

# Increasing Climate Resilience throughout the Royce Brook Watershed

*presented to  
Manville, New Jersey  
on October 14, 2024*



**RUTGERS**  
New Jersey Agricultural  
Experiment Station



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**Project goal is to reduce flooding in  
Hillsborough and Manville**  
*(supported by NFWF Coastal Resiliency Fund)*

- Design stormwater management systems that will manage the 100-year storm from existing development
- Prioritize nature-based solutions
- Design retrofits to manage the increase in rainfall due to climate change for sites that already have stormwater management

Condition (100-yr Design Storm)	24-hour rainfall total (in)
2000 Rainfall Total	8.21
2020 Rainfall Total	8.95
2100 Rainfall Total	12.15

# Types of Nature-Based Solutions (FEMA, 2021)

- **WATERSHED OR LANDSCAPE SCALE:** Interconnected systems of natural areas and open space

These are large-scale practices that require long-term planning and coordination.

- **NEIGHBORHOOD OR SITE SCALE:** Distributed stormwater management practices that manage rainwater where it falls

These practices can often be built into a site, corridor, or neighborhood without requiring additional space.

- **COASTAL AREAS:** Nature-based solutions that stabilize the shoreline, reducing erosion and buffering the coast from storm impacts

While many watershed and neighborhood-scale solutions work in coastal areas, these systems are designed to support coastal resilience.

# WATERSHED SCALE

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## LAND CONSERVATION

Land conservation is one way of preserving interconnected systems of open space that sustain healthy communities.

Land conservation projects begin by prioritizing areas of land for acquisition. Land or conservation easements can be bought or acquired through donation.



## GREENWAYS

Greenways are corridors of protected open space managed for both conservation and recreation.

Greenways often follow rivers or other natural features. They link habitats and provide networks of open space for people to explore and enjoy.



## FLOODPLAIN RESTORATION

Undisturbed floodplains help keep waterways healthy by storing floodwaters, reducing erosion, filtering water pollution, and providing habitat.

Floodplain restoration rebuilds some of these natural functions by reconnecting the floodplain to its waterway.



## WETLAND RESTORATION AND PROTECTION

Restoring and protecting wetlands can improve water quality and reduce flooding. Healthy wetlands filter, absorb, and slow runoff.

Wetlands also sustain healthy ecosystems by recharging groundwater and providing habitat for fish and wildlife.



## STORMWATER PARKS

Stormwater parks are recreational spaces that are designed to flood during extreme events and to withstand flooding.

By storing and treating floodwaters, stormwater parks can reduce flooding elsewhere and improve water quality.

# NEIGHBORHOOD OR SITE SCALE

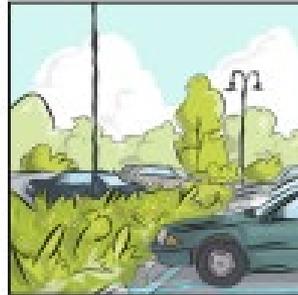
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## RAIN GARDENS

A rain garden is a shallow, vegetated basin that collects and absorbs runoff from rooftops, sidewalks, and streets.

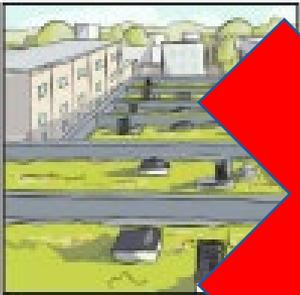
Rain gardens can be added around homes and businesses to reduce and treat stormwater runoff.



## VEGETATED SWALES

A vegetated swale is a channel holding plants or mulch that treats and absorbs stormwater as it flows down a slope.

Vegetated swales can be placed along streets and in parking lots to soak up and treat their runoff, improving water quality.



## GREEN ROOFS

A green roof is fitted with a planting medium and vegetation. A green roof can help soak up rainfall, reduce energy costs for the building.

Green roofs, which have deeper soil, are more common on commercial buildings. Intensive green roofs, which have shallower soil, are more common on residential buildings.



## RAINWATER HARVESTING

Rainwater harvesting systems collect and store rainwater for later use. They can reduce the need for potable water.

Systems include rain barrels that store gallons of rainwater and cisterns that store hundreds or thousands of gallons.



### PERMEABLE PAVEMENT

Permeable pavements allow more rainfall to soak into the ground. Common types include pervious concrete, porous asphalt, and interlocking pavers.

Permeable pavements are most commonly used for parking lots and roadway shoulders.



### TREE TRENCHES

A stormwater tree trench is a row of trees planted in an underground infiltration structure made to store and filter stormwater.

Tree trenches can be added to streets and parking lots with limited space to manage stormwater.



### TREE CANOPIES

Tree canopies reduce stormwater runoff by intercepting rainfall on leaves and increasing evaporation. By keeping streets cooler in the summer, tree canopies also reduce the "urban heat island effect."

Because of trees' many benefits, many cities have set urban tree canopy goals.



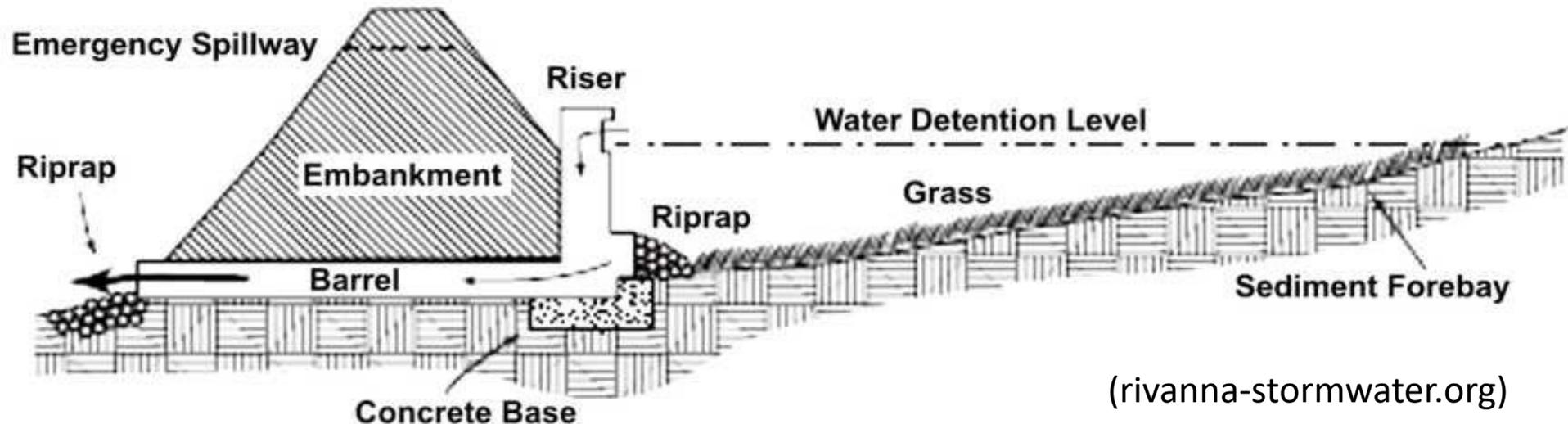
### GREEN STREETS

Green streets use a suite of green infrastructure practices to manage stormwater runoff and improve water quality.

Adding green infrastructure features to a street corridor can also contribute to a safer and more attractive environment for walking and biking.

# How can we reduce 100-YR storm flooding?

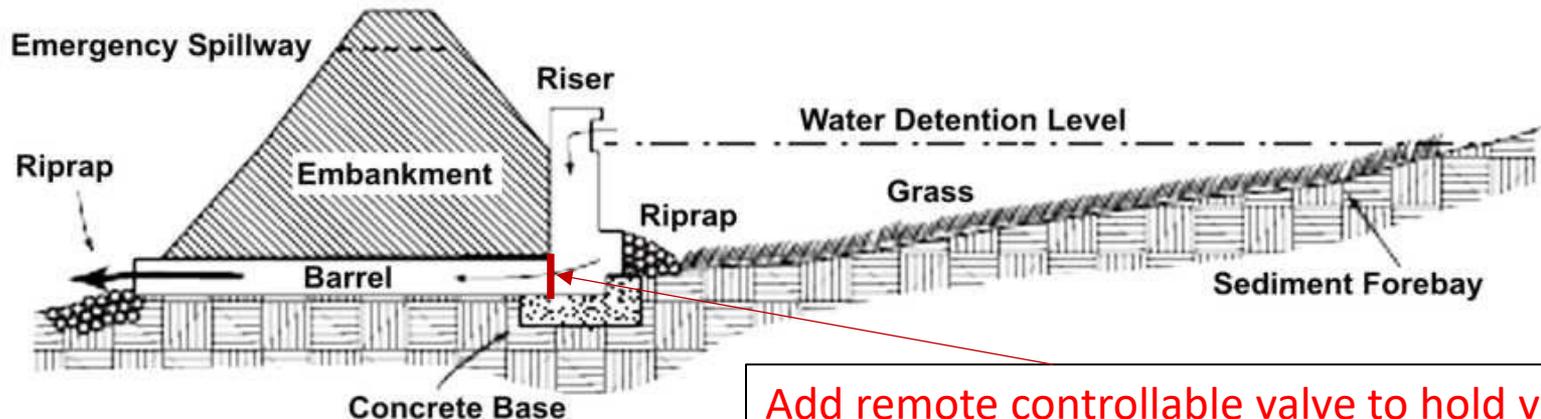
- Capture stormwater and detain it to reduce the peak flow of the flooding
  - Typical detention basin approach
  - Effective if no backup downstream
  - Can combine with distributed systems to hold more volume



(rivanna-stormwater.org)

# How can we reduce 100-YR storm flooding?

- Hold a retain stormwater as long as possible
  - More effective when floodwater backed up downstream
  - Digital control system to hold volume and release water once flood recedes
    - Would not work well as passive system due to smaller storm event management not draining quick enough
  - Difficult to combine with distributed storage systems



Add remote controllable valve to hold volume

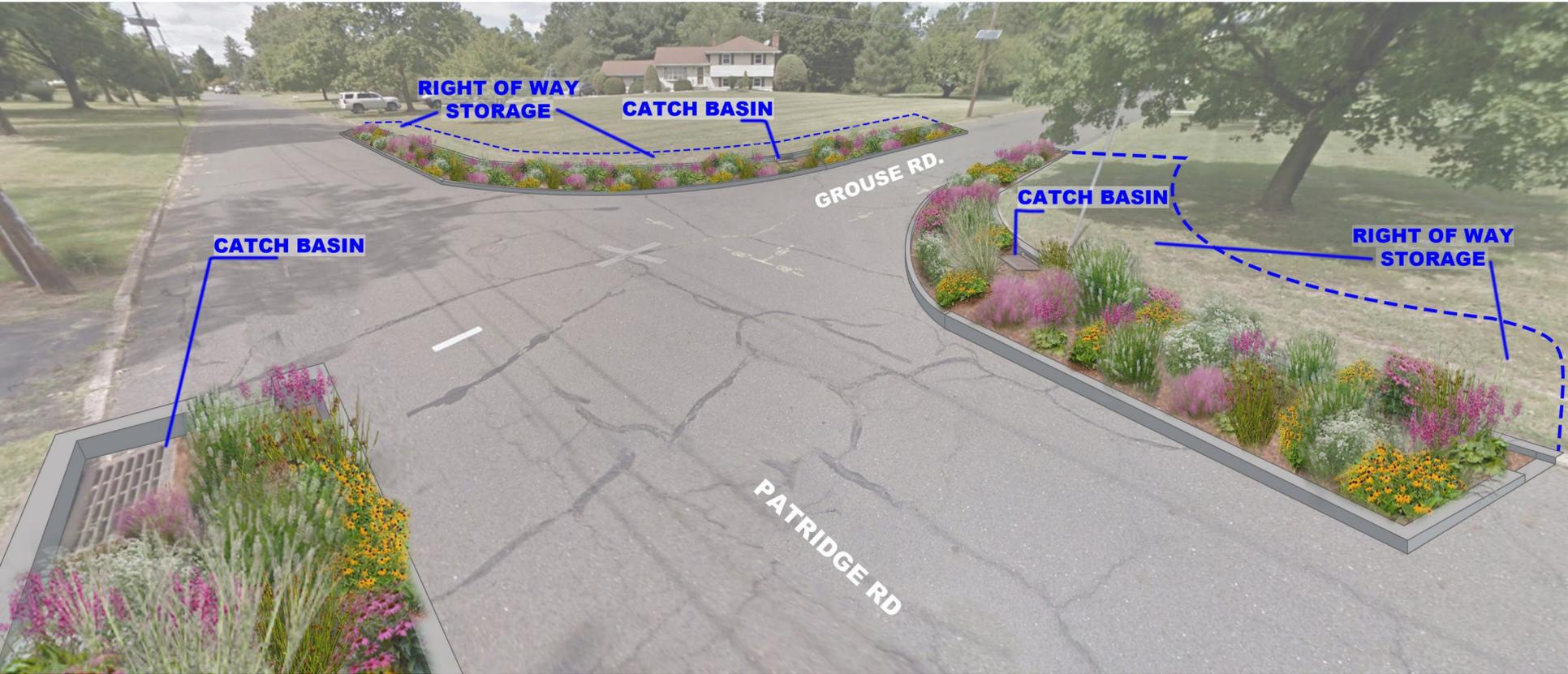
# Where do we target our efforts?

- Target developments with:
  - little to no existing stormwater management
  - available land to capture and hold large volumes of stormwater
  - willing participants for buyouts to create land for stormwater management
- Identify key flooding hotspots and identify areas contributing upstream of those areas
- Use right-of-way areas to capture stormwater
- In-line stream storage (complicated design and difficult to obtain NJDEP permits)

# How can we hold the volume?

- Smaller distributed systems
  - Individual household rain gardens
  - Pervious pavement
  - Right-of-way stormwater planters





**RIGHT OF WAY STORAGE**

**CATCH BASIN**

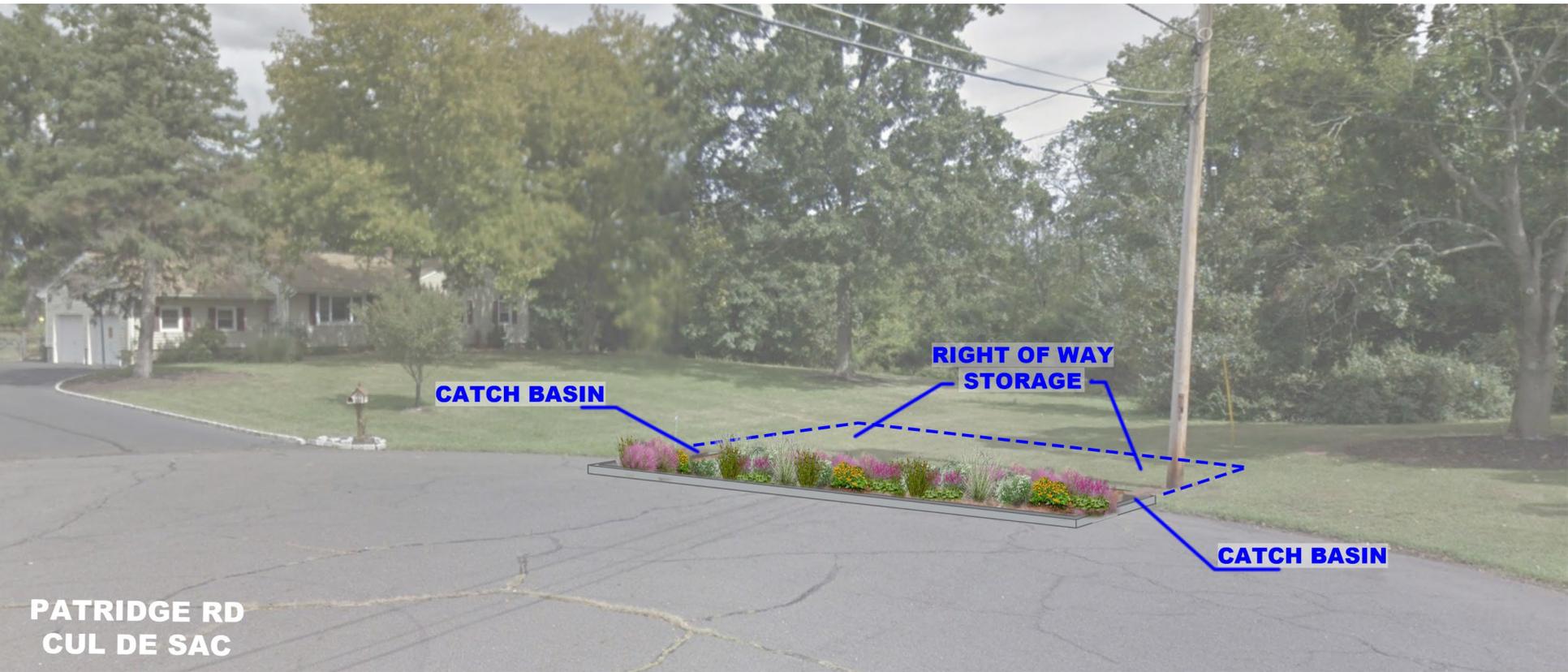
**GROUSE RD.**

**CATCH BASIN**

**CATCH BASIN**

**RIGHT OF WAY STORAGE**

**PATRIDGE RD**

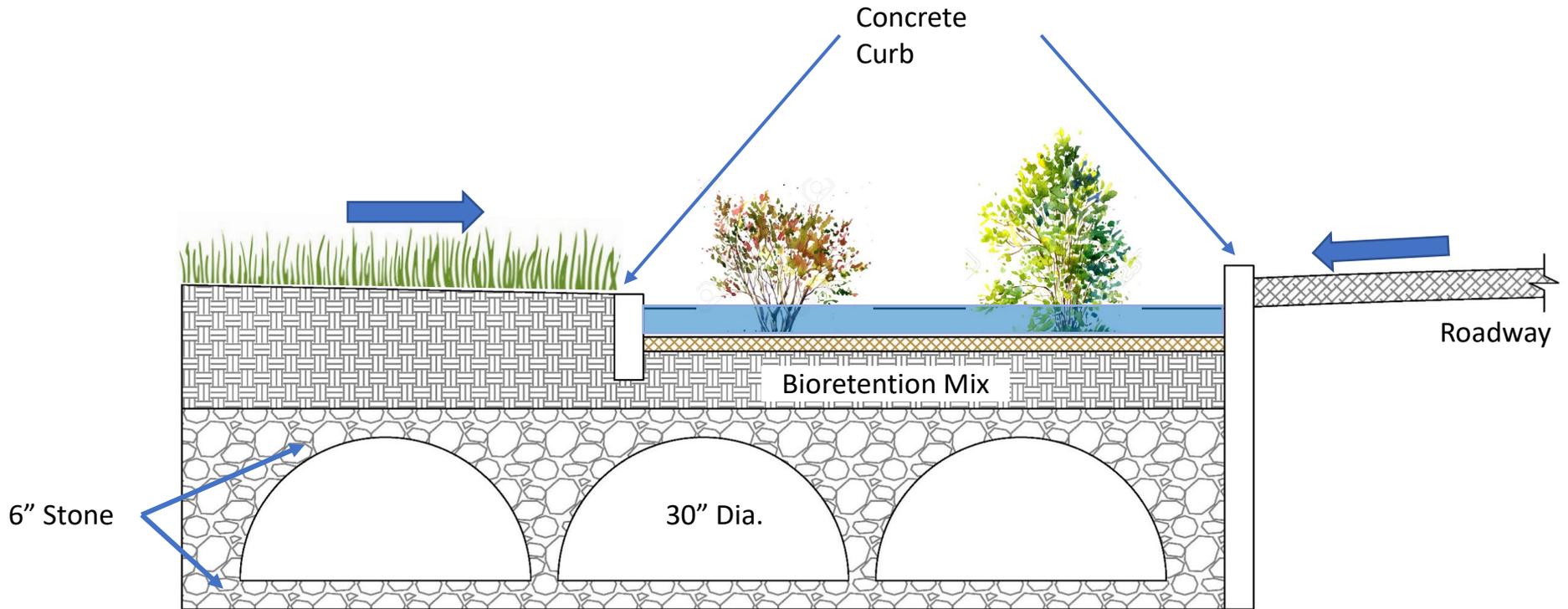


**PATRIDGE RD  
CUL DE SAC**

**CATCH BASIN**

**RIGHT OF WAY  
STORAGE**

**CATCH BASIN**



# How can we hold the volume?

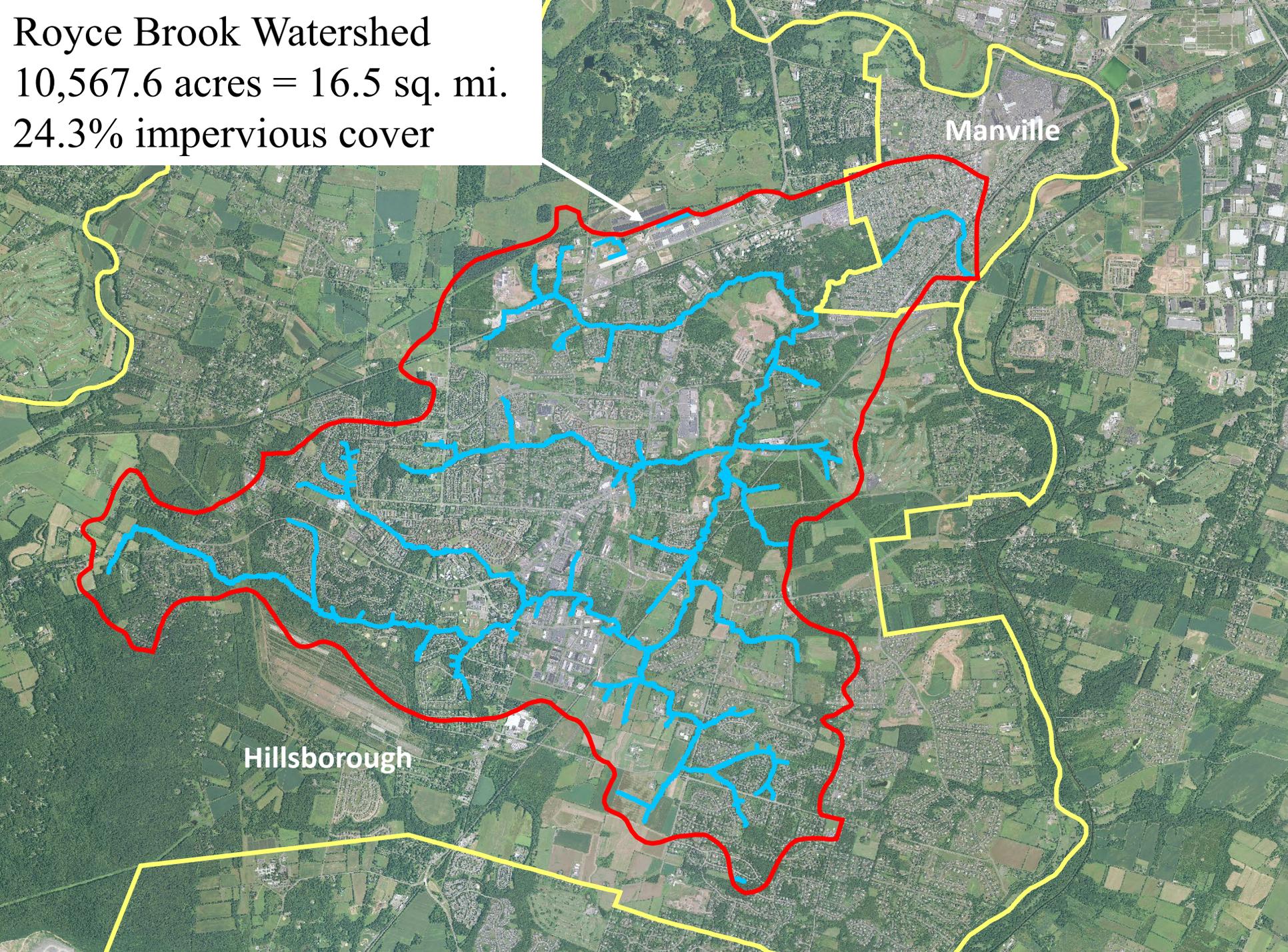
- Large detention/ bioretention basins
  - Can provide largest volume storage to land area
  
- Underground storage systems
  - Can create systems under lots by combining storage; allows mixed use of stormwater management area and recreational uses (i.e., parks)



# What are design options for retrofitting sites?

- Right of way only and public land
- Create distributed projects on private lands
- Residential
  - Small buyouts of residential area to create available land for stormwater capture
  - Large buyouts to maximize stormwater capture
- Commercial
  - Underground storage in parking lots
  - Remove sections of unutilized areas to create larger storage systems

Royce Brook Watershed  
10,567.6 acres = 16.5 sq. mi.  
24.3% impervious cover



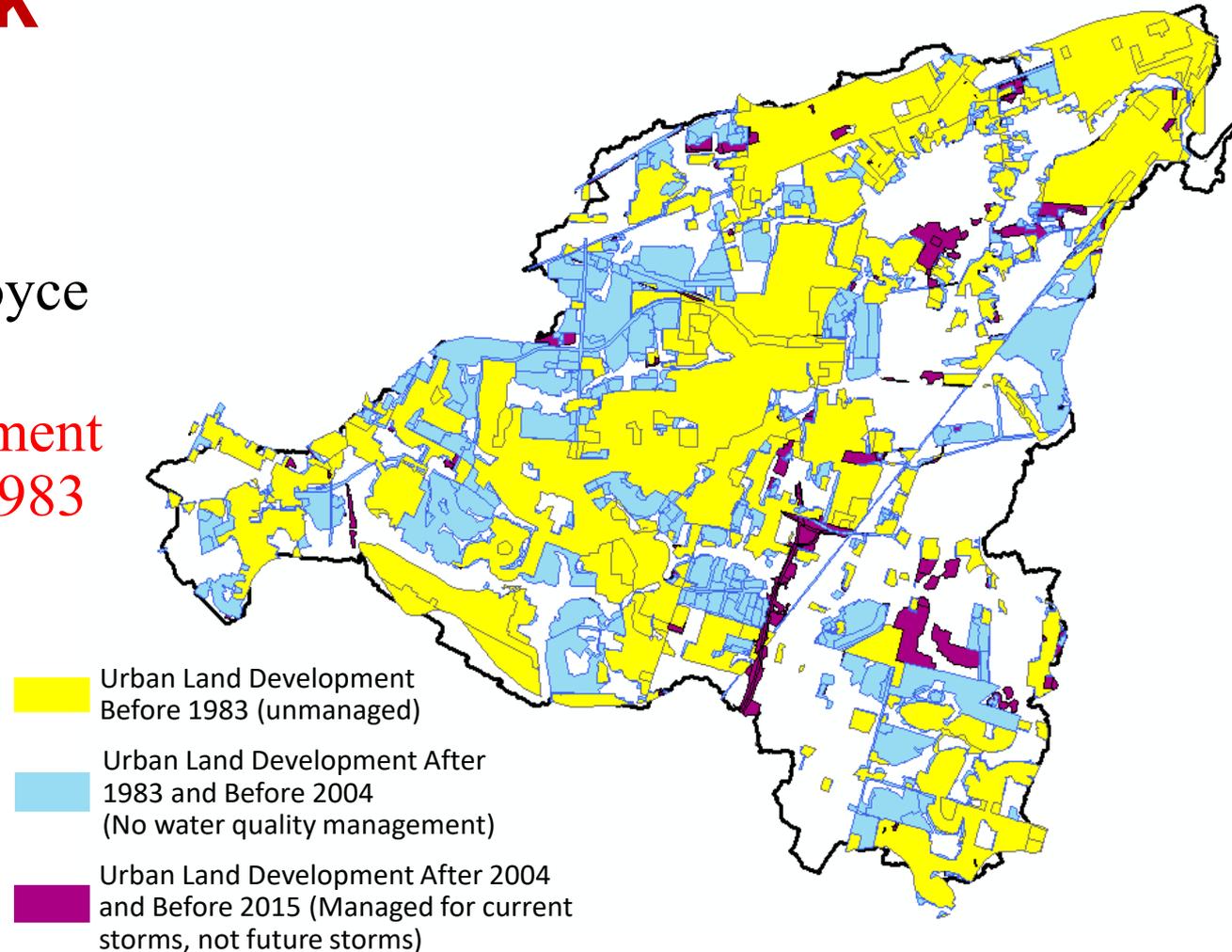
Manville

Hillsborough

# What land is being managed in the Royce Brook Watershed?

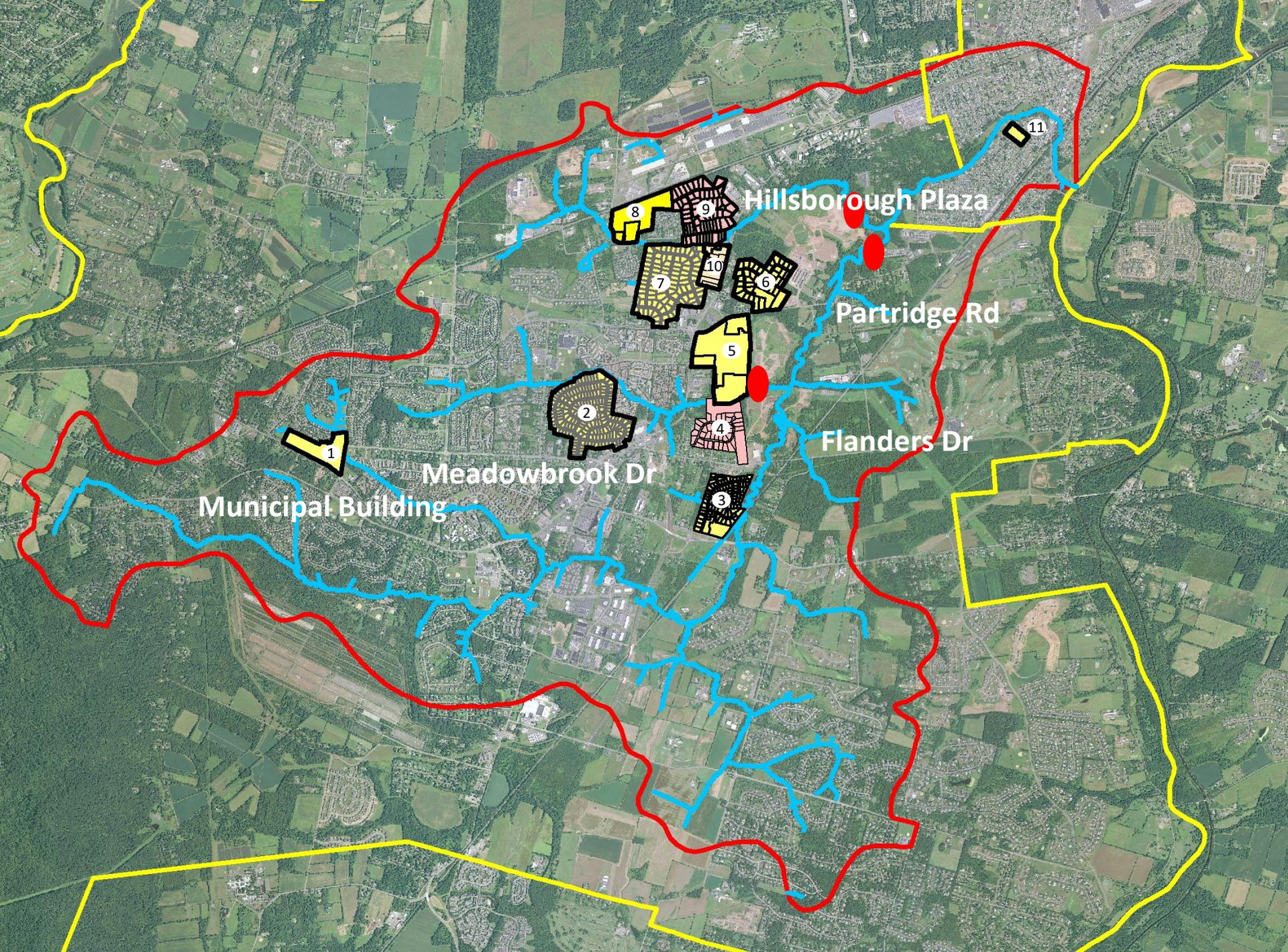
- Urban land in the Royce Brook Watershed
- Majority of development was created before 1983

Managed and Unmanaged Urban Land Use in the Royce Brook Watershed



# 11 potential development sites for retrofitting

- 673.4 acres = 1.05 sq. mi.
- Six residential developments
- Three commercial sites (one with some stormwater management)
- One municipal site
- One public school
- Possible solutions
  - Constructed wetlands
  - Bioretention
  - Permeable pavement
  - Roadside rain gardens
  - Homeowner rain gardens



Municipal Building

Meadowbrook Dr

Hillsborough Plaza

Partridge Rd

Flanders Dr

1

2

3

4

5

7

6

8

9

10

11

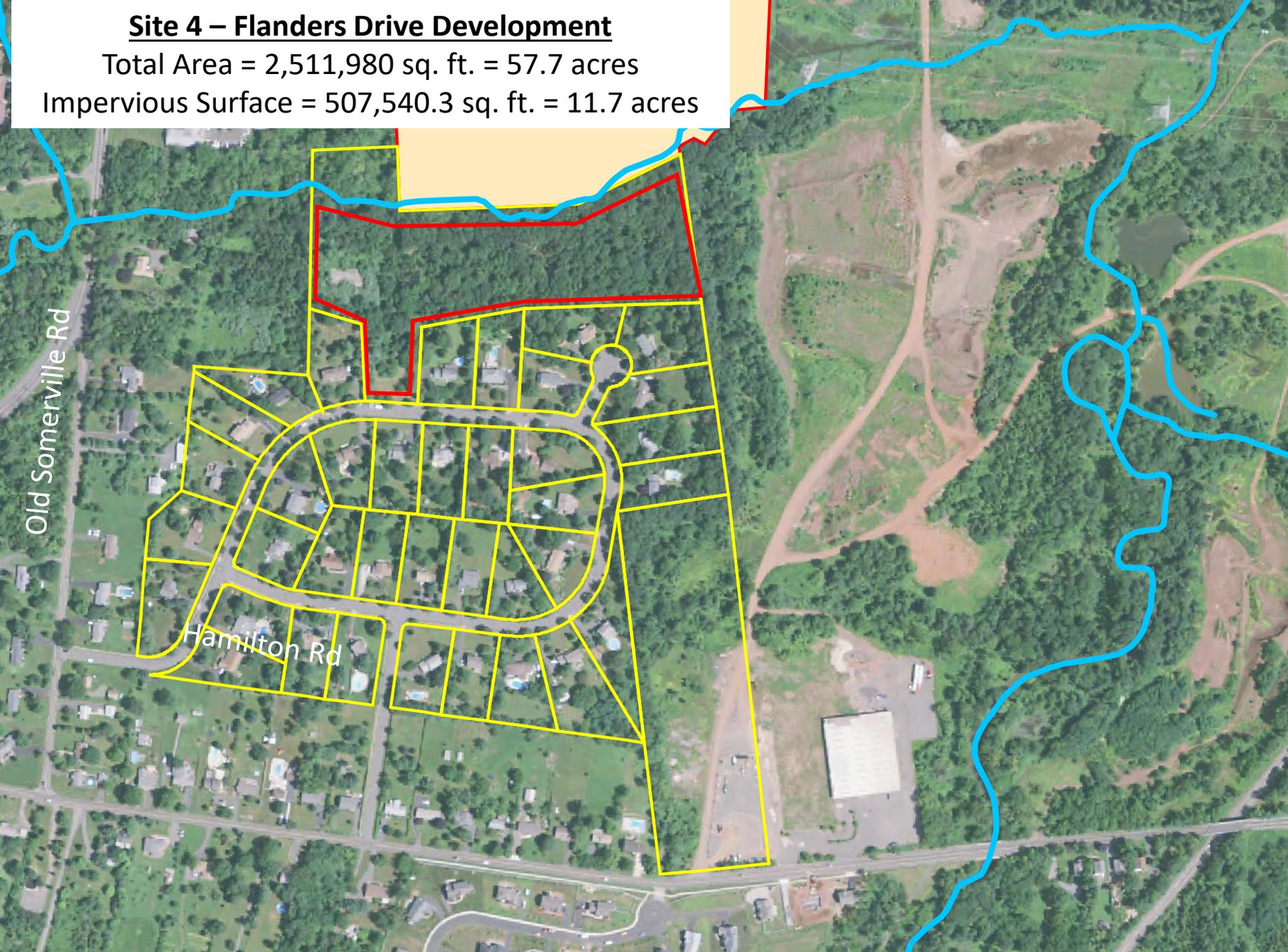
# Let's look at one of these sites for three different scenarios

- Design limited to municipal lands
- Design to retrofit
  - At least 80% reduction of predevelopment peak
- Design unrestrained to reach 100% capture and hold

# **Site 4 – Flanders Drive Development**

Total Area = 2,511,980 sq. ft. = 57.7 acres

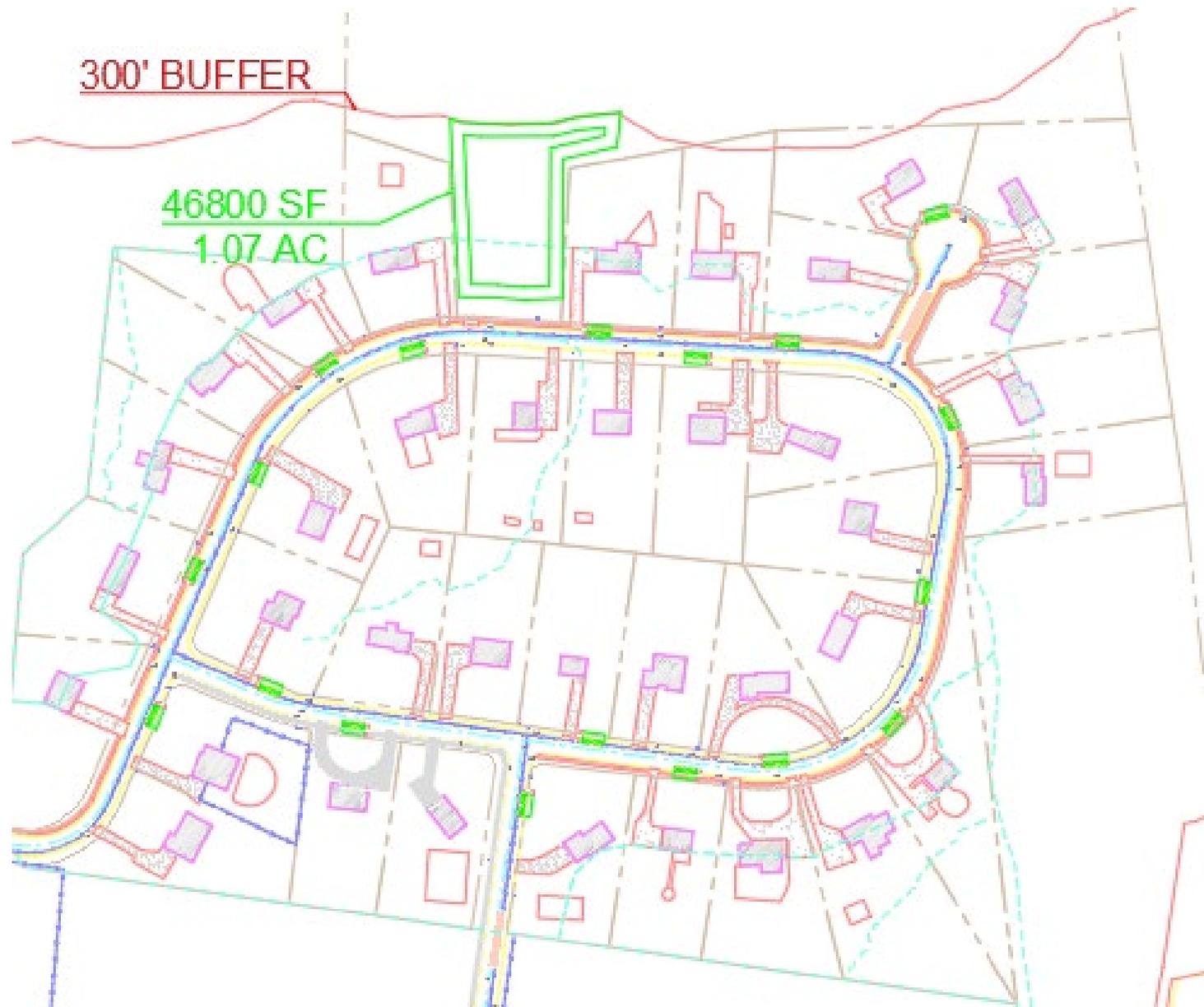
Impervious Surface = 507,540.3 sq. ft. = 11.7 acres



Old Somerville Rd

Hamilton Rd

# Municipal Land Only



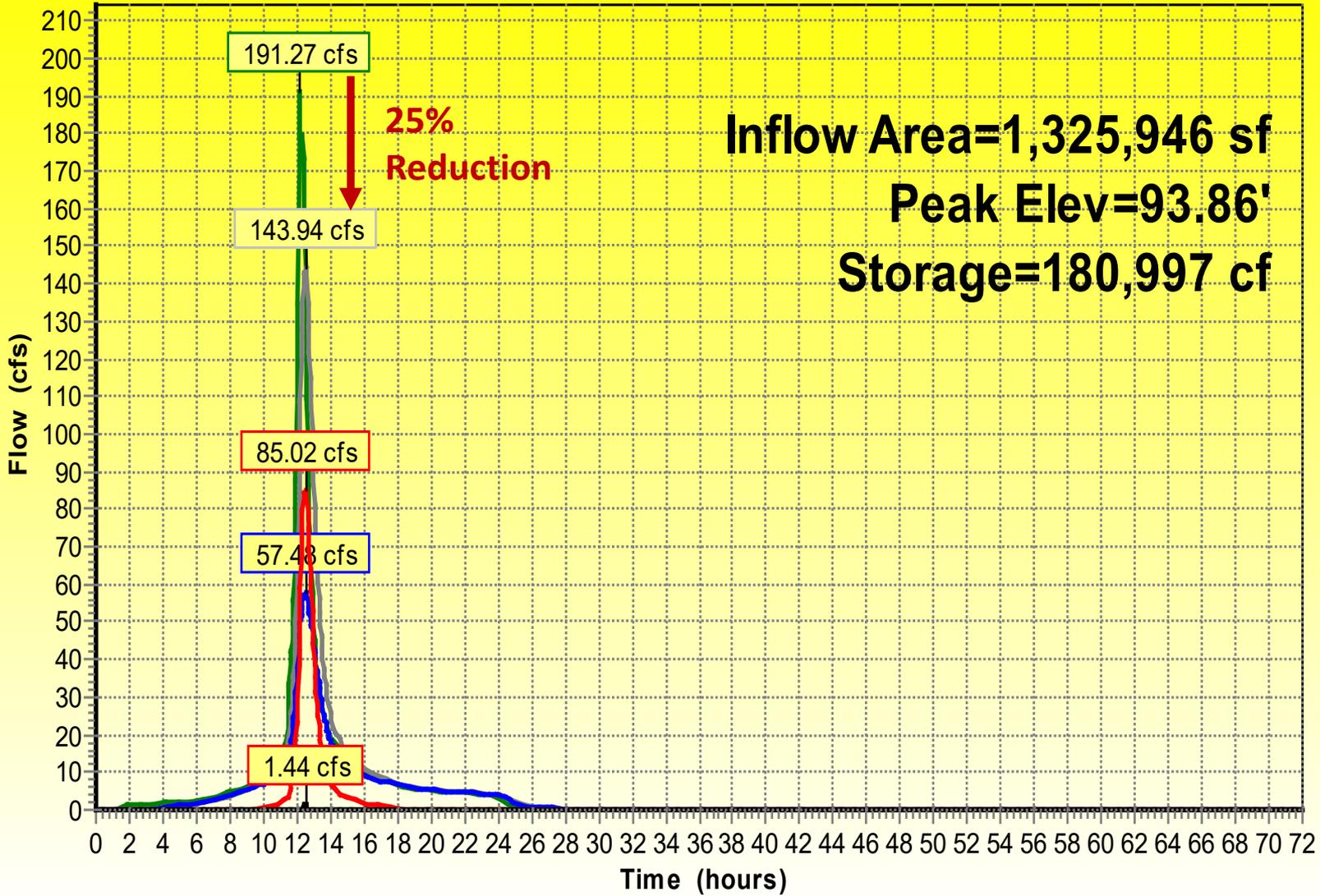
# Municipal Land Only

- Reduces peak by 25% meeting stormwater regulations
- Space for one basin and distributed systems in ROW

	Storage Volume (cf)	% Contribution
Basin	187,528	88%
Rain Gardens - Road	25,464	12%
Total Storage Volume	212,992	cf
Peak Discharge	144	cfs
Peak Reduction	25%	% of inflow (191.3cfs)
Detention Time 75%	14.4	hrs
Basin Area	1.07	ac

**Target Peak Flow = 154 cfs**

# Hydrograph

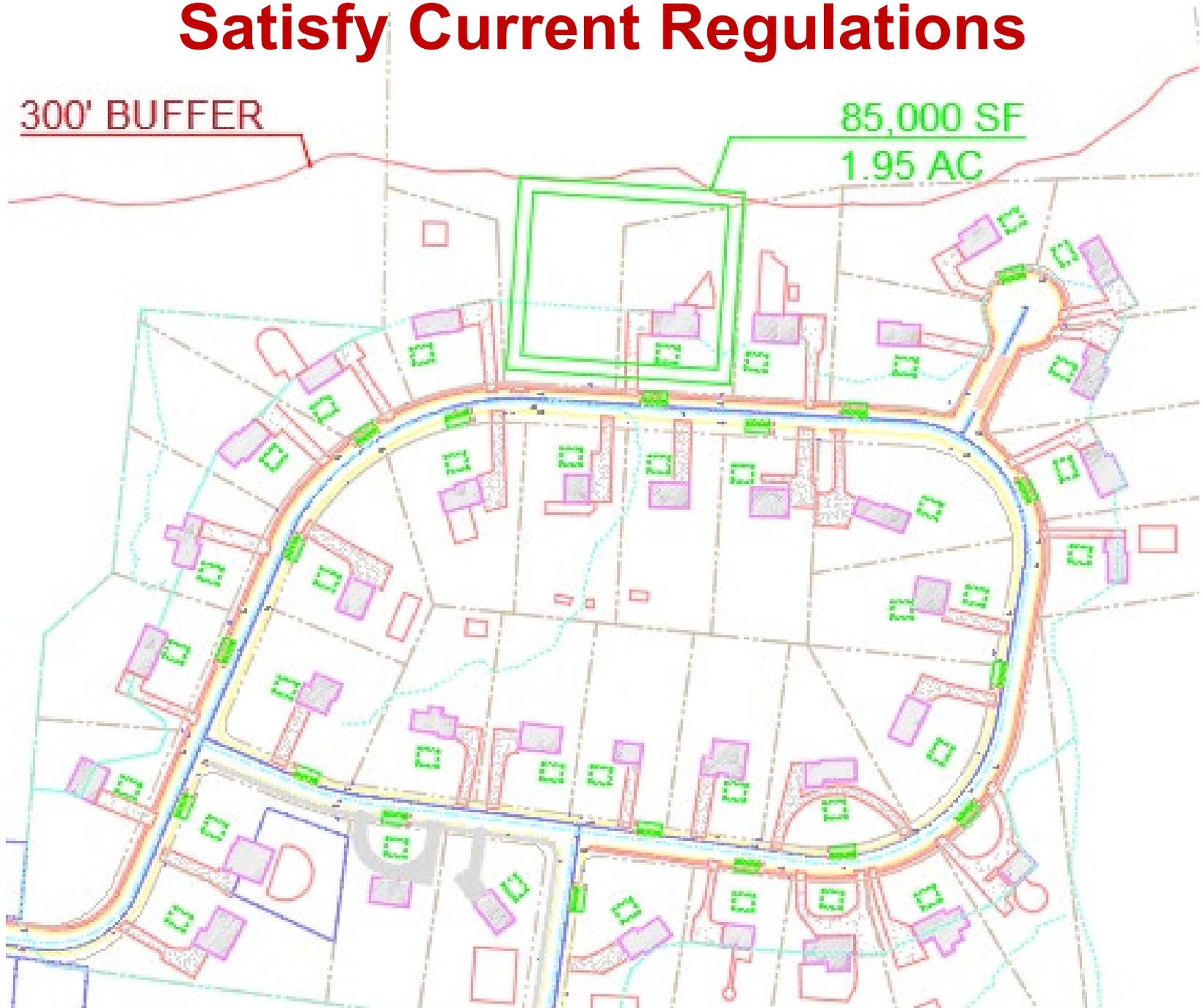


- Inflow
- Outflow
- Primary
- Secondary
- Tertiary

# Satisfy Current Regulations

300' BUFFER

85,000 SF  
1.95 AC



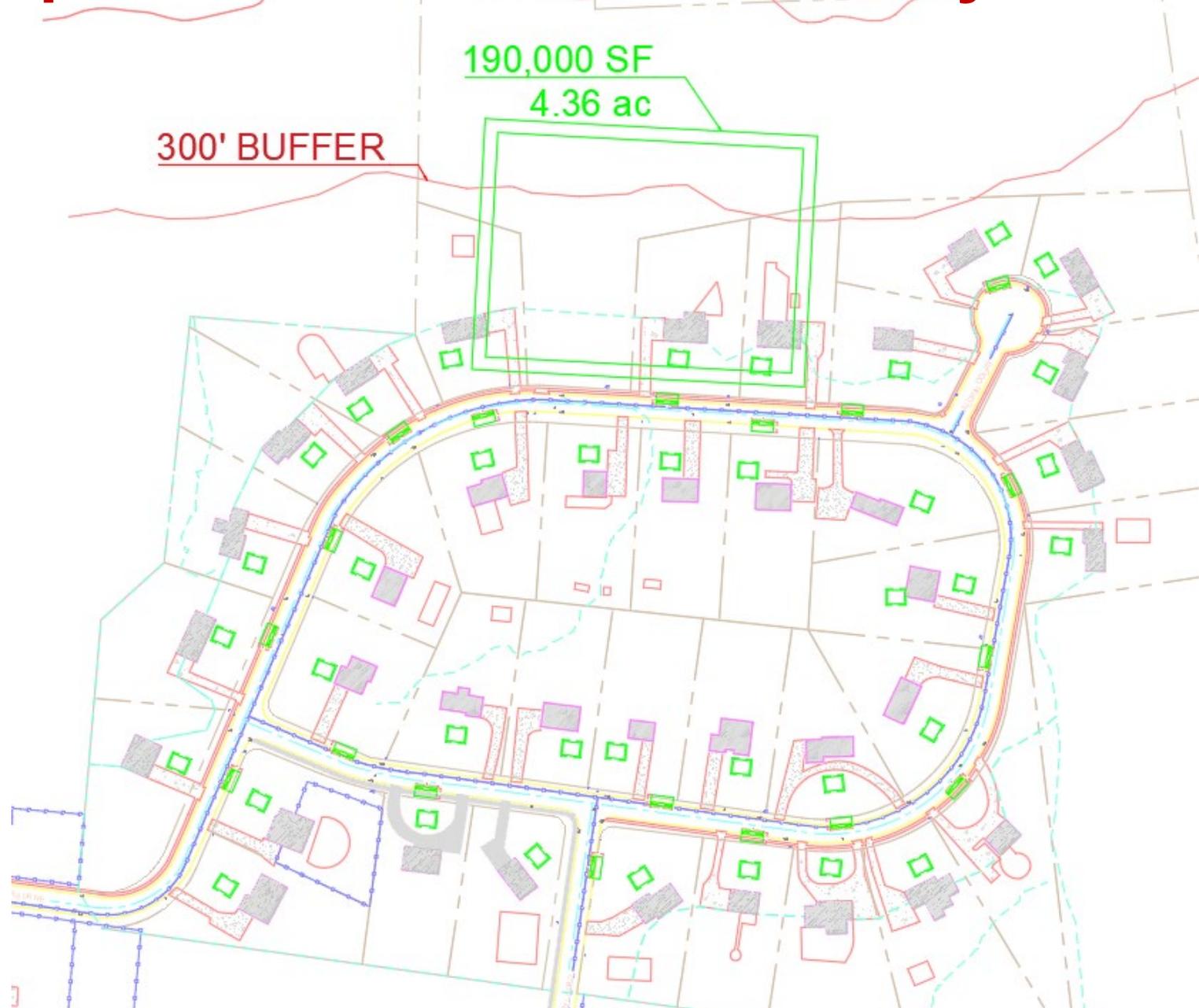
# Current Regulations

- Reduce peak to 80% of pre-development peak (100-yr storm)

	Storage Volume (cf)	% Contribution
Basin	370,550	78%
Permeable Pavement	58,570	12%
Rain Gardens – Roof	20,276	4%
Rain Gardens - Road	25,464	5%
Total Storage Volume	474,860	cf
Peak Discharge	52.72	cfs
Peak Reduction	72%	% of Inflow (191.3cfs)
Detention Time 75%	17.0	hrs
Basin Area	1.95	ac

**Target Peak Flow = 85.5 cfs**

# Capture entire volume for 100-yr storm



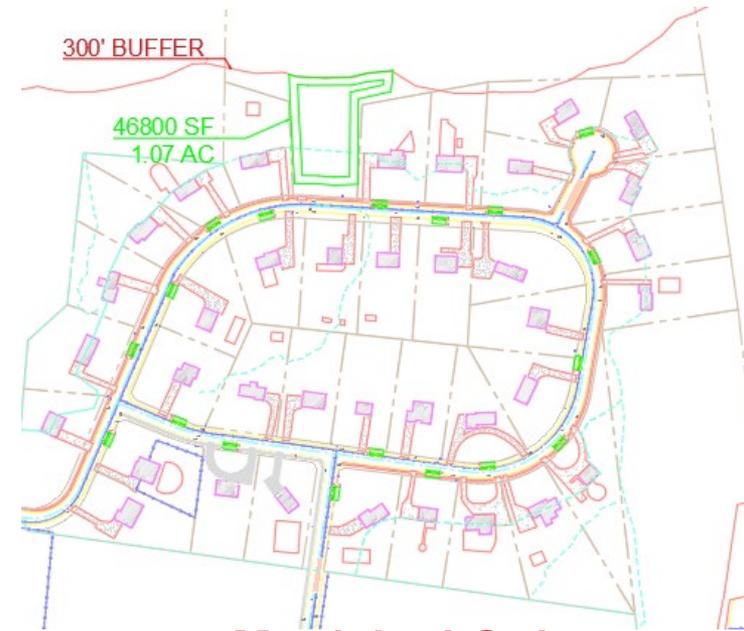
# Capture entire volume for 100-yr storm

- All of the volume held in basin
- Valve will need to be released later and drained in reasonable time

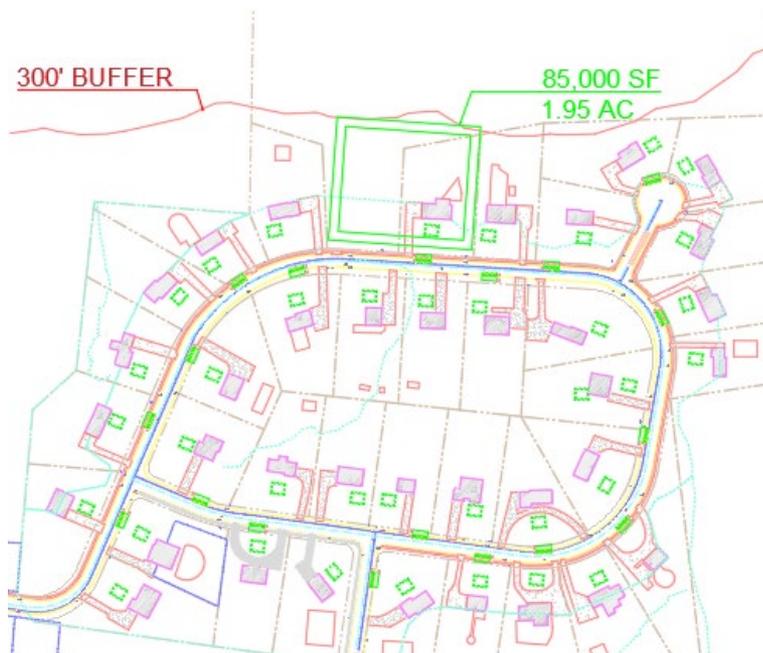
	Storage Volume (cf)	% Contribution
Basin	866,,000	89%
Porous Pavement	58,570	6%
Rain Gardens – Roof	20,276	2%
Rain Gardens - Road	25,464	3%
Total Storage Volume	970,310	cf
Peak Discharge	0	cfs
Peak Reduction	100%	% of Inflow (191.3cfs)
Basin Storage Peak	853,911	cf
Detention Time 75%	NA	hrs
Detention Time 100%	NA	hrs
Basin Area	4.36	ac

# Case comparison

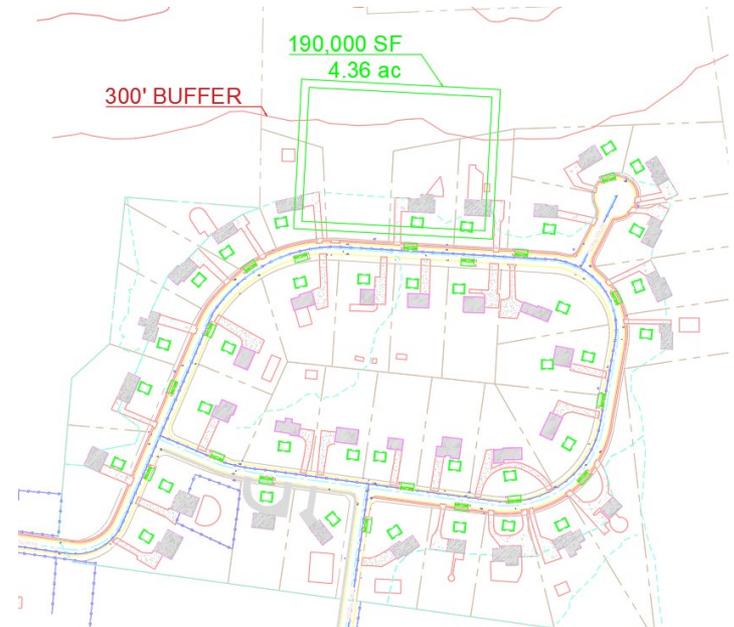
Parameter	Municipal	Current Reg	All Storage
Basin Size (acre)	1.07	1.95	4.36
Peak Red.	25%	72%	100%
Storage (CF)	212,992	474,860	970,310
Det. Time 75% (hr)	14.4	17.0	n/a



**Municipal Only**



**Current Regulation**



**All Storage**

# Engineering Designs

Storm Event	100-YR Current Peak Reduction (cfs%)		100-YR Future Peak Reduction (cfs)		Storage Volume (cubic feet)
	cfs	%	cfs	%	
Hillsborough Municipal Complex	72	85%	39	33%	230,862
Meadowbrook Drive	124	23%	204	26%	675,476
Flanders Drive	62	48%	87	46%	330,329
Partridge Farm Road	92	33%	158	39%	436,774
Hillsborough Plaza	130	68%	173	62%	345,491
<b>Totals</b>	<b>480</b>	<b>39%</b>	<b>661</b>	<b>37%</b>	<b>2,018,932</b>

# Hillsborough Municipal Complex

6 Rain Gardens  
6 Underground Storage Beds

**GENERAL NOTES:**

- CONTRACTOR SHALL SCHEDULE MEETING WITH ENGINEER AND PROPERTY OWNER PRIOR TO MOBILIZATION AND CONSTRUCTION.
- CONTRACTOR SHALL VERIFY ALL INFORMATION INCLUDING ELEVATIONS AND UTILITIES PRIOR TO CONSTRUCTION.
- CONTRACTOR SHALL VERIFY ALL PROPOSED MATERIALS WITH PROPERTY OWNER AND ENGINEER PRIOR TO CONSTRUCTION.
- CONTRACTOR SHALL STAKE OUT LOCATIONS OF PROPOSED SIPS AND OBTAIN APPROVAL FROM ENGINEER PRIOR TO INSTALLATION.
- CONTRACTOR SHALL BRUSH SITE AS SHOWN ON PLAN. CUT SOIL SHALL BE REPOSED ON SITE FOR TELL LOCATING.
- CONTRACTOR SHALL MAINTAIN EXCESS SOIL OF SITE UNLESS OTHERWISE NOTED BY PROPERTY OWNER.
- ALL FINISHED ELEVATIONS SHALL MATCH ADJOINING PAVEMENT ENSURING SMOOTH TRANSITIONS AND NO "TRIPPING HAZARDS".
- CONTRACTOR SHALL BE RESPONSIBLE FOR RESTORING ALL AREAS DISTURBED DURING CONSTRUCTION TO ORIGINAL CONDITIONS.

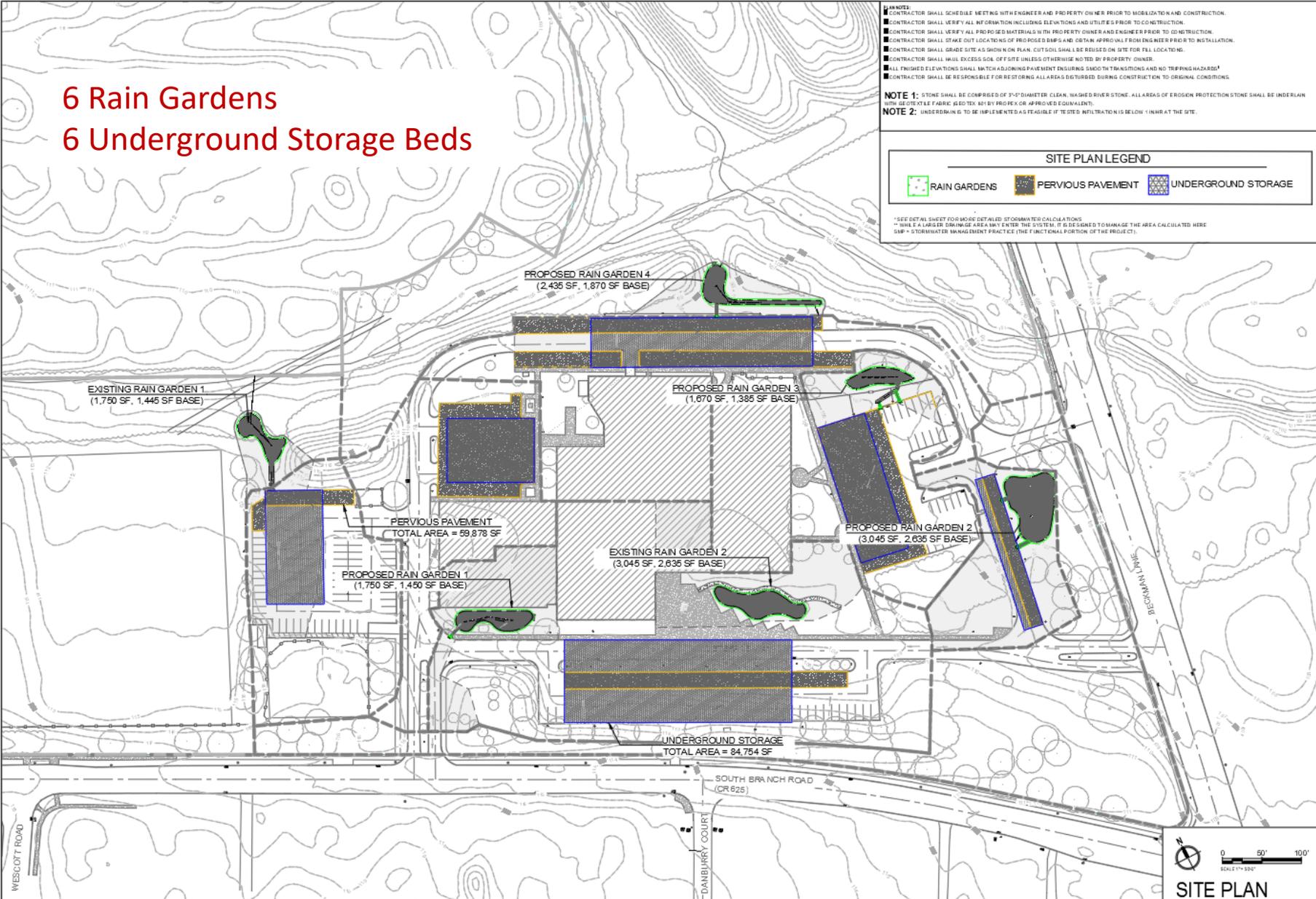
**NOTE 1:** STONE SHALL BE COMPOSED OF 3"-8" DIAMETER CLEAN, WASHED RIVER STONE. ALL AREAS OF EROSION PROTECTION STONE SHALL BE UNDERLAIN WITH GEOTEXTILE FABRIC (GEO-TEX 801 BY PRO-PEX OR APPROVED EQUIVALENT).

**NOTE 2:** UNDERDRAINING TO BE IMPLEMENTED AS FEASIBLE IF TESTED INFILTRATION IS BELOW 1 INHR AT THE SITE.

**SITE PLAN LEGEND**

- RAIN GARDENS
- PERVIOUS PAVEMENT
- UNDERGROUND STORAGE

\*SEE DETAIL SHEET FOR MORE DETAILED STORMWATER CALCULATIONS  
 \*\* WHILE A LARGER DRAINAGE AREA MAY ENTER THE SYSTEM, IT IS DESIGNED TO MANAGE THE AREA CALCULATED HERE  
 SIP = STORMWATER MANAGEMENT PRACTICES (THE FUNCTIONAL PORTION OF THE PROJECT).



CHRISTOPHER C. OBROPTA P.H.D., P.E.  
 PROFESSIONAL ENGINEER - LANDSCAPE ARCHITECTURE

**DRAFT**

HILLSBOROUGH MUNICIPAL COMPLEX  
 GREEN INFRASTRUCTURE IMPLEMENTATION PROJECT  
 379 SOUTH BRANCH ROAD, HILLSBOROUGH TOWNSHIP  
 SOMERSET COUNTY, NJ

PROPOSED CONCEPTUAL SITE PLAN OVERVIEW

RUTGERS  
 New Jersey Agricultural Experiment Station

14 COLLEGE FARM ROAD, NEW BRUNSWICK, NJ

SHEET NAME  
 P-2

# Meadowbrook Drive Overview

BIORETENTION BASIN  
 TOB AREA = 49,090SF  
 BASE AREA = 35,525SF  
 TOB ELEV. = 77'  
 BASE ELEV. = 72'

- PLAN NOTE:**
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  3. CONTRACTOR SHALL VERIFY ALL PROPOSED MATERIALS WITH PROPERTY OWNER AND ENGINEER PRIOR TO CONSTRUCTION.
  4. CONTRACTOR SHALL STAKE OUT LOCATIONS OF PROPOSED SMPs AND OBTAIN APPROVAL FROM ENGINEER PRIOR TO INSTALLATION.
  5. CONTRACTOR SHALL GRADE SITE AS SHOWN ON PLAN. CUT SOIL SHALL BE REUSED ON SITE FOR FILL LOCATIONS.
  6. CONTRACTOR SHALL WALL EXCESS SOIL OFF SITE UNLESS OTHERWISE NOTED BY PROPERTY OWNER.
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  8. CONTRACTOR SHALL BE RESPONSIBLE FOR RESTORING ALL AREAS DISTURBED DURING CONSTRUCTION TO ORIGINAL CONDITIONS.

**SITE PLAN LEGEND**

	ROADSIDE RAIN GARDEN WITH UNDERGROUND STORAGE		BASIN
	ROOF RAIN GARDEN		PERVIOUS PAVEMENT



Example Area

PREVIOUS PAVEMENT DRIVEWAYS  
 TOTAL AREA = 565,750 SF

UNDERDRAIN OUTFLOW

ROADSIDE STORMWATER PLANTER WITH STORMTECH STORAGE SYSTEM AREA = 575 SF (EACH)  
 BIORETENTION AREA = 175 SF (EACH)  
 101 ROADSIDE UNITS (58,075 SF)

ROOF RAIN GARDENS  
 BIORETENTION AREA = 500 SF EACH  
 152 TOTAL UNITS (91,000 SF)

- 101x Roadside Planters (575 SF each)
- 152x Rain Gardens (500 SF each)
- Pervious Pavement (565,750 SF)
- 1x Bioretention Basin



SITE PLAN

CHRISTOPHER C. ORSOTI, P.E.  
 PROFESSIONAL ENGINEER - NJ LICENSE # 3702

MEADOWBROOK DRIVE DEVELOPMENT  
 GREEN INFRASTRUCTURE IMPLEMENTATION PROJECT  
 MEADOWBROOK DRIVE, HILLSBOROUGH TOWNSHIP  
 SOMERSET COUNTY, NJ

DATE: 04/15/2024  
 TIME: 10:00 AM  
 SHEET NO: 01  
 PROJECT NO: 24000001  
 DRAWING NO: 01

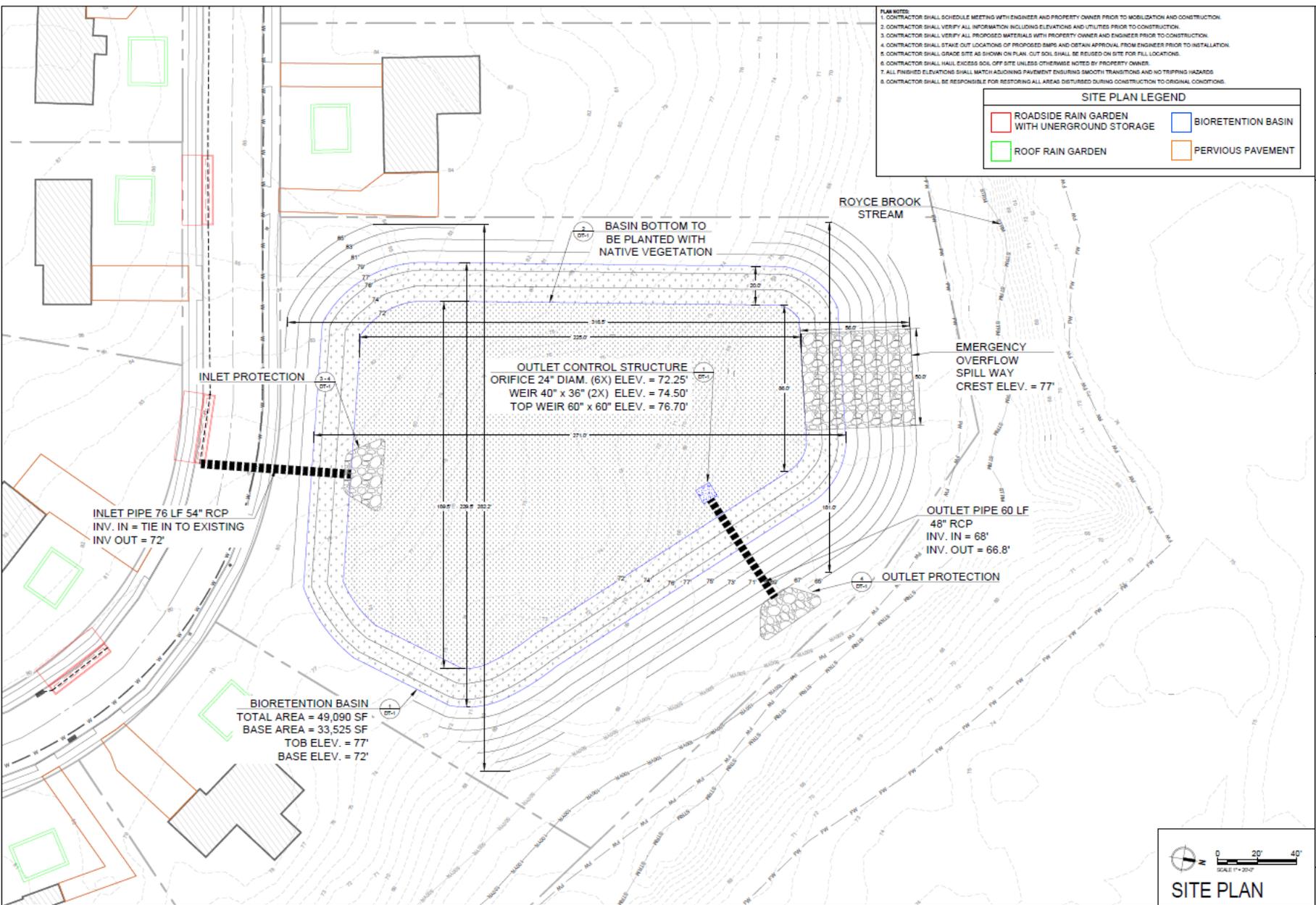
RUTGERS  
 New Jersey Agricultural Experiment Station

14 COLLEGE FARM ROAD, NEW BRUNSWICK, NJ  
 SHEET NAME  
 P-2

# Meadowbrook Drive Basin

- PLAN NOTES:**
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SITE PLAN LEGEND			
<span style="border: 1px solid red; display: inline-block; width: 15px; height: 10px;"></span>	ROADSIDE RAIN GARDEN	<span style="border: 1px solid blue; display: inline-block; width: 15px; height: 10px;"></span>	BIORETENTION BASIN
<span style="border: 1px solid green; display: inline-block; width: 15px; height: 10px;"></span>	ROOF RAIN GARDEN	<span style="border: 1px solid orange; display: inline-block; width: 15px; height: 10px;"></span>	PERVIOUS PAVEMENT



CHRISTOPHER C. ORSOTTI, P.E.  
 PROFESSIONAL ENGINEER - NJ LICENSE # 37022

MEADOWBROOK DRIVE DEVELOPMENT  
 GREEN INFRASTRUCTURE IMPLEMENTATION PROJECT  
 MEADOWBROOK DRIVE, HILLSBOROUGH TOWNSHIP  
 SOMERSET COUNTY, NJ

**DRAFT**

MEADOWBROOK DRIVE DEVELOPMENT  
 GREEN INFRASTRUCTURE IMPLEMENTATION PROJECT  
 MEADOWBROOK DRIVE, HILLSBOROUGH TOWNSHIP  
 SOMERSET COUNTY, NJ

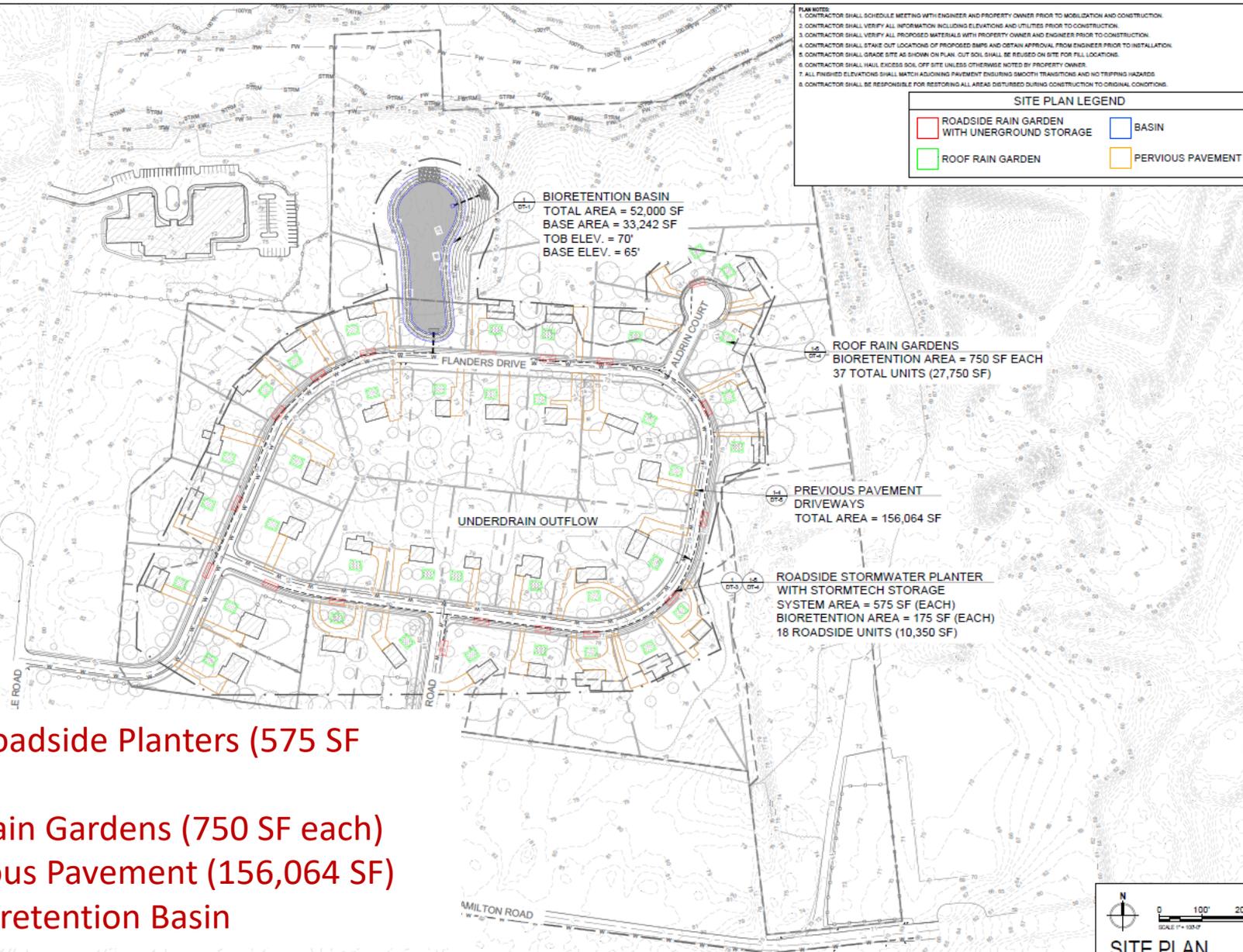
CONCEPTUAL BASIN DESIGN PLAN

**RUTGERS**  
 New Jersey Agricultural Experiment Station

14 COLLEGE FARM ROAD, NEW BRUNSWICK, NJ

SHEET NAME  
 P-2

# Flanders Drive



- 18x Roadside Planters (575 SF each)
- 37x Rain Gardens (750 SF each)
- Pervious Pavement (156,064 SF)
- 1x Bioretention Basin

CHRISTOPHER C. OBROPTA, P.L.D., P.E.  
 PROFESSIONAL ENGINEER - LANDSCAPE ARCHITECTURE

DATE: 2023.02.02  
 SHEET: 1100  
 PROJECT: 1100

FLANDERS DRIVE DEVELOPMENT  
 GREEN INFRASTRUCTURE IMPLEMENTATION PROJECT  
 FLANDERS DRIVE, HILLSBOROUGH TOWNSHIP  
 SOMERSET COUNTY, NJ

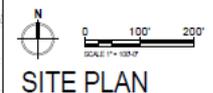
CONCEPTUAL SITE PLAN

**DRAFT**

RUTGERS  
 New Jersey Agricultural Experiment Station

14 COLLEGE FARM ROAD, NEW BRUNSWICK, NJ

SHEET NAME  
 P-2



SITE PLAN

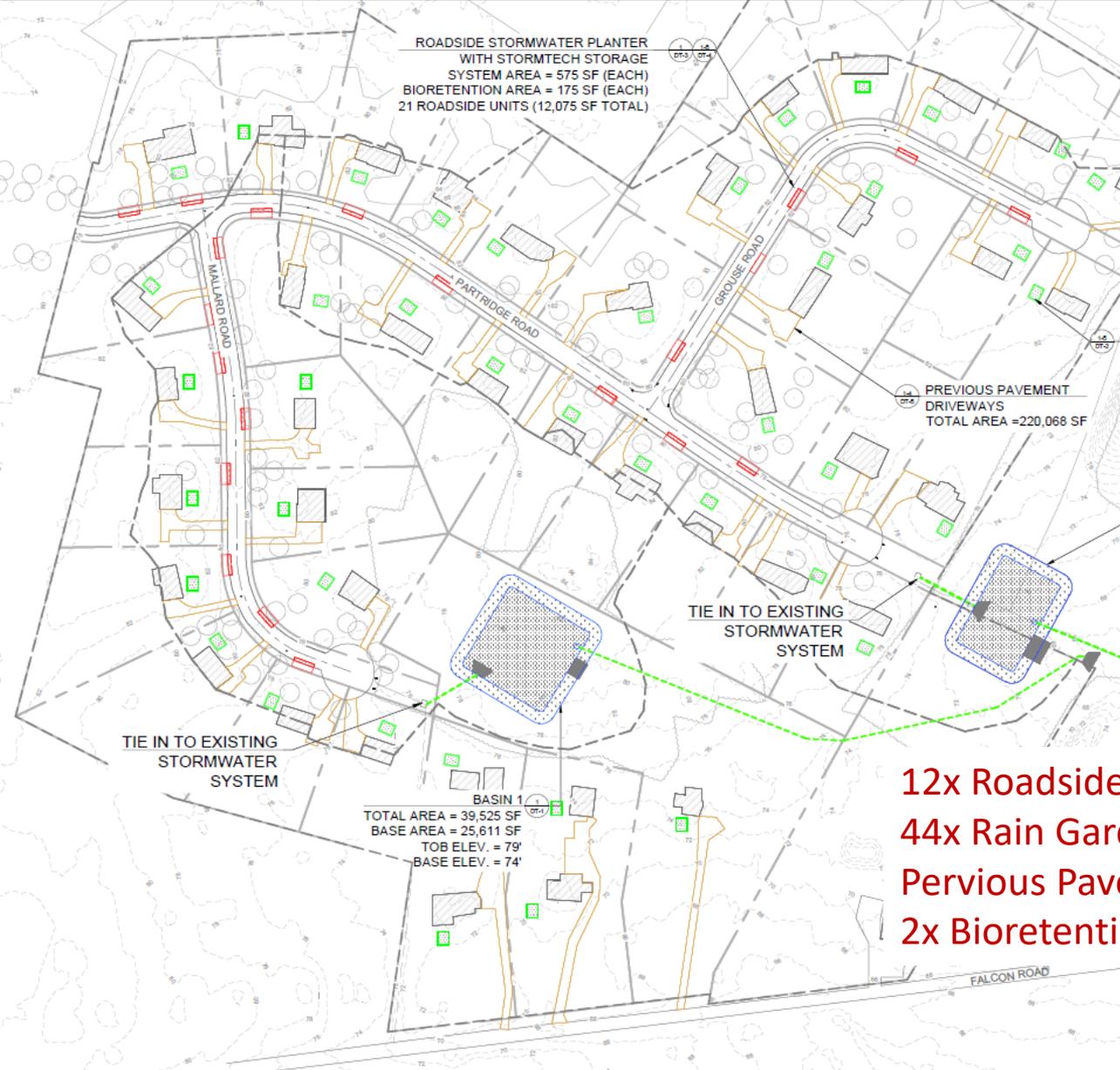
# Partridge Road

**PLAN NOTES:**

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**SITE PLAN LEGEND**

<span style="border: 1px solid red; display: inline-block; width: 15px; height: 10px;"></span>	ROADSIDE RAIN GARDEN WITH UNDERGROUND STORAGE	<span style="border: 1px solid blue; display: inline-block; width: 15px; height: 10px;"></span>	BASIN
<span style="border: 1px solid green; display: inline-block; width: 15px; height: 10px;"></span>	ROOF RAIN GARDEN	<span style="border: 1px solid orange; display: inline-block; width: 15px; height: 10px;"></span>	PERVIOUS PAVEMENT



**12x Roadside Planters (575 SF each)**  
**44x Rain Gardens (500 SF each)**  
**Pervious Pavement (220,068 SF)**  
**2x Bioretention Basin**

**SITE PLAN**

SCALE 1" = 80'

0 80' 160'

CHRISTOPHER C. ORROTTA, P.D., P.E.  
 PROFESSIONAL ENGINEER - NJ LICENSE # 17352

DATE: 05/20/2024

PROJECT NO: 2400000000

PROJECT NAME: PARTRIDGE ROAD DEVELOPMENT

DESCRIPTION: GREEN INFRASTRUCTURE IMPLEMENTATION PROJECT  
 PARTRIDGE FARM ROAD, HILLSBOROUGH TOWNSHIP  
 SOMERSET COUNTY, NJ

**DRAFT**

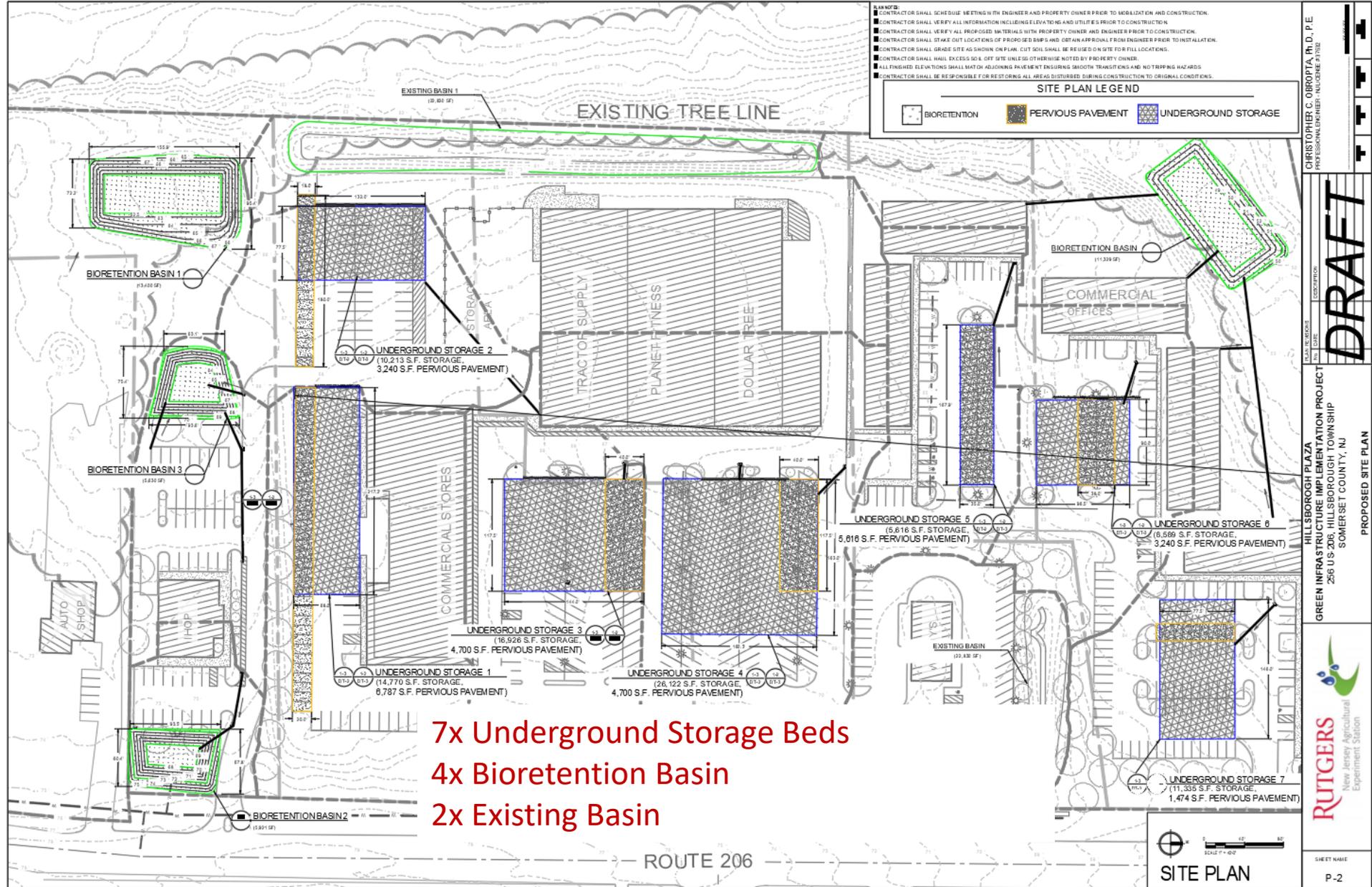
CONCEPTUAL SITE PLAN

RUTGERS  
 New Jersey Agricultural Experiment Station

14 COLLEGE FARM ROAD, NEW BRUNSWICK, NJ

SHEET NAME: P-2

# Hillsborough Plaza



7x Underground Storage Beds  
 4x Bioretention Basin  
 2x Existing Basin

CHRISTOPHER C. OBROPTA, Ph.D., P.E.  
 PROFESSIONAL ENGINEER - LANDSCAPE ARCHITECTURE

PLANNING & DESIGN

LOCATION: HILLSBOROUGH PLAZA  
 DATE: 08/2024

PROJECT: GREEN INFRASTRUCTURE IMPLEMENTATION PROJECT  
 256 U.S. 206, HILLSBOROUGH TOWNSHIP  
 SOMERSET COUNTY, NJ

PROPOSED SITE PLAN

**DRAFT**

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**Questions?**

# RUTGERS

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Experiment Station



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