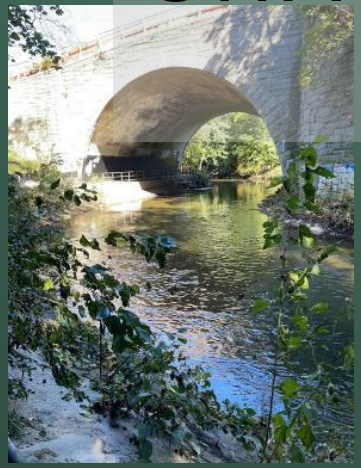
USGS
science for a changing world
July 2024

Urban Waters:
SWAT+ modeling of Green Infrastructure in the Bronx River Watershed



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Kristina Masterson

1915 Bronx Parkway Commission map.

U.S. Department of the Interior
U.S. Geological Survey

Purpose & Objectives

- Develop a SWAT+ modeling framework to evaluate the effectiveness of existing GI in the Bronx River watershed for mitigating hydrologic and qualitative impacts to sediment and nutrient transport during storm events
- Develop hypothetical scenarios to study where additional GI may be beneficial
- Apply lessons learned from Bronx River SWAT+ simulation to provide a more generalized assessment of the effects and benefits of GI in the Harlem River watershed.

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Study Area

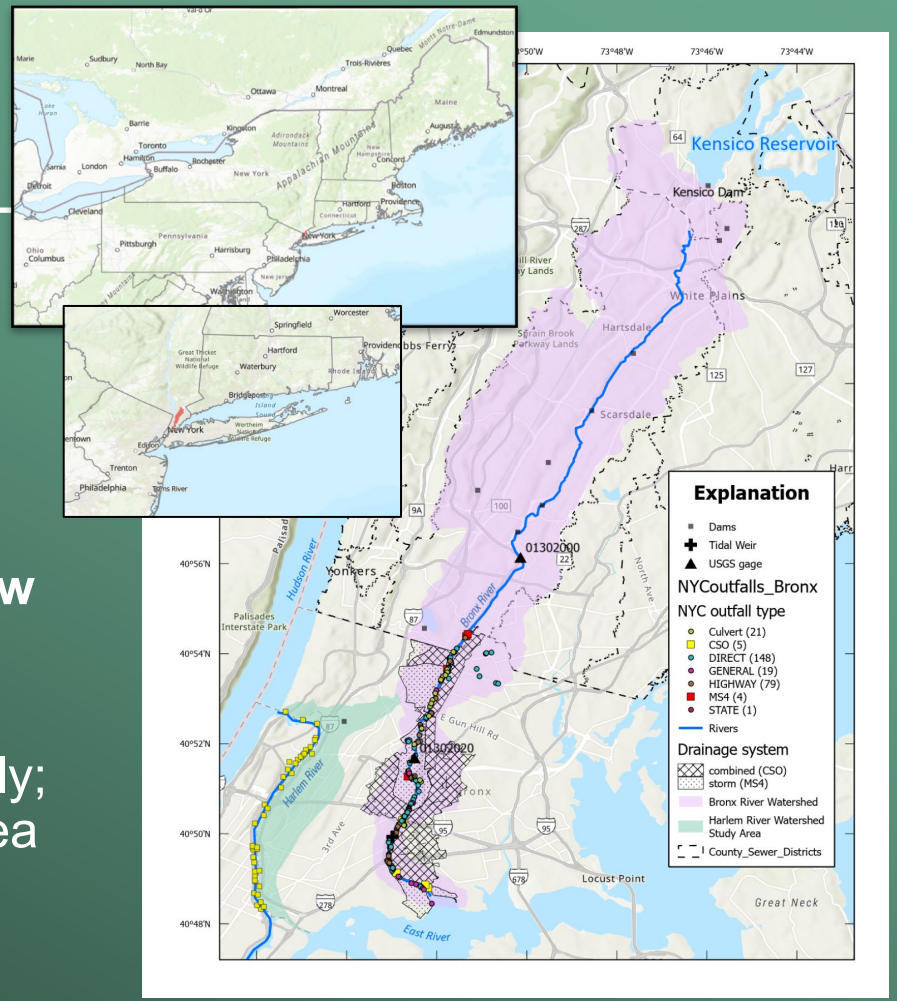
Bronx River Watershed

Soil and Water Assessment (SWAT+) Model Area

Bronx River watershed drainage area 115 km^2

Leverage USGS gage 01302020 on Bronx River -- monitored streamflow since WY 2008

Future: Harlem River (Bronx County only; Harlem River Watershed drainage area 11.9 km^2)



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USDA Land use – 2022 Cropland Data Layer

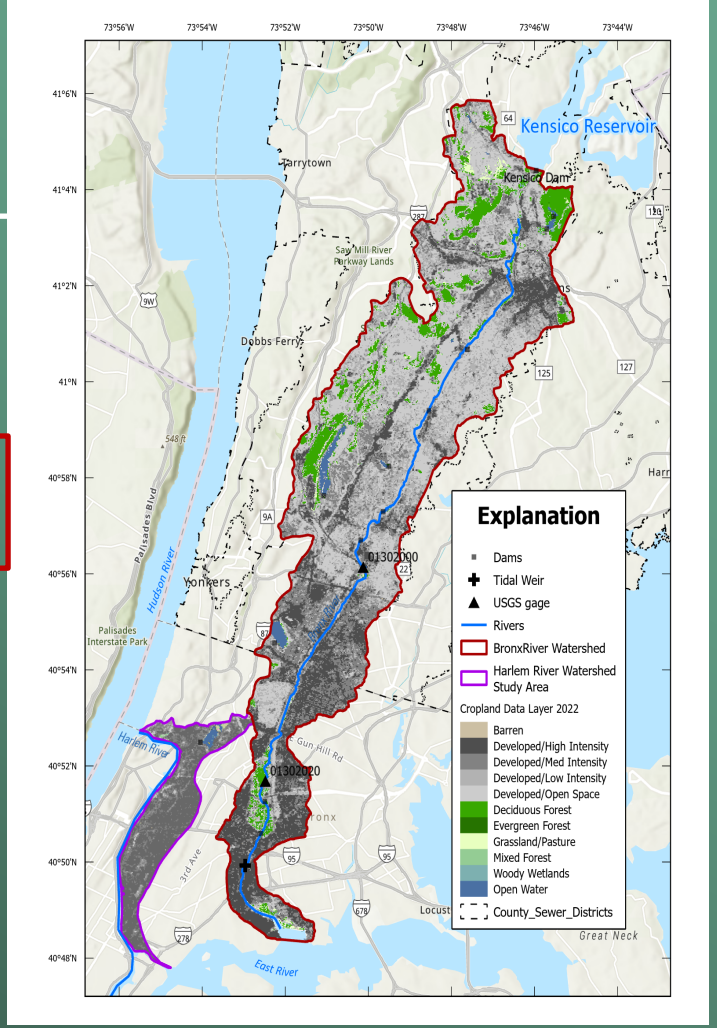
Urban Land use

Bronx River – 90%

Harlem River – 97%

Land use	Bronx River	Harlem River
	Percentage of watershed (%)	
Alfalfa	0.01	0.03
Barren	0.06	0.17
Corn	0.01	0.02
Deciduous Forest	7.79	0.23
Developed/High Intensity	17.00	63.62
Developed/Low Intensity	21.84	6.08
Developed/Medium Intensity	21.90	24.31
Developed/Open Space	28.56	2.73
Evergreen Forest	0.11	0.01
Fallow/Idle Cropland	0.01	--
Grass/Pasture	0.63	0.14
Herbaceous Wetlands	0.10	0.10
Mixed Forest	0.62	0.04
Open Water	1.00	1.98
Other Hay/Non-Alfalfa	0.02	--
Pears	--	0.01
Rye	0.00	0.01
Shrubland	0.04	0.44
Soybeans	0.00	0.01
Squash	--	0.01
Woody Wetlands	0.29	0.05

Land use data from USDA National Agricultural Statistics Service Cropland Data Layer. 2022. Published crop-specific data layer (Online). Available at https://nassgeodata.gmu.edu/CropScape/ (accessed January 2, 2024). USDA-NASS, Washington, DC.



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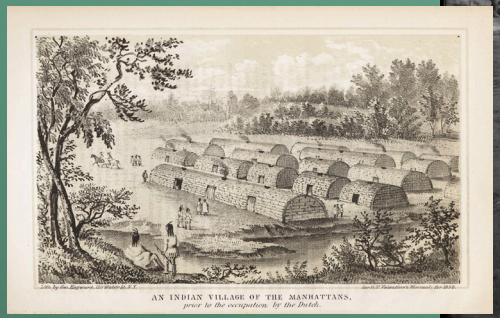
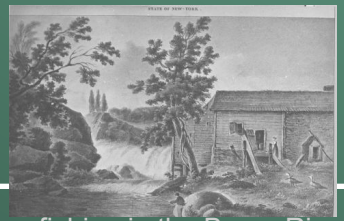
History of development of the Bronx River

- Indigenous Americans lived along this part of eastern NY.
- Within the first European settlement, there was a watermill in 1666.
- By the 1840s, railroad construction turned the area into an industrial corridor.



- By 1895, Bronx River was "promiscuous dumping grounds for refuse of all kinds."
- Westchester County built the Bronx River Valley Sewer in 1905.



[History — BRPRC (bronx-river.com)](bronx-river.com)

Boys fishing in the Bronx River, Bronx, N.Y., 1899.
New York Historical Society | Digital Collections (nyhistory.org)

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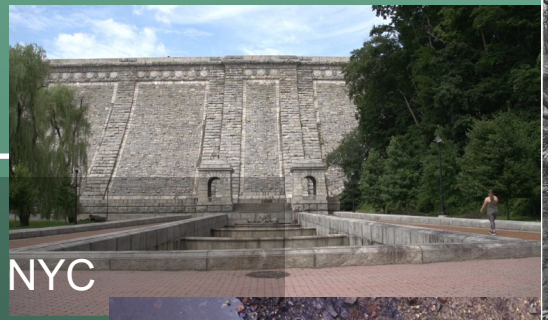
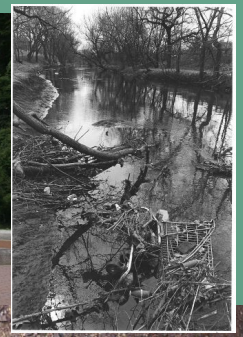
History of development of the Bronx River





- 1917 - Kensico Dam was completed.
  - Provides 30 billion gallons of drinking water to NYC
- 1925 - Bronx River Parkway - America's first public automobile parkway - was completed.
- 1974 - The Bronx River Restoration Project was formed.
- 1997 - The National Guard was brought in to remove vehicles from the Bronx River.
- 2010 - NYCDEP released the NYC Green Infrastructure Plan .
  - Requires Runoff from 10% of impervious surfaces in combined sewer watersheds through detention and infiltration source controls to be managed over 20 years

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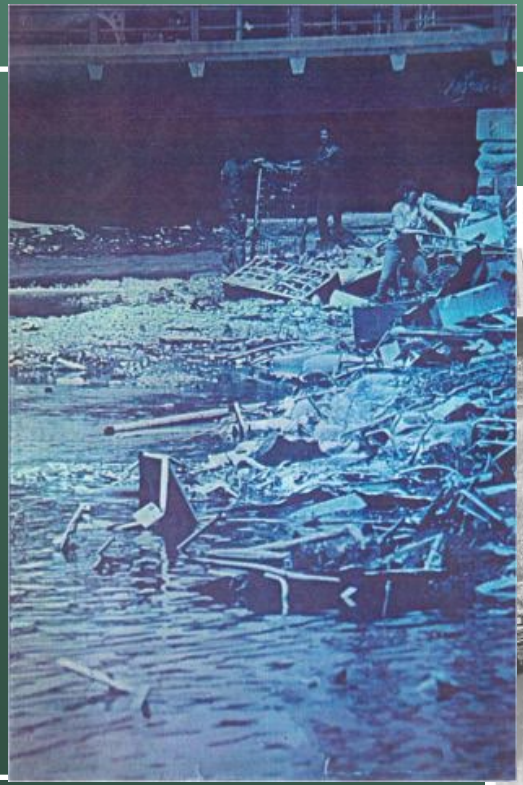
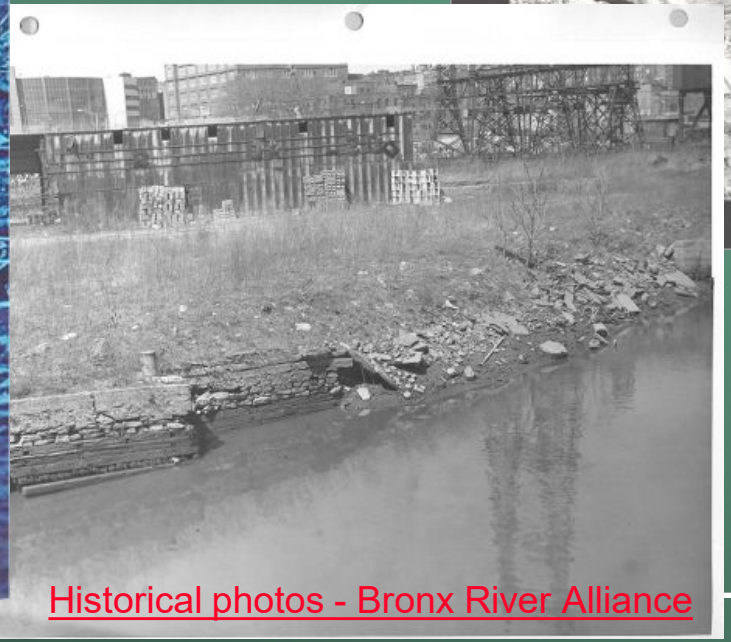
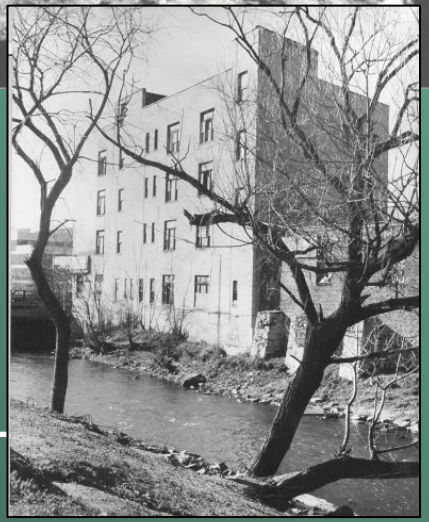
1970s Bronx River Restoration







Historical photos - Bronx River Alliance

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Bronx River Watershed

Green Infrastructure

- New York City Department of Environmental Protection Green Infrastructure
  - GI has been around (planned) since 2010
- The Bronx River watershed has 500+ constructed GI
- Majority of GI are infiltration basins (concrete tops), bioswales, and rain gardens

Green Infrastructure within Bronx and Harlem River watersheds

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Green infrastructure

Green Infrastructure	FREQUENCY	area (m²)
Blue Roof	4	2,303
Cistern	1	2.6
Combined Blue/Green Roof	2	372
Detention System	14	24,146
Detention System (Connected to Sewer)	24	553
Drywell	11	547
Engineered Soil Tree Pit	7	536
Green Roof	104	143,834
Multiple GI Components	11	28,754
Permeable Pavers	207	27,209
Porous Asphalt	40	14,010
Porous Concrete	32	6,816
Rain Garden	286	35,127
Rainwater Harvesting	2	64
Rooftop Farm	5	13,645
ROW Infiltration Basin with Combination of Concrete and Grass Top	187	1,435
ROW Infiltration Basin with Concrete Top	3820	25,770
ROW Infiltration Basin with Grass Top	977	6,097
ROW Median	1	107
ROW Porous Concrete	235	25,360
ROW Structural Soil	4	38
ROW Subsurface Pipe/Broken Stone	5	43
Right of Way Bioswale	7228	44,973
Right of Way Enhanced Bioretention	5	34
Right of Way Greenstrip	387	1,563
Right of Way Rain Garden	245	1,555
Right of Way Stormwater Greenstreet	155	10,435
Subsurface Detention System	85	15,260
Subsurface Pipe	6	436
Subsurface Pipe/Broken Stone	37	4,446
Subsurface Storage	192	24,110
Synthetic Turf Field Storage Layer	99	144,288
TOTAL		603,867

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Field visit



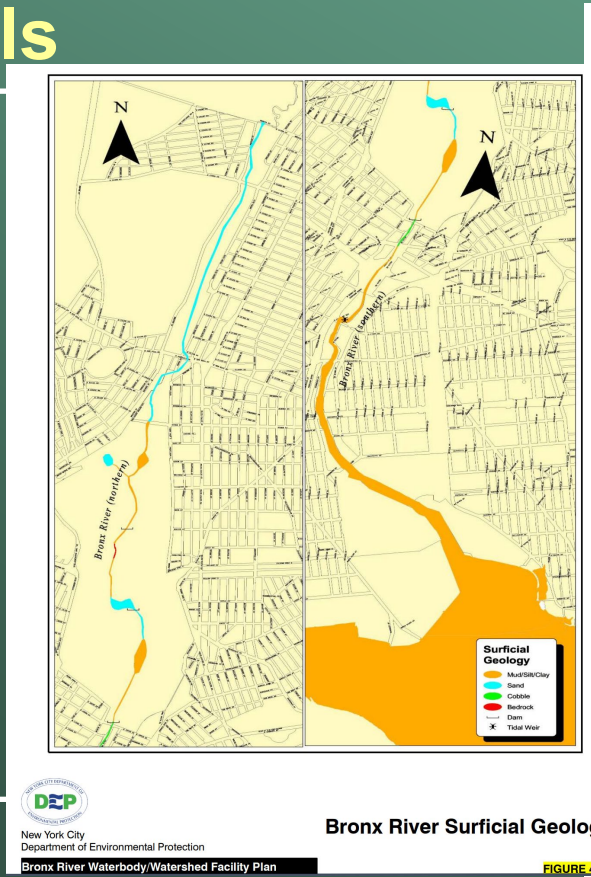






USGS gage at Botanical Gardens

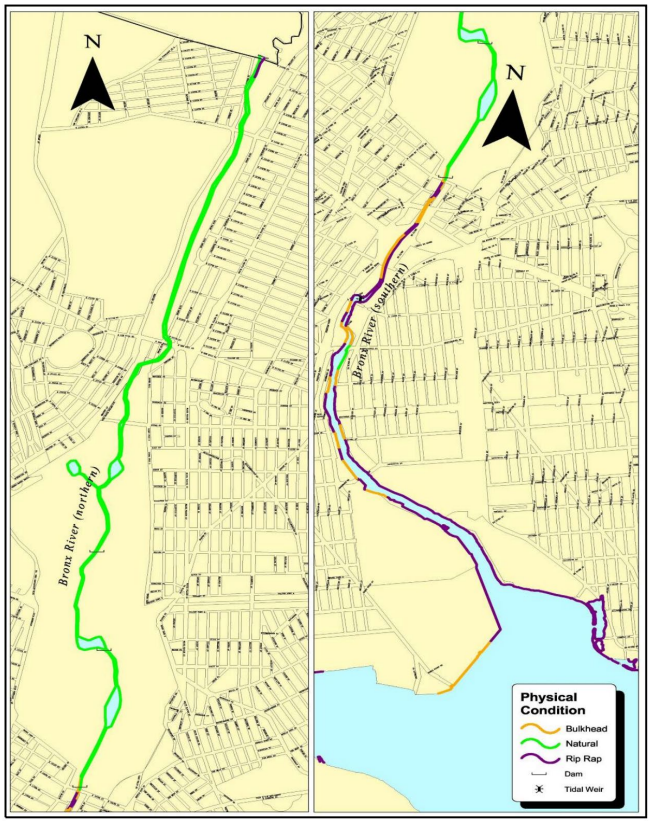
Stream bottoms and sides have different materials



New York City
Department of Environmental Protection
Bronx River Waterbody/Watershed Facility Plan

Bronx River Surficial Geology

FIGURE 4-13



Bronx River Existing Shoreline

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Select Modeling Input Data

Data Item	Data Source
Climate (Precipitation, Temperature, Relative Humidity, Wind Speed)	NOAA National Centers for Environmental Information (https://www.ncei.noaa.gov/)
Combined sewer operations and overflows (CSO) Concentrated animal feeding operations (CAFO) Wastewater facility locations and effluent flow and loads Water use	NYSDEC
Elevation data**	1-meter DEMs from: FEMA, 2019; USGS, 2020 (https://gis.ny.gov/elevation/)
Land cover data (based on tax parcels)	MapPLUTO Westchester County GIS
Septic	Westchester County Septic Pump Out layers 2018-2022
Soils	Soil Survey Geographic Database (SSURGO)
Streams	National Hydrography Dataset Plus
Streambed material	NYCDEP
Streamflow/peak flow	USGS NWIS
Road Lines	TIGER/Line Shapefiles (census.gov)
Wetlands/ponds	U.S. Fish and Wildlife Service National Wetlands Inventory (https://www.fws.gov/wetlands/)

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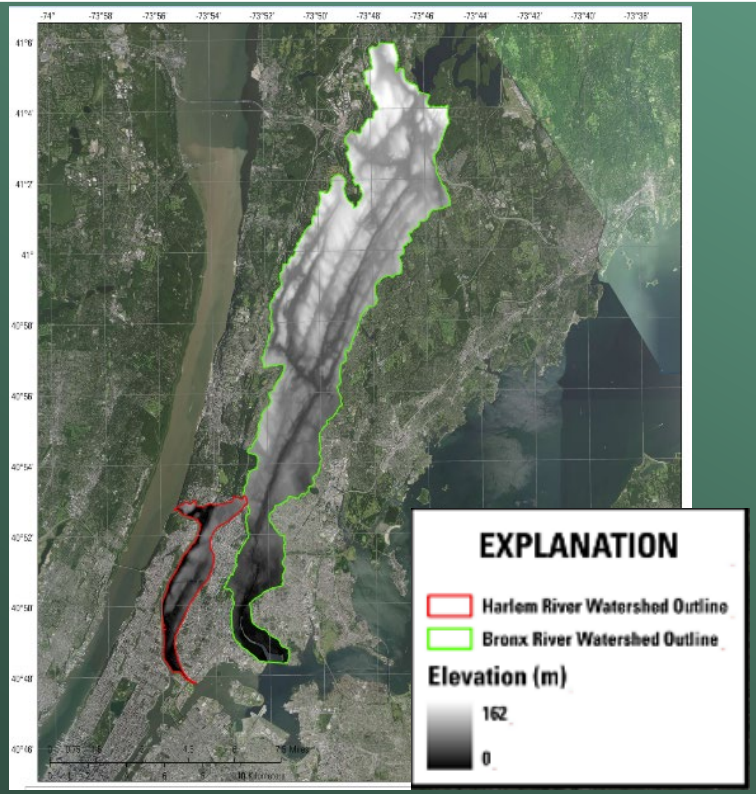
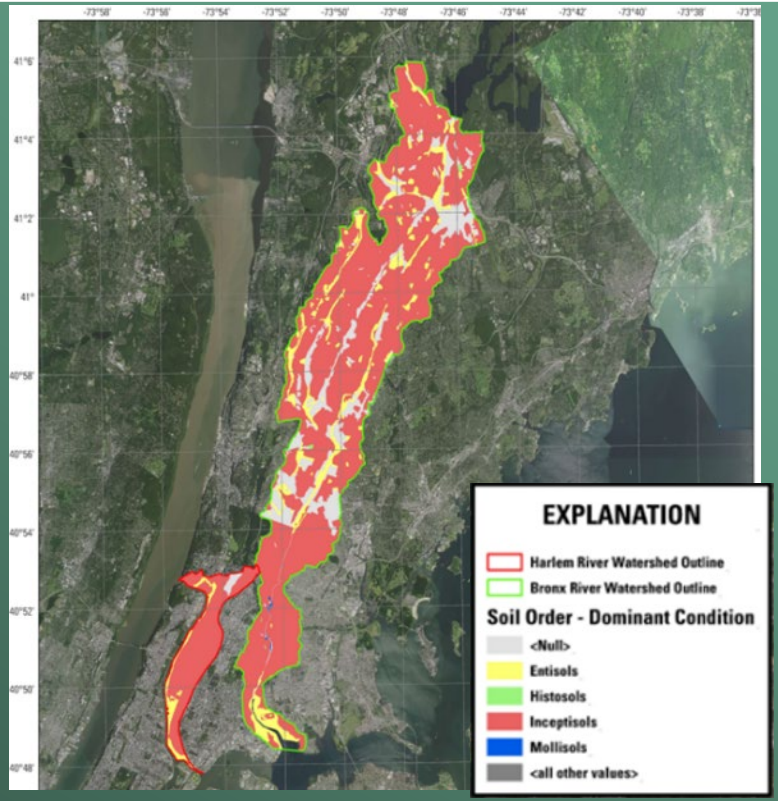
- **Elevation**

(merged USGS and FEMA 1m)



- **SSURGO soils**



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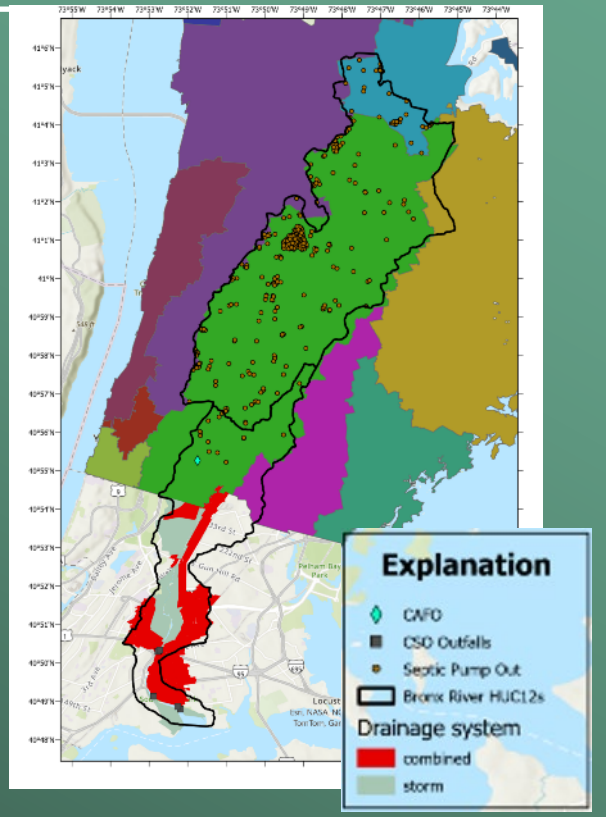
Select Modeling WQ Input Data Needs

Nutrient Sources

- Atmospheric Deposition
- Confined Animal Feeding Operation (CAFO)
- Combined Sewer Overflows (CSOs)
- Municipal Separate Storm Sewer System (MS4s)
- Fertilizer inputs
- Septic Systems



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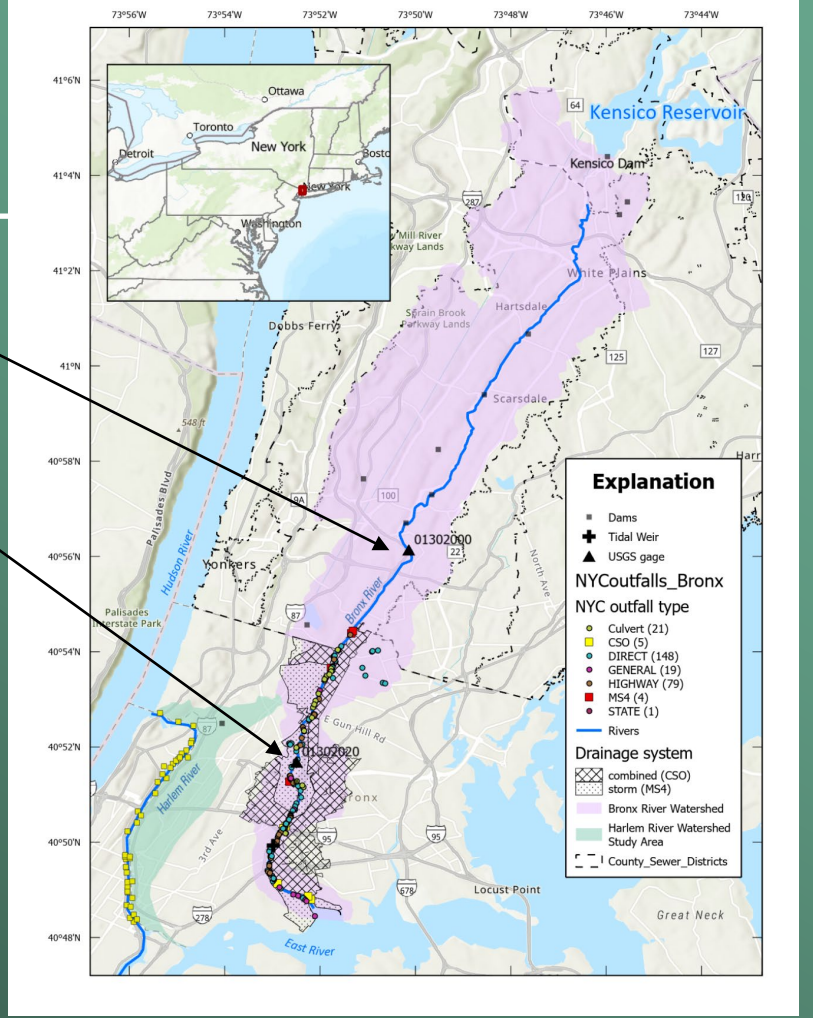
Modeling Q Calibration Data

Data Item	Data Source
Streamflow	USGS NWIS 1. USGS 01302000 BRONX RIVER AT BRONXVILLE NY 2. USGS 01302020 BRONX RIVER AT NY BOTANICAL GARDEN AT BRONX NY

- 277 outfalls of unknown flow volumes and timing in Bronx County alone



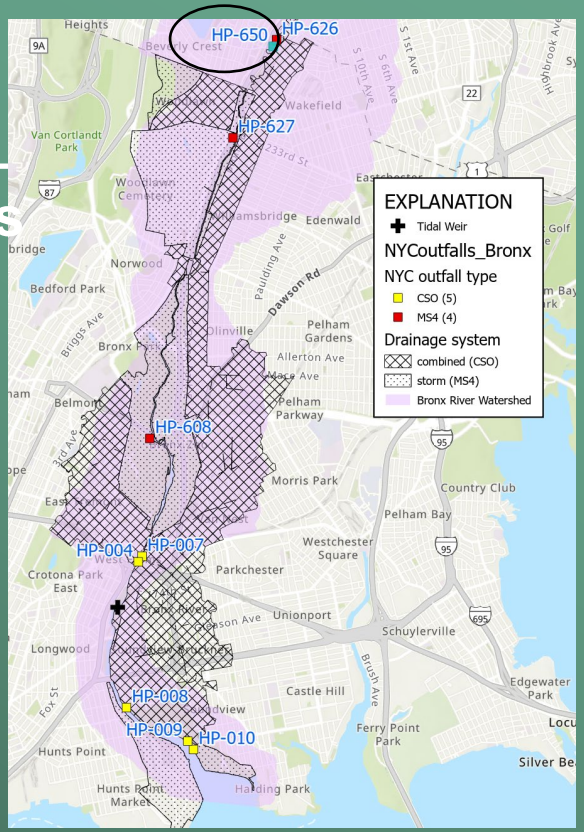
Anticipated Q Calibration Issues

- Will need to estimate wet and dry weather flows
  - CSOs are all downstream of 01302020

Table 3-8. Bronx River Discharge Summary for Baseline Condition (1, 2, 3, 4, 5)

Outfall	Discharge Volume (MG)	Percentage of CSO Volume	Number of Discharges
HP-004	100	10	56
HP-007	88	9	21
HP-008	4	0.4	17
HP-009	814	81	51
HP-010	0.6	0(4)	1
Total CSO	**1,006**	**100**	**NA**
Total Separate Storm Sewer System Overflows	**3,298**	**100**	**NA**

Notes: (1) Baseline condition reflects design precipitation record (JFK, 1988) and sanitary flows projected for year 2045
(2) Totals may not sum precisely due to rounding.
(3) Hunt Point Operating Capacity 259 MGD
(4) The model predicted only a trace discharge from HP-010, an estimated 0.06% of the total CSO volume.
(5) Represents total discharge from MS4s HP-608, 621, 626, & 627.



From Bronx River Waterbody/watershed Facility Plan Report, NYCDEP 2010

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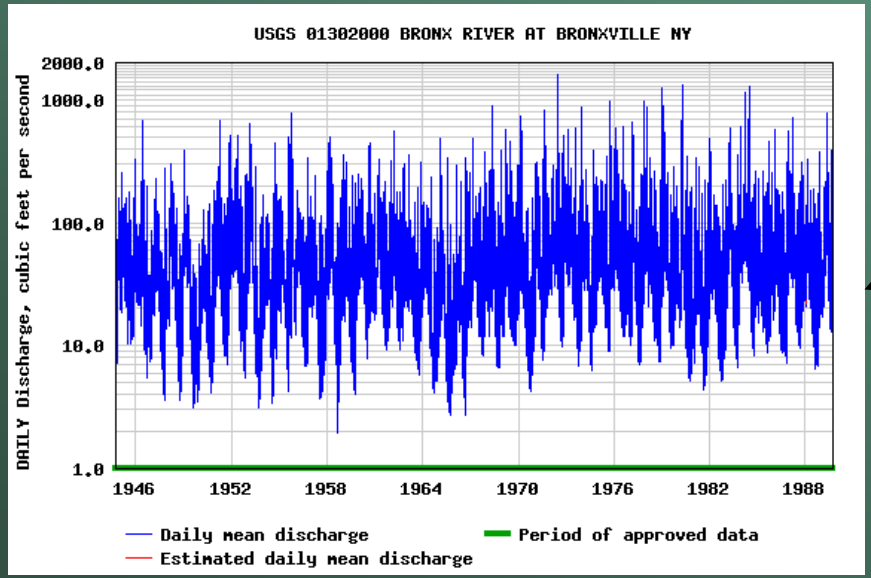
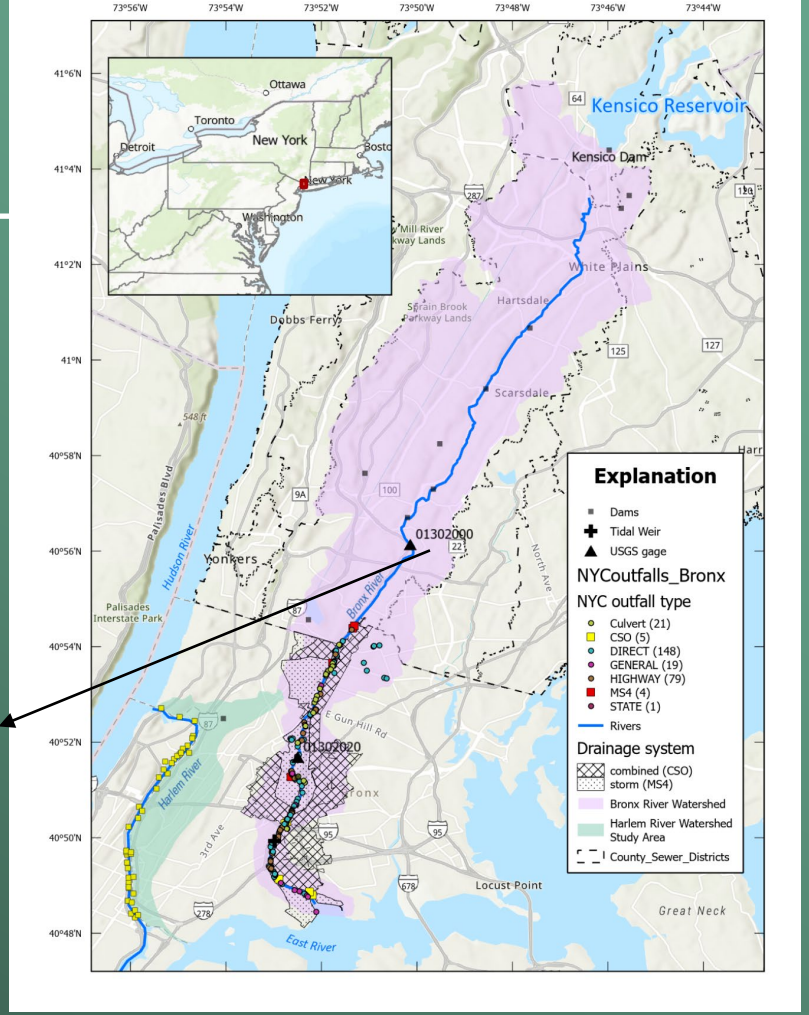
Anticipated Calibration issues

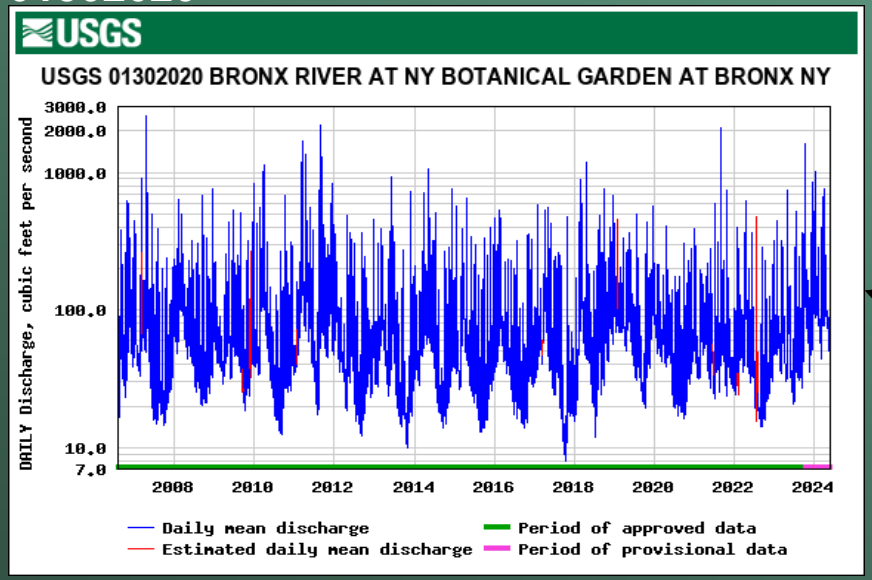
- Calibrate Q at the older Bronx River gage at Bronxville
  - Will need to consider LU change

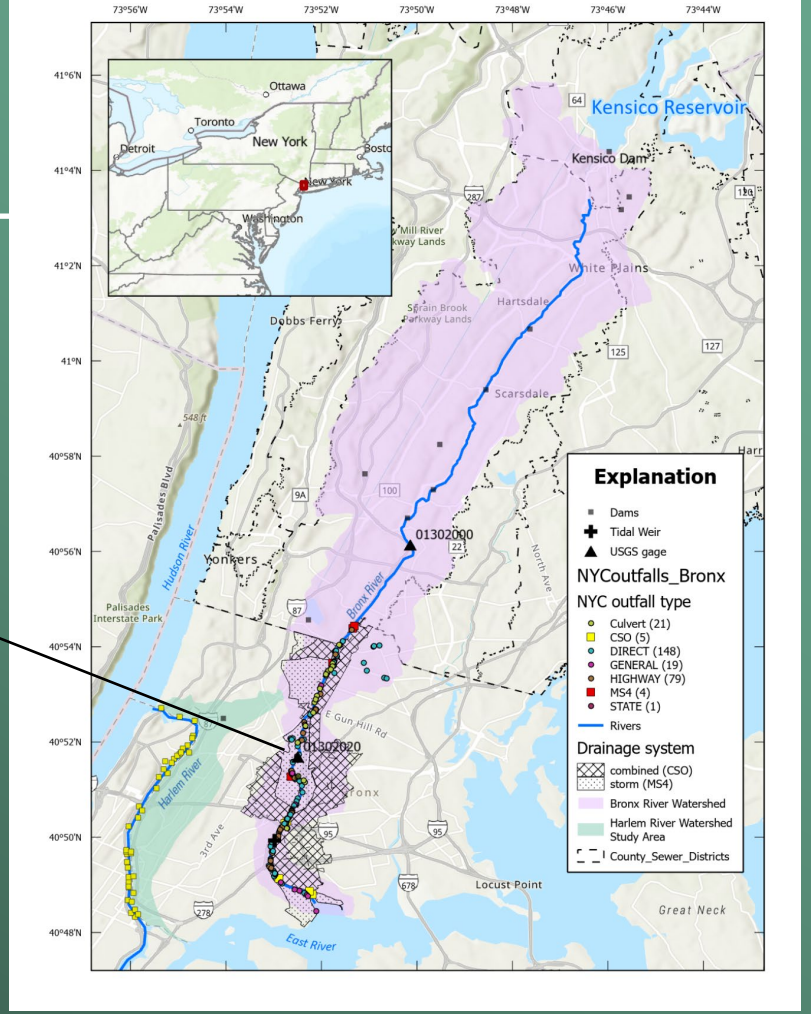




Anticipated Q Calibration issues

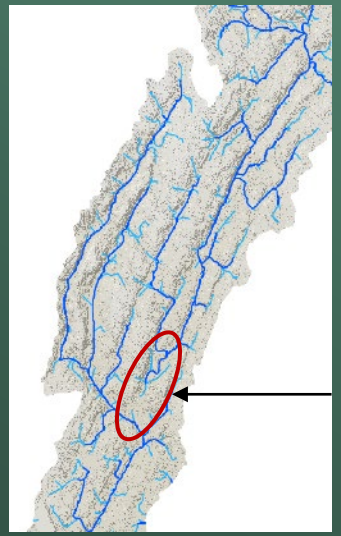
- Multiple ungaged outflows (277) above 01302020

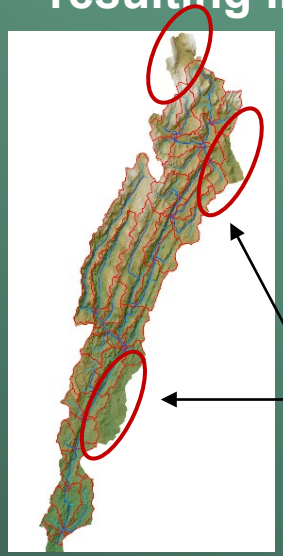




Model building: Subbasin delineation

- **Challenge: adequate subbasin delineation with a 1-m DEM**
  1. **Took 17 hours to delineate subbasins**
  2. **Stream threshold had to be very small – resulting in lots of streams**





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Attempted DEM resolutions

- Ran model at 1m DEM resolution, burned DEM prior to uploading into QSWAT+, and did not attempt to further burn with QSWAT+ interface.
- Ran model at 1m DEM resolution and did not burn flowlines into DEM prior to QSWAT+
- Burned flowlines using QSWAT+ for both previously listed scenarios.
- For all scenarios, reduced channel and stream cell count/area. Reducing cell count/area improved continuous flow, but often resulted in too many sub-basins (100+).
- For all scenarios increased stream depth for burning in the QSWAT+ parameters section.
- Ran 10m DEM as above, but still had flat elevation areas missing from subbasin delineation.
- Currently extending and redirecting flowlines to areas w/o subbasins (outside delineation)

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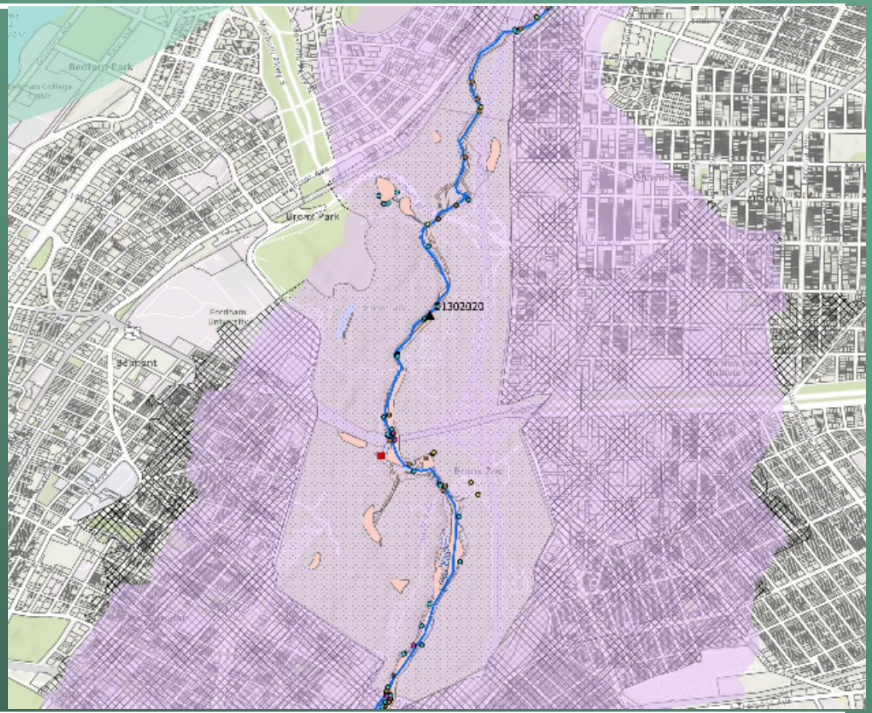
HRU definition: Urban field-scale resolution?

- Tax parcel data available for New York State.
- Results in 75,832 HRUs
- Manually manipulated
  - Lots of urban open space → FRSD
  - Included different transportation types
  - included green areas surrounding roads



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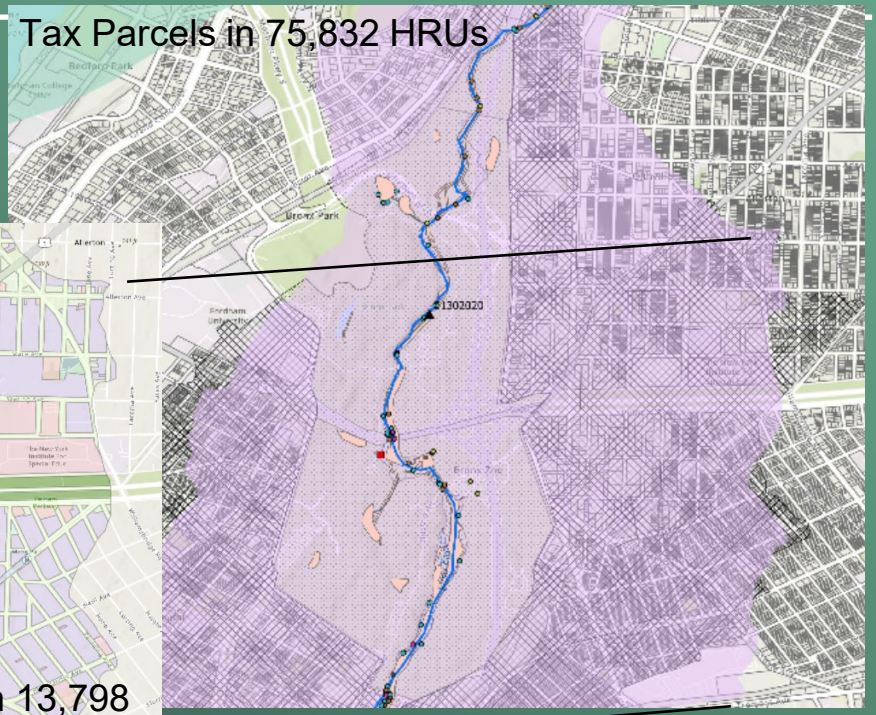
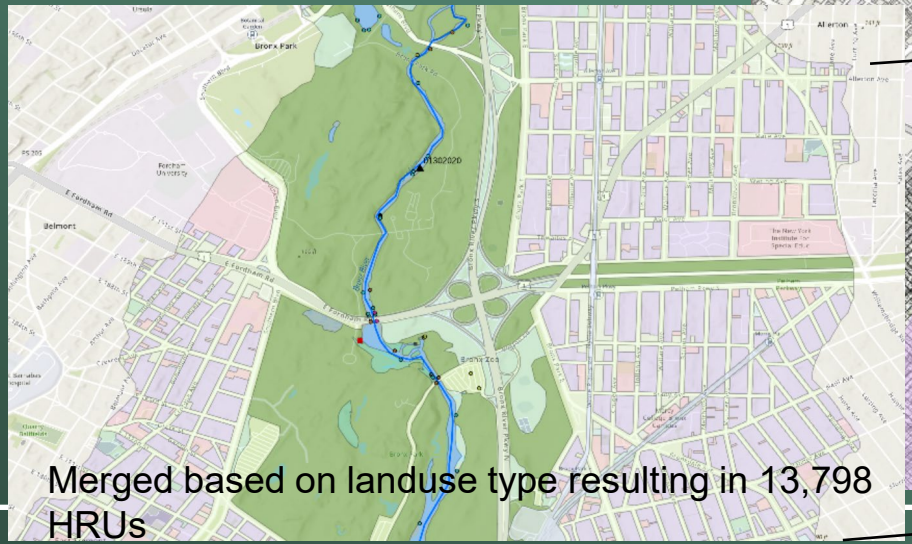
HRU definition: Urban field-scale resolution?

- Instead of each tax parcel (building) as an HRU, more equivalent to a city block





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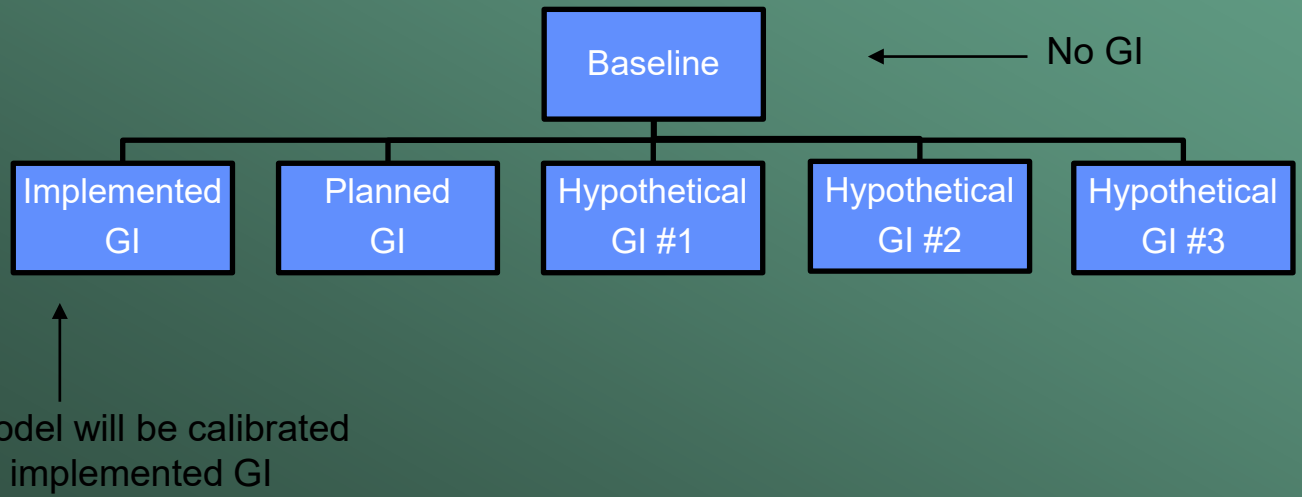
Scenario Examples

- **GI scenarios will be compared to a baseline scenario w/o GI**



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