RUTGERS UNIVERSITY
Water Resources Program
New Jersey Agricultural Experiment Station

Nature Based Solutions to Manage Extreme Weather Events in the Royce Brook Watershed, Somerset County, New Jersey

Rutgers Cooperative Extension Water Resources Program
Christopher C. Obropta, Ph.D., P.E.
February 21, 2026



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 water resources issues by engaging and empowering communities to employ practical science-based solutions to help create a more equitable and sustainable New Jersey.

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


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%

But let's adjust it for today's data and future rainfall

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


Let’s Talk About
Nature-Based
Solutions

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

LAND CONSERVATION

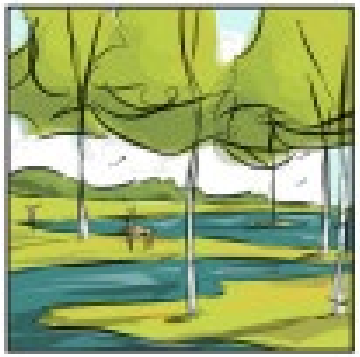
Land conservation is one way of preserving interconnected systems of open space that sustain healthy communities.

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.



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.

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.

NEIGHBORHOOD OR SITE SCALE

RAIN GARDENS

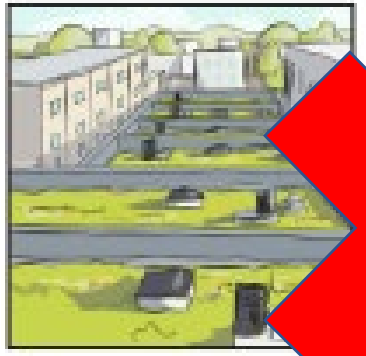
A rain garden is a shallow, vegetated basin that collects and absorbs runoff from rooftops, sidewalks, and streets.

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 helps by soaking up rainfall. It can reduce energy costs for the building.

There are two types of green roofs, which have different depths of soil. Extensive green roofs 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 rainfall for later use. They slow runoff and can reduce the demand for potable water.

Rainwater systems include rain barrels that store tens of gallons and rainwater cisterns that store hundreds or thousands of gallons.

PERMEABLE PAVEMENT

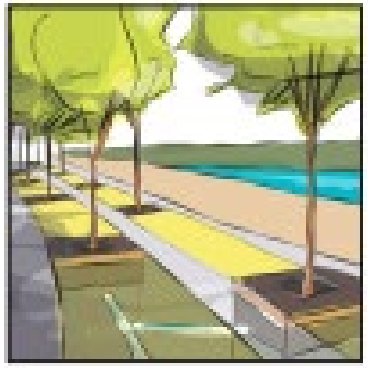
Permeable pavements allow more rainfall to soak into the ground. Common types include pervious concrete, porous asphalt, and interlocking pavers.

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

TREE CANOPY

Tre[illegible]py can reduce stormwater [illegible]tching rainfall on [illegible] and leaves and increasing [illegible]transpiration. By keeping [illegible]hoods cooler in the summer, [illegible]can also reduce the "ur[illegible]eat island effect."

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



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.

GREEN STREETS

Green streets use a suite of green infrastructure practices to manage stormwat 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 do we improve water quality and reduce flooding in the Royce Brook Watershed?

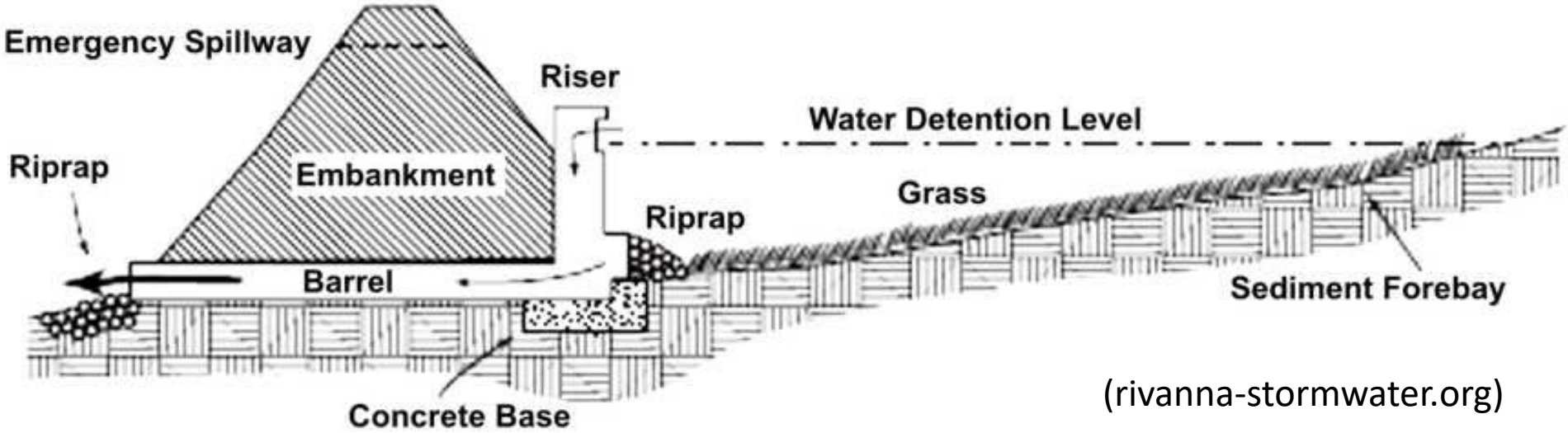
- Redesign existing stormwater basins to remove pollutants and enhance stormwater retention
- Install stormwater management for developed areas that currently are not managed

Issues with Existing Stormwater Management

- Basins are not designed to improve water quality or recharge groundwater
- Basins fill and drain quickly during rainfall events
- Low retention time results in excessive runoff volumes being released while stream is high
- All basin designs are similar

How can we reduce 100-YR storm flooding?

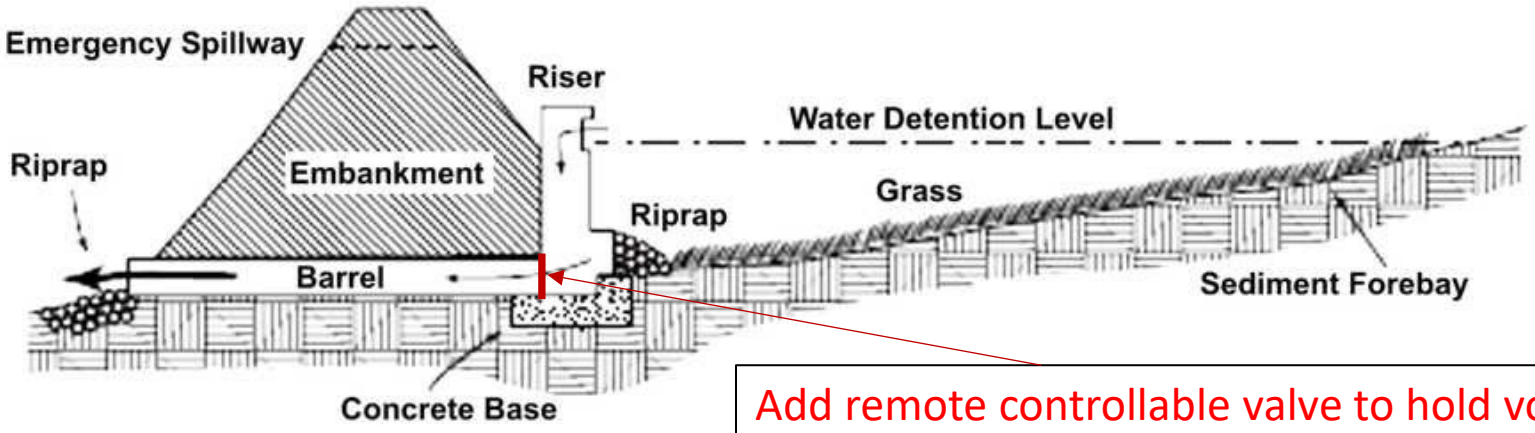
- Capture stormwater and detain it to reduce the peak flow of the flooding
  - Typical detention basin approach
  - Effective if no back-up downstream
  - Can combine with distributed systems to hold more volume



(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



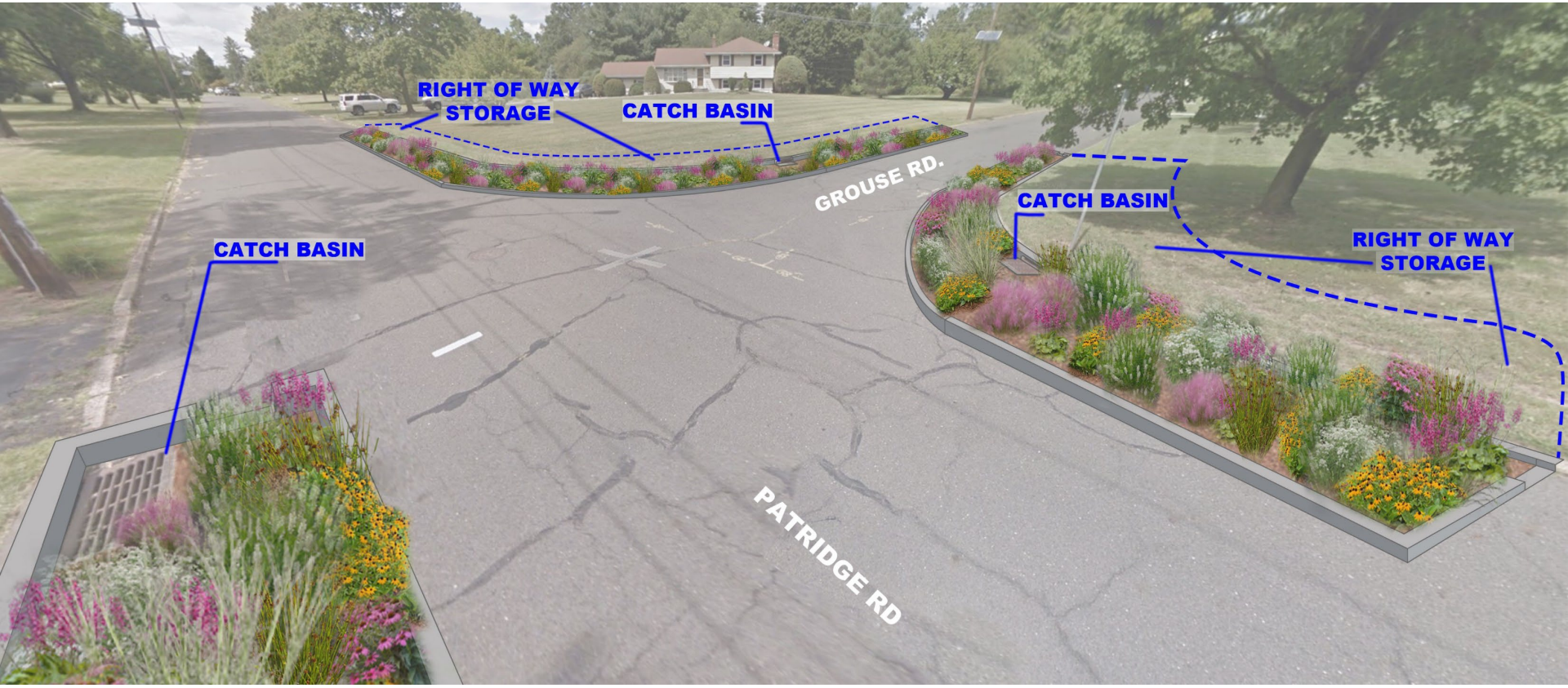
(rivanna-stormwater.org)

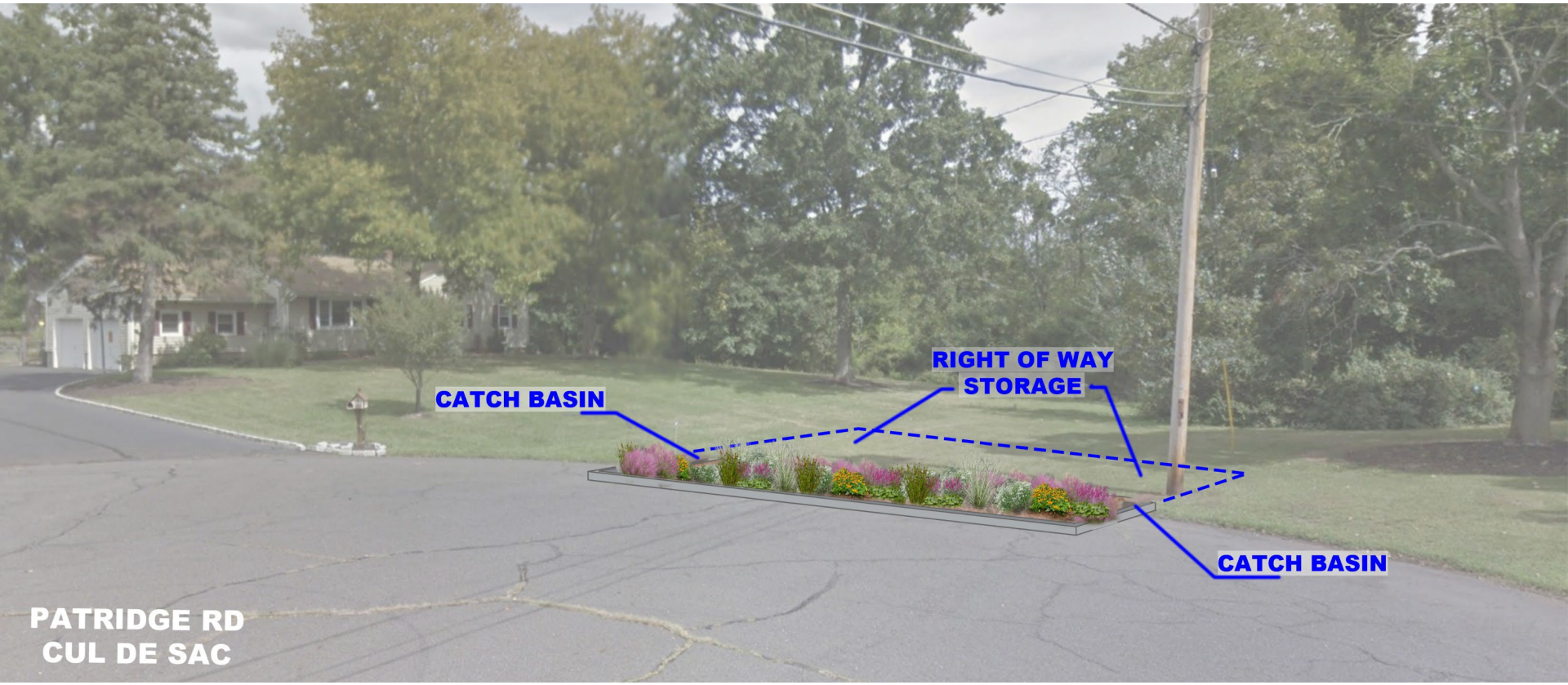
Where do we target our efforts?

- 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

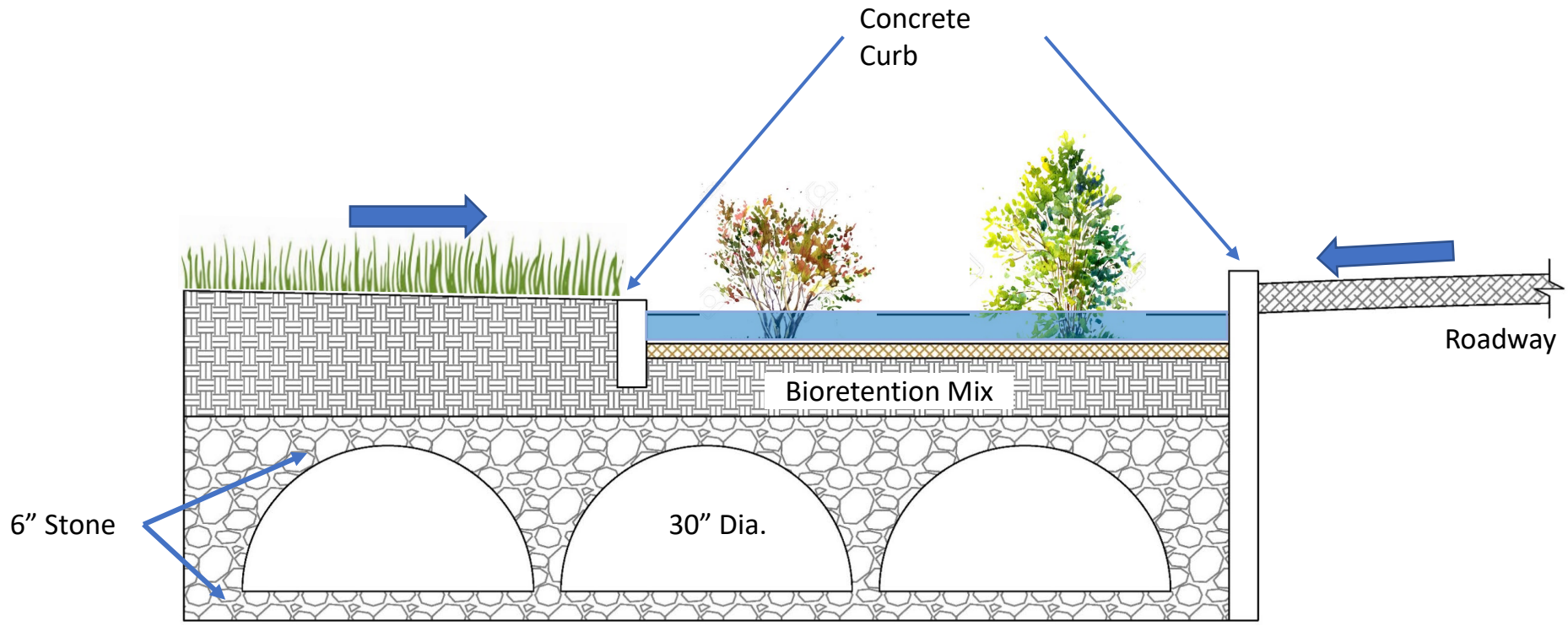

RIGHT OF WAY
STORAGE
CATCH BASIN
GROUSE RD.
CATCH BASIN
RIGHT OF WAY
STORAGE
CATCH BASIN
PATRIDGE RD


CATCH BASIN
RIGHT OF WAY
STORAGE
CATCH BASIN
PATRIDGE RD
CUL DE SAC

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 with
  - Allows mixed use of stormwater management area and recreational uses (i.e., parks)

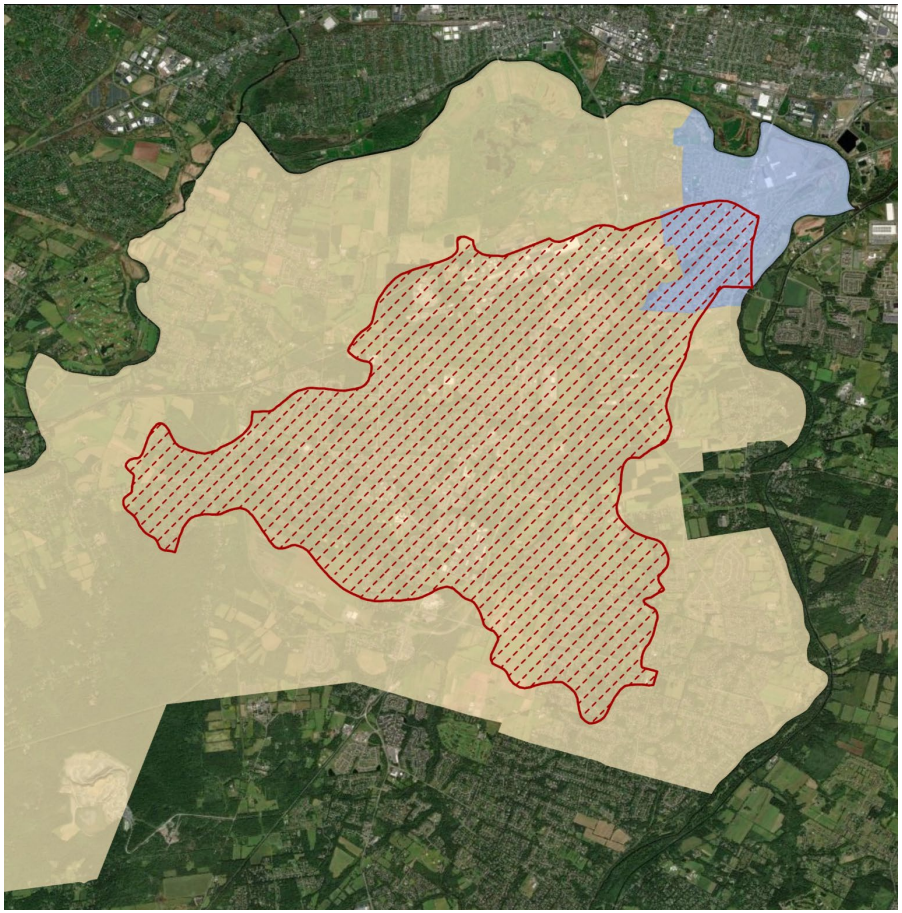

Concrete
Curb
Roadway
Bioretention Mix
6” Stone
30” Dia.

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

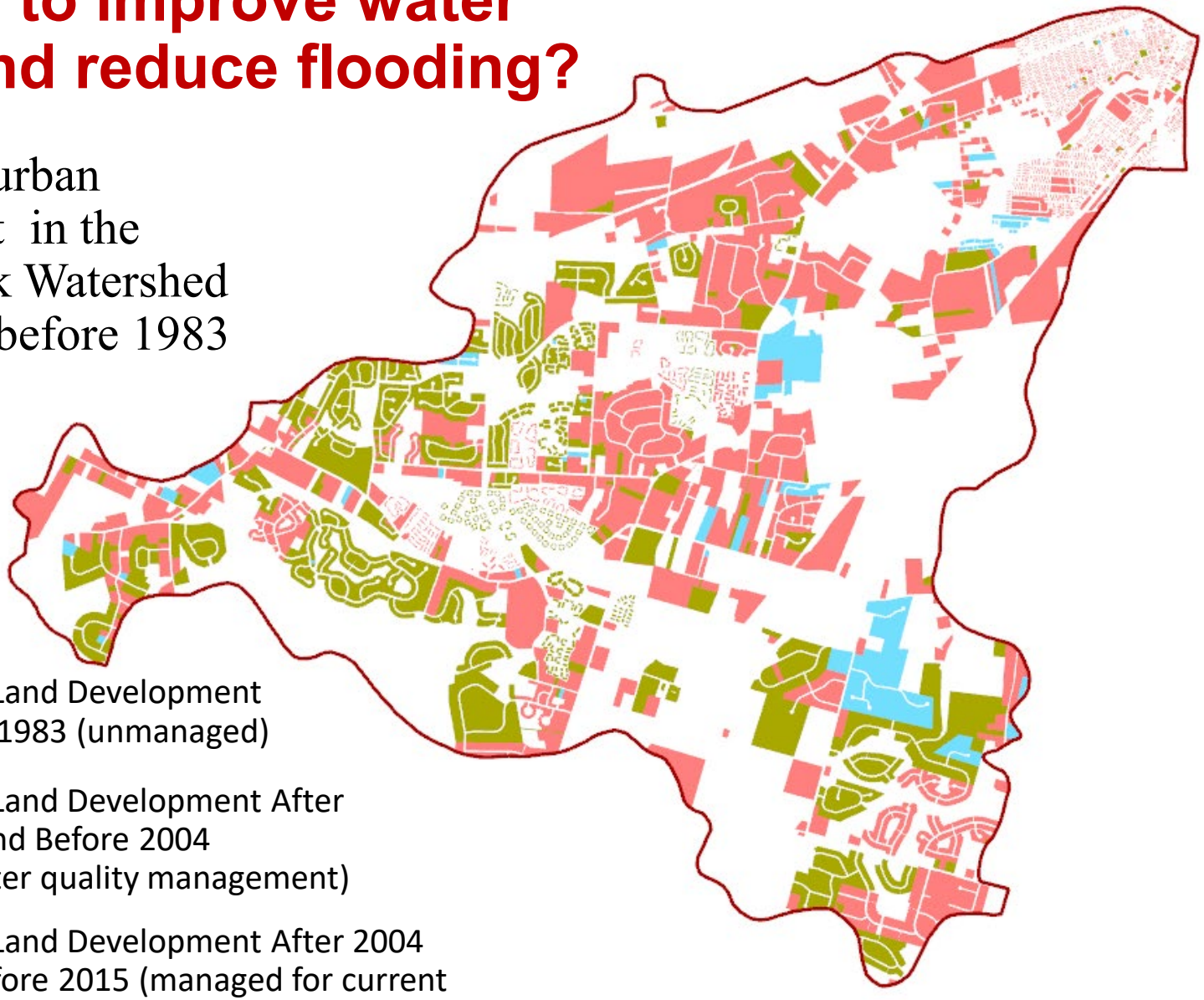
- Commercial
  - Underground storage in parking lots
  - Remove sections of unutilized areas to create larger storage systems




Royce Brook Watershed
10,567.6 acres = 16.5 sq. mi.
24.3% impervious cover
Manville
Hillsborough
LOWE'S
CVS
pharmacy

What land must be better managed to improve water quality and reduce flooding?

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



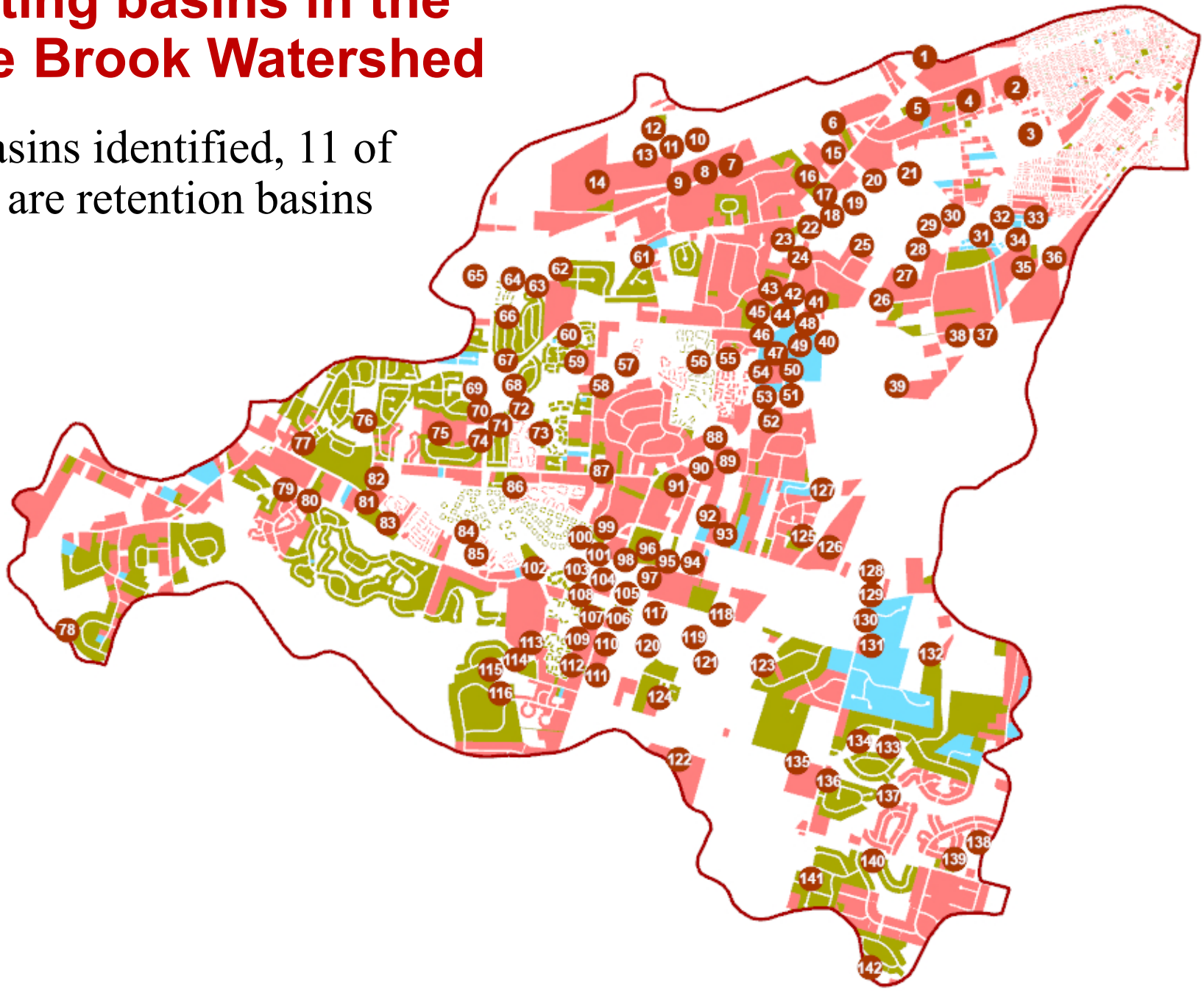
Urban Land Development Before 1983 (unmanaged)

Urban Land Development After 1983 and Before 2004 (no water quality management)

Urban Land Development After 2004 and Before 2015 (managed for current storms, not future storms

Existing basins in the Royce Brook Watershed

- 142 basins identified, 11 of which are retention basins

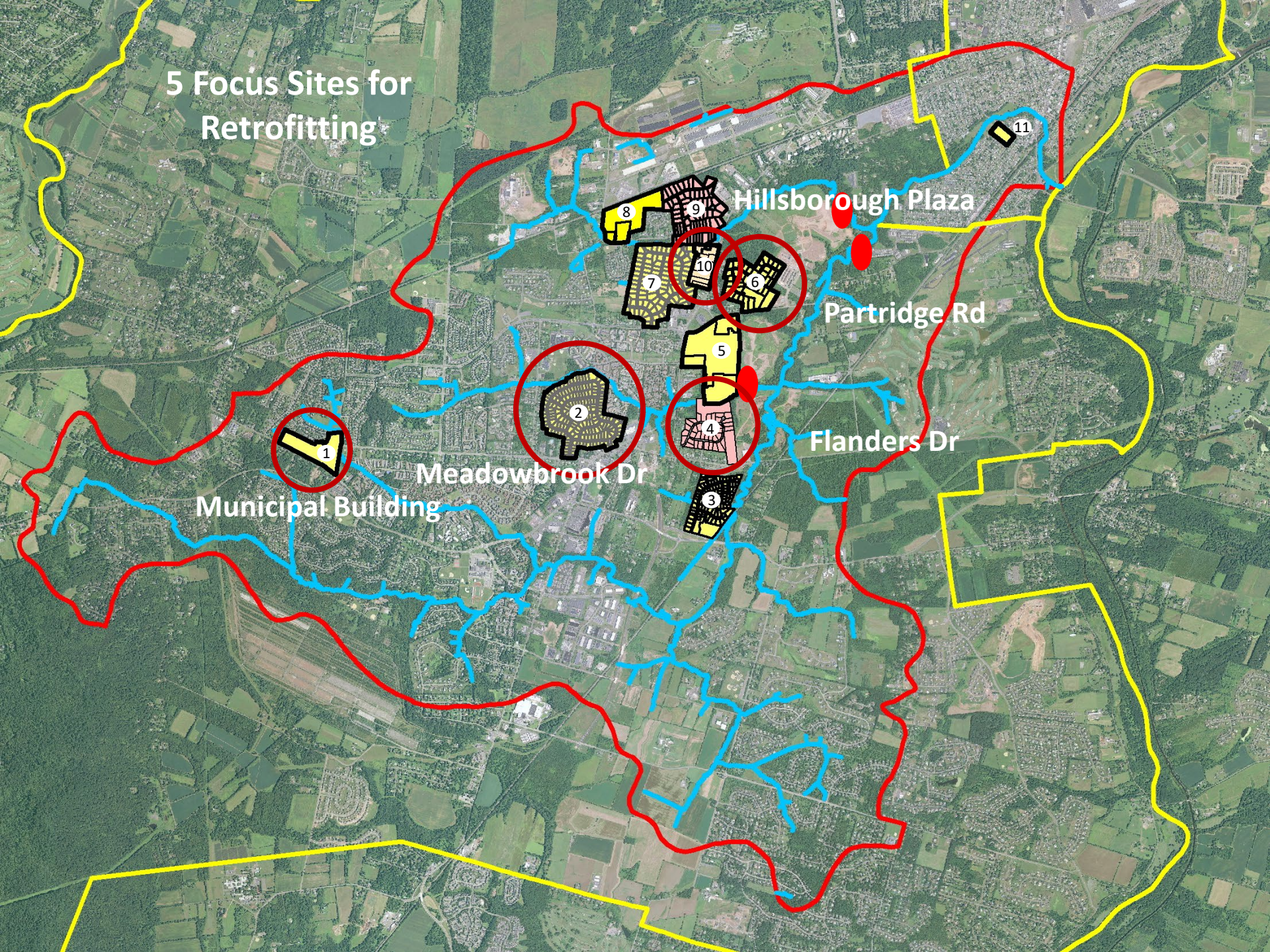


Existing Management

Total Watershed Area	16.5 square miles
Total Developed Area	10.2 square miles
Total Developed Area Managed by Existing Detention Basins	3.1 square miles
Unmanaged Developed Area	7.1 square miles
Undeveloped Forest Area	2.5 square miles
Undeveloped Wetland Area	2.2 square miles
Undeveloped Agriculture Area	1.2 square miles
Undeveloped Barren Land	0.3 square miles
Water	0.1 square miles

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


5 Focus Sites for Retrofitting
Hillsborough Plaza
Partridge Rd
Flanders Dr
Meadowbrook Dr
Municipal Building
1
2
3
4
5
6
7
8
9
10
11

5 Focus Sites for Retrofitting

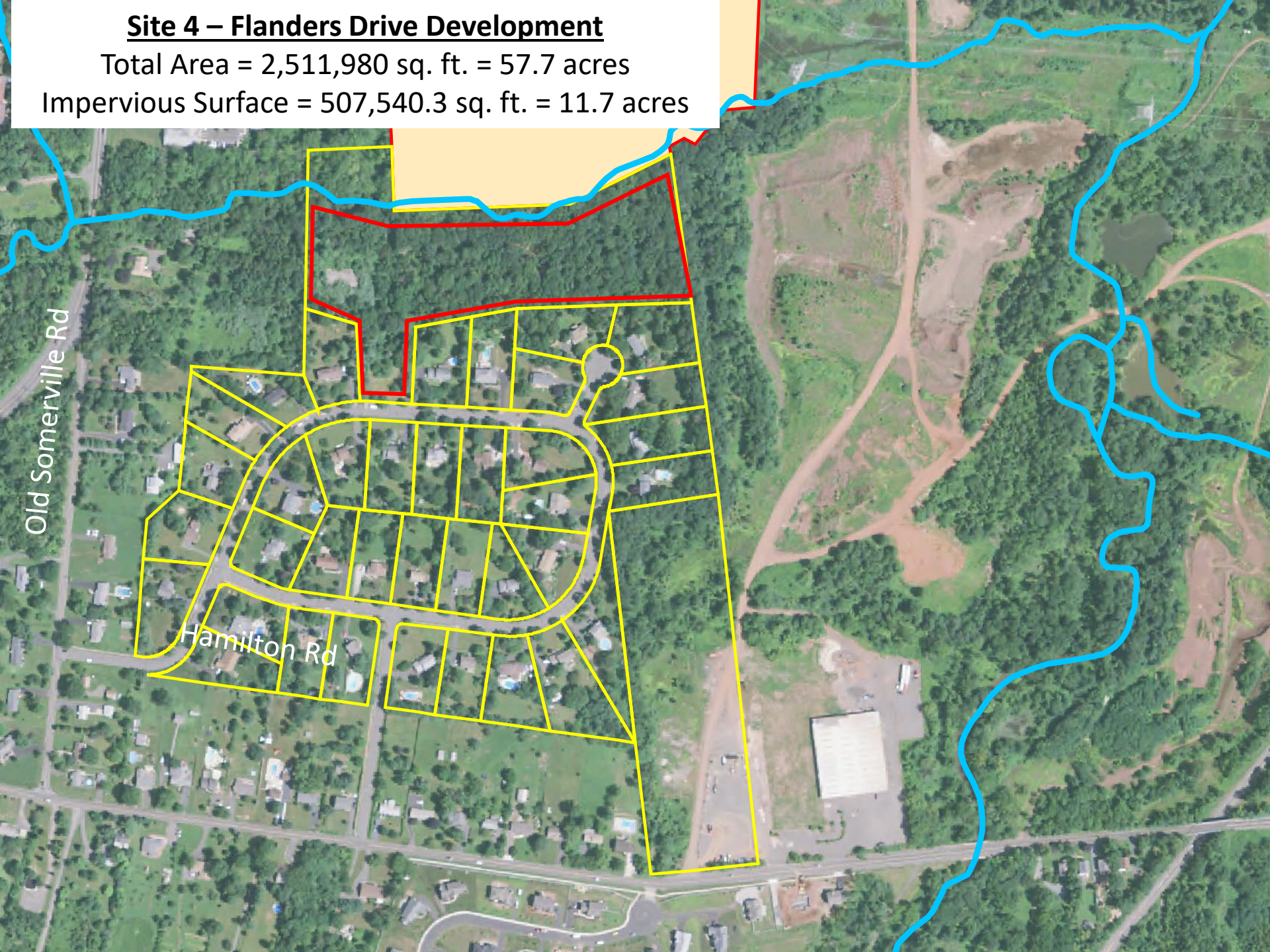
- Hillsborough Municipal Building
- Flanders Drive
- Partridge Farm Road
- Meadowbrook Drive
- Hillsborough Plaza (Tractor Supply)

3 Key Cases

- Design is limited to municipal lands

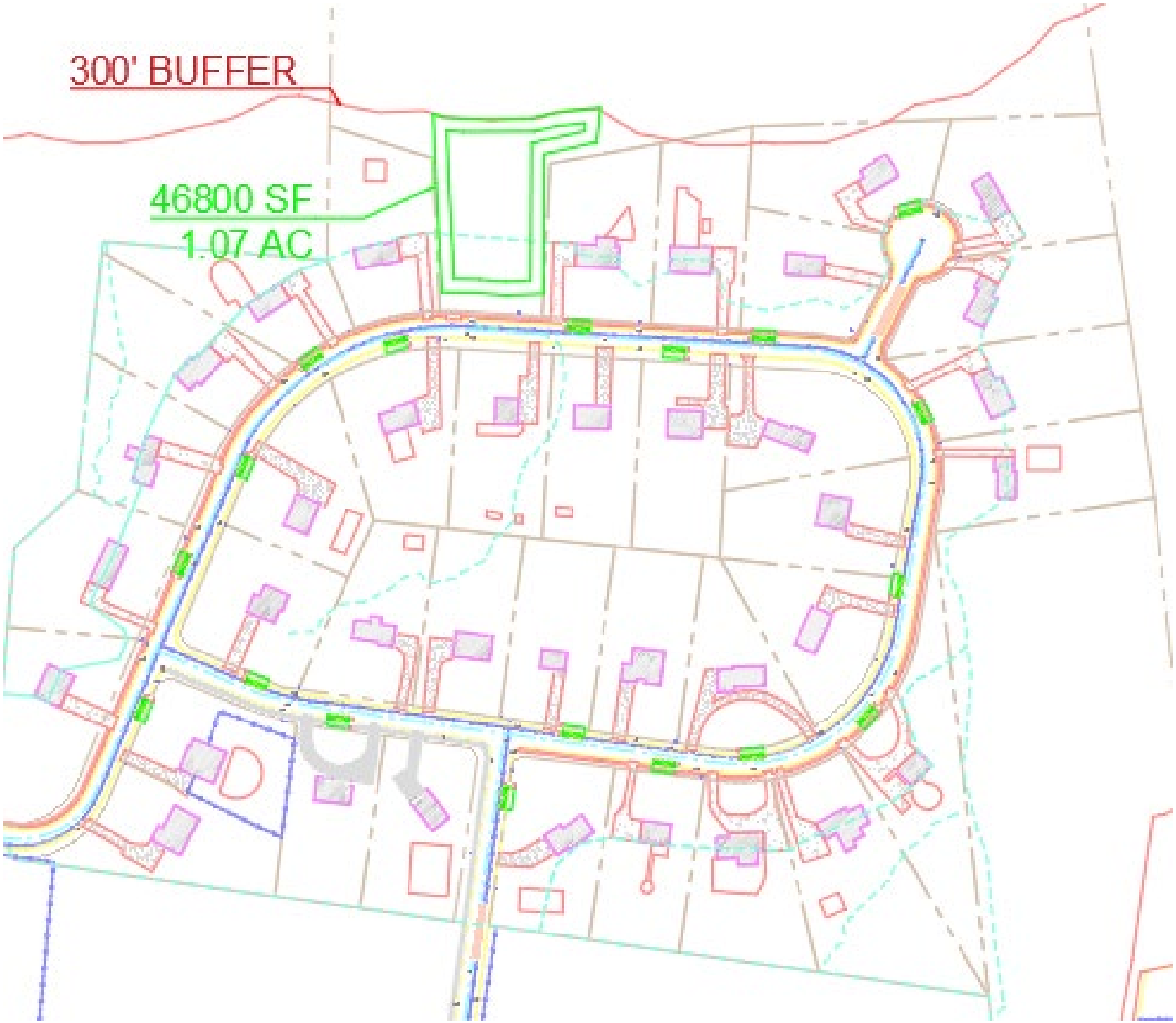
- Design to retrofit
  - At least 80% reduction of predevelopment peak

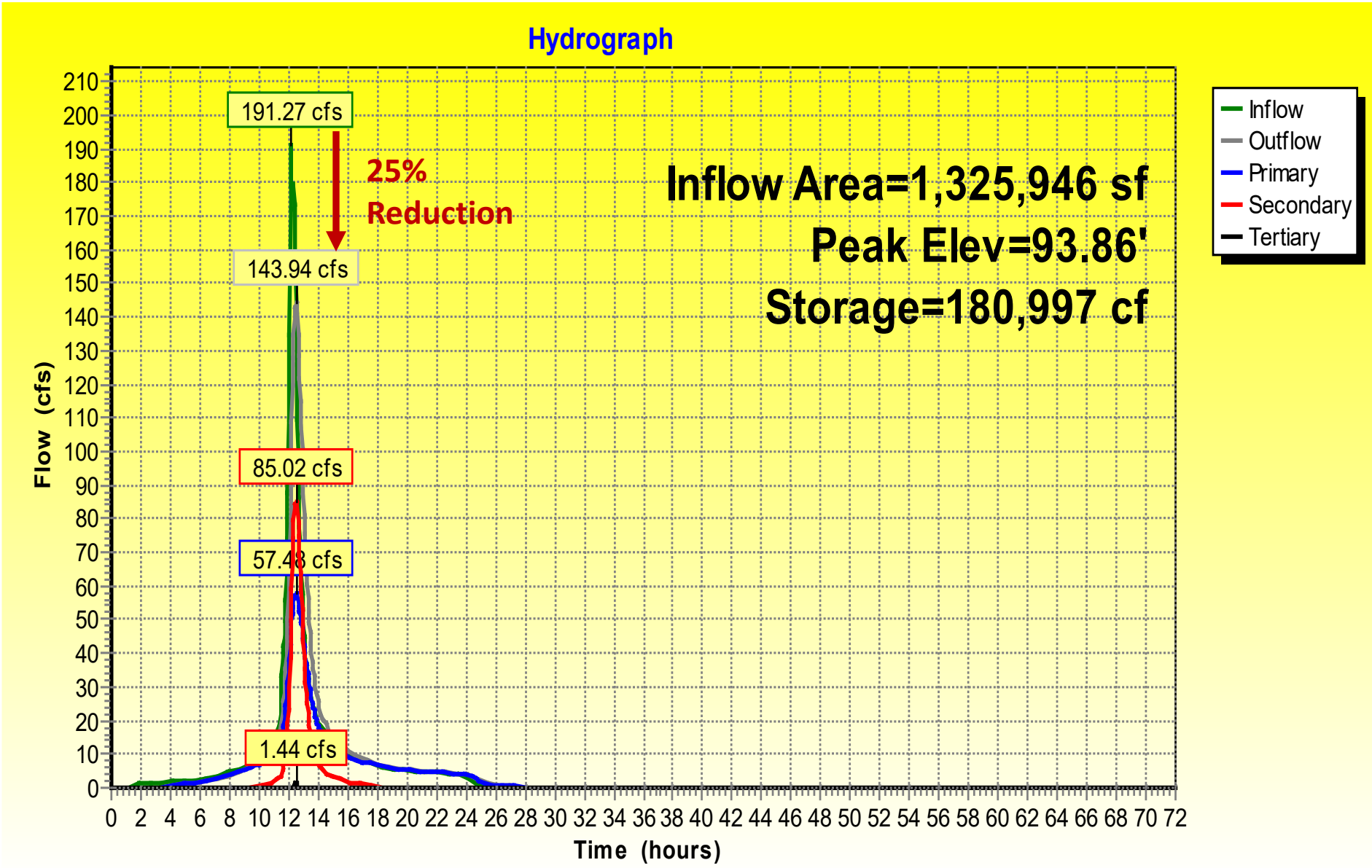
- Design unrestrained to reach 100% capture and hold


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

- Reduces peak by 25% meeting stormwater regulations
- Space for 1 basin and roadside distributed systems

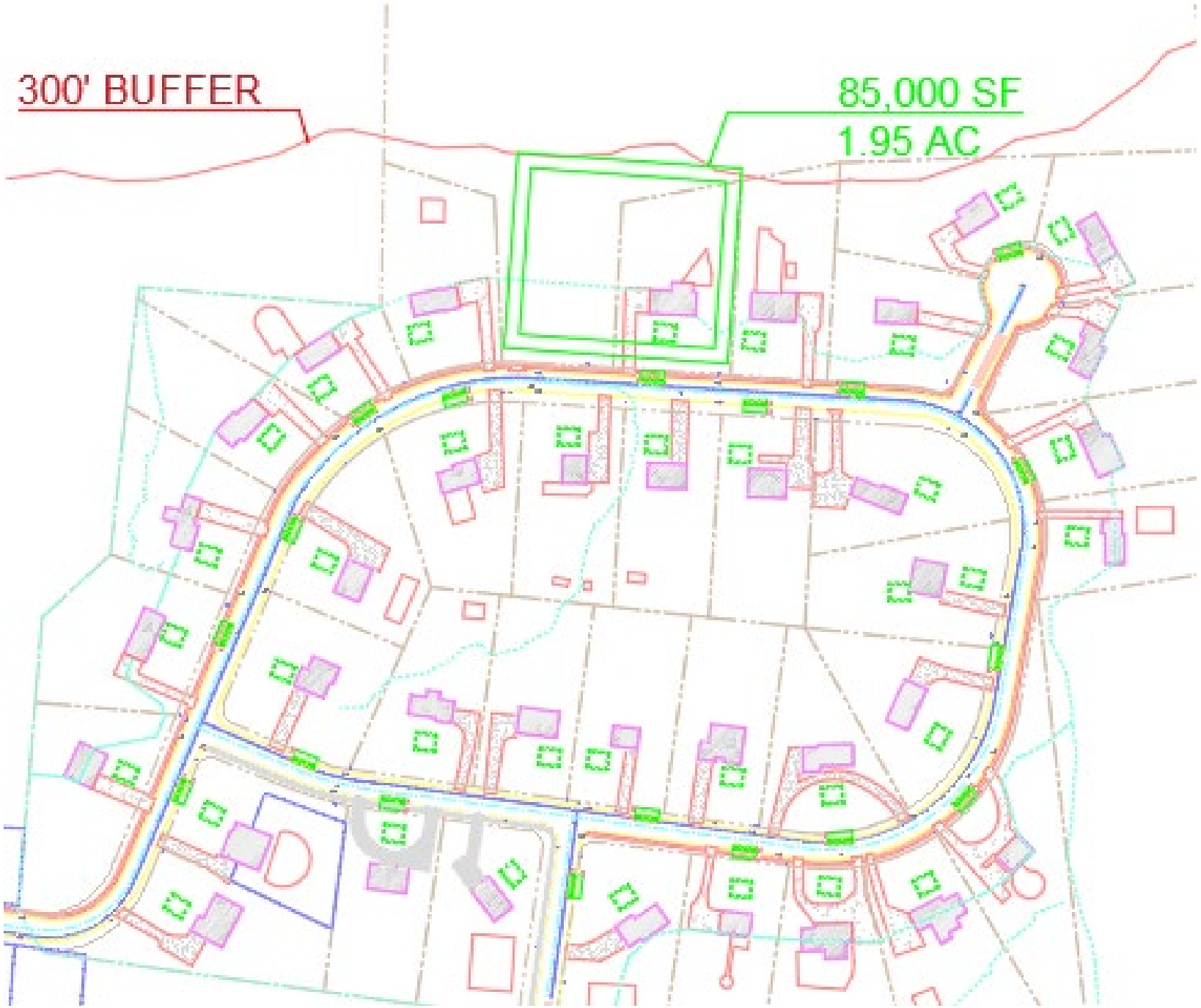

300' BUFFER
46800 SF
1.07 AC


Hydrograph
191.27 cfs
25%
Reduction
143.94 cfs
85.02 cfs
57.48 cfs
1.44 cfs
Inflow Area=1,325,946 sf
Peak Elev=93.86'
Storage=180,997 cf
Inflow
Outflow
Primary
Secondary
Tertiary
Flow (cfs)
Time (hours)
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62 64 66 68 70 72
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210

	Storage Volume (cf)	% Contribution
One acre Bioretention Basin	187,528	88%
Roadside Rain Gardens	25,464	12%
Total Storage Volume	212,992 cubic feet = 1,597,440 gallons	
Peak Reduction	25%	% of inflow
Detention Time 75%	14.4	hrs

Second Option

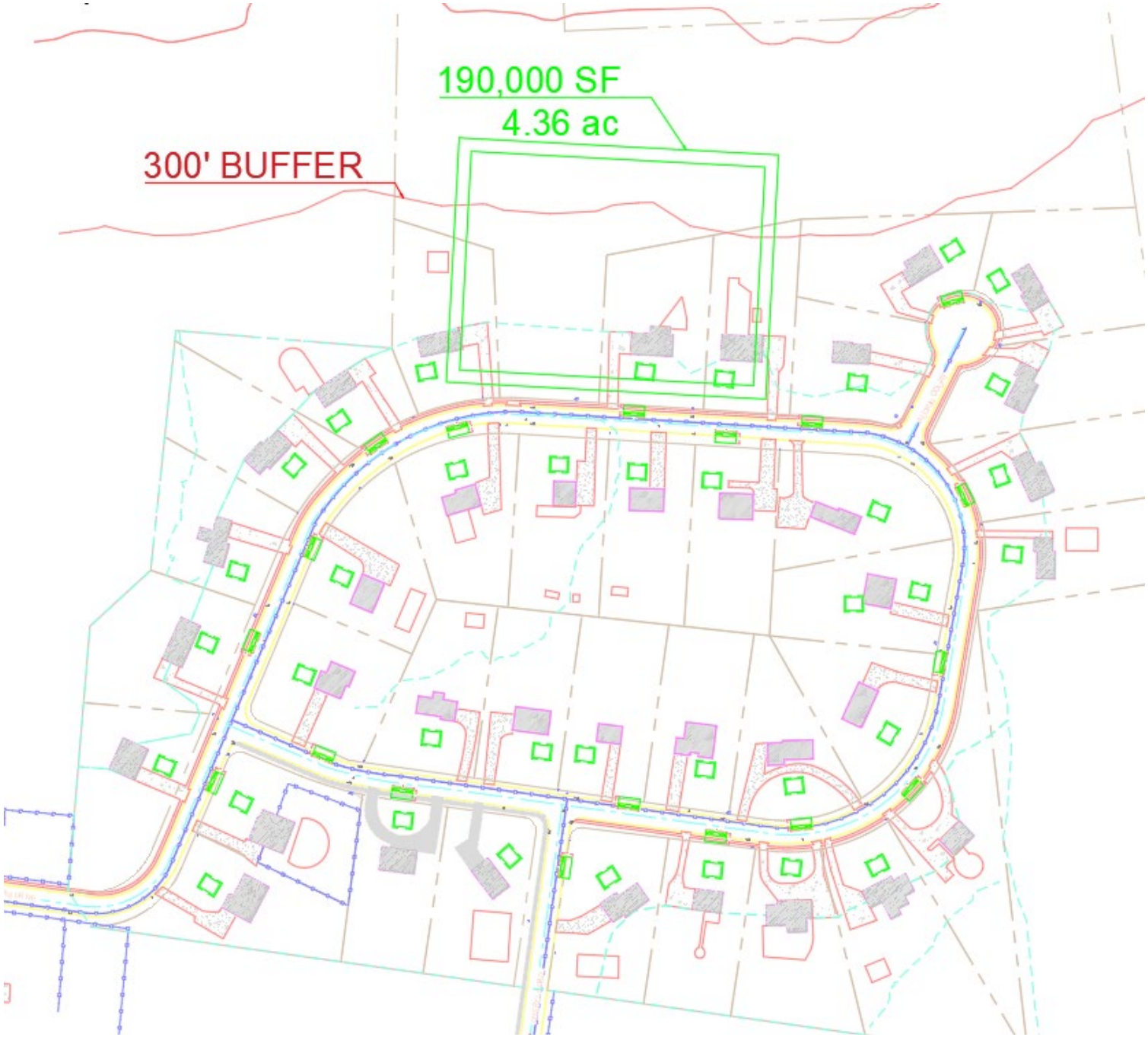
- Double the size of bioretention basin (two acres)
- Add homeowner rain gardens to take roof runoff


300' BUFFER
85,000 SF
1.95 AC

	Storage Volume (cf)	% Contribution
Bioretention Basin	370,550	78%
Porous Pavement	58,570	12%
Rain Garden - Roof	20,276	4%
Rain Garden - Road	25,464	5%
Total Storage Volume	474,860 cubic feet = 3,552,199 gallons	
Peak Discharge	52.7	cfs
Peak Reduction	72%	% of Inflow
Detention Time 75%	17	hrs
Basin Area	1.95	ac

Third Option

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

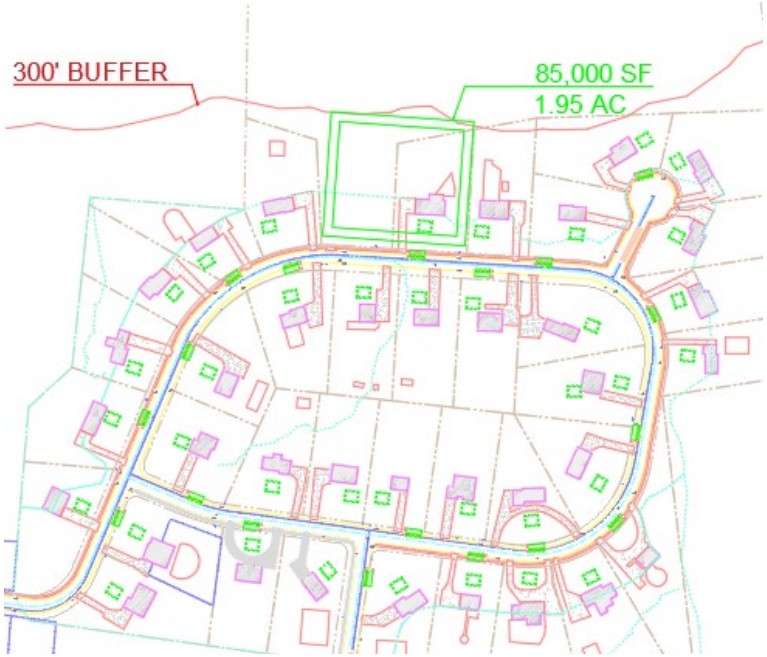

190,000 SF
4.36 ac
300' BUFFER

	Storage Volume (cf)	% Contribution
Bioretention Basin	866,000	89%
Porous Pavement	58,570	6%
Rain Garden – Roof	20,276	2%
Rain Garden - Road	25,464	3%
Total Storage Volume	970,310 cubic feet = 7,258,423 gallons	
Peak Discharge	0	cfs
Peak Reduction	100%	% of Inflow (191.3cfs)
Basin Storage Peak	853,911	cf
*Detention Time 50%	NA	hrs
Detention Time 75%	NA	hrs
Detention Time 100%	NA	hrs
Basin Area	190,000	sf
Basin Area	4.36	ac

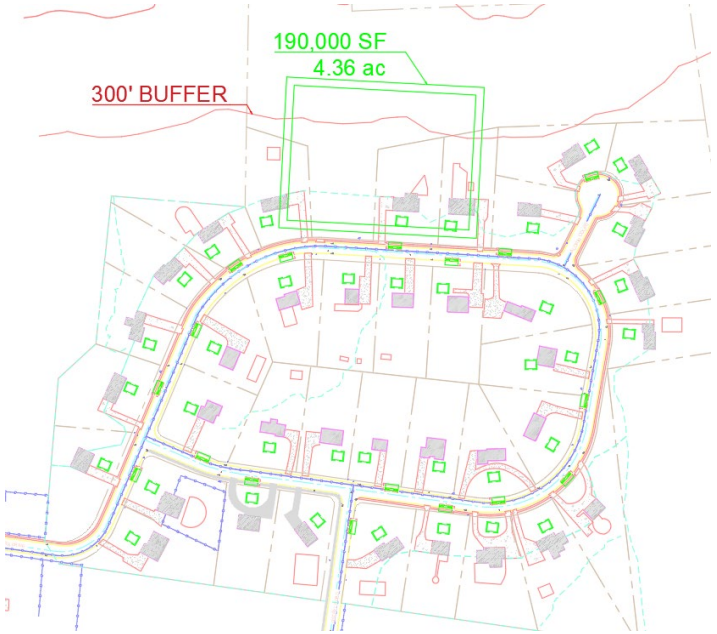
Case Comparison

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	n/a

Municipal Only



Current Regulation



All Storage

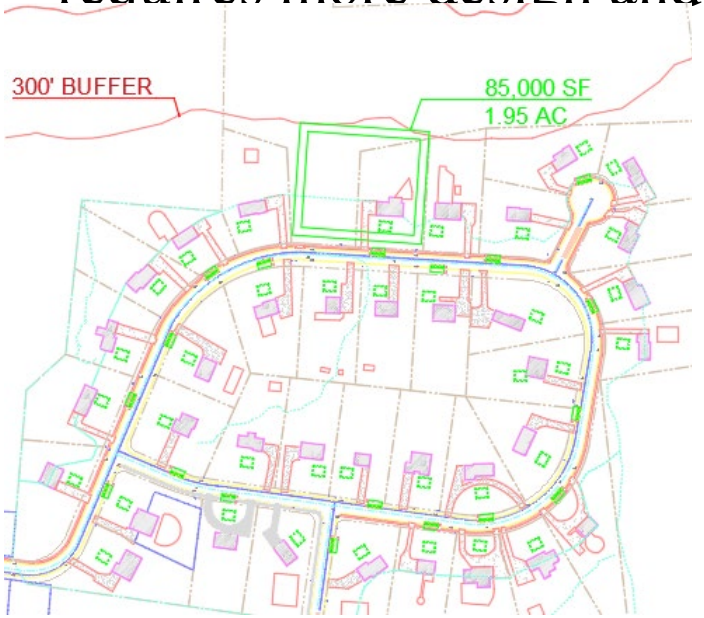
Cost Estimate Comparison

Parameter	Municipal	Current Reg	All Storage
Const. cost of systems w/ distributed	$534,002	$1,932,535	$2,229,011
Cost of property buyouts	$0 (0 properties)	$538,500.00 (1 property)	$1,634,700 (3 properties)
Total w/ distributed systems	**$534,002**	**$2,471,035**	**$3,863,711**

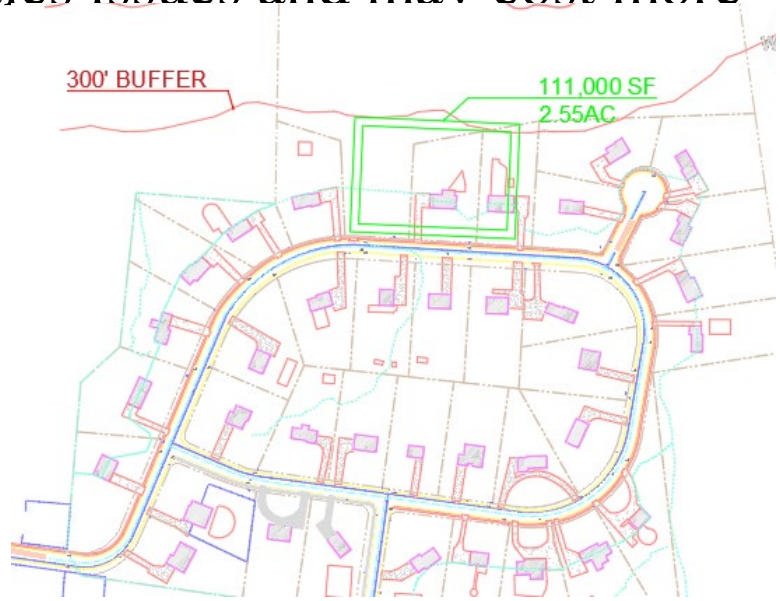
Parameter	Municipal (same basin)	Current Reg (larger basin)	All Storage (larger basin)
Const. cost w/ larger basin only (est.)	$190,202	$424,050	$866,487
Cost of property buyouts (basin only)	$0 (0 properties)	$1,117,900 (2 properties)	$2,140,400 (4 properties)
Total larger basin only	**$190,202**	**$1,541,950**	**$3,006,887**

How much do distributed systems help?

- Types of systems
  - Roadway stormwater planters (160 SF x 18 planters)
  - All non-road pavement pervious w/ storage underneath (6")
  - Rain garden at each house (750 SF x 37 gardens)
- Significantly reduces size of basin & water quality benefits
  - requires more design and logistics issues and may cost more

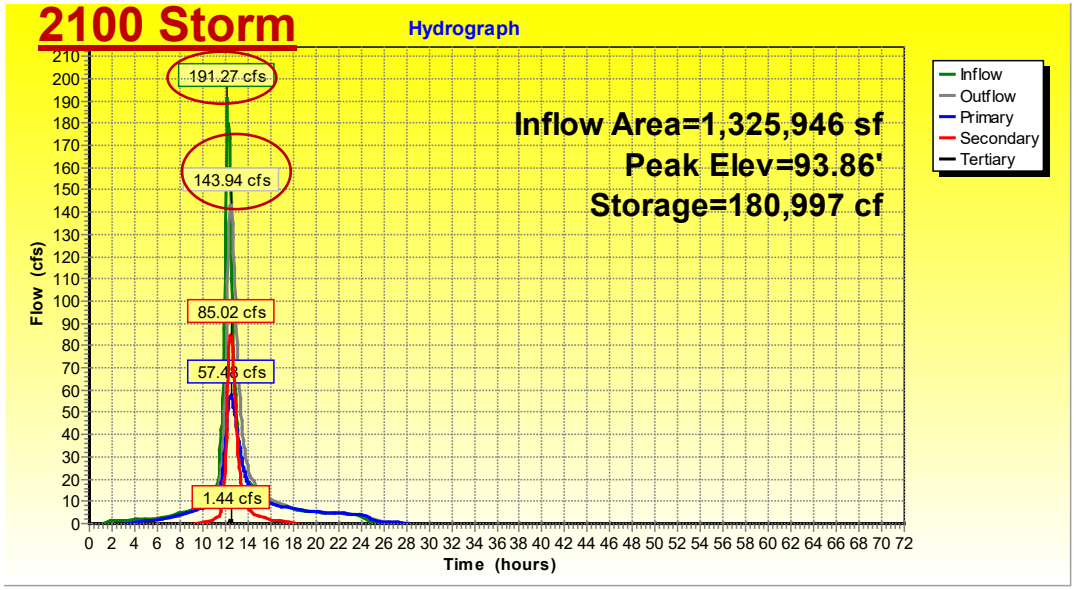


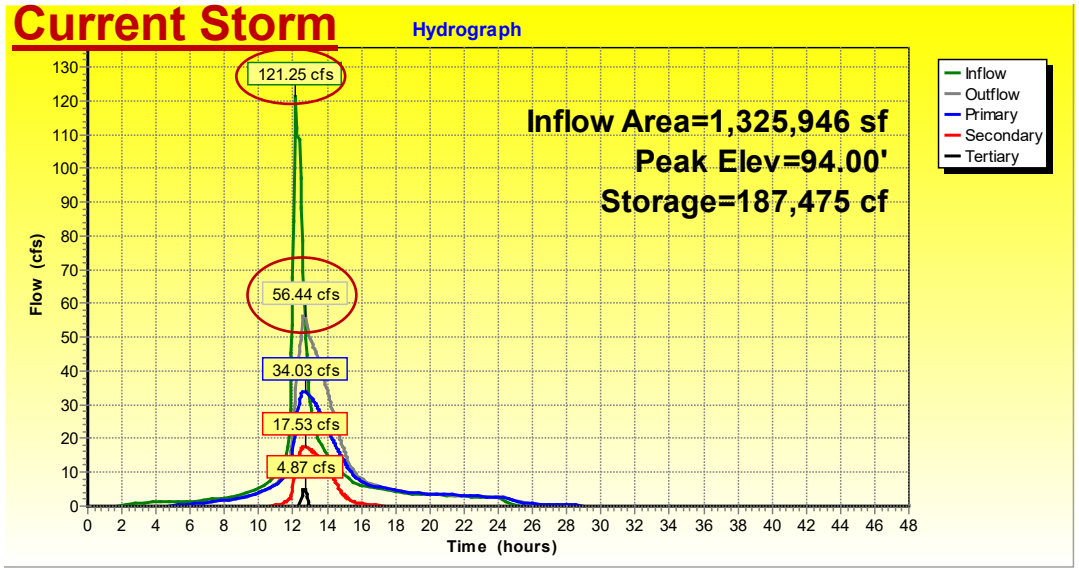
w/ distributed



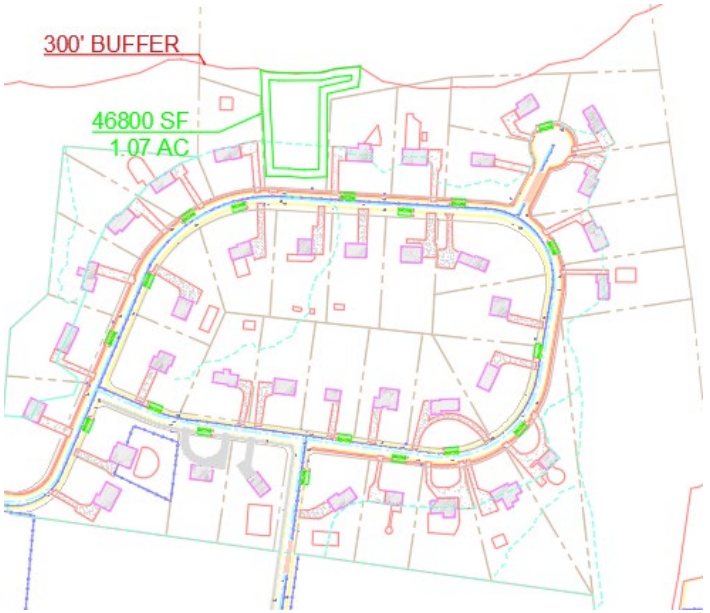
Basin only

Current 100-YR vs 2100 100-YR Storm?





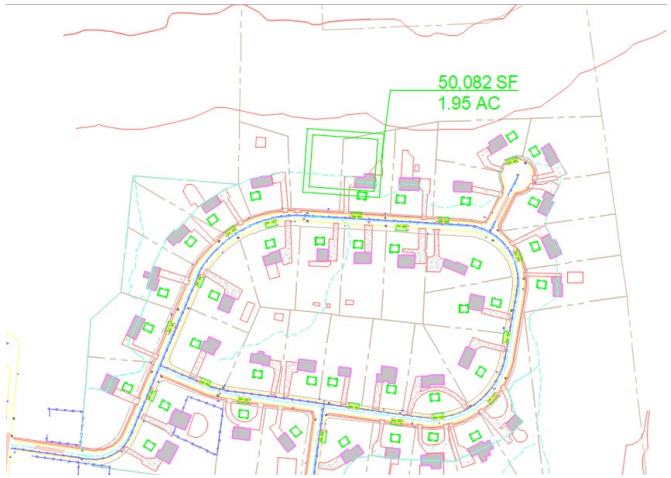
- Much higher inflow and outflow peaks in 2100 storm



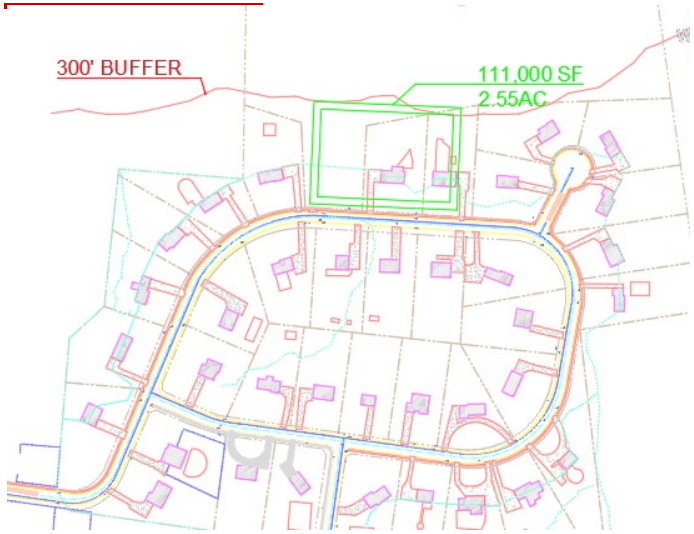
Municipal Only

How much do basins need to increase to manage 2100 storm vs. current?

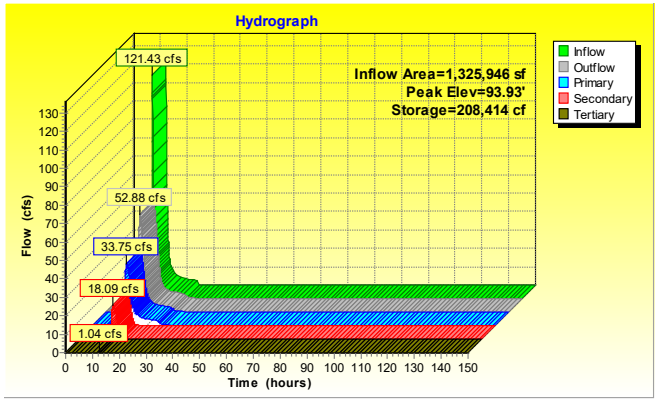
Current Storm

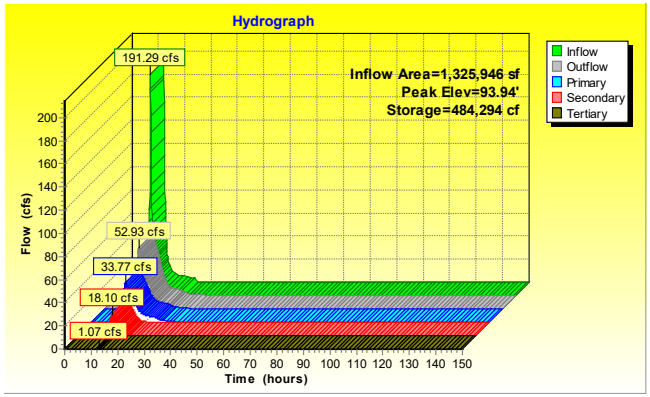


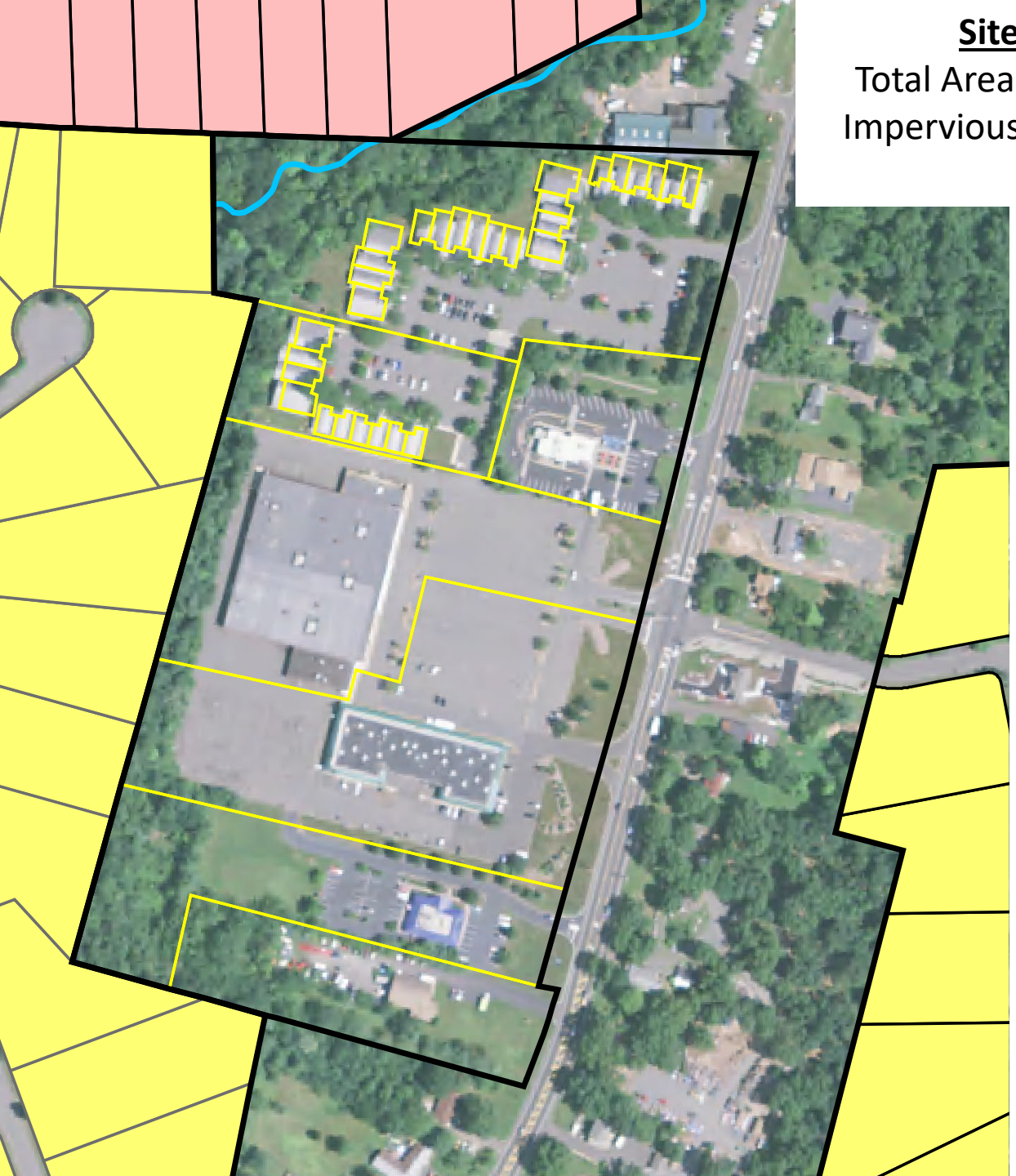
2100 Storm



- Basins may need to be about 120% larger to produce similar hydrologic outputs (basin only case)
  - Highly variable based on site conditions and basin dimensions







Site 10 – Hillsborough Plaza

Total Area = 1,036,600 sq. ft. = 23.8 acres

Impervious Surface = 626,500 sq. ft. = 14.4 acres

HILLSBOROUGH PLAZA

GREEN INFRASTRUCTURE IMPLEMENTATION PROJECT
256 US-206, HILLSBOROUGH CITY]
SOMERSET COUNTY, NEW JERSEY

PROJECT DESCRIPTION:

GREEN INFRASTRUCTURE DEMONSTRATION PROJECT WILL BE INSTALLED IN 256 US-206 PLAZA.

1. ISLANDS OF PARKING LOT WILL BE DE-PAVED AND RE-INSTALLED TO BE RAIN GARDENS, TO CAPTURE, INFILTRATE THE STORMWATER RUNOFF FROM THE ROAD.
2. RAIN GARDENS WILL BE INSTALLED ON THE GRASS AREA AROUND THE PLAZA, TO CAPTURE, INFILTRATE THE STORMWATER RUNOFF FROM THE ROAD.
3. PARKING LOT AT THE SOUTH SIDE OF PLANET FITNESS WILL BE REPLACED WITH PERVIOUS CONCRETE TO CAPTURE THE STORMWATER RUNOFF FROM THE ROAD AND THE ROOF.
4. UNDERGROUND STORAGE TANK WILL BE INSTALLED UNDER THE PARKING LOT TO INCREASE THE CAPACITY OF GREEN INFRASTRUCTURES.

THE PROJECT WILL SERVE AS A DEMONSTRATION FOR CITIZEN TO LEARN ABOUT SUSTAINABLE STORMWATER MANAGEMENT AND LOCAL POLLINATOR ECOLOGY.

LIST OF DRAWINGS:

SHEET NAME	TITLE
COVER	COVER SHEET
P-1	EXISTING CONDITIONS AND DEMOLITION PLAN
P-2	PROPOSED SITE PLAN
DT-1	DETAILS
DT-2	DETAILS 2
DT-3	DETAILS 3
DT-4	DETAILS 4

LOCATION MAP (N.T.S):

LEGEND:

- EXISTING DRAINAGE AREA
- EDGE OF PAVEMENT
- EXISTING CENTERLINE
- EXISTING TREELINE
- EXISTING TREE/SHRUB
- EXISTING BUILDING
- EXISTING LIGHT POLE
- AREA TO BE DEPAVED
- PROPOSED GREEN INFRASTRUCTURE
- PROPOSED POROUS ASPHALT
- PROPOSED TOP OF BERM

GENERAL NOTES:

1. SURVEY CONDUCTED BY RUTGERS COOPERATIVE EXTENSION WATER RESOURCES PROGRAM. ALL ELEVATIONS ARE RELATIVE TO THE 100.00' BENCHMARK POINT. (OR ELEVATION DATA OBTAINED FROM [INSERT DATA SOURCE HERE, TYP NOAA DIGITAL COASTAL LIDAR]. ELEVATION ARE HEIGHT ABOVE MEAN SEA LEVEL SET BY NAVD 1988).
2. EXISTING SOILS ARE PENN SILT LOAM WHICH ARE CLASSIFIED AS HYDROLOGIC SOIL GROUP C WHICH HAVE LOW INFILTRATION RATES BASED ON THE NRCS WEB SOIL SURVEY (websoilsurvey.sc.egov.usda.gov).
3. ANY OVERHEAD AND UNDERGROUND UTILITIES SHOWN ARE FROM FIELD OBSERVATIONS AND ARE NOT A COMPLETE REPRESENTATION. A UTILITY MARKOUT NEEDS TO BE CONDUCTED PRIOR TO MOBILIZATION BY THOSE RESPONSIBLE FOR EXCAVATION. NJ ONE CALL: 811 OR 800-272-1000

PLAN REVISIONS		
REV. DATE	REV. SUMMARY	REV. SHEETS

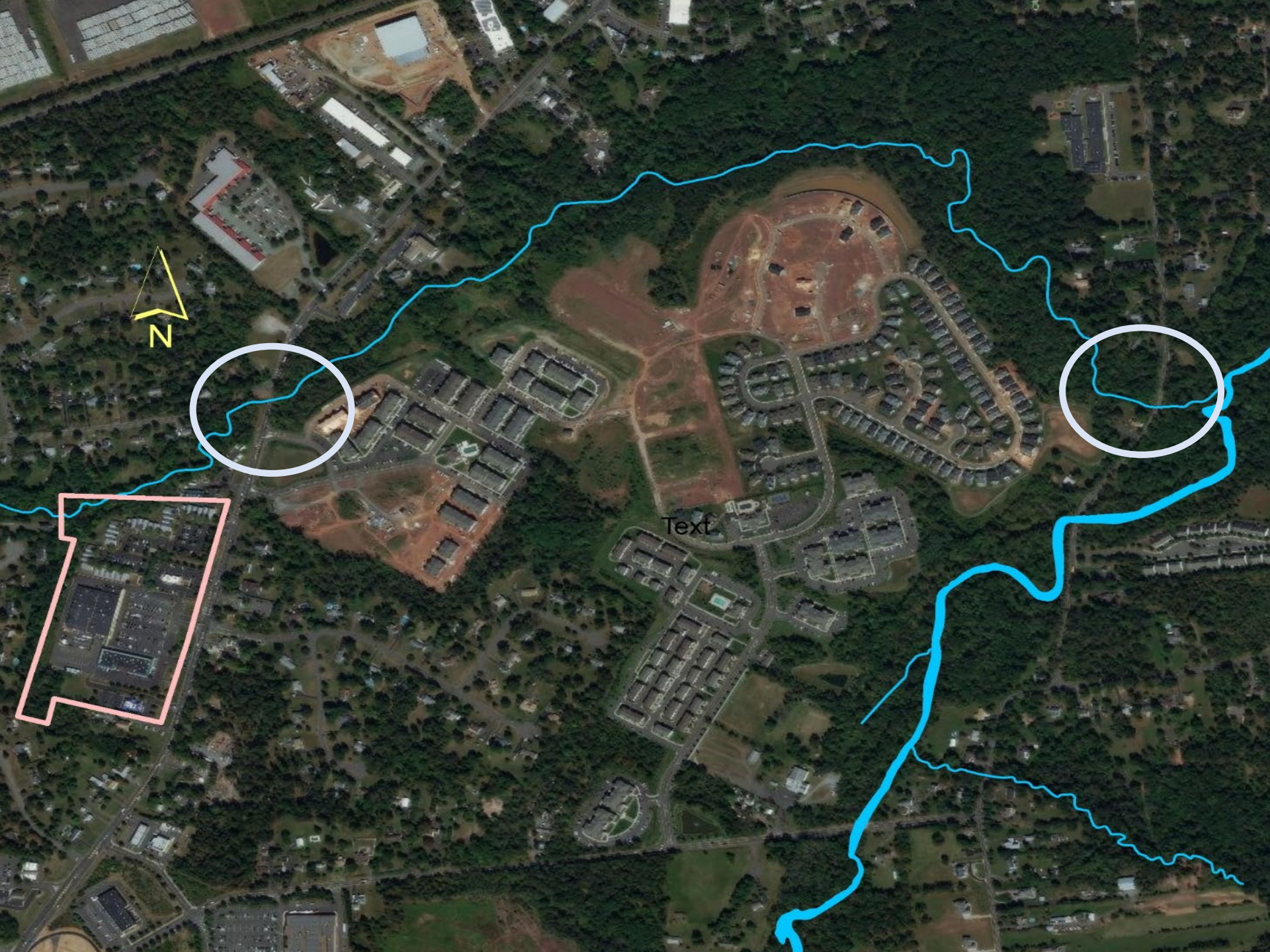
CHRISTOPHER C. OBROPTA, Ph.D., P.E.
PROFESSIONAL ENGINEER - N.J. LICENSE # 37532

DRAFT

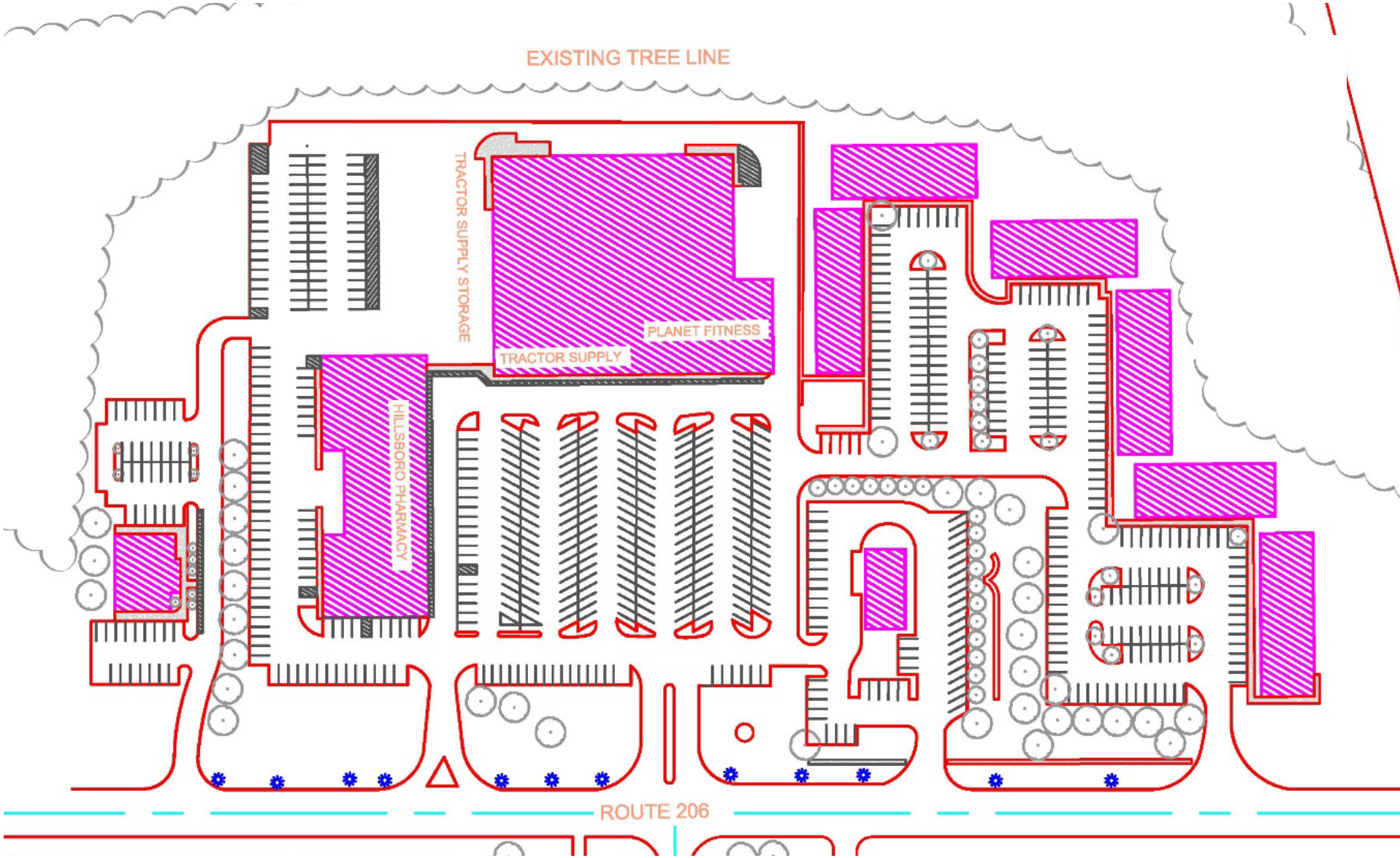
HILLSBOROUGH PLAZA
GREEN INFRASTRUCTURE IMPLEMENTATION PROJECT
256 US-126, HILLSBOROUGH CITY]
SOMERSET COUNTY, NJ

RUTGERS
New Jersey Agricultural Experiment Station

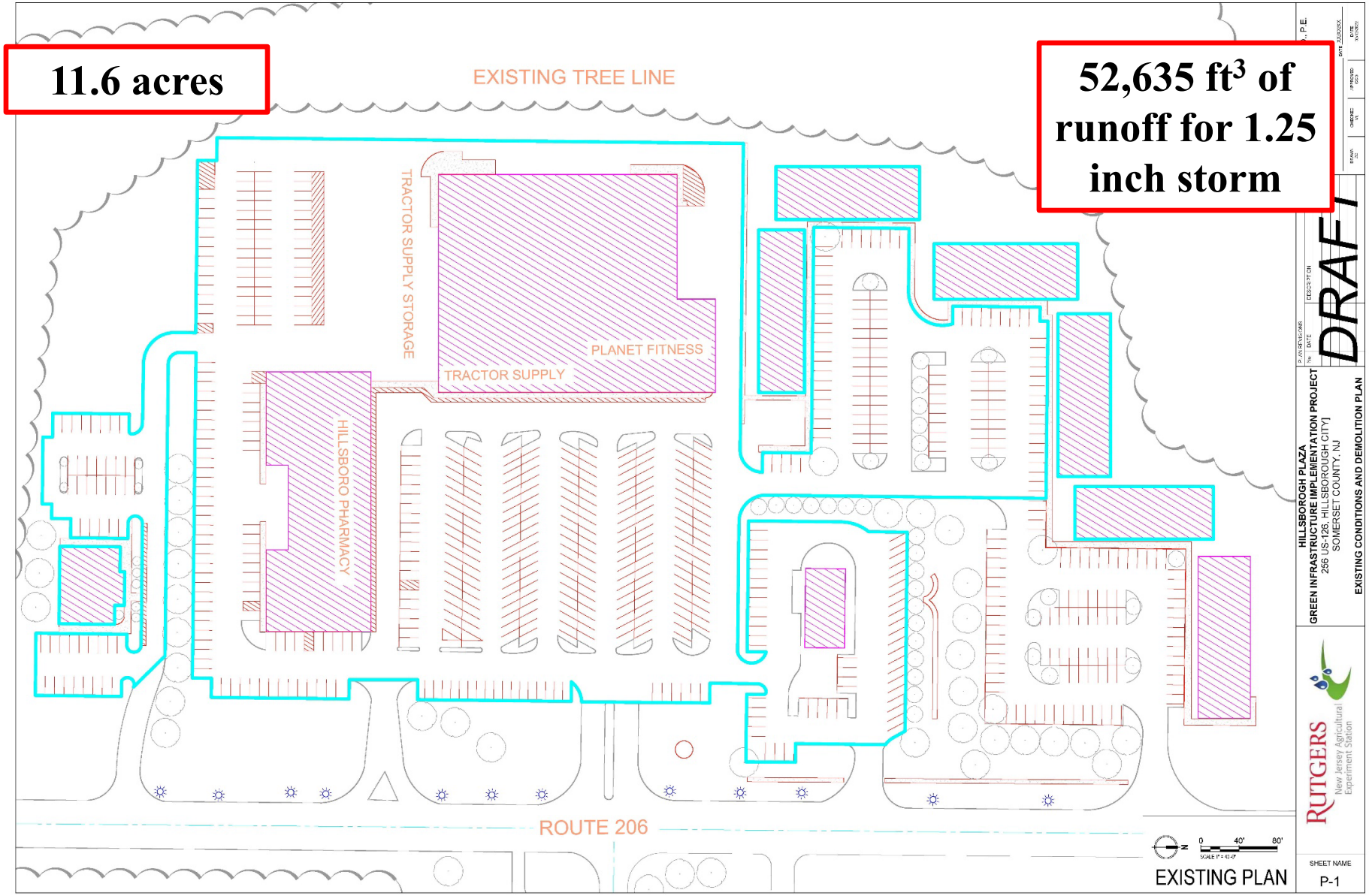
SHEET NAME
COVER


N
Text

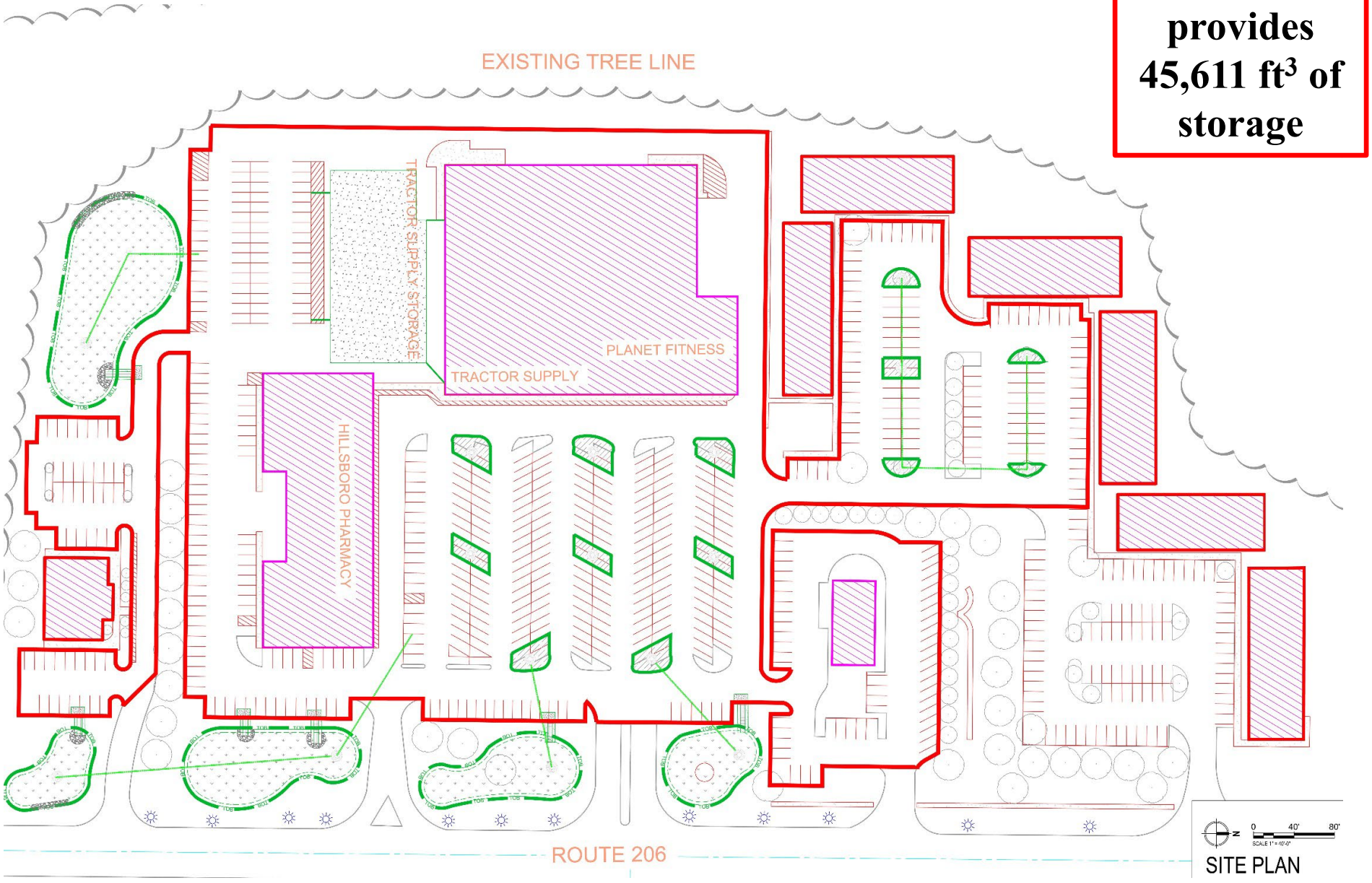
Hillsborough Plaza
256 Route 206
Hillsborough, New Jersey


EXISTING TREE LINE
TRACTOR SUPPLY STORAGE
PLANET FITNESS
TRACTOR SUPPLY
HILLSBORO PHARMACY
ROUTE 206

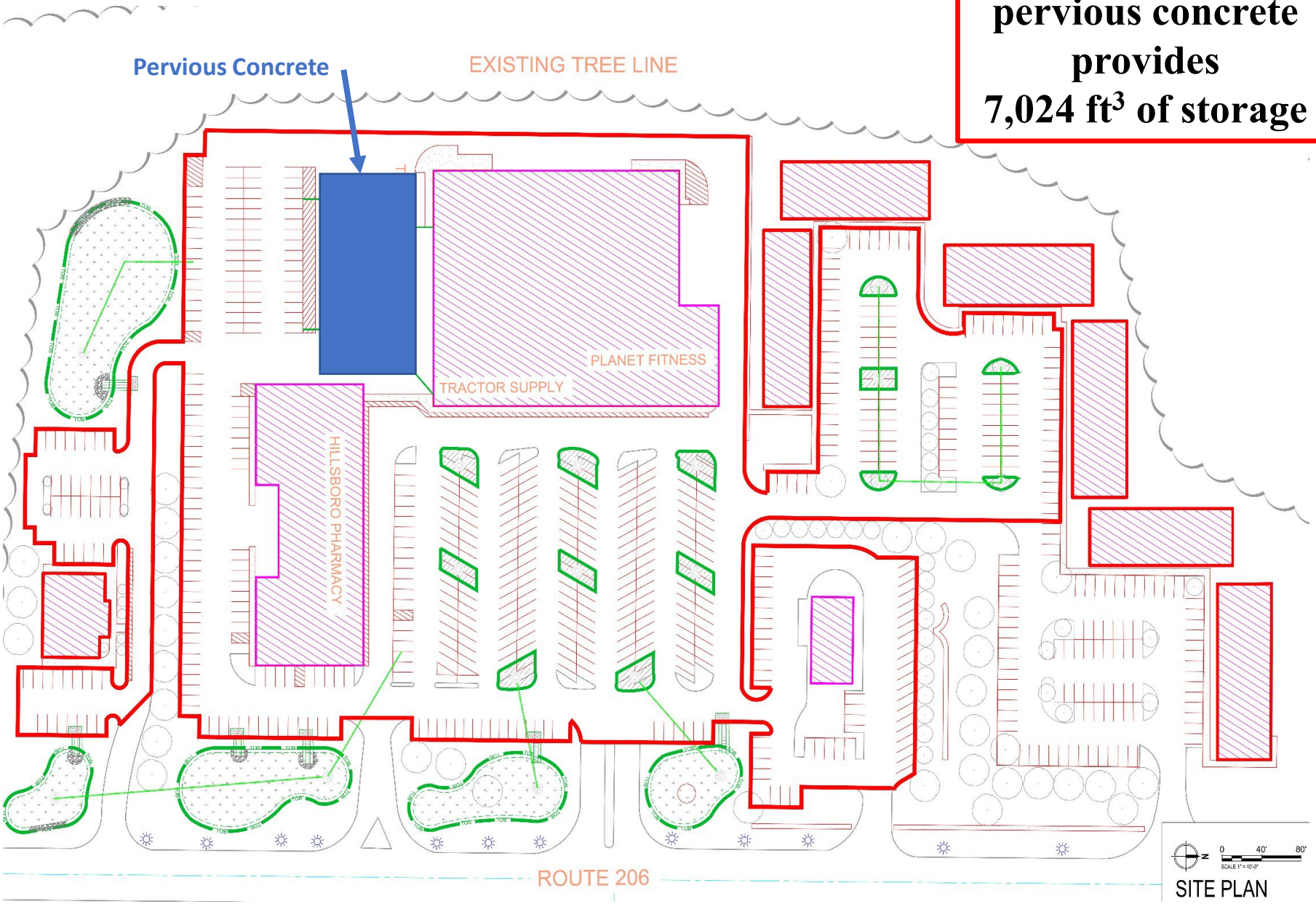
Water Quality Storm Analysis (1.25 inches)



1.23 acres of rain gardens provides 45,611 ft^3 of storage



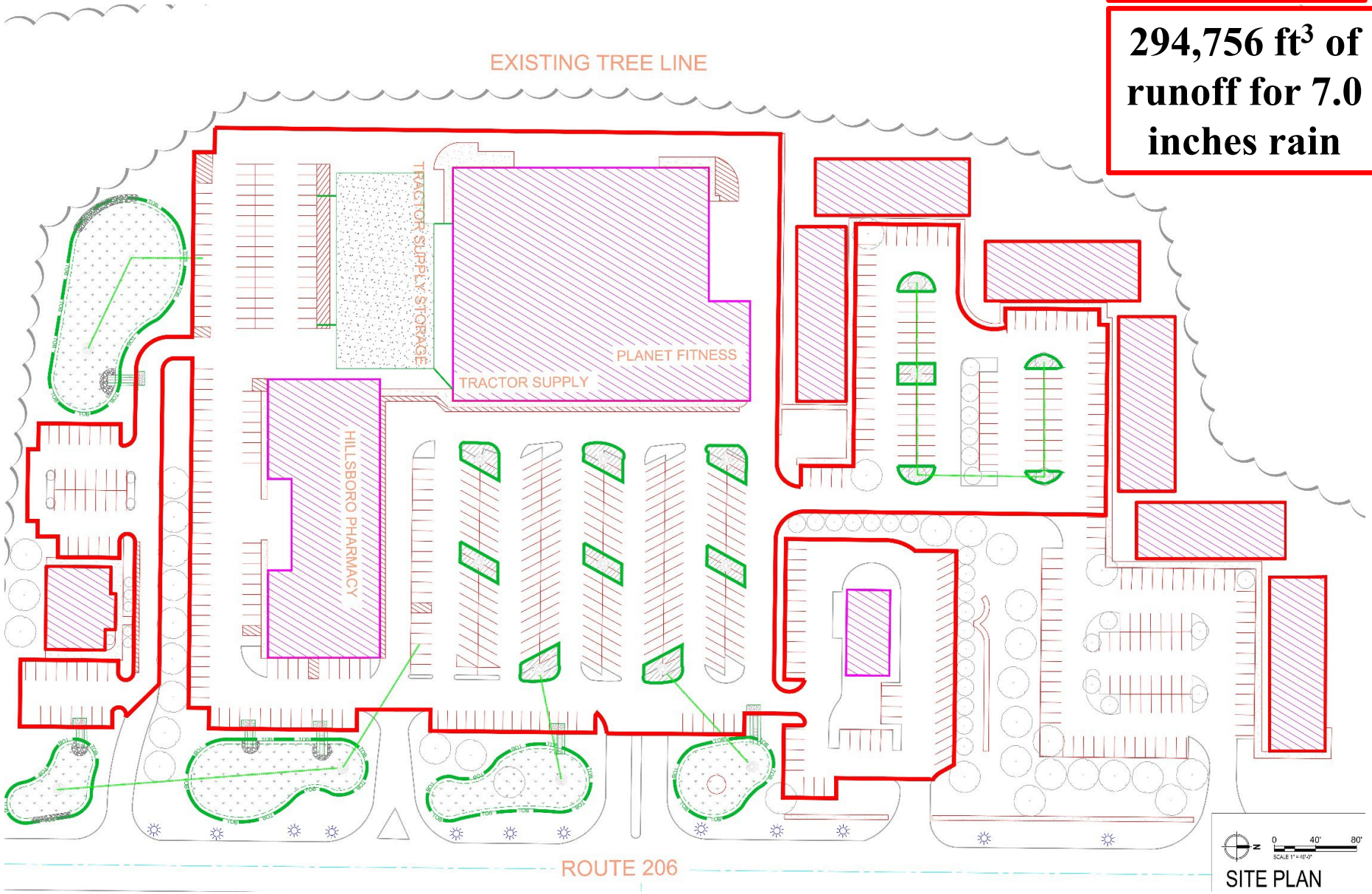
17,560 ft² of pervious concrete provides 7,024 ft³ of storage



100-Year Storm Analysis 8.25 inches

11.6 acres

294,756 ft^3 of runoff for 7.0 inches rain



2.4 acres of underground storage system provides 351,208 ft^3 of storage

64,800 ft of two-foot diameter pipe

EXISTING TREE LINE

ROUTE 206

SITE PLAN

CHRISTOPHER C. OBROPTA, Ph.D., P.E.

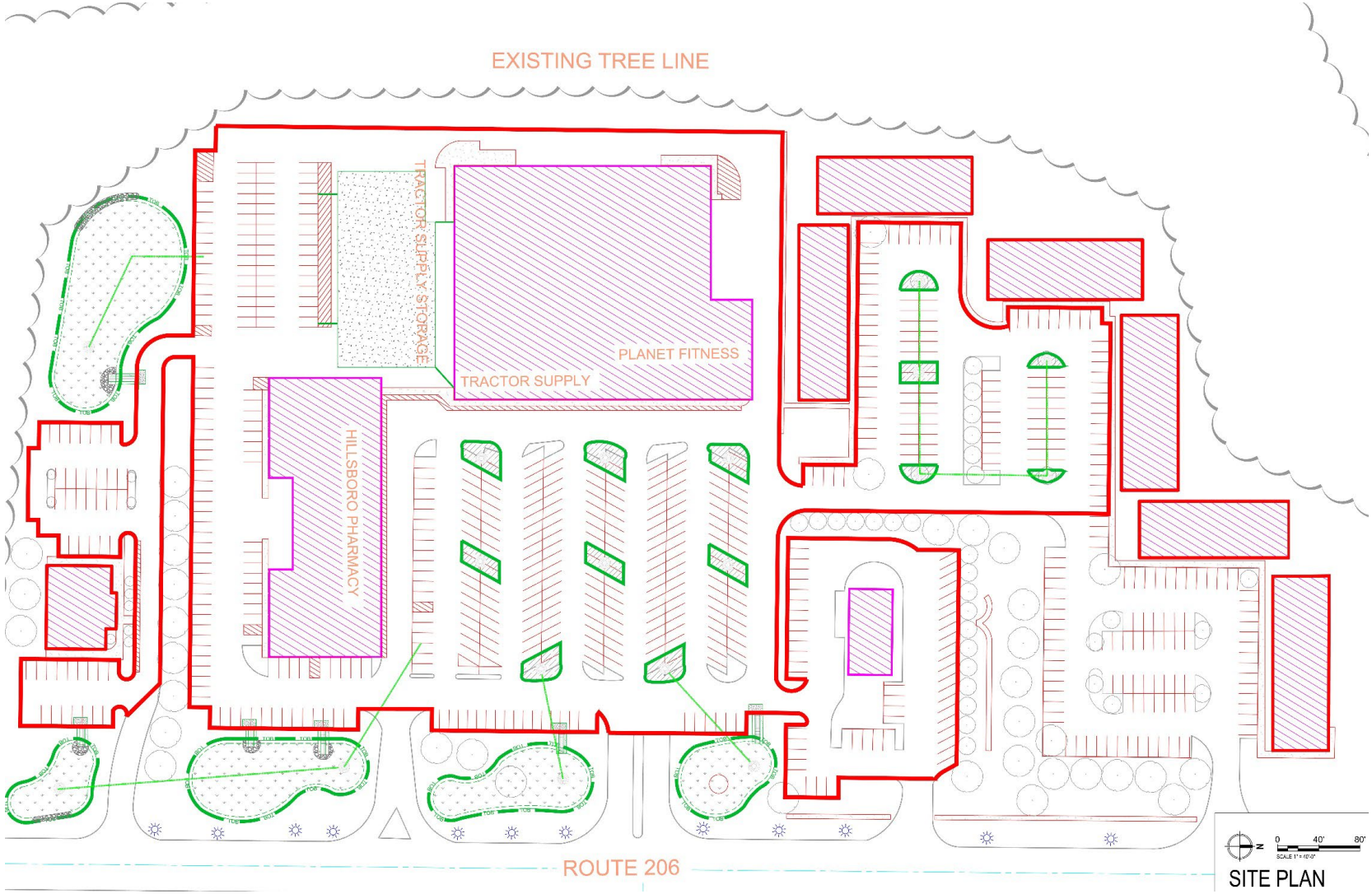
DRAFT

HILLSBOROGH PLAZA
GREEN INFRASTRUCTURE IMPLEMENTATION PROJECT
256 US-126, HILLSBOROUGH CITY]
SOMERSET COUNTY, NJ
PROPOSED SITE PLAN

RUTGERS New Jersey Agricultural Experiment Station

SHEET NAME
P-2

Green and Gray Infrastructure Practices



Next Steps: Public Outreach

Stakeholder Engagement and Collaboration

- Municipalities, non-governmental organizations (NGOs), individual residents and homeowners

Public Demonstration Projects

- Use the Hillsborough Plaza Green Infrastructure Project as a primary case study. Specify that this project serves as a demonstration for citizens to learn about sustainable stormwater management and local pollinator ecology

Residential and Private Land Outreach

- How to do your part with homeowner rain gardens: Focus on educating residents about installing individual household rain gardens

New Jersey Blue Acres Program

- The state buys homes located in high-risk flood areas
- Some homeowners may not be legally permitted to elevate their homes
- The offered price may not be sufficient for people looking to purchase a new home

BLUE ACRES

Can we expand the scope of the Blue Acres Program?

- Look to buy land at higher elevations rather than purchasing homes in high-risk flood zones
- Construct water management systems (i.e., stormwater parks) to hold water for longer periods
- Reduce the peak flooding experienced downstream

Questions?

Christopher C. Obropta, Ph.D., P.E.
Phone: 908-229-0210
Email: obropta@envsci.rutgers.edu