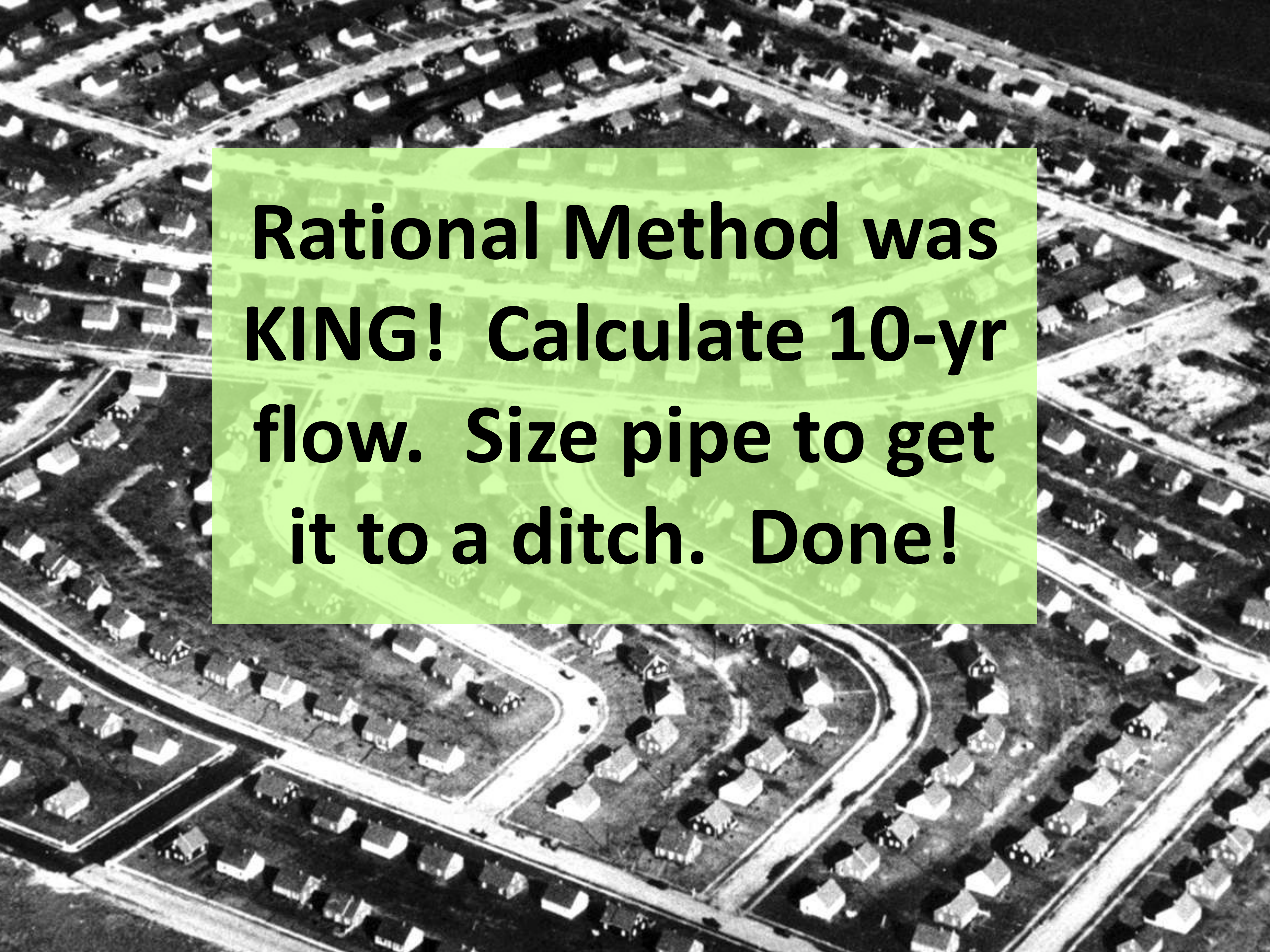
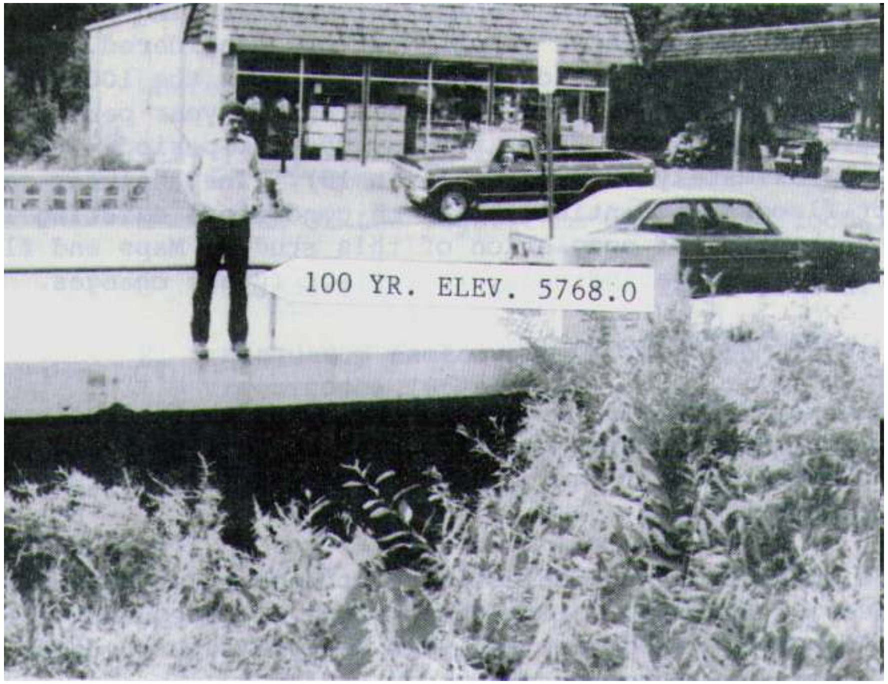
PRACTICAL LONG-TERM GREEN INFRASTRUCTURE DESIGN


Johnny wanted a 2-bedroom ranch in a tidy neighborhood



Rational Method was KING! Calculate 10-yr flow. Size pipe to get it to a ditch. Done!

Hurricane Diane - August, 1955
Photo by: Clyde Roberson


100 YR. ELEV. 5768.0

<u>PARADIGM SHIFT</u>: **Detention Ponds (bucket + hose)**

10yr storm. Post = Pre. Calculate 10yr hydrograph, route it, done!

MAXIMUM KNOWN STAGES AND DISCHARGES OF NEW YORK STREAMS, 1865-1989, WITH DESCRIPTIONS OF FIVE SELECTED FLOODS, 1913-85

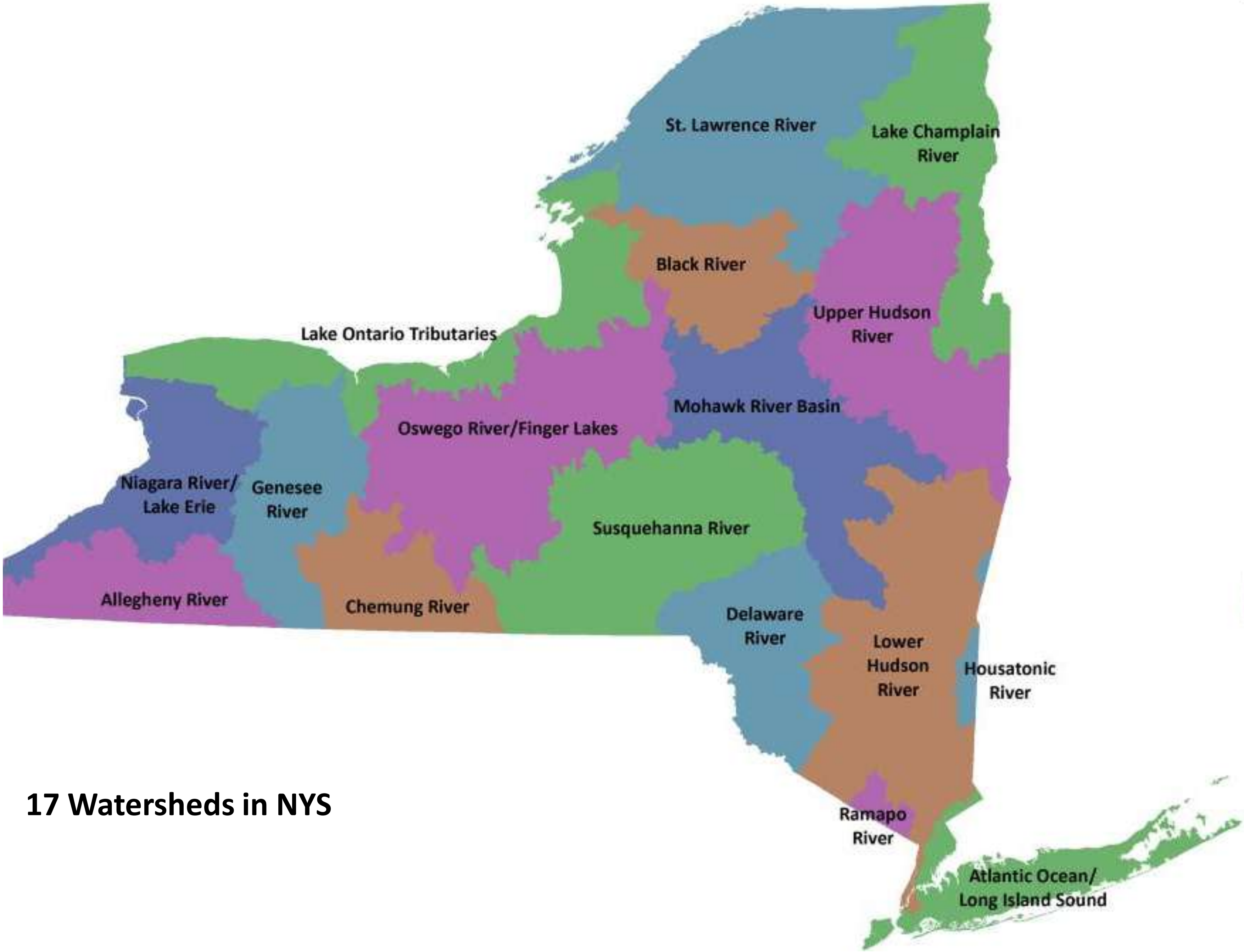
By Richard Lumia and Patricia M. Murray

U.S. GEOLOGICAL SURVEY

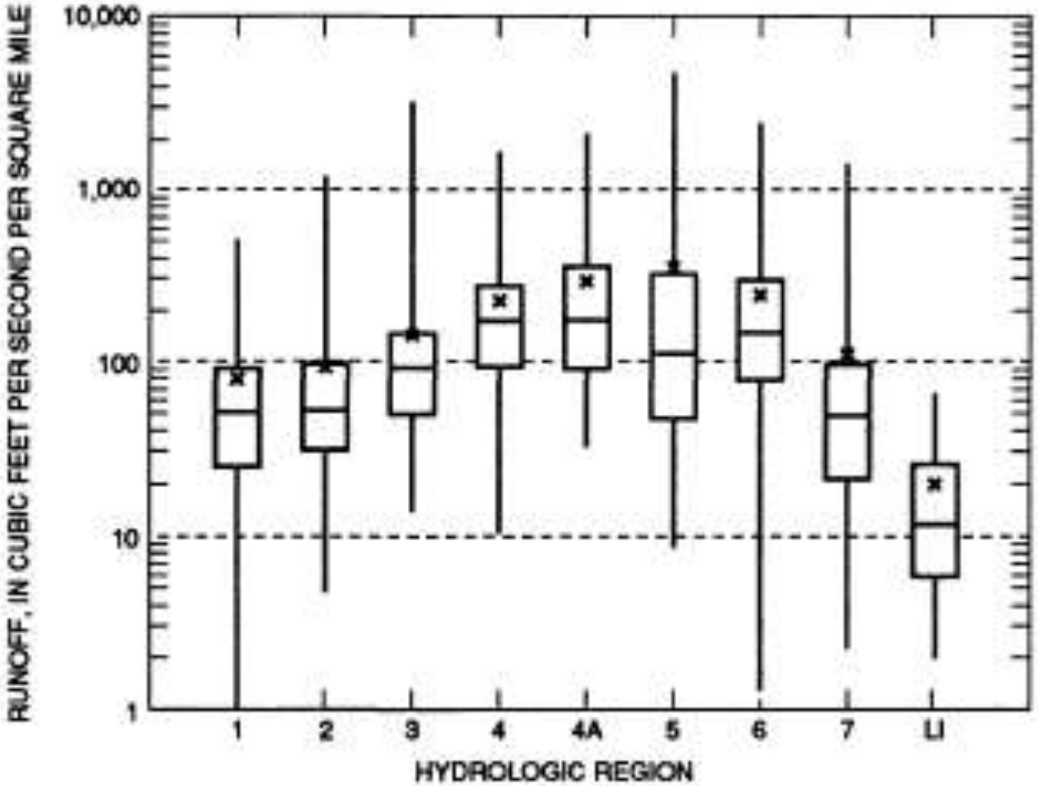
Water-Resources Investigations Report 92-4042

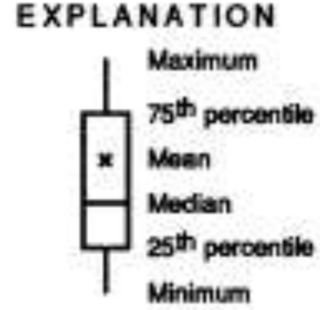
Prepared in cooperation with the

NEW YORK STATE DEPARTMENT
OF TRANSPORTATION



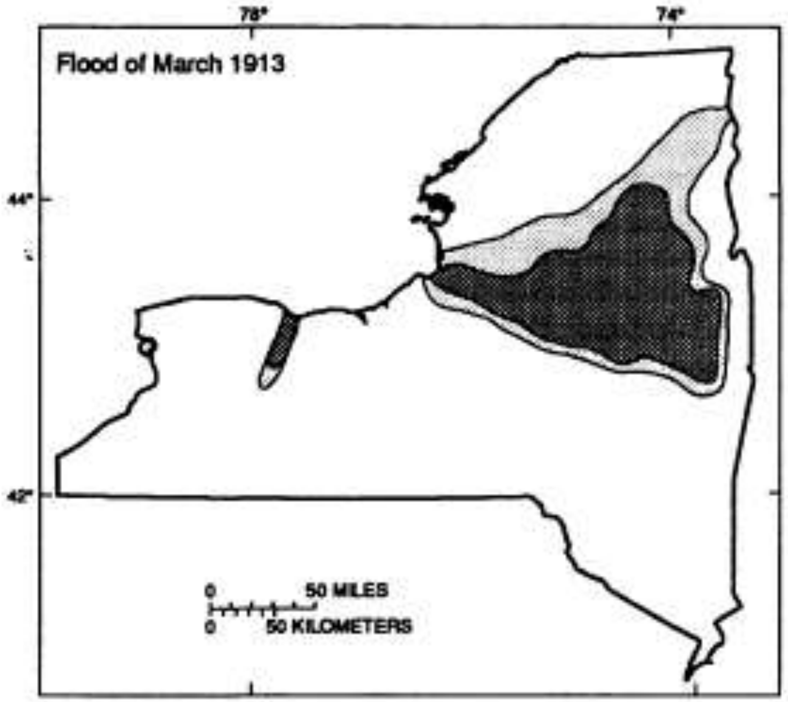
17 Watersheds in NYS

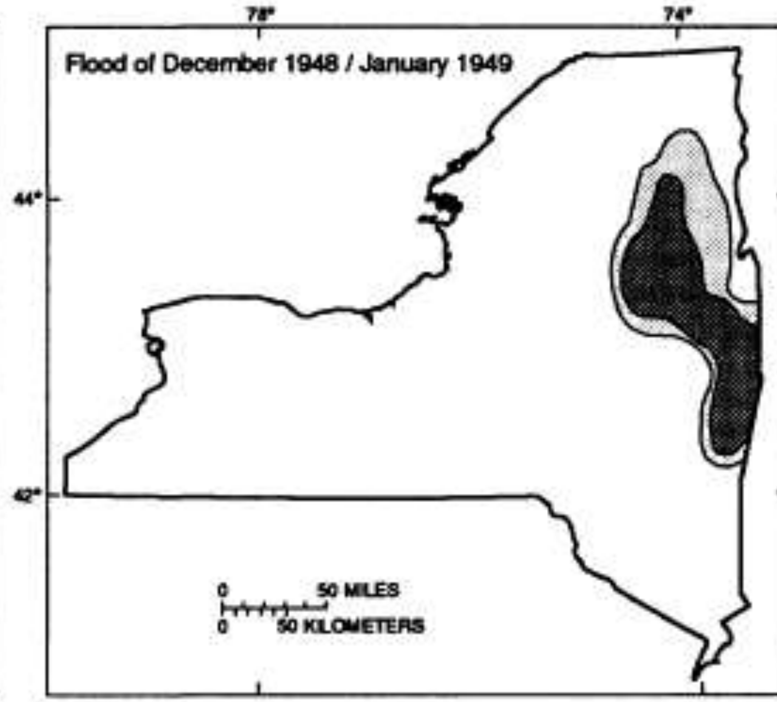




Hydrologic region	Number of stations
1	111
2	174
3	144
4	134
4A	70
5	157
6	310
7	159
LI	21
All sites	1280

Figure 4.—Maximum known runoff for nine hydrologic regions of New York.



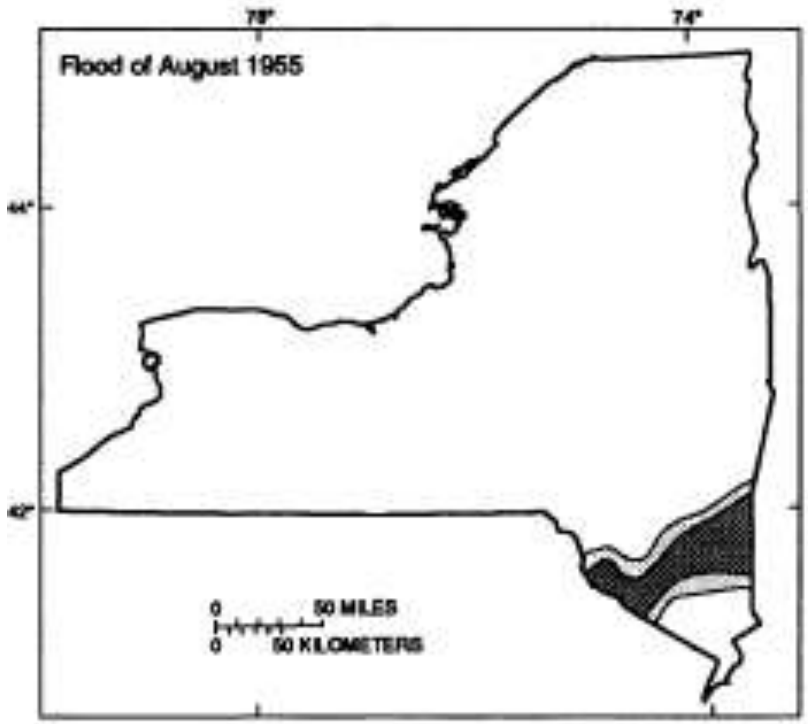


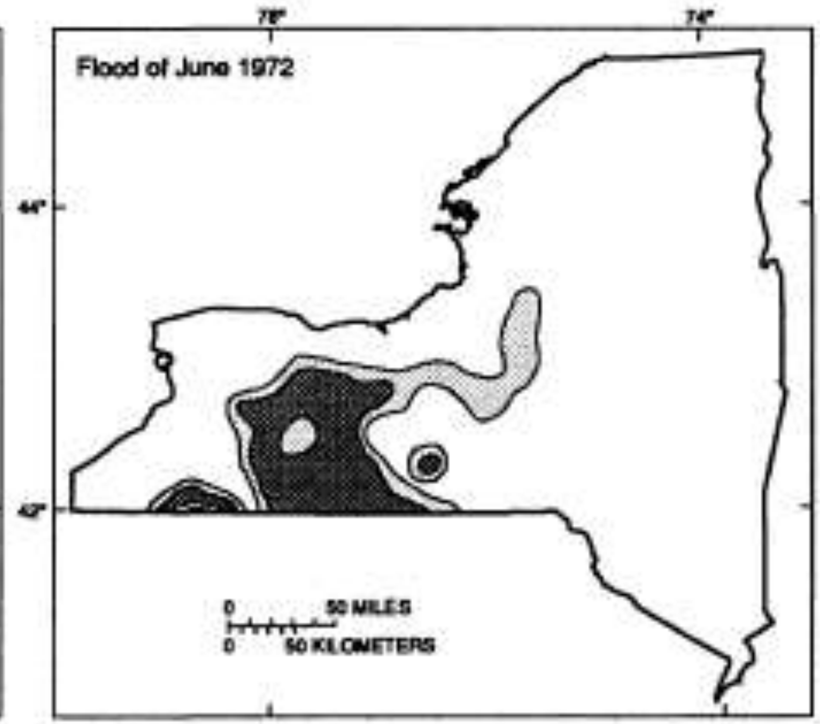
- March 6-8” above-normal rainfall
- A single 4.4” event
- Snowmelt
- Frozen ground
- Peak record discharge *(>100yr RI)*:
  - Sacandaga
  - Hudson
  - Mohawk
- Big Indian Lake 5.4’ over spillway

- 5-12” of rainfall
- Frozen ground
- Peak record discharge *(>75yr RI)*:
  - Sacandaga
  - Hudson
  - Hoosic
- $4M in total damage


STEWART
FIRE APPARATUS


HAMDEN
RS. INC.

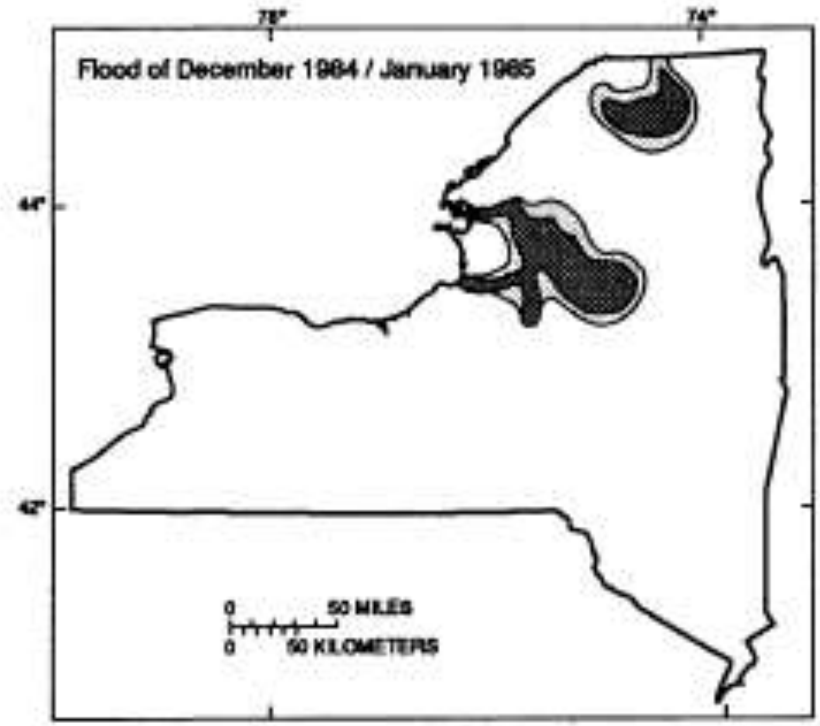




- Hurricanes Connie & Diane
- 18.3” total rainfall at Slide Mtn.
- Single-day highs of 8.2”
- Rain band parallel w/ Delaware, w/ a peak record discharge.
- 100-yr recurrence interval Hudson River
- Several million $ in damage.

- Hurricane Agnes
- Merged with low-pressure stationary event and produced 16” rainfall
- 100-yr recurrence intervals Chemung, Genessee, and Allegheny.
- Peak stage of Chemung 8’ higher than previous historical high.
- $703M in damages

Figure 2.—Flood-boundaries for five selected storms, 1913-85. (From Gravlee and others, 1991.)



- Warm-front rain + warm temp/snow melt
- 8.4”
- Black and Salmon Rivers > 100yr RI
- Black River discharge record high.
- $5M damages
- 8 counties declared “disaster areas” by Governor of NY, and 2 counties declared Federally.

Long Island Express 1938

200 fatalities and millions in damage

Donna 1960

Created an 11-ft storm tide


PHOENICIA
WINES
LIQUORS
Phoenicia
Delicatessen
VALERO


Getty Images

OUR LOCALIZED HYDROLOGIC FUTURES ARE UNKNOWN

AND GREEN INFRASTRUCTURE IS THE NEXT PARADIGM SHIFT

USEPA DEFINITION OF GREEN INFRASTRUCTURE

An adaptable term used to describe an array of products, technologies, and practices that use natural systems – **or engineered systems that mimic natural processes** – to enhance overall environmental quality and provide utility services.

PURPOSES

- Combined Sewer Overflow (CSO) reduction
- Municipal Separate Storm Sewer System (MS4) compliance

- Stream baseflow maintenance
- Ecological preservation
- Stream stabilization
- Water supply protection
- Flood reduction

PURPOSES CONT.

- Aesthetics
- Property value preservation
- Retail sales improvement
- Keeping the millennial generation happier
- Mayoral prestige preservation

PURPOSES CONT.

PURPOSES CONT.

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PURPOSES CONT.

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- Flood reduction

CONTEXT

- Rural, Suburban or Urban
- Site and adjacent site topography
- Land cover, vegetation
- Geology
- Soils
- Current hydrology (site walks while raining?)
- Proximity to water bodies & groundwater
- Seasonal effects
- Invasive species influence
- Floodplain/climate change/surging

TECHNIQUE

- Conserve natural area
- Riparian buffer
- Vegetated swale
- Tree planting/pit
- Rooftop disconnection
- Stream daylighting
- Rain garden
- Green roof
- Planters
- Rain barrels/cisterns
- Porous pavement

BUCKET + HOSE

- All individual GI practices can be thought of as a bucket and hose.
- The **<u>bucket</u>** reflects provisional storage space for instantaneous rainfall capture volume.
- The **<u>hose</u>** represents the ability of the GI to remove rainwater volume from the bucket to some destination with less impact than pavement during and in-between rain events.

BUCKET + HOSE

- Hose destinations might include:
  - Infiltration as interflow or deeper groundwater
  - Evapotranspiration
  - Delayed pipe discharge
  - Graywater reuse
  - Irrigation
  - Even drinking water (Atlanta, GA)

EXAMPLES OF
(GI) BUCKETS + HOSES

CISTERN

- A cistern is all bucket.
- The hose is the spigot, and unless automated, depends on someone turning it on.

TREE

- A tree is almost all hose.
- A tree can capture little instantaneous rainfall with its leaves, so in order to maximize it’s effectiveness, we pair it with a bucket.

RAIN GARDEN (BIORETENTION)

- A well-balanced bucket + hose.
- Popular.
- Can be effective for WQ treatment.
- For flood control, it can look and work like a leaky undersized detention system.

INJECTION WELL

- Injection well into deep gravel or sand can be a great hose.
- Used in Florida, the Rockies, and the Pacific Northwest routinely for flood control.
- This approach provides little pollution removal without top-end filtration.

OPEN SPACE

- Open space can be an amazing combination of bucket and hose if it is amended to improve infiltration and contact time is enhanced with designed sheet flow, terracing, or berms.

GRAVEL / UNDERGROUND VAULTS

- Can be great buckets and, when the hose is properly sized to match demand intensity, can work even at low native soil infiltration rates.

GREEN ROOF

- A green roof is a fairly pricey bucket, and the hose depends on evapotranspiration alone, unless it is extended to detention outlets.
- Many or simplifying these systems, while reducing (upfront and operating costs), by removing the "green" and installing blue roofs (rooftop detention). This system utilizes evaporation as it's hose – no transpiration.

HOW TO BEST DESIGN HOSES + BUCKETS

IF MANDATE 1
CSO REDUCTION

THAN NEAR INSTANTANEOUS VOLUME CAPTURE WITH EVENTUAL VOLUME REMOVAL OR RUNOFF DELAY IS REQUIRED

EVAPOTRANSPIRATION
IS OF LITTLE VALUE DURING AN OVERFLOW EVENT, BUT CAN BE HELPFUL IN-BETWEEN EVENTS IN RESTORING BUCKET CAPACITY.

CAN GI OFFER
PEAK FLOW REDUCTION?
YES & NO.

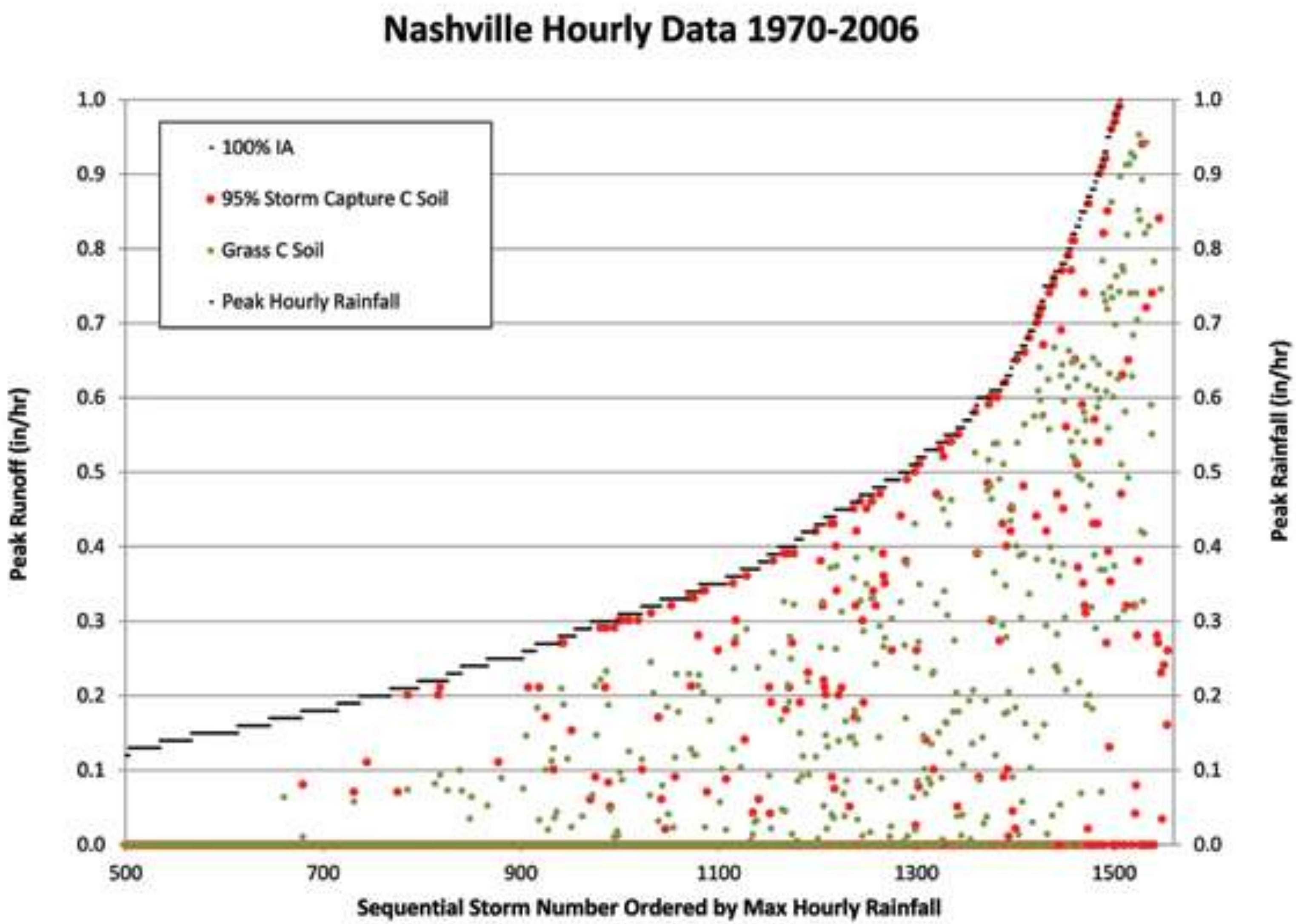


Figure 1. Peak flow reduction 95% storm capture; C soil

DATA

- Hourly data divided into storms with a 72-hour inter-event dry period.
- 100% impervious area development routed through bioretention designed for instantaneous capture of the 95% storm.

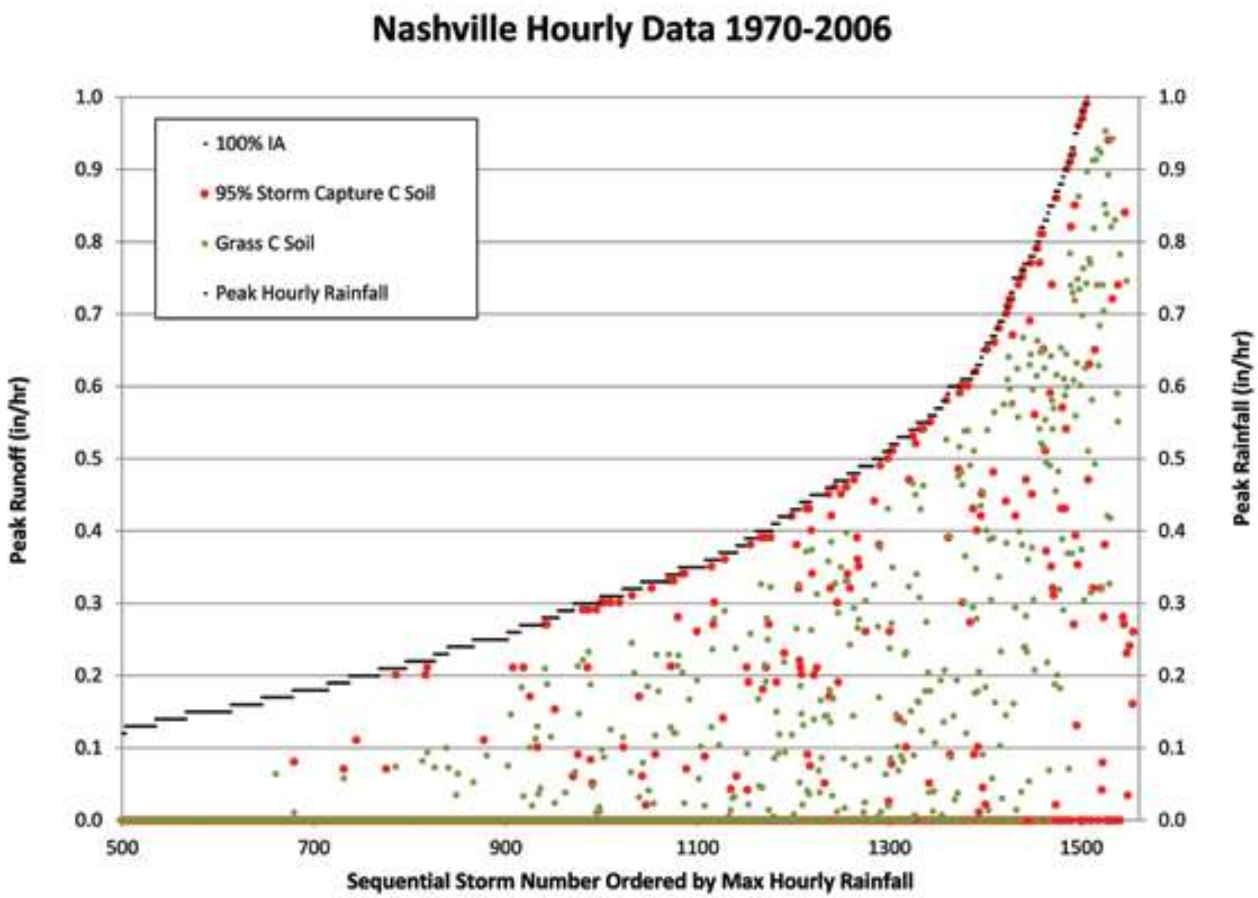


Figure 1. Peak flow reduction 95% storm capture; C soil

- Bioretention reduces many of the storms significantly, some below predevelopment condition.
- On average if reduces all storms with at least a max hourly rainfall of ½” per hour by 65%
- However flood control is not about averages, rather it’s about safety and zero tolerence.
- Some red dots are near equal to the impervious area. They’ve reached capacity.

REDUCING MINOR OVERFLOWS THAT HAPPEN SEVERAL TIMES PER YEAR CAN LIKELY BE ACHIEVED. **ELIMINATING** OVERFLOWS & FLOODING LIKELY CANNOT. UNDERSIZED DETENTION.


STORMWATER RUNOFF
OVERFLOW
CATCH BASIN
SEWER MANHOLE
NYC
Environmental
Protection
Michael R. Bloomberg, Mayor
GREEN INFRASTRUCTURE
RIGHT OF WAY BIOSWALE

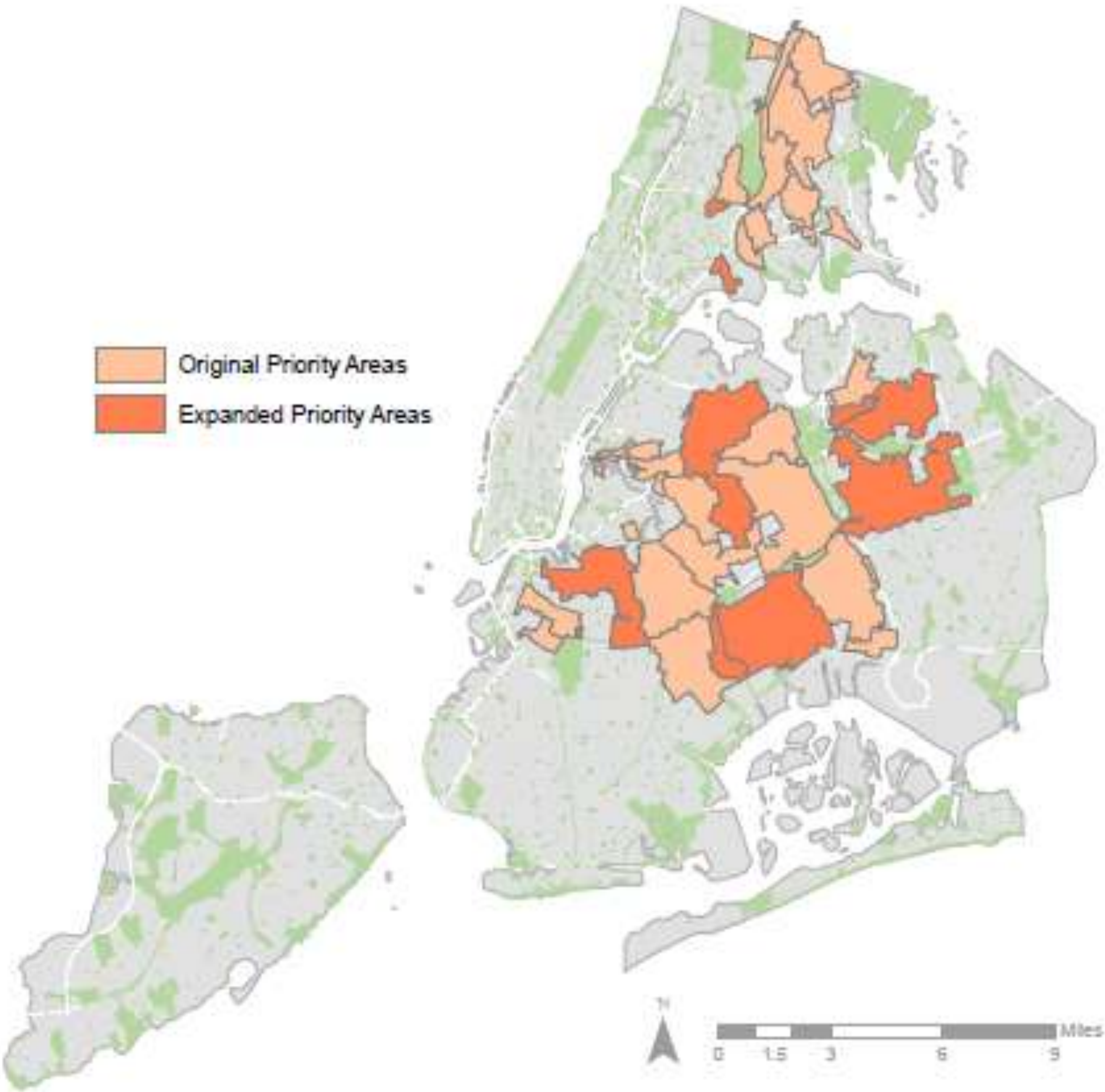


Figure 2: Original and Expanded Priority CSO Tributary Areas.

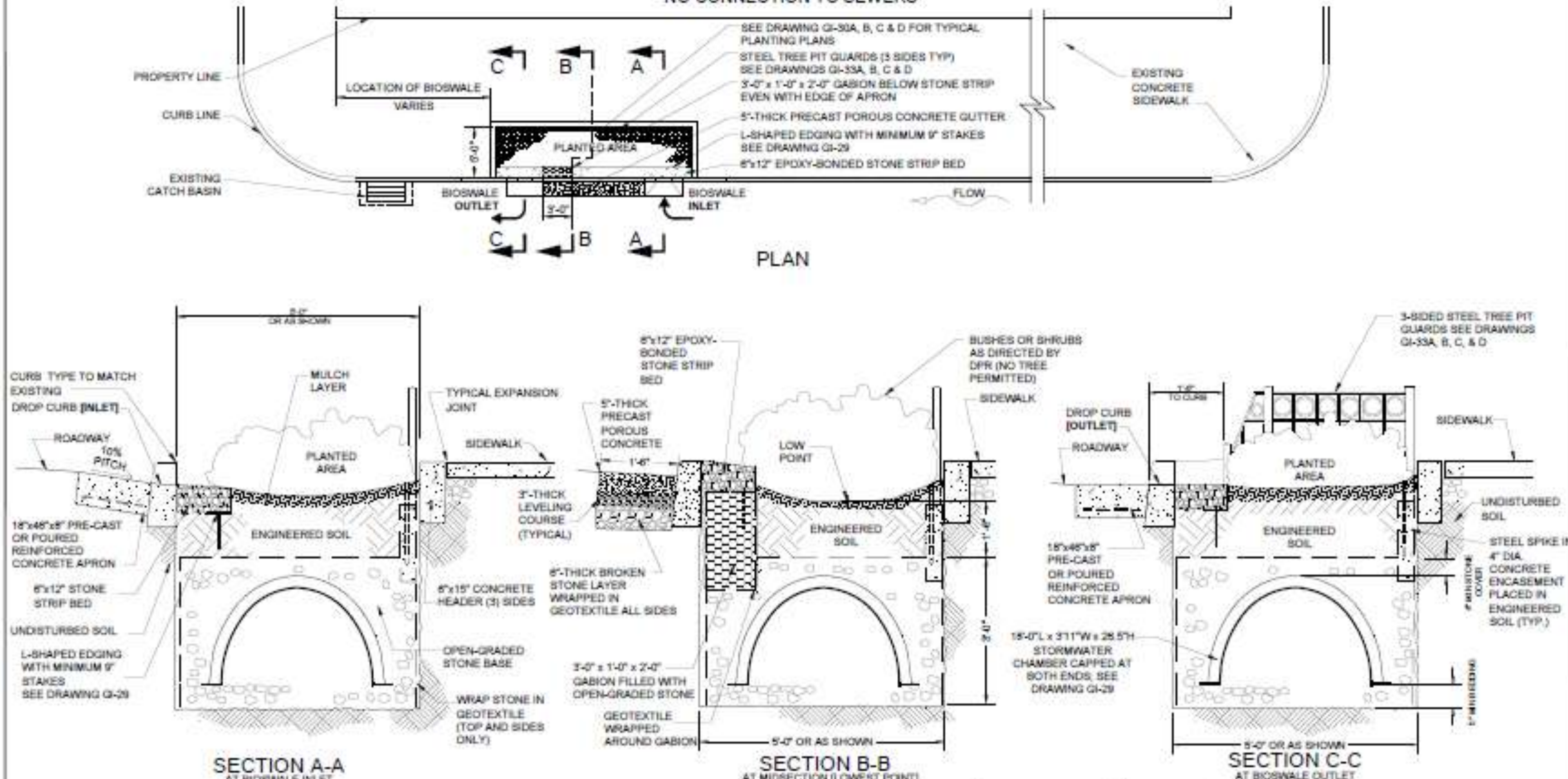
GI-07

GI-07

CITY OF NEW YORK
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OFFICE OF GREEN INFRASTRUCTURE

STANDARD FOR 20'x5' R.O.W. BIOSWALE TYPE 1C - WITH STORMWATER CHAMBER

- NO CONNECTION TO SEWERS



P.E., F. ASCE

ASSISTANT COMMISSIONER, OFFICE OF GREEN INFRASTRUCTURE
DEPARTMENT OF ENVIRONMENTAL PROTECTION

08-29-2014
DATE

GI-07 GI-07

CITY OF NEW YORK
DEPARTMENT OF ENVIRONMENTAL PROTECTION
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STANDARD FOR 20'x5' R.O.W. BIOSWALE TYPE 1C - WITH STORMWATER CHAMBER

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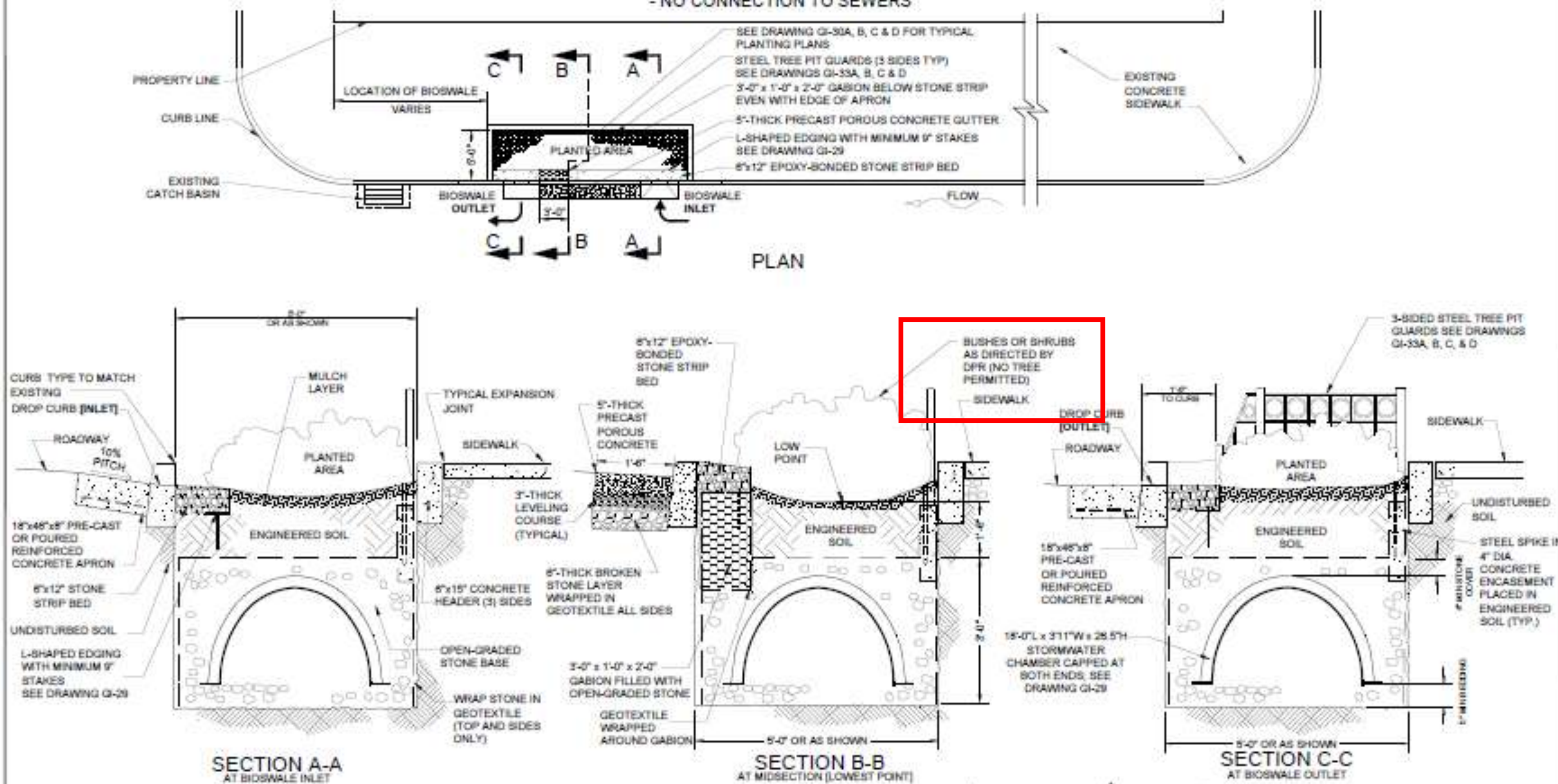

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08-29-2014
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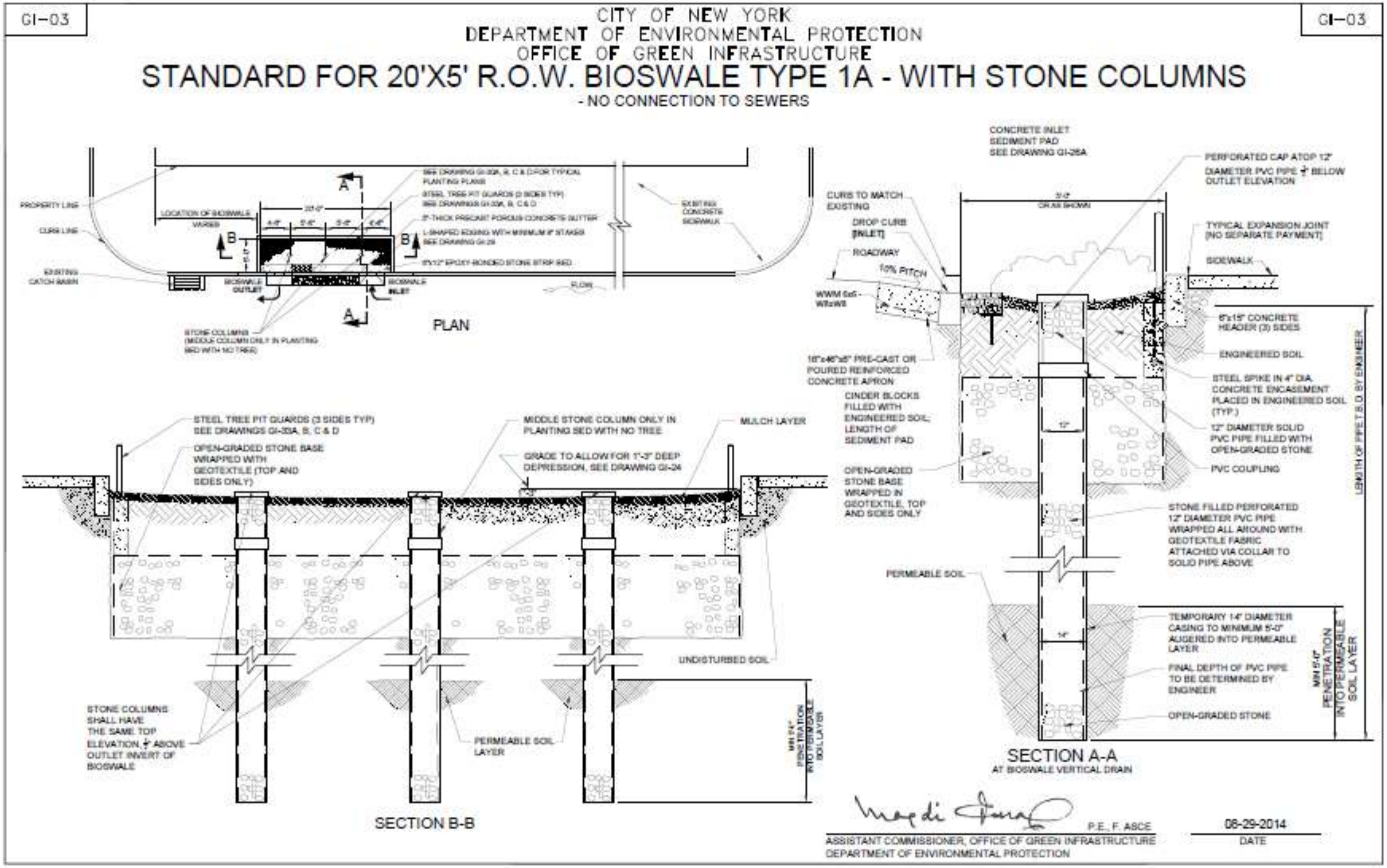


The beginning of a true CSO reduction and flood control GI measure. Injection to a large underground vault (gravel, sand, engineered) required, or perhaps bedrock.

Contractor Constructability

Soils Quality vs. Depth

Foundation/Footings Proximity

Basement Recharge

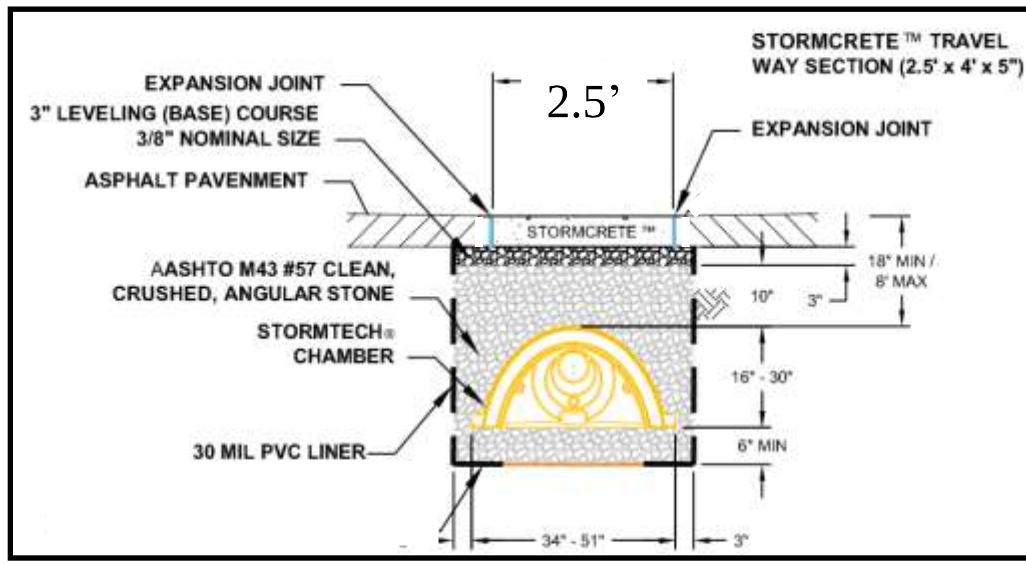
Combined Sewer Recharge (latency)

Stormcrete™ "inside" NYC Bio-Swale

(Provides a stable, pervious surface for pedestrians to safely exit their cars)


SIM


STOP


STORMCRETE ™ TRAVEL WAY SECTION (2.5' x 4' x 5")
2.5’
EXPANSION JOINT
3" LEVELING (BASE) COURSE
3/8" NOMINAL SIZE
ASPHALT PAVENMENT
EXPANSION JOINT
STORMCRETE ™
AASHTO M43 #57 CLEAN,
CRUSHED, ANGULAR STONE
STORMTECH®
CHAMBER
30 MIL PVC LINER
18" MIN /
8' MAX
10"
3"
16" - 30"
6" MIN
34" - 51"
3"

PRODUCT SPECIFICATIONS	SC-310	SC-740	DC-780	MC-3500	MC-4500
Height, in. (mm)	16 (406)	30 (762)	30 (762)	45 (1143)	60 (1524)
Width, in. (mm)	34 (864)	51 (1295)	51 (1295)	77 (1956)	100 (2540)
Length, in. (mm)	90.7 (2300)	90.7 (2300)	90.7 (2300)	90 (2286)	52 (1321)
Installed Length, in. (mm)	85.4 (2170)	85.4 (2170)	85.4 (2170)	86.0 (2184)	48.3 (1227)
Bare Chamber Storage, cf (cm)	14.7 (0.42)	45.9 (1.30)	46.2 (1.30)	109.9 (3.11)	106.5 (3.01)
Stone above, in. (mm)	6 (152)	6 (152)	6 (152)	12 (305)	12 (305)
Stone below, in. (mm)	6 (152)	6 (152)	9 (229)	9 (229)	9 (229)
Row Spacing, in. (mm)	6 (152)	6 (152)	6 (152)	9 (229)	9 (229)
Minimum Installed Storage, cf (cm)	**31.0 (0.88)**	**74.9 (2.12)**	**78.4 (2.22)**	**178.9 (5.06)**	**162.6 (4.60)**
Storage Per Unit Area, cf/sf (cm/sm)	1.31 (0.39)	2.21 (0.67)	2.32 (0.70)	3.48 (1.06)	4.45 (1.35)

Chamber Design Specifications

ASTM F2787

AASHTO LRFD Bridge Design

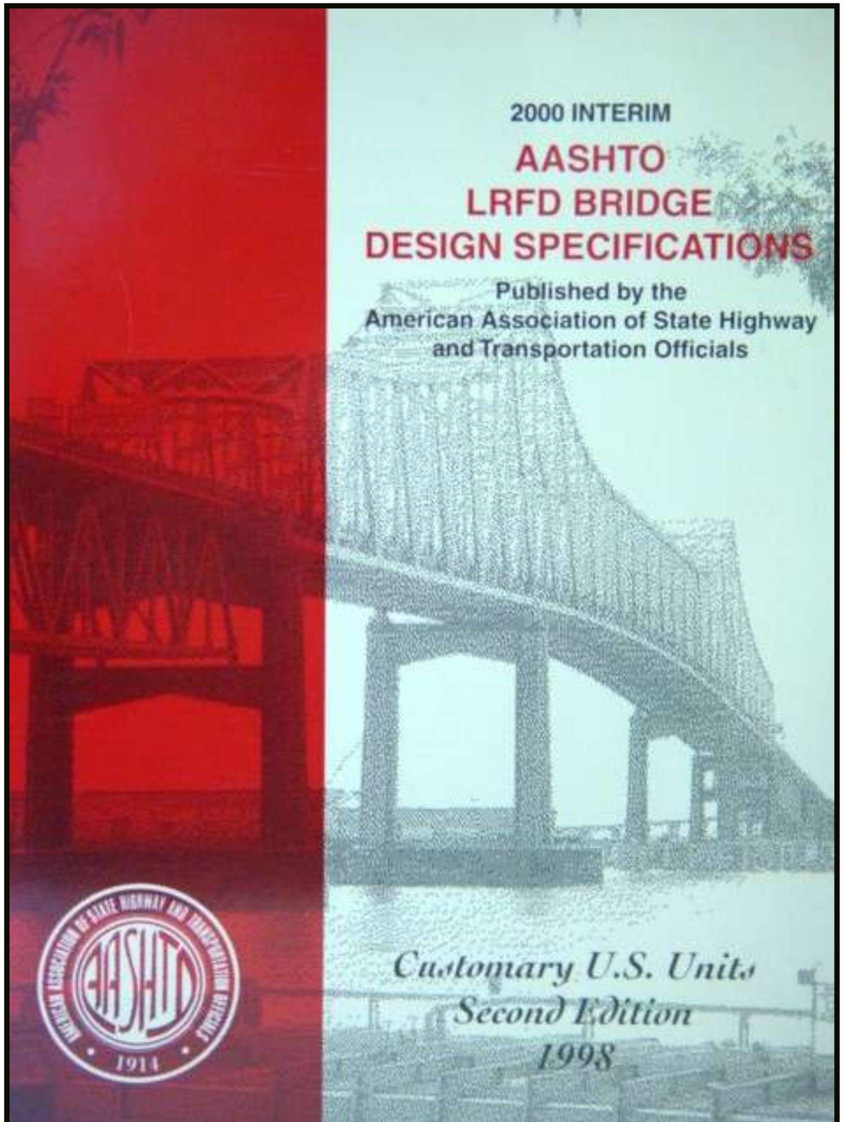
Section 3 – Loads and Load factors

Section 12.12 – Thermoplastic Chamber Design

Resin Specifications

ASTM F2418 (PP)

ASTM F2298 (HDPE)



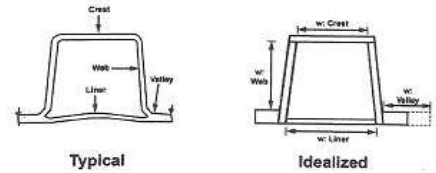


Figure 12.12.3.5.3b-1 Typical and Idealized Cross-Section of Profile Wall Pipe.

12.12.3.5.3c Slenderness and Effective Width

The effective width of each element for buckling shall be determined as:

$$b = \rho w \quad (12.12.3.5.3c\text{-}1)$$

in which:

$$\rho = \frac{\left(1 - \frac{0.22}{\lambda}\right)}{\lambda} \leq 1 \quad (12.12.3.5.3c\text{-}2)$$

$$\lambda = \left(\frac{w}{t}\right)\sqrt{\frac{\varepsilon}{k}} > 0.673 \quad (12.12.3.5.3c\text{-}3)$$

in which:

$$\varepsilon = \frac{T_L}{(AE_{50})} \quad (12.12.3.5.3c\text{-}4)$$

where:

A = wall area specified in Article 12.12.3.5.1 (in.^{2}/ft.)

b = element effective width (in.)

ε = strain in element (in./in.)

ρ = effective width factor

w = total clear width of element between supporting elements (in.)

λ = slenderness factor

t = thickness of element (in.)

k = edge support coefficient

E_{50} = 50-year modulus of elasticity (ksi)

C12.12.3.5.3c

The resistance to local buckling is based on the effective width concept used by the cold formed steel industry (*AISI, 1997*). This theory assumes that even though buckling is initiated in the center of a plate element, the element still has substantial post-buckling strength at the edges where the element is supported. This concept is demonstrated in Figure C1.

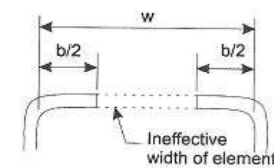
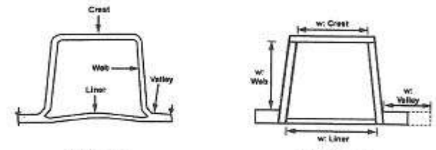


Figure C12.12.3.5.3c-1 Effective Width Concept.

<u>Design Elements</u>:

- Section Properties
- Material Properties
- Chamber/Soil Interaction
- Loading conditions
- Wall thrust
- Deflection
- Buckling
- Bending strain
- Combined strain

LONG-TERM STRAIN LIMITS OF THERMOPLASTIC!



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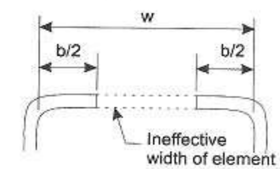


Figure C12.12.3.5.3c-1 Effective Width Concept.

AASHTO LRFD Section 12.12
Factored Vertical Crown Pressure

$$P_F = \eta_{EV}\left(\gamma_{EV} \cdot VAF \cdot P_{SP} + 1.3 \cdot \gamma_{WA} \cdot P_W\right) + \eta_{LL} \cdot \gamma_{LL} \cdot C_L \cdot P_L$$

Earth Load

Hydrostatic Load

Live Load

Dead Load

<u>These factors INCREASE the actual load conditions</u>

$\eta_{EV} = 1.05$

$\gamma_{EV} = 1.95$

$1.3 * \gamma_{EV} = 1.3 * 1.0$

$\eta_{LL} * \gamma_{LL} = 1.0 * 1.75$

=2.05

=1.37

=1.75

REMOVABLE

REUSABLE

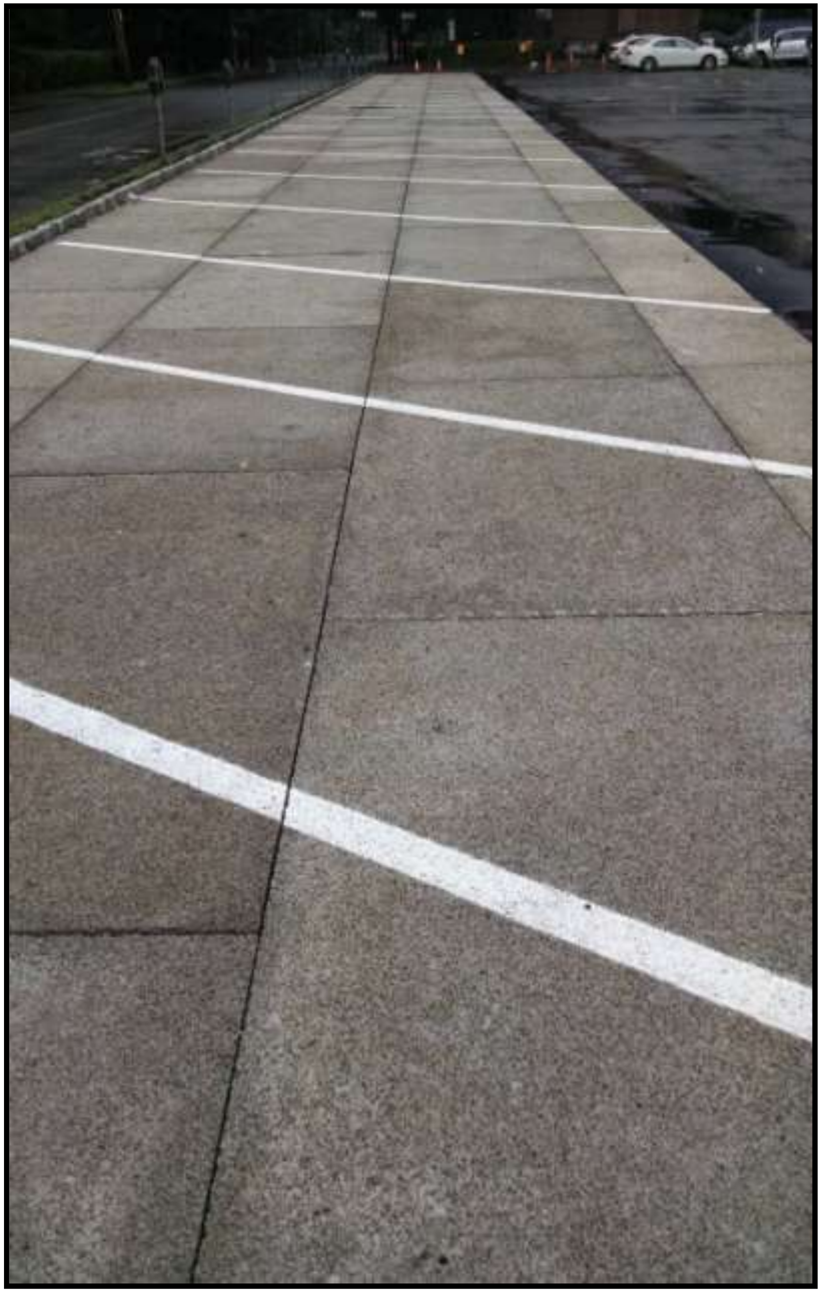
Manufacturing

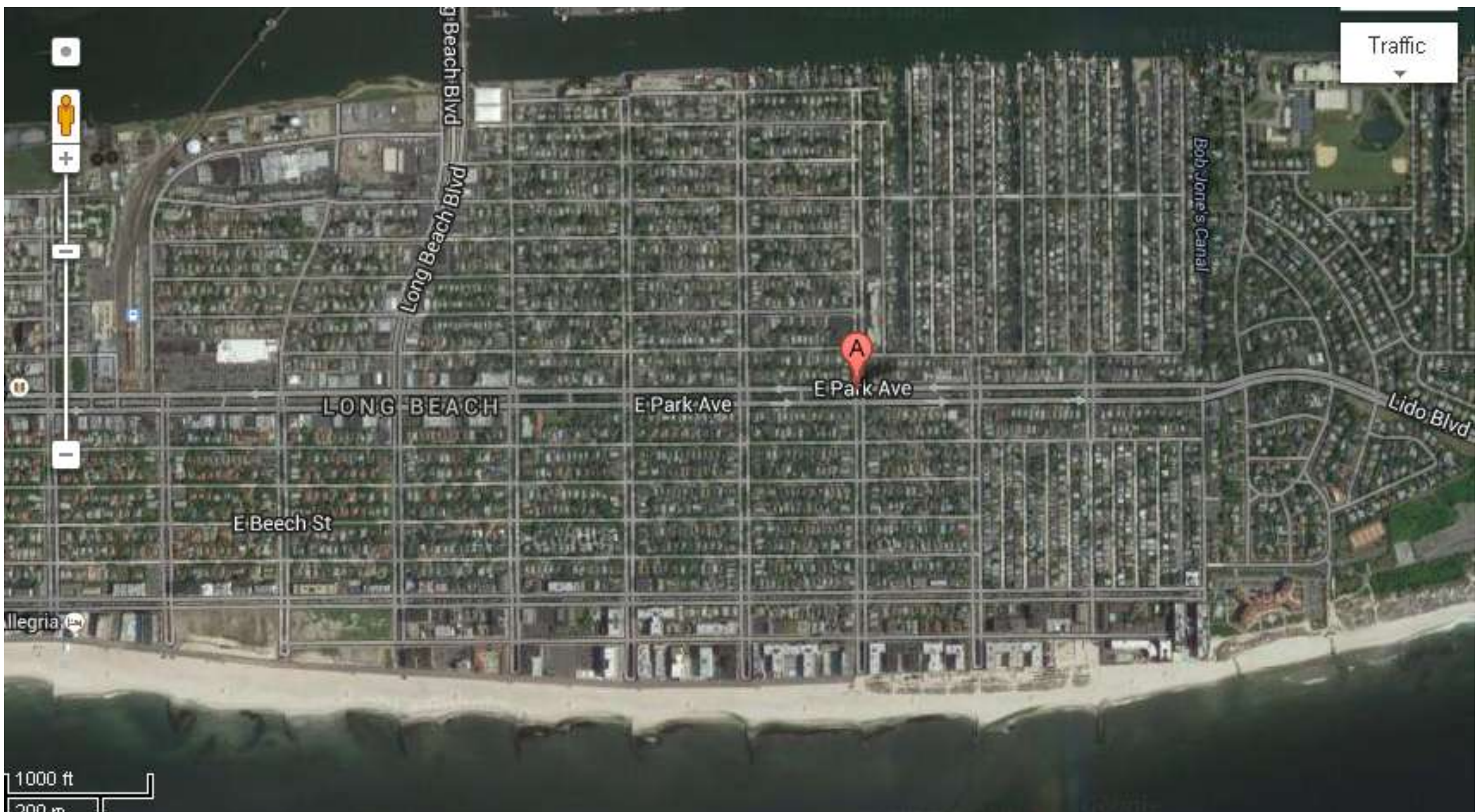
Municipal Parking

Bronxville, NY

Municipal Parking

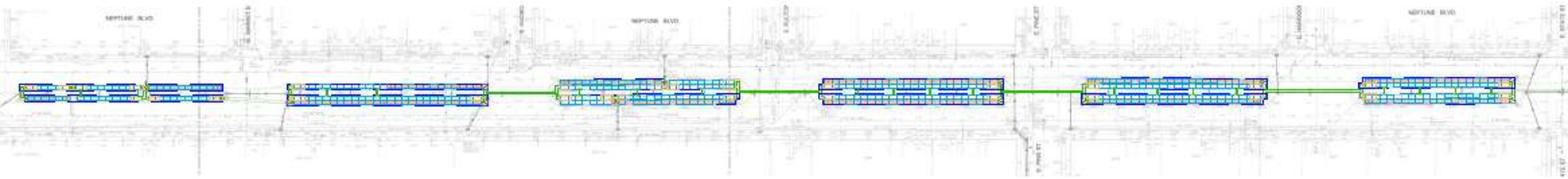
Bronxville, NY

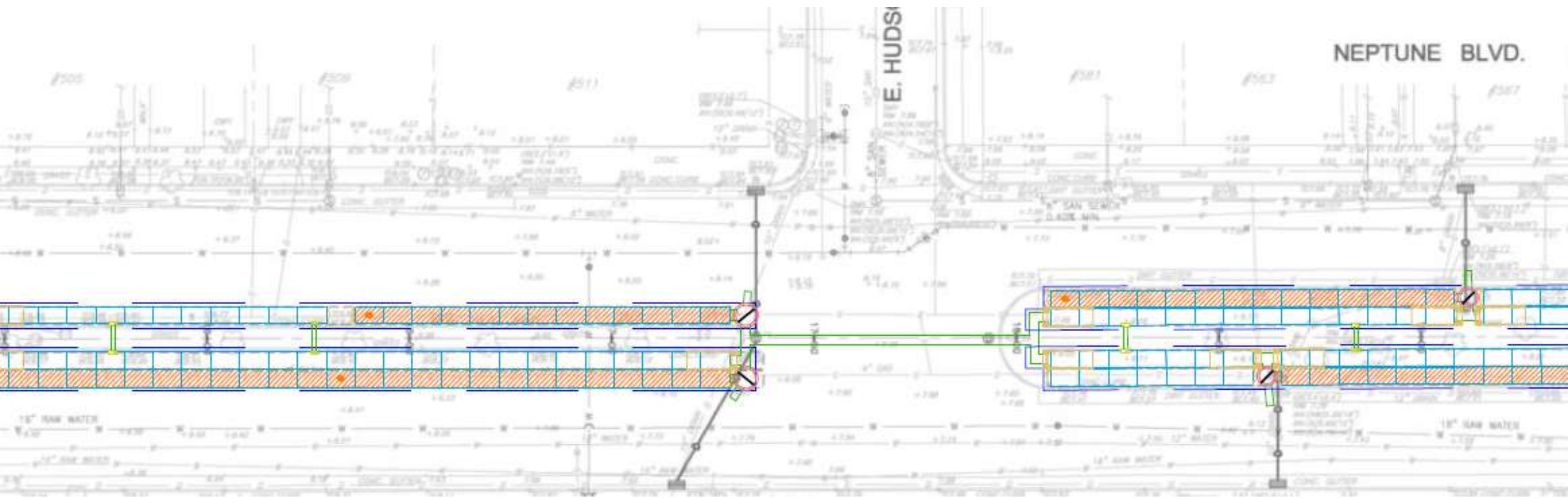



Baldwin Harbor
Inwood
Cedarhurst
Lawrence
878
Island Park
Bayswater
Far Rockaway
Edgemere
A
Point Lookout
Atlantic Beach
Long Beach
Lido Beach
Jones Beach

Traffic
Long Beach Blvd
Long Beach Blvd
Bob Jone's Canal
A
E Park Ave
LONG BEACH
E Park Ave
Lido Blvd
E Beech St
llegria
1000 ft
200 m

LONG BEACH, NY

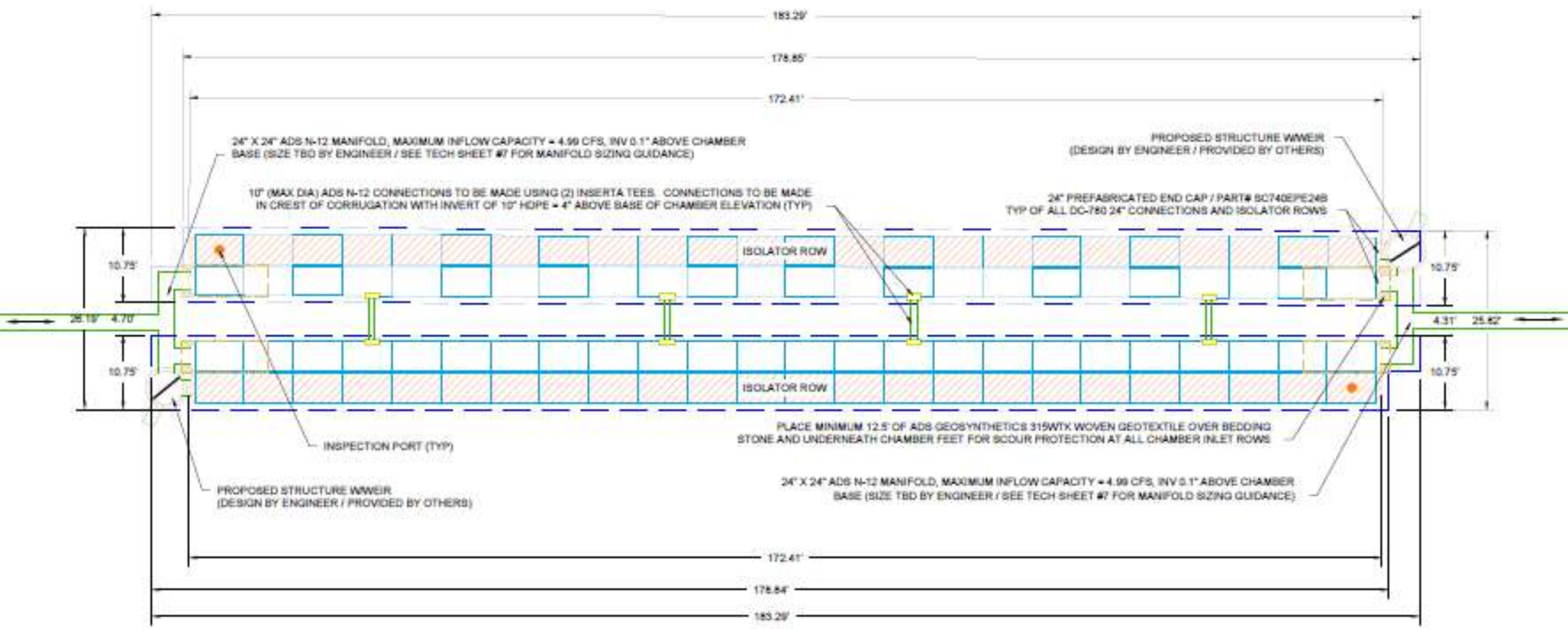
1.5” event, 30” tall chambers, 12” pipe





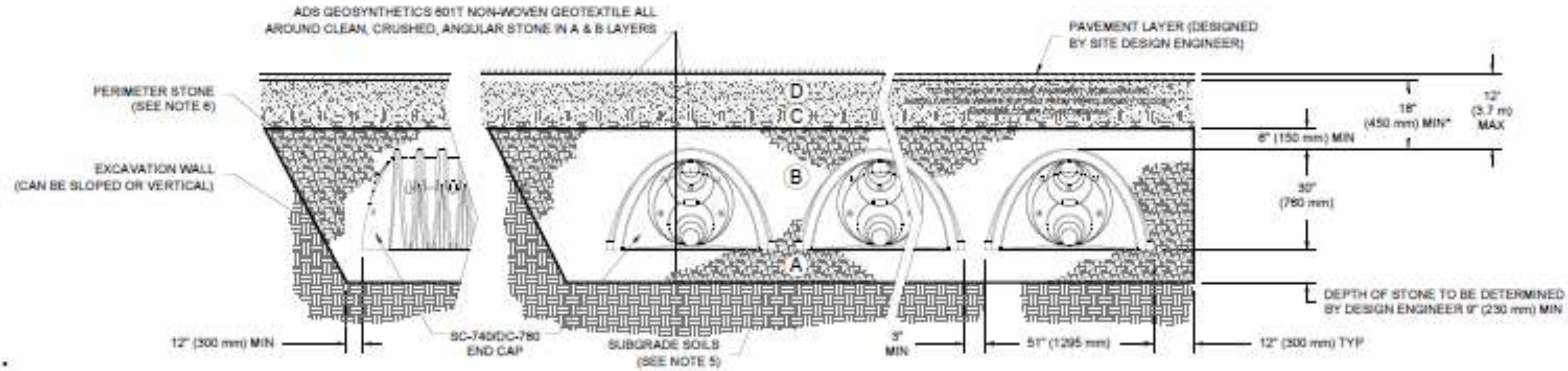
LONG BEACH, NY

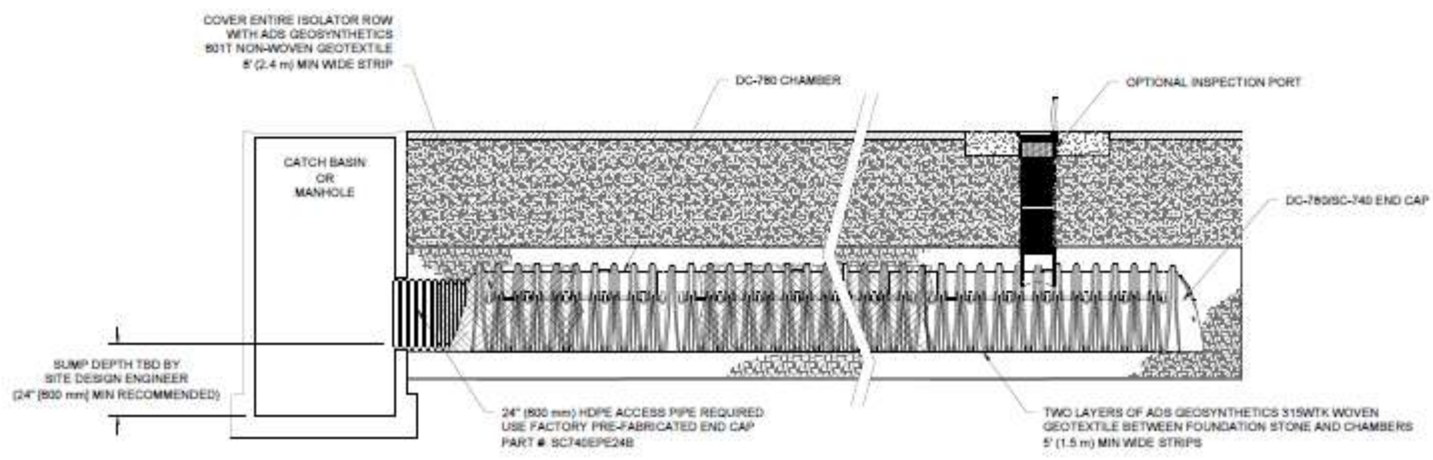
1.5” event, 30” tall chambers, 12” pipe



LONG BEACH, NY

1.5” event, 30” tall chambers, 12” pipe



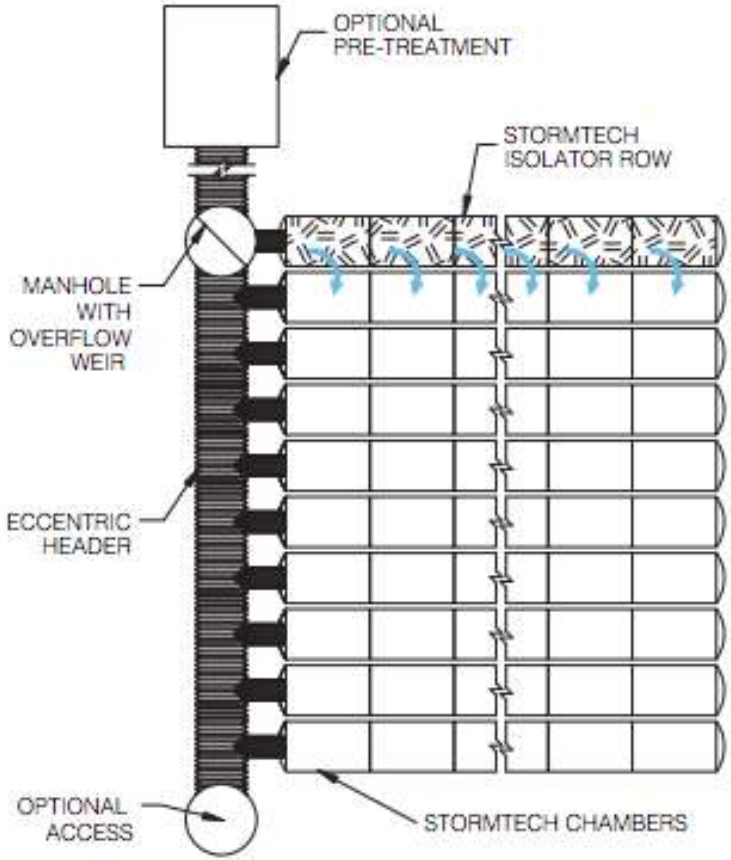


DC-780 ISOLATOR ROW DETAIL

NTS

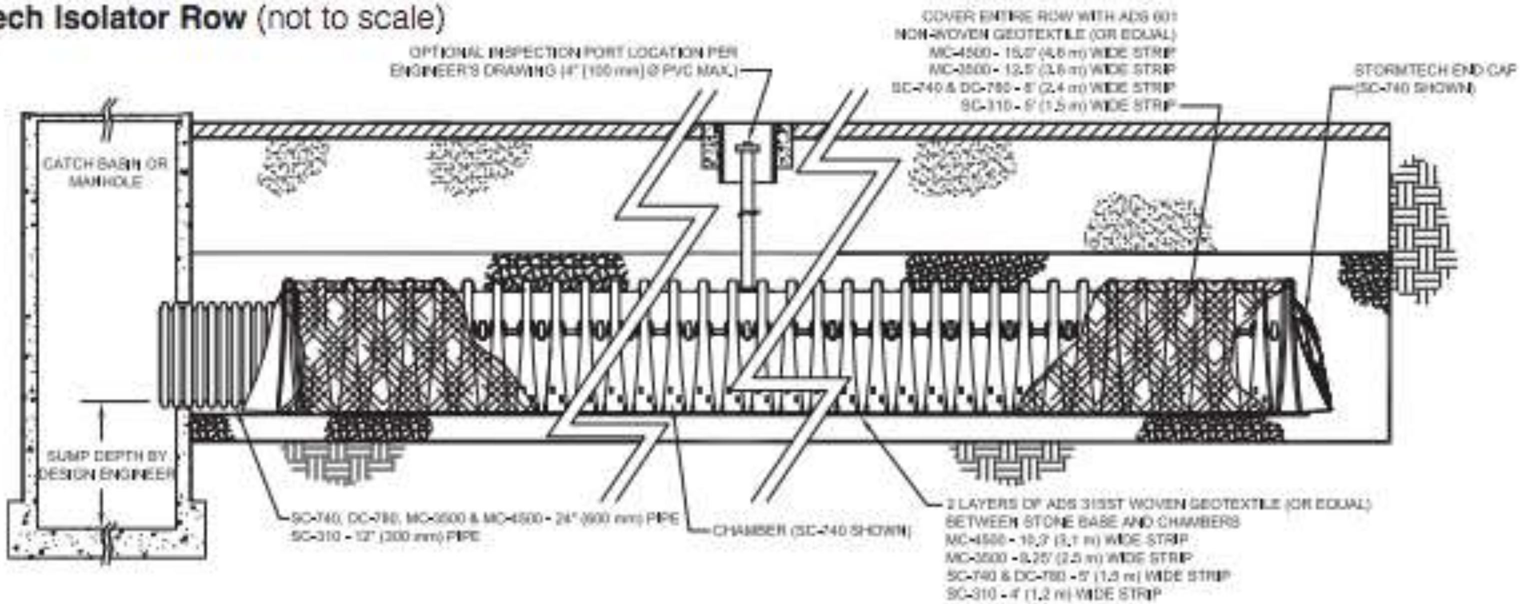
MAINTENANCE

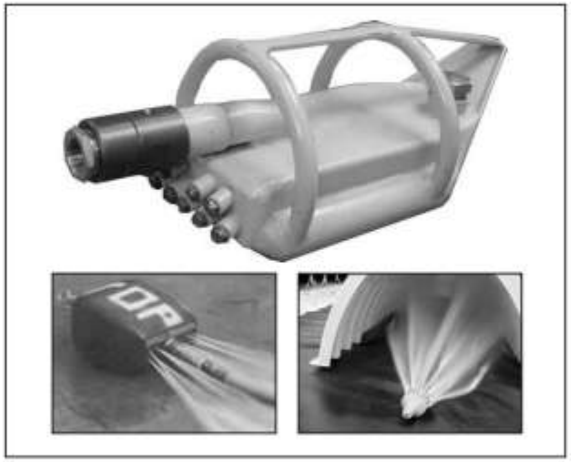
StormTech Isolator Row with Overflow Spillway
(not to scale)



MAINTENANCE

StormTech Isolator Row (not to scale)





- **3.3 CF of sediment per impervious acre**
- **Average Isolator Row is 10 chambers long**
- **Recommended to clean Isolator Row @ 2" of sediment**
- **3.3CF/year (10 chambers) = Maintenance every 7 years!**


165210

MAINTENANCE

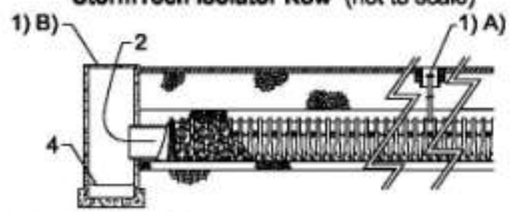
Just Prior to Jet-Vac

Post-Jet-Vac

MAINTENANCE

MAINTENANCE

StormTech Isolator Row (not to scale)



Step 1) Inspect Isolator Row for sediment

A) Inspection ports (if present)

i. Remove lid from floor box frame

ii. Remove cap from inspection riser

iii. Using a flashlight and stadia rod, measure depth of sediment and record results on maintenance log.

iv. If sediment is at, or above, 3 inch depth proceed to Step 2. If not proceed to Step 3.

B) All Isolator Rows

i. Remove cover from manhole at upstream end of Isolator Row

ii. Using a flashlight, inspect down Isolator Row through outlet pipe

1. Mirrors on poles or cameras may be used to avoid a confined space entry
2. Follow OSHA regulations for confined space entry if entering manhole

iii. If a sediment layer is visible proceed to Step 2. If not proceed to Step 3.

Step 2) Clean out Isolator Row using the JetVac process

A) A fixed culvert cleaning nozzle with rear facing nozzle spread of 45 inches or more is preferable

B) Apply multiple passes of JetVac until backflush water is clean

C) Vacuum manhole sump as required

Step 3) Replace all caps, lids and covers, record observations and actions

Step 4) Inspect & clean basins and manholes upstream of the StormTech system

Additional Notes

1. Inspect every 6 months during the first year of operation. Adjust the inspection interval based on previous observations of sediment accumulation and high water elevations.
2. Conduct jetting and vactoring annually or when inspection shows that maintenance is necessary

DATE	STADIA ROD READINGS FIXED POINT TO CHAMBER BOTTOM (1)	FIXED POINT TO TOP OF SEDIMENT (2)	SEDIMENT DEPTH (1) - (2)	OBSERVATIONS/ACTIONS	INSPECTOR

Sample Maintenance Log

Date	Stadia rod readings: Fixed point to chamber bottom (1)	Fixed point to top of sediment (2)	Sediment Depth (1) - (2)	Observations/Actions	Inspector
3/15/01	6.3 ft	none		New installation. Fixed point is CI frame at grade	djm
9/24/01		6.2	0.1 ft	Some grit felt	sm
6/20/03		5.8	0.5 ft	Mucky feel, debris visible in manhole and in isolator row, maintenance due	rv
7/07/03	6.3 ft		0	System jetted and vacuumed	djm

StormTech

Detention • Retention • Water Quality

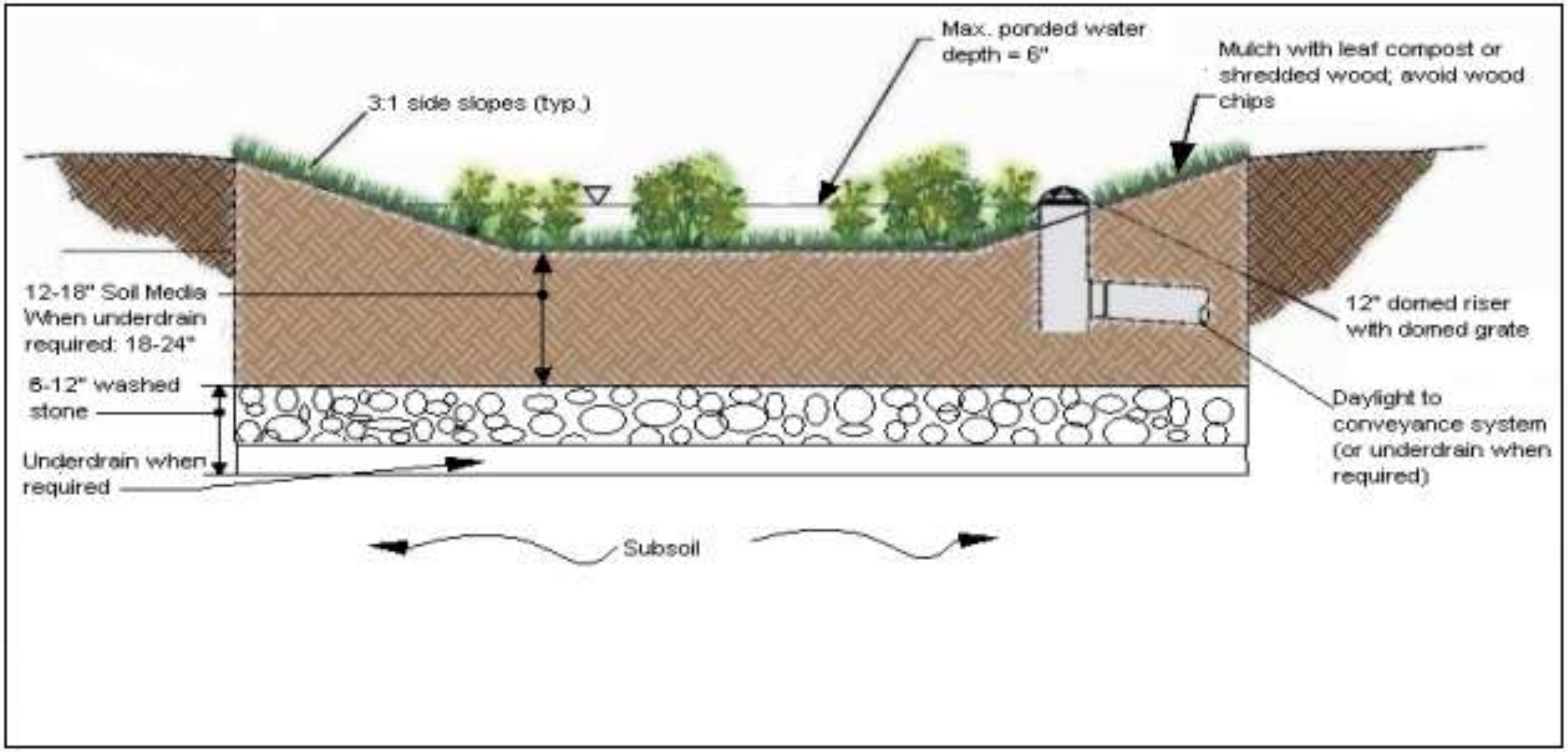
STORMTECH
OPERATION AND MAINTENANCE PLAN

STORMTECH, LLC
20 BEAVER RD., SUITE 104
WETHERSFIELD, CT 06109
WWW.STORMTECH.COM

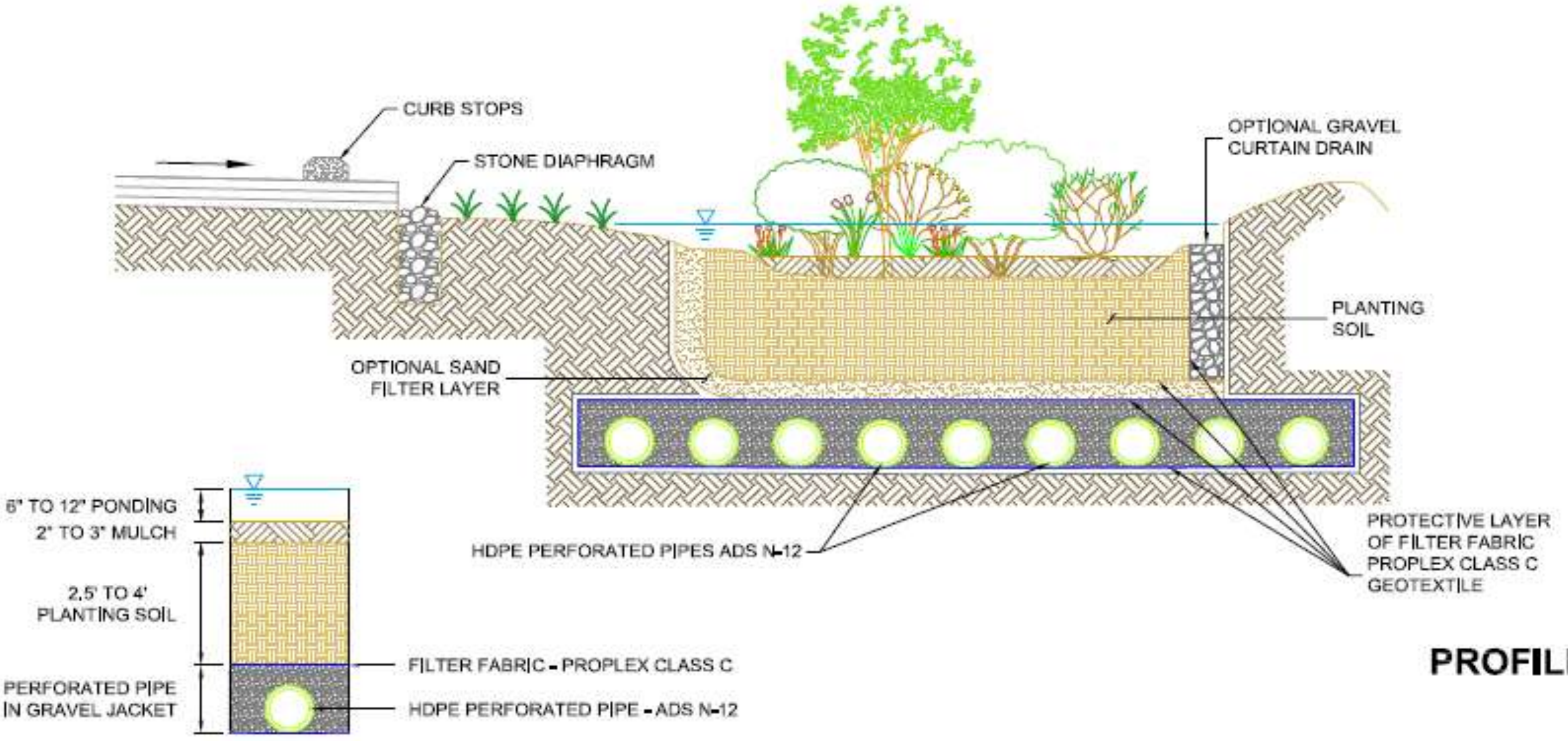
IF MANDATE 2
MS4 COMPLIANCE / PREDEV SITE MIMICRY

RAIN GARDEN

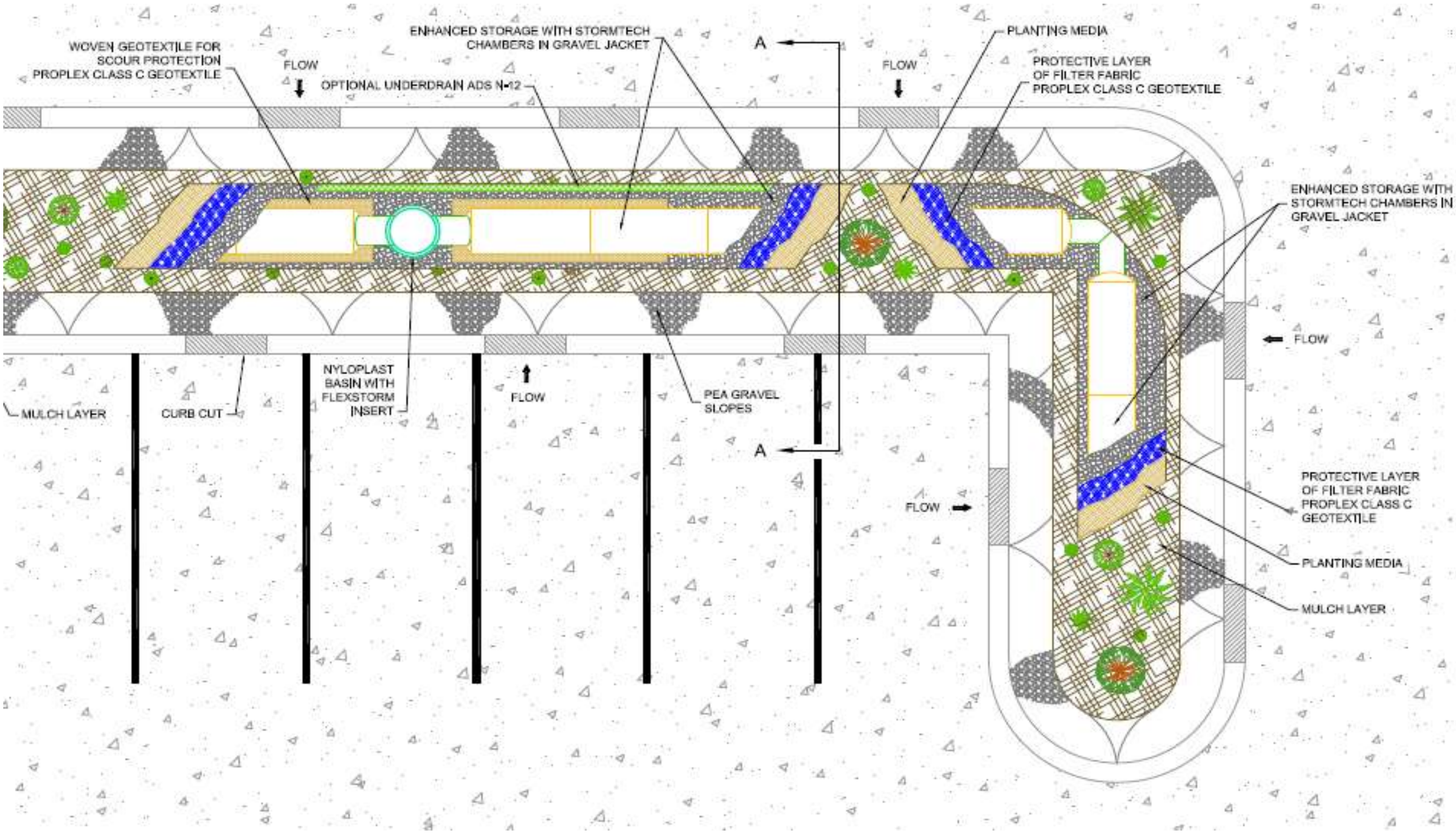
Figure 5. 42 Profile of a typical rain garden



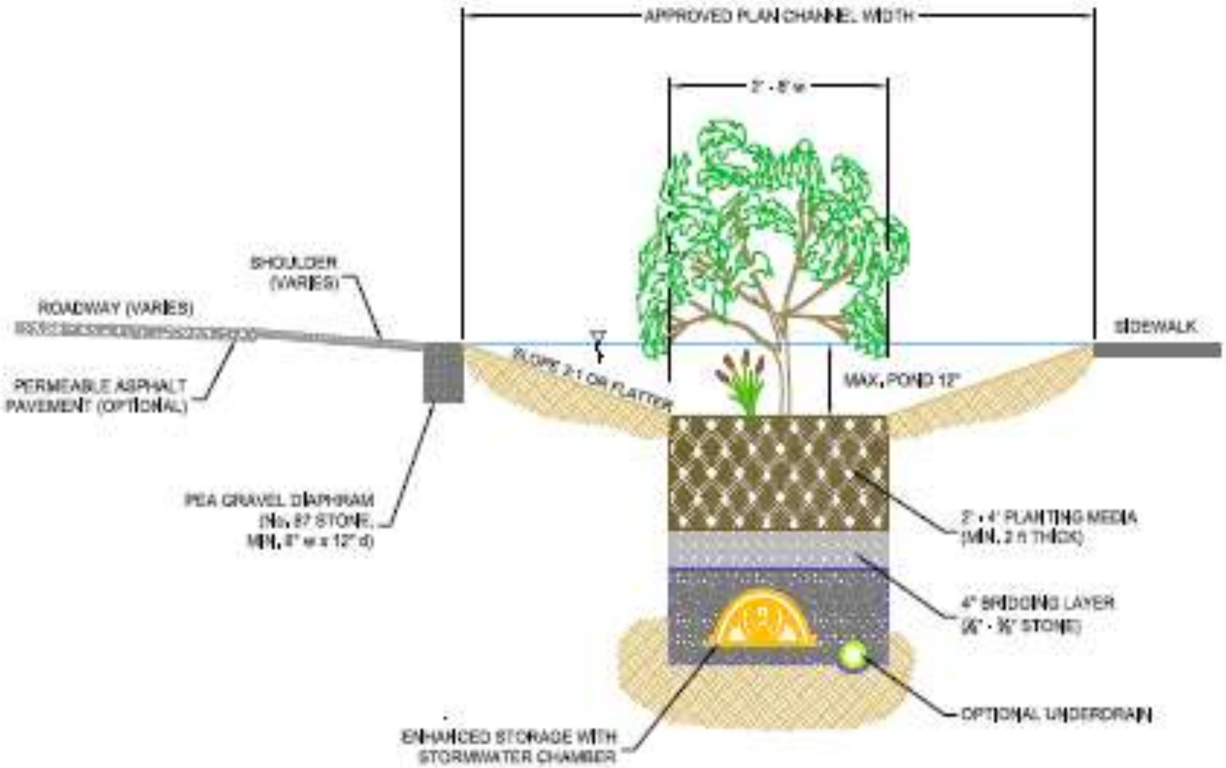
EXPAND BUCKET + HOSE CAPACITIES


CURB STOPS
STONE DIAPHRAGM
OPTIONAL GRAVEL
CURTAIN DRAIN
PLANTING
SOIL
OPTIONAL SAND
FILTER LAYER
6" TO 12" PONDING
2" TO 3" MULCH
2.5' TO 4'
PLANTING SOIL
PERFORATED PIPE
IN GRAVEL JACKET
HDPE PERFORATED PIPES ADS N-12
PROTECTIVE LAYER
OF FILTER FABRIC
PROPLEX CLASS C
GEOTEXTILE
FILTER FABRIC - PROPLEX CLASS C
HDPE PERFORATED PIPE - ADS N-12

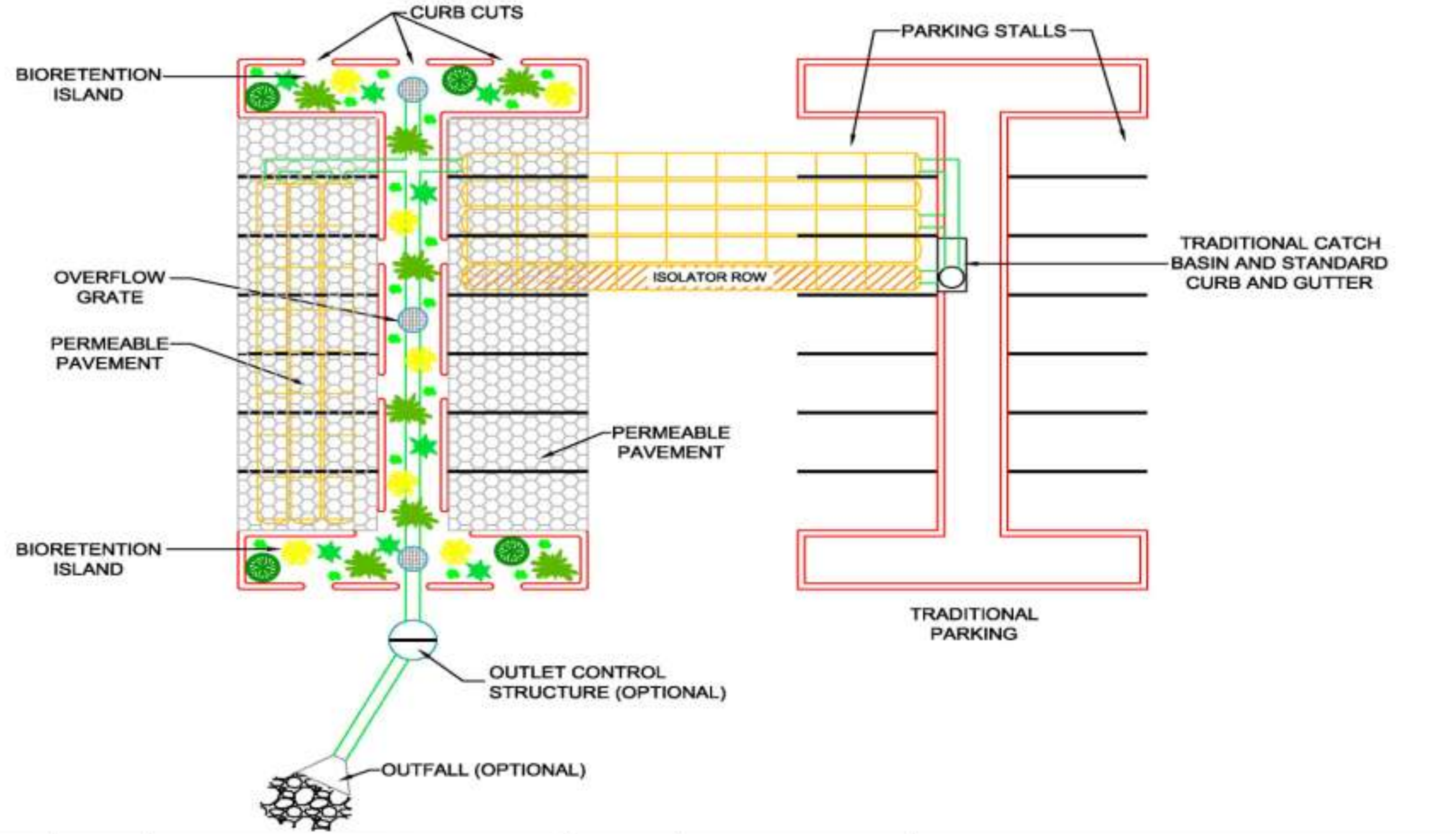
PROFILE



WOVEN GEOTEXTILE FOR SCOUR PROTECTION PROPLEX CLASS C GEOTEXTILE
FLOW
OPTIONAL UNDERDRAIN ADS N-12
ENHANCED STORAGE WITH STORMTECH CHAMBERS IN GRAVEL JACKET
A
FLOW
PLANTING MEDIA
PROTECTIVE LAYER OF FILTER FABRIC PROPLEX CLASS C GEOTEXTILE
ENHANCED STORAGE WITH STORMTECH CHAMBERS IN GRAVEL JACKET
FLOW
MULCH LAYER
CURB CUT
NYLOPLAST BASIN WITH FLEXSTORM INSERT
FLOW
PEA GRAVEL SLOPES
A
FLOW
PROTECTIVE LAYER OF FILTER FABRIC PROPLEX CLASS C GEOTEXTILE
PLANTING MEDIA
MULCH LAYER



APPROVED PLAN CHANNEL WIDTH
2' - 8' w
SHOULDER (VARIES)
ROADWAY (VARIES)
SIDEWALK
PERMEABLE ASPHALT PAVEMENT (OPTIONAL)
SLOPE 2:1 OR FLATTER
MAX. POND 12"
PEA GRAVEL DIAPHRAM
2' - 4' PLANTING MEDIA (MIN. 2 ft THICK)
4" BRIDGING LAYER
OPTIONAL UNDERDRAIN
ENHANCED STORAGE WITH STORMWATER CHAMBER



DATE	DRAWN	CHECKED	DESCRIPTION

STORMTECH PLAN DISCLAIMER
THIS PLAN WAS PRODUCED TO DEMONSTRATE A CHAMBER BED LAYOUT THAT PROVIDES THE VOLUME LISTED ON THE PLAN. IT IS THE RESPONSIBILITY OF THE CONSULTING ENGINEER TO ENSURE THAT THE CHAMBER BED LAYOUT MEETS ALL DESIGN REQUIREMENTS AND IS IN COMPLIANCE WITH APPLICABLE LAWS AND REGULATIONS GOVERNING THIS PROJECT. THE CONSULTING ENGINEER IS RESPONSIBLE FOR ALL DESIGN DESCISIONS. **STORMTECH CHAMBER SYSTEMS MUST BE DESIGNED AND INSTALLED IN ACCORDANCE WITH THE STORMTECH DESIGN MANUAL AND STORMTECH INSTALLATION INSTRUCTIONS.**

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Subsurface Stormwater Management
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WETHERSFIELD, CT 06109
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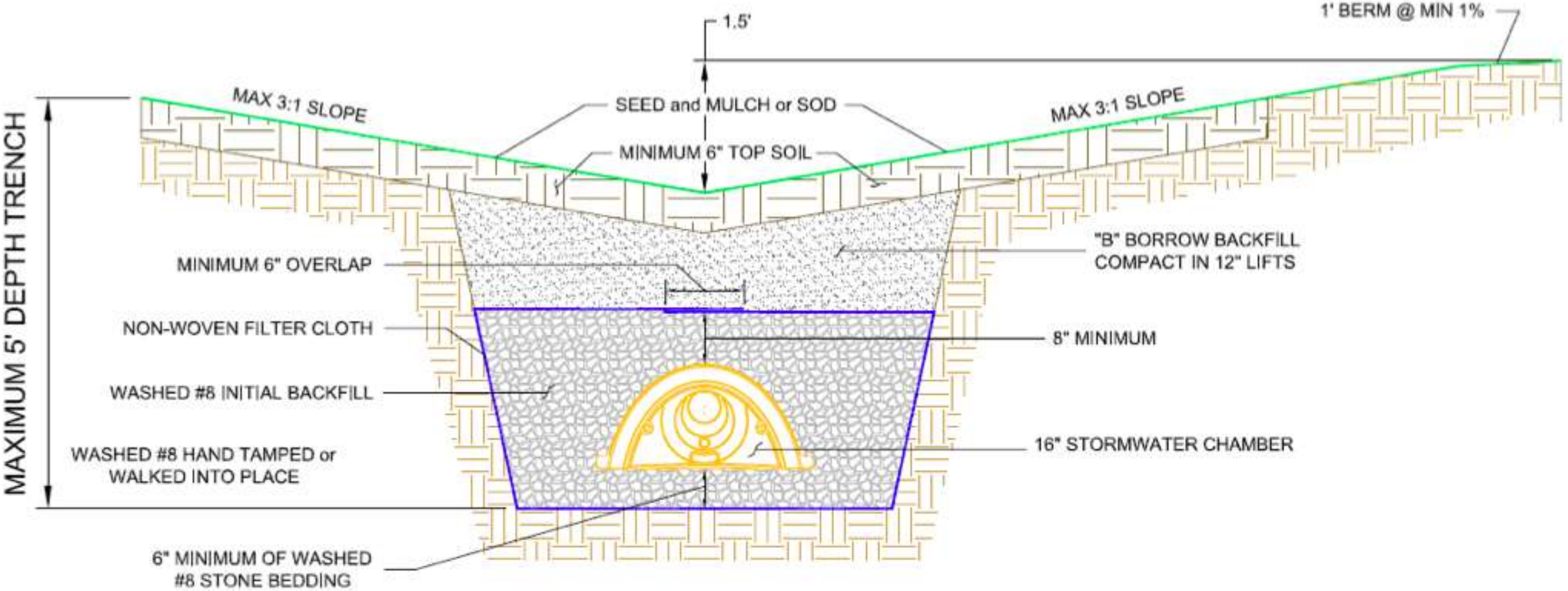
WWW.STORMTECH.COM

STORMTECH AND GREEN INFRASTRUCTURE

DATE:	1-8-10	PROJECT:	
DRAWN:	KAM	SCALE:	NTS
CHECKED:		PAGE:	OF



1.5'
1' BERM @ MIN 1%
MAX 3:1 SLOPE
SEED and MULCH or SOD
MAX 3:1 SLOPE
MINIMUM 6" TOP SOIL
MAXIMUM 5' DEPTH TRENCH
"B" BORROW BACKFILL
COMPACT IN 12" LIFTS
MINIMUM 6" OVERLAP
NON-WOVEN FILTER CLOTH
8" MINIMUM
WASHED #8 INITIAL BACKFILL
16" STORMWATER CHAMBER
WASHED #8 HAND TAMPED or
WALKED INTO PLACE
6" MINIMUM OF WASHED
#8 STONE BEDDING

NOT TO SCALE

GI CONCERNS

STORM SIZING

- WQv: size for the capture and treatment of 90% of average stormwater runoff volume
- Alternative method: design to prevent discharge of the precipitation from all rainfall events less than or equal to the 95th percentile, computed by a continuous simulation model
  - Arbitrarily disqualify large events
  - Arbitrary break at midnight for daily rain data
  - Inter-event dry periods should be modeled

SOILS

- Parcels with best infiltration rates may be developed first.
- These are typically areas of vast natural recharge. They will be redesigned to mimic predev conditions.

PLANT MAINTENANCE

- Select lower growing species that stay upright.
- Keep plants pruned if they start to get leggy and floppy.
- Cut off flower heads after plant is done blooming.
- Keeping the garden weeded is one of the most important tasks, especially in the first couple of years while the native plants are establishing their root systems.
- Invasive species protection.
- Remove sedimentation.
- Remove top few inches of planting soil when water ponds for more than 48 hours.
- Maintain elevations. Settlement and low spots must be repaired

PLANTS' ROLE

- Root uptake of water, nutrient and contaminant loading.
- Roots create conduits for water movement greater than media porosity.
- Roots stabilize the rain garden.
- Look pretty. Community aesthetic benefit.
- Effect by invasive species?

POROUS MAINTENANCE

Back mounted. Best during construction.

POROUS MAINTENANCE

Walk Behind

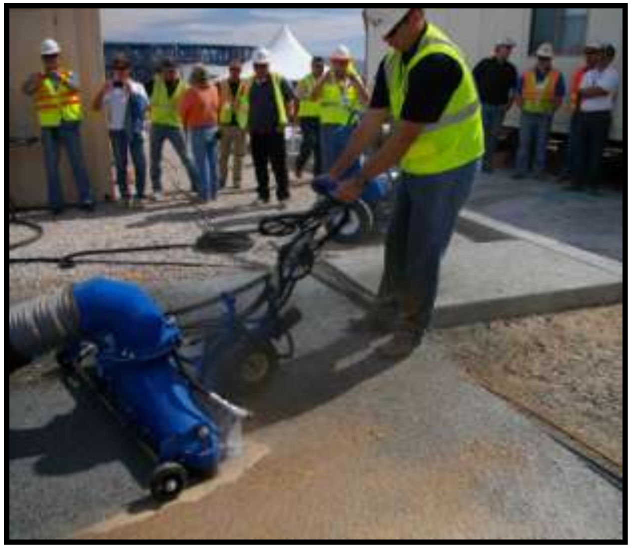
POROUS MAINTENANCE

Mechanical

Vacuum

POROUS MAINTENANCE

POROUS MAINTENANCE

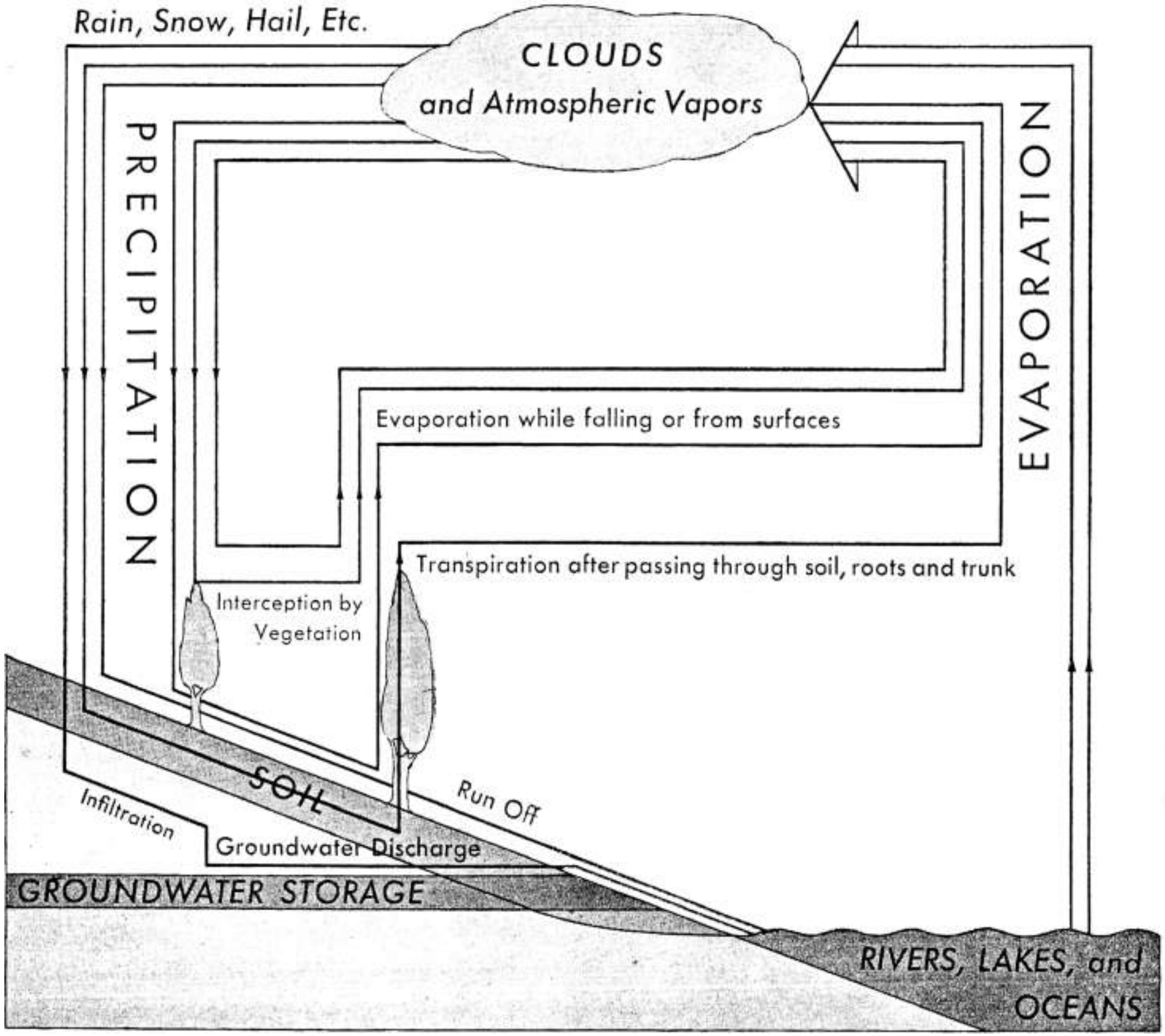


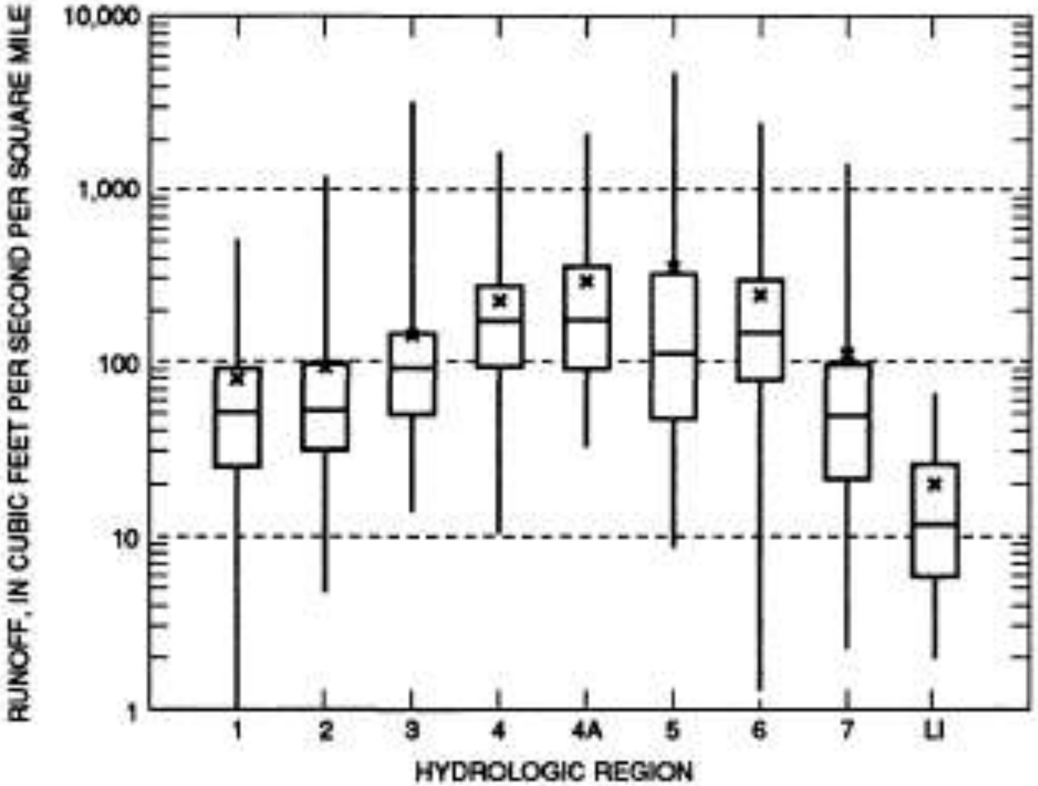
POROUS MAINTENANCE

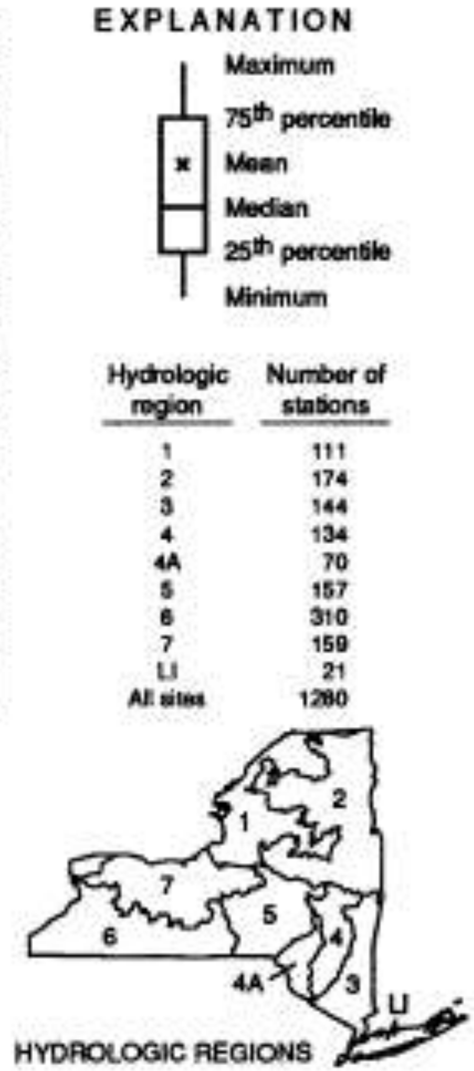
POOR MAINTENANCE

IN SUMMARY

Precipitation and the Hydrologic Cycle







Hydrologic region	Number of stations
1	111
2	174
3	144
4	134
4A	70
5	157
6	310
7	159
LI	21
All sites	1280

Figure 4.—Maximum known runoff for nine hydrologic regions of New York.


STEWART
FIRE APPARATUS
WORKS

SHOULD GI BE THE NEXT PARADIGM SHIFT?

PURPOSES CONT.

CONSCIOUS SIZING OF THEN BUCKET + HOSE, IN THE RIGHT CONTEXT

THE END

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