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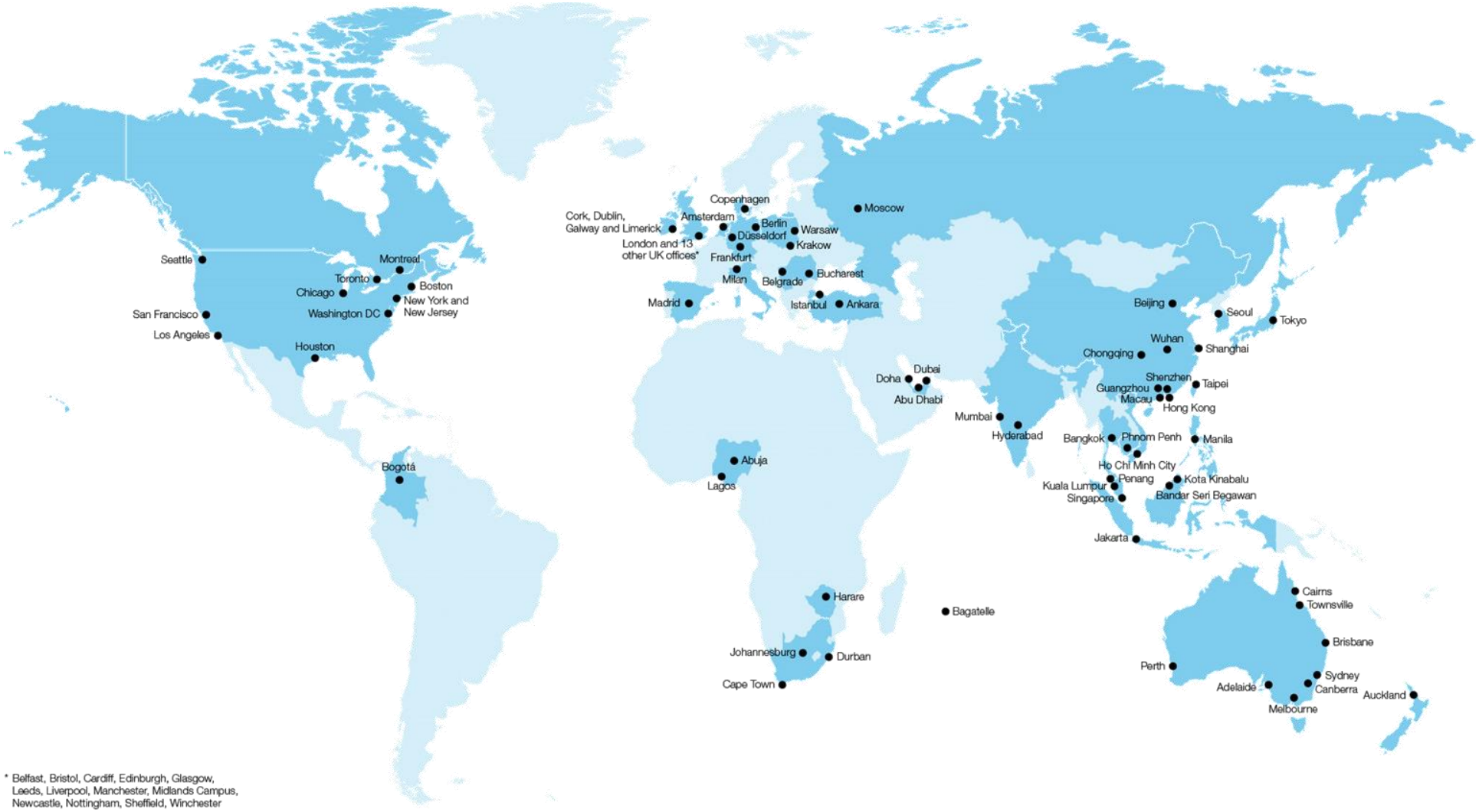
Blue/Green Infrastructure for City Resilience: A Global Overview on Implementation and Best Practices

Vincent Lee, PE LEED AP ENV SP

TRIECA Conference | March 20, 2019

ARUP

We are truly global. From some 90 offices worldwide more than 15,000 planners, designers, engineers and consultants deliver innovative projects around the globe.



* Belfast, Bristol, Cardiff, Edinburgh, Glasgow, Leeds, Liverpool, Manchester, Midlands Campus, Newcastle, Nottingham, Sheffield, Winchester

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climate adaptation

is your city prepared for the impacts of climate change?

water

economic

© Graeme Burton, Sara Burton, Peel

In 2013, the Rockefeller Foundation pledged US$100M to enable at least 100 cities around the world to hire resilience officers to improve response to climate change and other shocks. —Philanthropy News Digest, *Thirteen New Commitments Announced at 2013 Clinton Global Initiative Meeting* (2013)

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flood risk

what if a 100-year storm happened yearly?

water

environmental

© Global Water Partnership

2013 saw the highest recorded number of billion-dollar weather disasters in history. Out of the 261 weather-related disasters that year, 41 caused at least $1bn in damage, with flooding causing a large portion of the losses. —Brian Kahn, *Record Number of Billion-Dollar Disasters Globally in 2013*, Climate Central (2014)

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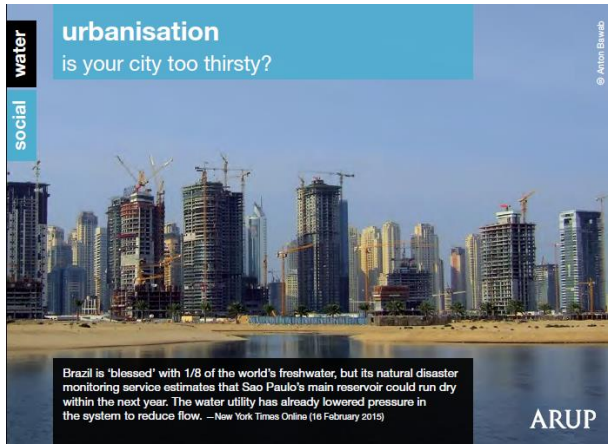
urbanisation

is your city too thirsty?

water

social



© Anton Baweb

Brazil is 'blessed' with 1/8 of the world's freshwater, but its natural disaster monitoring service estimates that Sao Paulo's main reservoir could run dry within the next year. The water utility has already lowered pressure in the system to reduce flow. —New York Times Online (16 February 2015)

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ecosystem services

how much is your local ecosystem worth?

water

economic

© U.S. Fish and Wildlife Service Northeast Region

A study on The Economics of Ecosystems and Biodiversity (TEEB) in Southeast Asia predicted that under business-as-usual circumstances, mangrove losses would account for roughly US$2.2bn in foregone annual benefits by 2050. —UNEP et al (12 October 2013).

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ecosystem pollution

are you poisoning your own well?

water

environmental

© Gustavo Veríssimo

According to research by the United Nations Environment Program (UNEP), every year, lakes, rivers, and deltas take in pollution that is equivalent to the weight of the entire human population — nearly 7bn people. —UNEP, Clearing The Waters Report (2010)

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ageing infrastructure

how old are the water pipes in your city?

water

economic

© Jo Dorgan

If the 10tn litres of treated water that leaks from US infrastructure each year ended up in New York City, a 298-foot deep flood would engulf Manhattan. —Center for Neighborhood Technology, The Case for Fixing Leaks Report (2013)

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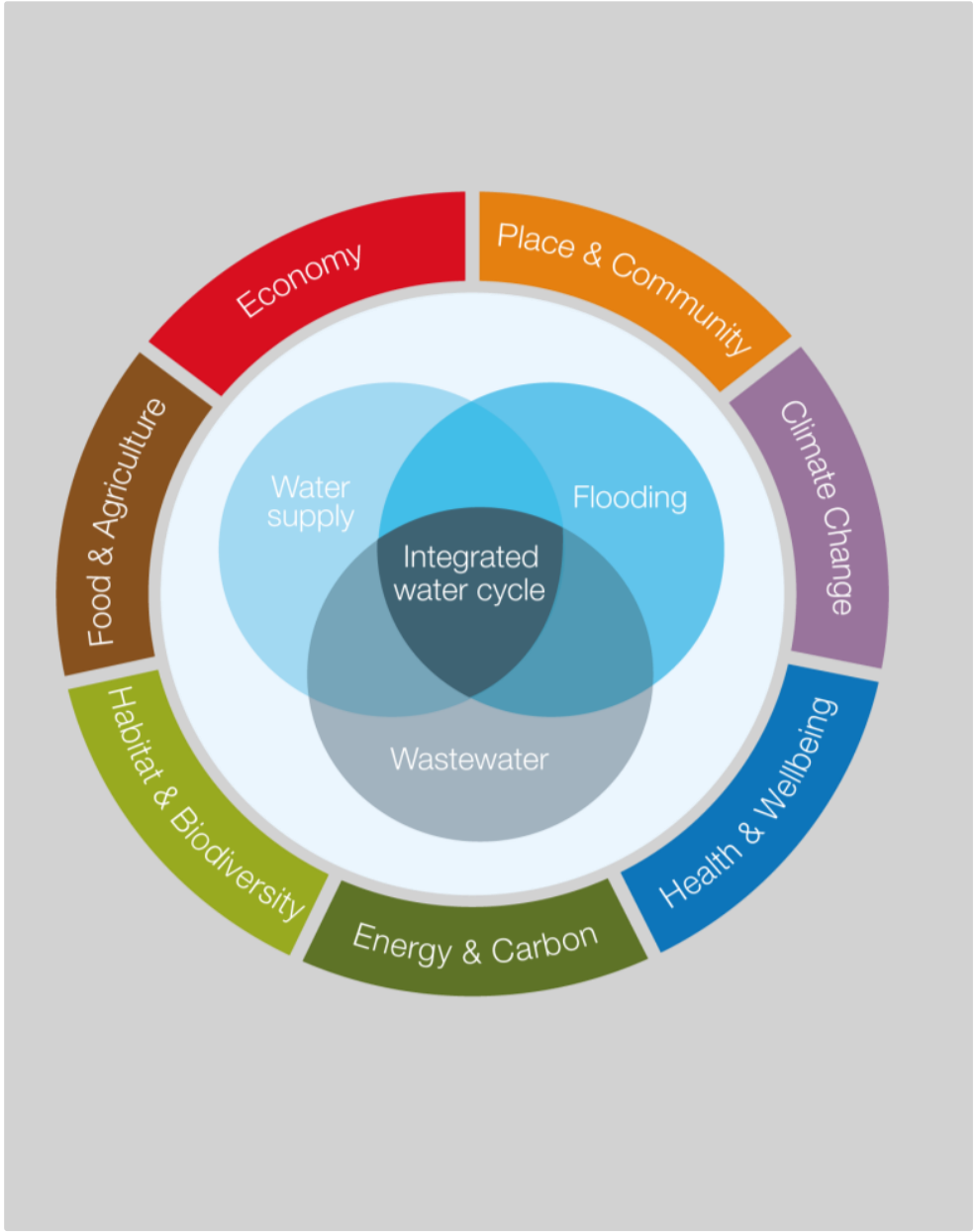

What is Design with Water?

- Innovative Framework across the water cycle that can be applied to masterplanning and design of cities, neighborhoods and buildings
- Placing water at the center of the urban design process
- Concept for water resilience using green and blue thinking
- Through an assessment, water strategies are assessed against multiple secondary benefits

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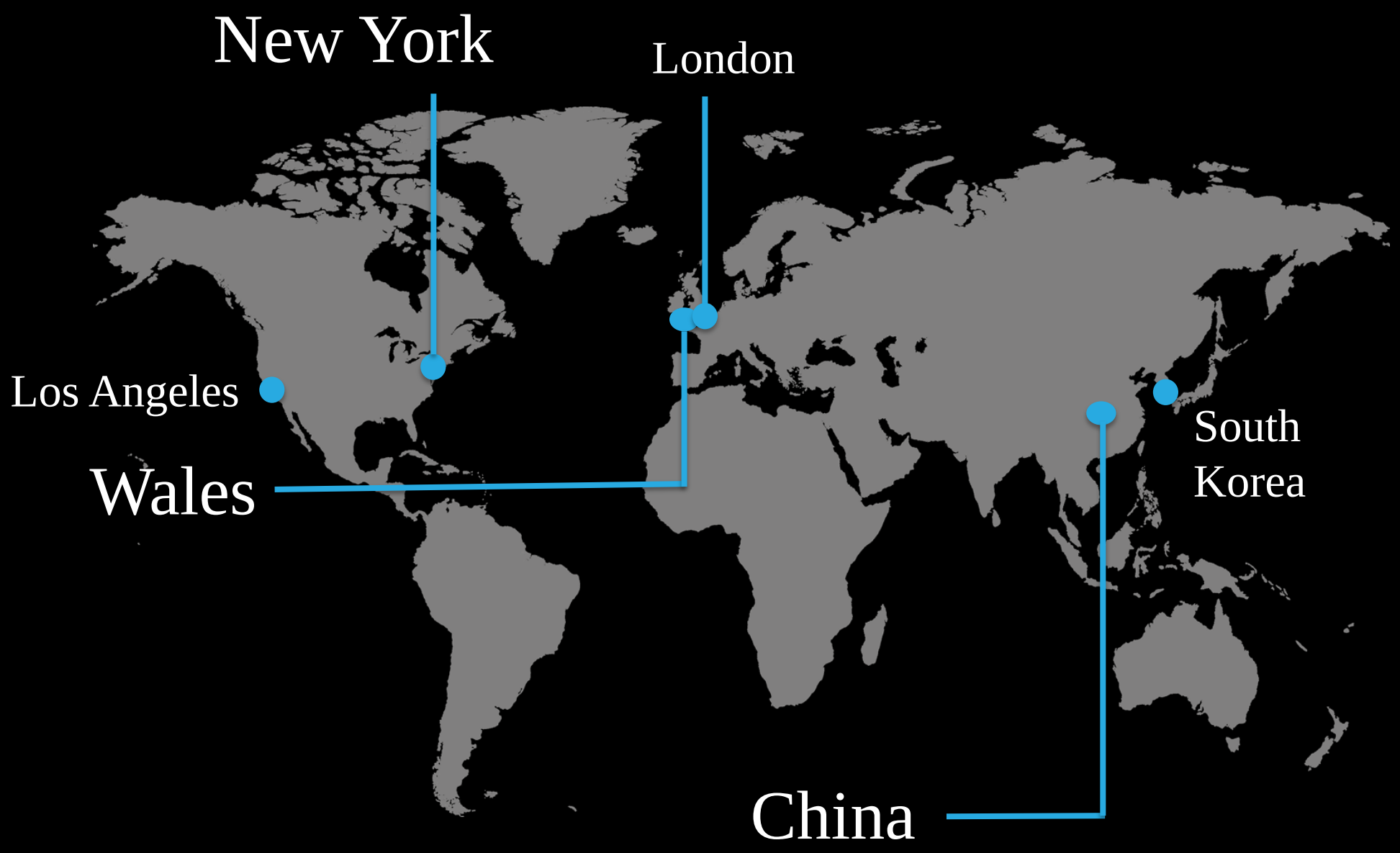
New York
London
Los Angeles
Wales
South Korea
China

China

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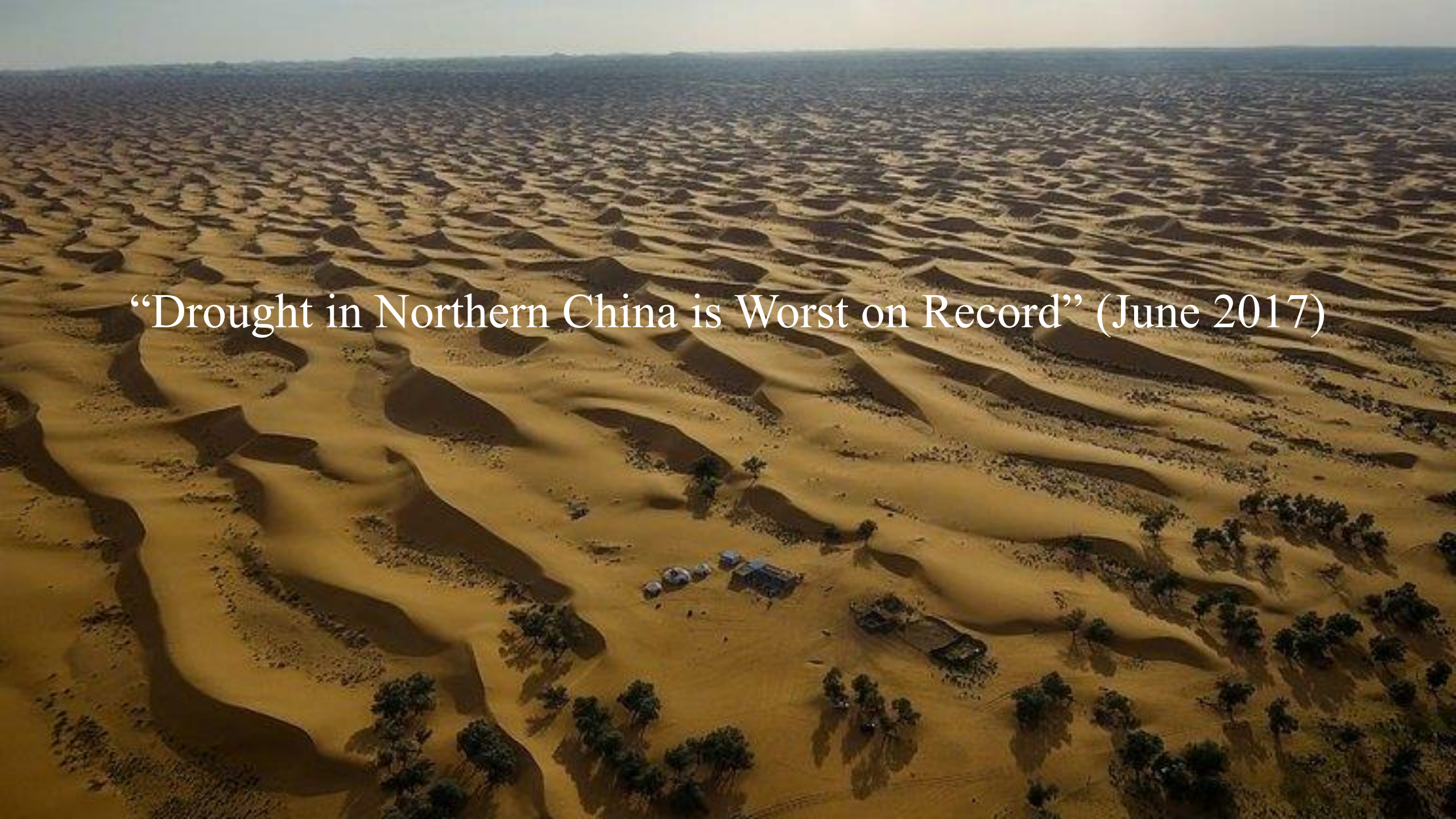
- Last summer, 241 rivers in 24 provinces had flooded, causing direct economic losses of 25.9 billion yuan ($3.87 billion)


“Drought in Northern China is Worst on Record” (June 2017)

Flooding in China

- Record breaking with maximum 460mm rainfall fell on 21 July 2012
- Some 57,000 people evacuated, more than 1.6M people affected
- Killed 79 people
- Damaged 8,200 homes
- 10B RMB economic loss ($1.45 billion)

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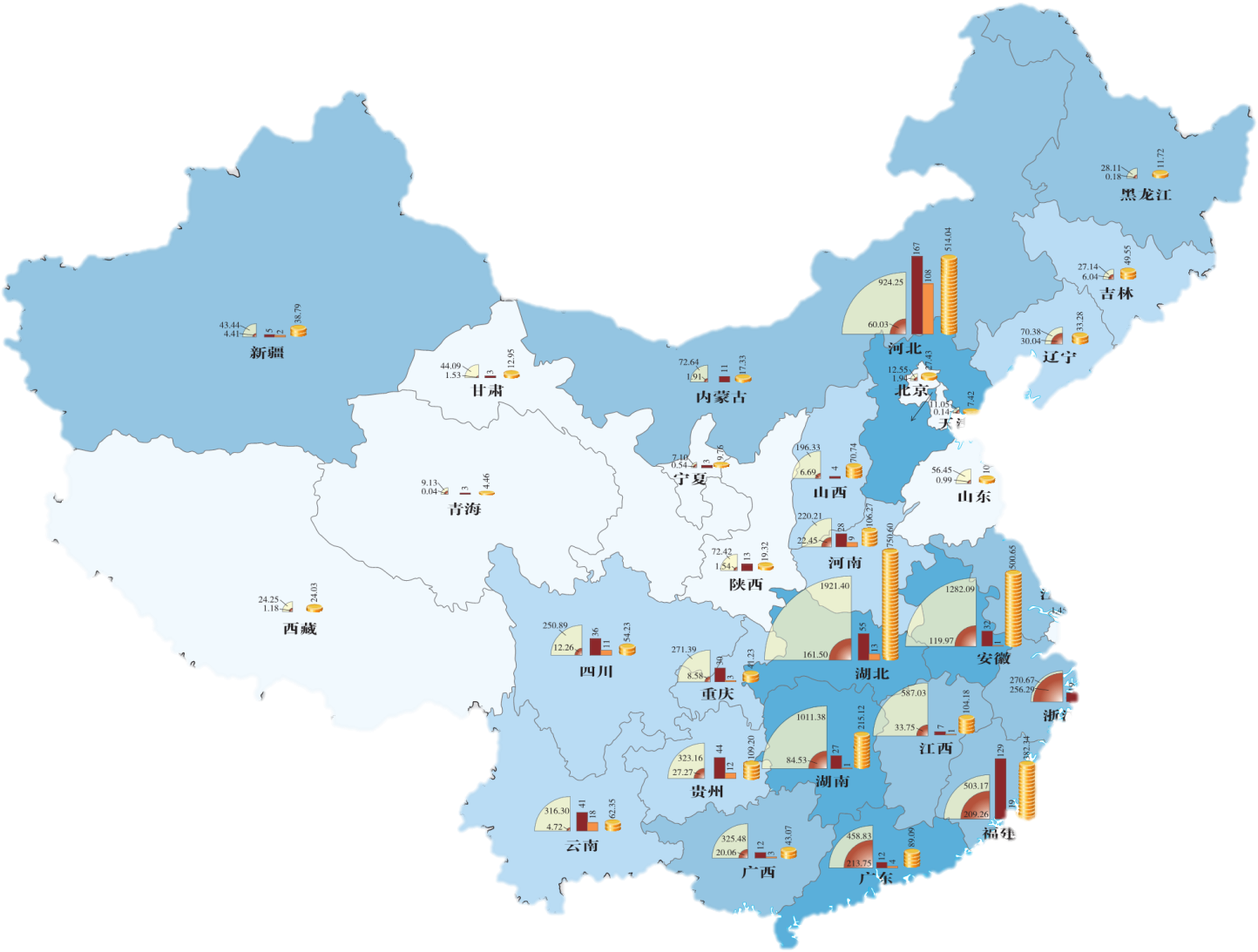
Flooding in China

For example in Hebei Province:

- Economic Loss: 51.4B RMB ($7.5bn)
- Affected Population: 9.2M
- Death:167
- Missing Persons:108



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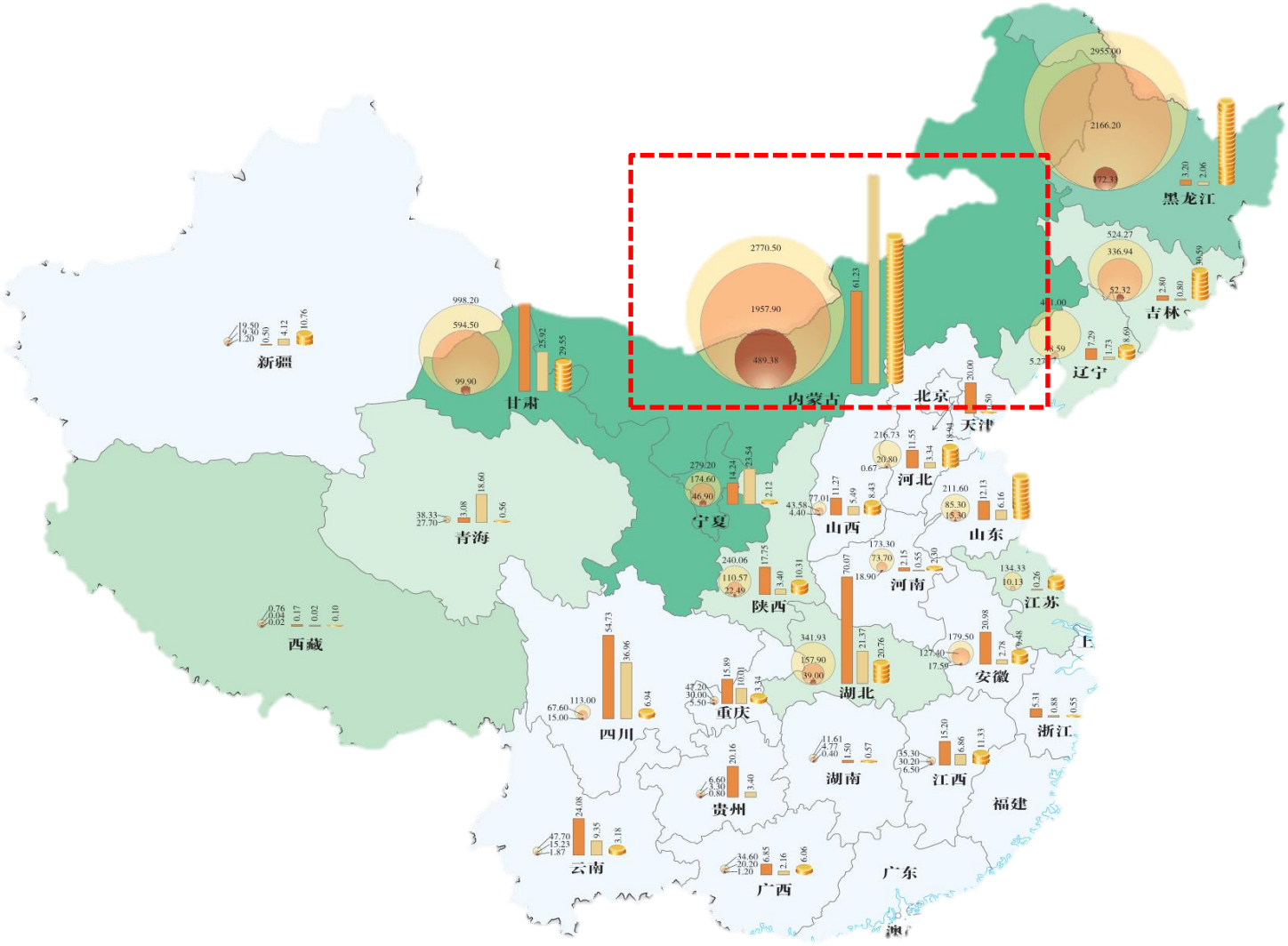
Drought in China

For example in Inner Mongolia:

- Economic Loss: 15.0B RMB ($2.2bn)
- Affected Population: 612,300
- Livestock Affected: 4.5M
- Corps Affected Area: 2.8M ha



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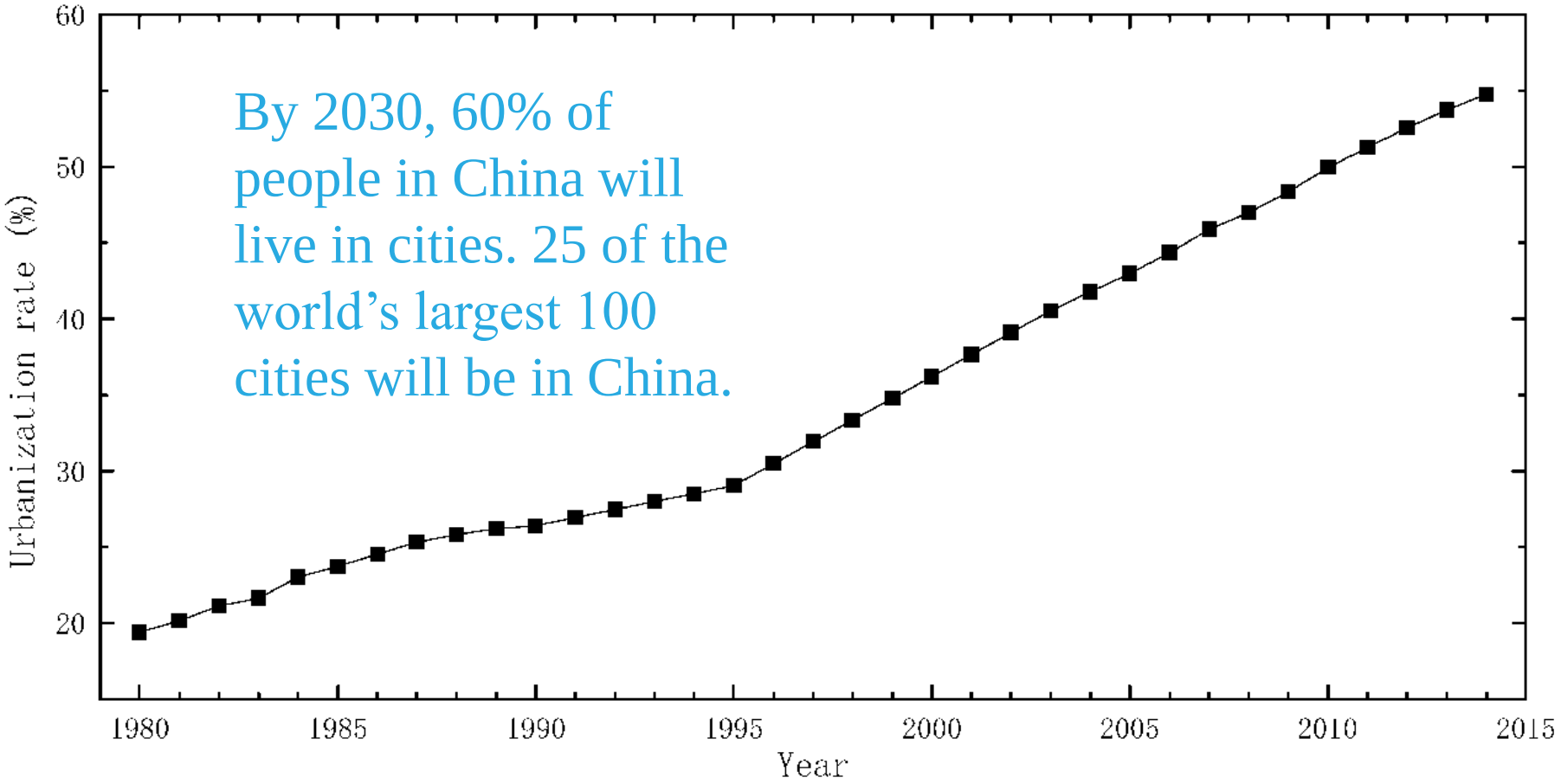
Urbanization in China



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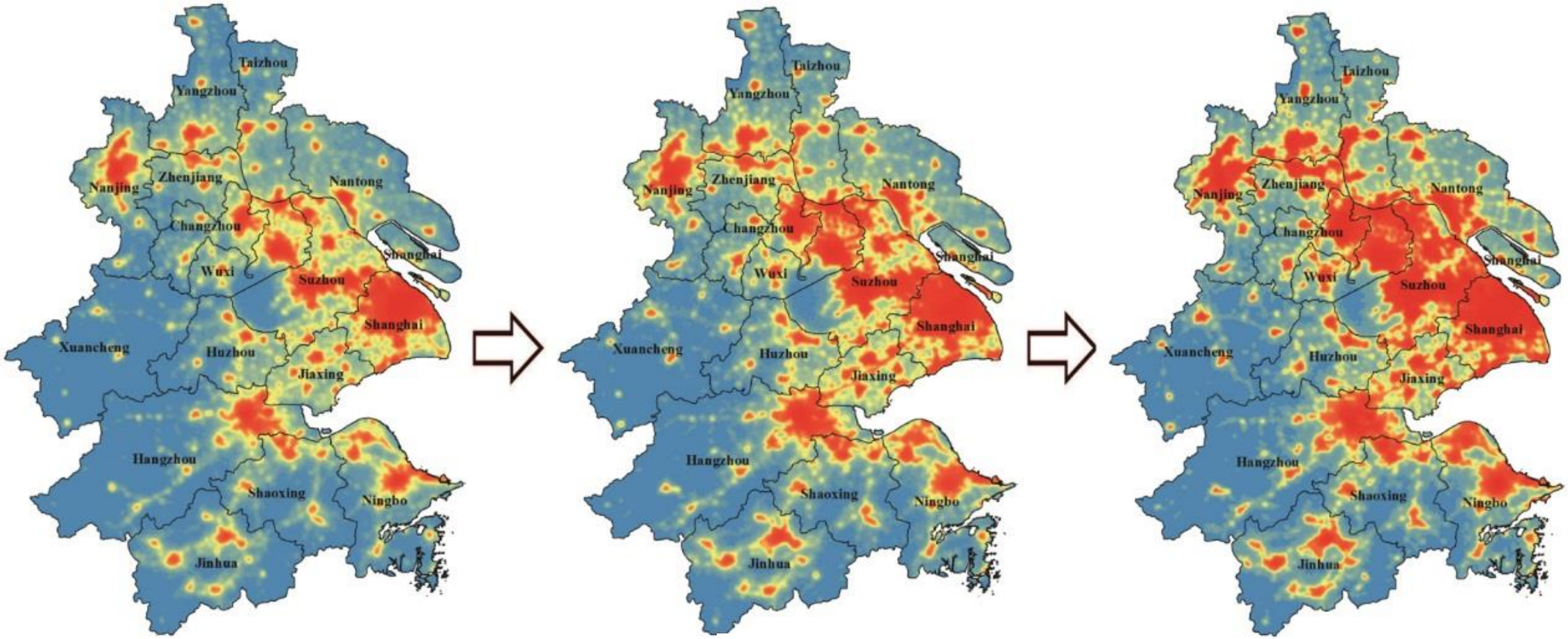

2006 2010 2014

Urbanization in the Yangtze Delta Region

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Shanghai 1997

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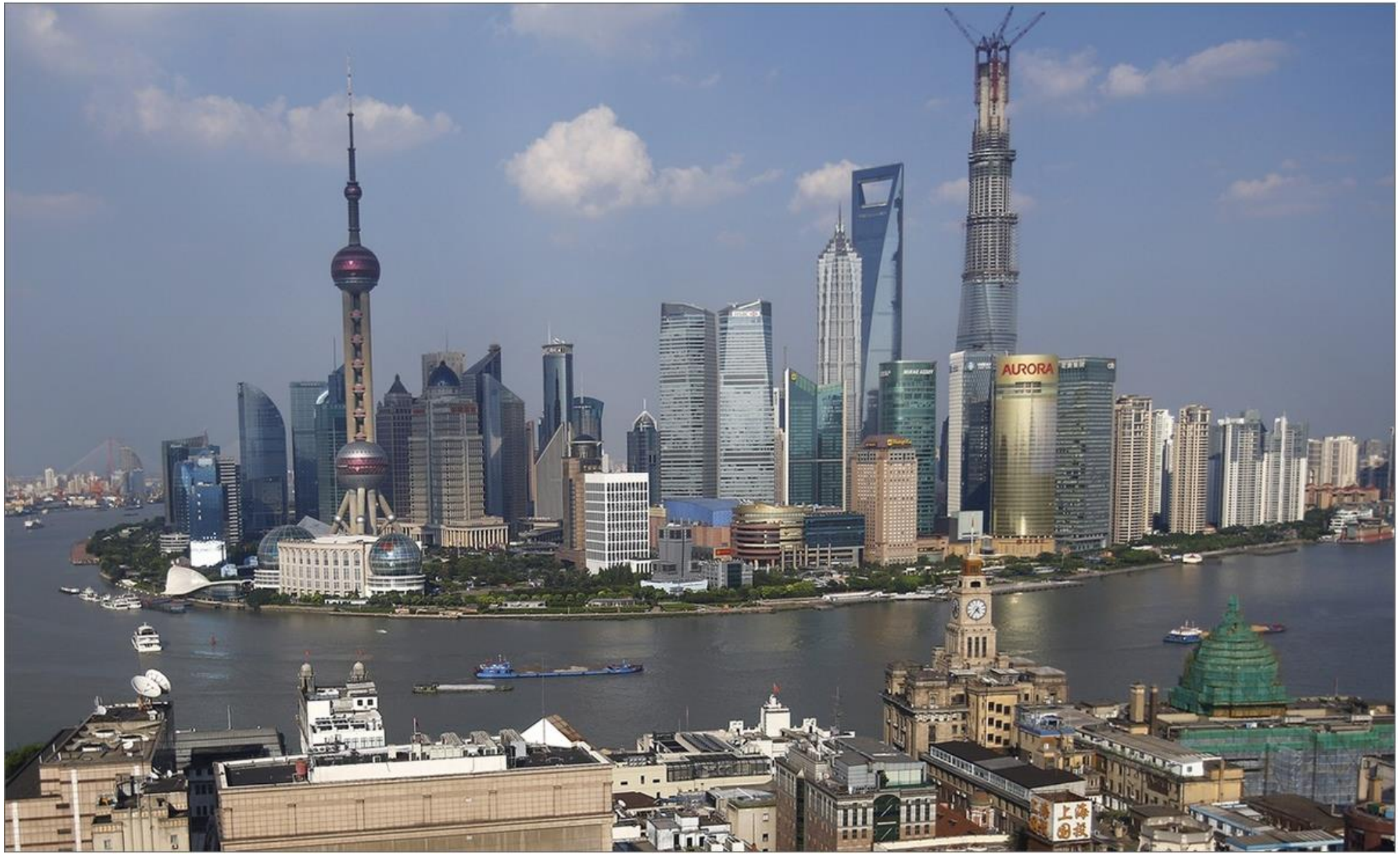

Shanghai 2013

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China’s urban population will increase by 300 million within the next decade. 75 cities with populations of 4 million are needed

…. and by over 400 million by 2035. 100 cities needed.

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“We need to develop sponge-like cities that naturally accumulate, filter and purify rainwater”

Xi Jinping, 2013

Sponge Cities Objectives

Deal with “too much water” and reuse rainfall to help with “not enough water”

Reduce economic losses due to urban flooding

Create investment opportunities in infrastructure upgrading, engineering projects and new technologies

Boost / maintain China’s GDP target growth rate

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President Xi Jinping delivered a key note speech during the China Central Government Urbanization Meeting on 12 December 2013, promoting sponge city as one of the National Major Development Strategies.

Ministry of Finance, Ministry of Housing and Urban-Rural Development and Ministry of Water Resources announced on 20 January 2015 that the Central Government will provide financial support to the "pilot sponge city" construction works.

The China State Council issued the Trial Version of "Technical Guideline for Sponge City – Establishment of Low Impact Development Drainage System on 22 October 2014.

16 cities were selected as the 1st batch pilot cities in April 2015.

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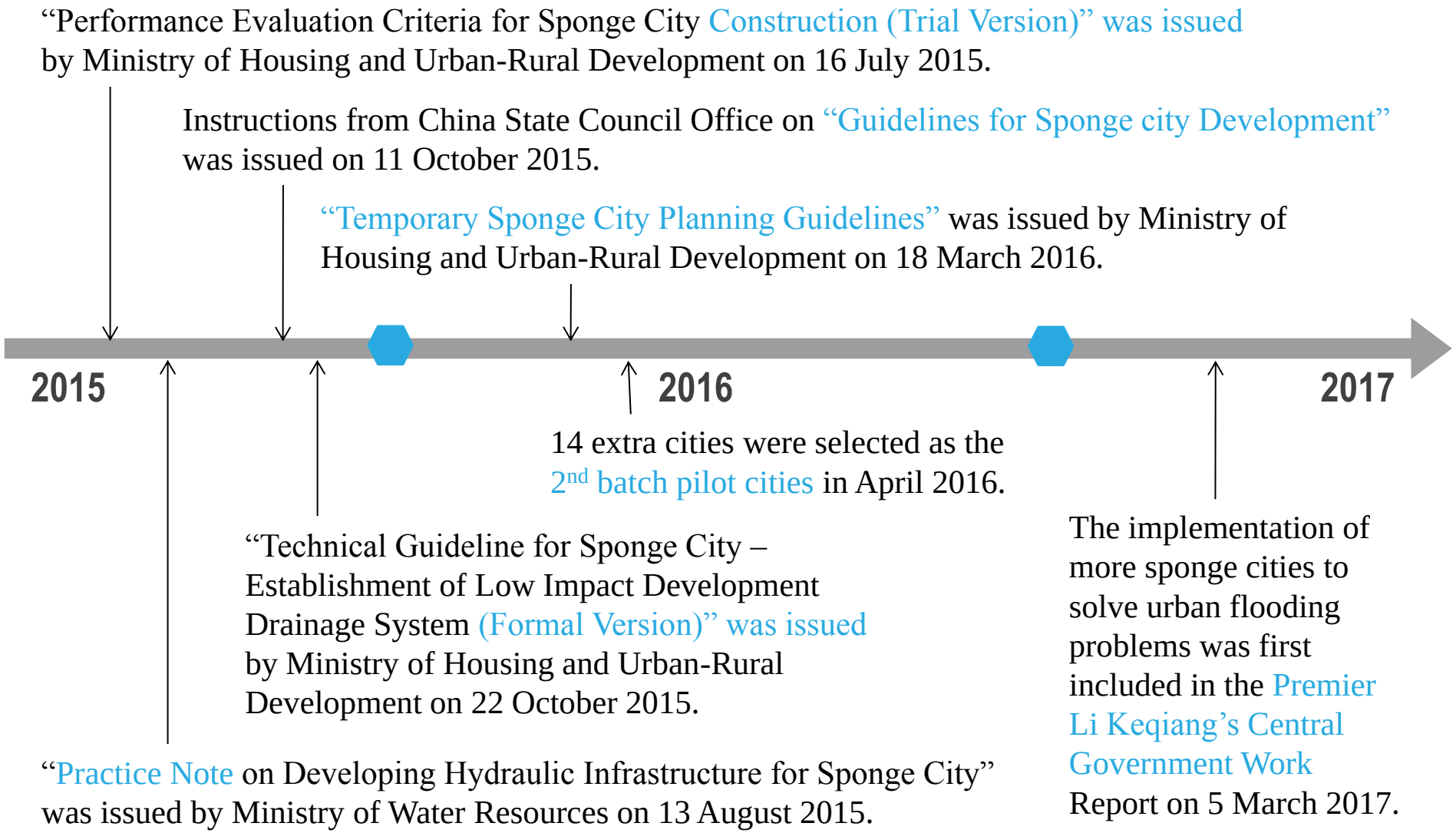
"Performance Evaluation Criteria for Sponge City Construction (Trial Version)" was issued by Ministry of Housing and Urban-Rural Development on 16 July 2015.
Instructions from China State Council Office on "Guidelines for Sponge city Development" was issued on 11 October 2015.
"Temporary Sponge City Planning Guidelines" was issued by Ministry of Housing and Urban-Rural Development on 18 March 2016.
2015
2016
2017
14 extra cities were selected as the 2nd batch pilot cities in April 2016.
"Technical Guideline for Sponge City – Establishment of Low Impact Development Drainage System (Formal Version)" was issued by Ministry of Housing and Urban-Rural Development on 22 October 2015.
The implementation of more sponge cities to solve urban flooding problems was first included in the Premier Li Keqiang's Central Government Work Report on 5 March 2017.
"Practice Note on Developing Hydraulic Infrastructure for Sponge City" was issued by Ministry of Water Resources on 13 August 2015.

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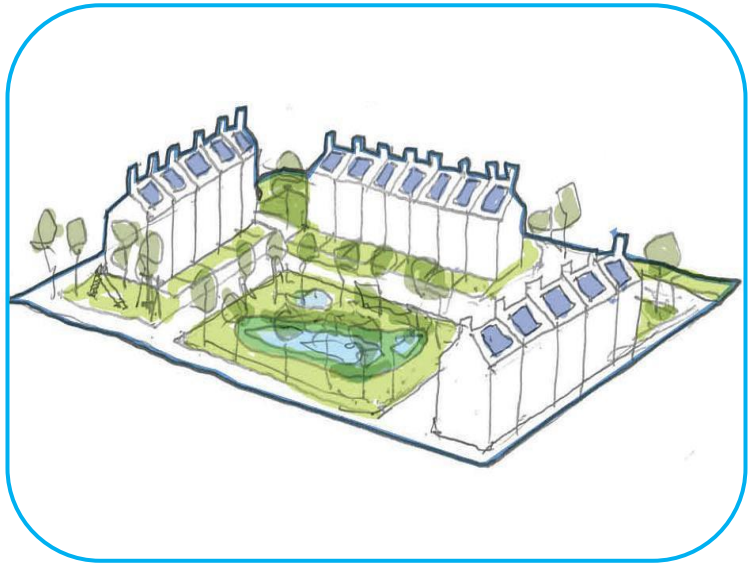
Development Target

To store, infiltrate and reuse 70% of rainwater on-site.

National Target



By 2020

20% of the urban areas will achieve the 70% storage, infiltration and reuse target

By 2030

80% of the urban areas will achieve the 70% storage, infiltration and reuse target

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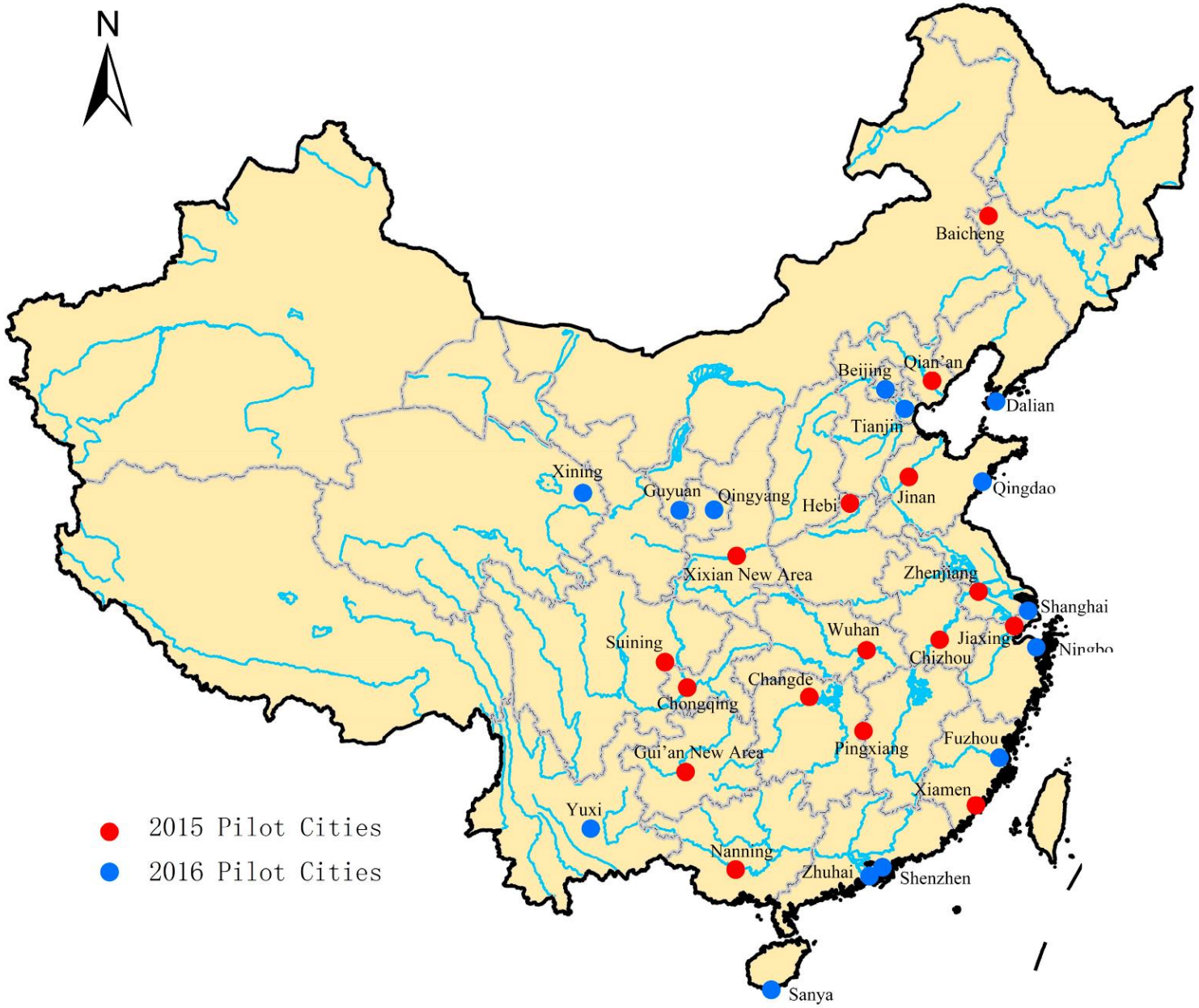
Pilot Cities

2015

16 “smaller” pilot cities (e.g. Wuhan, Xiamen & Jinan)

2016

14 “larger” pilot cities (e.g. Beijing, Tianjin, Shanghai, Shenzhen & Zhuhai)



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Sponge City | Investment on Pilot Cities

- The ambitious project is being funded by central government (15-20%), local government and the private sector.
- The central government is giving each city 400m yuan ($58M) a year for the first three years.
- The majority of funds are still expected to be raised by local municipalities. The commitment of funding from local municipalities is one of basic preconditions to apply for a sponge city project.
- In return, 20% of the chosen cities must be constructed to a sponge city standard by 2020, and 80% by 2030.

Sponge City | Investment on Pilot Cities

Investment Type

- Central Government will provide a “Special Fund” to initiate sponge city investment.
- Other private investment funding, e.g. PPP, franchise.

Investment in Pilot Sponge Cities

- Central Government will provide “Special Fund” of ~0.4 billion RMB each year to initial 16 pilot cities (depending on scale of the city).
- Total investment for the 16 pilot sponge cities (including Central Government’s Special Fund and other funding sources) are expected to reach 130 billion RMB ($18.9bn).

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Tung Chung West New Town Extension

Yuen Long South Development

Shanghai Expo

Beijing Yongding River New Ecological Cultural Zone

Baotou Inner Mongolia

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Wales, United Kingdom

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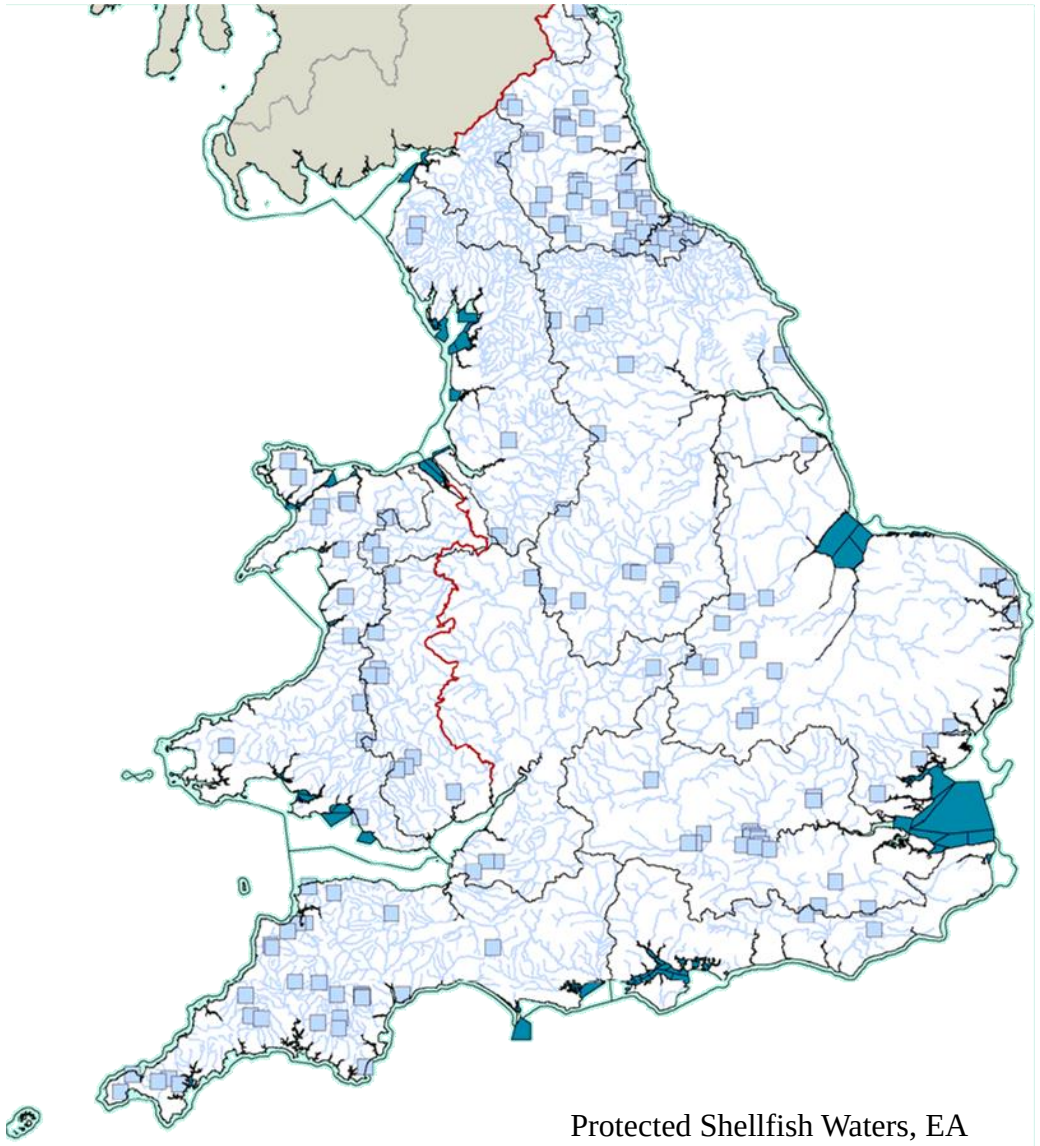
Llanelli Rainscape

- The Cambrian catchment has a population of 4,500 and is located in Llanelli, South Wales.
- The CSO discharges approximately 52 times per year into the Loughor Estuary, a designated Shellfish Water.
- The National Environment Programme (NEP) placed a requirement to significantly reduce to only 10 by March 2020.



Protected Shellfish Waters, EA

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Llanelli Rainscape

- To meet this target Dŵr Cymru Welsh Water implemented a £7.9m catchment wide surface water removal and sustainable drainage systems (SuDS) solution (£114m total).
- Arup and Morgan Sindall have delivered this work as part of Welsh Water's Capital Delivery Alliance, closely engaging Carmarthenshire County Council, Natural Resources Wales and customers. Construction began in November 2015 and completion was in 2017.

Fig 1 Cambrian North Basin before construction (February 2016)

Fig 2 Cambrian North Basin artists impression

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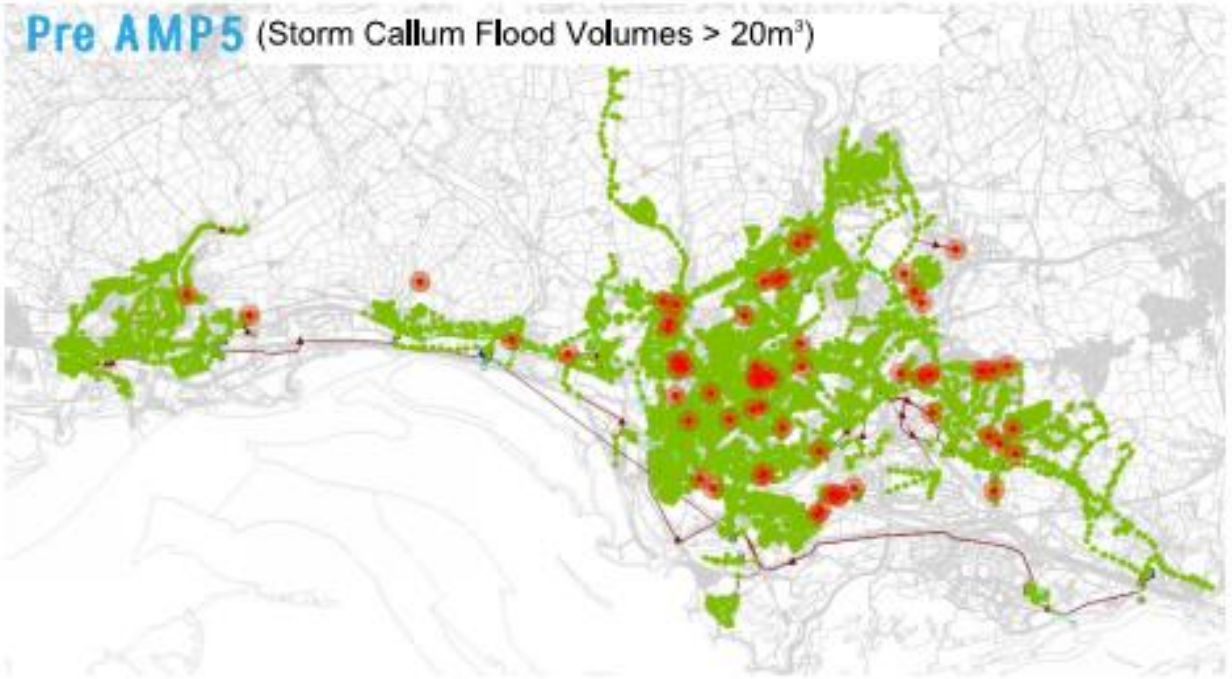
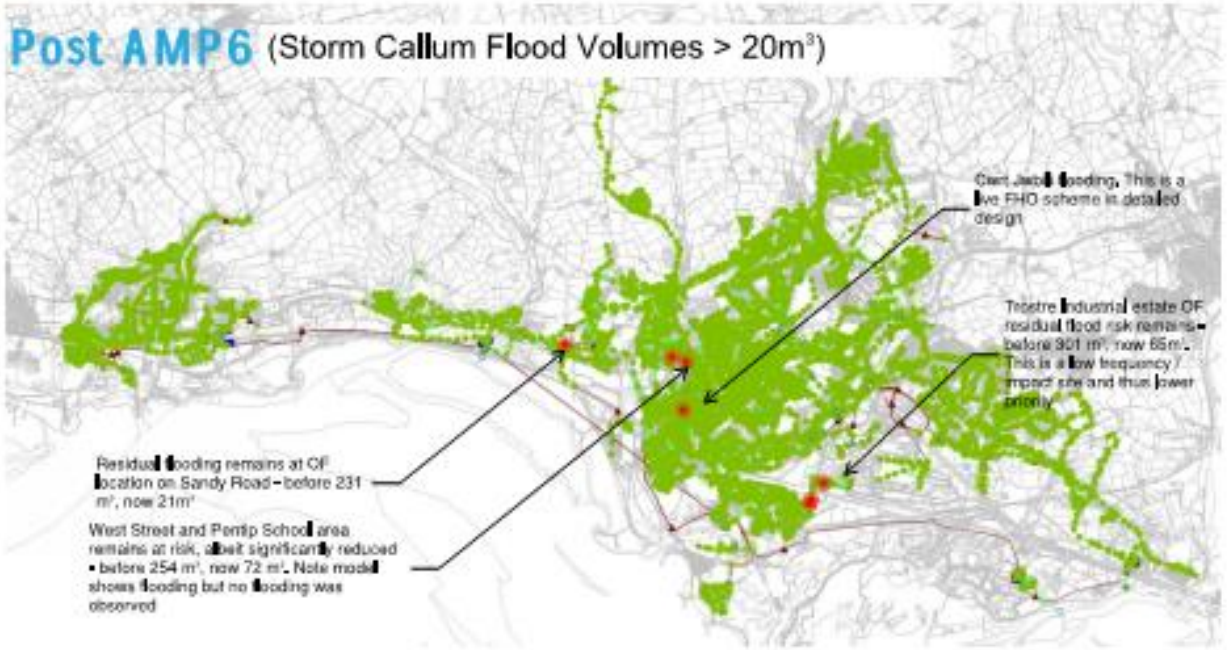

Pre AMP5 (Storm Callum Flood Volumes > 20m³)


Post AMP6 (Storm Callum Flood Volumes > 20m³)
Giant Jacob flooding. This is a live FHO scheme in detailed design
Trostre Industrial estate OF residual flood risk remains - before 301 m³, now 65m³. This is a low frequency / impact site and thus lower priority
Residual flooding remains at OF location on Sandy Road - before 231 m³, now 21m³
West Street and Penllp School area remains at risk, albeit significantly reduced - before 254 m³, now 72 m³. Note model shows flooding but no flooding was observed

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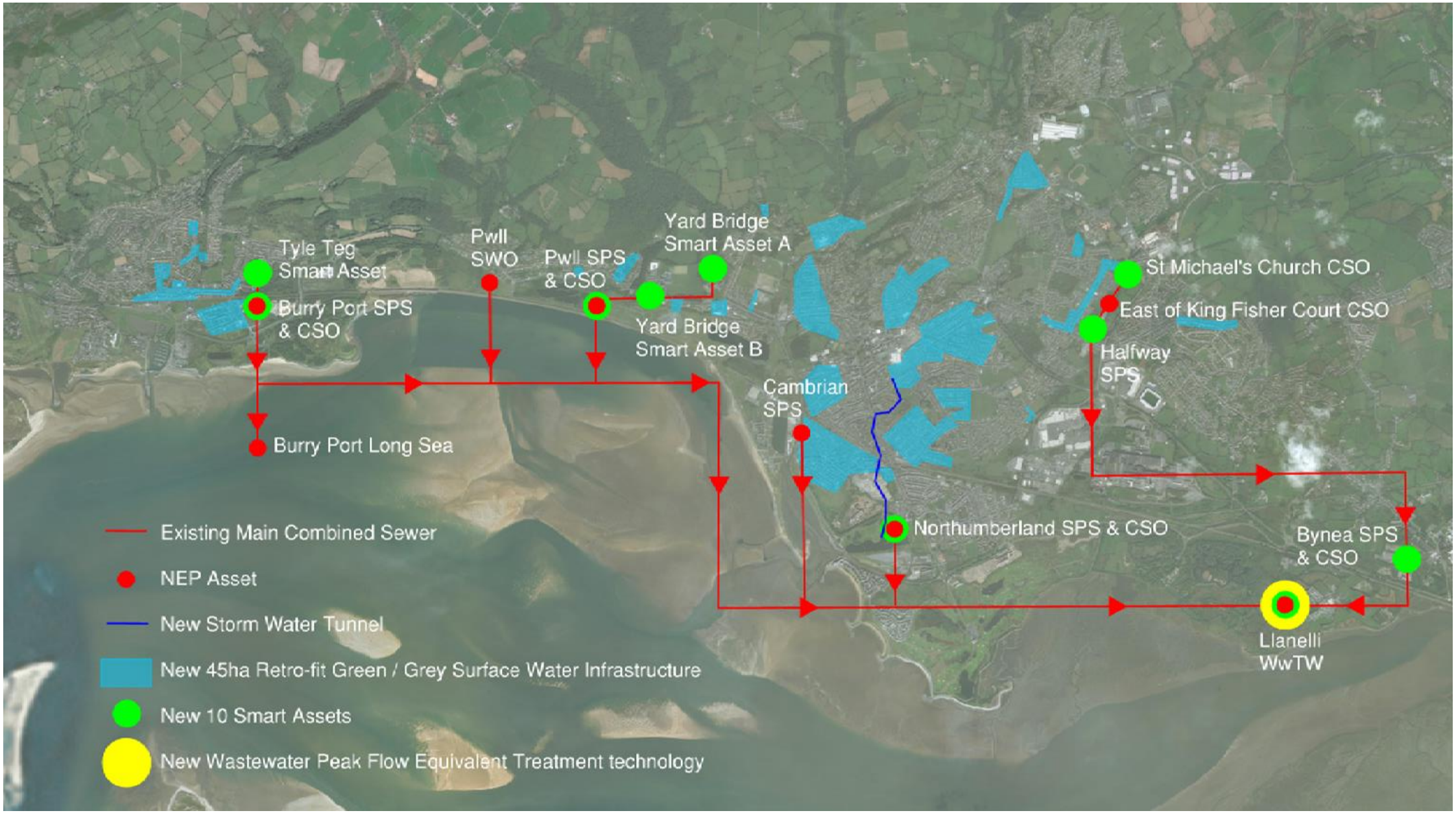
Tyle Teg
Smart Asset
Burry Port SPS
& CSO
Burry Port Long Sea
Pwll
SWO
Pwll SPS
& CSO
Yard Bridge
Smart Asset A
Yard Bridge
Smart Asset B
Cambrian
SPS
Northumberland SPS & CSO
St Michael's Church CSO
East of King Fisher Court CSO
Halfway
SPS
Bynea SPS
& CSO
Llanelli
WwTW
Existing Main Combined Sewer
NEP Asset
New Storm Water Tunnel
New 45ha Retro-fit Green / Grey Surface Water Infrastructure
New 10 Smart Assets
New Wastewater Peak Flow Equivalent Treatment technology

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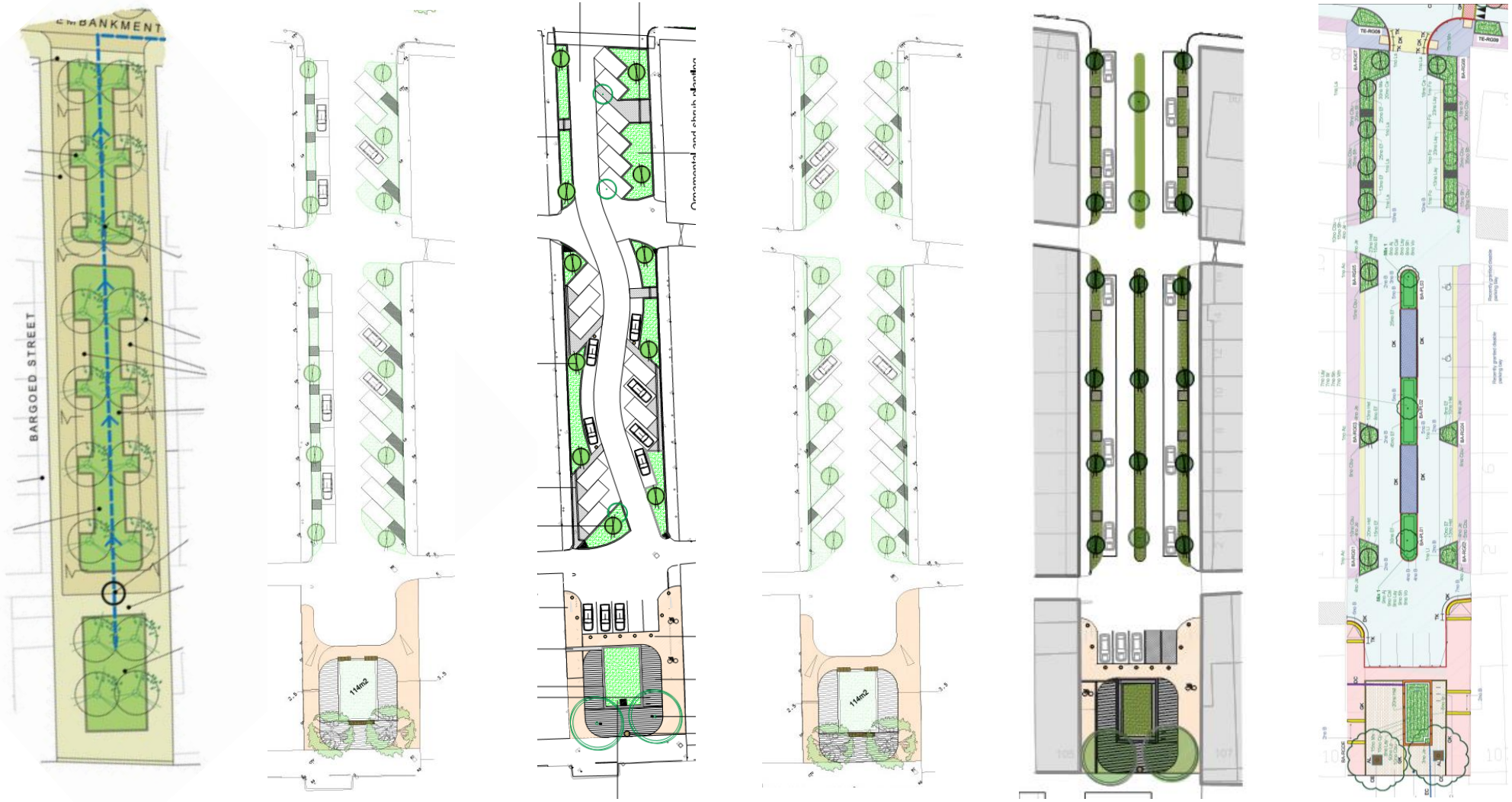
Feasibility …. Outline and optioneering…. Consultation…. Final design



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Priority over oncoming vehicles
7.5T
Except for access
Ac eithrio mynediad
Channel View Centre

ARUP


7.5t
Except for access
Ac eithrio mynediad
Ardal tawelu traffig
Traffic calmed area
7.5t
Ac eithrio mynediad
Except for access
Channel View Centre
ARUP

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Llanelli Rainscape | Wales, UK

ARUP

Llanelli Rainscape in the News

Local media printed a positive success story based around RainScape in Llanelli. The town avoided flooding during Storm Callum, unlike neighbouring areas. This was largely attributed to Welsh Water investment in the town. Extracts below from the Llanelli Star and South Wales Evening Post (17/10/2018)

'RainScape' scheme hailed as a success as town escapes worst

WITH much of west and north Carmarthenshire still clearing up in the aftermath of Storm Callum and the worse floods in three decades, Llanelli has emerged unscathed.

It is business as usual across the town with very little standing water on playing fields or streets despite being battered by Storm Callum at the weekend.

Praise for drain work as town is 'spared'

WITH much of west and north Carmarthenshire still clearing up in the aftermath of Storm Callum and the worse floods in three decades, Llanelli has emerged unscathed.

Storm 'held out' by flood scheme

Storm not a drain on town as rain scheme plays role

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New York, NY

Hunters Point South

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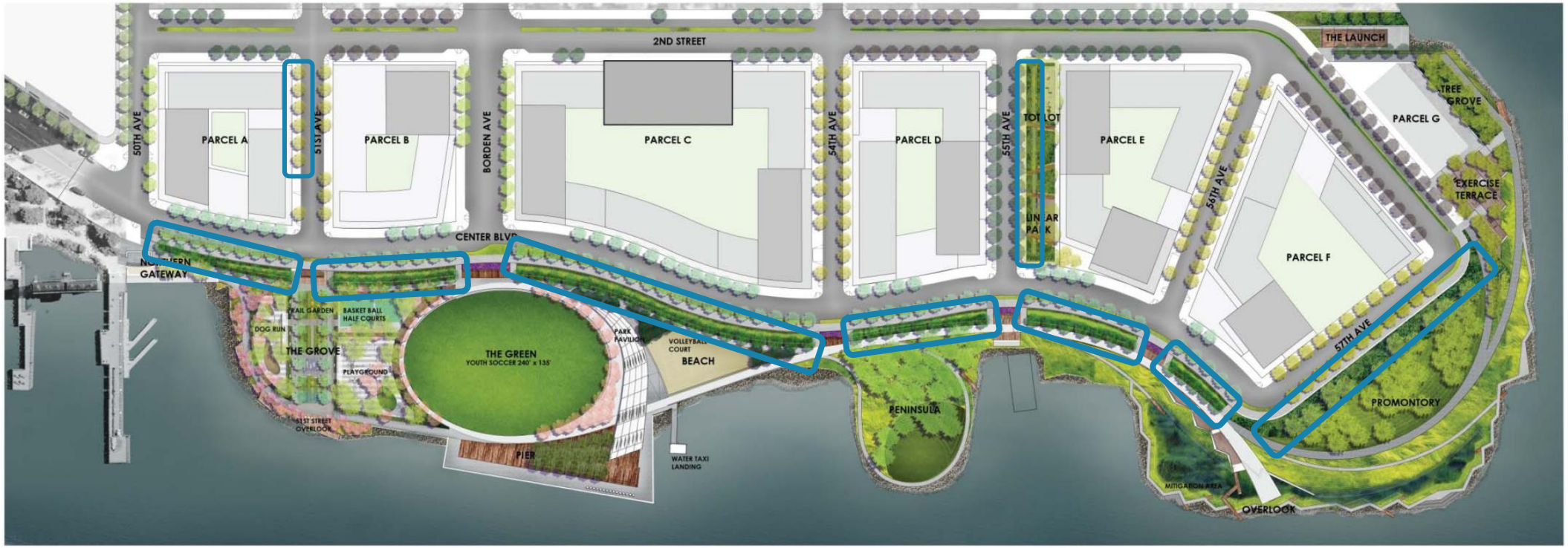
2ND STREET
THE LAUNCH
50TH AVE
51ST AVE
BORDEN AVE
54TH AVE
55TH AVE
56TH AVE
57TH AVE
PARCEL A
PARCEL B
PARCEL C
PARCEL D
PARCEL E
PARCEL F
PARCEL G
TOT LOT
TREE GROVE
EXERCISE TERRACE
CENTER BLVD
GATEWAY
TRAIL GARDEN
BASKET BALL HALF COURTS
DOG RUN
THE GROVE
PLAYGROUND
THE GREEN
YOUTH SOCCER 240' x 135'
PARK PAVILION
VOLLEYBALL COURT
BEACH
PENINSULA
PIER
WATER TAXI LANDING
PROMONTORY
MITIGATION AREA
OVERLOOK

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Green infrastructure integrated with the park

Constructed wetlands for waterfront resilience

Mobility

Green Space & Trees

Reconnecting People with Water

Vision Zero
Shared Streets
Traffic Flow
Safe Access

Public Space
Healthy Trees
Recreation
Habitat Creation

Combined Sewer Overflow
Improved Water Quality
Flood Risk
Drainage

NEW YORK CITY DOT

NYC Parks

NYC Environmental Protection

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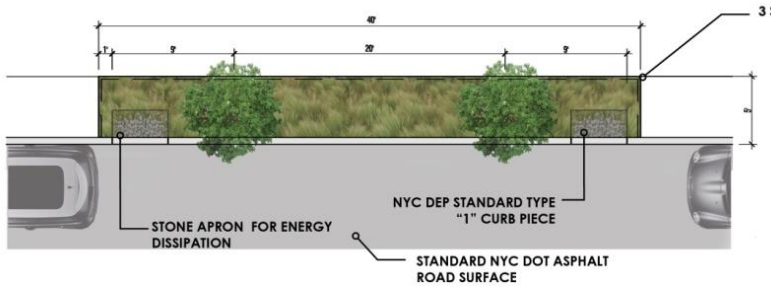
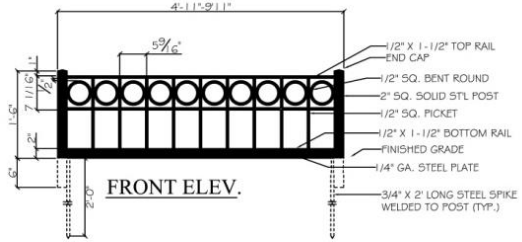


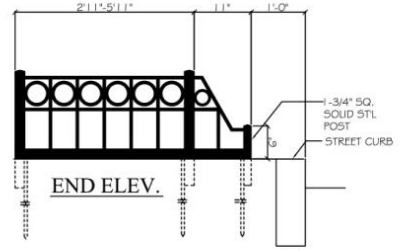
TYPICAL 51ST AVENUE STORM WATER PLANTER

NOTES:
TREE SPECIES, NYSSA SYLVATICA

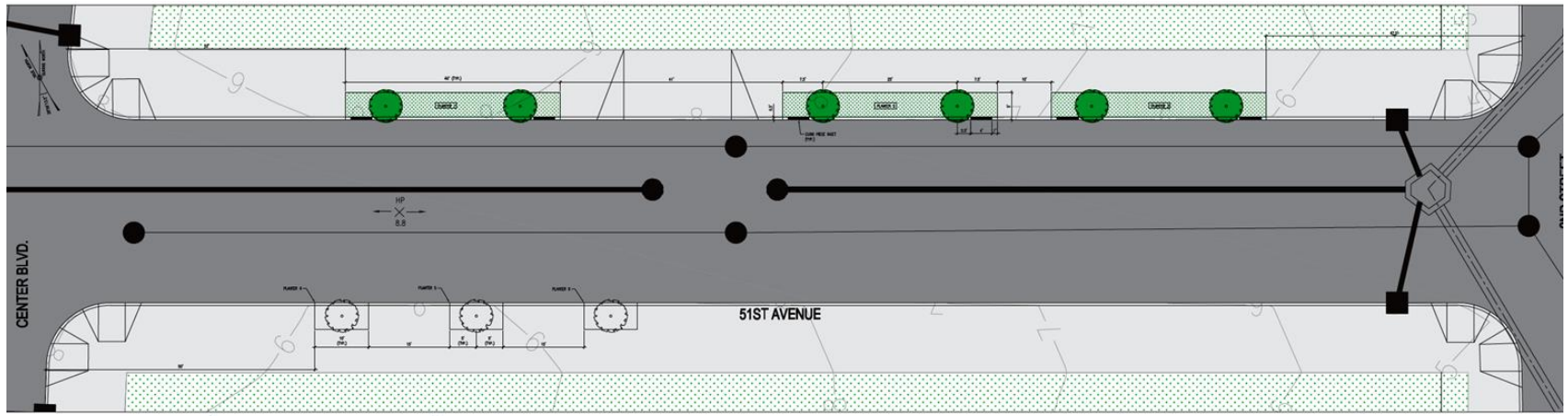
GROUNDCOVER SPECIES,
JUNCUS EFFUSSUS
EUPATORIUM MACULATUM
ELYMUS VIRGINICUS

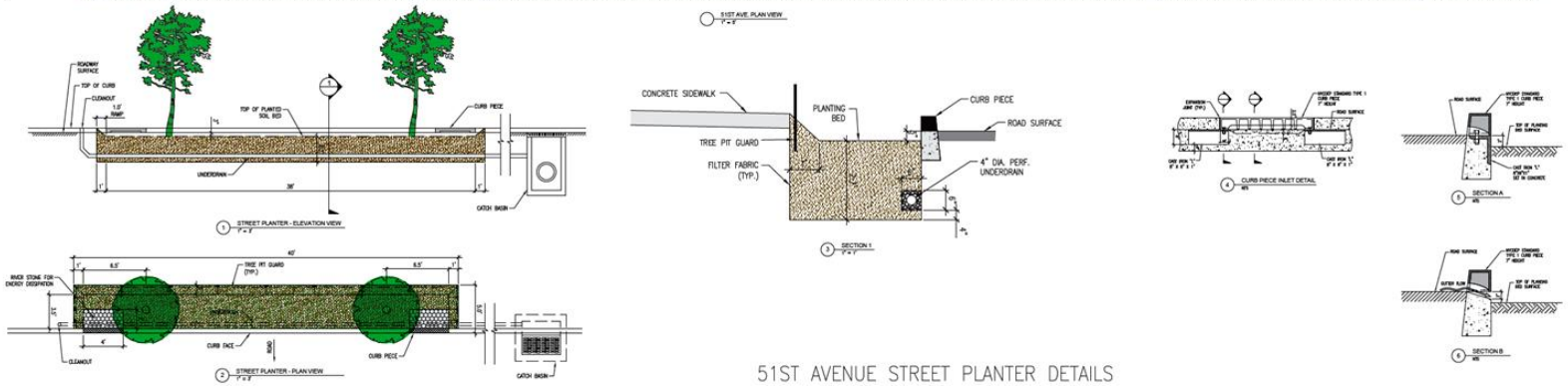


TREE PIT GUARD TYPE 'B'
SCALE: NTS
TREE PIT GUARD: STANDARD DOT DETAIL



TYPE 'B' THREE SIDED DESIGN





51ST AVENUE STREET PLANTER DETAILS

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7AM - 6PM
MON - FRI
FINES
HIGHER
STOP

New York, NY

NYC Green Infrastructure

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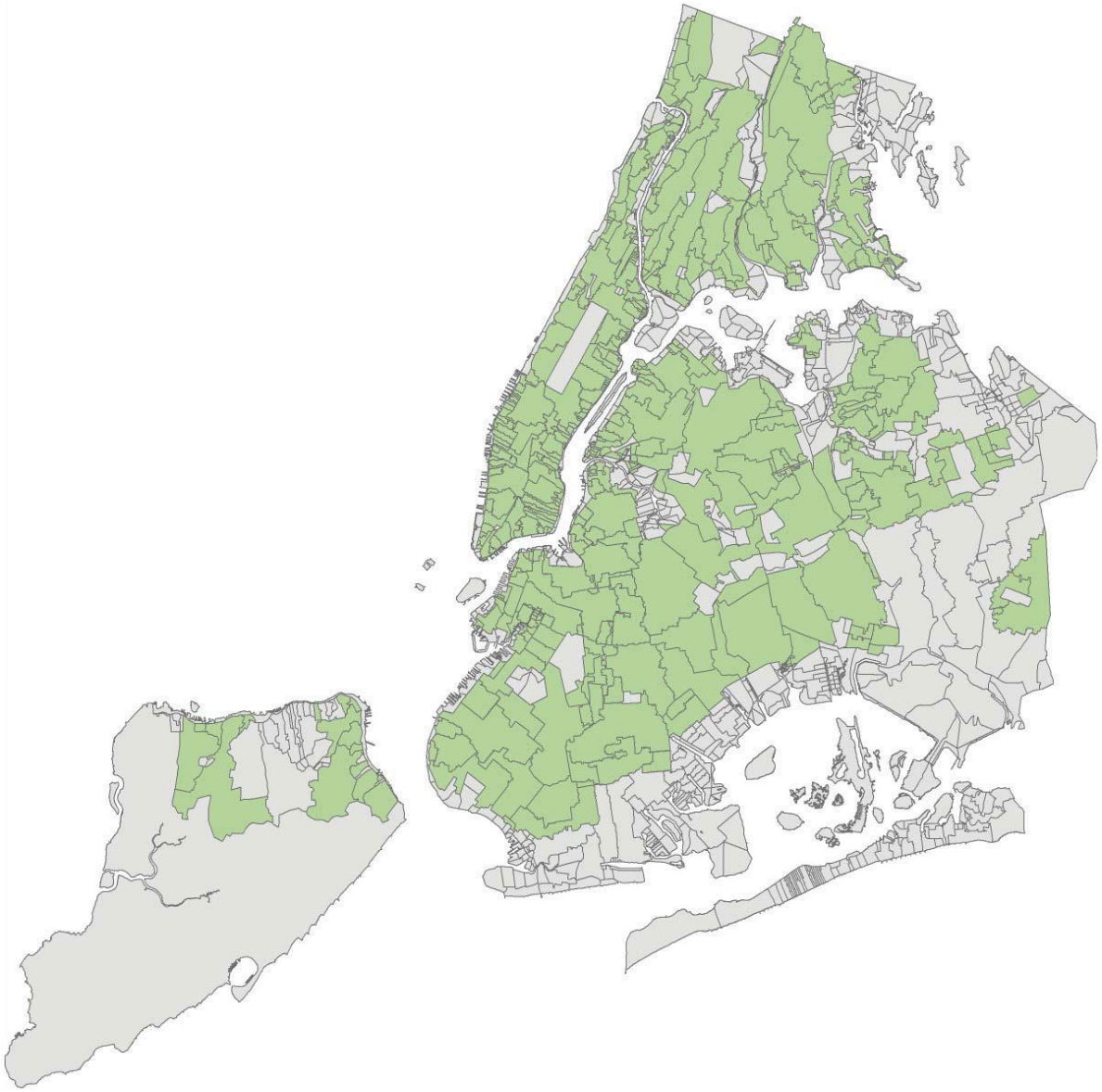
NYC Sewer System

- 7,400 total miles of sewers
  - 3,337 miles of combined sewer
- 14 Wastewater Treatment Plants
- Over 430 CSO outfalls



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NYC Sewer System

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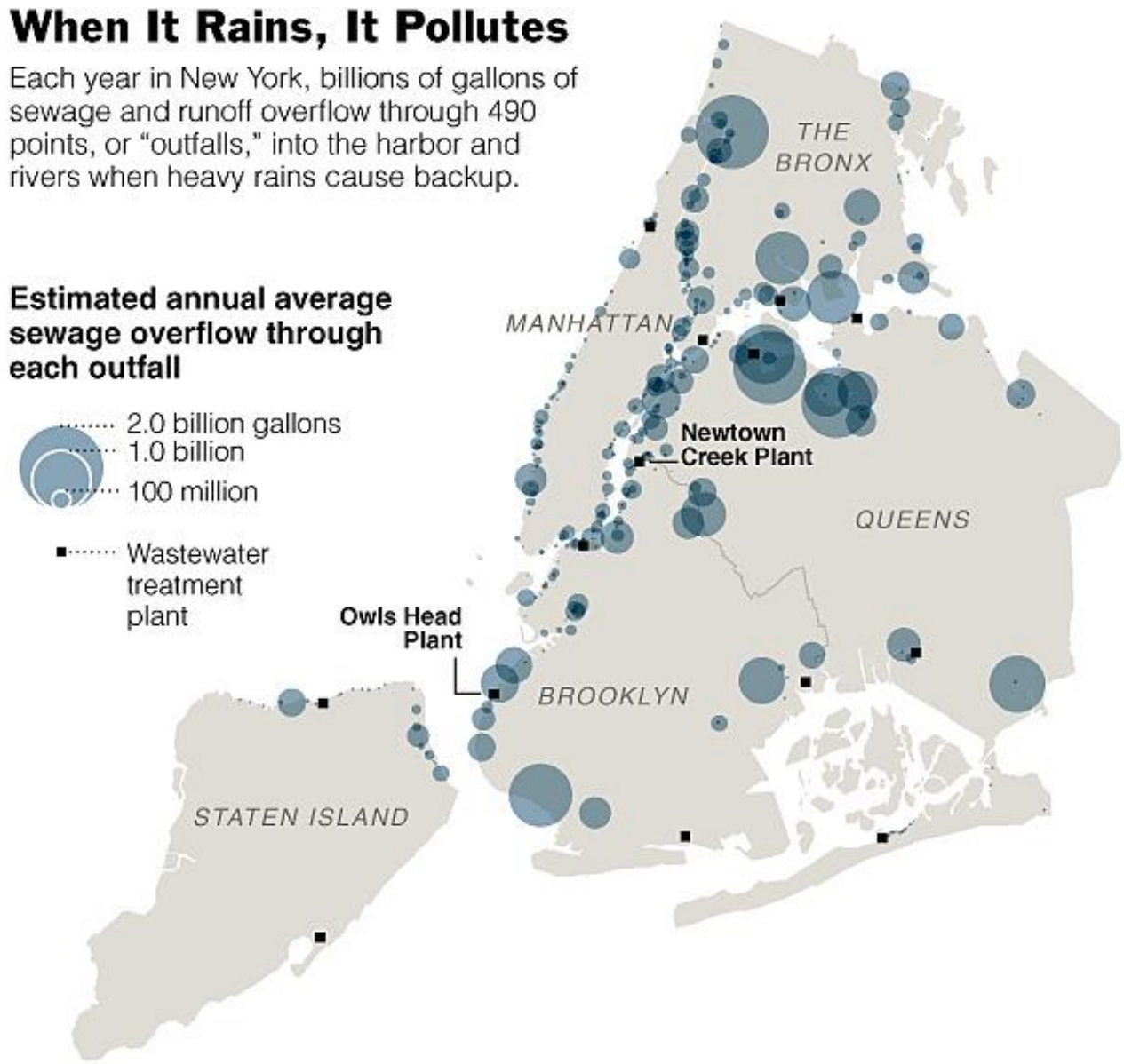

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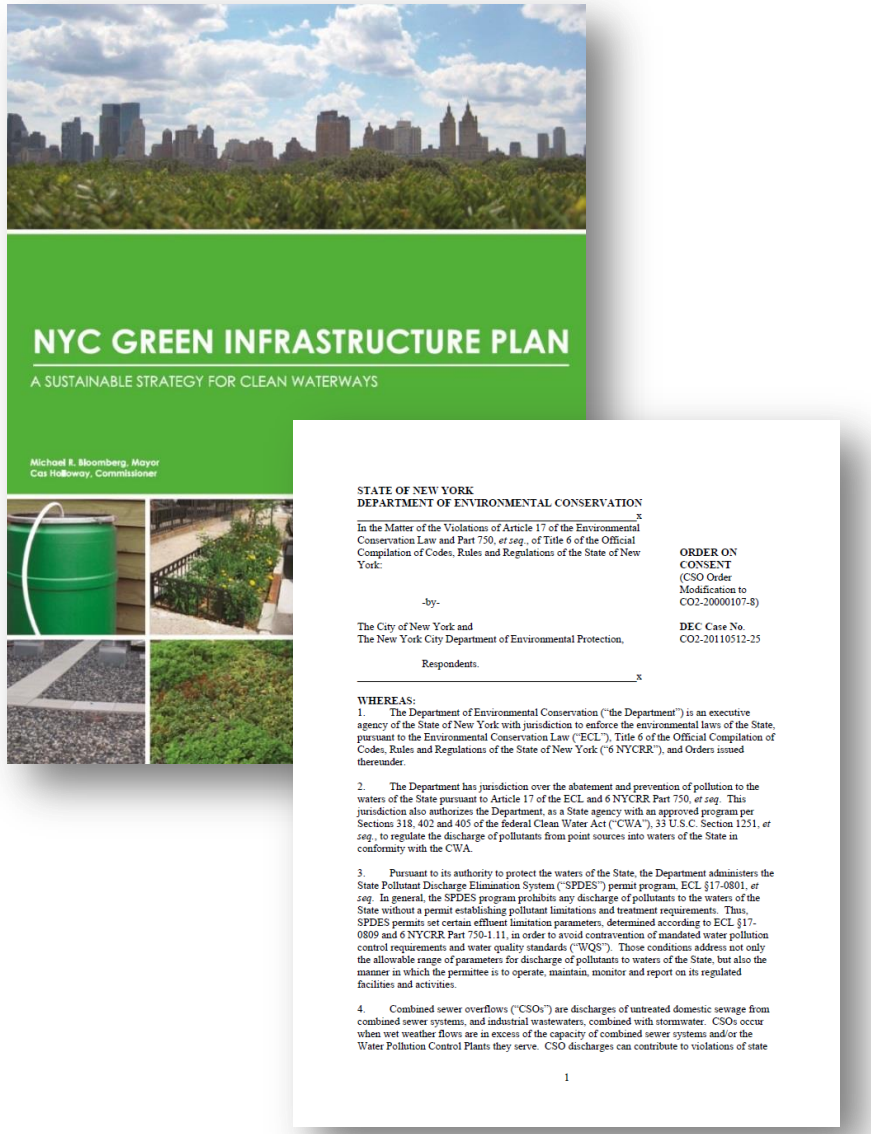
NYC Green Infrastructure Plan

- **2010 – NYC Green Infrastructure Plan**
  - Laid framework to use green infrastructure to manage 1” of stormwater runoff from 10% of impervious surfaces in combined sewer areas by 2030.
- **2011 – DEP Office of Green Infrastructure (OGI)**
  - Created to implement GI Plan
- **2012 – Amended Consent Order**
  - DEP and NYS Department of Environmental Conservation (DEC) signed a historic agreement to incorporate a green and grey adaptive management approach into the CSO program.



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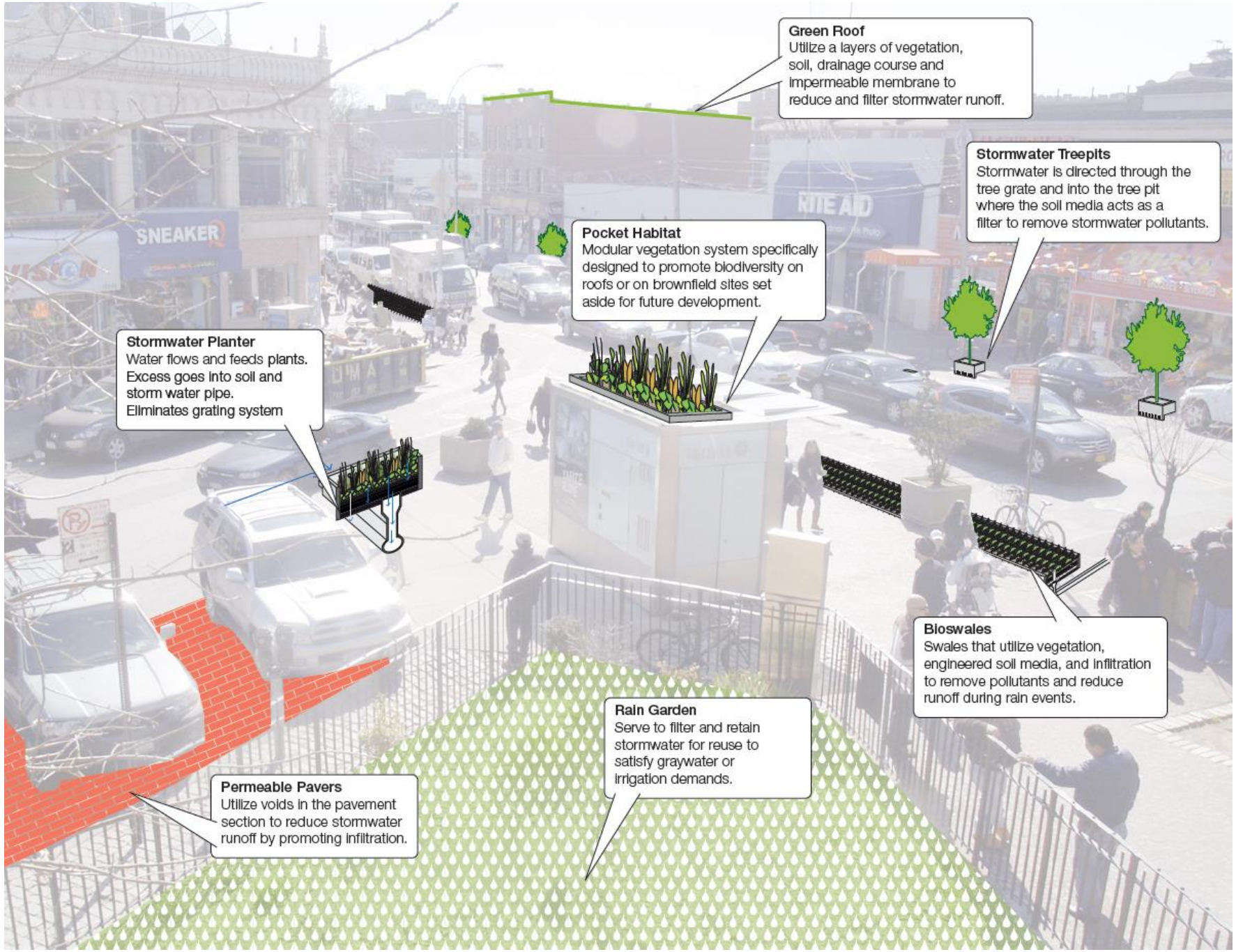
Green Roof
Utilize a layers of vegetation, soil, drainage course and impermeable membrane to reduce and filter stormwater runoff.
Stormwater Treepits
Stormwater is directed through the tree grate and into the tree pit where the soil media acts as a filter to remove stormwater pollutants.
Pocket Habitat
Modular vegetation system specifically designed to promote biodiversity on roofs or on brownfield sites set aside for future development.
Stormwater Planter
Water flows and feeds plants. Excess goes into soil and storm water pipe. Eliminates grating system
Bioswales
Swales that utilize vegetation, engineered soil media, and infiltration to remove pollutants and reduce runoff during rain events.
Rain Garden
Serve to filter and retain stormwater for reuse to satisfy graywater or irrigation demands.
Permeable Pavers
Utilize voids in the pavement section to reduce stormwater runoff by promoting infiltration.

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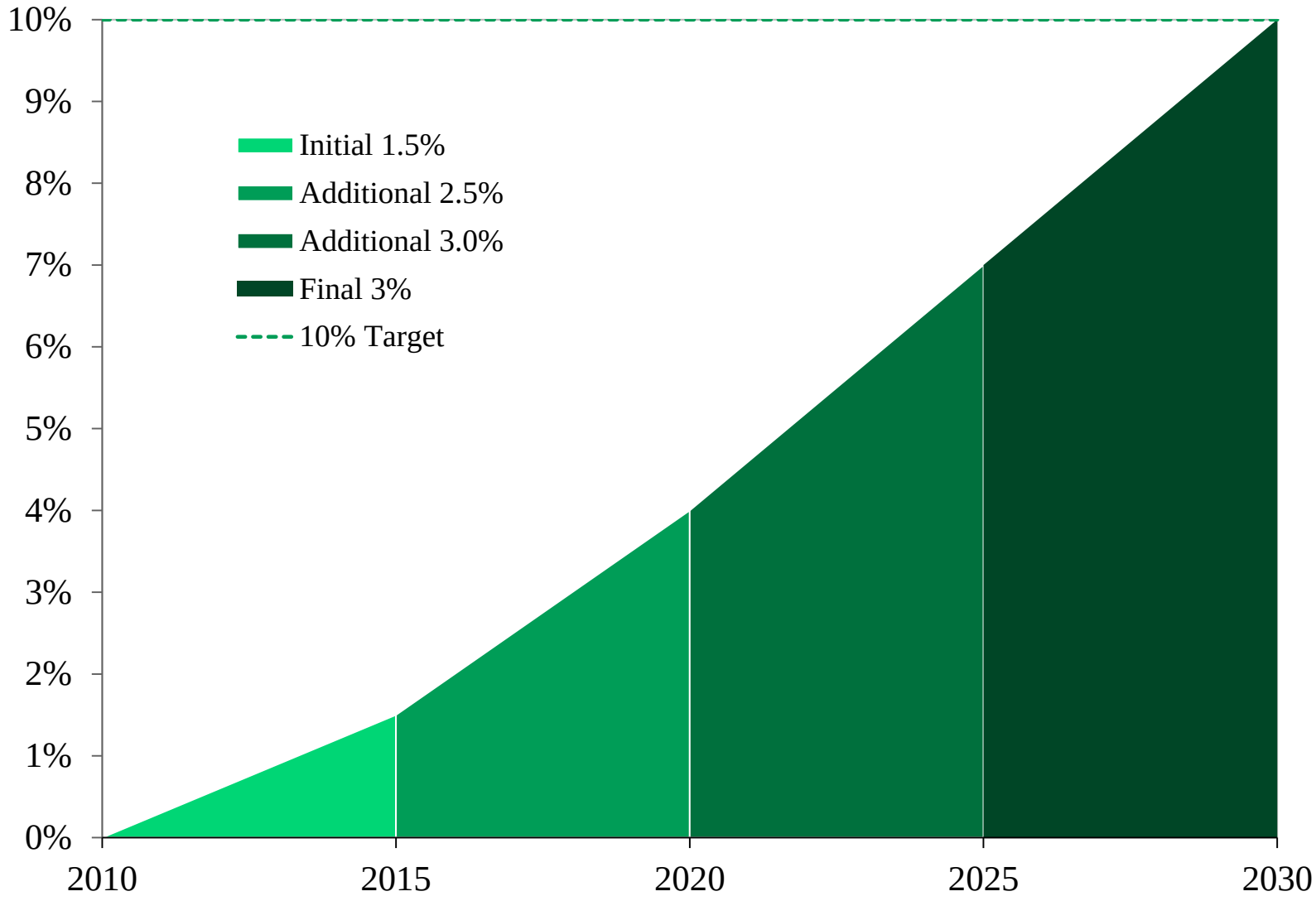
NYC Green Infrastructure Plan

- Manage 1” of stormwater runoff from 10% of impervious surfaces in combined sewer areas by 2030

- DEP has committed to invest $1.5 billion in green infrastructure through 2030.



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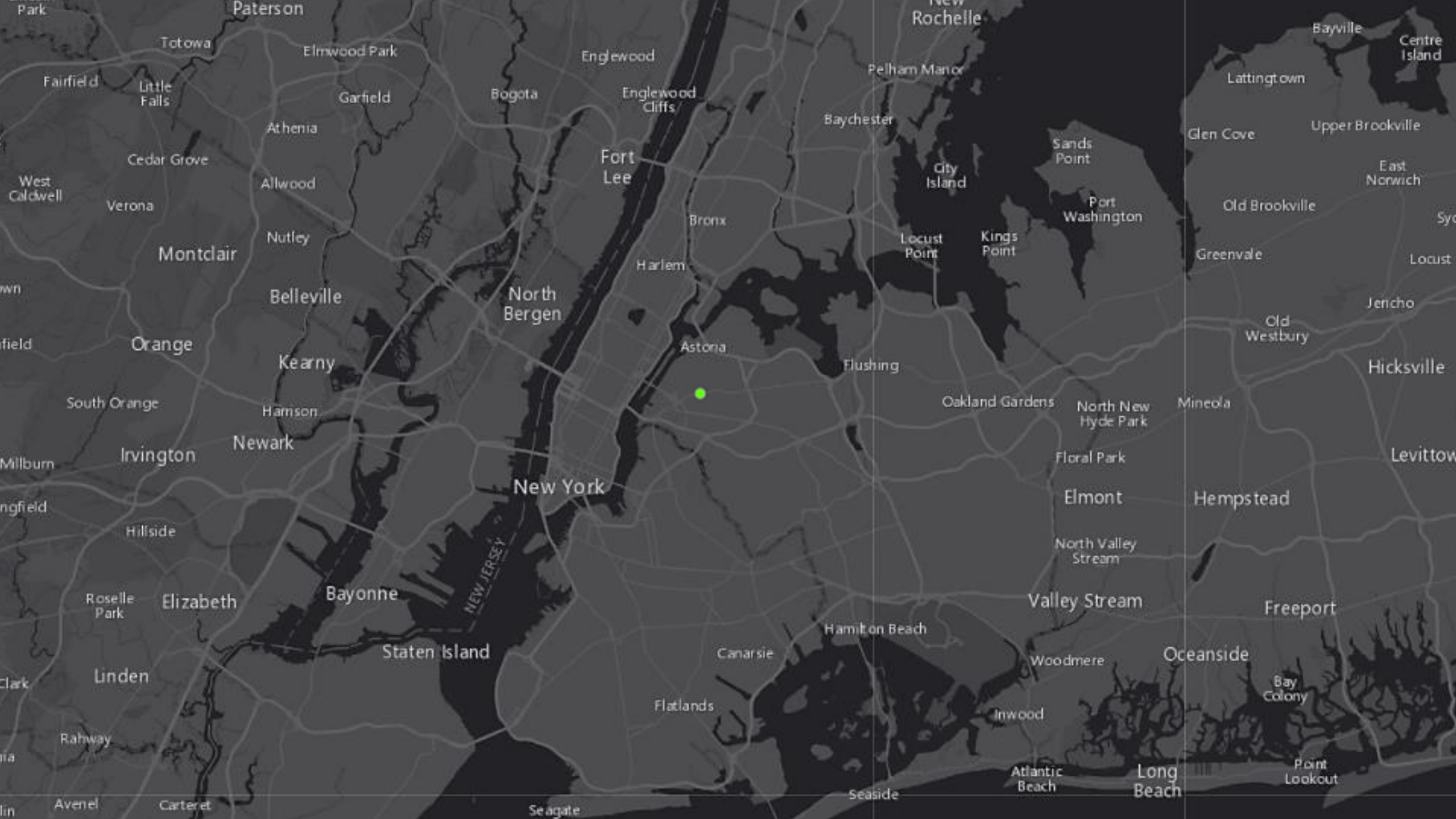
Paterson
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Rochelle
Bayville
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Little Falls
Garfield
Bogota
Englewood Cliffs
Pelham Manor
Lattingtown
Athenia
Baychester
Glen Cove
Upper Brookville
Cedar Grove
Fort Lee
Sands Point
West Caldwell
Allwood
City Island
East Norwich
Verona
Port Washington
Old Brookville
Bronx
Nutley
Locust Point
Kings Point
Montclair
Harlem
Greenvale
Locust
Belleville
North Bergen
Jericho
Old Westbury
Orange
Astoria
Kearny
Flushing
Hicksville
South Orange
Oakland Gardens
North New Hyde Park
Mineola
Harrison
Newark
Irvington
Floral Park
Millburn
New York
Elmont
Hempstead
Hillside
North Valley Stream
NEW JERSEY
Roselle Park
Elizabeth
Bayonne
Valley Stream
Freeport
Hamilton Beach
Staten Island
Canarsie
Woodmere
Oceanside
Linden
Bay Colony
Flatlands
Inwood
Rahway
Point Lookout
Atlantic Beach
Long Beach
Avenel
Carteret
Seaside
Seagate

108,000 gallons/year managed

0.69 job/year

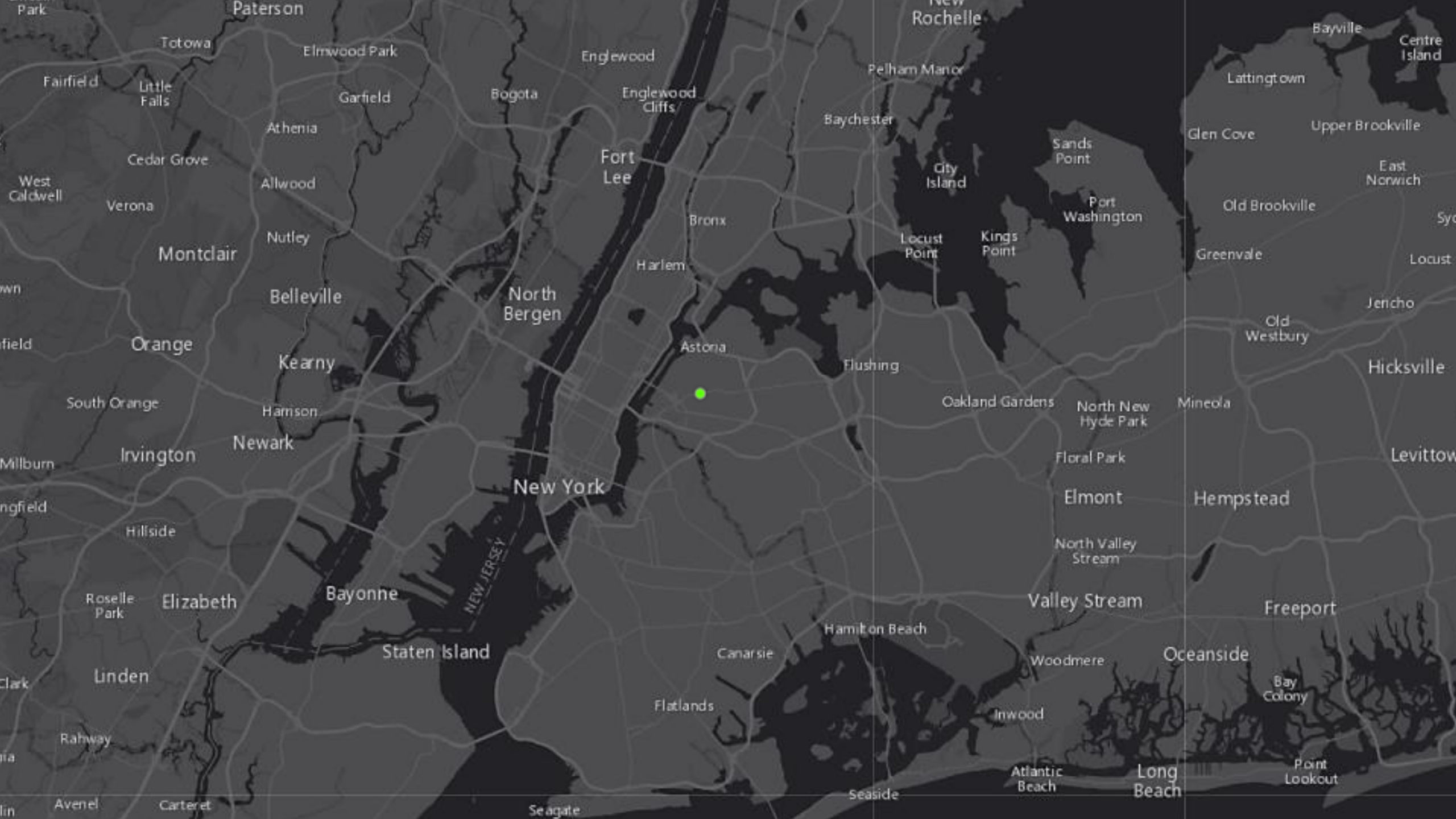
$19.39 treatment savings/year

9% potential property value increase

2% urban heat island reduction

84 lbs CO_2 sequestered/year

ARUP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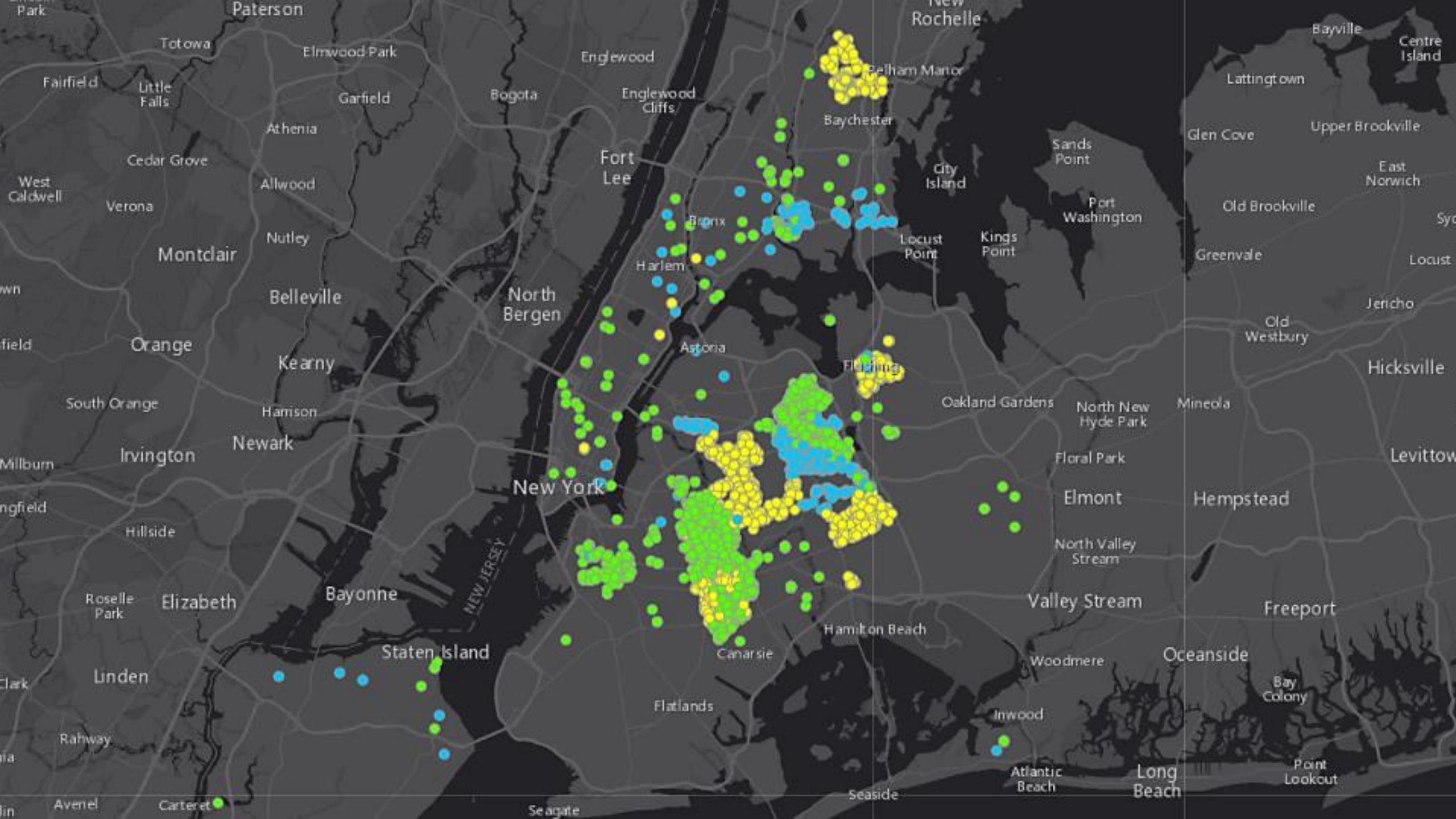
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Point Lookout
Atlantic Beach
Long Beach
Seaside
Avenel
Carteret
Seagate

618,000,000 gallons/year managed

3,970 jobs/year

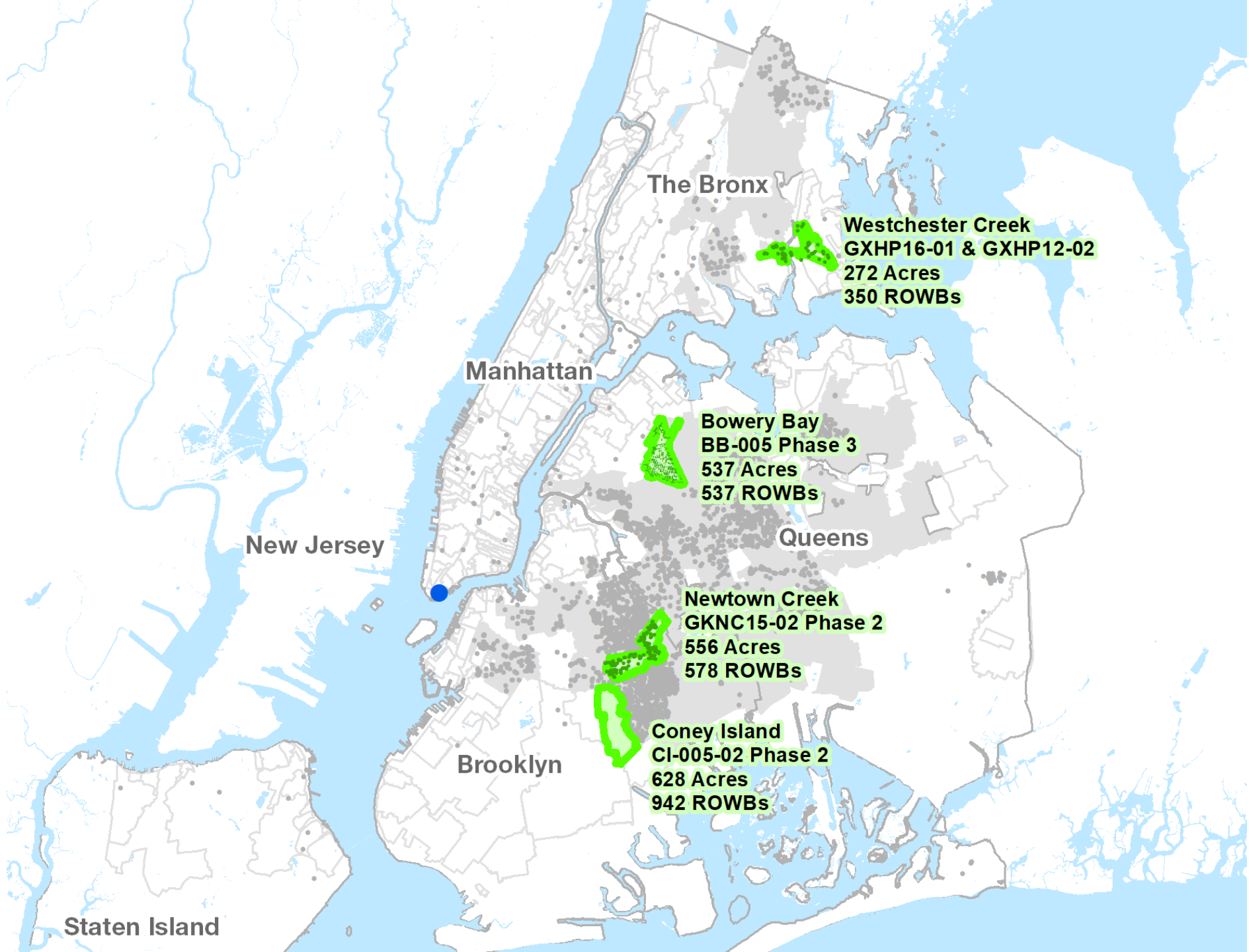
$112,000 treatment savings/year

9% potential property value increase

12% urban heat island reduction

539,297 lbs CO_2 sequestered/year

ARUP


The Bronx
Westchester Creek
GXHP16-01 & GXHP12-02
272 Acres
350 ROWBs
Manhattan
Bowery Bay
BB-005 Phase 3
537 Acres
537 ROWBs
New Jersey
Queens
Newtown Creek
GKNC15-02 Phase 2
556 Acres
578 ROWBs
Coney Island
CI-005-02 Phase 2
628 Acres
942 ROWBs
Brooklyn
Staten Island

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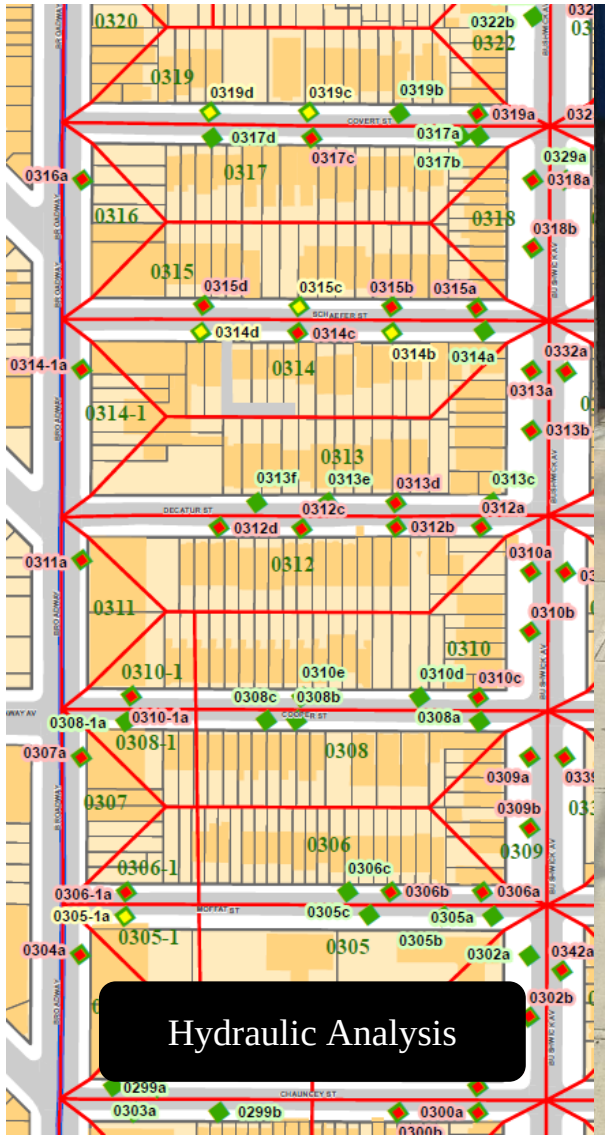
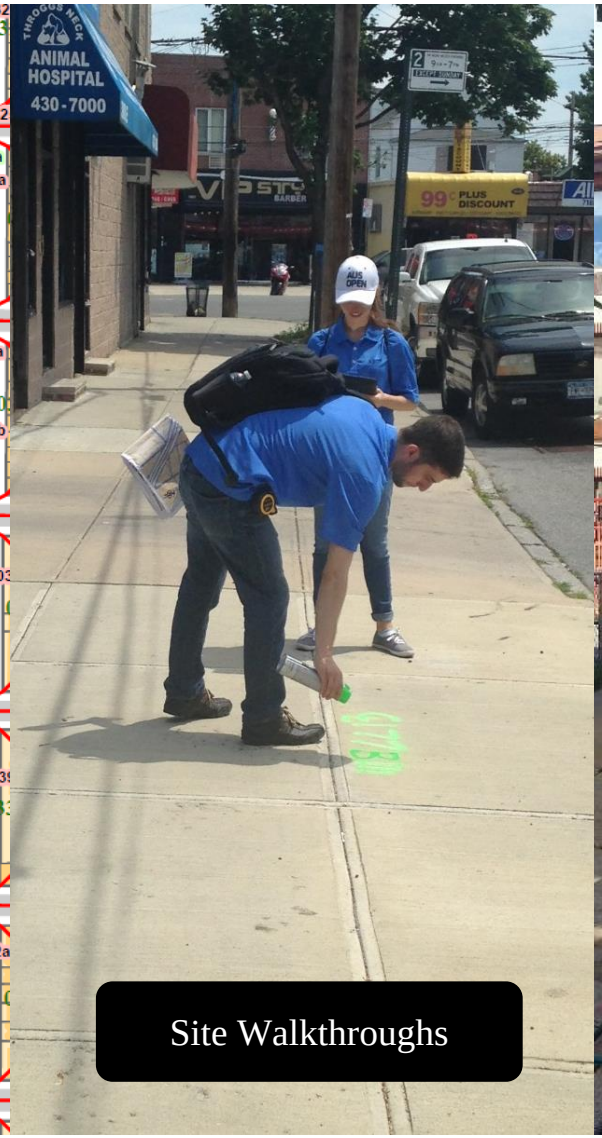
STONE STRIP
EVAPOTRANSPIRATION
STORMWATER RUNOFF
2' ENGINEERED SOIL
STONE GABION
OPEN GRADED STONE BED
OVERFLOW
CATCH BASIN
INFILTRATION
SEWER MANHOLE
NYC Environmental Protection
Michael R. Bloomberg, Mayor
Carter H. Strickland, Jr. Comissioner
GREEN INFRASTRUCTURE
RIGHT OF WAY BIOSWALE

Bioswales constructed from the Newtown Creek contract

Design Procedure

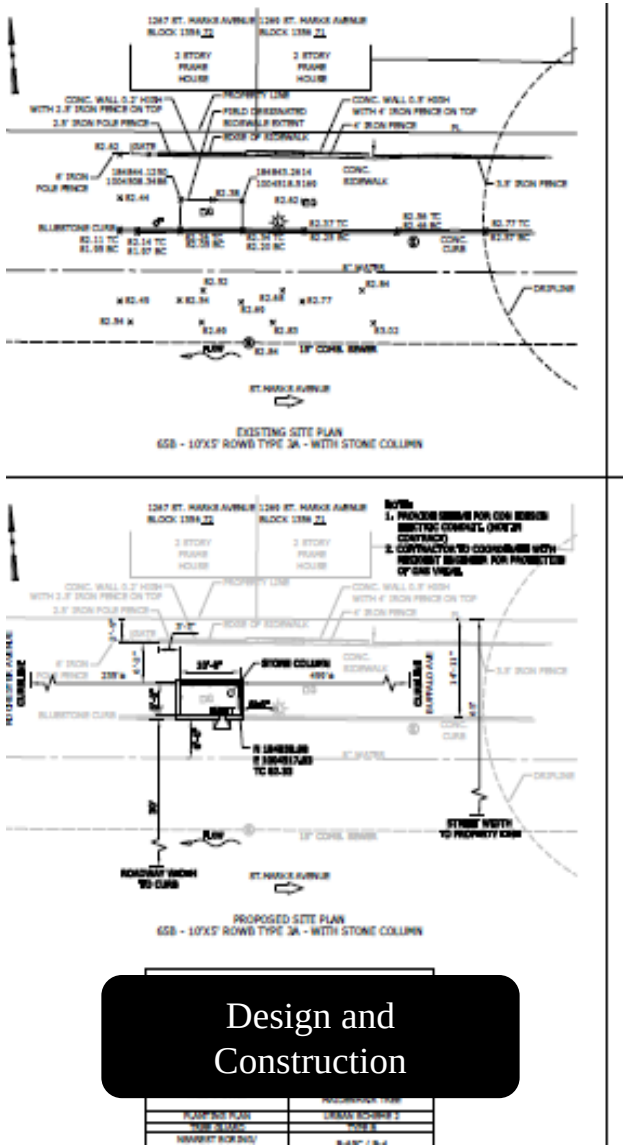


Hydraulic Analysis



Site Walkthroughs

Geotechnical Investigations and Topographic Survey



Design and Construction

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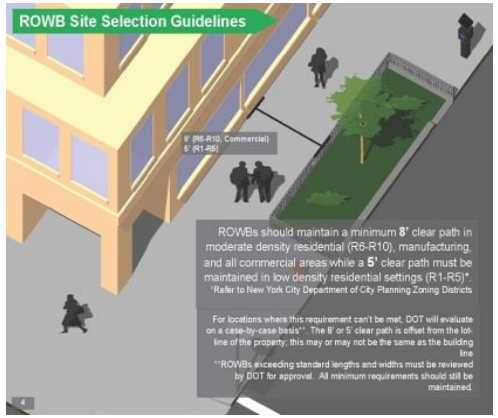
ROWB Site Selection Guidelines
ROWBs shall preferably be located in low to moderate density areas


ROWB Site Selection Guidelines
5' minimum
ROWBs are to maintain a minimum 5' from any marked or unmarked crosswalk
ROWBs are to maintain a minimum 5' from any pedestrian ramp


ROWB Site Selection Guidelines
3' or greater
1' additional
ROWBs are to maintain an additional 1' of sidewalk clearance when sited adjacent to walls or fences 3' or greater in height. In locations where the additional 1' clearance cannot be met, Type III (10' long) ROWBs may be permitted.


ROWB Site Selection Guidelines
ROWBs are to maintain a minimum 5' from any revocable consent structure.
5' minimum


ROWB Site Selection Guidelines
30' minimum
Trunks of trees in ROWBs must maintain a minimum 30' distance to Stop Signs.

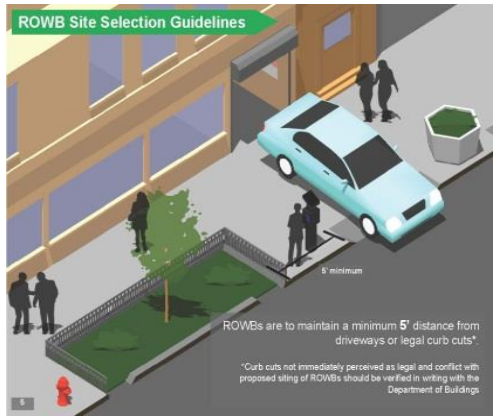

ROWB Site Selection Guidelines
8' (R6-R10, Commercial)
5' (R1-R5)
ROWBs should maintain a minimum 8' clear path in moderate density residential (R6-R10), manufacturing, and all commercial areas while a 5' clear path must be maintained in low density residential settings (R1-R5)*.
*Refer to New York City Department of City Planning Zoning Districts
For locations where this requirement can't be met, DOT will evaluate on a case-by-case basis**. The 8' or 5' clear path is offset from the lot-line of the property; this may or may not be the same as the building line.
**ROWBs exceeding standard lengths and widths must be reviewed by DOT for approval. All minimum requirements should still be maintained.


ROWB Site Selection Guidelines
2' minimum
2' minimum
ROWBs are to maintain a minimum of 2' offset horizontal from a perpendicular extension of the building entrance, measured from the door frame, stoop, stairs or path gate (whichever is greater) perpendicular to the curb.


ROWB Site Selection Guidelines
ROWBs must not be sited within 100' of either side of a posted bus stop.
100' each direction

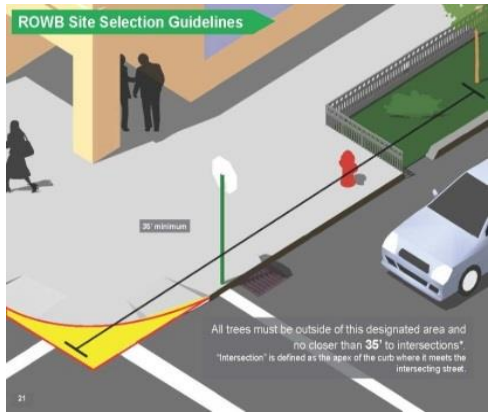

ROWB Site Selection Guidelines
4' each side
3' each side
ROWBs are to maintain a minimum 3' clear path between either side of adjacent fire hydrants.
ROWBs are to maintain a minimum 4' clear path between either side of adjacent Muni Meters.


ROWB Site Selection Guidelines
Trunks of trees in ROWBs must maintain a minimum 25' distance to street lights and traffic signals per DPR Tree Planting guidelines. A minimum of 5' clearance between pit edge of ROWB and street light footing must be maintained.
Trunks of trees in ROWBs must maintain a minimum 10' distance to utility poles. A minimum of 5' clearance between pit edge of ROWB and utility pole must be maintained.
DPR discretion may be used when siting trees closer than 25' to a light pole.
25' minimum street lights & traffic signals
10' minimum utility poles


ROWB Site Selection Guidelines
5' minimum
ROWBs are to maintain a minimum 5' distance from driveways or legal curb cuts*.
*Curb cuts not immediately perceived as legal and conflict with proposed siting of ROWBs should be verified in writing with the Department of Buildings


ROWB Site Selection Guidelines
Sidewalk corners must be kept clear.


ROWB Site Selection Guidelines
ROWBs must not be sited within a 10' radius of subway entrances and exits. ROWBs sited within the vicinity of underground subway structures, sites are to be coordinated with NYCTA.
10'
10'


ROWB Site Selection Guidelines
35' minimum
All trees must be outside of this designated area and no closer than 35' to intersections*.
*Intersection' is defined as the apex of the curb where it meets the intersecting street.


ROWB Site Selection Guidelines
A minimum 25' distance must be maintained between the trunk centerline of ROWB trees and the trunk centerline of any existing trees. A minimum 5' distance is required between the edge of a ROWB and an existing tree pit or bioswale.
*DPR discretion may be used when siting trees closer than 25'.
25' minimum trunk centerlines
5' minimum pit edge

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Near bus stop?
In low / moderate / high density neighborhood or corridor?
Near schools and churches?
Proximity to entrances and driveways?
Utilities / Underground vaults?
Outside drip line?
Street furnishings?
High point verified?
Parking rules?
Subway above or underneath?
Catch basin locations verified?
Sidewalk width?
Soil permeability?
Proximity to corner quadrant?

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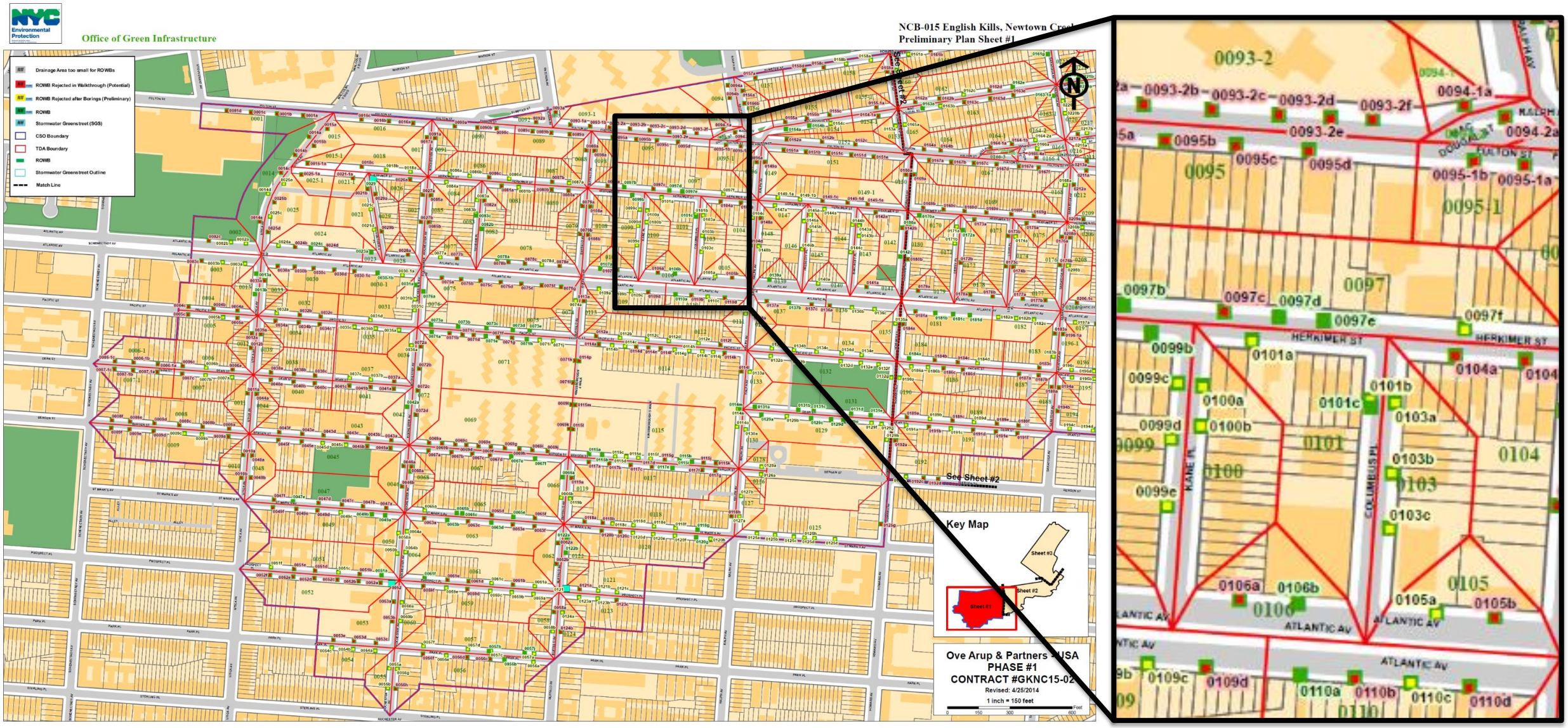
Hydrologic Analysis



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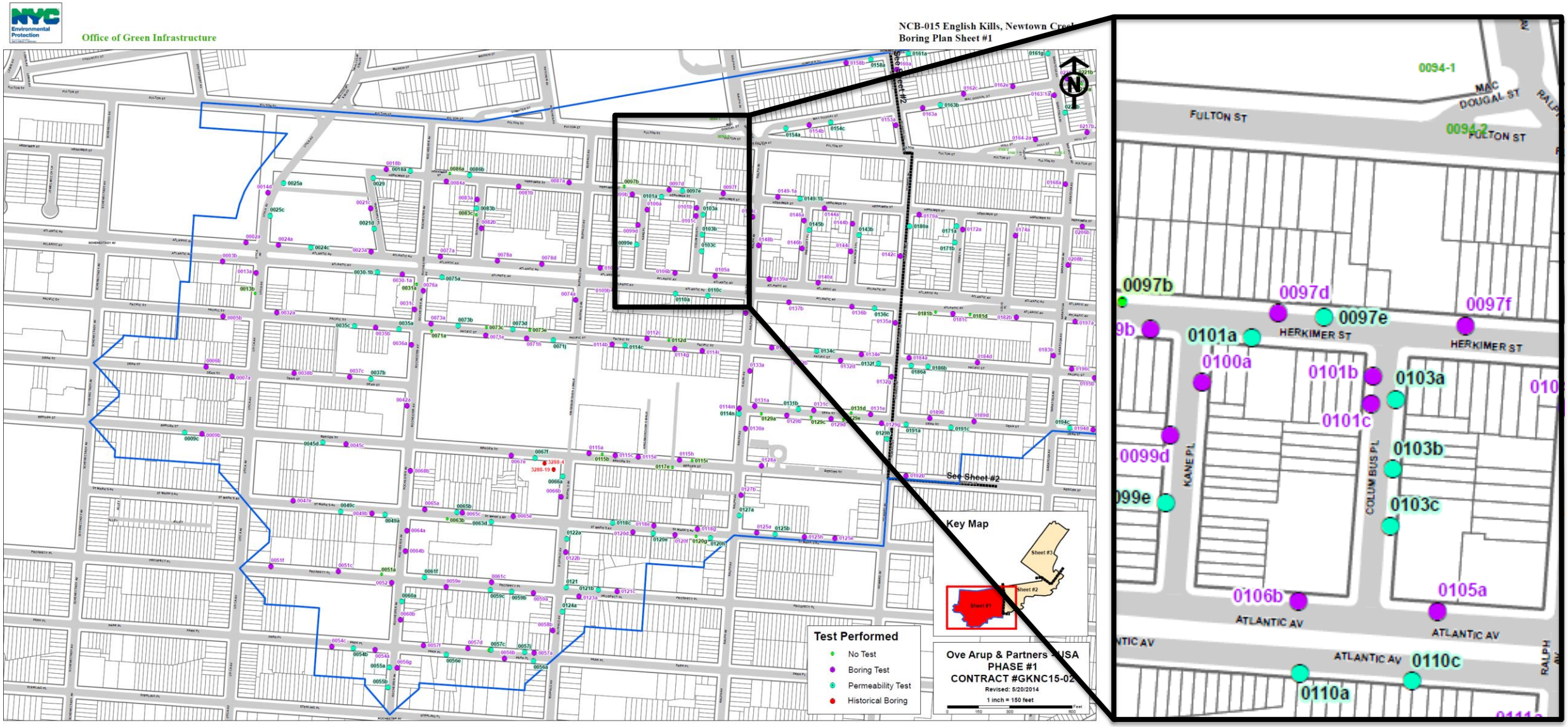
Geotechnical Investigations



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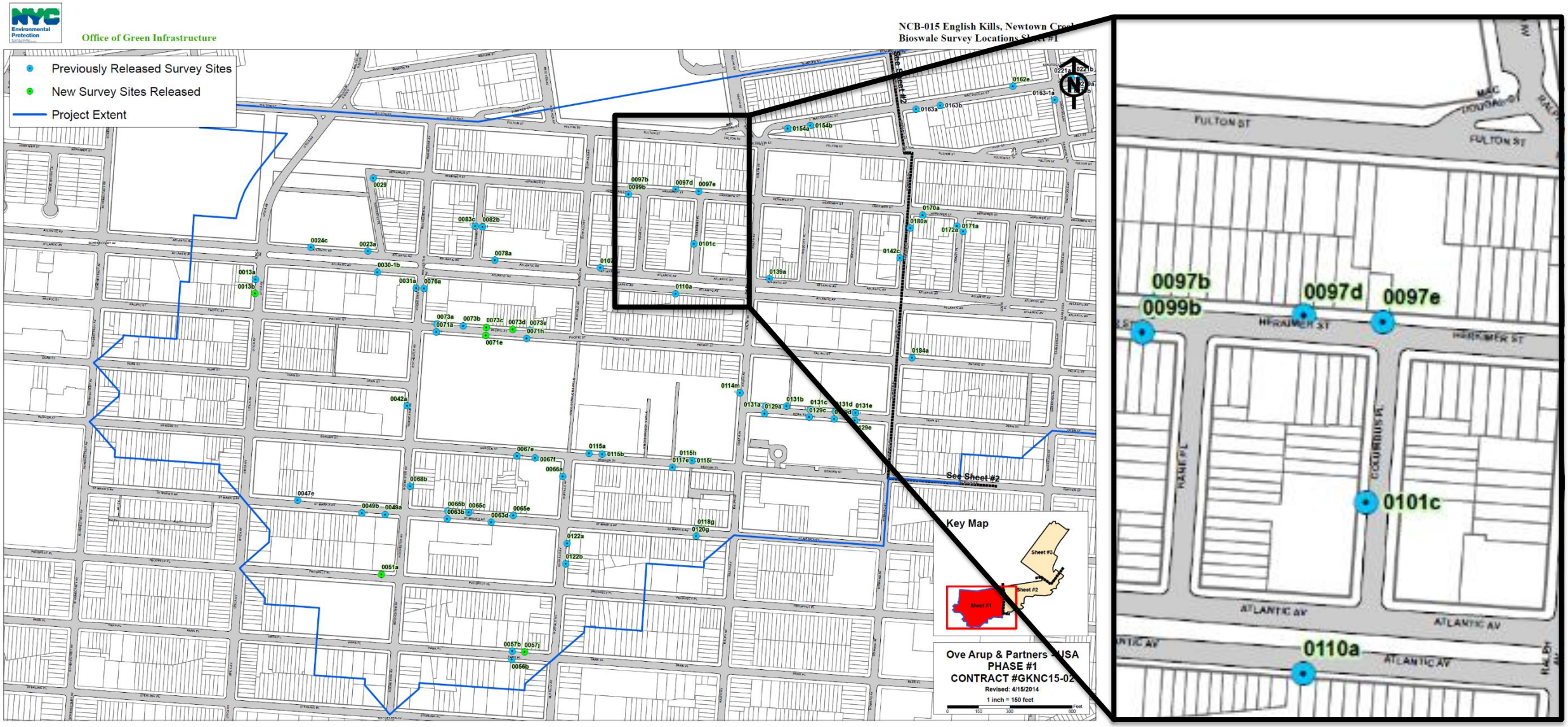
Survey | Engineering Design



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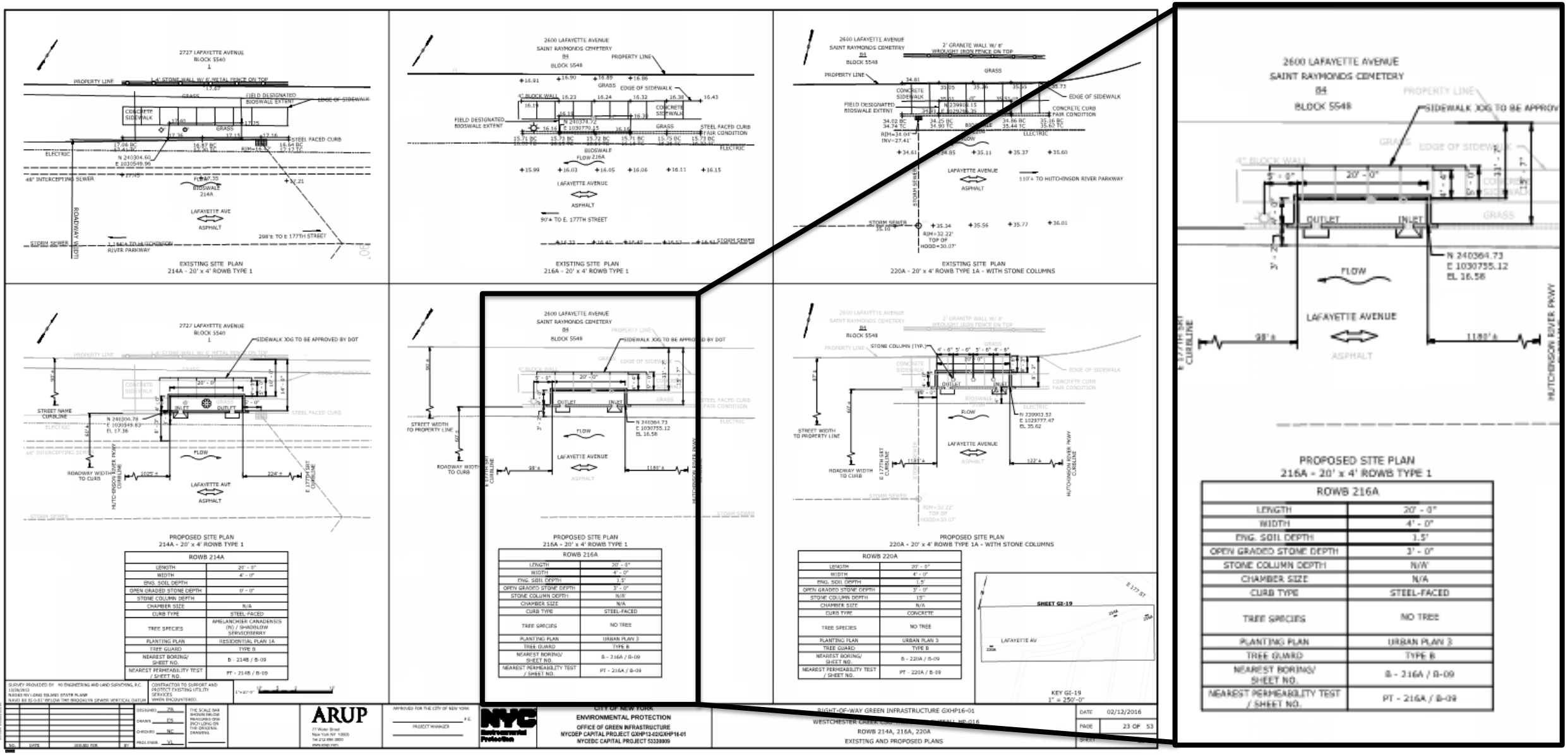
Contract Drawings



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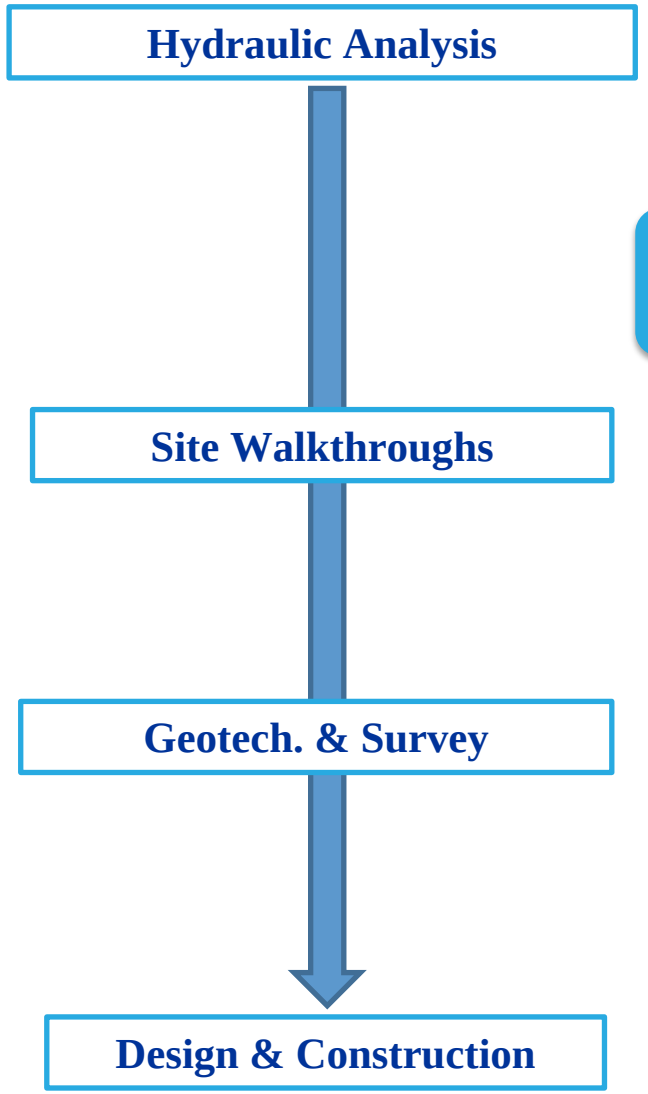

Contract Target: **578 ROWBs**

704 Potential ROWBs

655 Preliminary ROWBs

197 ROWBs

143 ROWBs

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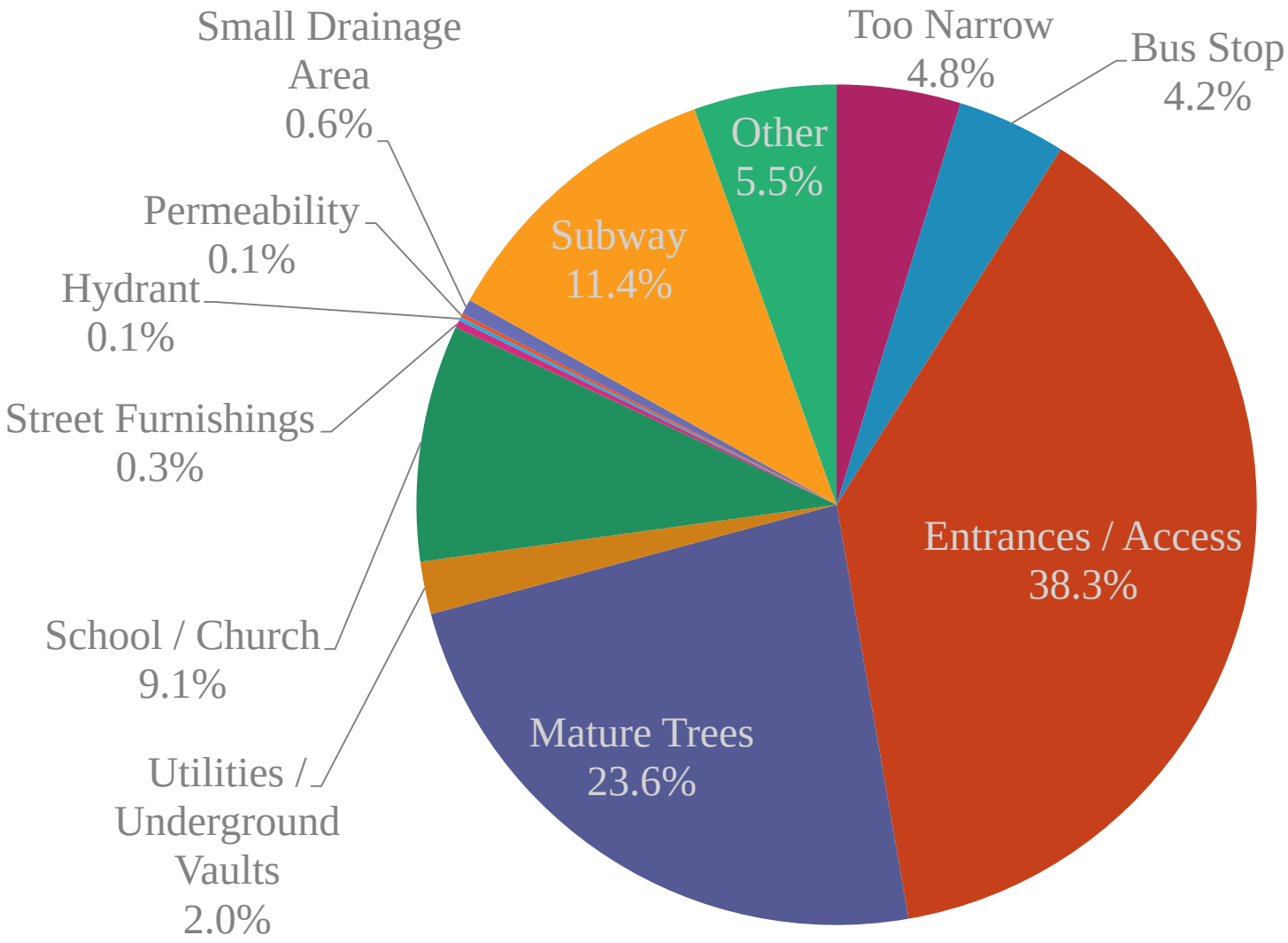
Small Drainage Area 0.6%
Too Narrow 4.8%
Bus Stop 4.2%
Other 5.5%
Permeability 0.1%
Subway 11.4%
Hydrant 0.1%
Street Furnishings 0.3%
Entrances / Access 38.3%
School / Church 9.1%
Mature Trees 23.6%
Utilities / Underground Vaults 2.0%

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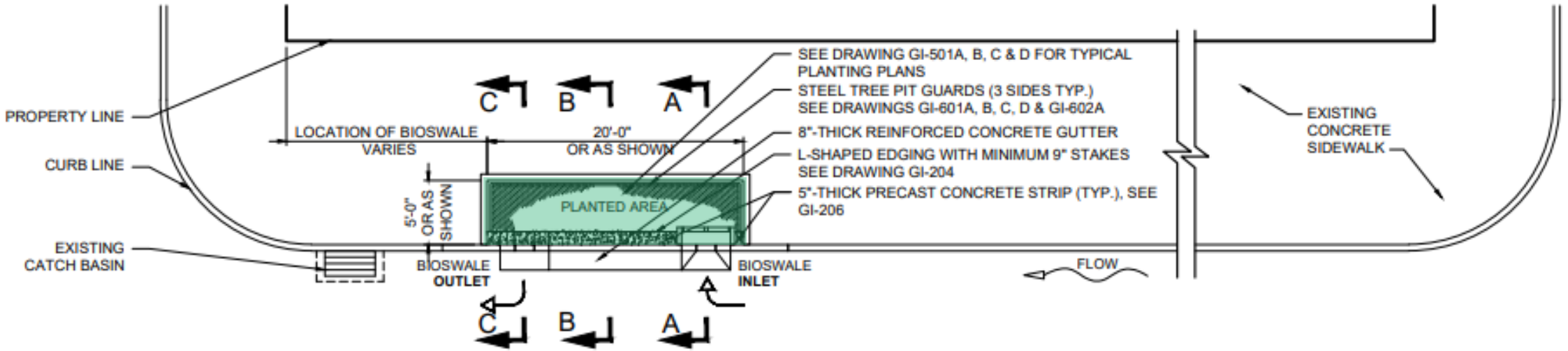
“Original” 5’ X 20’ ROW Bioswale



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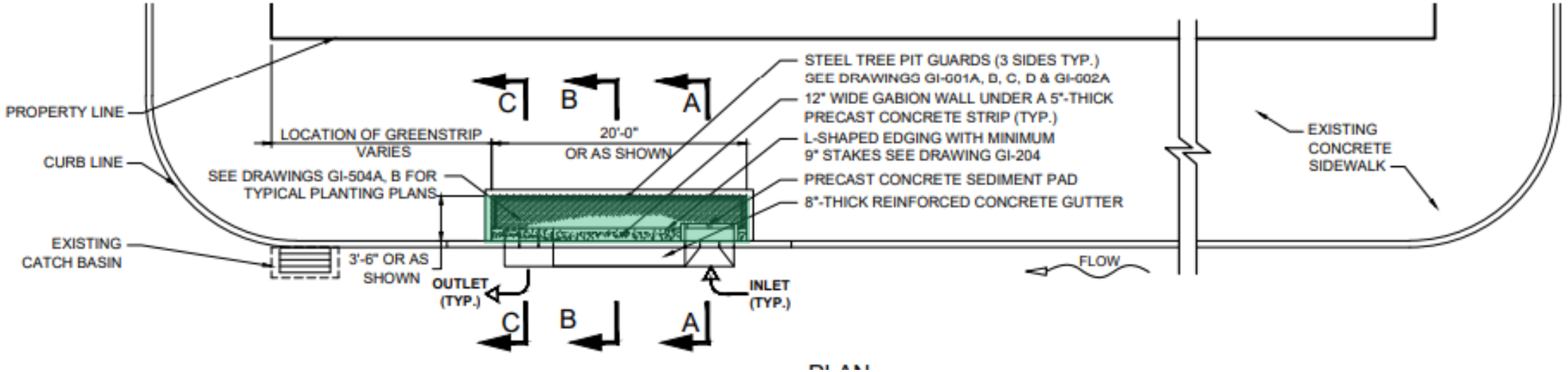
3.5’ X 20’ ROW Greenstrip



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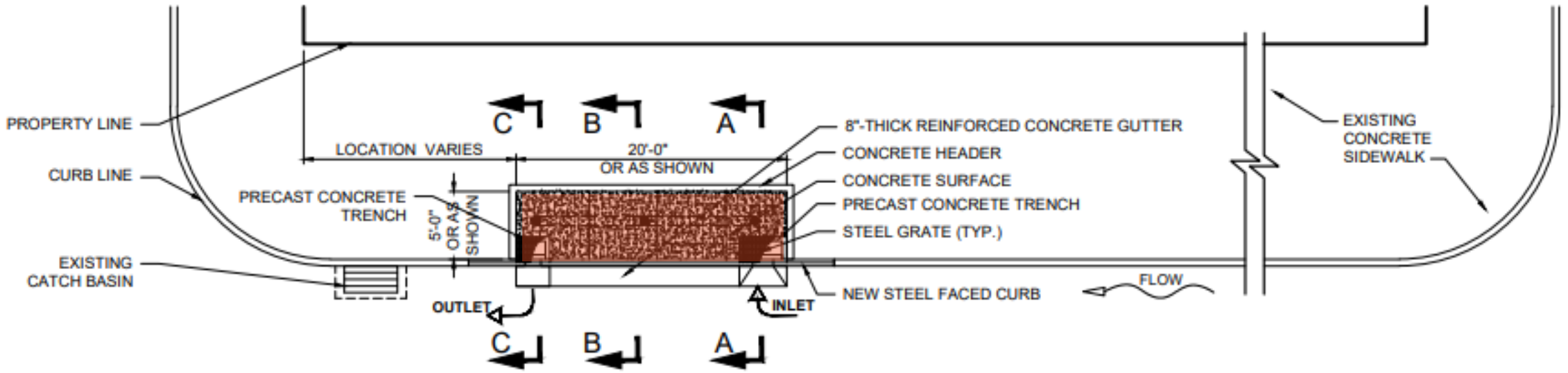
5’ X 20’ ROW Infiltration Basin



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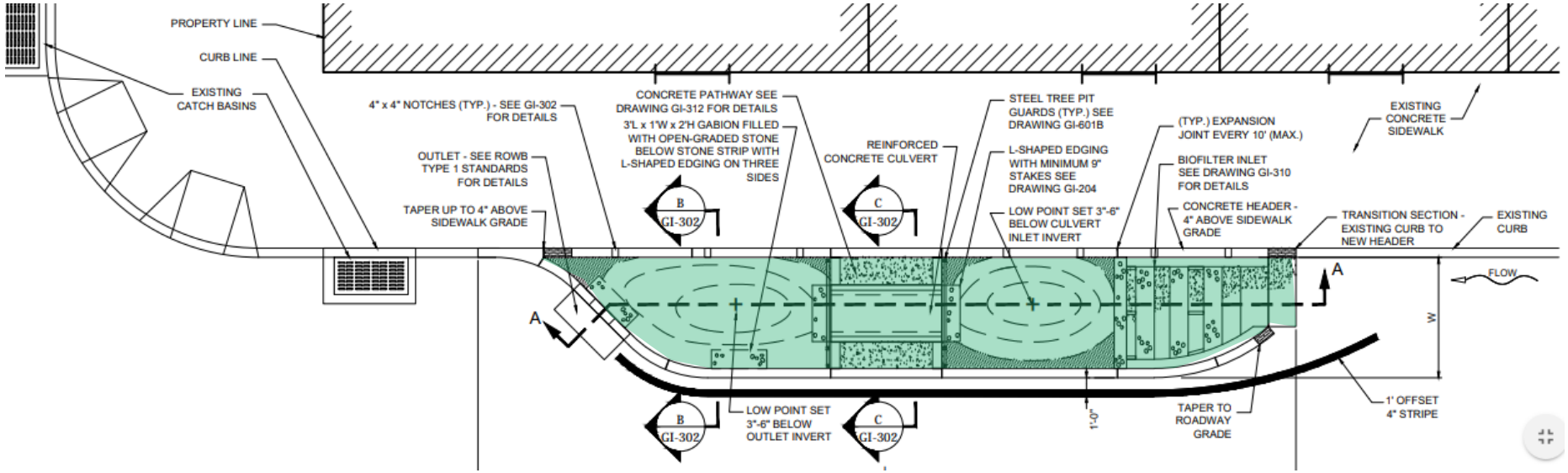
Stormwater Green Street (SGS)



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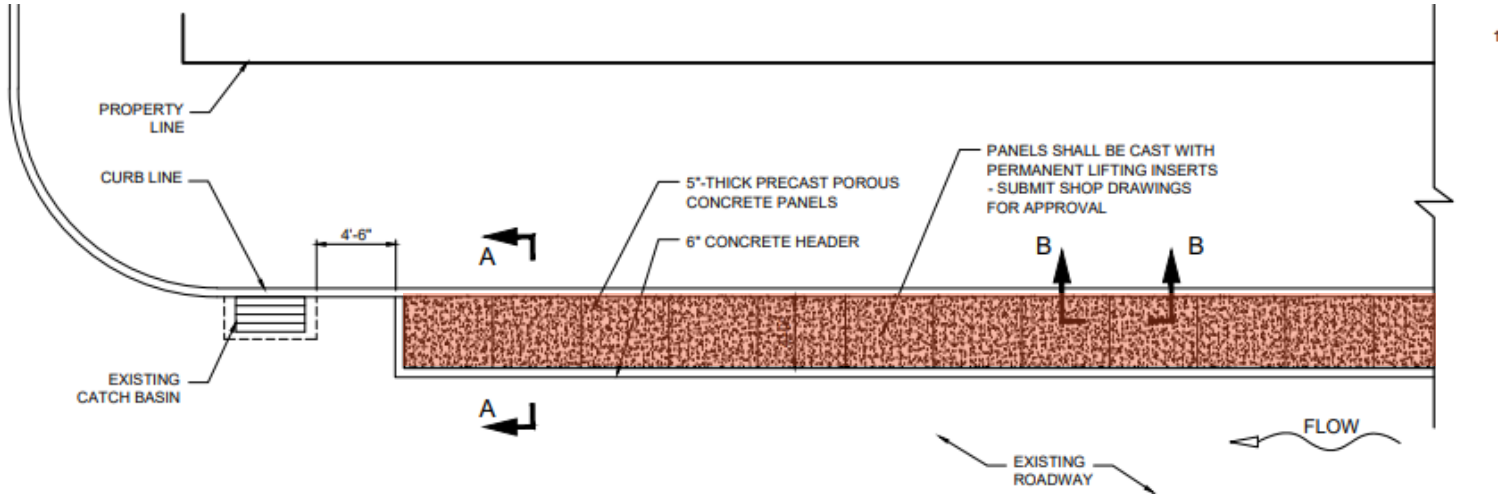
Porous Pavement



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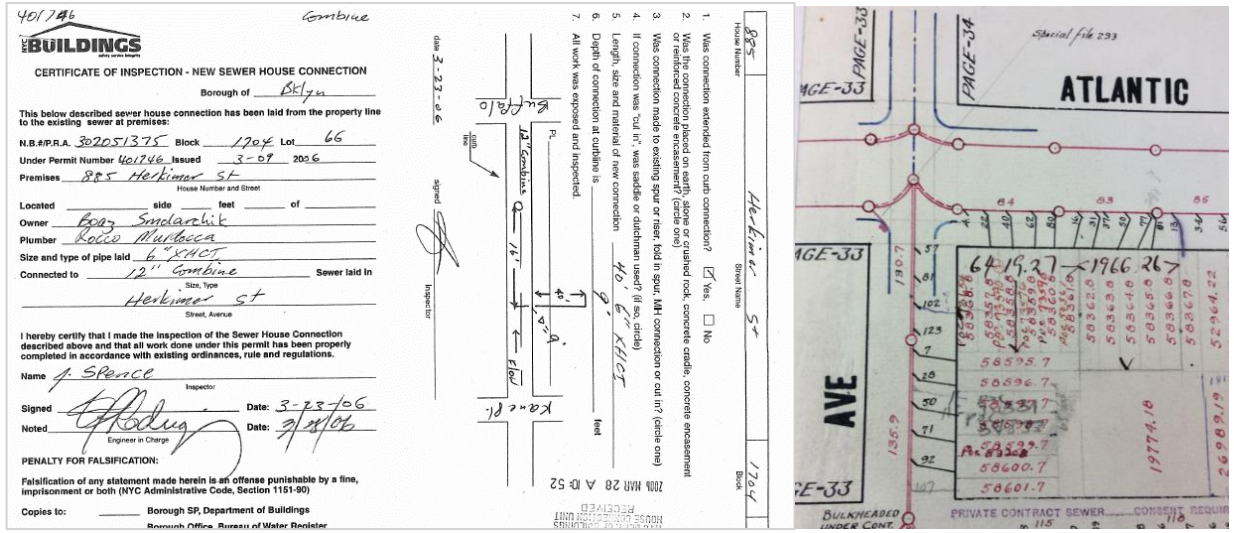
Groundwater Infiltration



House Sewer Records

Unmapped Underground

Resolving Utility Conflicts

Construction Coordination

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Lessons Learned Summary

Sponge Cities

- One technical challenge is making sure that the masterplans accurately consider the local hydrology and climate change
- Challenges around financing the project by public private partnership (PPP) investment, due to the need to identify the returns for all parties and develop a healthy financial model
- Designers and stakeholders to understand the operation of Sponge city LIDs
- Stakeholders accept the flooding of green space during rain events and an acceptable duration for flooding
- Appropriate design details of the landscape design within LIDs.
- Depending on how local pilot cities manage technical and management challenges; implementation timelines vary significantly

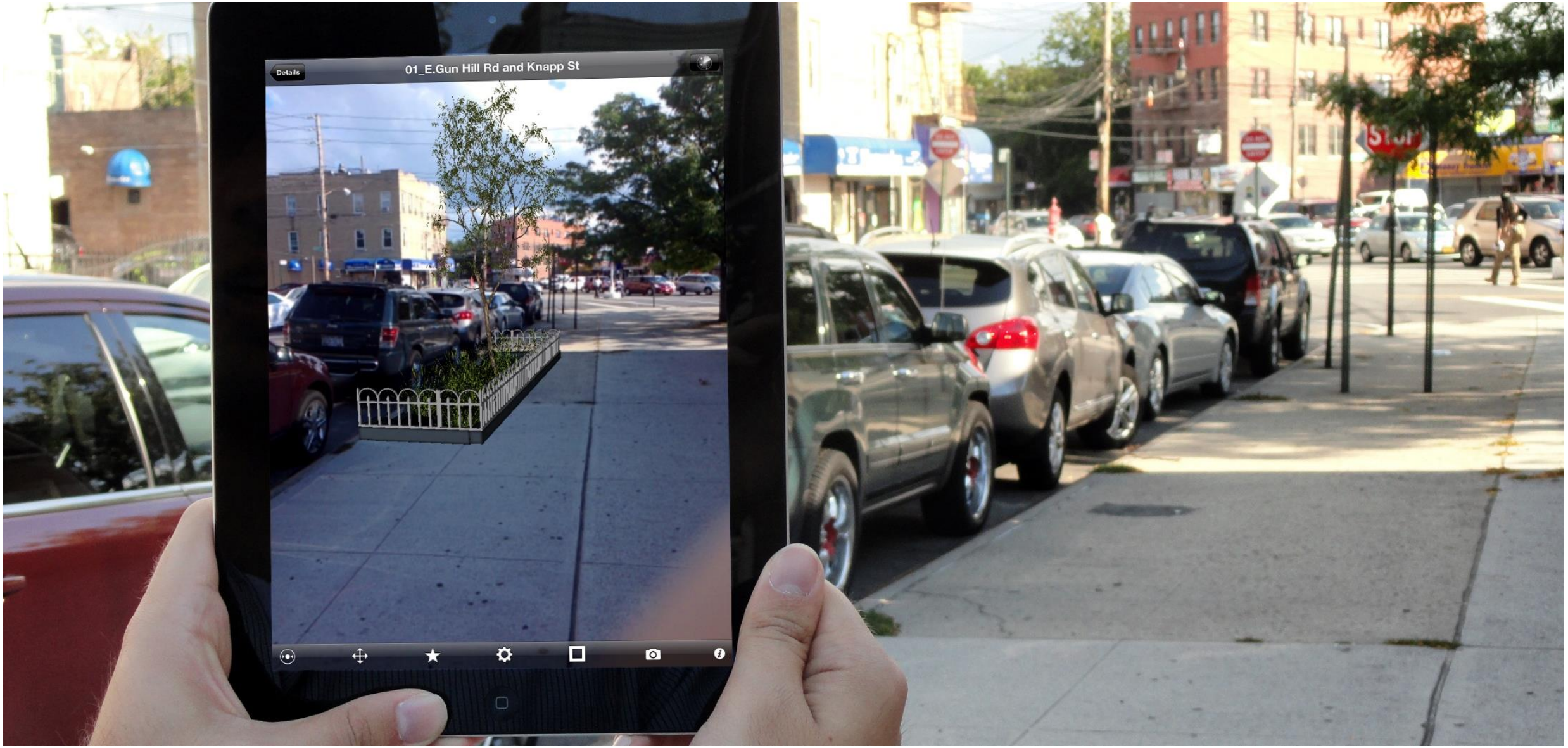
Lessons Learned Summary

Hunters Point South

- Interagency Coordination
- Design Guidelines + Standards
- Demonstration Projects
- Community Buy-In

NYC Green Infrastructure

- Define objective + the Benefits
- Establish targets + long term plan
- Maintenance + Ownership
- Funding?
- Evolution of Design through Research
- Prepare for construction challenges
- Context-sensitive
- Community Buy-In



Westchester Creek Green Infrastructure | Bronx, NY

BIM + Augmented Reality

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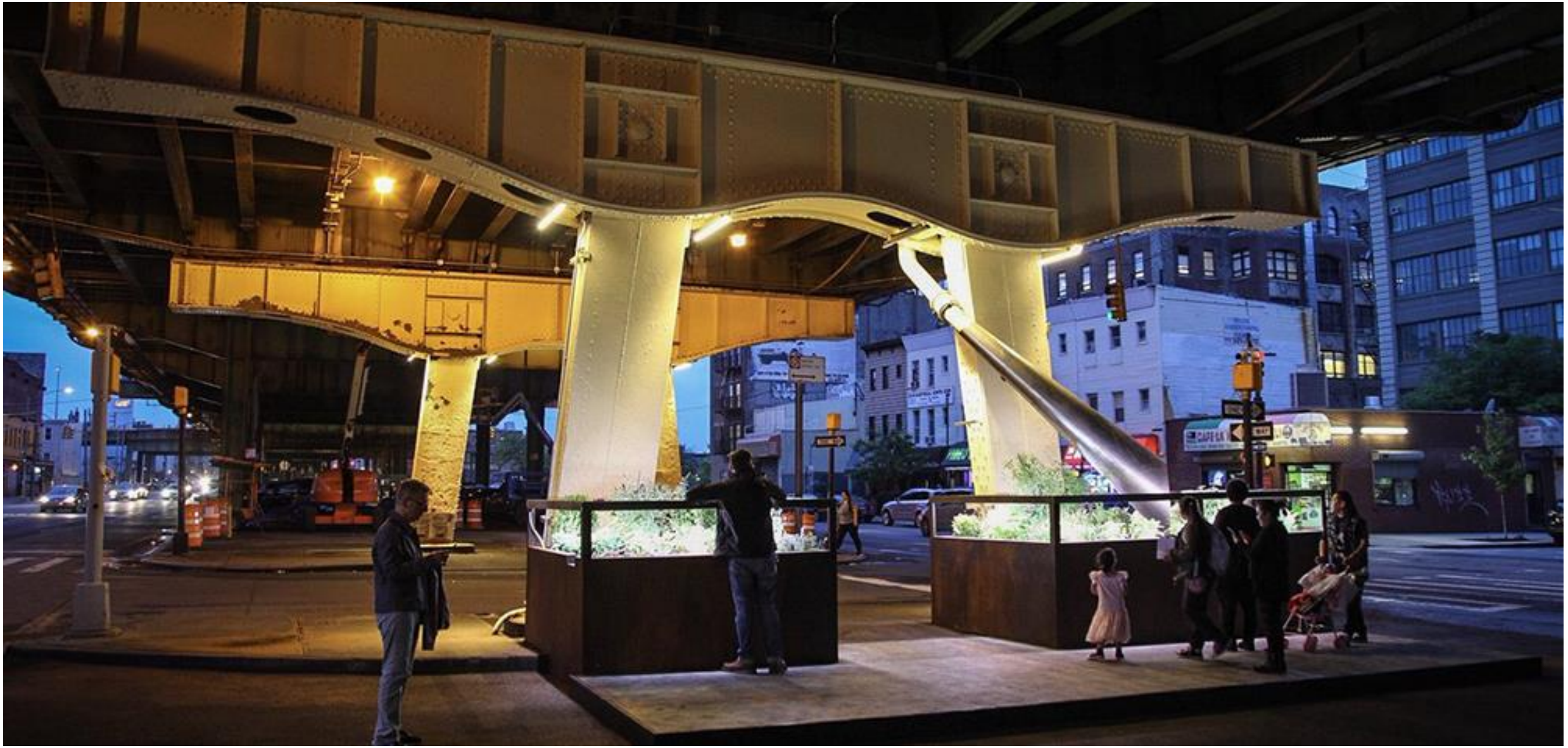

Green Infrastructure below the viaduct

Under The Elevated | Sunset Park, Brooklyn

Songdo, South Korea

NYC Green Infrastructure

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New masterplanned smart city 10 minutes from the Incheon International Airport

Songdo City | Incheon, South Korea

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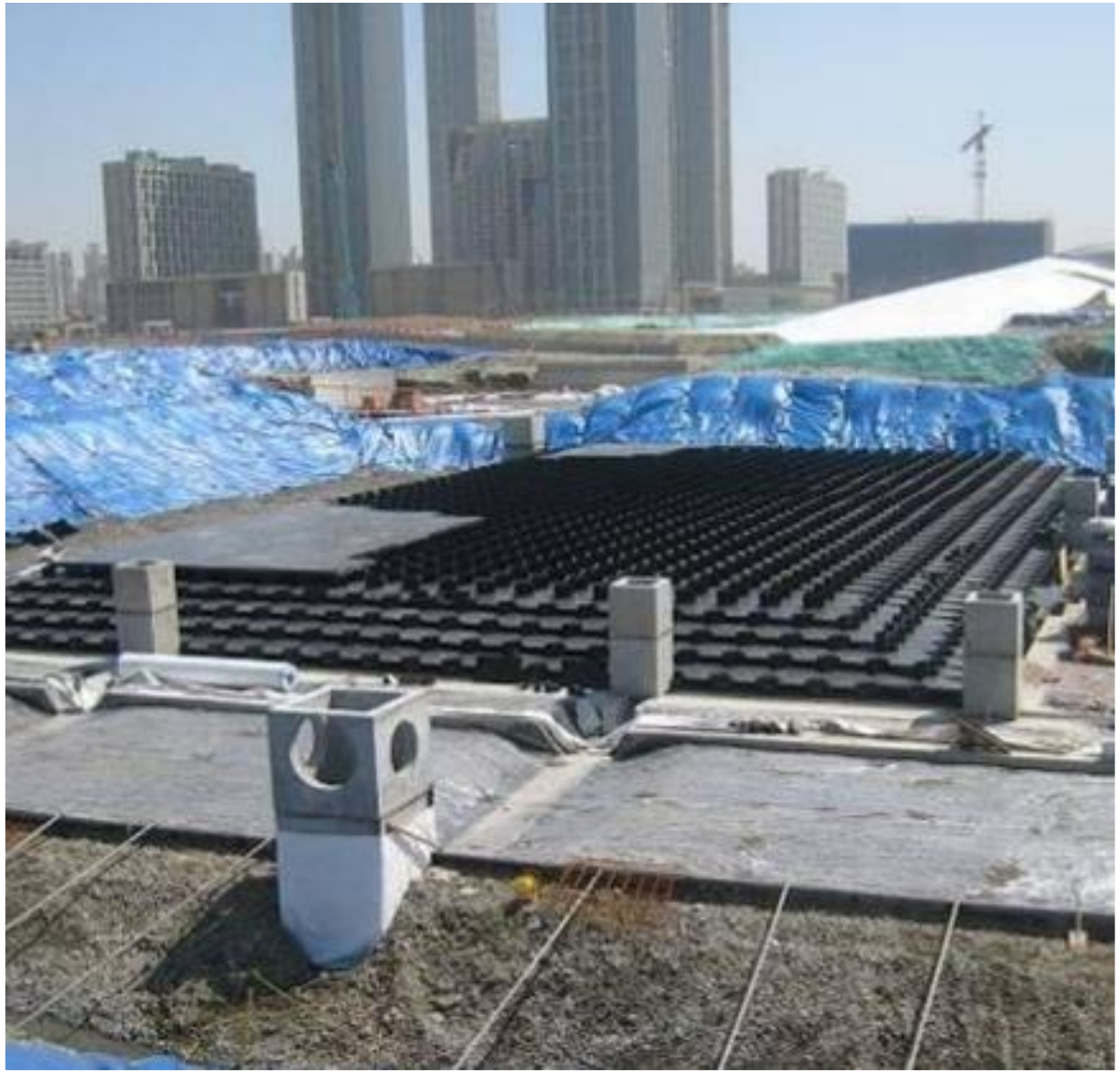

Rainwater harvesting cells beneath the park

London, England

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Green network
Private accessible
Public accessible
Public amenity
Green Infrastructure
Allotment 1
Extensive green roof 40
Intensive green roof 9
Modular planter 4
Open space 8
Planter 17
Pocket parks 1
Vertical greening 10
Habitat Features
Tree
Leaflet | © OpenStreetMap © CartoDB
BLOOMSBURY
MARYLEBONE
FITZROVIA
PADDINGTON
SOHO
ST GILES
HOLBORN
TEMPLE
SOUTHWARK
KNIGHTSBRIDGE
BELGRAVIA
CITY OF WESTMINSTER
GROSVENOR
CROWN ESTATE
LONDON
Marylebone Road
Harrow Road
Oxford Street
Piccadilly
Strand
Victoria Embankment
Park Lane
Whitehall
Kingsway
Aldwych
Theobalds Road
High Holborn
Bayswater Road
Sussex Gardens
Praed Street
Browning's pool
The Long Water
The Round Pond
The Serpentine
Huntress Fountain
Joy of Life Fountain
Saint James's Park Lake
Shakespeare Fountain

Wild West End | London, England

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Los Angeles, CA

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Community-driven green infrastructure in Pacoima

Bradley Green Alley | Los Angeles, CA

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Green Alley Precedents

Community-driven green infrastructure in Pacoima

Bradley Green Alley | Los Angeles, CA

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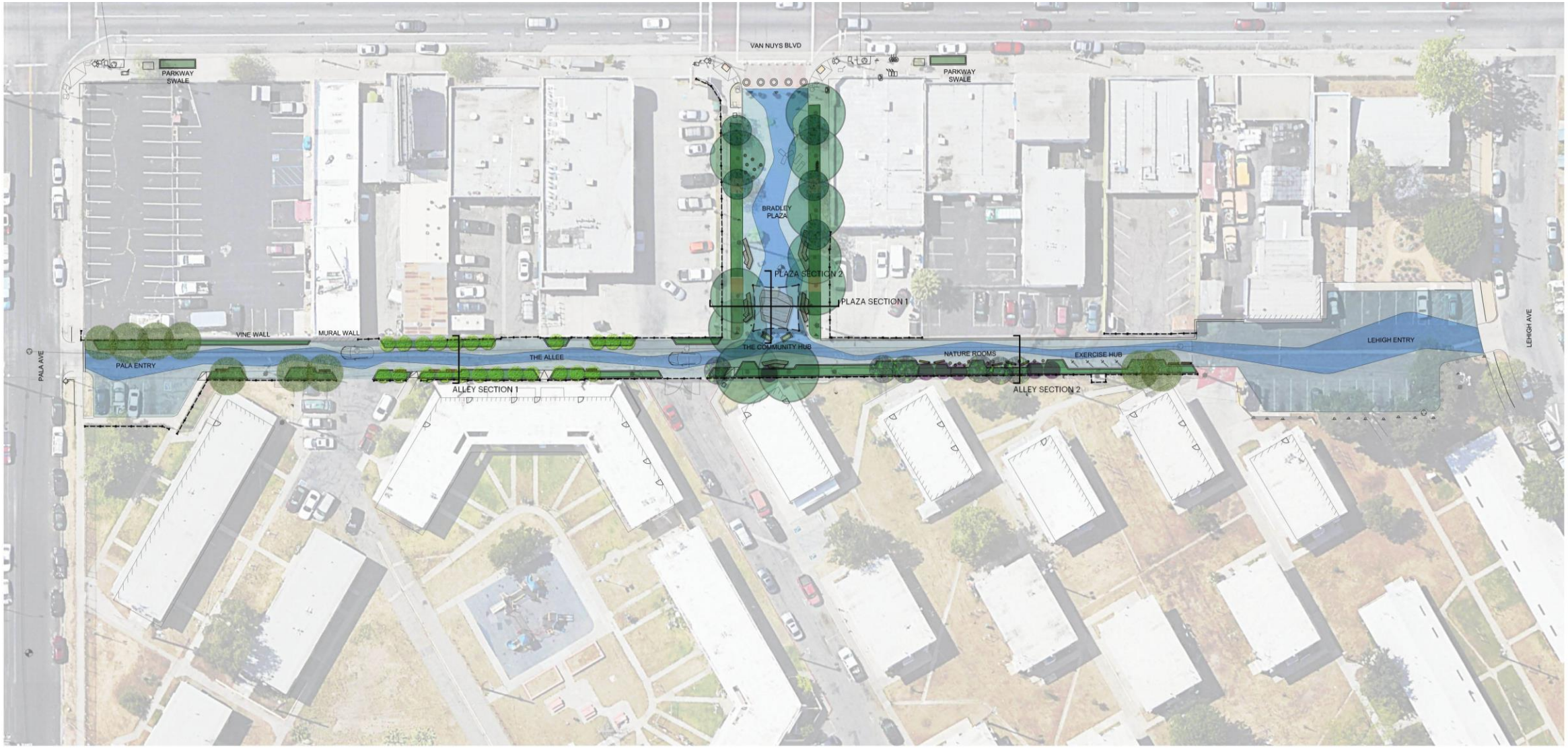

Community-driven green infrastructure in Pacoima

Bradley Green Alley | Los Angeles, CA

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Thank You!

vincent.lee@arup.com
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