

Nature-based Green Infrastructure Solutions for Managing Extreme Weather Events

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in Old Saybrook, CT on April 11, 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



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



RAIN GARDENS

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

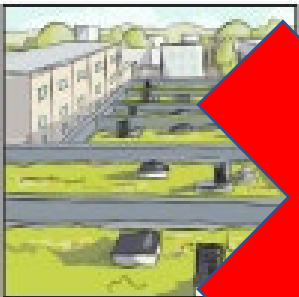
Rain gardens can be added around homes and businesses to reduce and treat stormwater runoff.



VEGETATED SWALES

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

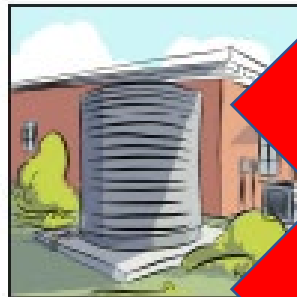
Vegetated swales can be placed along streets and in parking lots to soak up and treat their runoff, improving water quality.



GREEN ROOFS

A green roof is fitted with a planting medium and vegetation. A green roof can help absorb and slowly soaking up rainfall. Green roofs can also reduce energy costs for buildings.

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 rain that falls for later use. Rainwater harvesting can reduce the need for potable water.

Systems include rain barrels that store tens of 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.



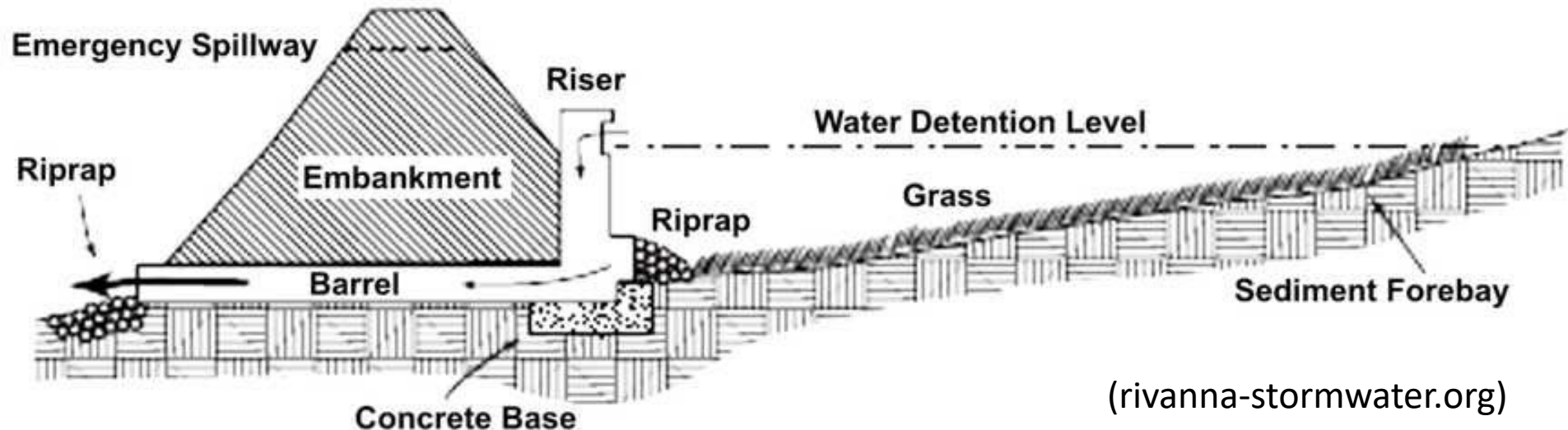
GREEN STREETS

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?

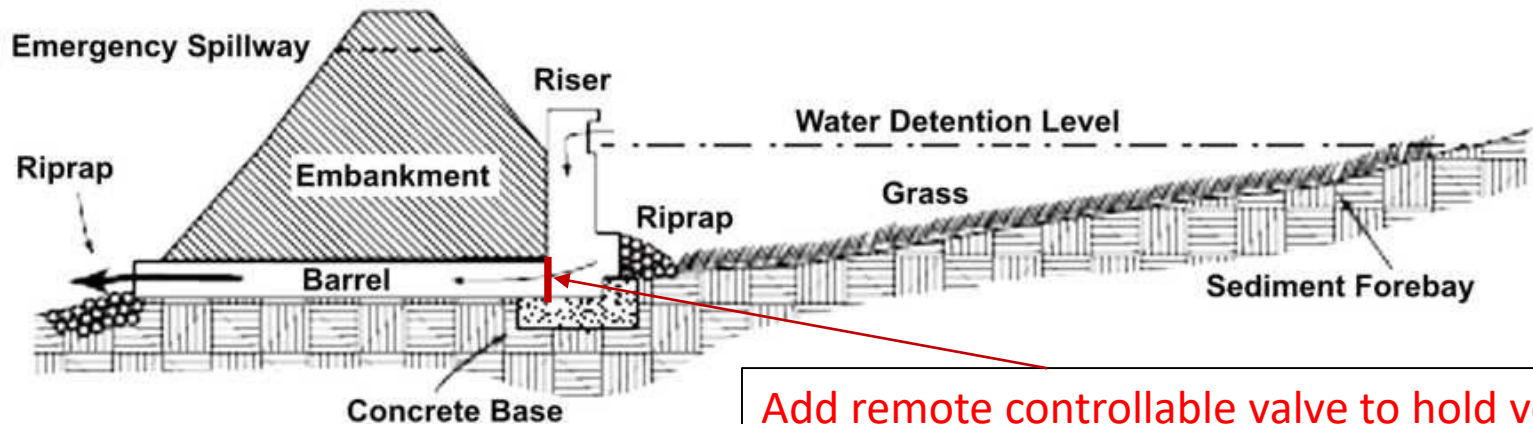
- Capture stormwater and detain it to reduce the peak flow of the flooding
 - Typical detention basin approach
 - Effective if no back-up downstream
 - Can combine with distributed systems to hold more volume



(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



Add remote controllable valve to hold volume

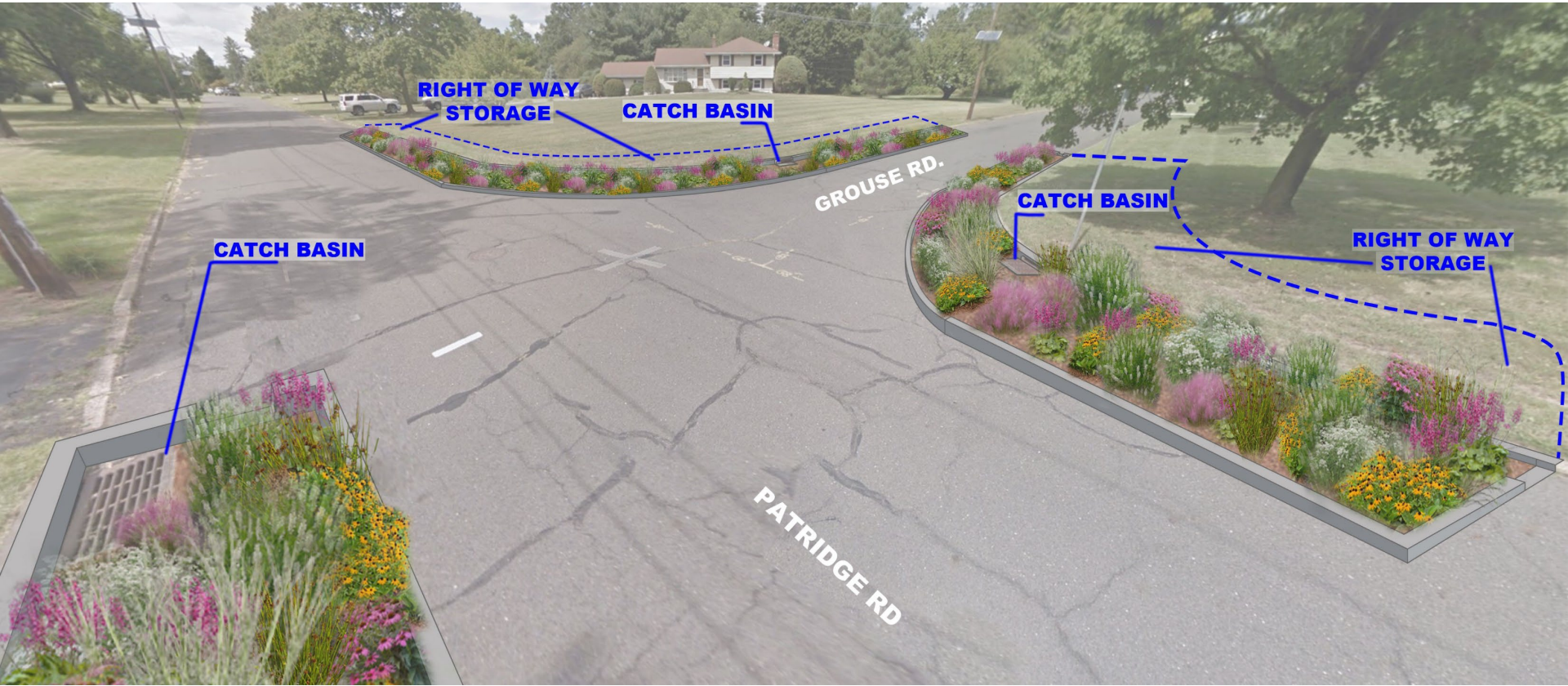
Where do we target our efforts?

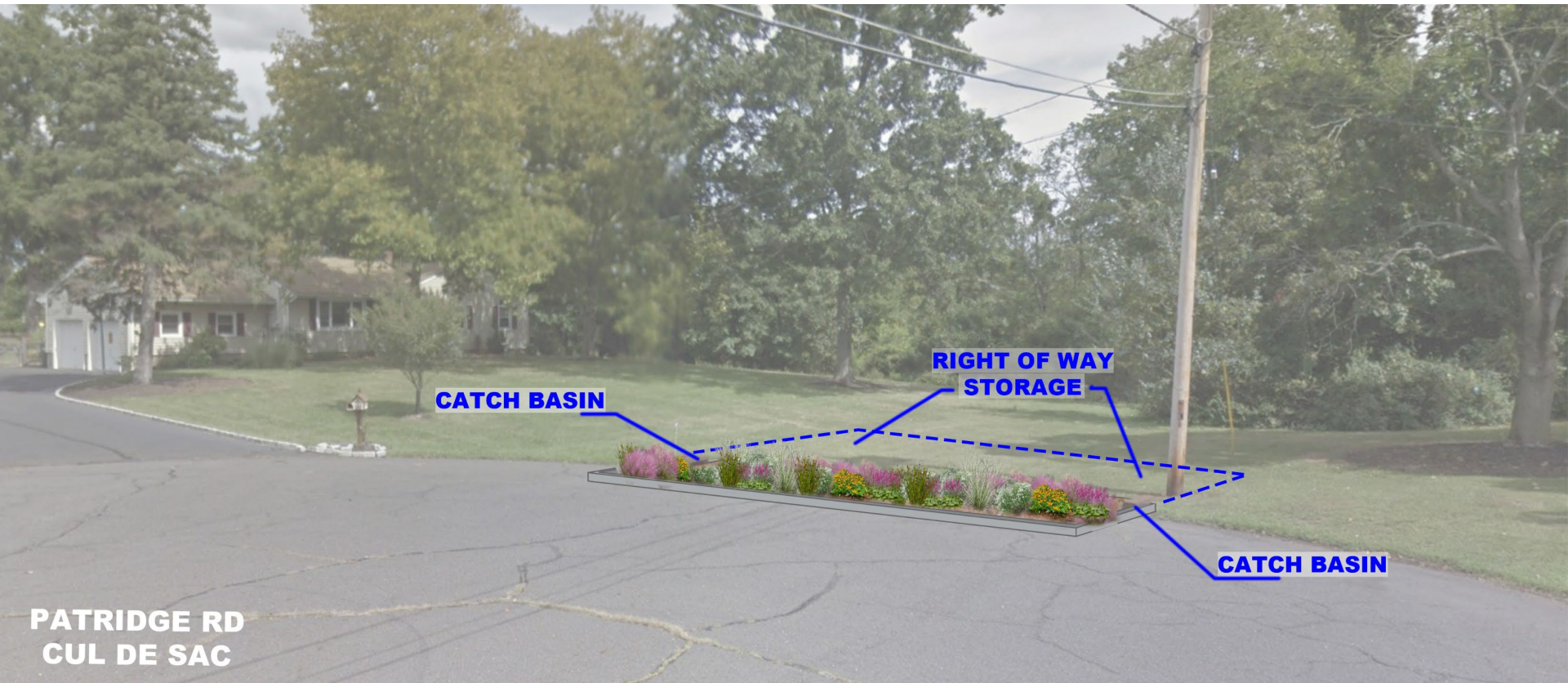
- Target developments with:
 - little to no existing stormwater management
 - available land to capture and hold large volumes of stormwater
 - willing participants for buyouts to create land for stormwater management.
- Identify key flooding hotspots and identify areas contributing upstream of those 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





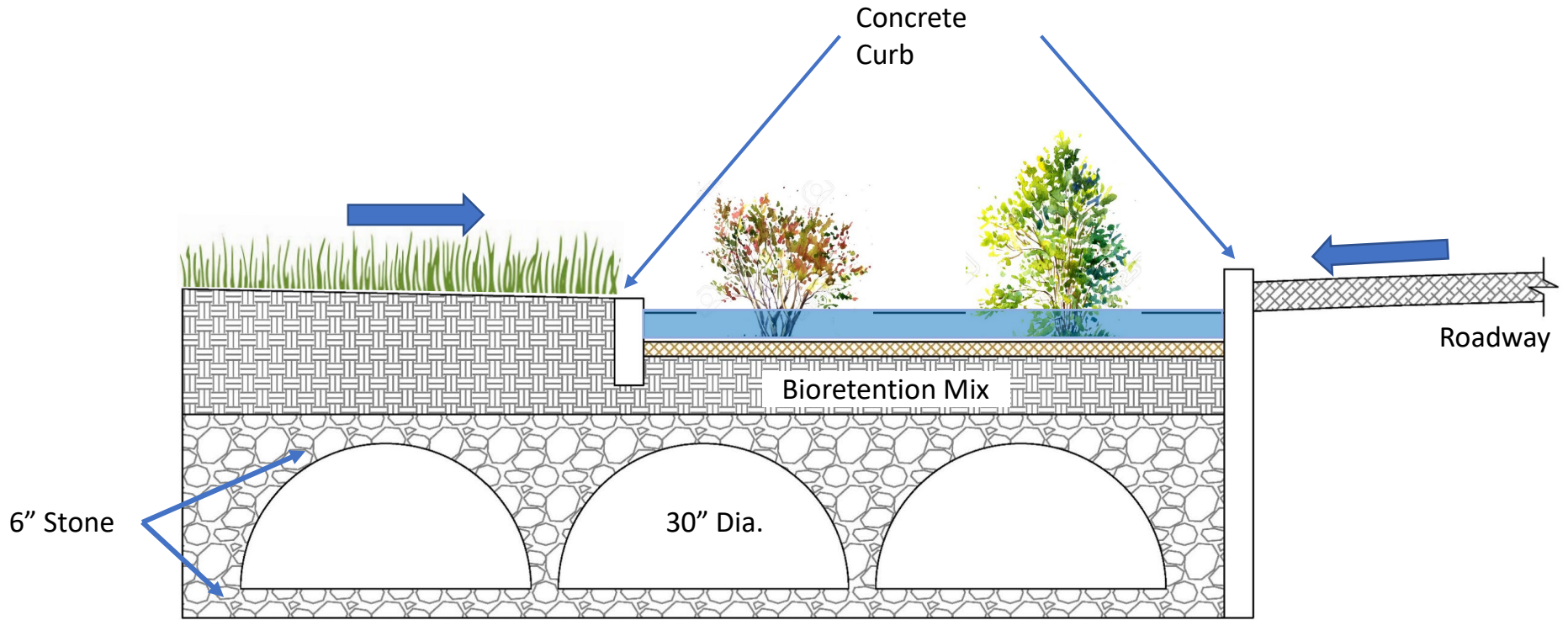


**PATRIDGE RD
CUL DE SAC**

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

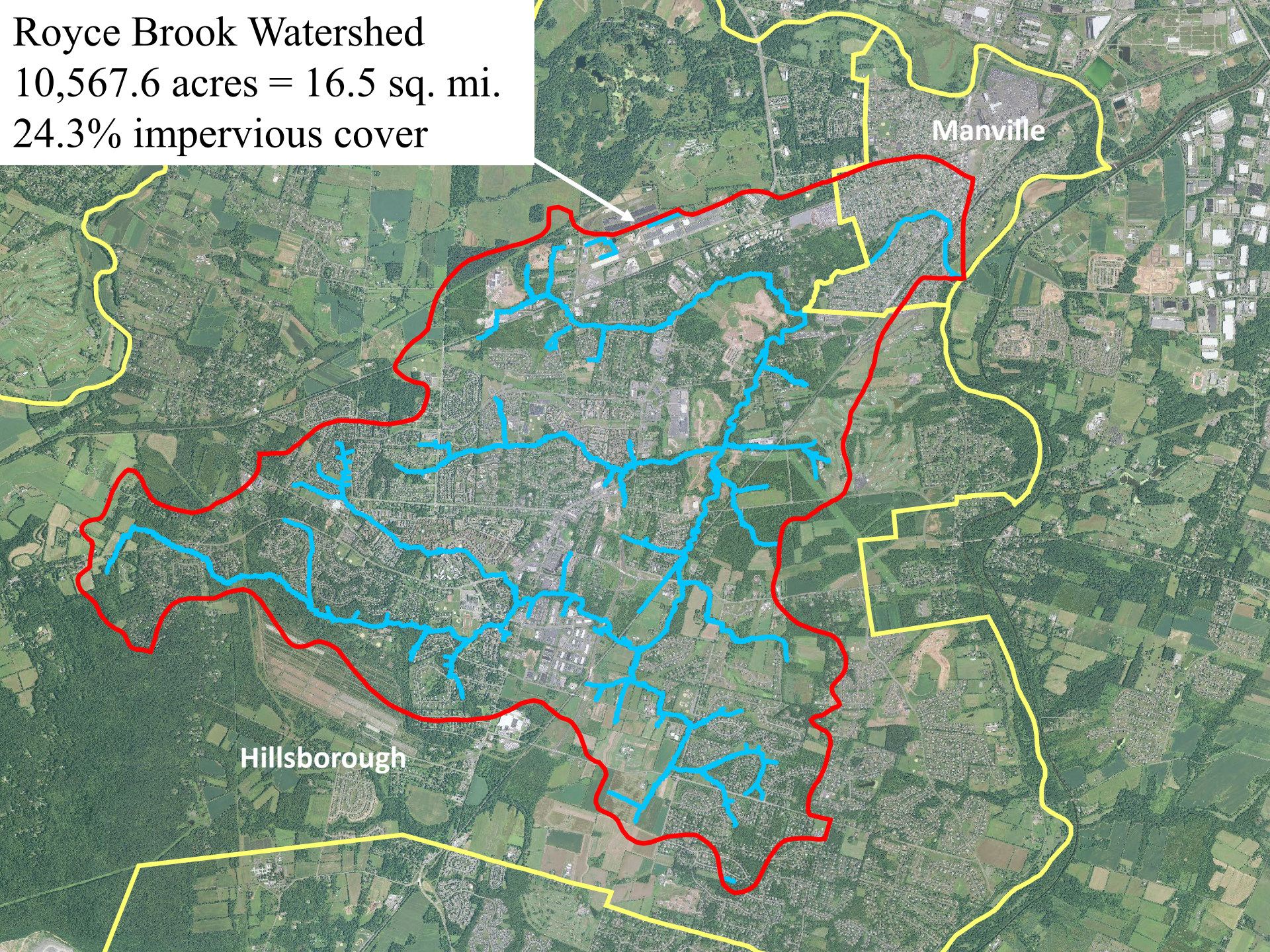
- Underground Storage Systems
 - Can create systems under lots by combining storage with. Allows mixed use of stormwater management area and recreational uses (i.e. parks)



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

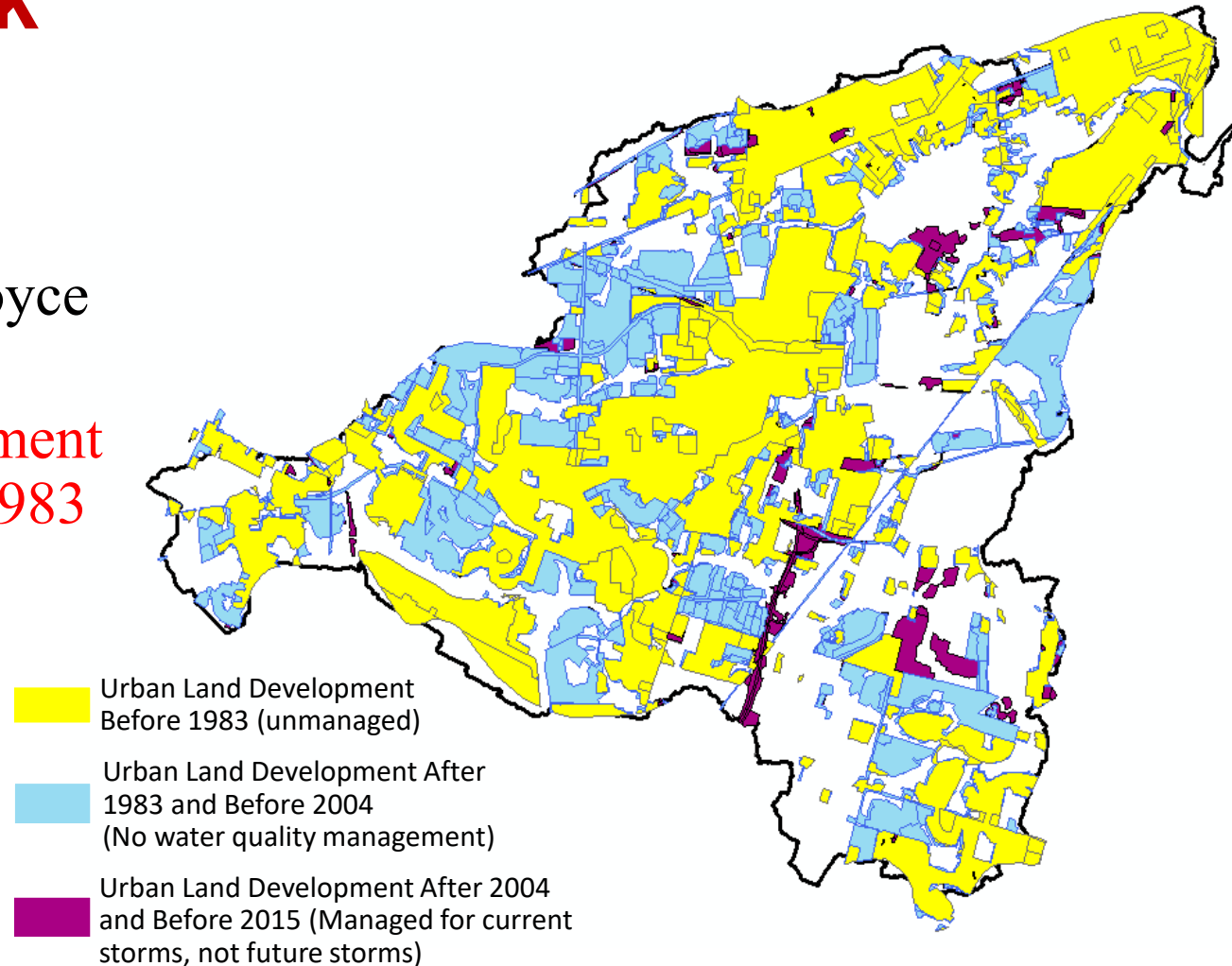
Royce Brook Watershed
10,567.6 acres = 16.5 sq. mi.
24.3% impervious cover



What Land is Being Managed in the Royce Brook Watershed?

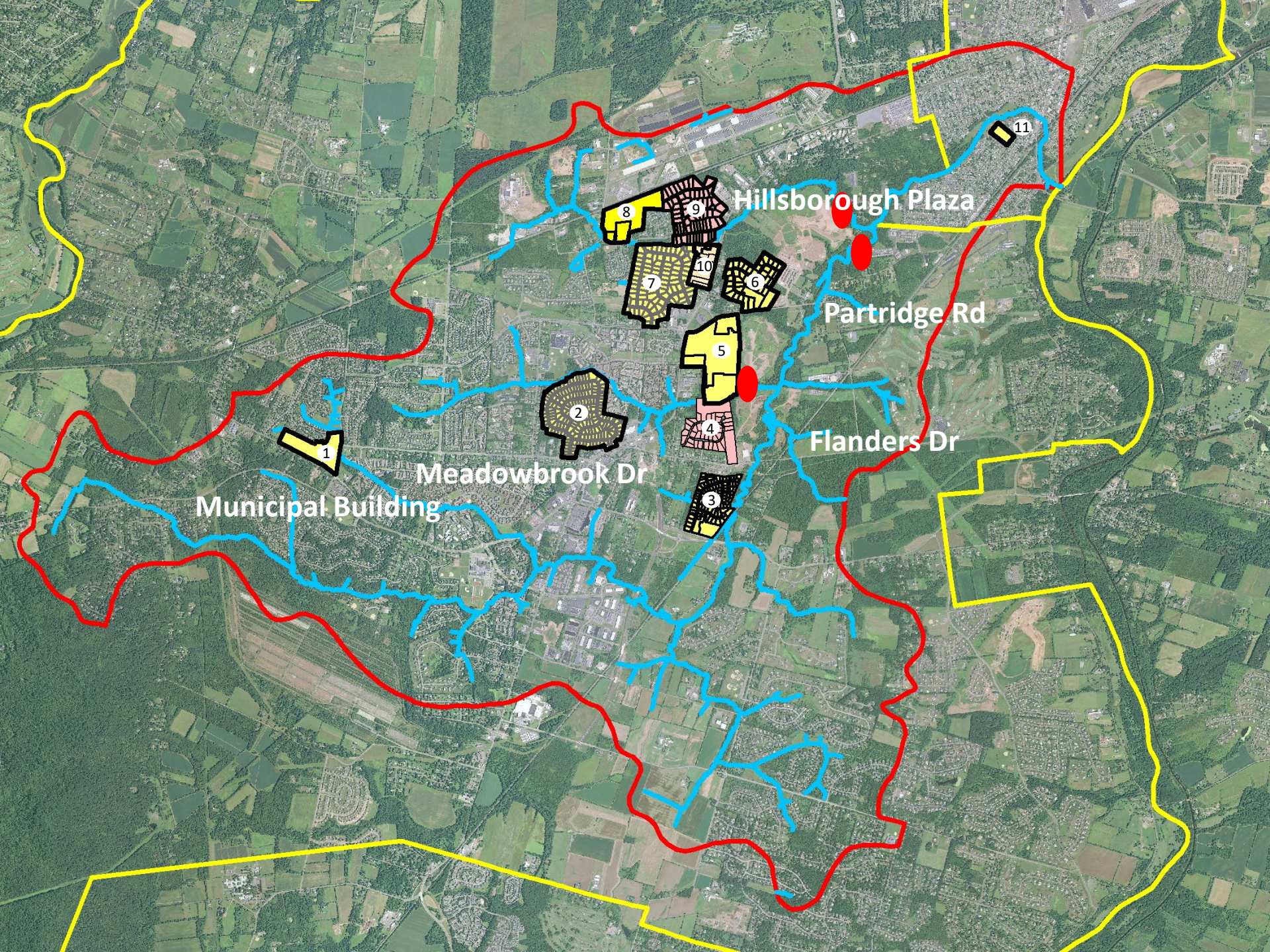
- Urban land in the Royce Brook Watershed
- Majority of development was created before 1983

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

8

7

10

6

9

11

5 Focus Sites for Retrofitting

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

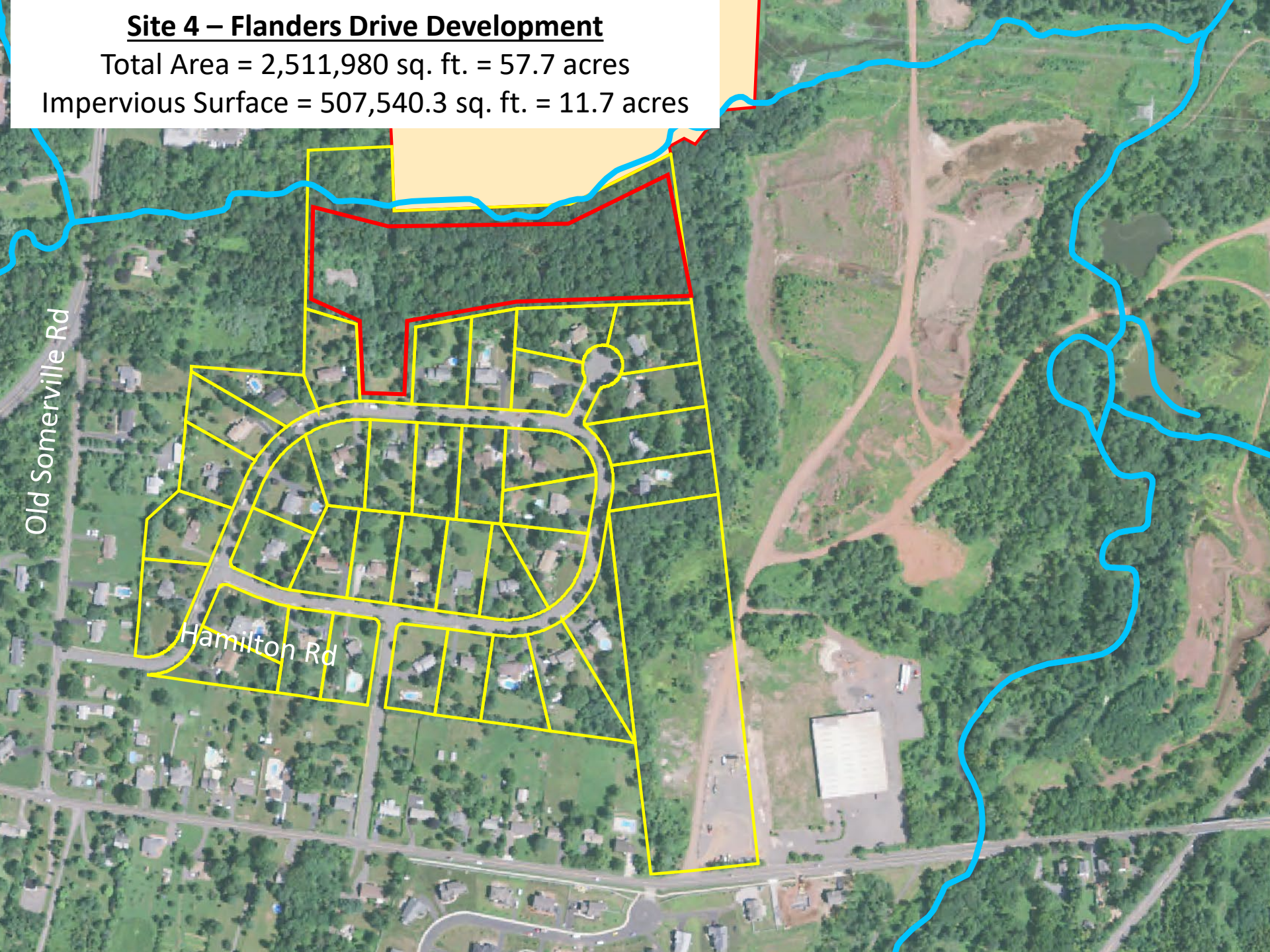
3 Key Cases

1. Design limited to municipal lands
2. Design to retrofit (At least 80% reduction of predevelopment peak)
3. Design unrestrained to reach 100% capture and hold

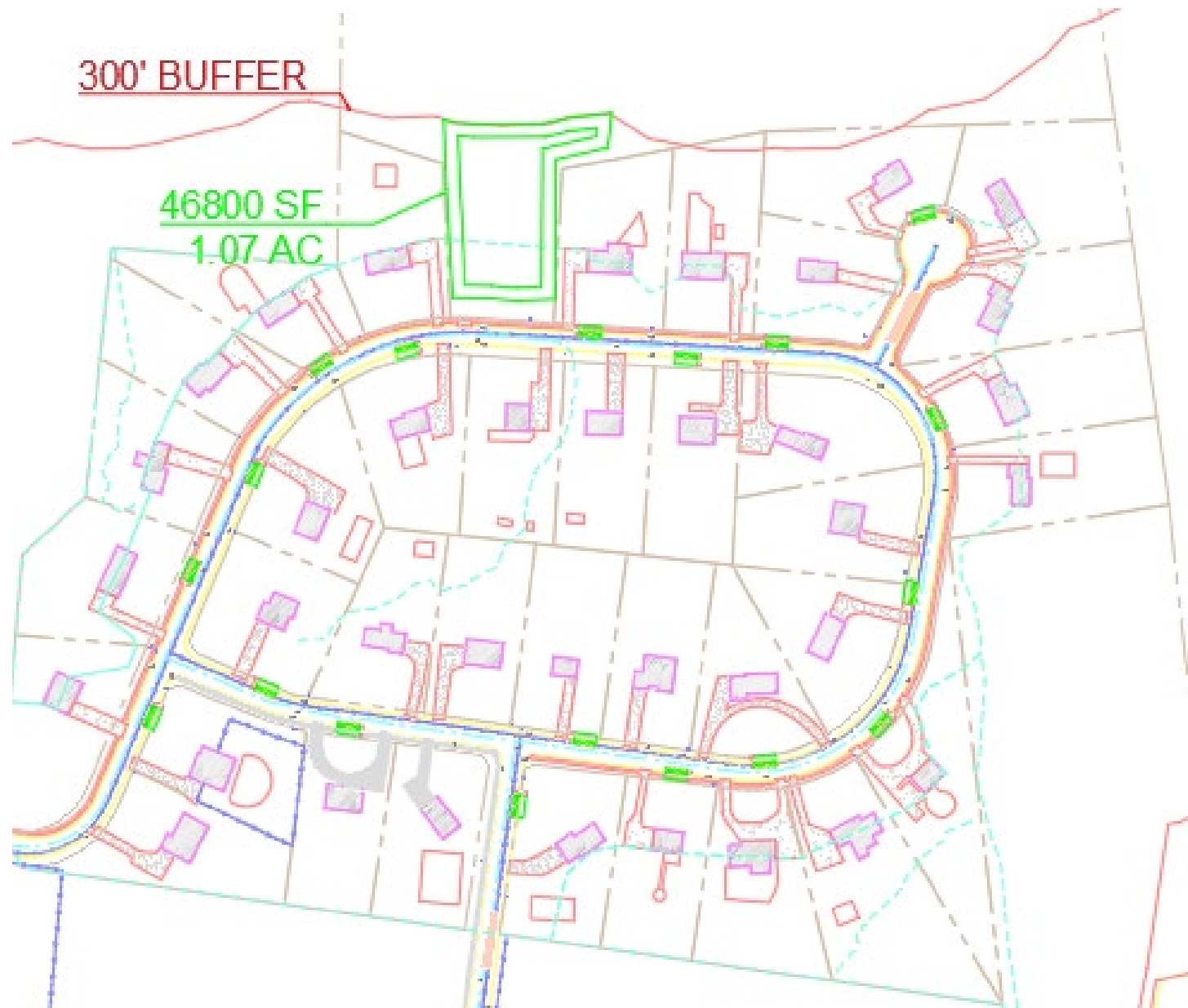
Site 4 – Flanders Drive Development

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

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



Municipal Land Only



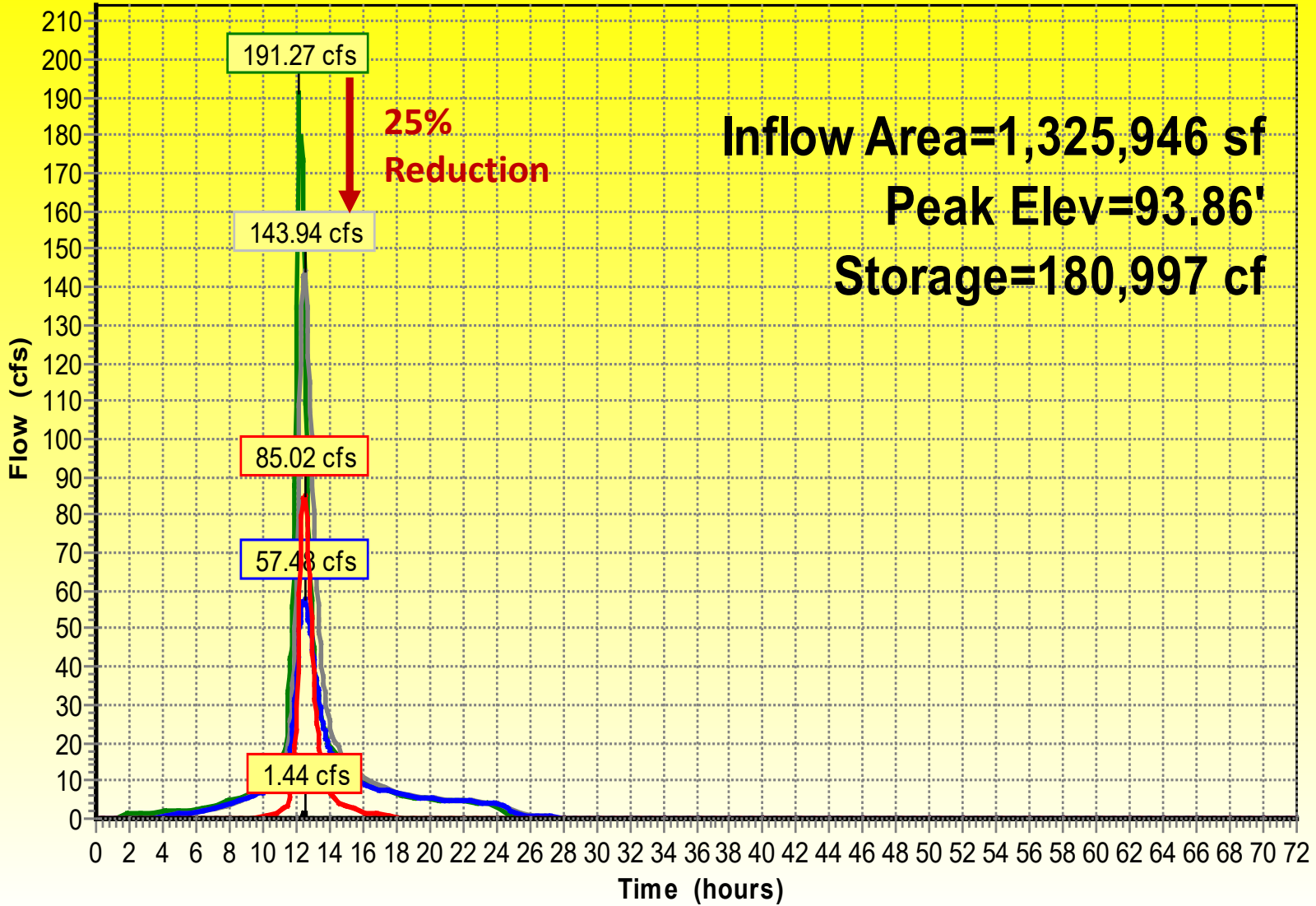
Municipal Land Only

- 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

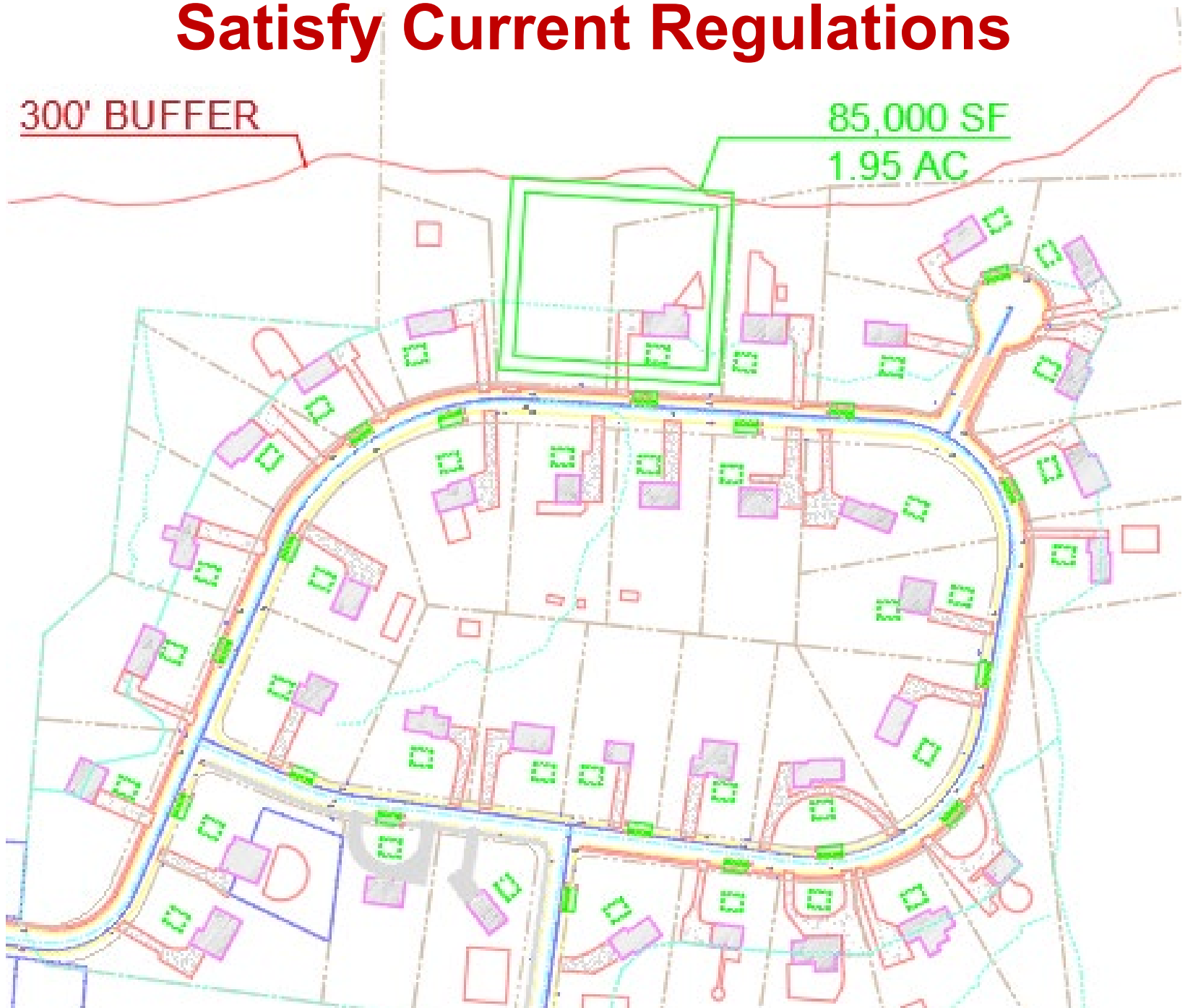


- Inflow
- Outflow
- Primary
- Secondary
- Tertiary

Satisfy Current Regulations

300' BUFFER

85,000 SF
1.95 AC



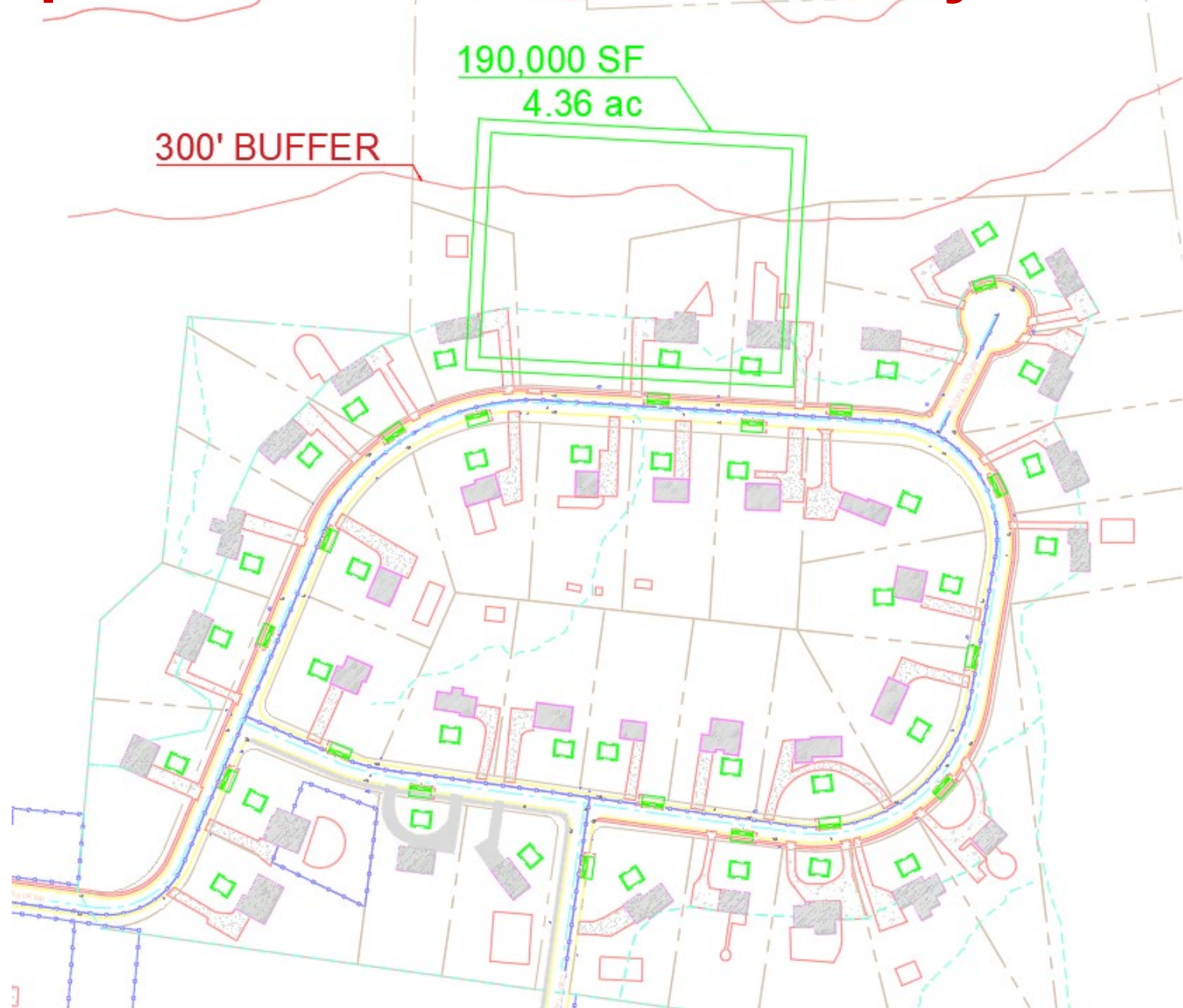
Current Regulations

- 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



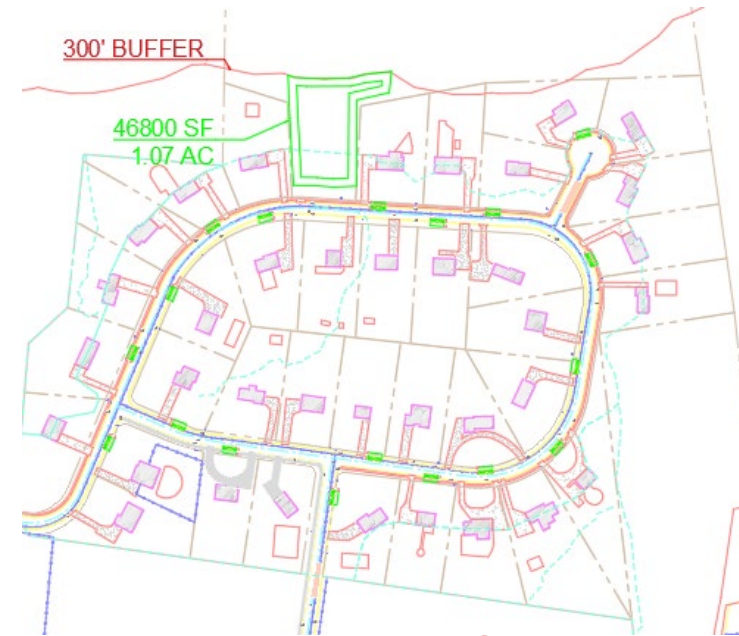
Capture entire volume for 100-yr storm

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

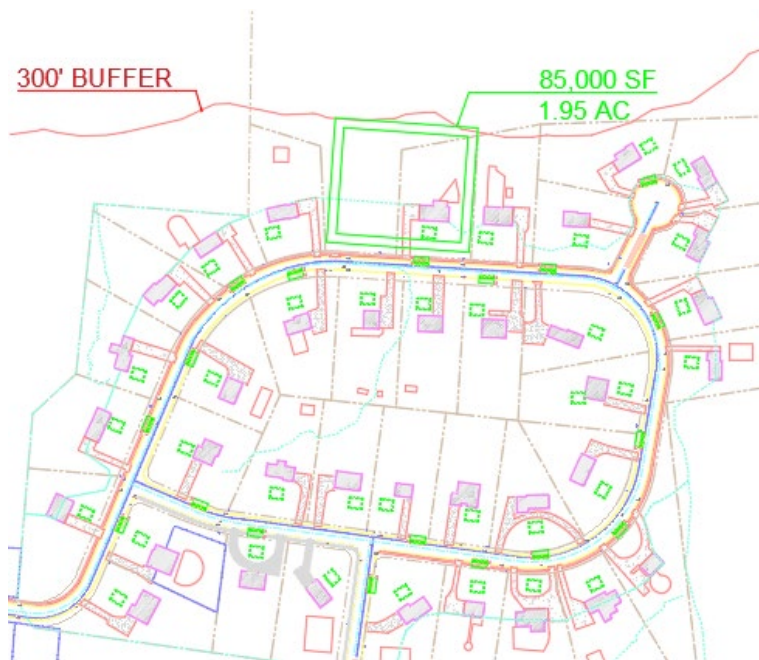
	Storage Volume (cf)	% Contribution
Basin	866,,000	89%
Porous Pavement	58,570	6%
Rain Gardens – Roof	20,276	2%
Rain Gardens - Road	25,464	3%
Total Storage Volume	970,310	cf
Peak Discharge	0	cfs
Peak Reduction	100%	% of Inflow (191.3cfs)
Basin Storage Peak	853,911	cf
Detention Time 75%	NA	hrs
Detention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

Case comparison

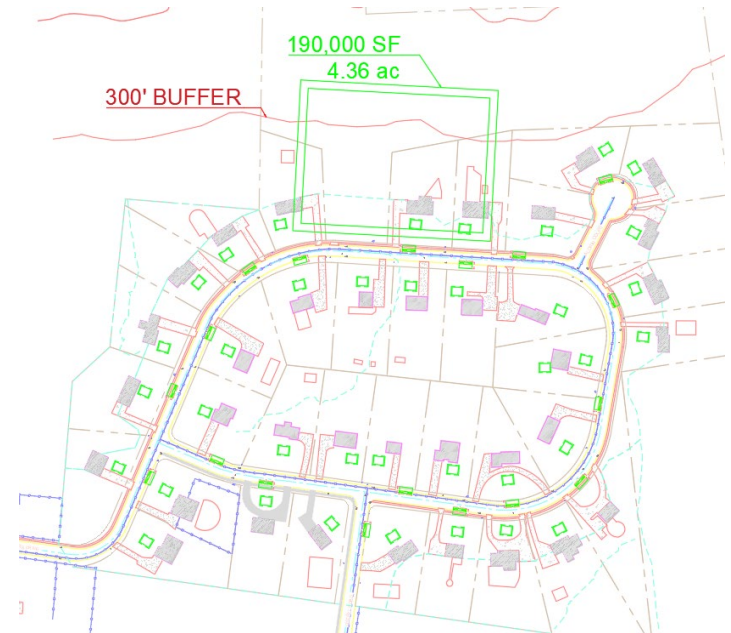
Parameter	Municipal	Current Reg	All Storage
Basin Size (acre)	1.07	1.95	4.36
Peak Red.	25%	72%	100%
Storage (CF)	212,992	474,860	970,310
Det. Time 75% (hr)	14.4	17.0	n/a



Municipal Only



Current Regulation



All Storage

Cost Estimate Comparison

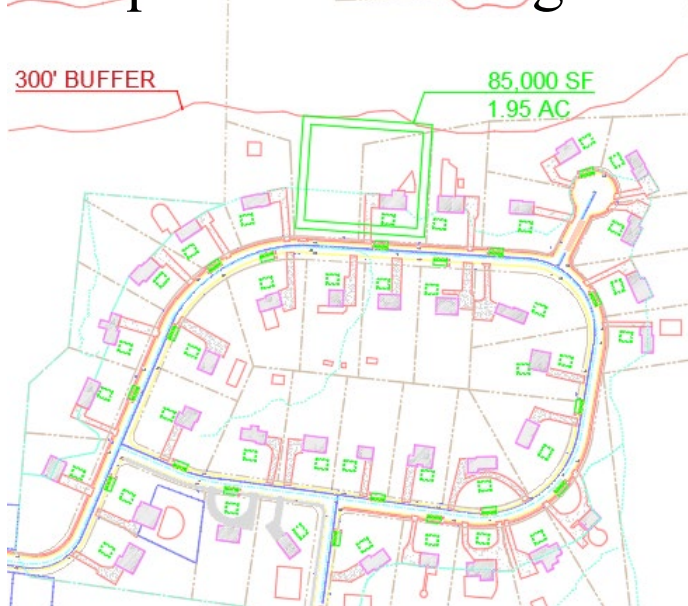
Parameter	Municipal	Current Reg	All Storage
Const. cost of systems w/ distributed	\$534,002	\$1,932,535	\$2,229,011
Cost of property buyouts	\$0 (0 properties)	\$538,500.00 (1 property)	\$1,634,700 (3 properties)
Total w/ distributed systems	\$534,002	\$2,471,035	\$3,863,711

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

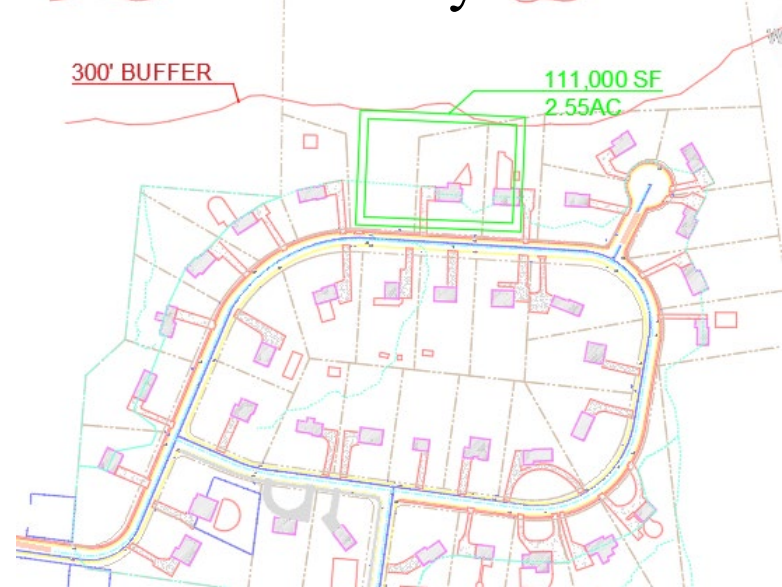
How much do distributed systems help?

- 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



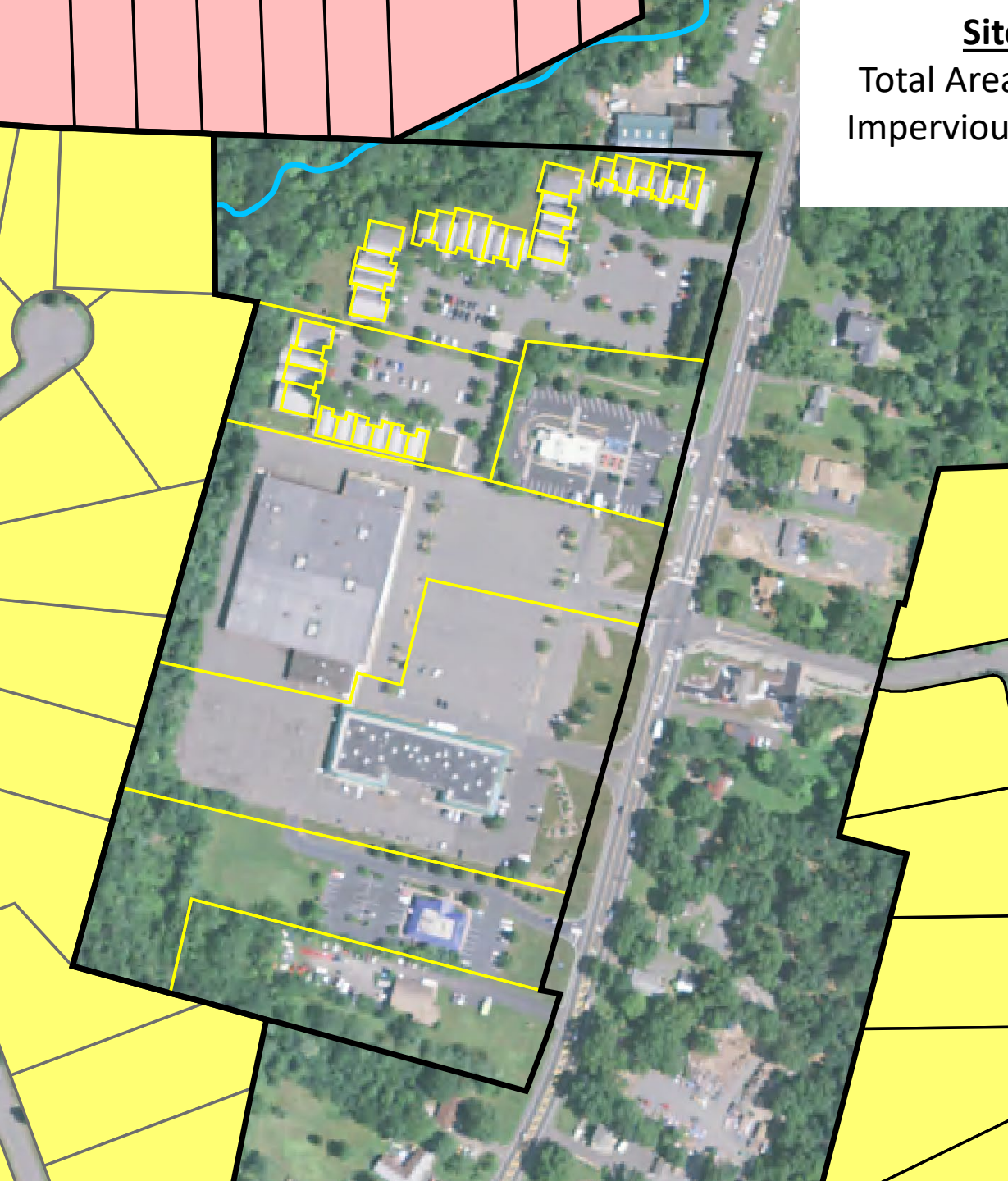
w/ distributed



Basin only

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.

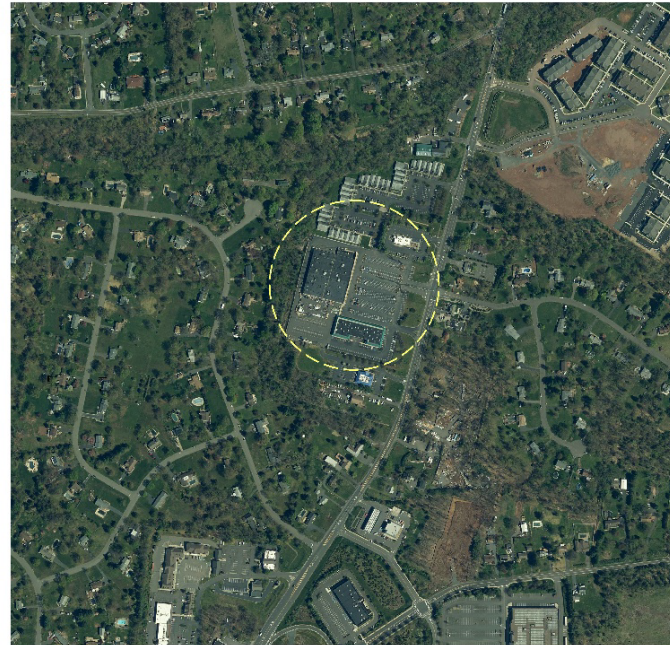
LIST OF DRAWINGS:

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

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

LOCATION MAP (N.T.S):

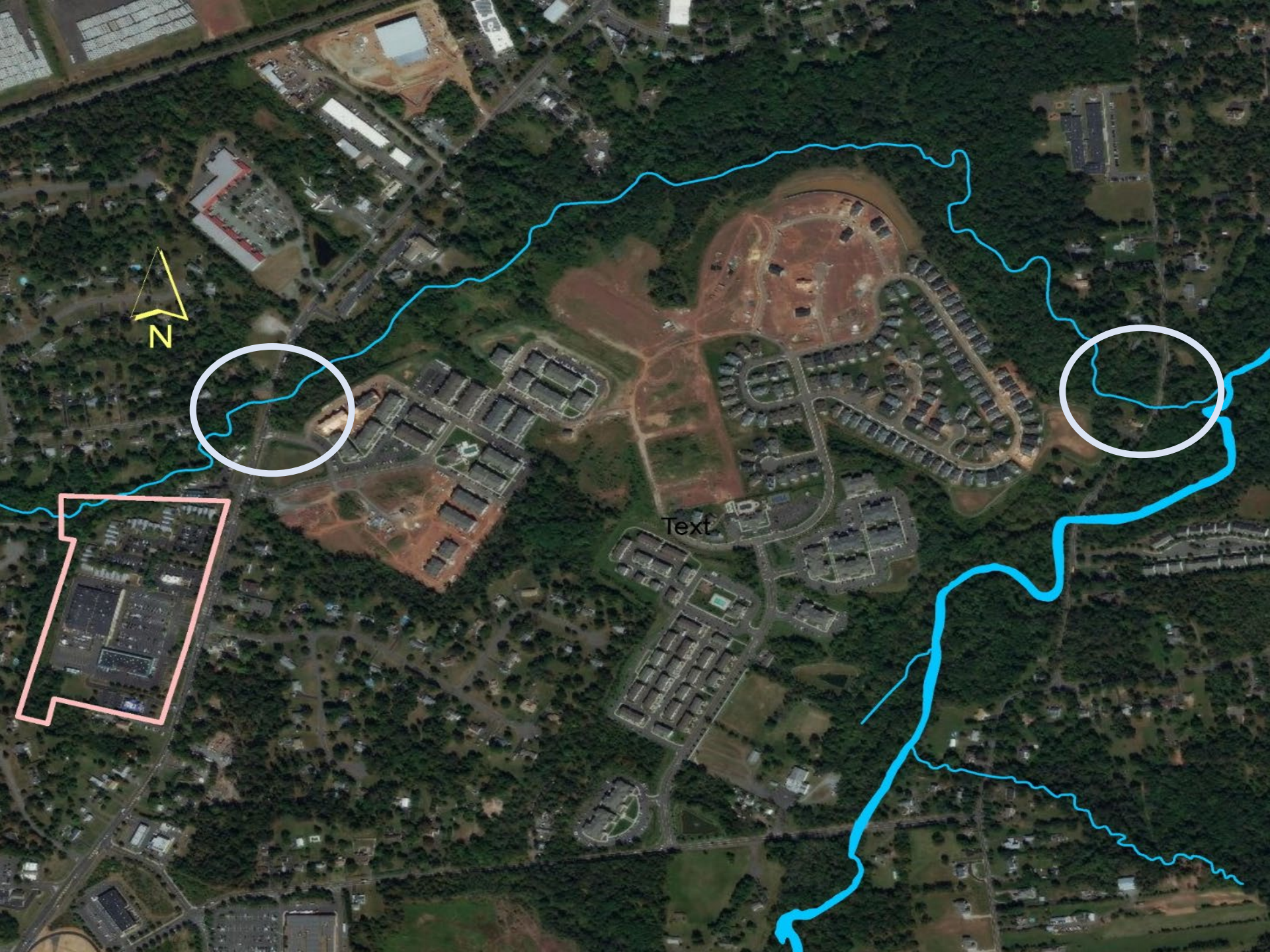


LEGEND:

	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

PLAN REVISIONS		
REV. DATE	REV. SUMMARY	REV. SHEETS



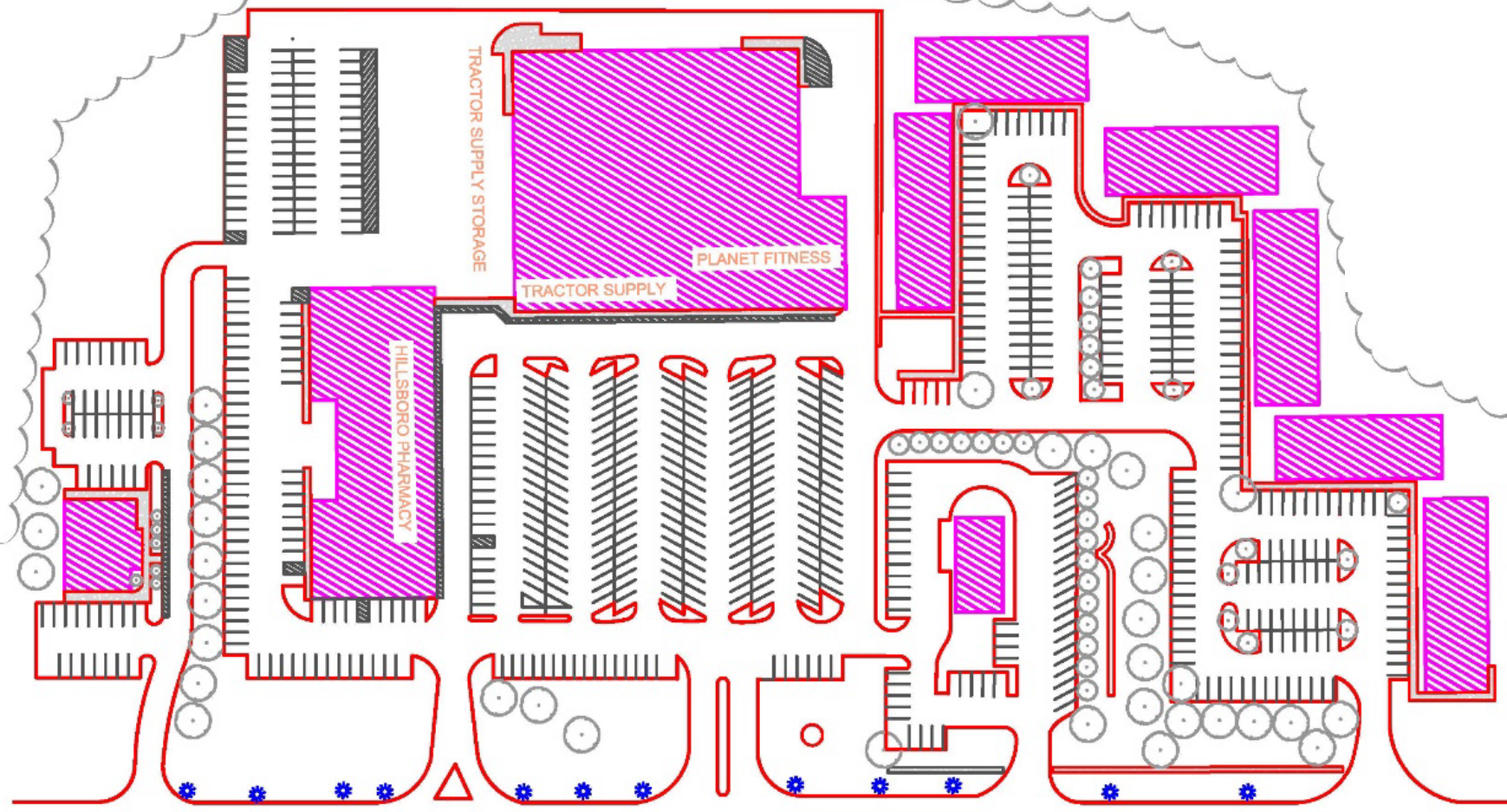


Text



Hillsborough Plaza
256 Route 206
Hillsborough, New Jersey

EXISTING TREE LINE

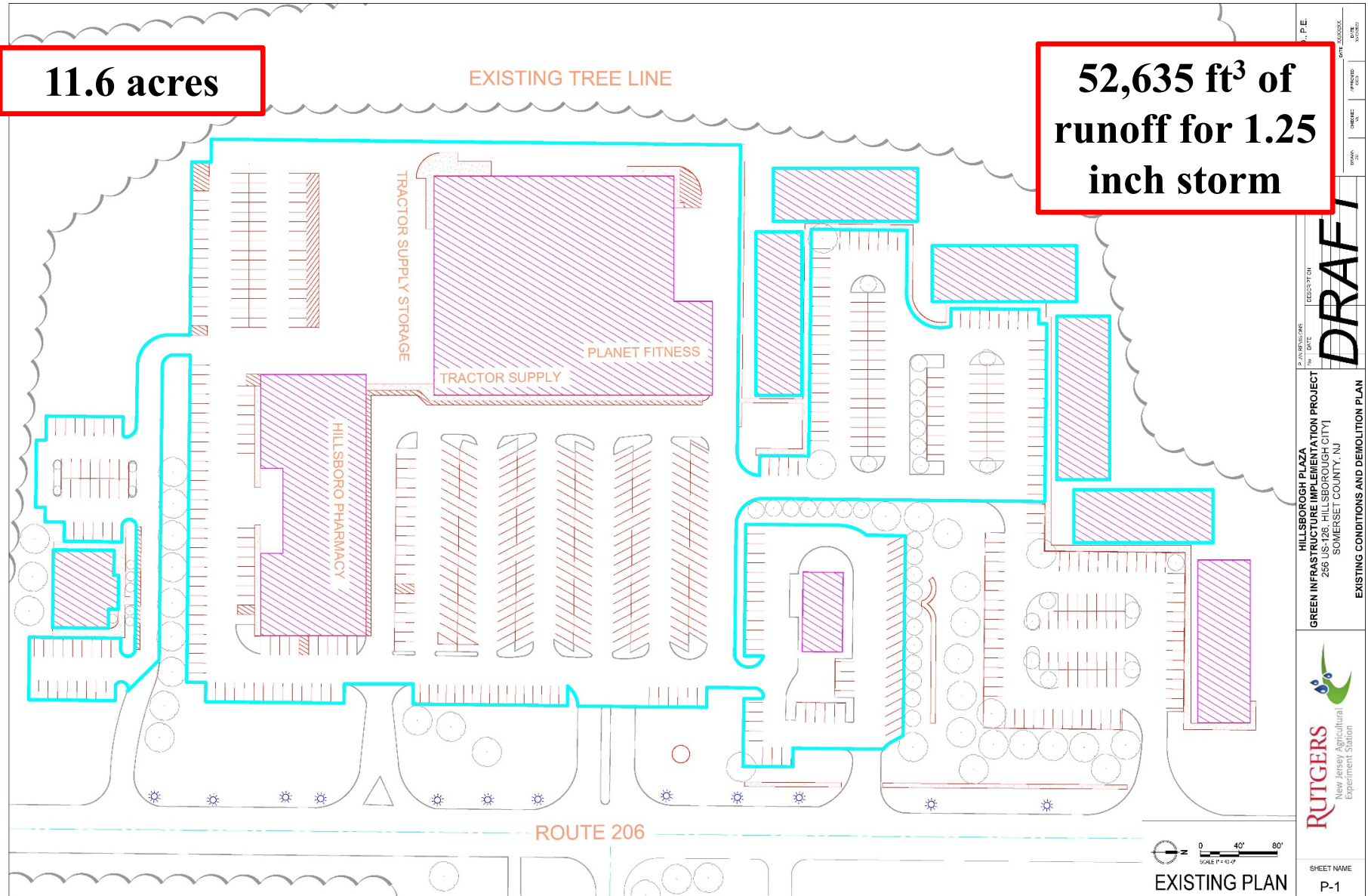


ROUTE 206

Water Quality Storm Analysis (1.25 inches)

11.6 acres

52,635 ft³ of runoff for 1.25 inch storm



P.E.
DATE: 10/20/2020
PROJECT: 266 US-126 HILLSBOROUGH CITY SOMERSET COUNTY, NJ
SHEET NAME: EXISTING PLAN
P-1

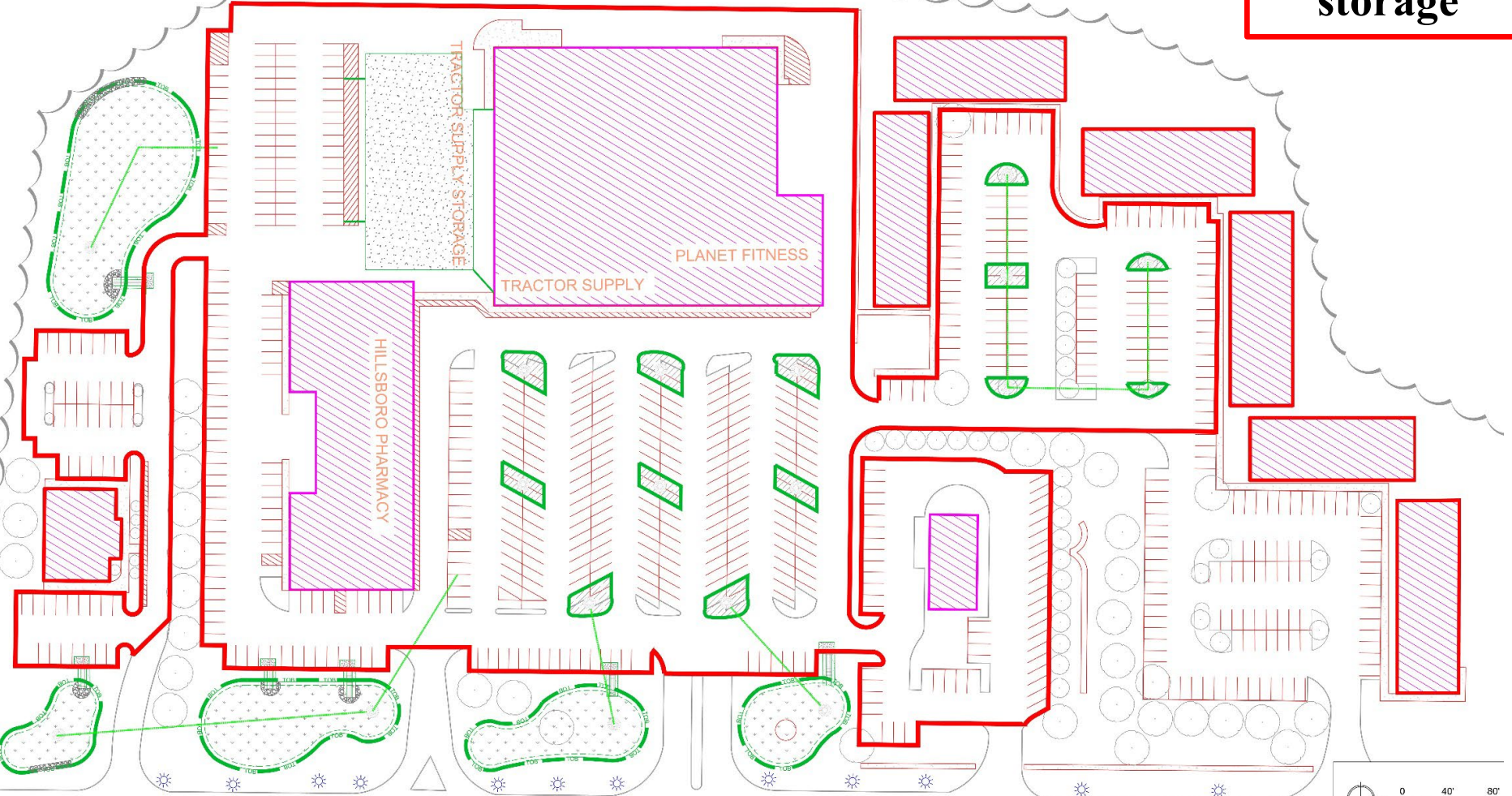
HILLSBORO PLAZA
GREEN INFRASTRUCTURE IMPLEMENTATION PROJECT
266 US-126 HILLSBOROUGH CITY
SOMERSET COUNTY, NJ
EXISTING CONDITIONS AND DEMOLITION PLAN

DRAFT

RUTGERS
New Jersey Agricultural
Experiment Station

**1.23 acres of
rain gardens
provides
45,611 ft³ of
storage**

EXISTING TREE LINE



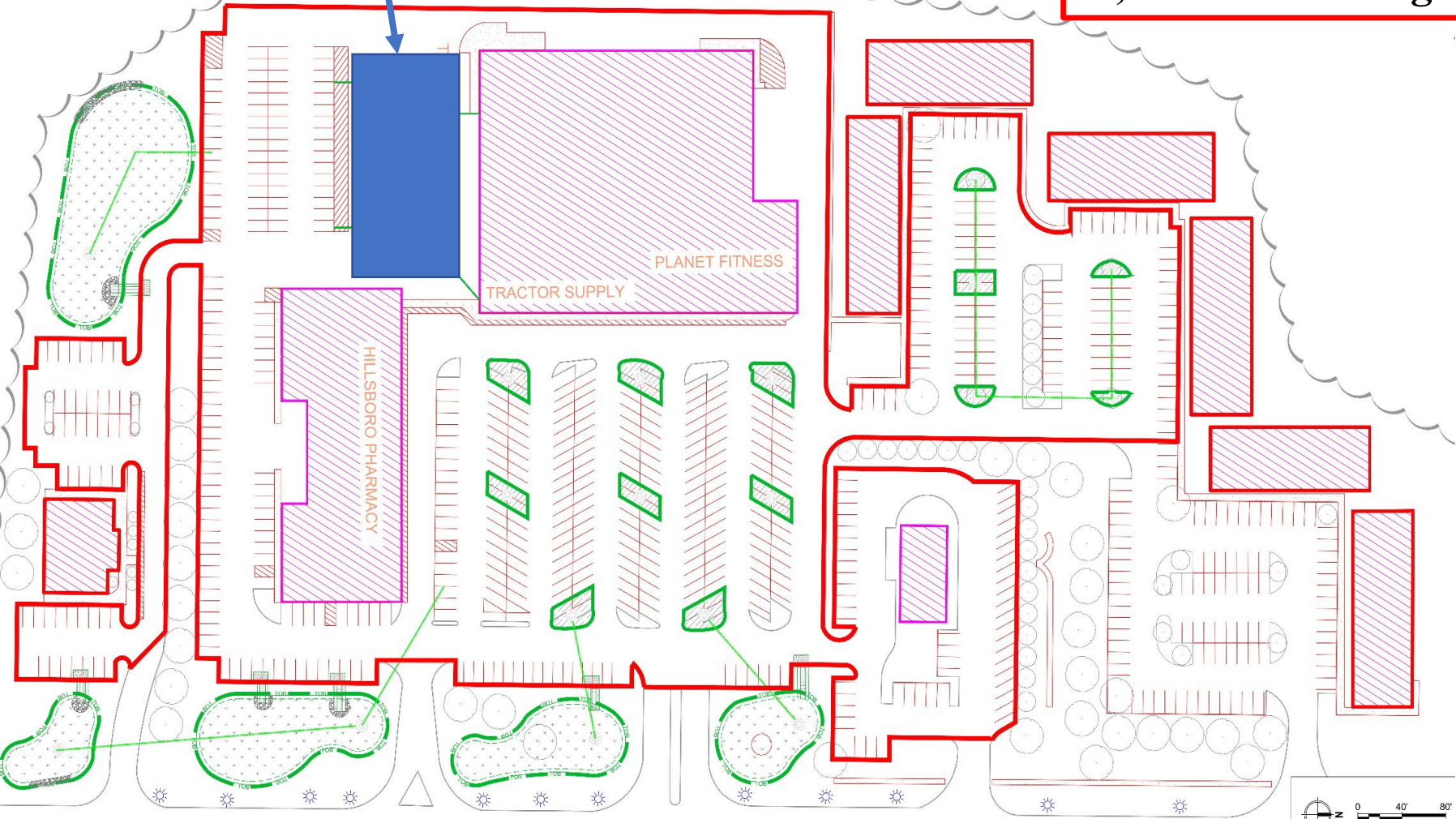
ROUTE 206

0 40' 80'
SCALE 1" = 40'
SITE PLAN

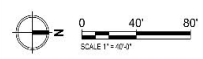
**17,560 ft² of
pervious concrete
provides
7,024 ft³ of storage**

Pervious Concrete

EXISTING TREE LINE



ROUTE 206

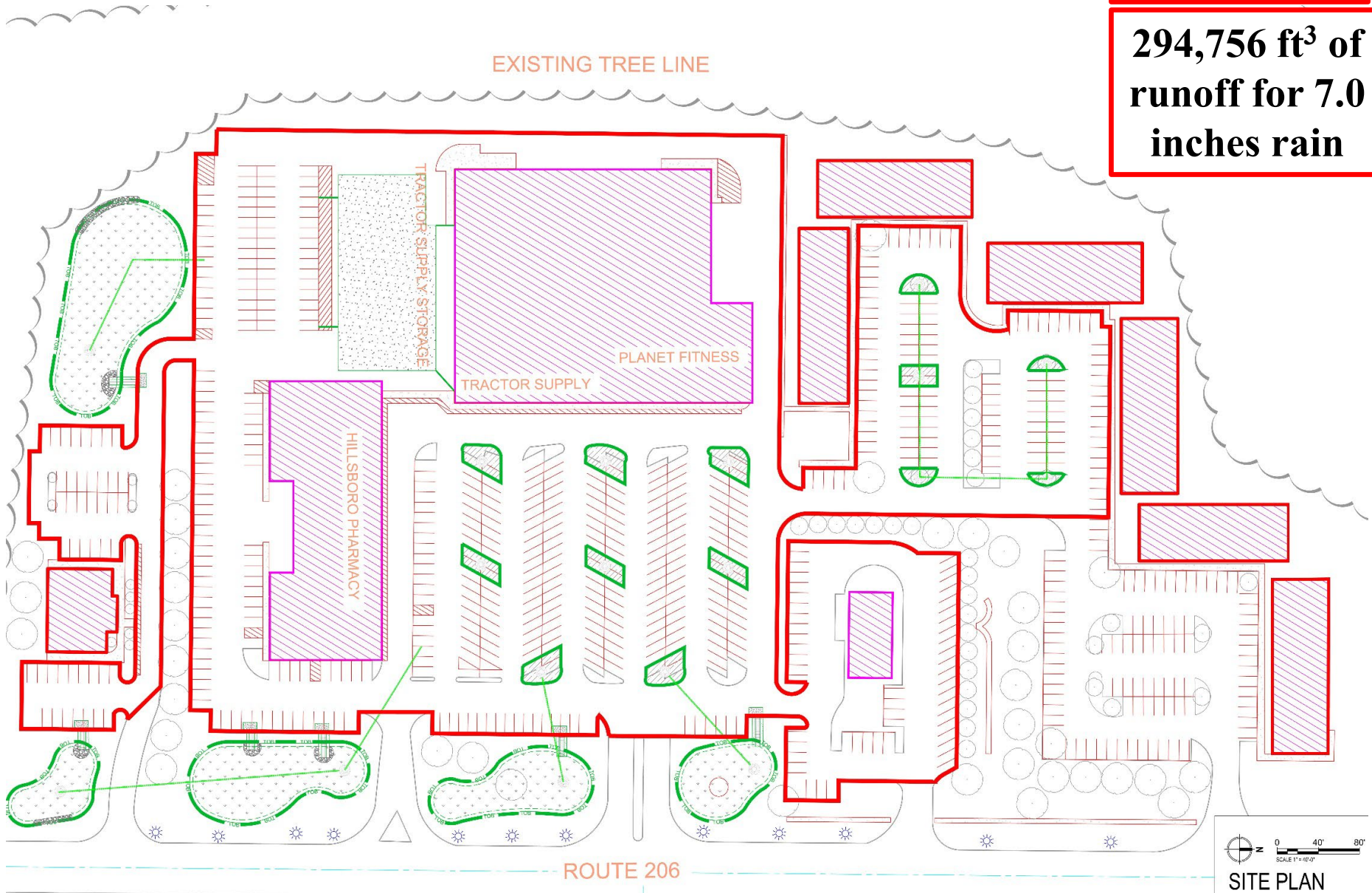


SITE PLAN

100-Year Storm Analysis 8.25 inches

11.6 acres

294,756 ft³ of runoff for 7.0 inches rain

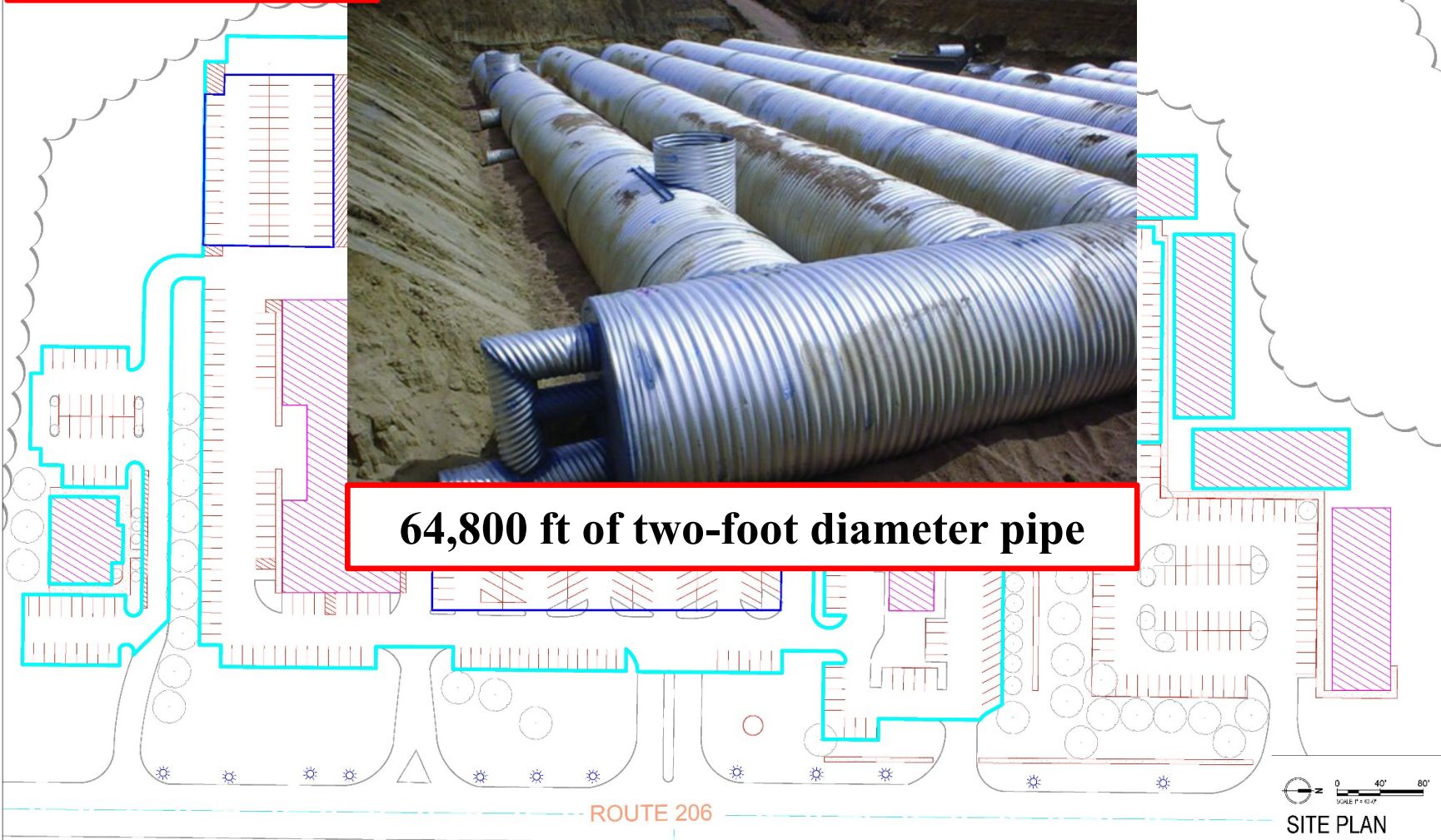


SITE PLAN

**2.4 acres of
underground
storage system
provides 351,208
ft³ of storage**

EXISTING TREE LINE

64,800 ft of two-foot diameter pipe

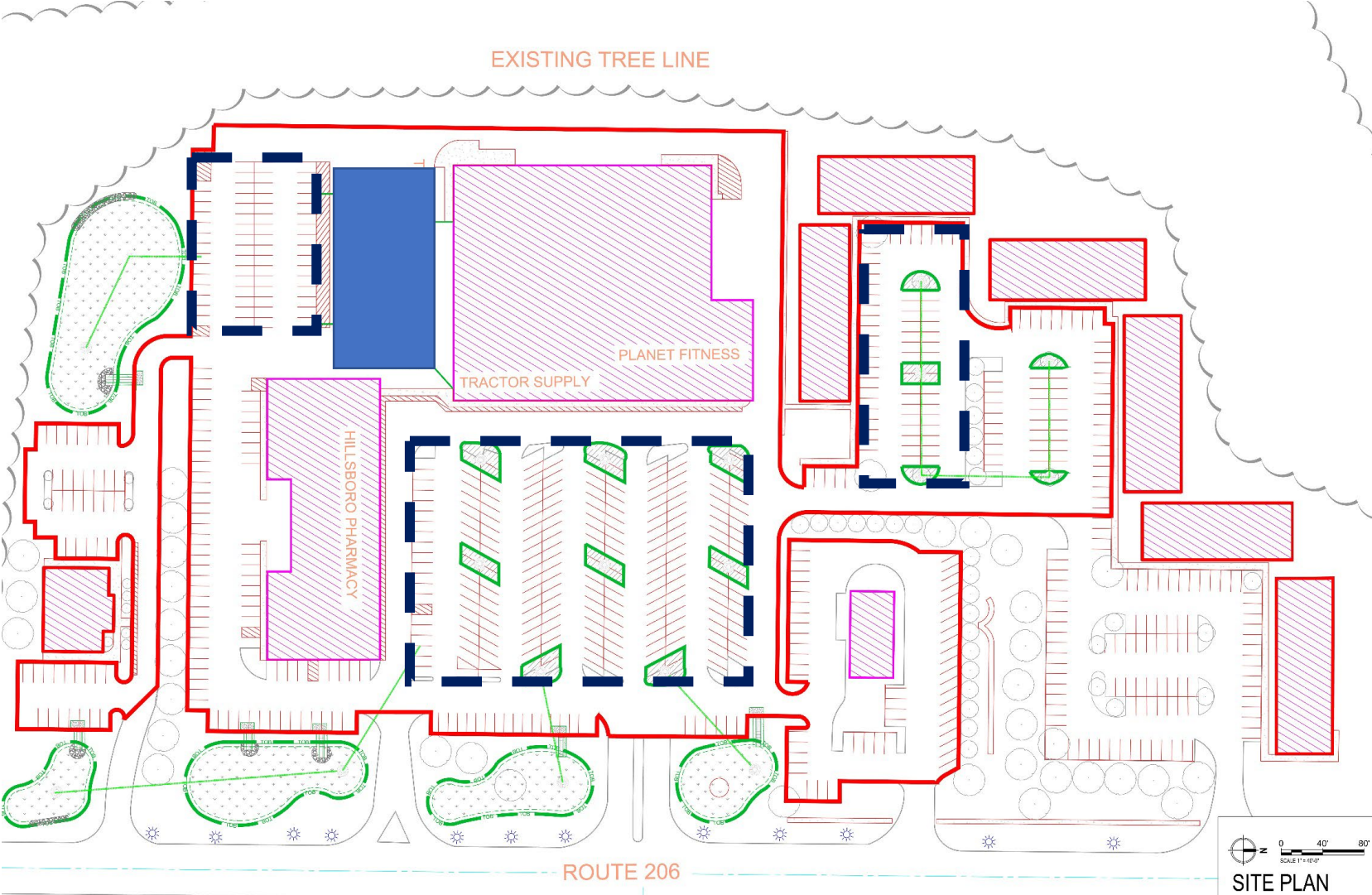


 RUTGERS New Jersey Agricultural Experiment Station	HILLSBOROUGH PLAZA GREEN INFRASTRUCTURE IMPLEMENTATION PROJECT 266 US-126, HILLSBOROUGH CITY, SOMERSET COUNTY, NJ	PROPOSED SITE PLAN
	DATE: _____ DRAWN BY: _____ CHECKED BY: _____ DATE: _____	DESCRIPTION: DRAFT
SHEET NAME P-2		CHRISTOPHER C. OBROPTA, Ph.D., P.E. PROFESSOR OF CIVIL ENGINEERING, RUTGERS-CAMDEN



SITE PLAN

Green and Gray Infrastructure Practices



Finalize Preliminary Designs

- Finalize design
- Determine if this will reduce flooding in Hillsborough and Manville (need more modeling)



Questions?

RUTGERS

New Jersey Agricultural
Experiment Station



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