- Text







# 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:  
 $0.95 \times 44'' = 41.8''/\text{year} = 3.5 \text{ ft}/\text{year}$
- 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!**

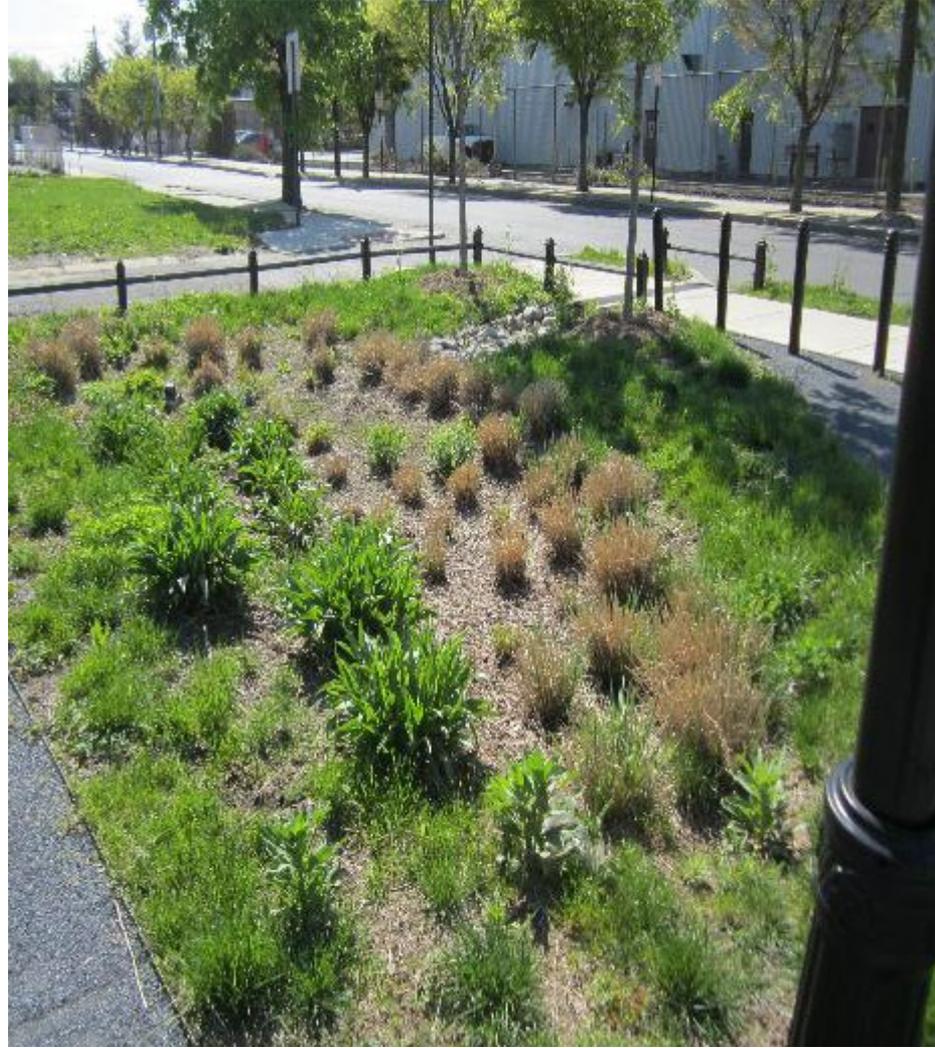




Rain garden at Catto School in Camden, NJ



Rain garden installation at Ferry Avenue Library in Camden, NJ



Rain garden at Waterfront South Park in Camden, NJ

# Stormwater Planters – rain garden built into the curb



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

# Stormwater Planters

## How it works:

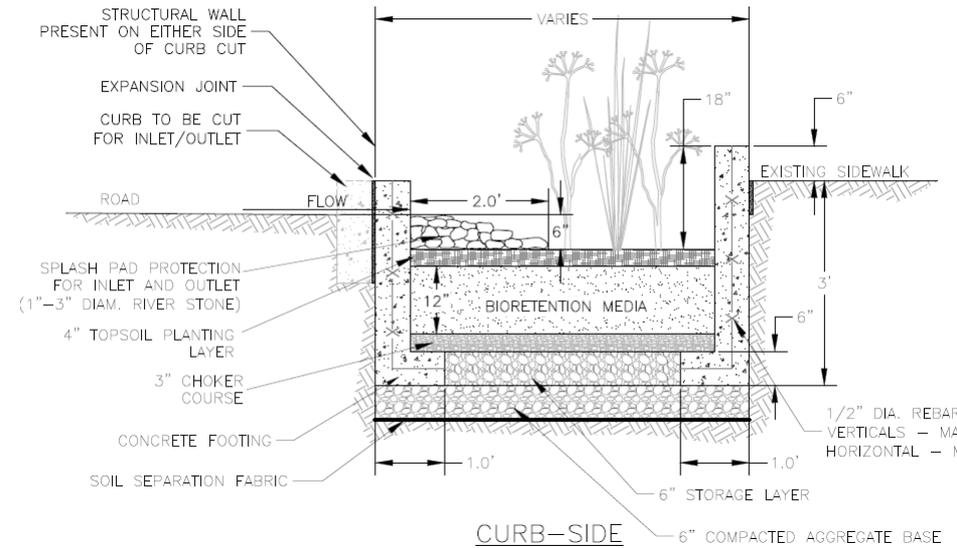
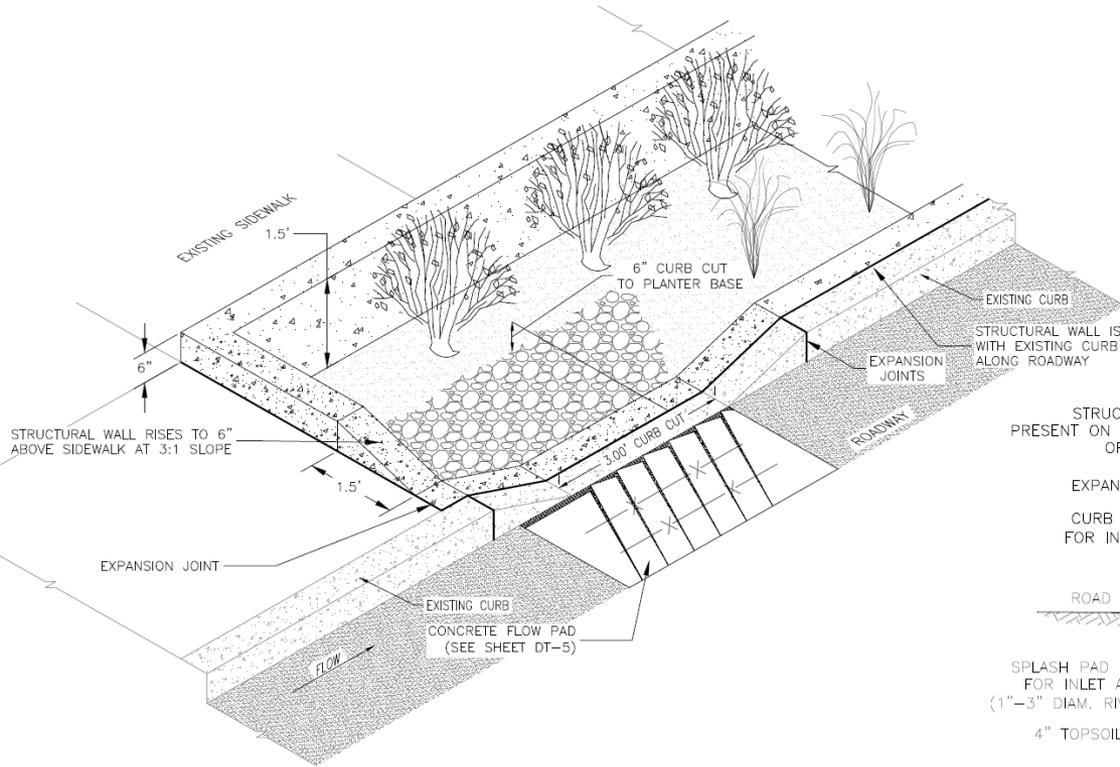
- It is a structural bioretention system that is installed in a sidewalk
- Contains a layer of stone that is topped with bioretention media and plants or trees
- Captures stormwater runoff from the roadway and sidewalk
- Once the system fills up, runoff flows back into the street or into an overflow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



CURB-SIDE



Stormwater Planter at the Brimm School  
in Camden, NJ



Stormwater Planters at Community Garden in Camden, NJ

# 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

# Typical Planter

- 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



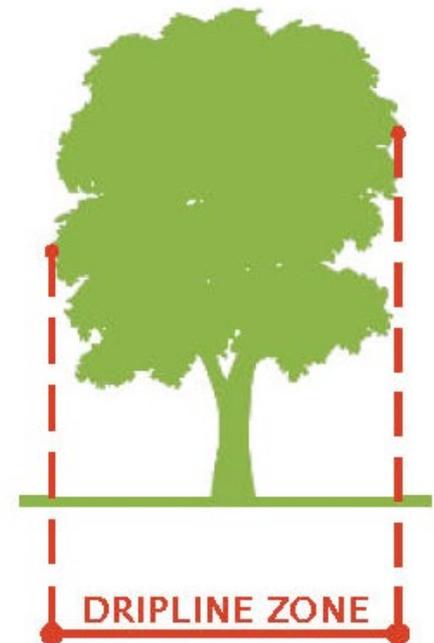
SITE SELECTION & DESIGN

# PLANNING YOUR RAIN GARDEN



# SITE SELECTION

1. Next to a building with a basement, rain garden should be located min. 10' from building; no basement: 2' from building
2. Do not place rain garden within 25' of a septic system
3. Do not situate rain garden in soggy places where water already ponds
4. Avoid seasonably-high water tables within 2' of rain garden depth
5. Consider flat areas first – easier digging
6. Avoid placing rain garden within dripline of trees
7. Provide adequate space for rain garden





# CALL BEFORE YOU DIG

## LOCATE YOUR UTILITY LINES!

*Call BEFORE You Dig!*

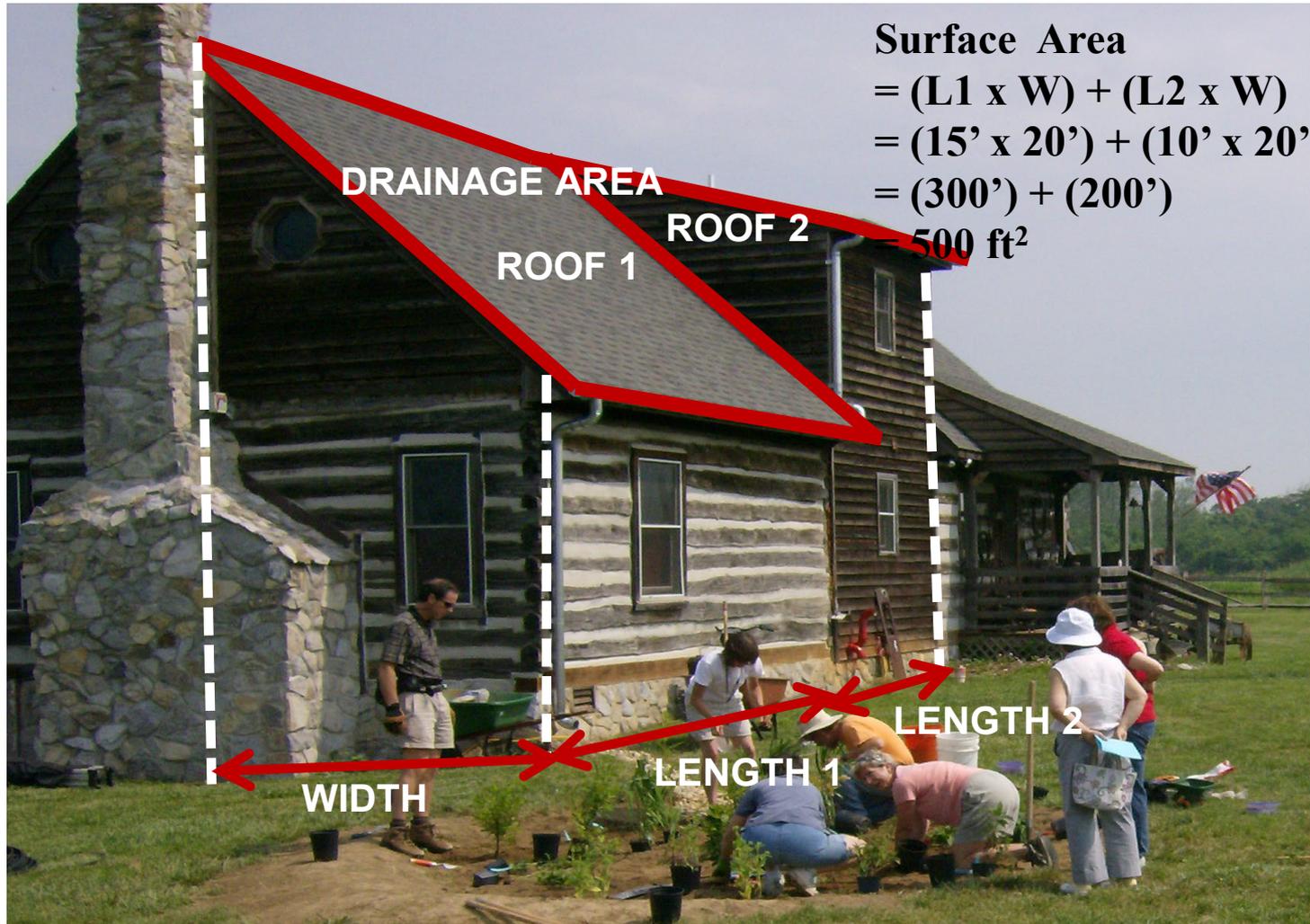
*NJ One Call  
1-800-272-1000*

*The different colors of the markout flags represent specific utilities.*

-  ELECTRIC
-  GAS, OIL, STEAM
-  COMMUNICATIONS, CATV
-  WATER
-  SEWER

- **NJ One Call: 1-800-272-1000**
- Free markout of underground gas, water, sewer, cable, telephone, and electric utility lines
- Call at least 3 full working days, but not more than 10 days, prior to planned installation date
- Do not place rain garden within 5' horizontally and 1' vertically from any utilities

# DRAINAGE AREA CALCULATION



**Surface Area**

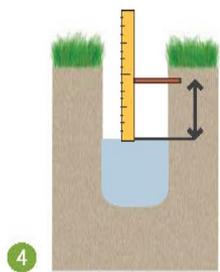
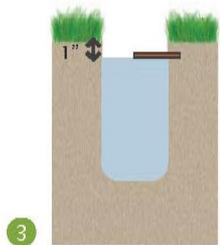
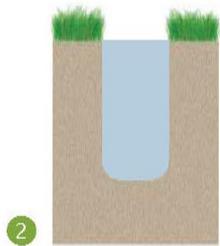
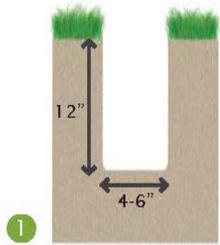
$$= (L1 \times W) + (L2 \times W)$$

$$= (15' \times 20') + (10' \times 20')$$

$$= (300') + (200')$$

$$= 500 \text{ ft}^2$$

# CHECK YOUR SOIL



- Infiltration/Percolation Test
  1. Dig a hole in the proposed rain garden site (12" deep, 4-6" wide)
  2. Fill with water to saturate soil and then let stand until all the water has drained into the soil
  3. Once water has drained, refill the empty hole again with water so that the water level is about 1" from the top of the hole
  4. Check depth of water with a ruler every hour for at least 4 hours
  5. Calculate how many inches of water drained per hour

# DETERMINING THE DEPTH OF THE RAIN GARDEN



6" DEEP RAIN GARDEN - NO SOIL AMENDMENTS



3" DEEP RAIN GARDEN - SOIL AMENDMENTS



- Depth of rain garden is dependent upon the soil texture found at the site of the rain garden
- Depth is usually 3-8 inches

# DETERMINING THE SIZE OF THE RAIN GARDEN



- The size of the rain garden is dependent upon the amount of runoff entering the rain garden

## Rain Garden Sizing Table

Based on New Jersey's Water Quality Design Storm (1.25" of rain over 2 hours)

Drainage Area	Size of 3" Deep Rain Garden CLAY SOIL*	Size of 6" Deep Rain Garden SILTY SOIL	Size of 8" Deep Rain Garden SANDY SOIL
500 ft <sup>2</sup>	200 ft <sup>2</sup>	100 ft <sup>2</sup>	75 ft <sup>2</sup>
750 ft <sup>2</sup>	350 ft <sup>2</sup>	150 ft <sup>2</sup>	112 ft <sup>2</sup>
1,000 ft <sup>2</sup>	400 ft <sup>2</sup>	200 ft <sup>2</sup>	149 ft <sup>2</sup>
1,500 ft <sup>2</sup>	600 ft <sup>2</sup>	300 ft <sup>2</sup>	224 ft <sup>2</sup>
2,000 ft <sup>2</sup>	800 ft <sup>2</sup>	400 ft <sup>2</sup>	299 ft <sup>2</sup>

\*SOIL TEXTURE AMENDMENTS NEEDED



# SOIL AMENDMENTS

- Soil amendments improve the rain garden's infiltration rate and help the plants grow





# DETERMINING THE INLET AND OVERFLOW

- Stormwater runoff enters the rain garden from an **inlet**
- Stormwater exits through the **overflow**





# PREVENTING EROSION

- Slope no greater than 3:1
- Slow down velocity of water flowing through rain garden
  - Add rocks to inlet area (River Stone)



# DETERMINING MULCH QUANTITY



- Allow for a 3” depth mulch (triple-shredded hardwood with no dye) to be spread throughout the entire rain garden
- Every 100 square feet of rain garden needs 1 cubic yards (3” depth)



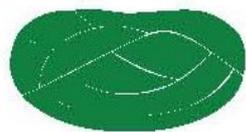
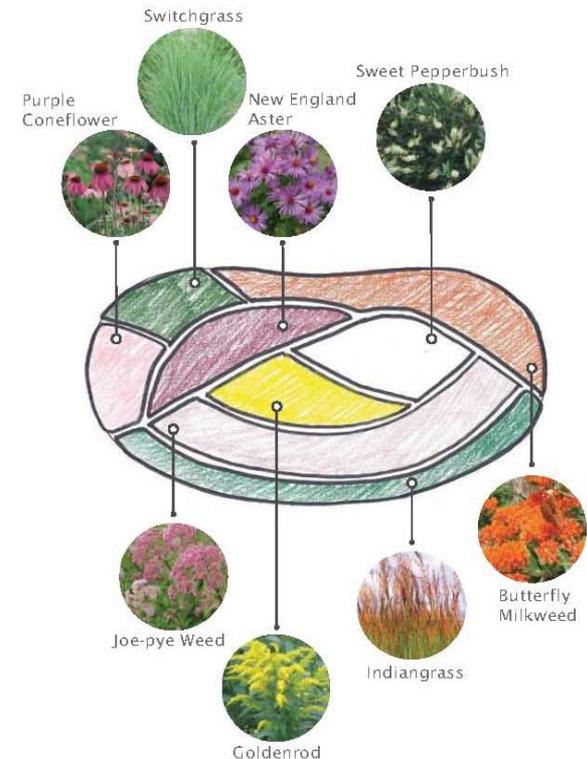


# RAIN GARDEN DESIGN

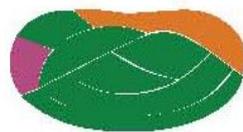
## SHAPING YOUR RAIN GARDEN

- Use a garden hose or rope to outline the desired shape of your rain garden on the ground
- Many rain gardens are in the shape of a circle or kidney bean, but your rain garden can take on whatever shape you prefer

Butterfly Habitat Rain Garden: Planting Plan



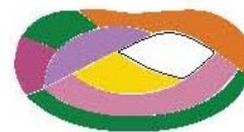
May



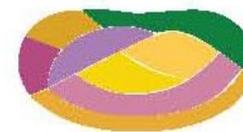
June



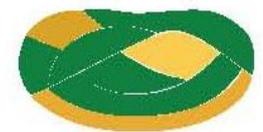
July



August



September



October



THE FUN PART!

# INSTALLING YOUR RAIN GARDEN



# STEP ONE

- Delineate rain garden area



- Remove existing grass with a shovel or machinery



# STEP TWO

- Excavate to design depth based on necessary storage and soil amendment requirements



# STEP THREE

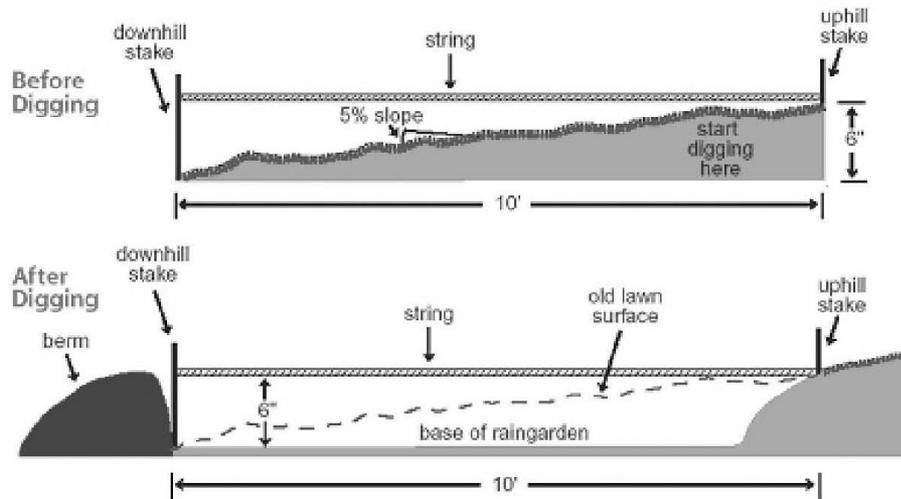
- Add soil amendments, if necessary



- Combine amendments with existing soil using shovels or rototiller
- Loosen and prepare soil for grading and planting

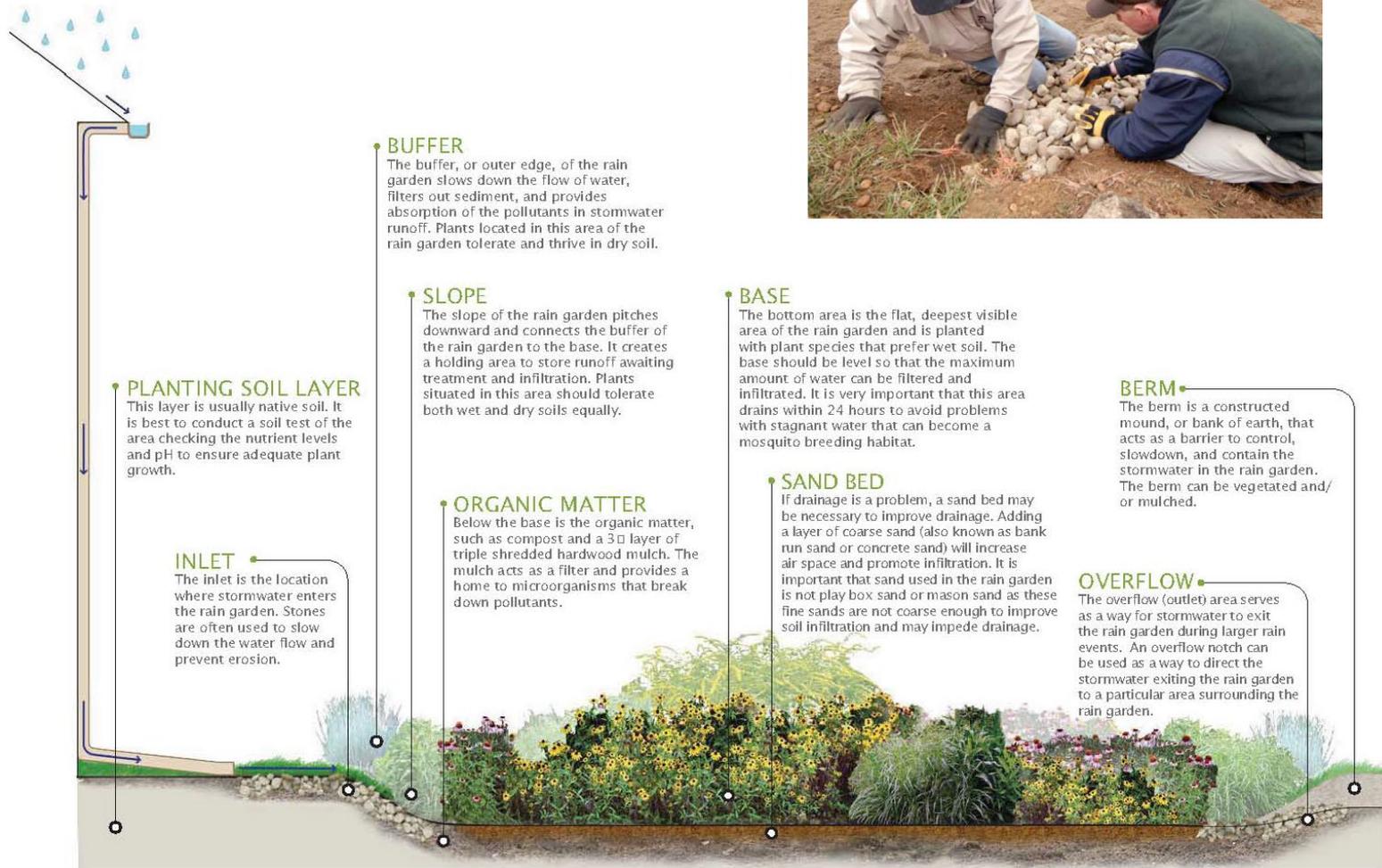
# STEP FOUR

- Prepare the berm, if necessary



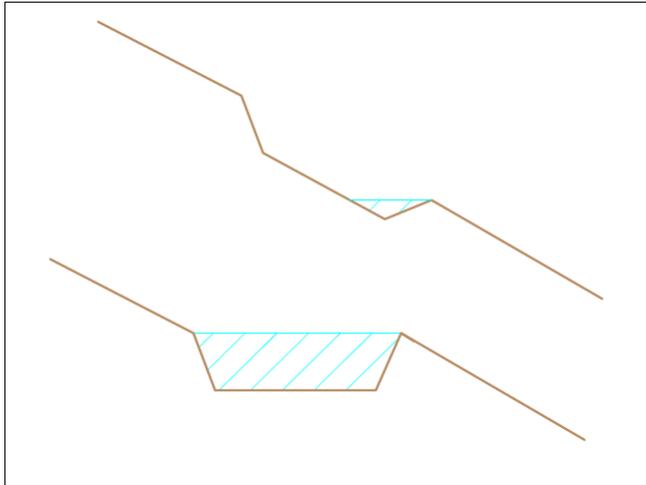
# STEP FIVE

- Prepare the overflow



# STEP SIX

- Level the rain garden base



# STEP SEVEN

- Plant native species



# STEP EIGHT

- Apply mulch



- Allow for a 3” depth mulch (triple-shredded hardwood with no dye) to be spread throughout the entire rain garden
- For every 100 square feet of rain garden, you will need about 1 cubic yard of mulch (3” depth)

# STEP NINE

- Water Plants



# STEP TEN

- Appreciate a job well done





**Rain Garden**  
Water Quality and Habitat  
Enhancement Project  
This garden is designed to intercept,  
treat, and infiltrate stormwater at the  
source, before it becomes runoff.  
The plants are native to the region  
and help retain pollutants that could  
otherwise harm nearby waterways.  
Rain gardens are beautiful,  
low-maintenance, and inexpensive  
gardens that you can install at home.  
[www.water.rutgers.edu](http://www.water.rutgers.edu)

A rain garden is a landscaped, shallow depression that is designed to intercept, treat, and infiltrate stormwater at the source before it becomes runoff. Rain Gardens are covered with native plants of the region and help retain pollutants that could otherwise harm nearby waterways.

# RAIN GARDEN PLANTING DESIGN



# DESIGN AESTHETICS

- Formal or traditional design
  - Shrub bed
  - Perennial garden
  - Hedges
- Naturalized planting & design
  - Butterfly garden
  - Meadow (warm season grasses & wildflowers)
  - Buffer plantings



# SITE CONSTRAINTS

- Sun vs. shade
- Exposure/wind
- Soil characteristics
- Hydrologic conditions
- Road salts
- Vehicle/pedestrian traffic



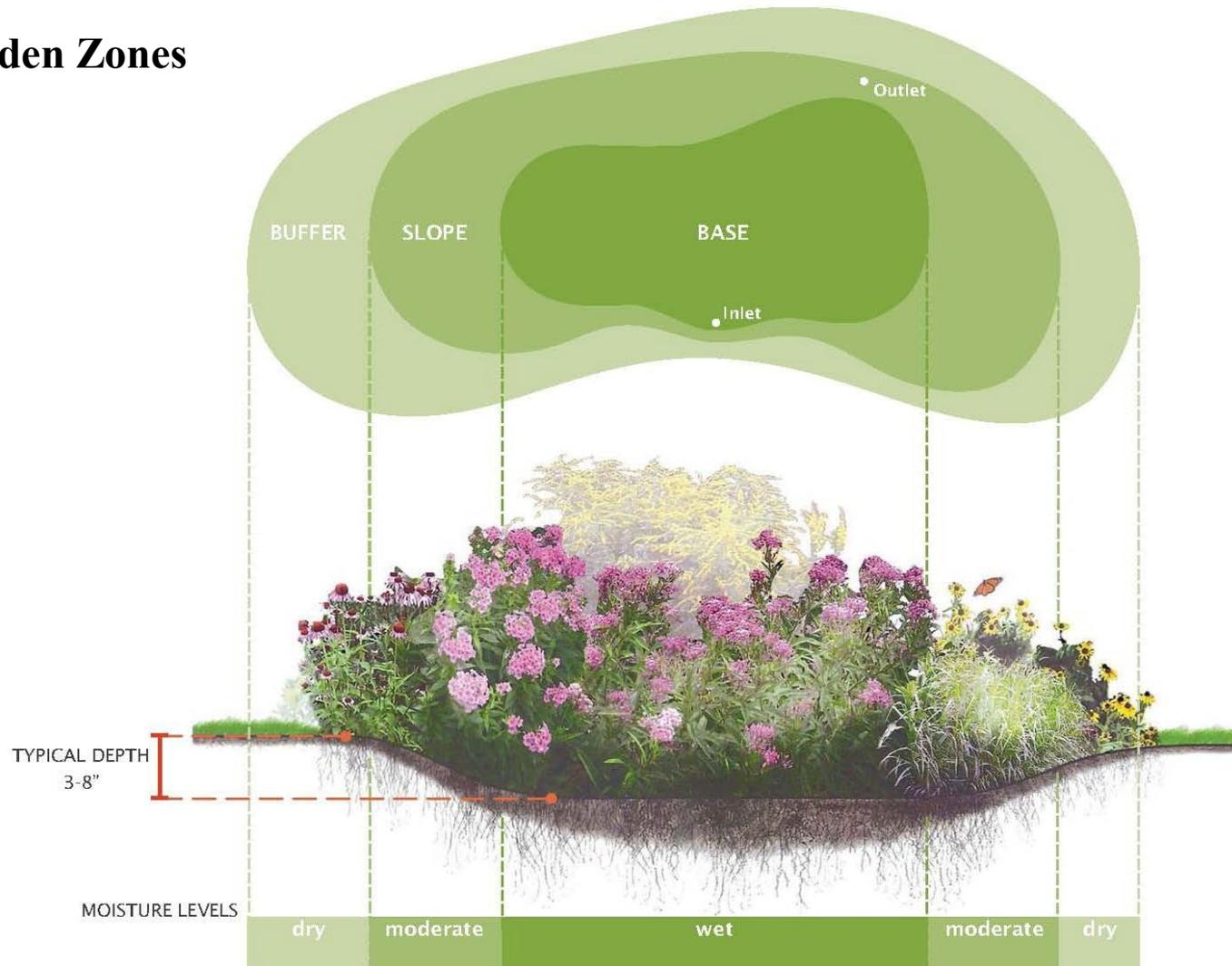
# PLANTS IN THE RIGHT PLACE...



*Courtesy of Pinelands Nursery & Supply*

# PLANTING DESIGN: Wet + Dry Conditions

## Rain Garden Zones



# SELECTING PLANT SPECIES

- Mature plant size
  - Proximity to buildings and utility lines
  - Pruning and shaping
- Seasonal interest
  - Flowers
  - Fall color
  - Winter character
- Beneficial wildlife
  - Flowers for butterflies
  - Fruits for song birds



# GRASSES & GROUND COVERS



## **BUFFER**

- Broomsedge
- Bearberry
- Panic grass
- Switchgrass
- Little bluestem
- Indiangrass

## **BASE**

- Big bluestem
- Virginia wild-rye
- Switchgrass
- Wool grass

## **SLOPE**

- Bluejoint grass
- Sedges
- Fowl mannagrass
- Softrush



# GRASSES & GROUND COVERS

**Switchgrass**  
**(*Panicum virgatum*) - FAC**



**Tussock Sedge**  
**(*Carex stricta*) - OBL**



**Woolgrass (*Scirpus cyperinus*) - FACW+**



**Little Bluestem**  
**(*Schizachyrium scoparium*) - FACU**



# WILDFLOWERS & FERNS



## BUFFER

- Butterfly milkweed
- Wild indigo
- Purple coneflower
- Beebalm
- Black-eyed susan

## BASE

- New England aster
- New York aster
- Columbine
- Coreopsis
- Joe-pye weed
- Blazing star
- Sensitive fern
- Cinnamon fern
- Ironweed

## SLOPE

- Swamp milkweed
- Marsh marigold
- Turtlehead
- Boneset
- Rose-mallow/hibiscus
- Blueflag iris
- Cardinal flower
- Blue lobelia
- Monkey flower



# WILDFLOWERS



**Blueflag  
(*Iris versicolor*) - OBL**



**Black-eyed Susan  
(*Rudbeckia hirta*) - FACU-**



**Joe-Pye Weed  
(*Eupatorium perfoliatum*)  
- FAC**



**New England Aster (*Aster  
novae-angliae*) - FACW**

# TREES & SHRUBS



## BUFFER

- Hackberry
- Red Bud
- Pepperbush
- American Holly
- Bayberry
- Witchhazel
- White Oak
- Red Oak
- Arrowwood
- Viburnum

## BASE

- Red Maple
- Service Berry
- River Birch
- Silky Dogwood
- Red-twig Dogwood
- Inkberry Holly
- Winterberry
- Sweetbay
- Magnolia

## SLOPE

- River Birch
- Buttonbush
- Silky Dogwood
- Green Ash
- Swamp White Oak
- Pin Oak
- Cranberrybush
- Viburnum



# TREES & SHRUBS



**Summersweet  
(*Clethra alnifolia*) - FAC+**



**Winterberry Holly  
(*Ilex verticillata*) - FACW+**



**River Birch  
(*Betula nigra*) - FACW**

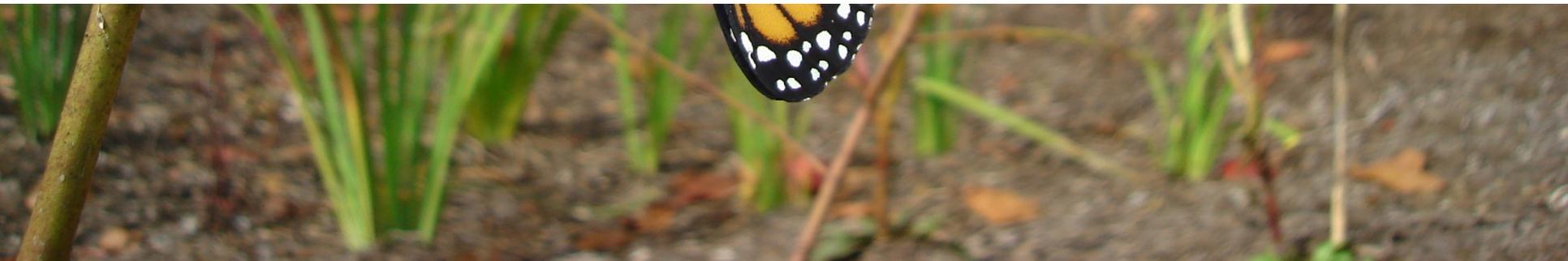


**Inkberry Holly  
(*Ilex glabra*) - FACW-**



INSPECTION AND MAINTENANCE

# **MAINTAINING YOUR RAIN GARDEN**



# MAINTENANCE MEASURES

## *WEEKLY TASKS:*

1. Watering
2. Weeding
3. Inspecting

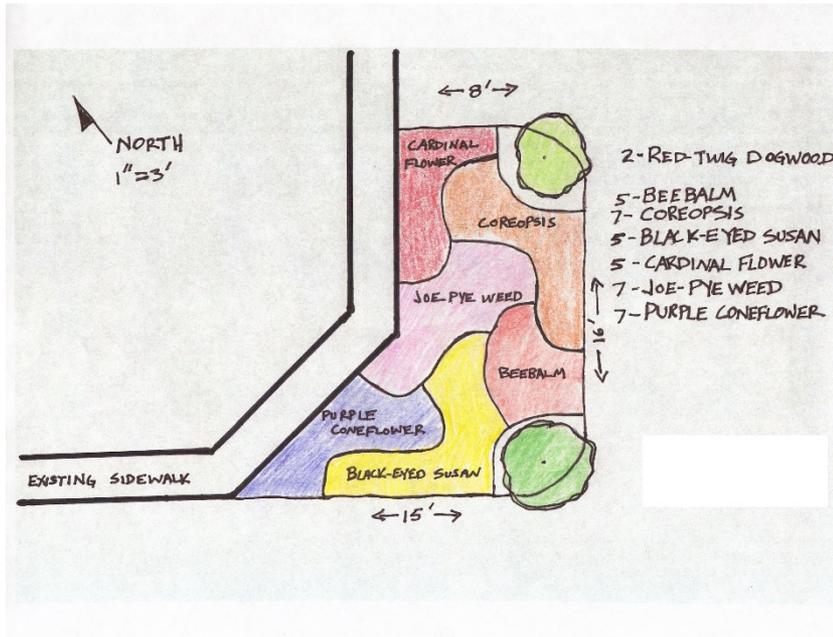
## *ANNUAL TASKS:*

1. Mulching
2. Pruning
3. Re-planting
4. Removing sediment
5. Soil Testing
6. Harvesting Plants
7. Cleaning of Gutters
8. Replacing materials (stone, landscape fabric)

# Installed Rain Gardens by Past Rebate Participants

# Design Example for Roof Runoff

## Design



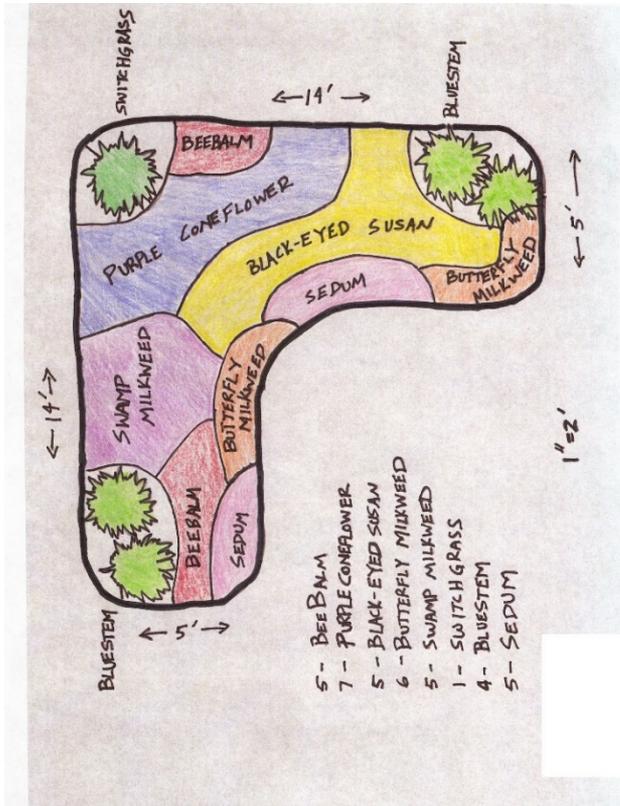
## Installed Rain Garden





# Design Example for Parking Lot Runoff

## Design



## Installed Rain Garden

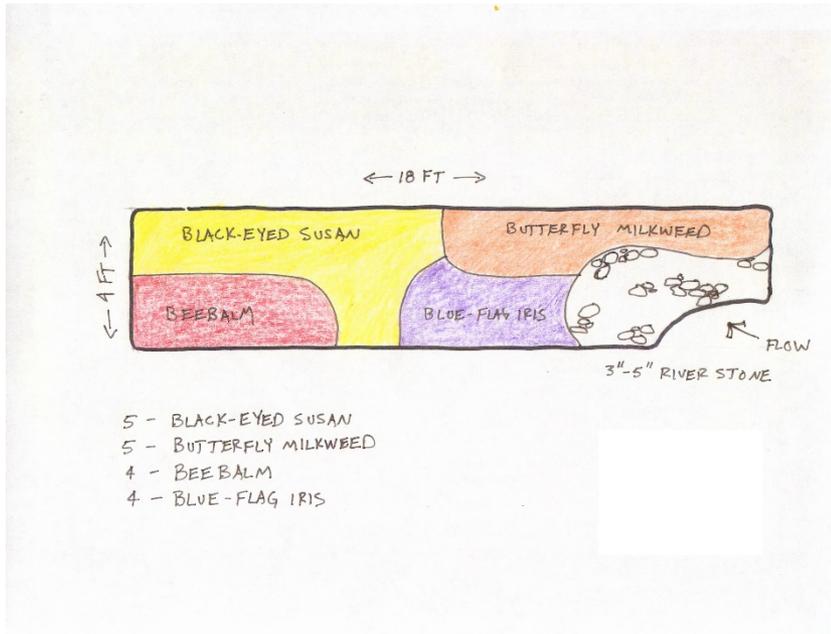




# Roof, Sump Pump and Driveway Runoff – WOW!

## Design

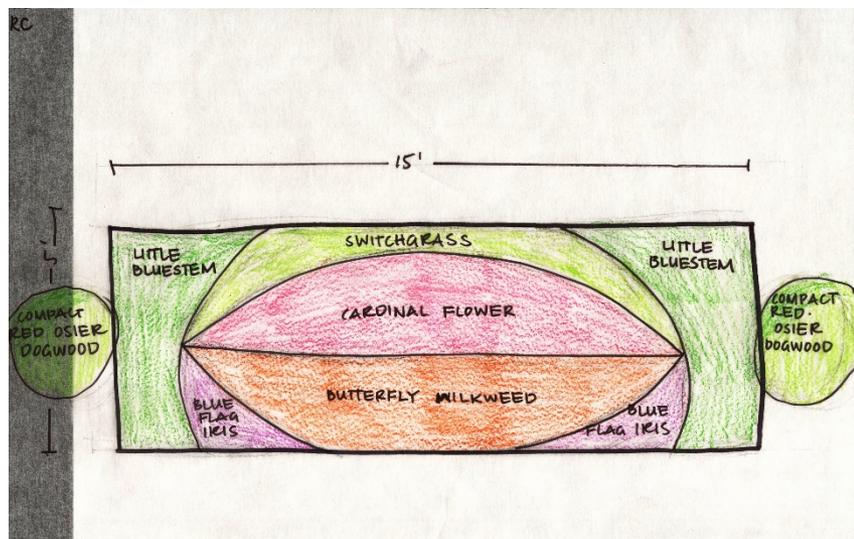
## Installed Rain Garden





# Roof Runoff from Rain Barrel Overflow

Design



Installed Rain Garden

