Green Infrastructure Champions Program

This program is partially funded by the Rutgers New Jersey Agricultural Experiment Station, Geraldine R. Dodge Foundation, NJ Sea Grant Consortium, and William Penn Foundation and is a collaboration of the Rutgers Cooperative Extension Water Resources Program and the Green Infrastructure Subcommittee of Jersey Water Works.

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JERSEY WATER WORKS
Smart infrastructure. Strong communities.

Please enter your full name and affiliation in the chat. This is how will take attendance.

GERALDINE R. DODGE FOUNDATION

Sea Grant
NJ Sea Grant Consortium

WILLIAM PENN FOUNDATION

Green Infrastructure Champion Training: Part 7

“How To Design and Build a Rain Garden”

April 7, 2023
Virtual Class

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.

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New Jersey Agricultural Experiment Station

Water Resources Program

Water Resources Program

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

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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 (years)

100-year storm	= 100/100	= 1%
10-year storm	= 100/10	= 10%
2-year storm	= 100/2	= 50%

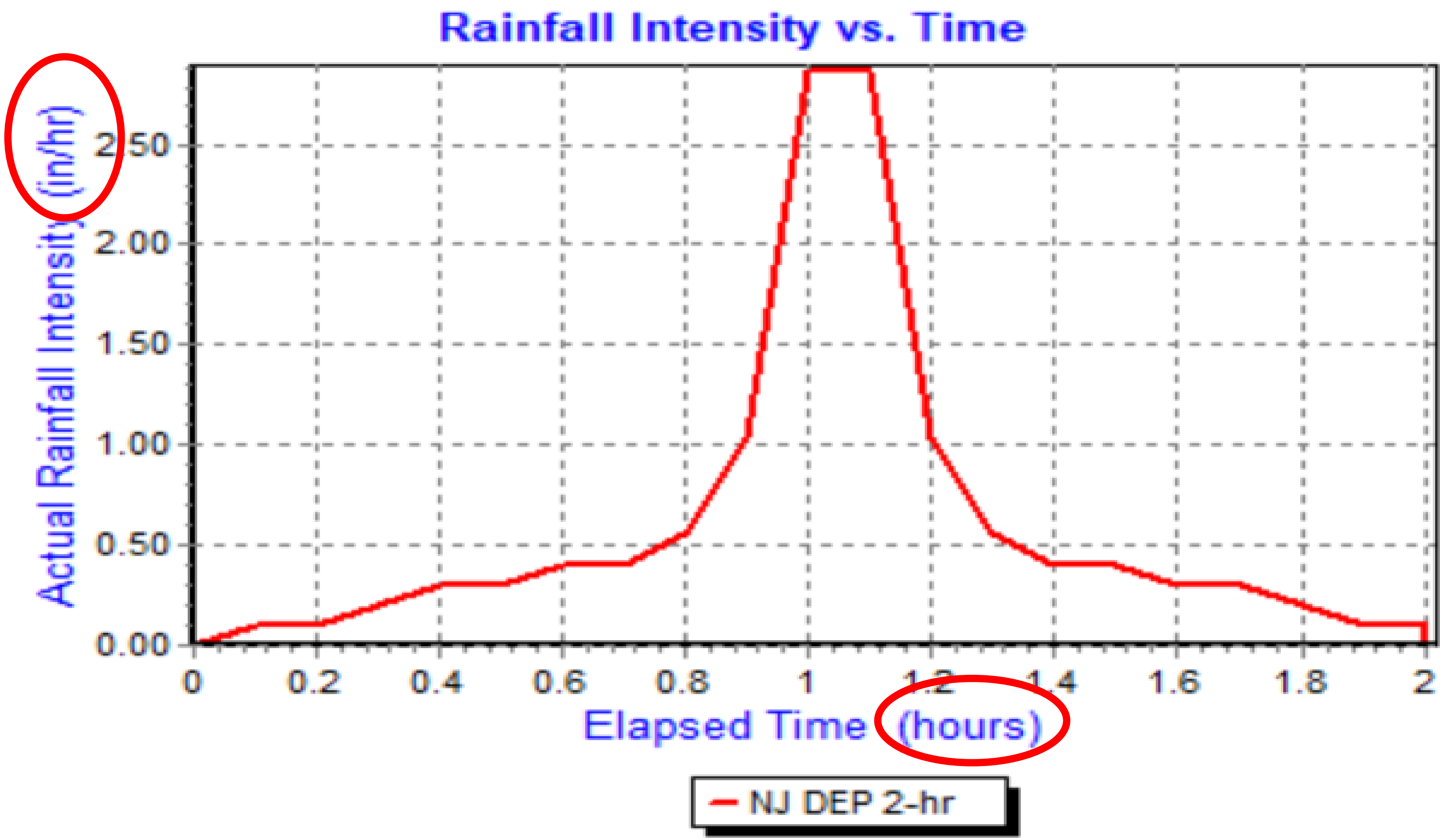
NEW JERSEY 24 HOUR RAINFALL FREQUENCY DATA

Rainfall Amounts in Inches

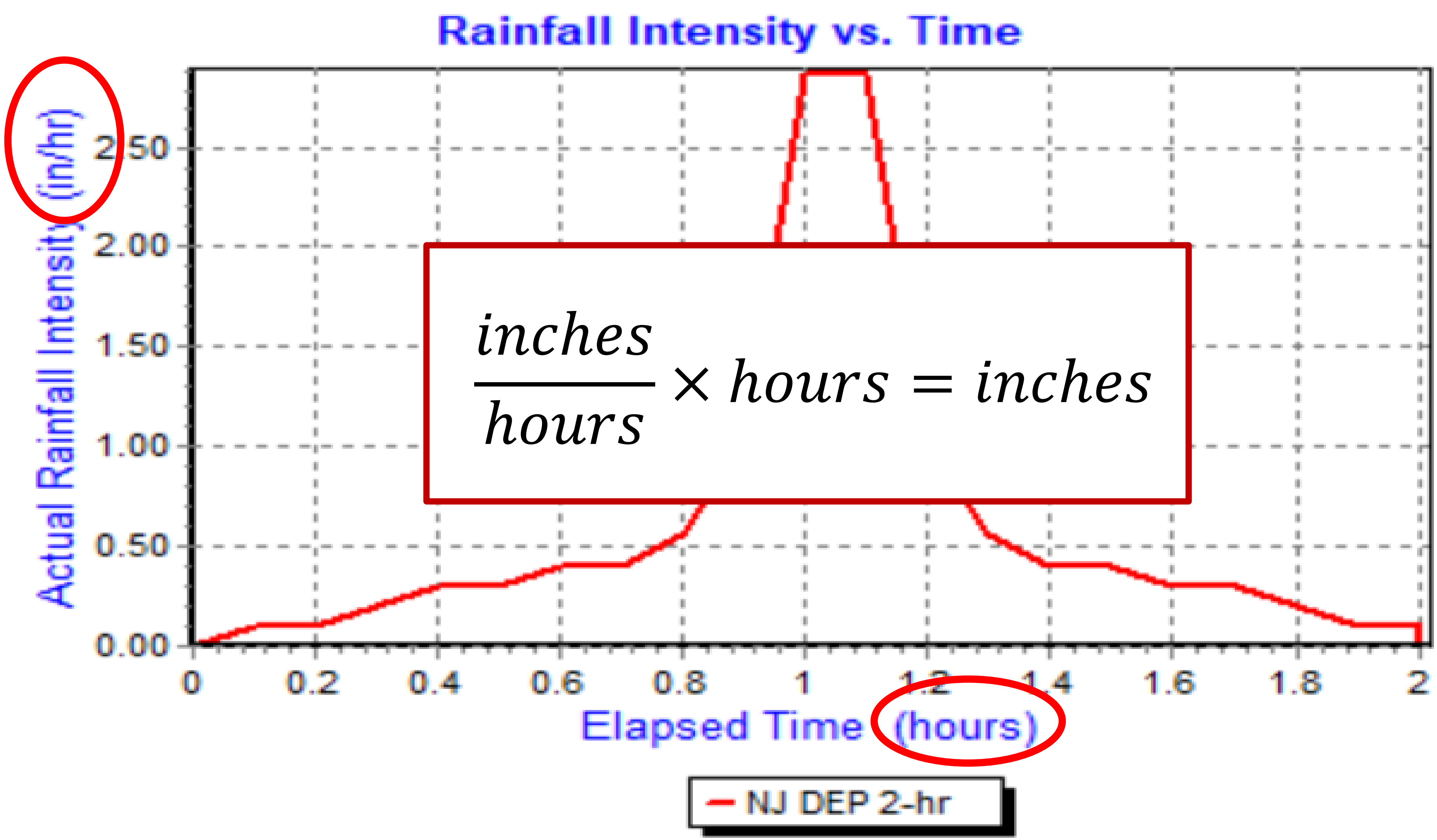
County	1 year	2 year	5 year	10 year	25 year	50 year	100 year
Atlantic	2.8	3.3	4.3	5.2	6.5	7.6	8.9
Bergen	2.8	3.3	4.3	5.1	6.3	7.3	8.4
Burlington	2.8	3.4	4.3	5.2	6.4	7.6	8.8
Camden	2.8	3.3	4.3	5.1	6.3	7.3	8.5
Cape May	2.8	3.3	4.2	5.1	6.4	7.5	8.8
Cumberland	2.8	3.3	4.2	5.1	6.4	7.5	8.8
Essex	2.8	3.4	4.4	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



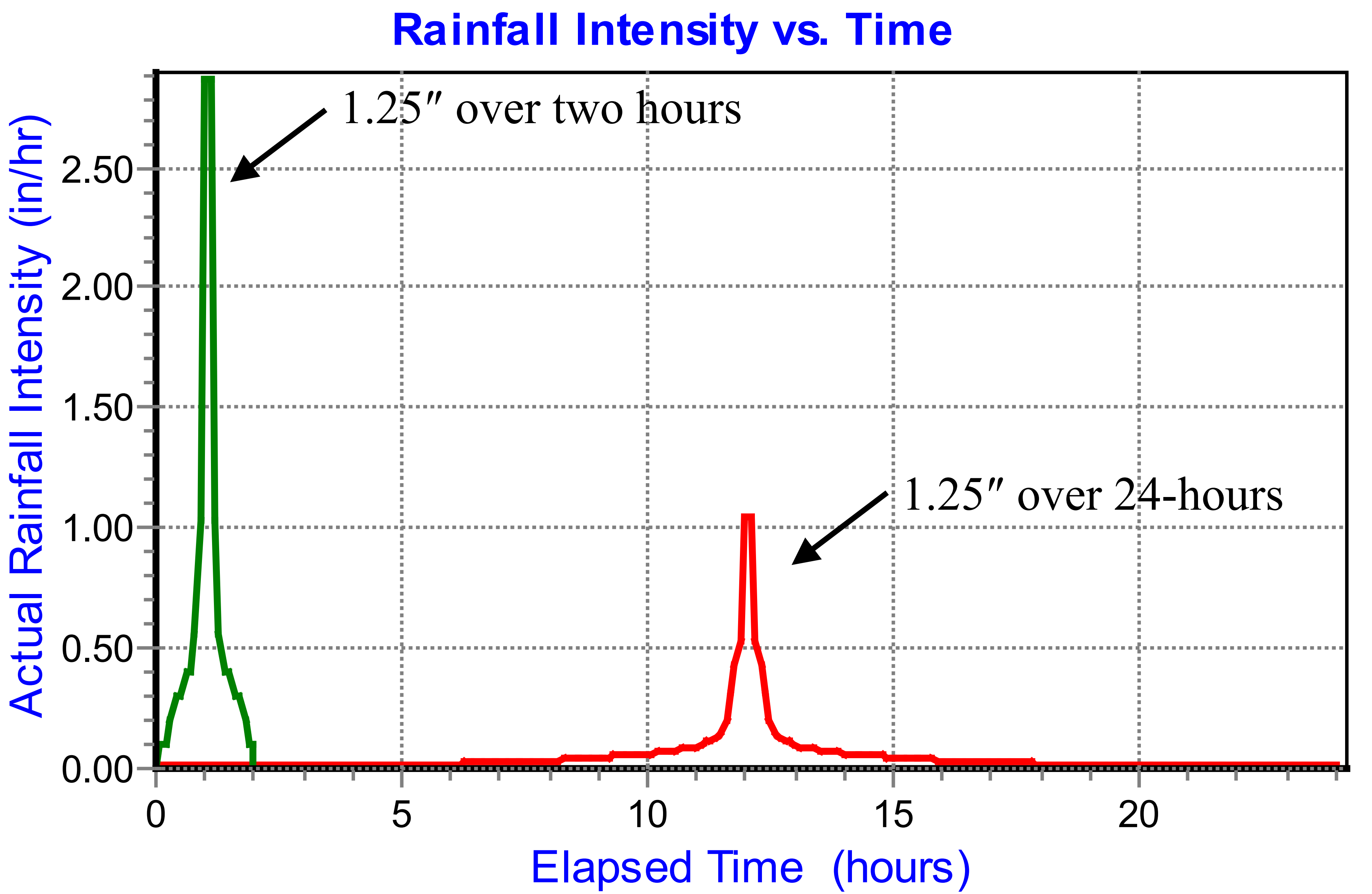
New Jersey Water Quality Storm = 1.25 inches of rain over two hours

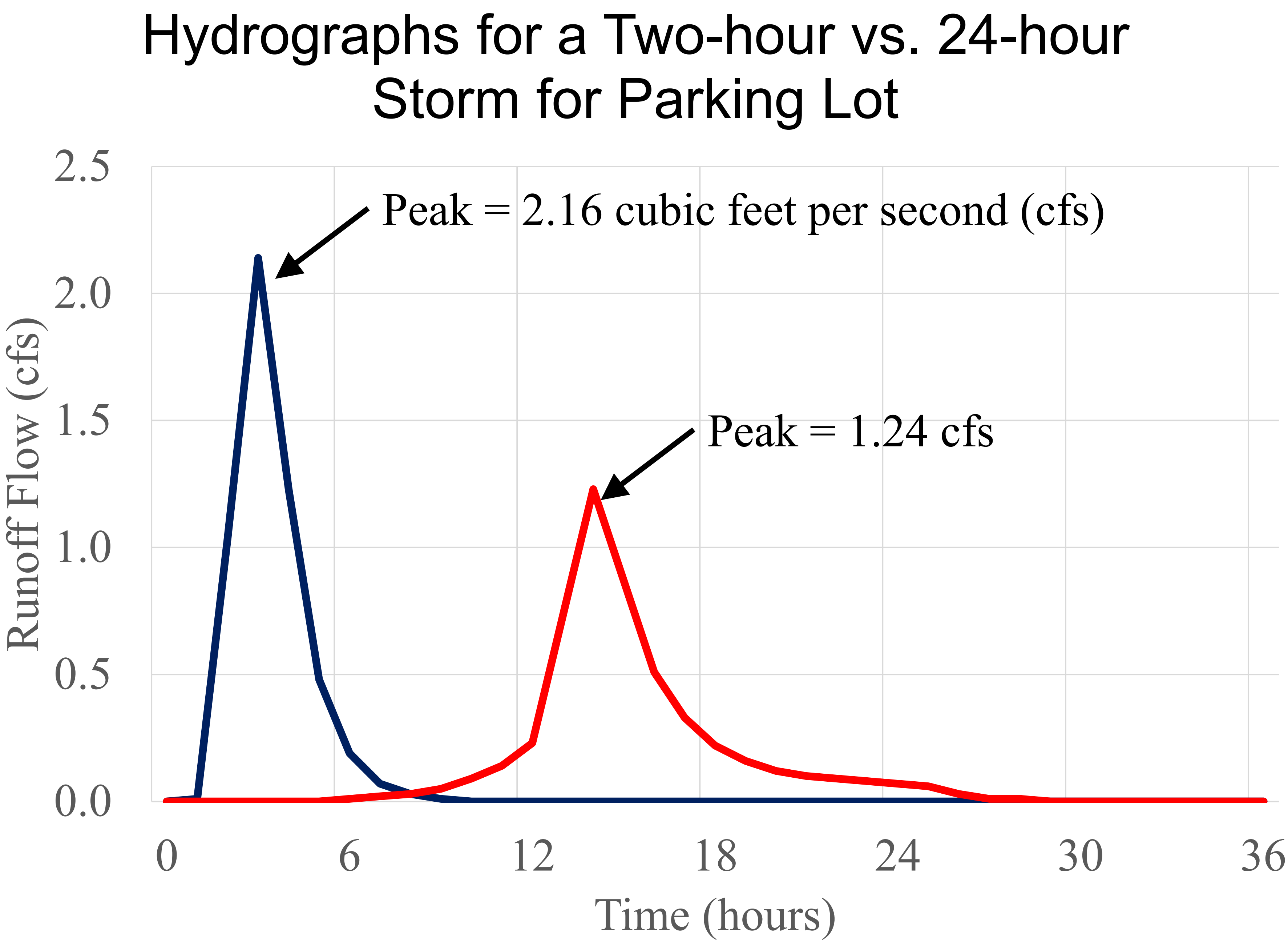


$$\frac{inches}{hours} \times hours = inches$$

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.

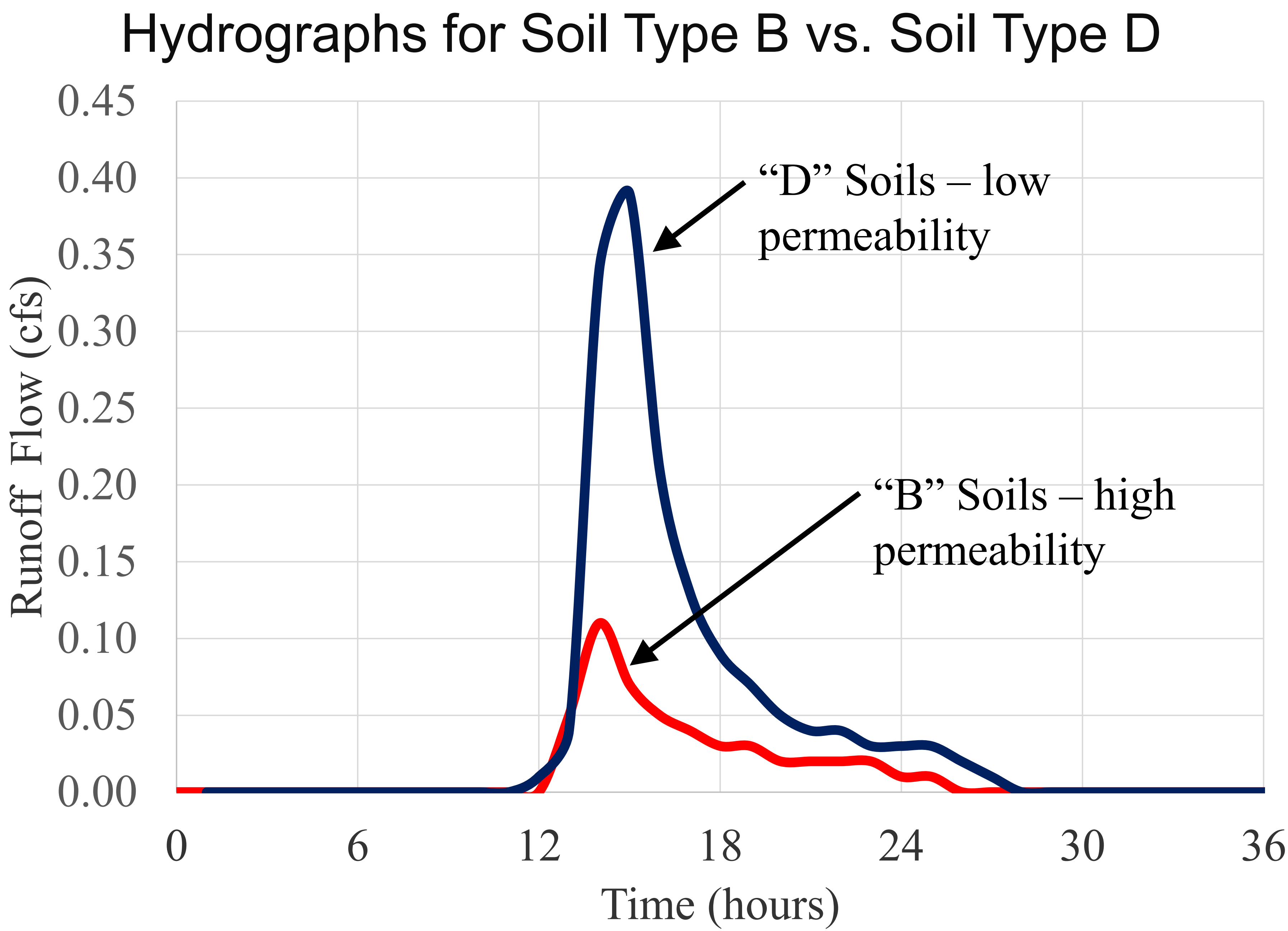

Rainfall Intensity vs. Time
1.25″ over two hours
1.25″ over 24-hours
Actual Rainfall Intensity (in/hr)
0.00
0.50
1.00
1.50
2.00
2.50
0
5
10
15
20
Elapsed Time (hours)



Hydrographs for a Two-hour vs. 24-hour Storm for Parking Lot
Peak = 2.16 cubic feet per second (cfs)
Peak = 1.24 cfs
Runoff Flow (cfs)
2.5
2.0
1.5
1.0
0.5
0.0
0
6
12
18
24
30
36
Time (hours)

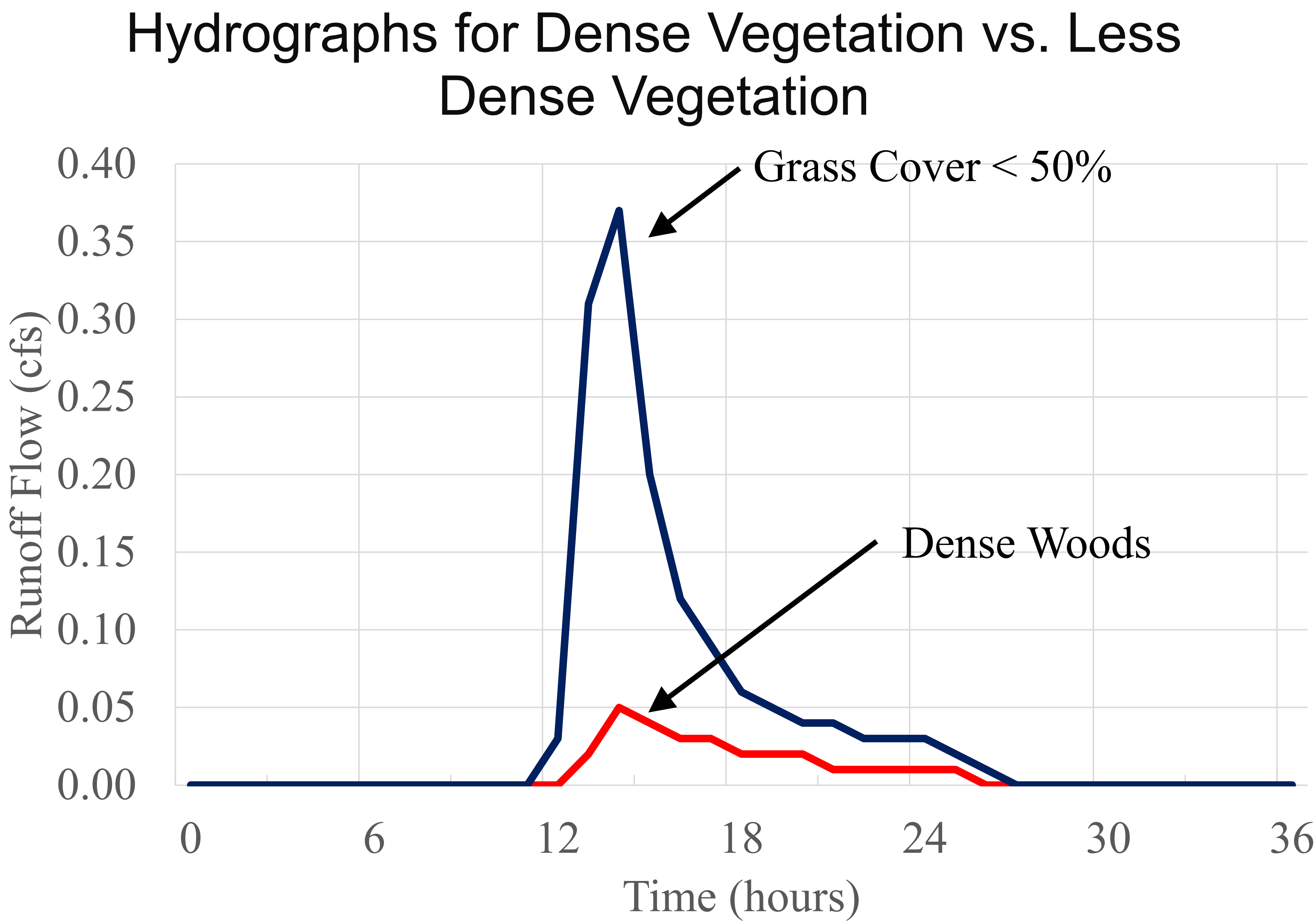
Characteristics of Rainfall and Drainage Area Can Influence Runoff

#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
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Runoff Flow (cfs)
0
6
12
18
24
30
36
Time (hours)
“D” Soils – low permeability
“B” Soils – high permeability

Characteristics of Rainfall and Drainage Area Can Influence Runoff

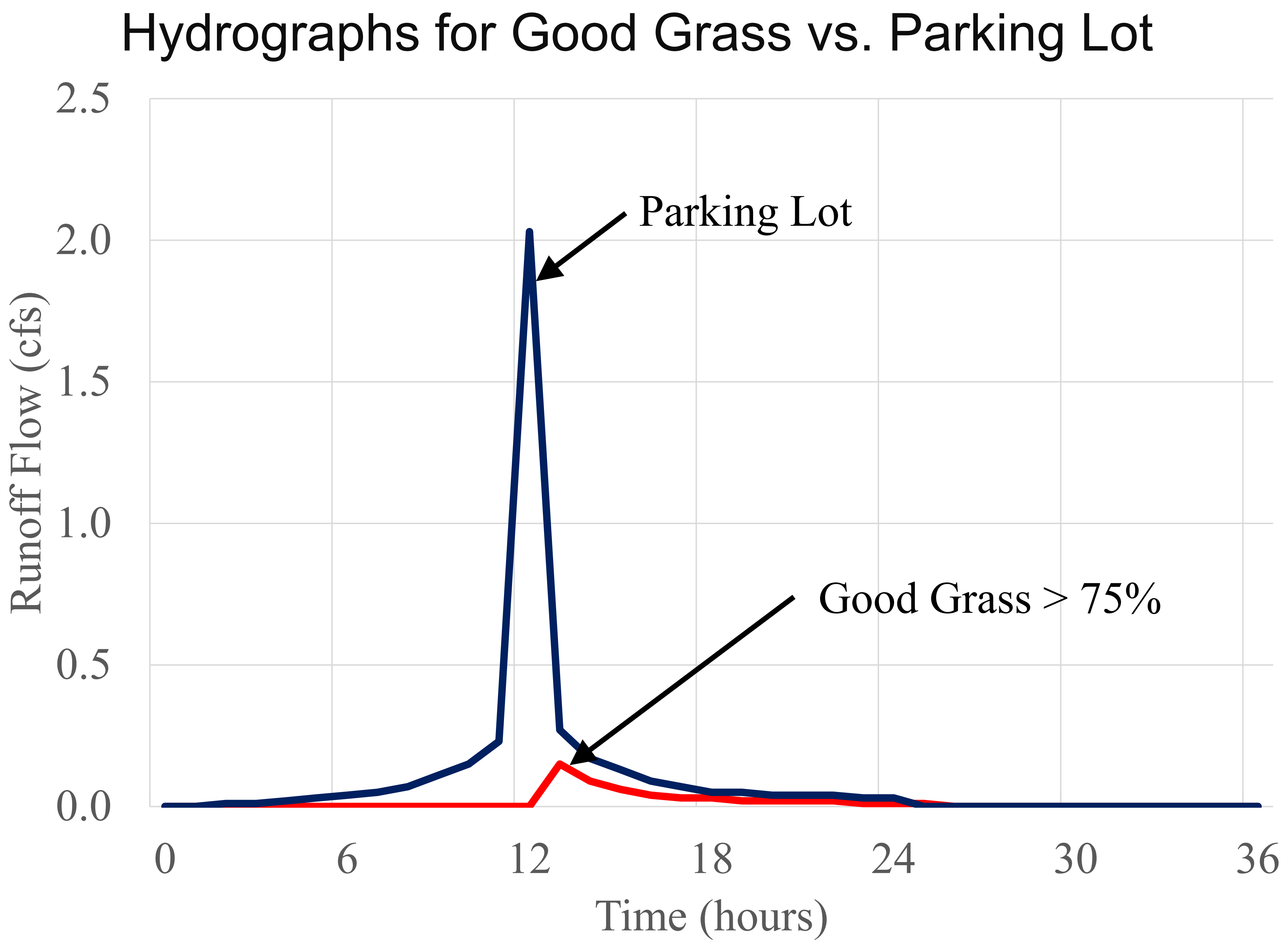
#3. Dense vegetation, such as woodland, intercepts and helps infiltrate rainfall, thereby reducing runoff volumes and rates.



Hydrographs for Dense Vegetation vs. Less Dense Vegetation
Grass Cover < 50%
Dense Woods
Runoff Flow (cfs)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
6
12
18
24
30
36
Time (hours)

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
Parking Lot
Good Grass > 75%
Runoff Flow (cfs)
Time (hours)
0.0
0.5
1.0
1.5
2.0
2.5
0
6
12
18
24
30
36

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 retrofitting existing development with stormwater management practices

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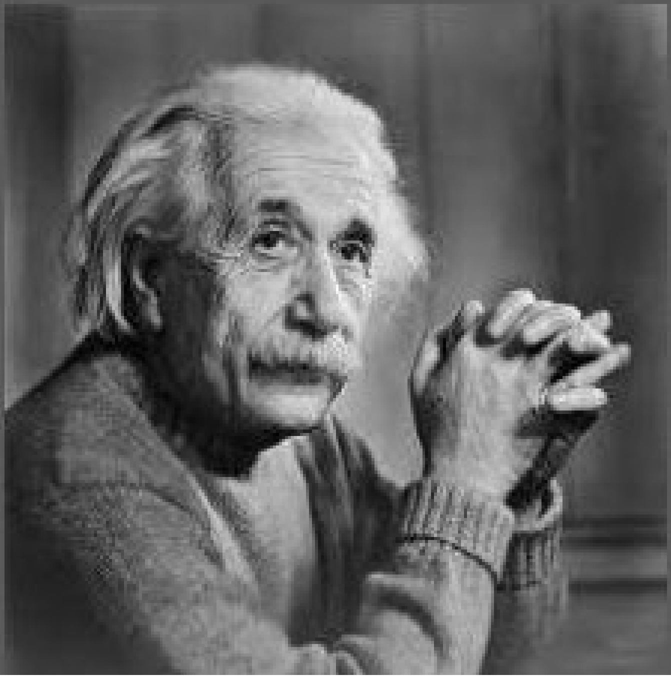
Albert Einstein was not a believer in excuses; "Man must cease attributing his problems to his environment, and learn again to exercise his will - his personal responsibility."



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?

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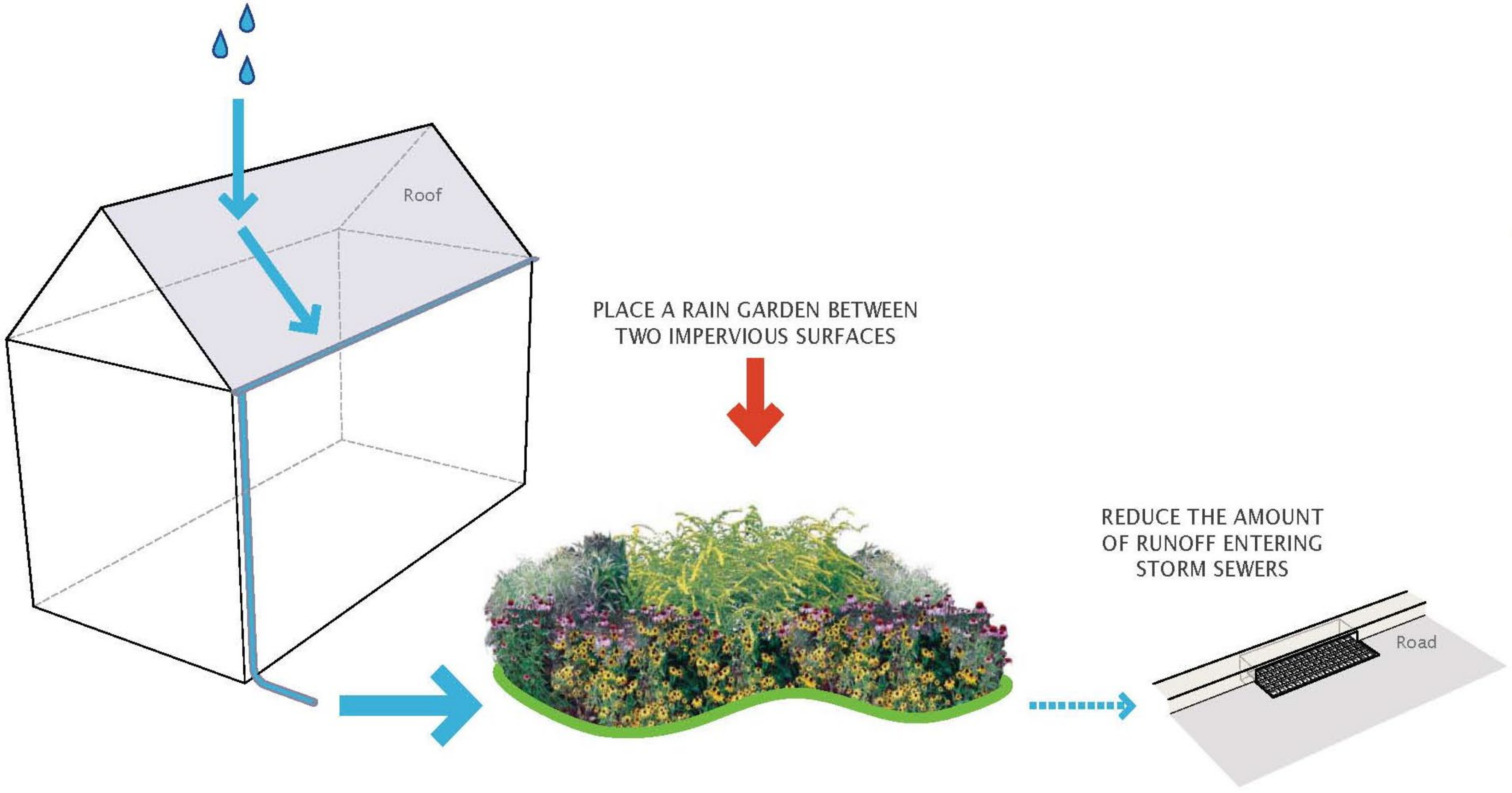
The Solution…



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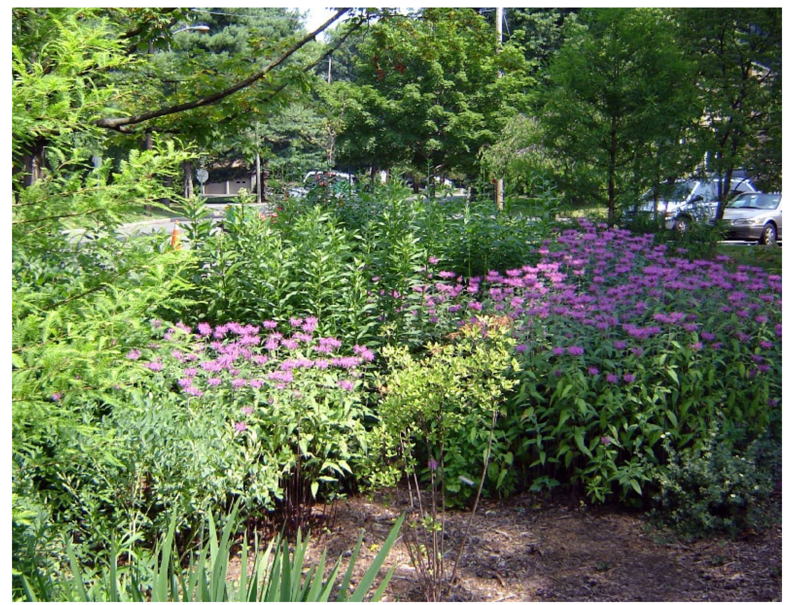
Rain Gardens

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

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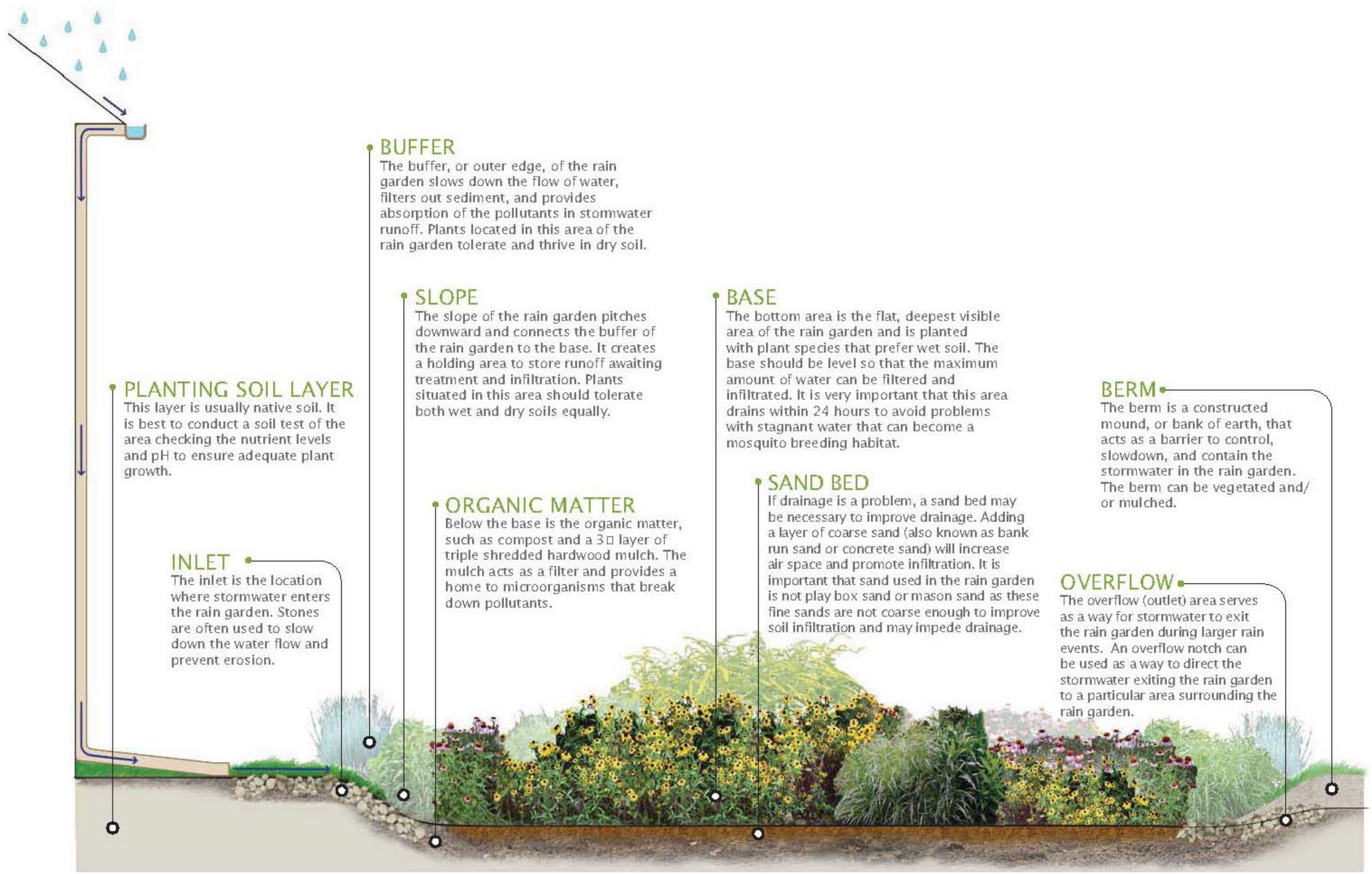
Rain Garden

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:

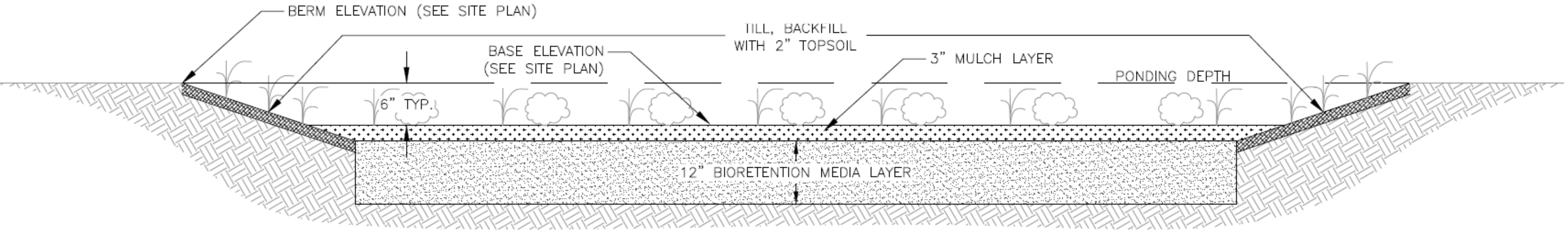
Removes nonpoint source pollutants from stormwater runoff while recharging groundwater

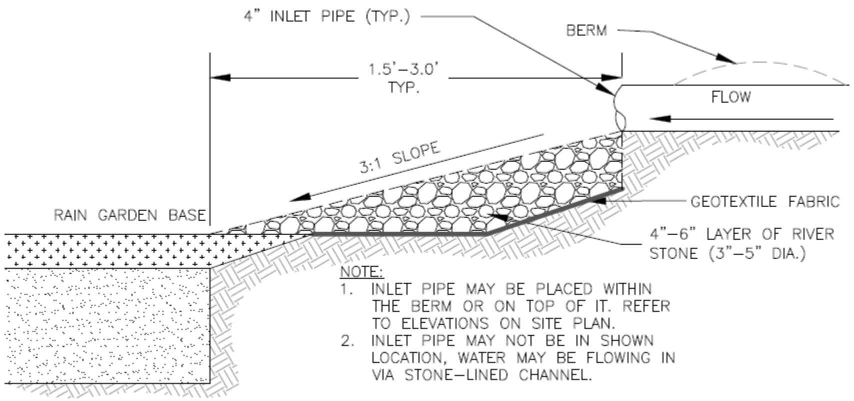
Restore/“mimic” predevelopment site hydrology
- Infiltration
- Evapotranspiration

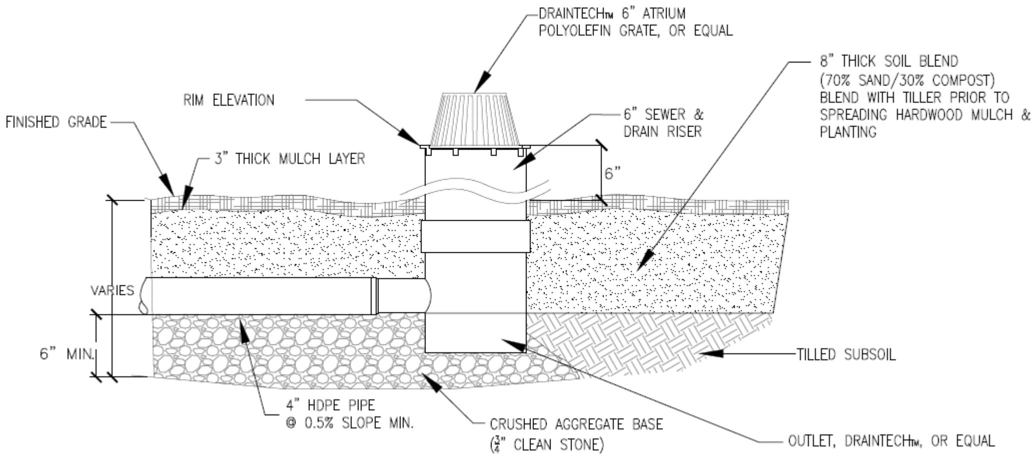
Improve water quality
- Sedimentation, filtration, and plant uptake
- Microbial Activity

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)

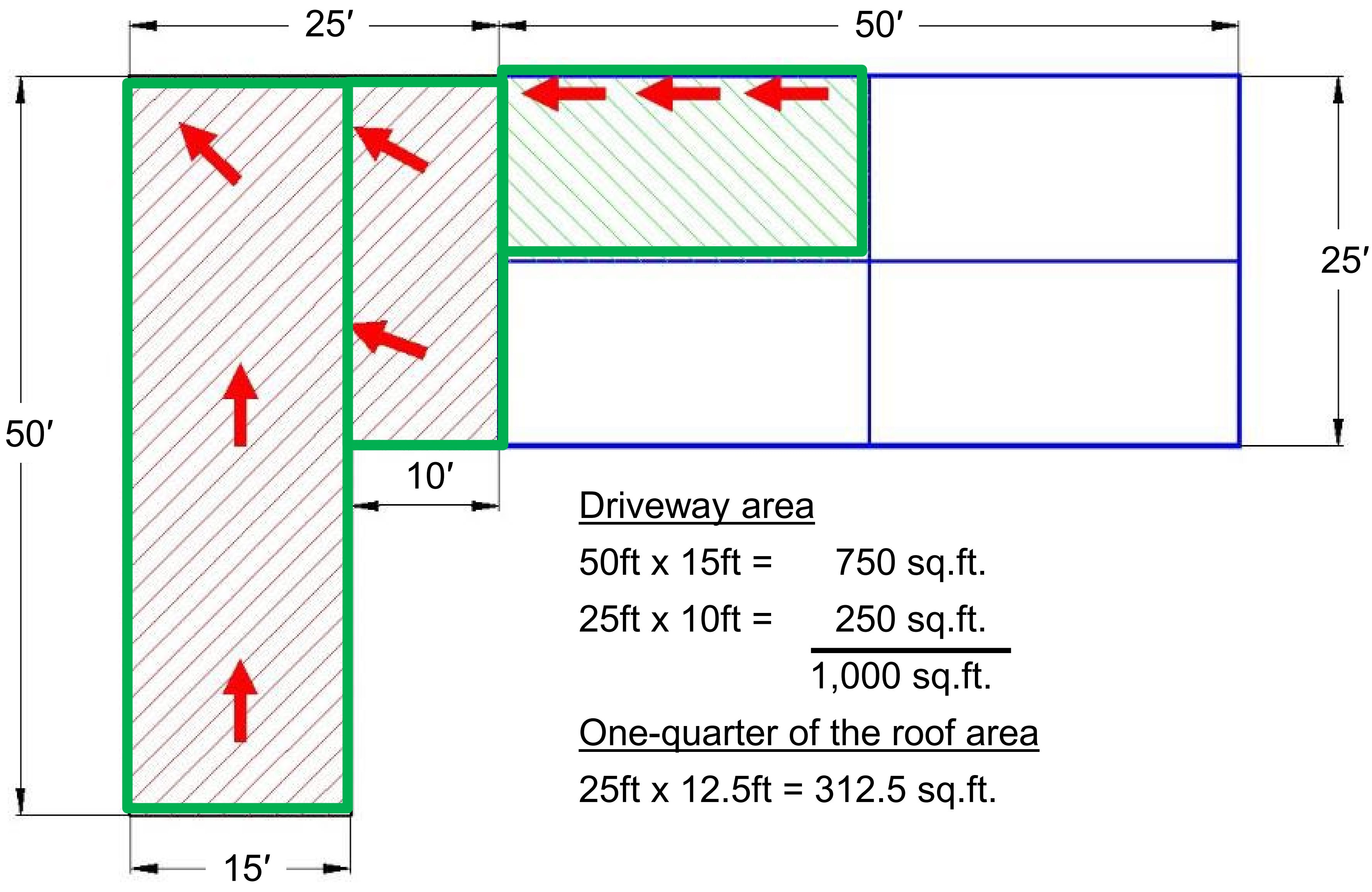
Design Parameters:

- 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

50ft x 15ft = 750 sq.ft.

25ft x 10ft = 250 sq.ft.

1,000 sq.ft.

One-quarter of the roof area

25ft x 12.5ft = 312.5 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 ÷ 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 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 (or 0.5 feet) deep
- 156 cubic feet ÷ 0.5 feet = 312 square feet

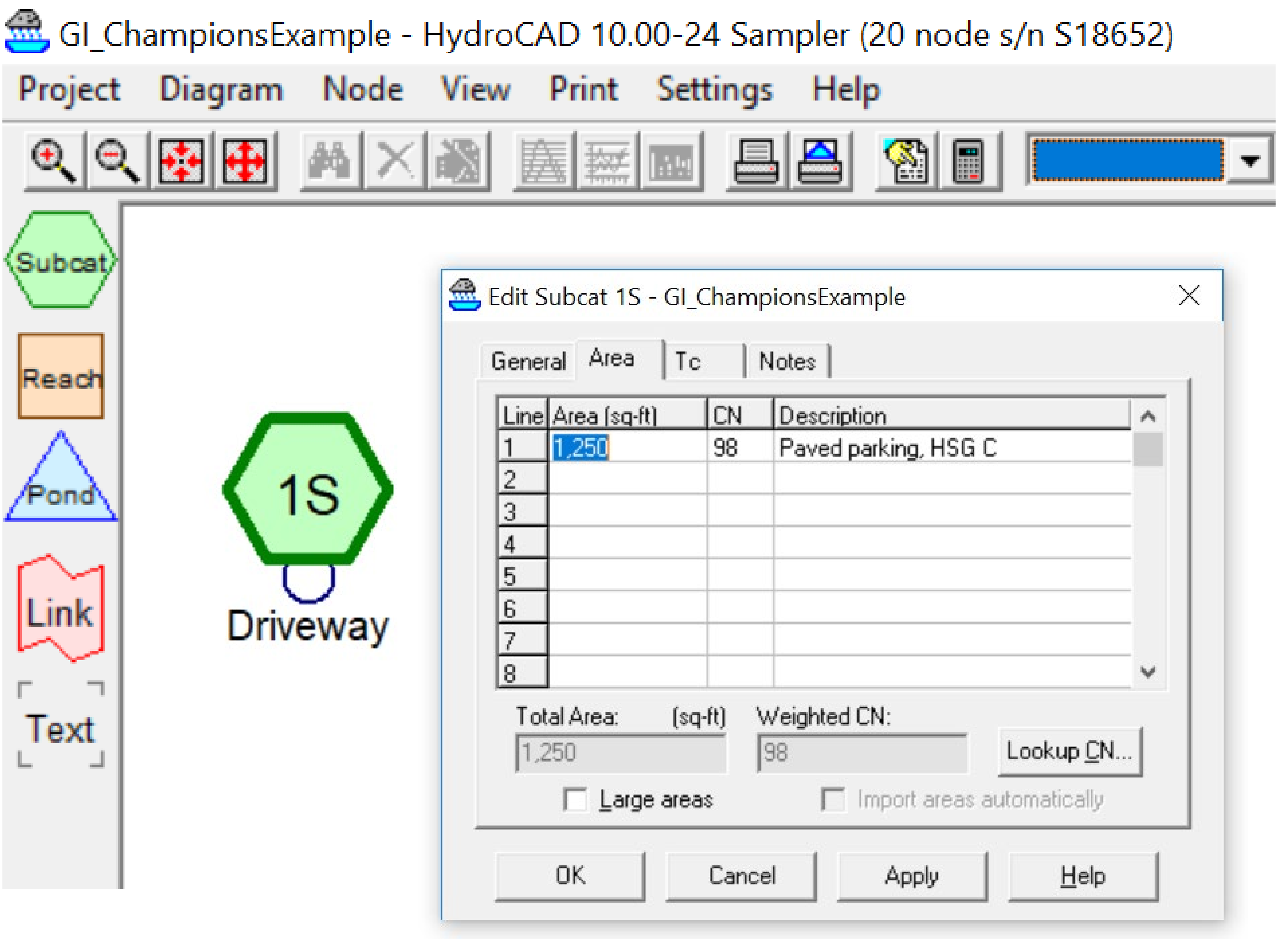
Answer:

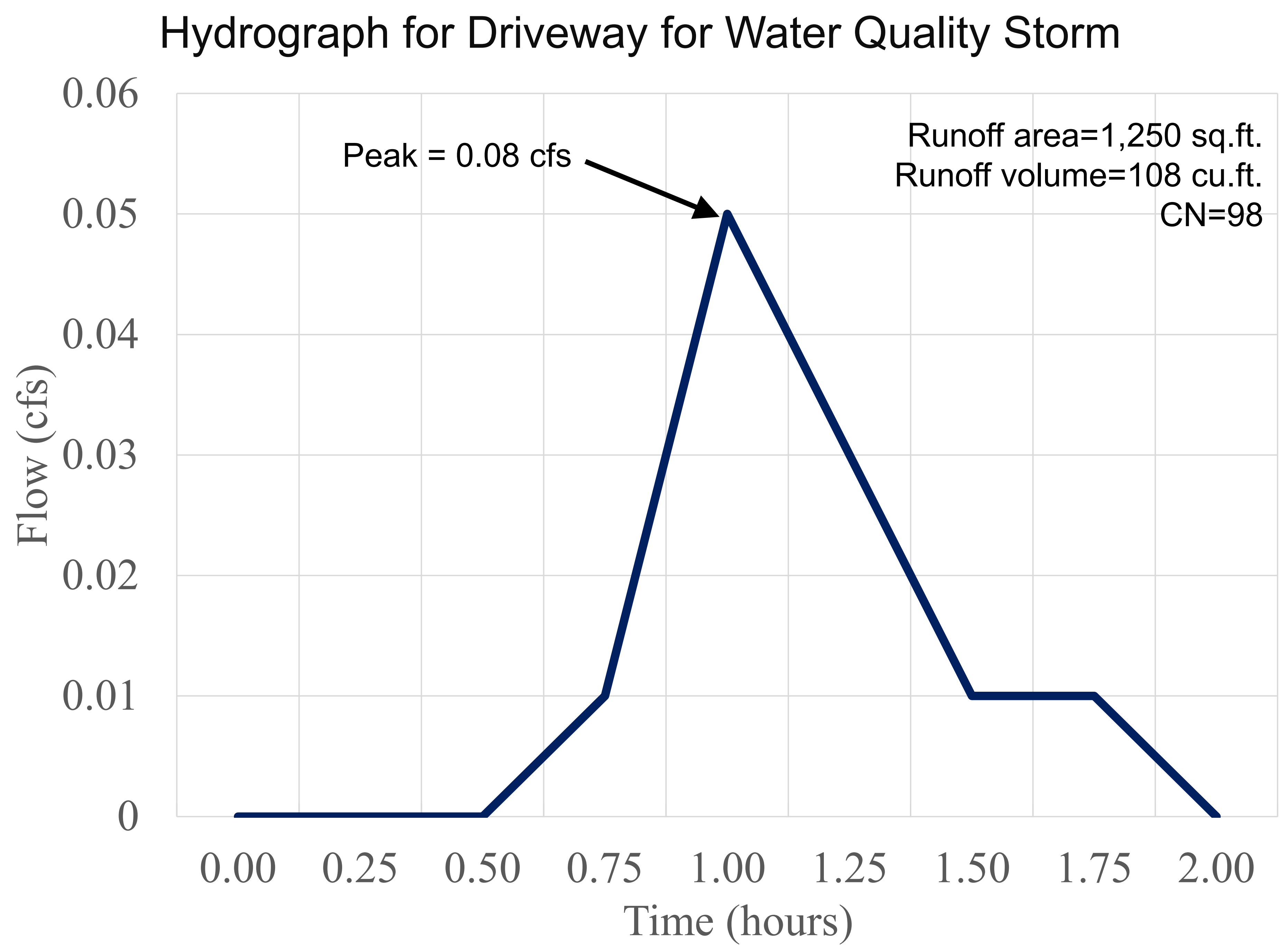
10 ft wide x 31.2 ft long = 312 square feet

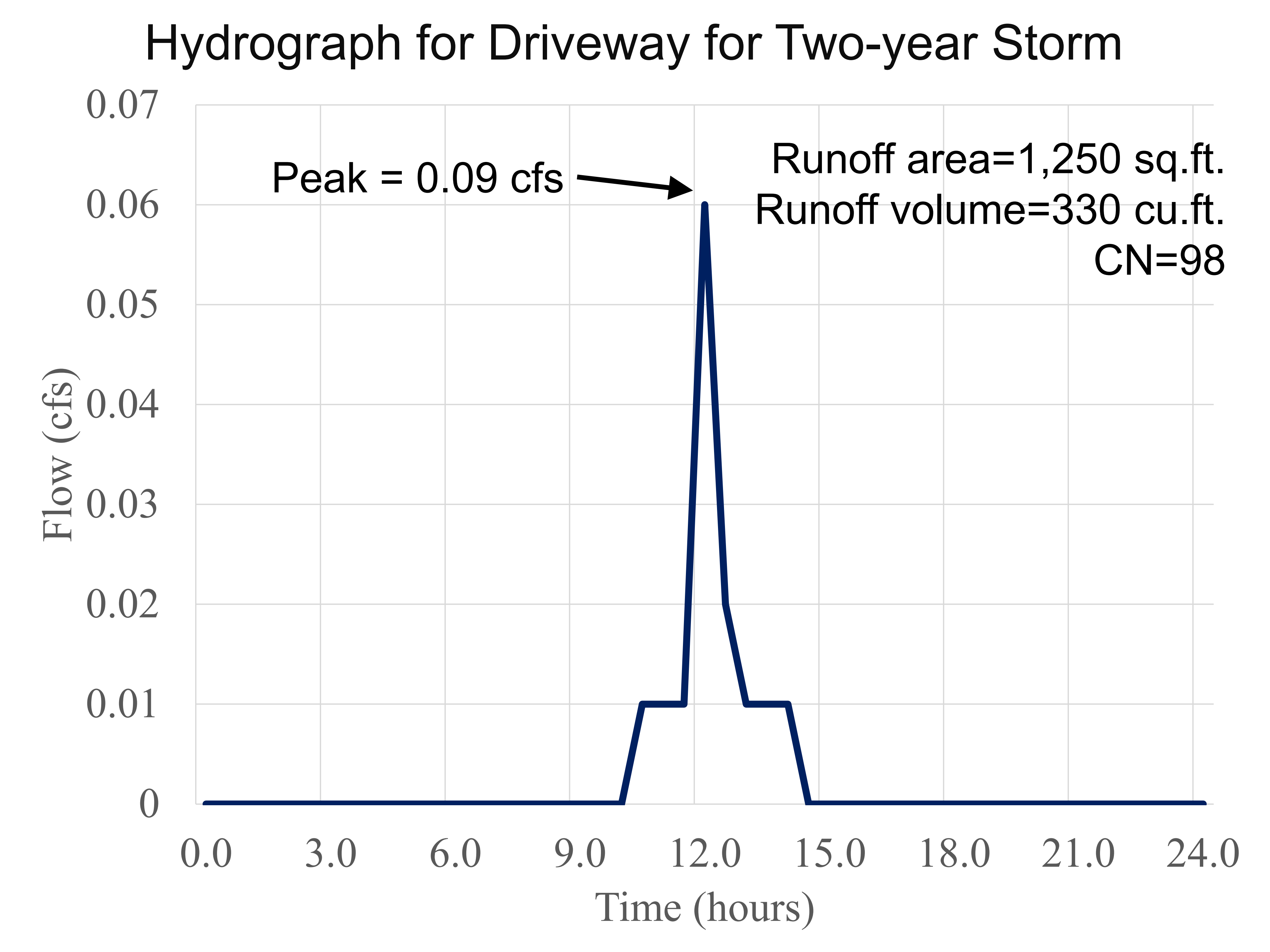
HydroCAD®

Stormwater Modeling

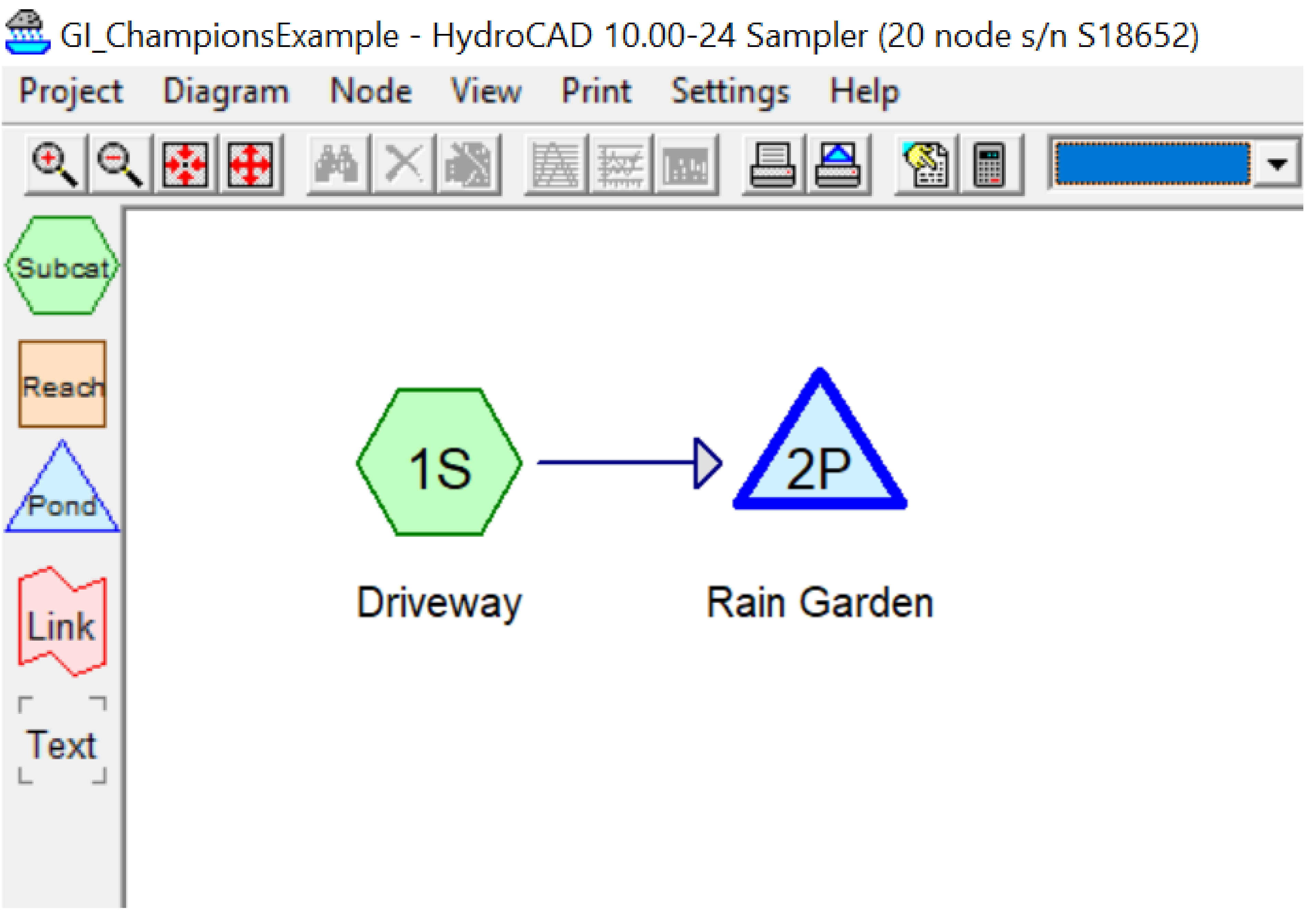
https://hydrocad.net/


GI_ChampionsExample - HydroCAD 10.00-24 Sampler (20 node s/n S18652)
Project Diagram Node View Print Settings Help
Subcat
Reach
Pond
Link
Text
1S
Driveway
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)
1,250
Weighted CN:
98
Lookup CN...
Large areas
Import areas automatically
OK Cancel Apply Help

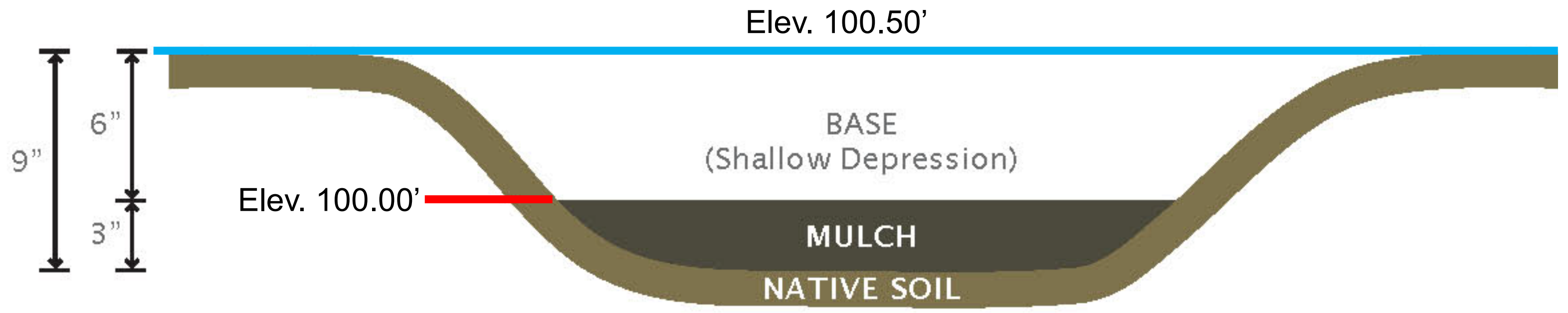

Hydrograph for Driveway for Water Quality Storm
Peak = 0.08 cfs
Runoff area=1,250 sq.ft.
Runoff volume=108 cu.ft.
CN=98
Flow (cfs)
0.06
0.05
0.04
0.03
0.02
0.01
0
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
Time (hours)



Hydrograph for Driveway for Two-year Storm
Peak = 0.09 cfs
Runoff area=1,250 sq.ft.
Runoff volume=330 cu.ft.
CN=98
Flow (cfs)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.0
3.0
6.0
9.0
12.0
15.0
18.0
21.0
24.0
Time (hours)


GI_ChampionsExample - HydroCAD 10.00-24 Sampler (20 node s/n S18652)
Project
Diagram
Node
View
Print
Settings
Help
Subcat
Reach
Pond
Link
Text
1S
Driveway
2P
Rain Garden

6" DEEP RAIN GARDEN - NO SOIL AMENDMENTS



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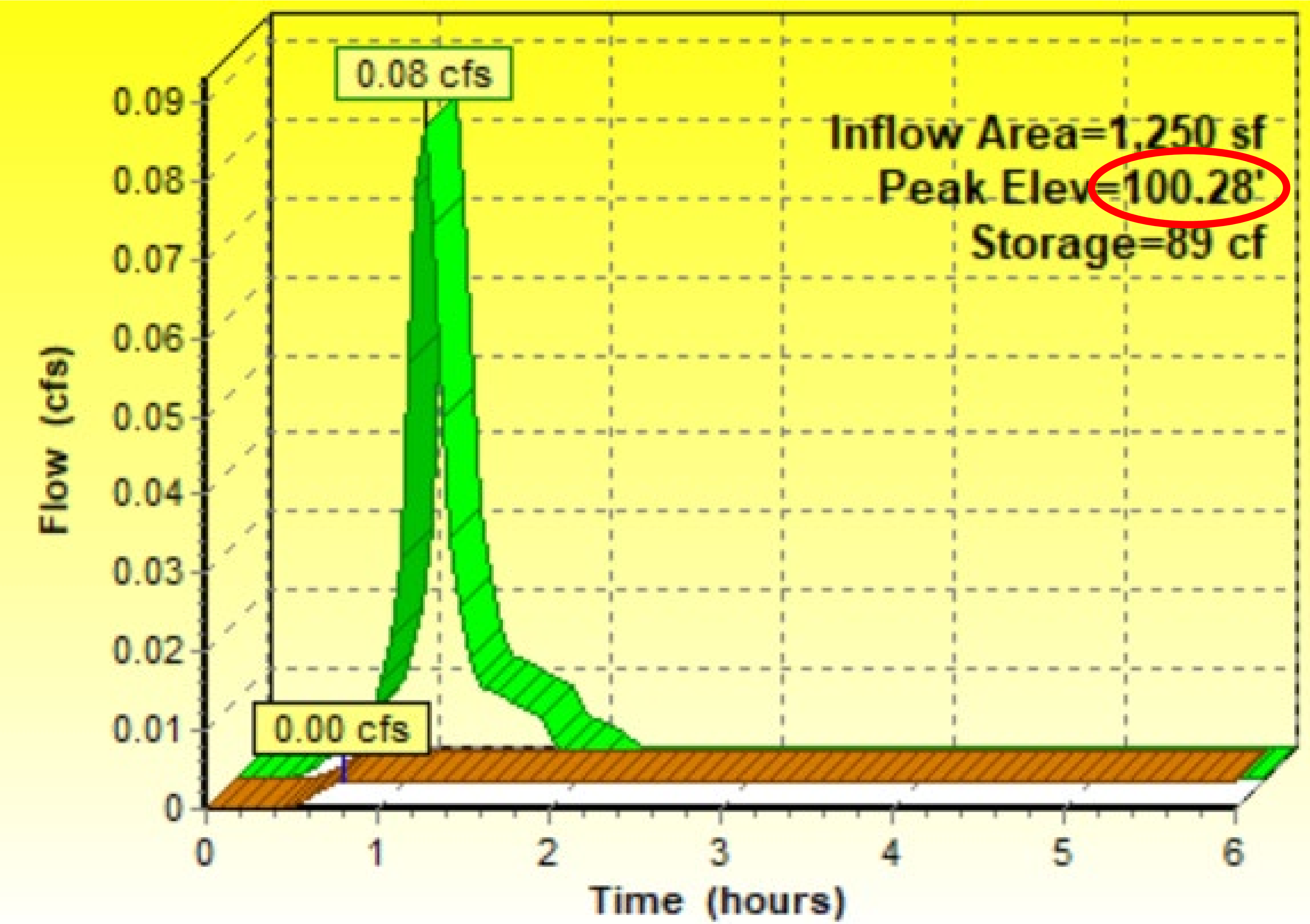
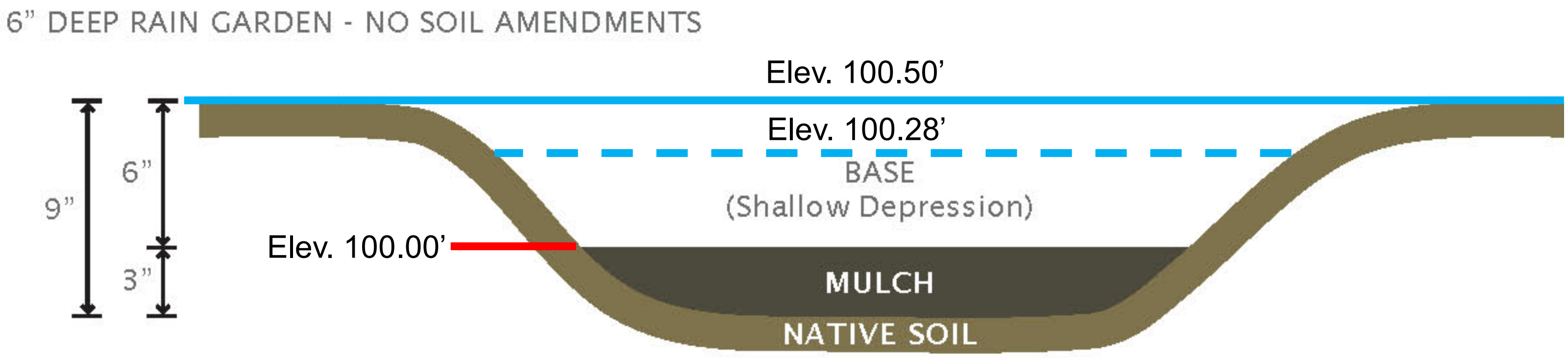
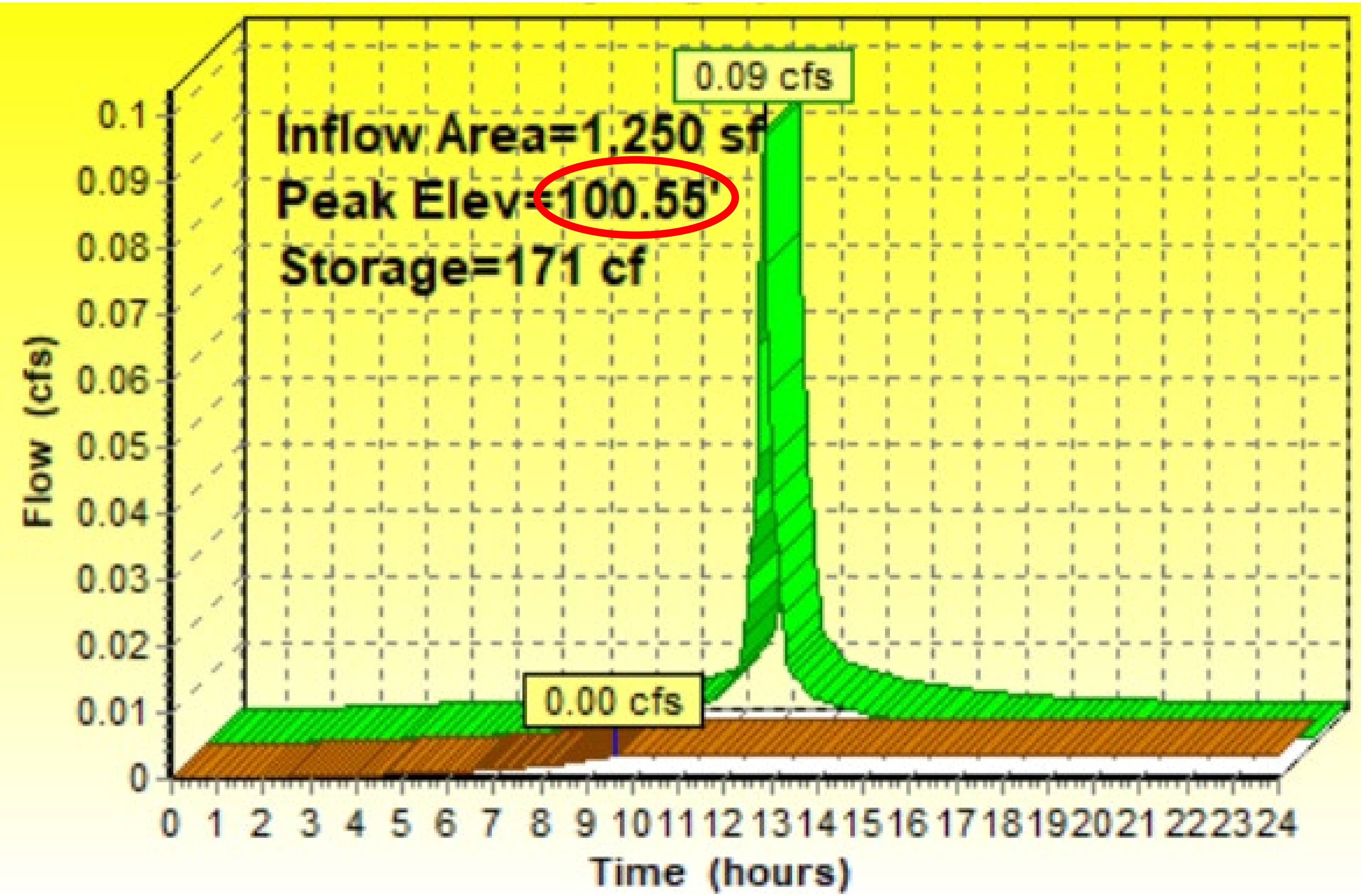


0.08 cfs
Inflow Area=1,250 sf
Peak Elev=100.28'
Storage=89 cf
0.00 cfs
Flow (cfs)
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
1
2
3
4
5
6
Time (hours)


6" DEEP RAIN GARDEN - NO SOIL AMENDMENTS
Elev. 100.50'
Elev. 100.28'
BASE
(Shallow Depression)
Elev. 100.00'
6"
9"
3"
MULCH
NATIVE SOIL



0.09 cfs
Inflow Area=1,250 sf
Peak Elev=100.55'
Storage=171 cf
0.00 cfs
Flow (cfs)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (hours)

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!**

How much pollution load does the rain garden remove?
What is pollutant load?

Pollutant concentration is measured in parts per million or milligrams per liter. For example, the wastewater treatment plant is discharging 3 mg/L of total phosphorus to the river. The state criteria is 0.1 mg/L.

Pollutant load is measured in pounds per day or kilogram per day. The wastewater treatment plant is discharging 3 million gallons per day and its discharge has a concentration of 3.0 mg/L of total phosphorus. The treatment plant is discharging 75 lb/day of total phosphorus.

(Lbs/day = MGD x (ppm or mg/L) x 8.34 lbs/gal)

How much pollution load does the rain garden remove?

<u>If it has an underdrain system</u>:

- 90% total suspended solids
- 60% total phosphorus
- 30% total nitrogen

This is pollutant concentration reduction

<u>Without an underdrain system</u>:

- 95% total suspended solids
- 95% total phosphorus
- 95% total nitrogen

This is pollutant load reduction

Typical loads from commercial land uses is 200 lbs/acre/year of TSS, 22 lbs/acre/year of total nitrogen, and 2.1 lbs/acre/year of total phosphorus

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:

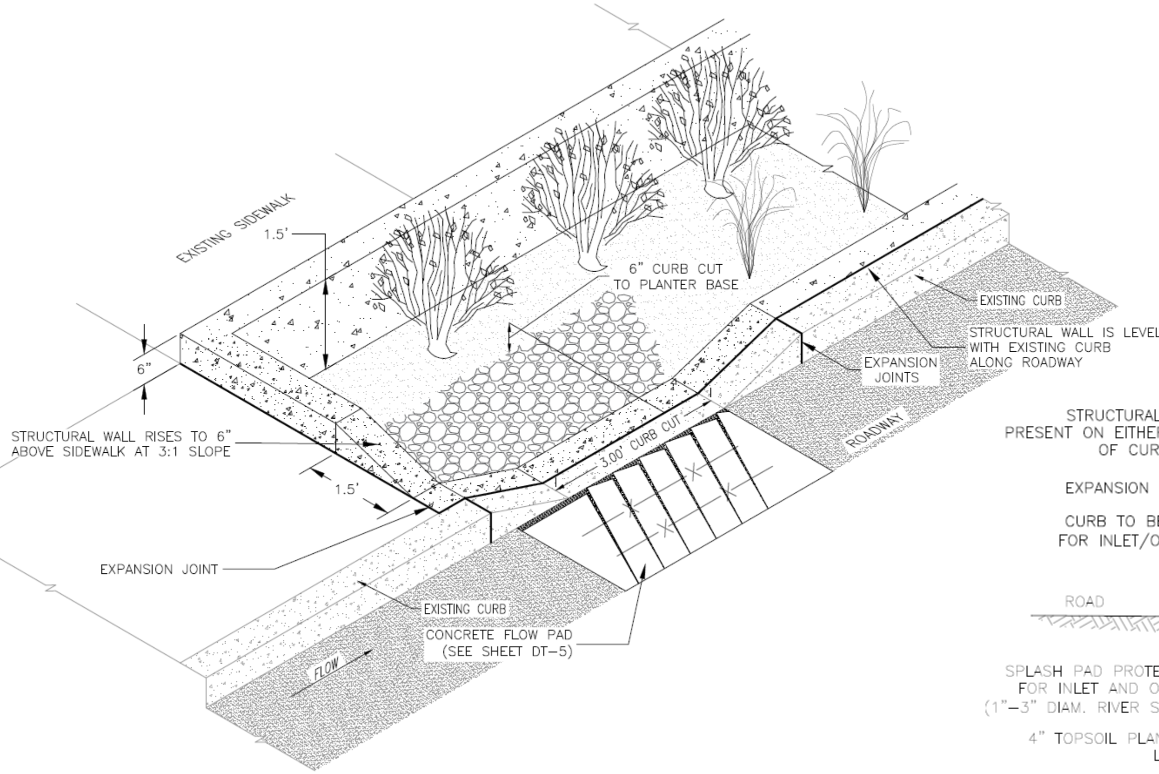
- It is a structural bioretention system that is installed in a sidewalk
- Contains a layer of stone that is topped with bioretention media and plants or trees
- Captures stormwater runoff from the roadway and sidewalk
- Once the system fills up, runoff flows back into the street or into an overflow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

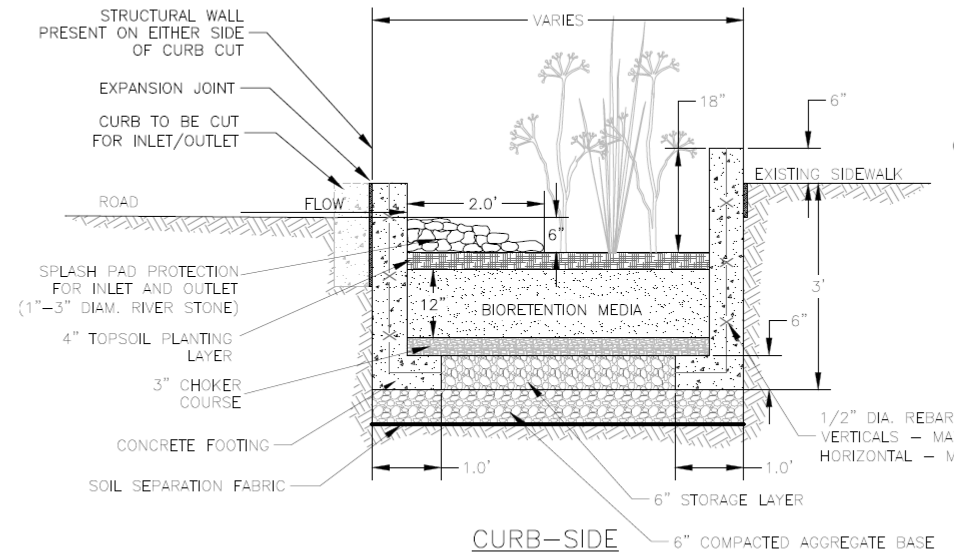
Benefits:

- Allows water to infiltrate into the ground

Stormwater Planters

Typically, 4 feet wide by 20 feet long





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 inch/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 inch/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

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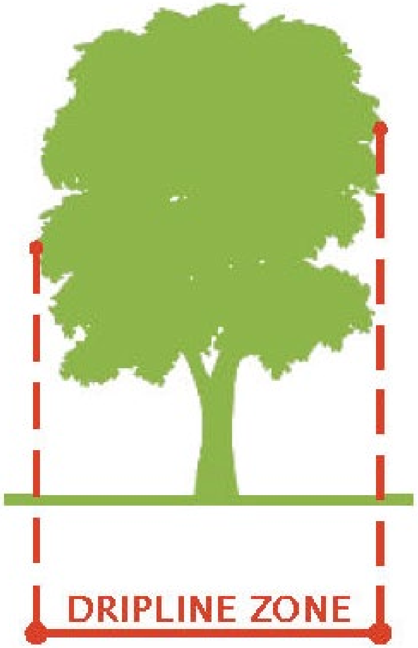
1. Next to a building with a basement, rain garden should be located min. 10′ from building; no basement: 2′ from building
2. Do not place rain garden within 25′ of a septic system
3. Do not situate rain garden in soggy places where water already ponds
4. Avoid seasonably-high water tables within 2′ 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



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CALL BEFORE YOU DIG

LOCATE YOUR UTILITY LINES!

Call BEFORE You Dig!

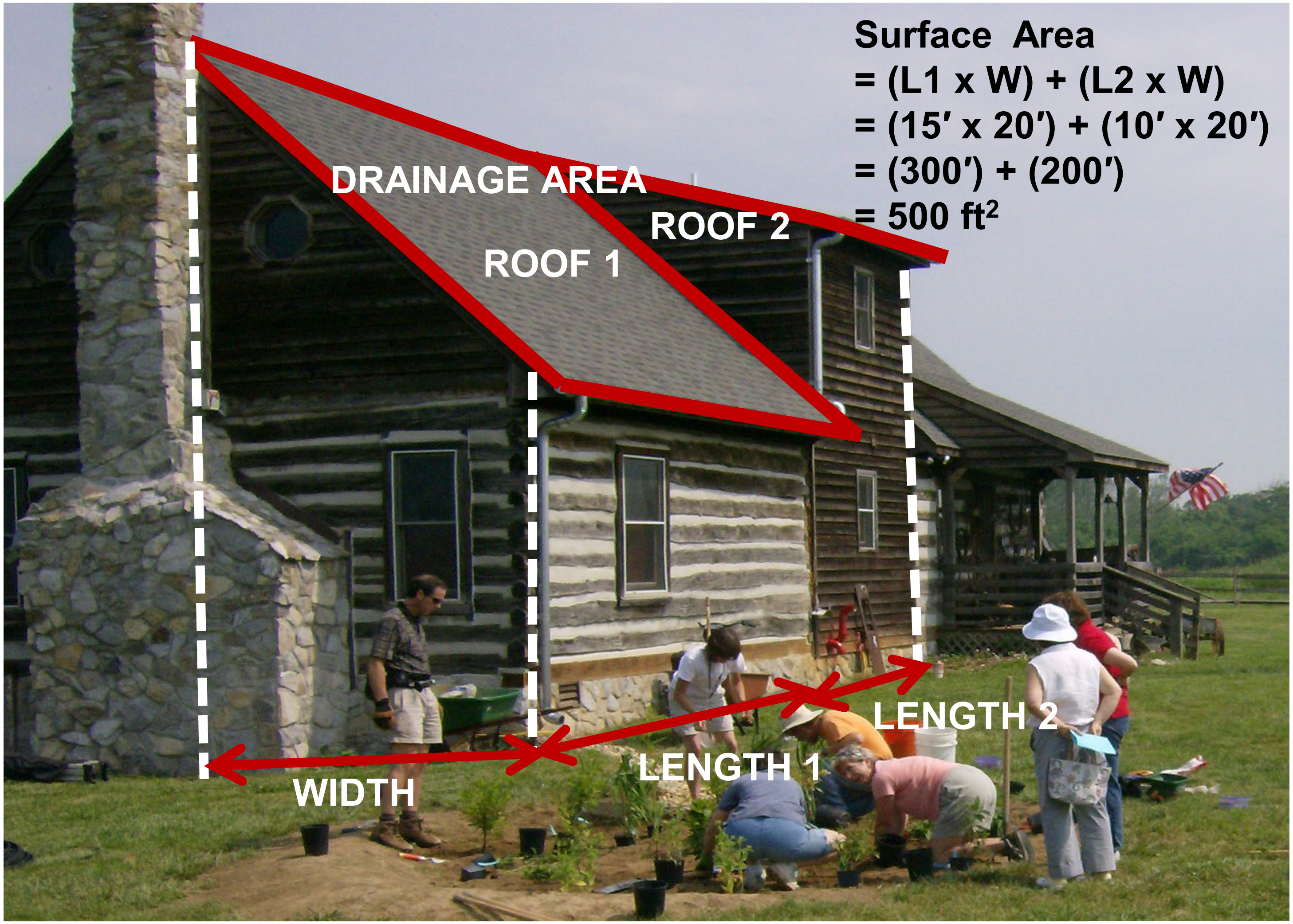
NJ One Call
1-800-272-1000

The different colors of the markout flags represent specific utilities.

- *ELECTRIC* (red)
- *GAS, OIL, STEAM* (yellow)
- *COMMUNICATIONS, CATV* (orange)
- *WATER* (blue)
- *SEWER* (green)

- **NJ One Call: 1-800-272-1000**
- Free markout of underground gas, water, sewer, cable, telephone, and electric utility lines
- Call at least three (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



CHECK YOUR SOIL

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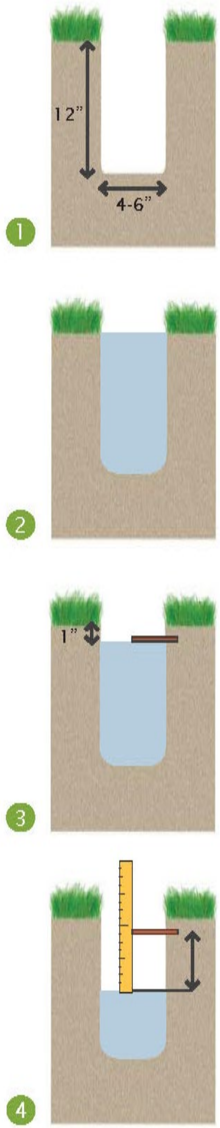

- Infiltration/Percolation Test
  1. Dig a hole in the proposed rain garden site (12″ deep, 4-6″ wide)
  2. Fill with water to saturate soil and then let stand until all the water has drained into the soil
  3. Once water has drained, refill the empty hole again with water so that the water level is 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

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DETERMINING THE DEPTH OF THE RAIN GARDEN

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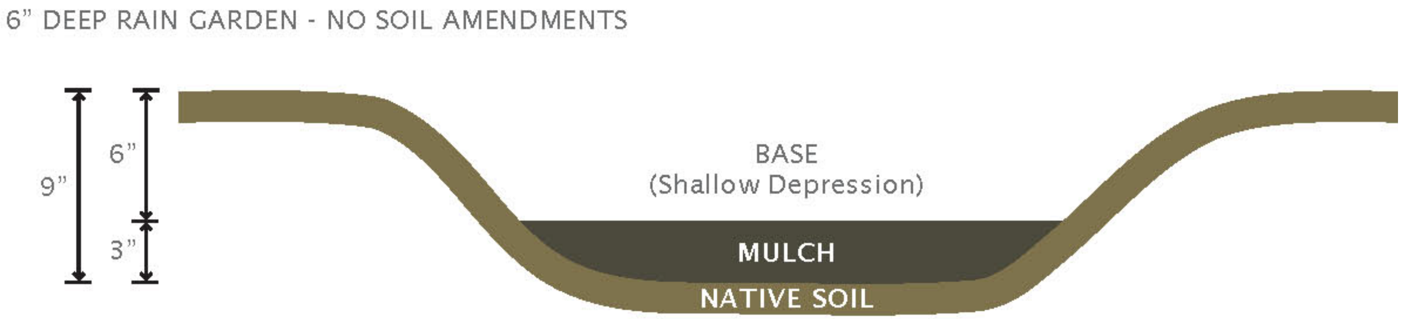

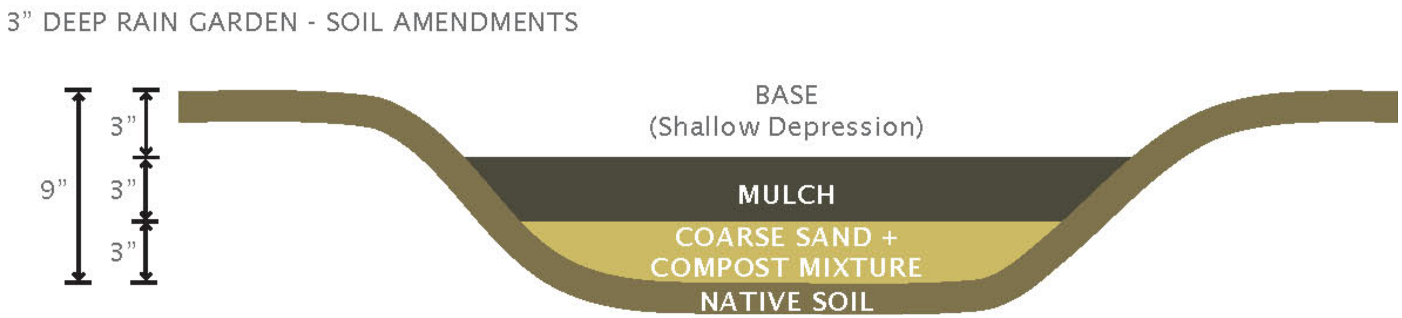

- Depth of rain garden is dependent upon the soil texture found at the site of the rain garden
- Depth is usually 3-8 inches

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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^2	200 ft^2	100 ft^2	75 ft^2
750 ft^2	350 ft^2	150 ft^2	112 ft^2
1,000 ft^2	400 ft^2	200 ft^2	149 ft^2
1,500 ft^2	600 ft^2	300 ft^2	224 ft^2
2,000 ft^2	800 ft^2	400 ft^2	299 ft^2

*SOIL TEXTURE AMENDMENTS NEEDED

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SOIL AMENDMENTS

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

DETERMINING THE INLET AND OVERFLOW

p. 27

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

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PREVENTING EROSION

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

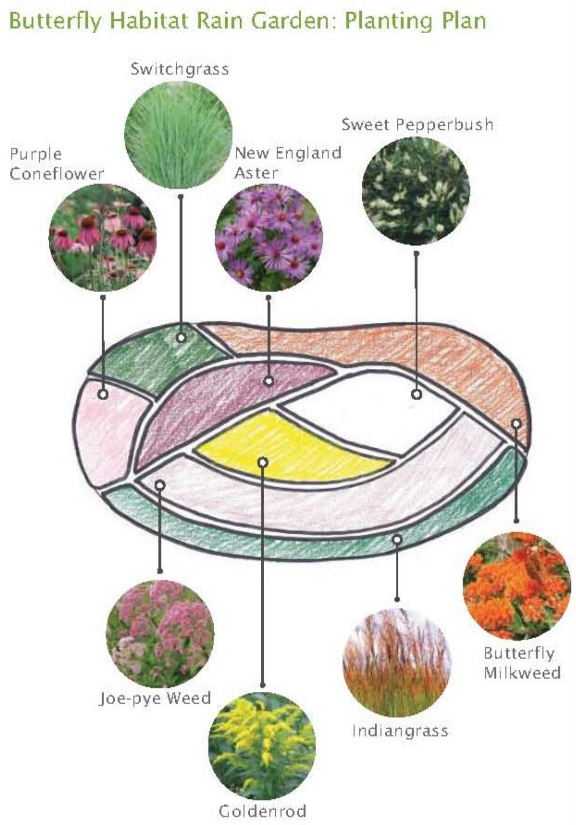
DETERMINING MULCH QUANTITY

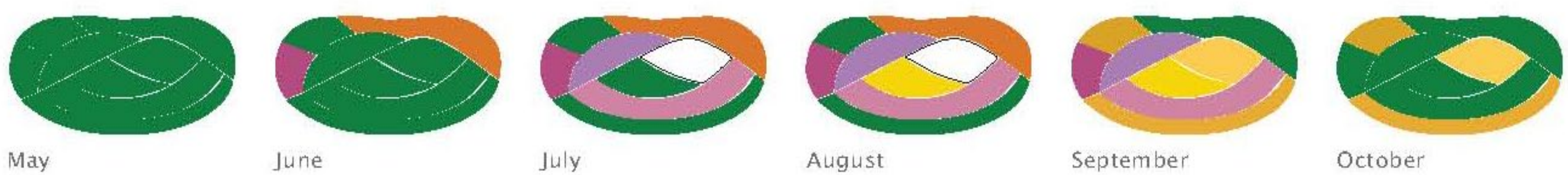
- Allow for a 3″ depth of mulch (triple-shredded hardwood with no dye) to be spread throughout the entire rain garden
- Every 100 square feet of rain garden needs 1 cubic yard (3″ depth)

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; your rain garden can take on whatever shape you prefer





THE FUN PART!

INSTALLING YOUR RAIN GARDEN

STEP ONE

- Delineate rain garden area

- Remove existing grass with a shovel or machinery

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STEP TWO

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

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STEP THREE

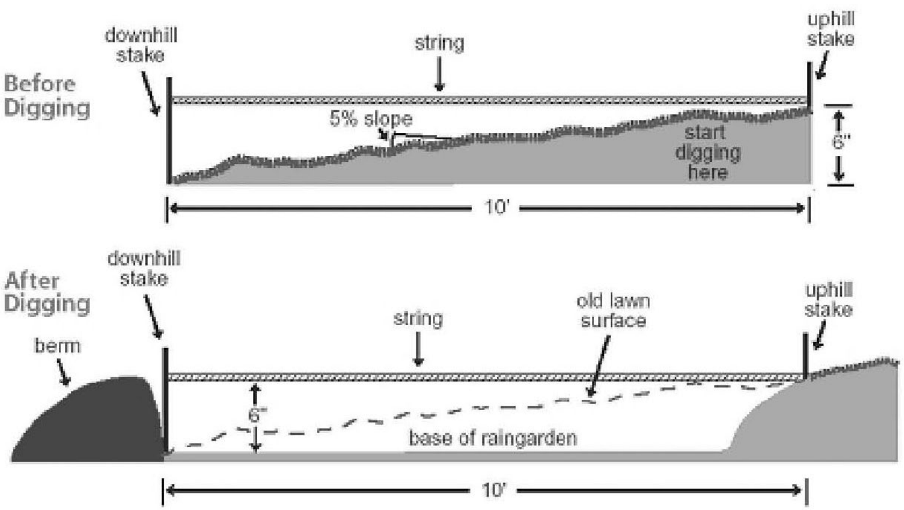
- Add soil amendments, if necessary



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

STEP FOUR

- Prepare the berm, if necessary



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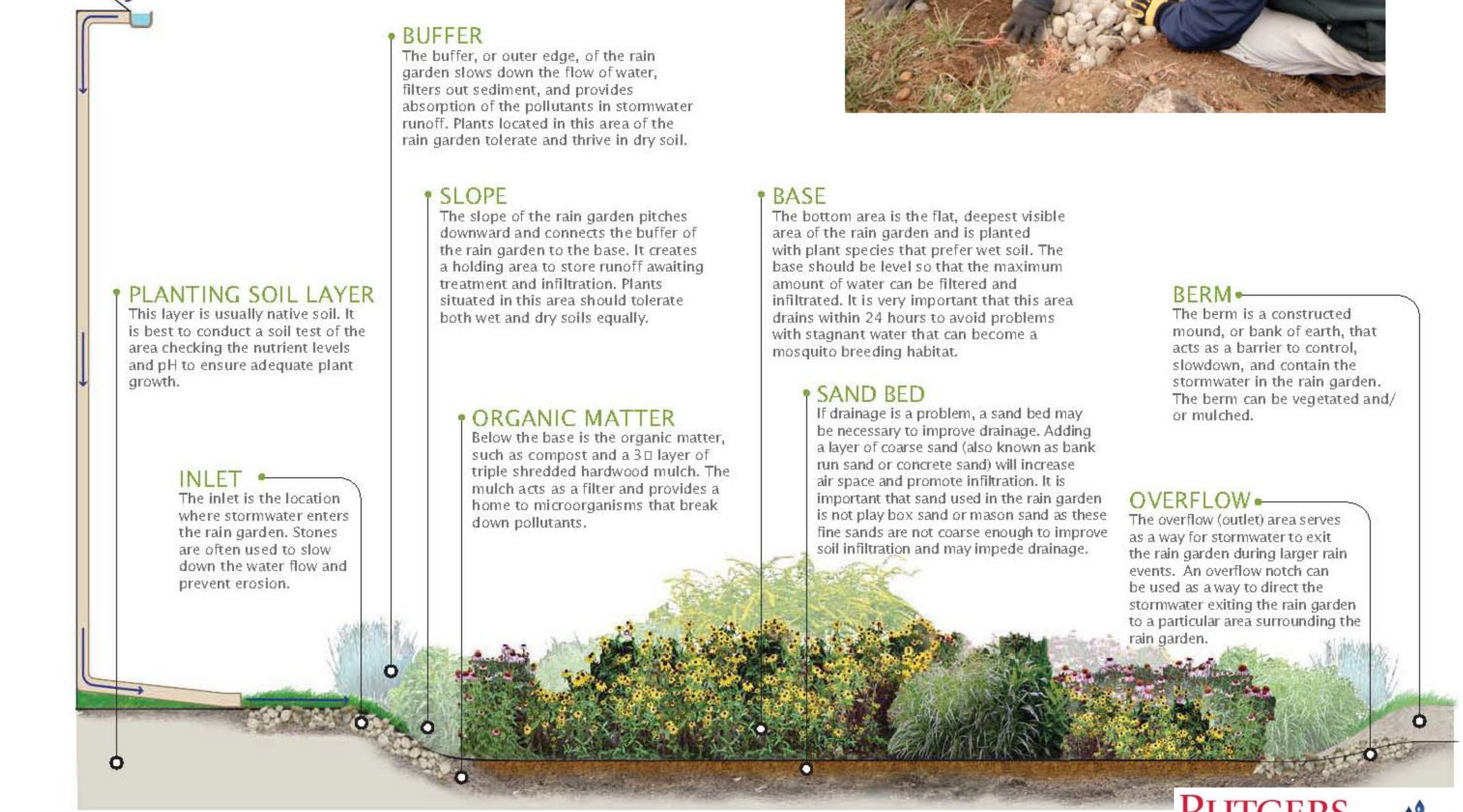
STEP FIVE

- Prepare the overflow



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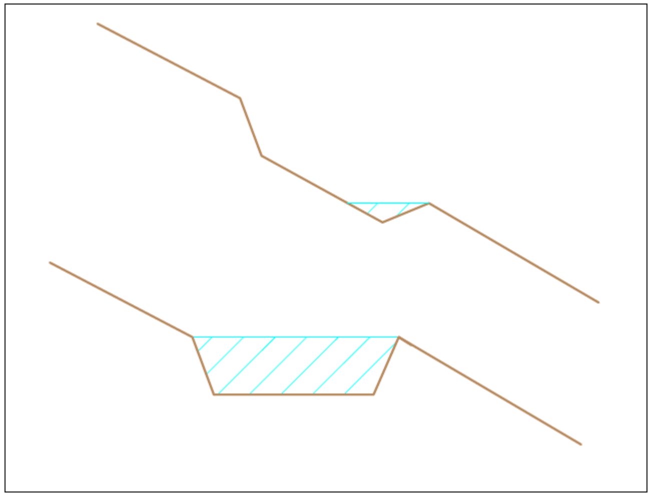
STEP SIX

- Level the rain garden base



STEP SEVEN

- Plant native species







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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 the plants

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STEP TEN

- Appreciate a job well done

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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






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PLANTS IN THE RIGHT PLACE…

Courtesy of Pinelands Nursery & Supply

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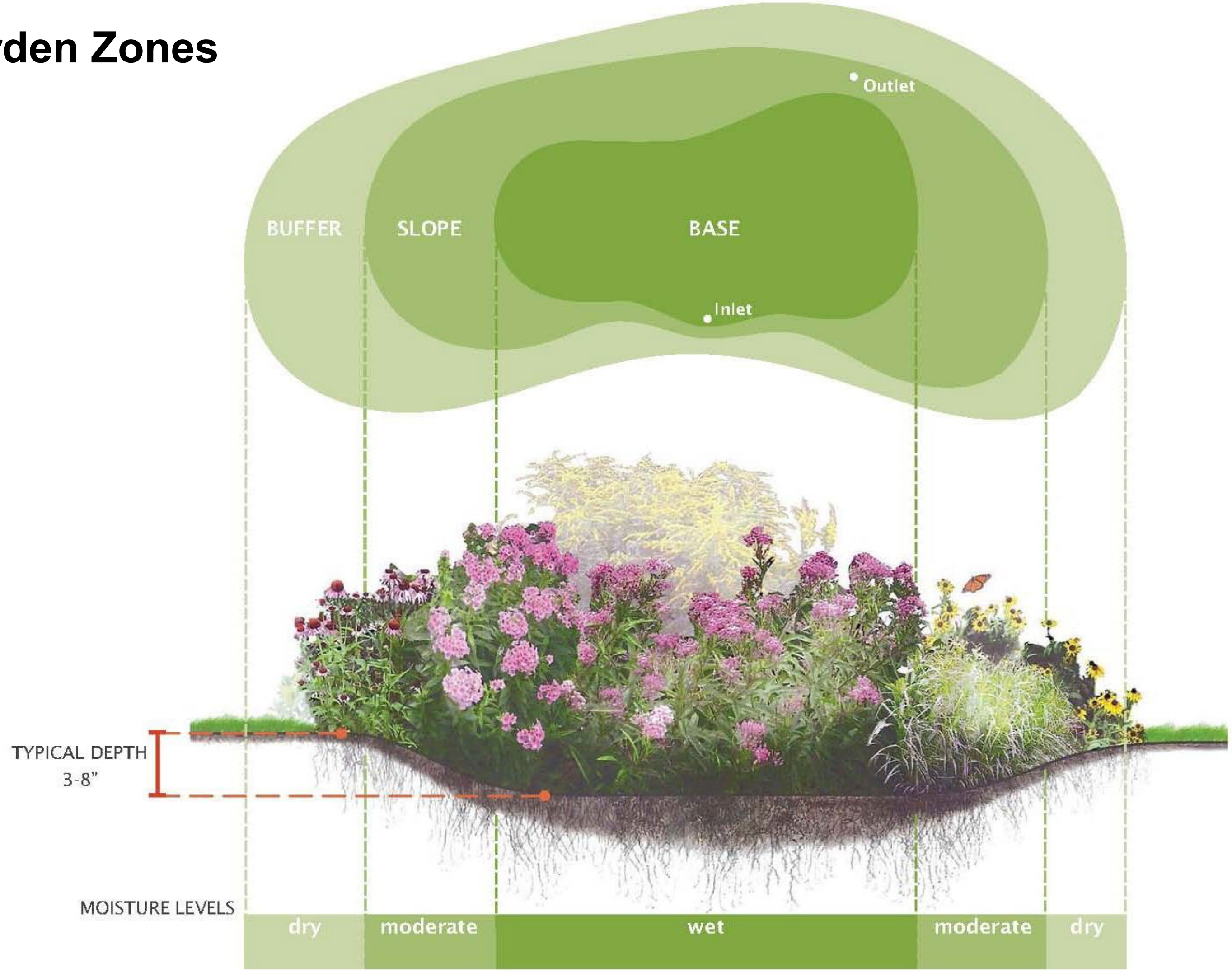
PLANTING DESIGN: Wet + Dry Conditions

Rain Garden Zones



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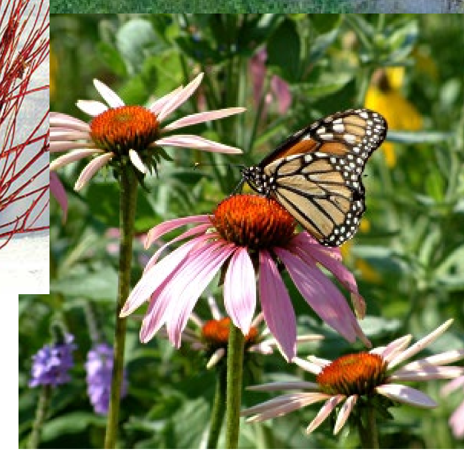
SELECTING PLANT SPECIES

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



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GRASSES & GROUND COVERS

UPL | FACU | FAC | FACW | OBL

DRY → WET

BUFFER

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

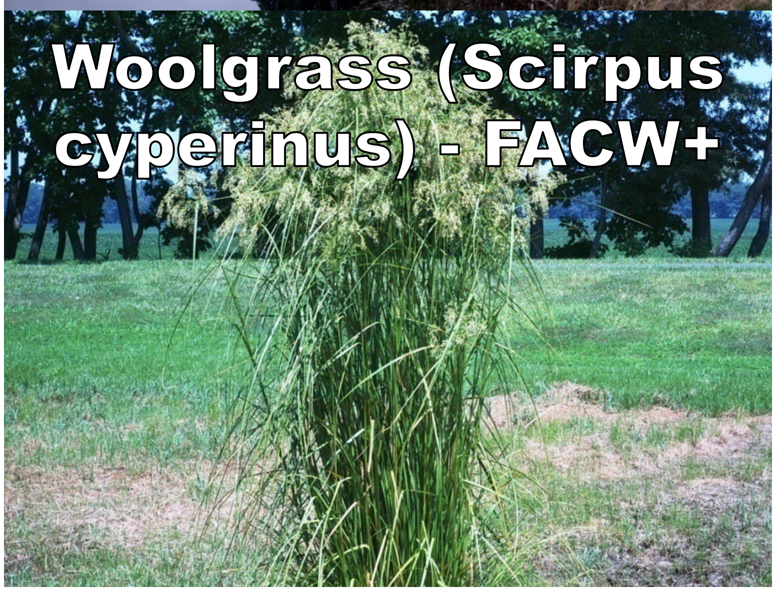
BASE

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

SLOPE

- Bluejoint grass
- Sedges
- Fowl mannagrass
- Softrush

GRASSES & GROUND COVERS



WILDFLOWERS & FERNS

UPL | FACU | FAC | FACW | OBL

DRY → WET

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

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WILDFLOWERS

TREES & SHRUBS

UPL | FACU | FAC | FACW | OBL

DRY → WET

BUFFER

- Hackberry
- Red Bud
- Pepperbush
- American Holly
- Bayberry
- Witch-Hazel
- 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

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TREES & SHRUBS

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INSPECTION AND MAINTENANCE

MAINTAINING YOUR RAIN GARDEN

MAINTENANCE MEASURES

WEEKLY TASKS:

1. Watering
2. Weeding
3. Inspecting

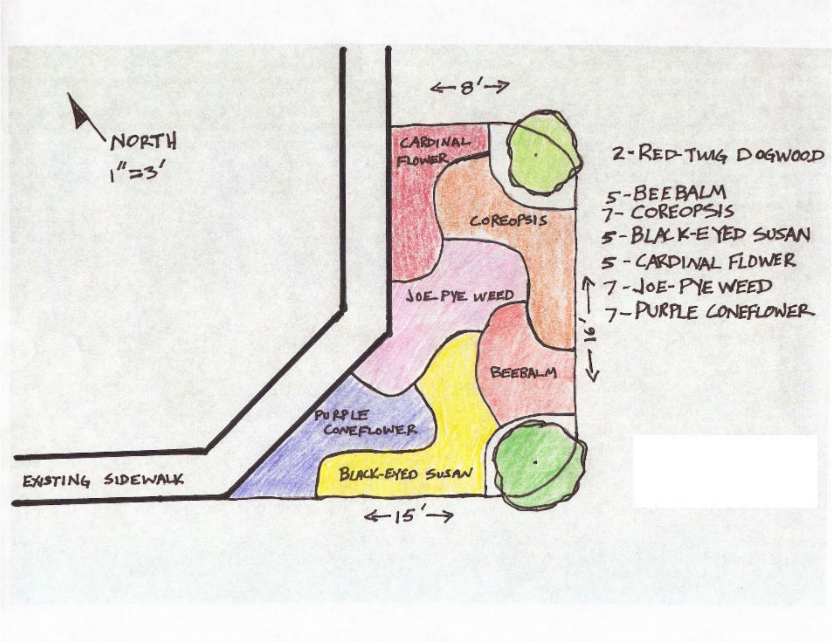
ANNUAL TASKS:

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

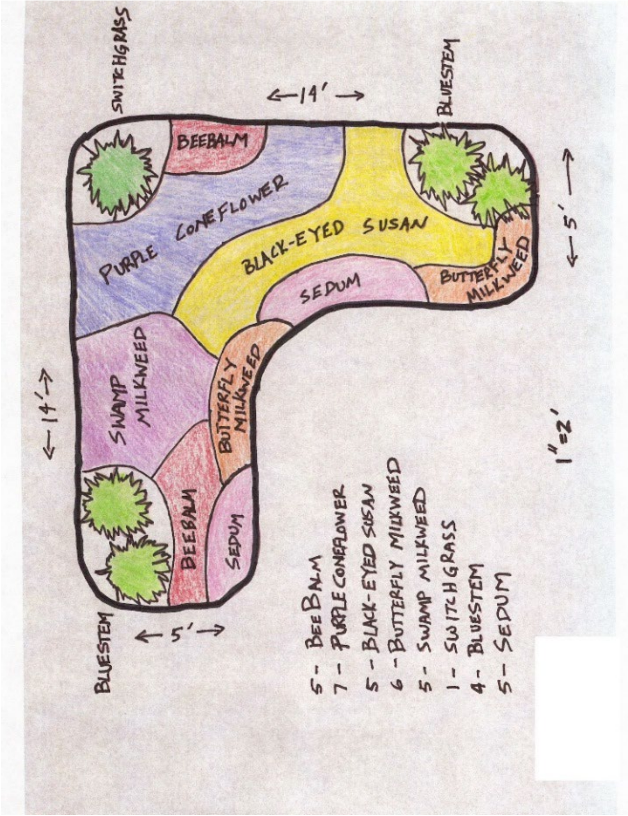
Design



Installed Rain Garden

Design Example for Parking Lot Runoff

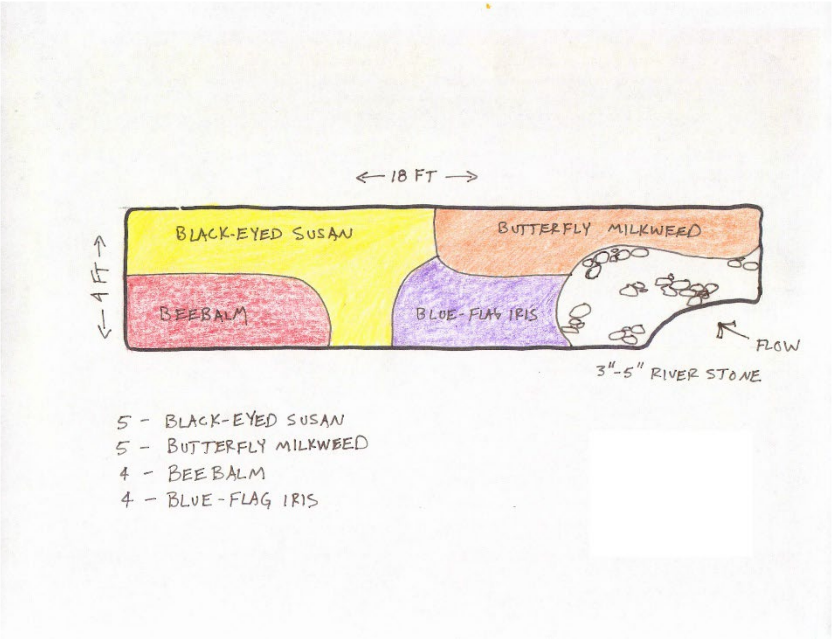
Design



Installed Rain Garden

Roof, Sump Pump and Driveway Runoff – WOW!

Design



Installed Rain Garden

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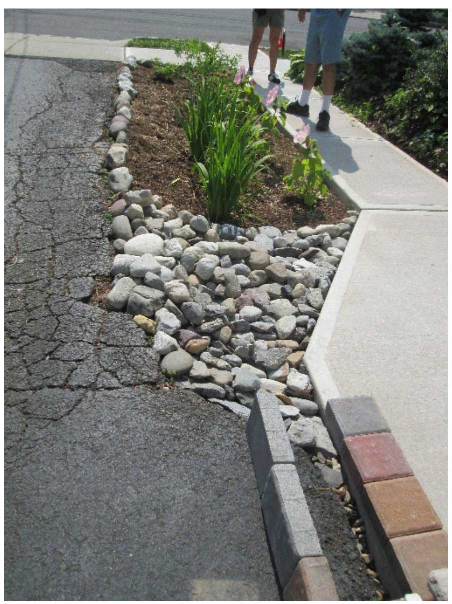

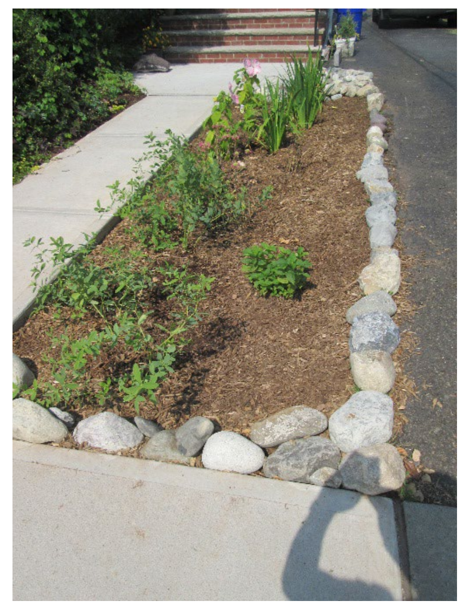

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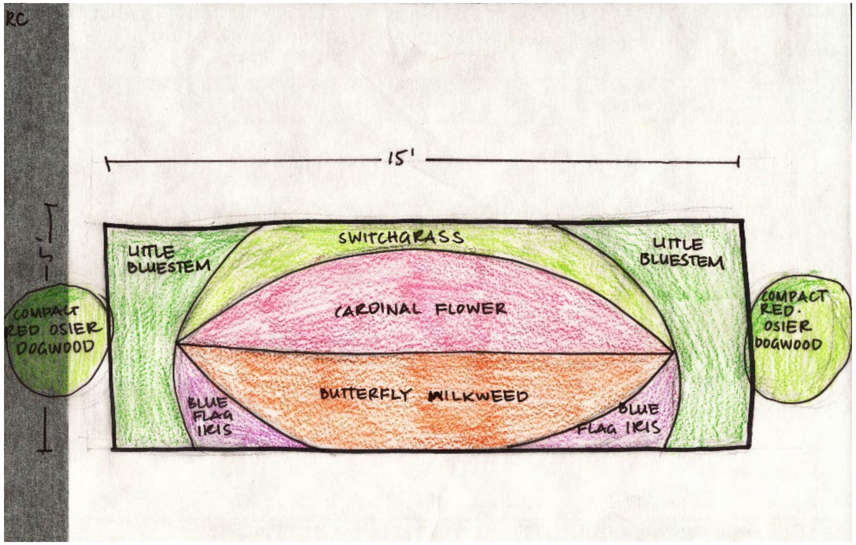
Roof Runoff from Rain Barrel Overflow

Design



Installed Rain Garden

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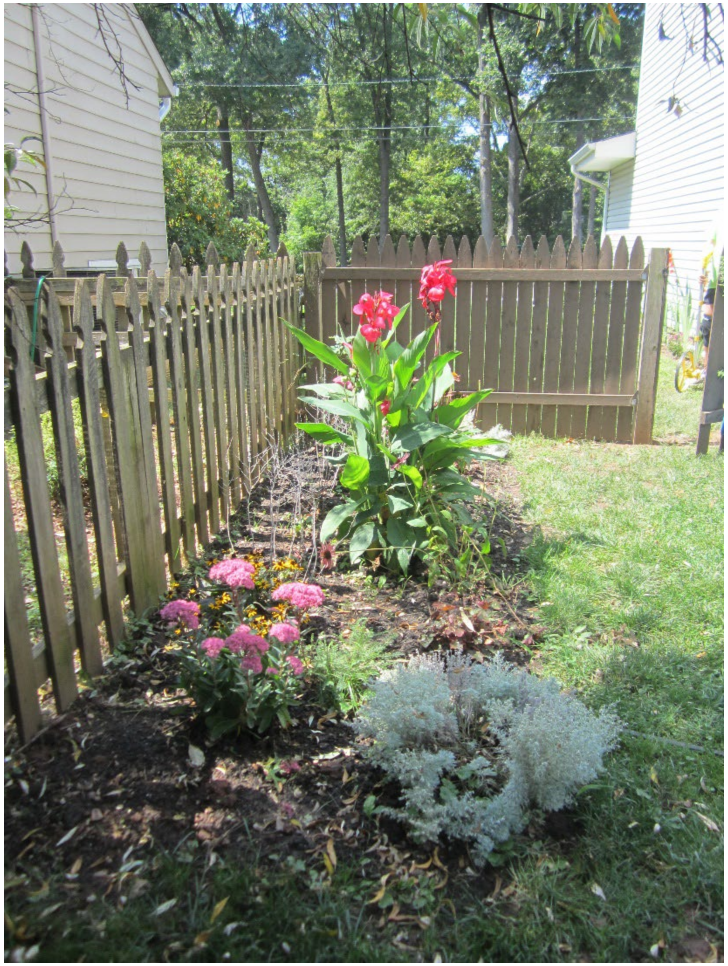


QUESTIONS?