Center for Advanced Research of Spatial Information

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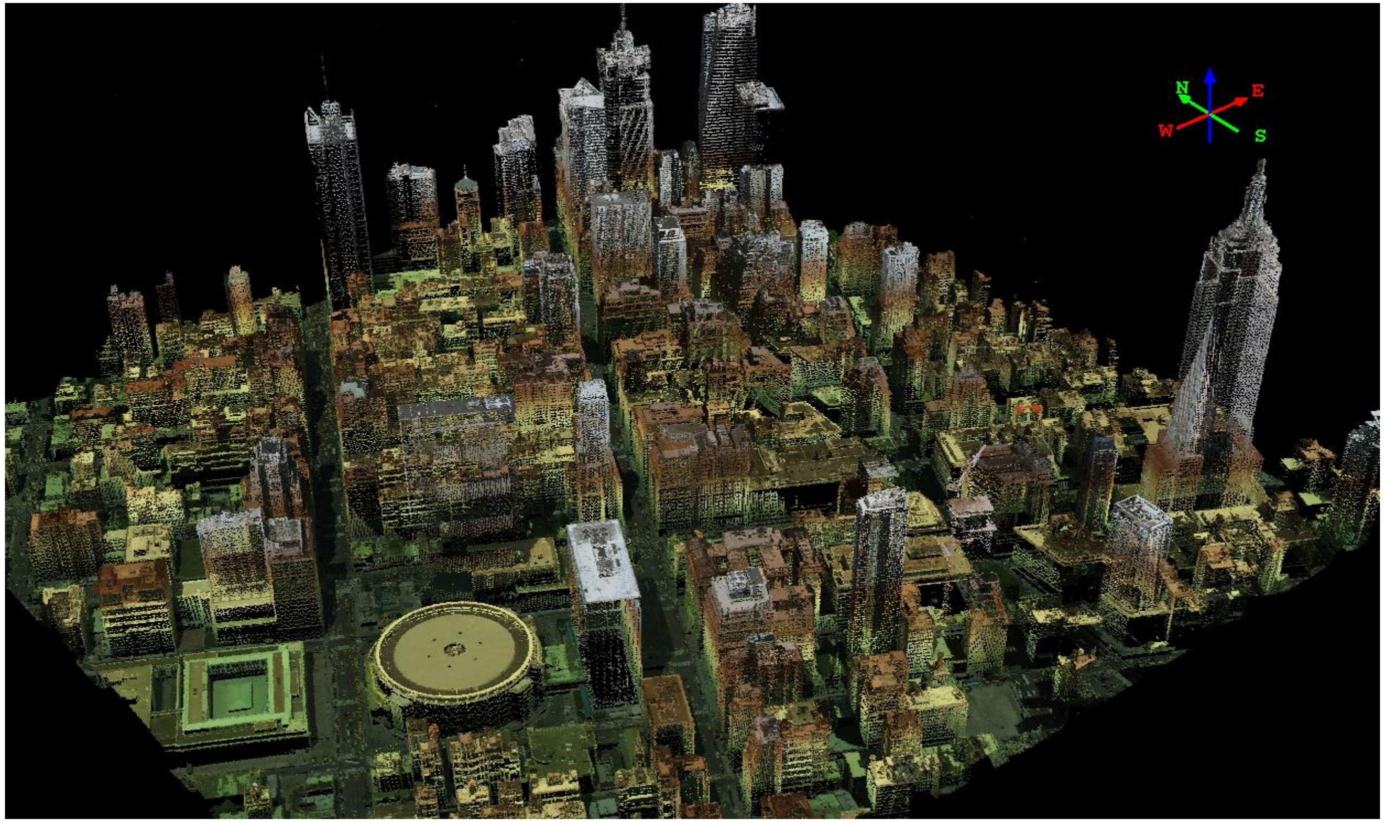
# Toward a NYC Digital Twin




*2010 LiDAR NYC*

SPARC Workshop on Digital Twins
Arizona State University
February 27-8, 2023

Professor Sean C. Ahearn, Director
Center for Advanced Research of Spatial Information
Hunter College – CUNY
New York New York

# Timeline for NYC Geo-Spatial Infrastructure

**Managed by CARSI**

- **1994** — NYC GIS steering committee
- **1996** — Photogrammetric Base-map 1ft orthos
- **2001** — *5 meter DEM*; Photogrammetric Base-map (update) 0.75ft true-orthos; *Conflation of core layers: Lion; COGIS; BIN assignments*
- **9 1 1**
- **2004** — Photogrammetric Base-map (update*) 0.5ft true-orthos; *Sewer digitization and logical network generation*
- **2010** — *30 cm DEM & DSM*; Solar Map & first high density Lidar acquisition 12-20 $ppm^2$ (2010-1)
- **2014** — *Water conversion*
- **2023** — Underground Infrastructure MUDDI data model & pilot; *Planimetric update and QA 2022-3*

*Update to the base-map (NYCMap) were made every 2-4 years going forward

http://carsi.hunter.cuny.edu/charting-ground-zero-the-role-of-geospatial-technology-a-retrospect-of-two-decades-past/

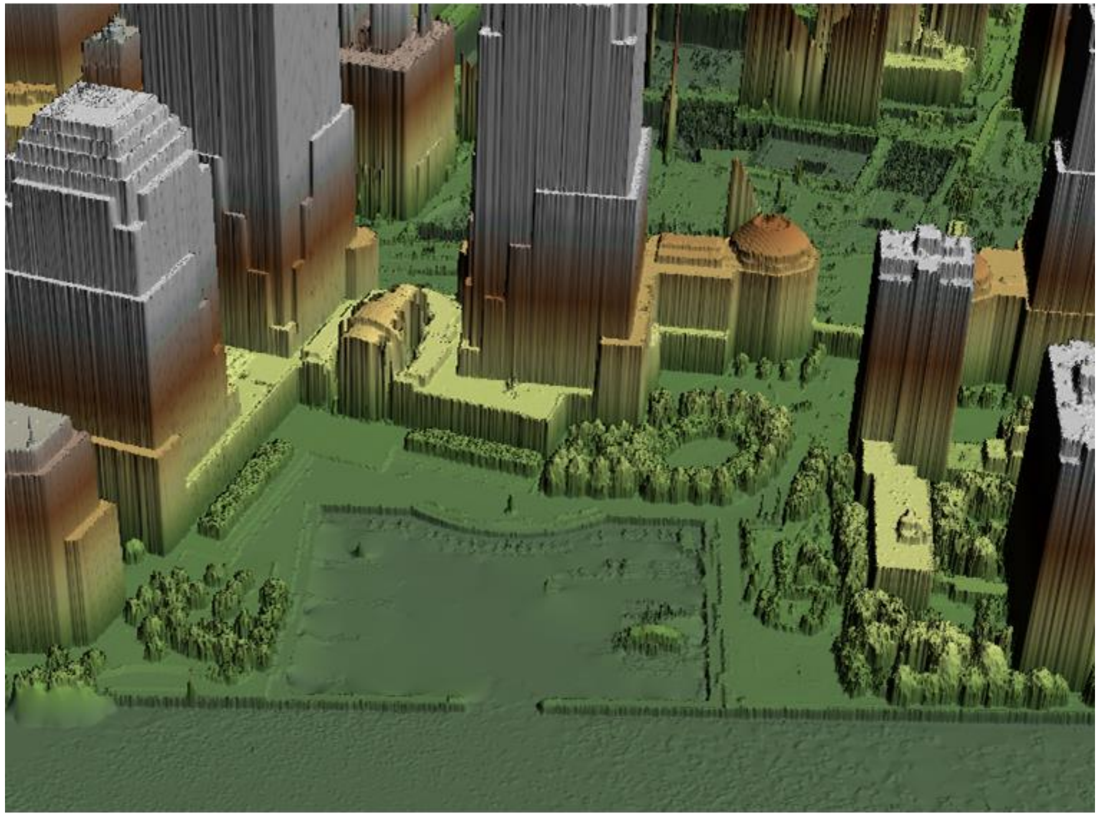
*Rarely does a single event help both to transform the value and use of a technology. The World Trade Center (WTC) Disaster was one of those events. What started out as an exclusive technology known to a few and used primarily by experts in the mapping sciences discipline, ended up playing a critical role in almost every aspect of the WTC disaster recovery. Firemen who had never worked a computer were using some of the most advanced mapping technologies ever deployed to log the location of victims and equipment found on the "pile". They would rely on images produced from an airborne laser-measuring device for command and control at Ground Zero. Building inspectors who had previously depended on paper and pencil to do their inspections were wirelessly tapping into one of the world's largest urban geographic databases (NYCMap) to retrieve and send the geographic and inspection information of damaged buildings. The immediacy of the moment would drive the innovation necessary to make these developments possible*. (History Channel: https://www.youtube.com/watch?v=o5uzSvk7K7k )

# Key data principles

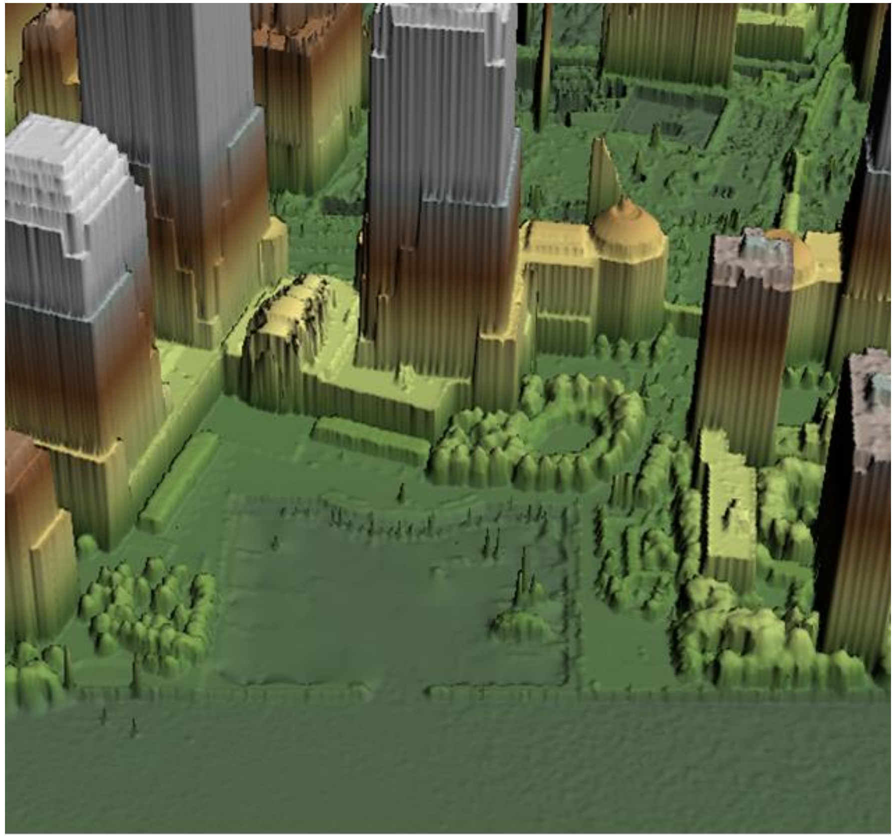
- Clear and comprehensive specification for acquisition and compilation of NYCMap
- City-wide agreement by relevant agencies on specification
  - What data solves which problem for a given Agency?
  - What is the spec that meets those requirements?
- Quality control performed by a separate/independent entity than the contractor for image acquisition and compilation
- Cross-validation of data sets to discover potential errors

# Example: LiDAR Resolution

***How many points per m² are enough?***



***30cm DSM***



***One meter DSM***

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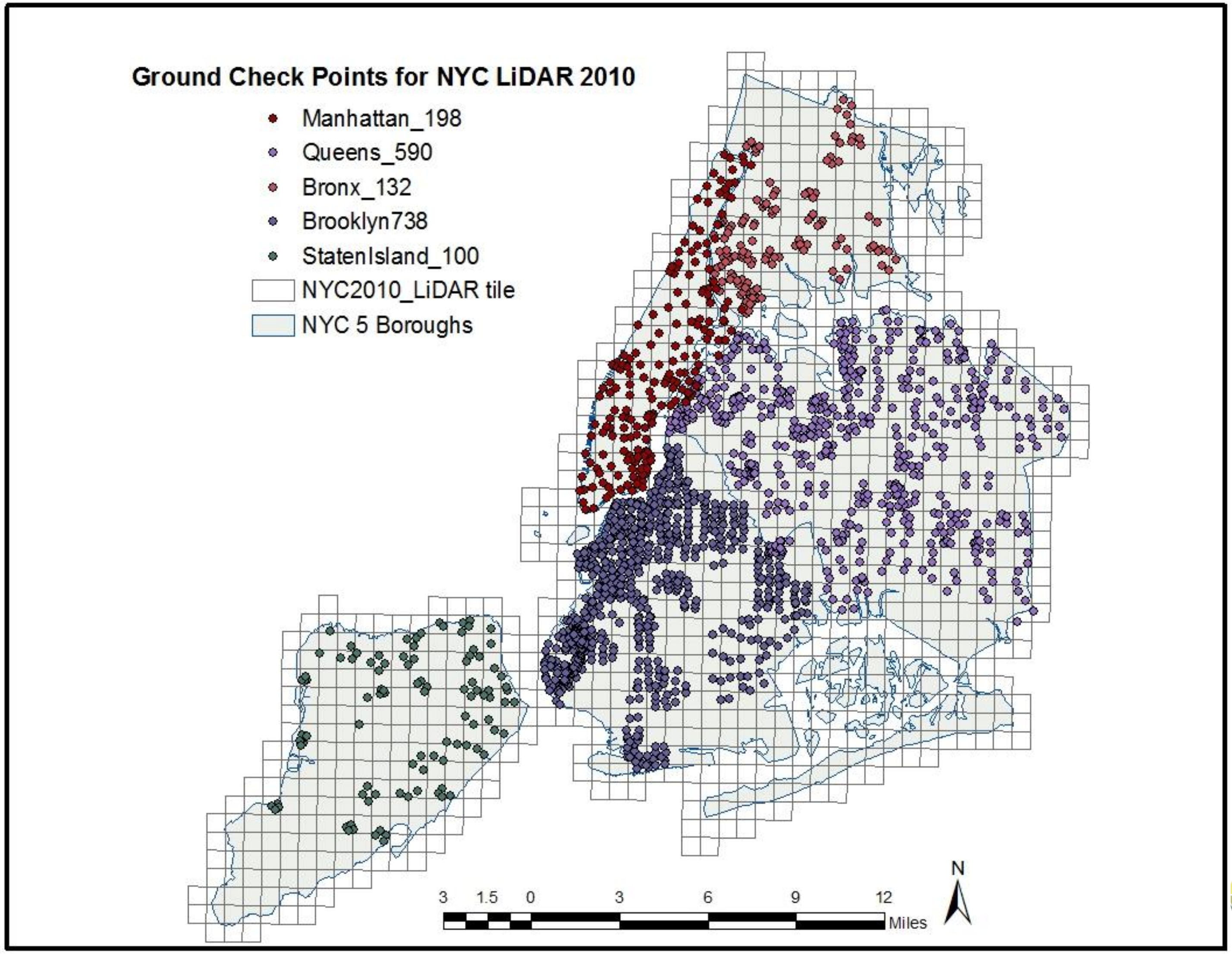
# Quality Control

## 1,758 GCPs for VERTICAL ACCURACY ASSESSMENT

**2 cm Survey Control Points**

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# Data Quality and the DT (cross-validation)

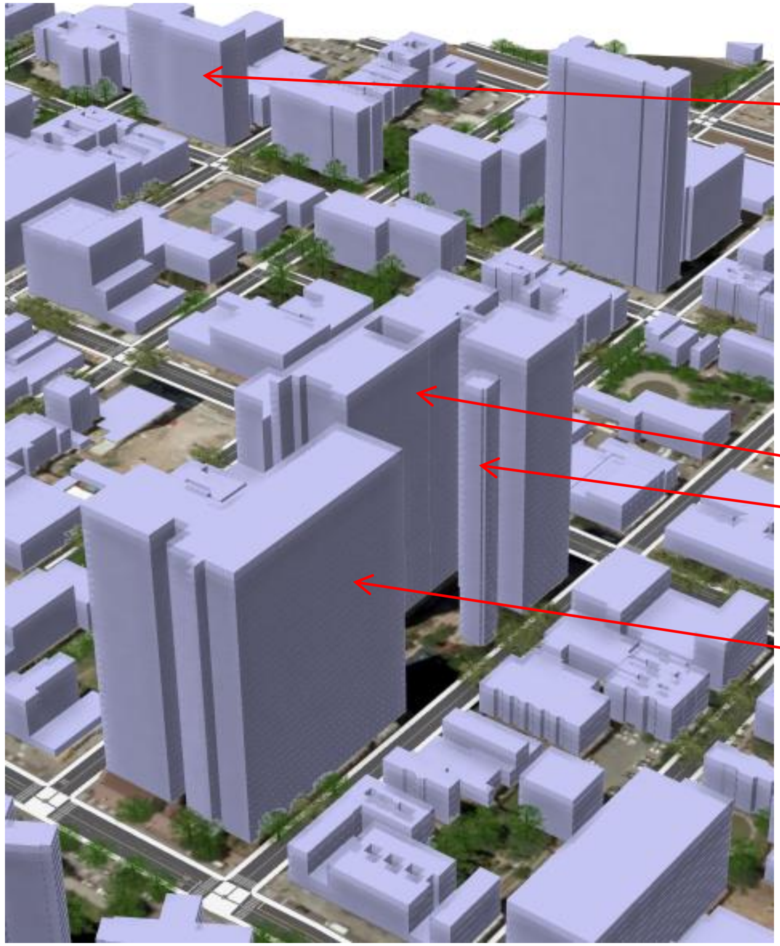
***Pluto*** *is one of the core NYC data sets on buildings derived from DOB & DCP data sources.*
*We did a cross validation of Pluto with LiDAR and discovered some important issues*

- **Square footage** in Pluto is assigned as an **aggregate** for each parcel
  - For parcels with multiple buildings there is a single value (disaggregate)

- The **number of floors** for a building is given by the part of the building that has the maximum height
  - Some buildings have two distinct towers with very differing height
  - Visualization using the maximum height will give a false view of buildings

- Our testing has show that the **reliability of the sqft** estimates for buildings is not high (use LiDAR for sqft estimates to flag possible issues)

# Number of Floors



Visualization based on Pluto # floors

Visualization using LiDAR  heights

# Topology: why it matters

- 2-D models
  - Geometry centered models only capture topology within a “layer”
  - Need object-based models where multiple geometries can be attributes
  - Need topological connections between interacting layers (e.g. sewer connection to house).
  - Shared geometry (cables sharing a duct)

- 3-D models: relative relationships between objects is essential (e.g. underground infrastructure)

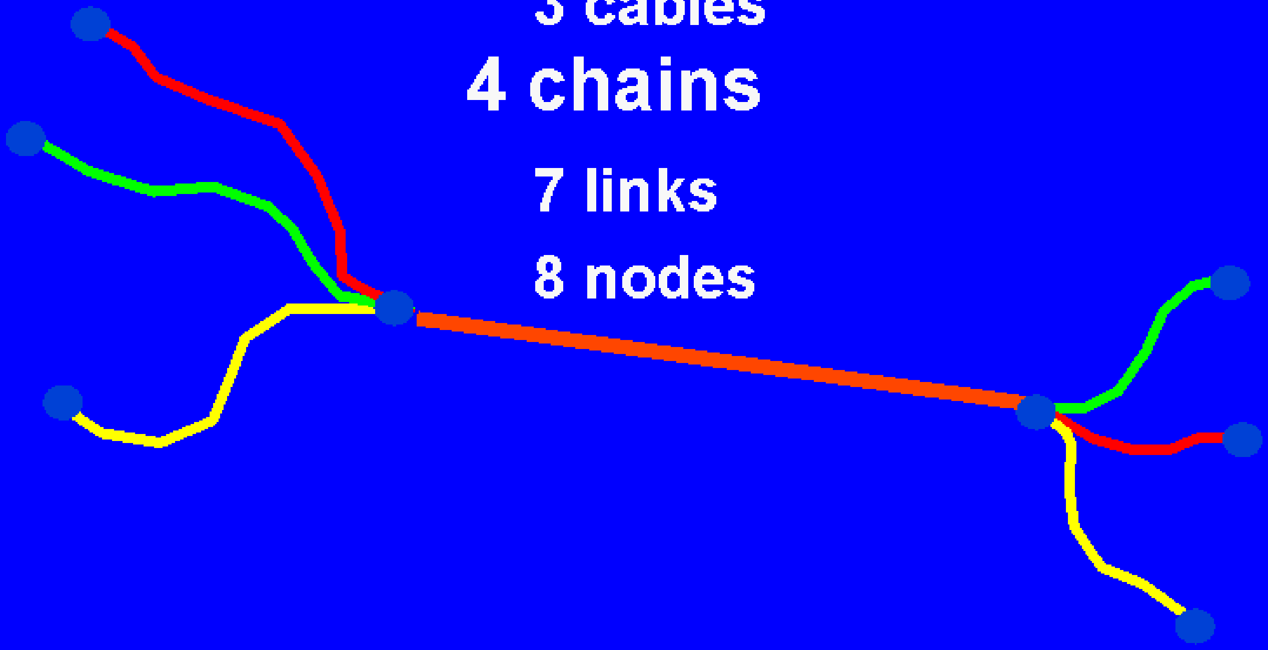
# Shared Geometry

**4 objects**

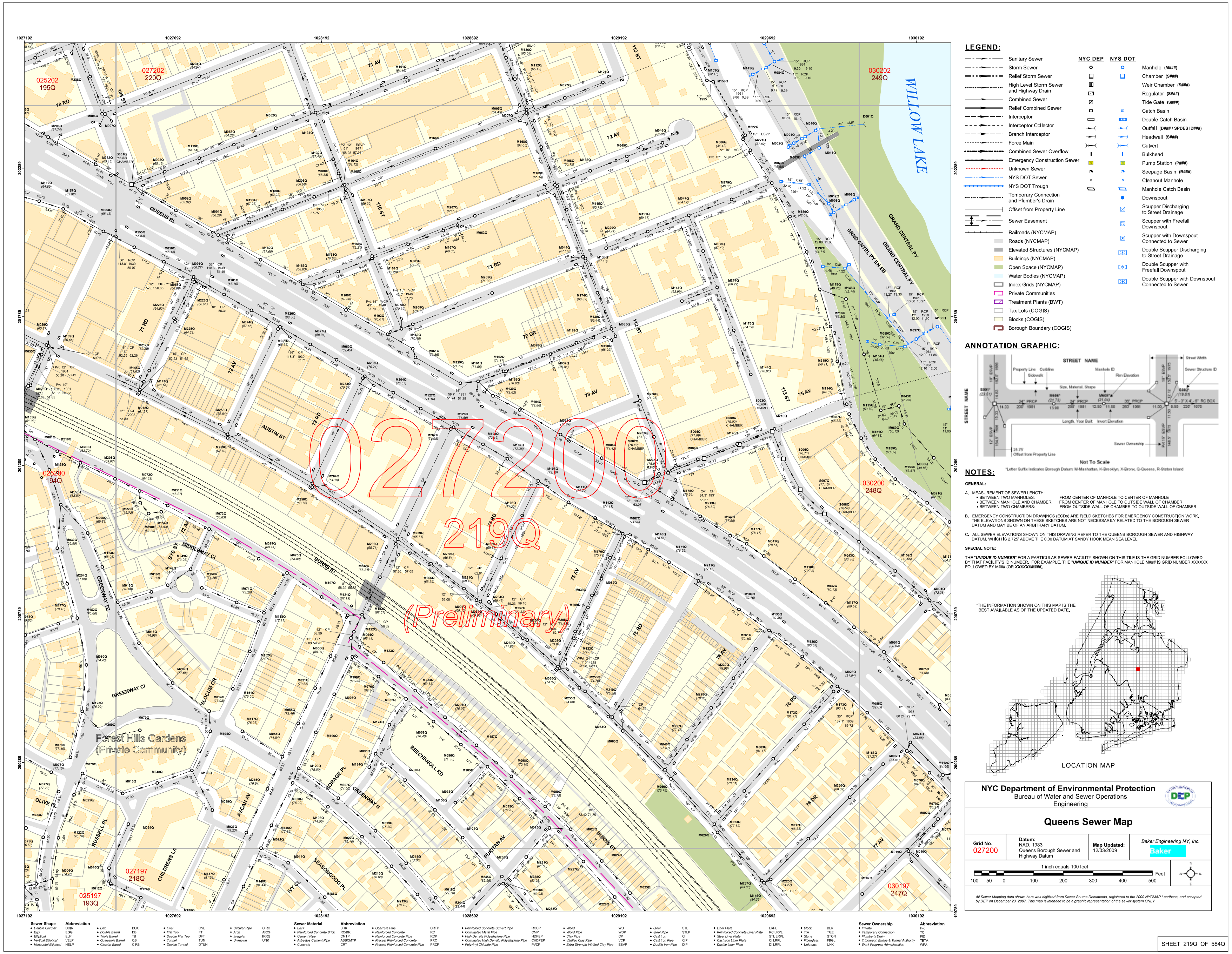
- 1 duct
- 3 cables

**4 chains**

- 7 links
- 8 nodes



# S E W E R M A P

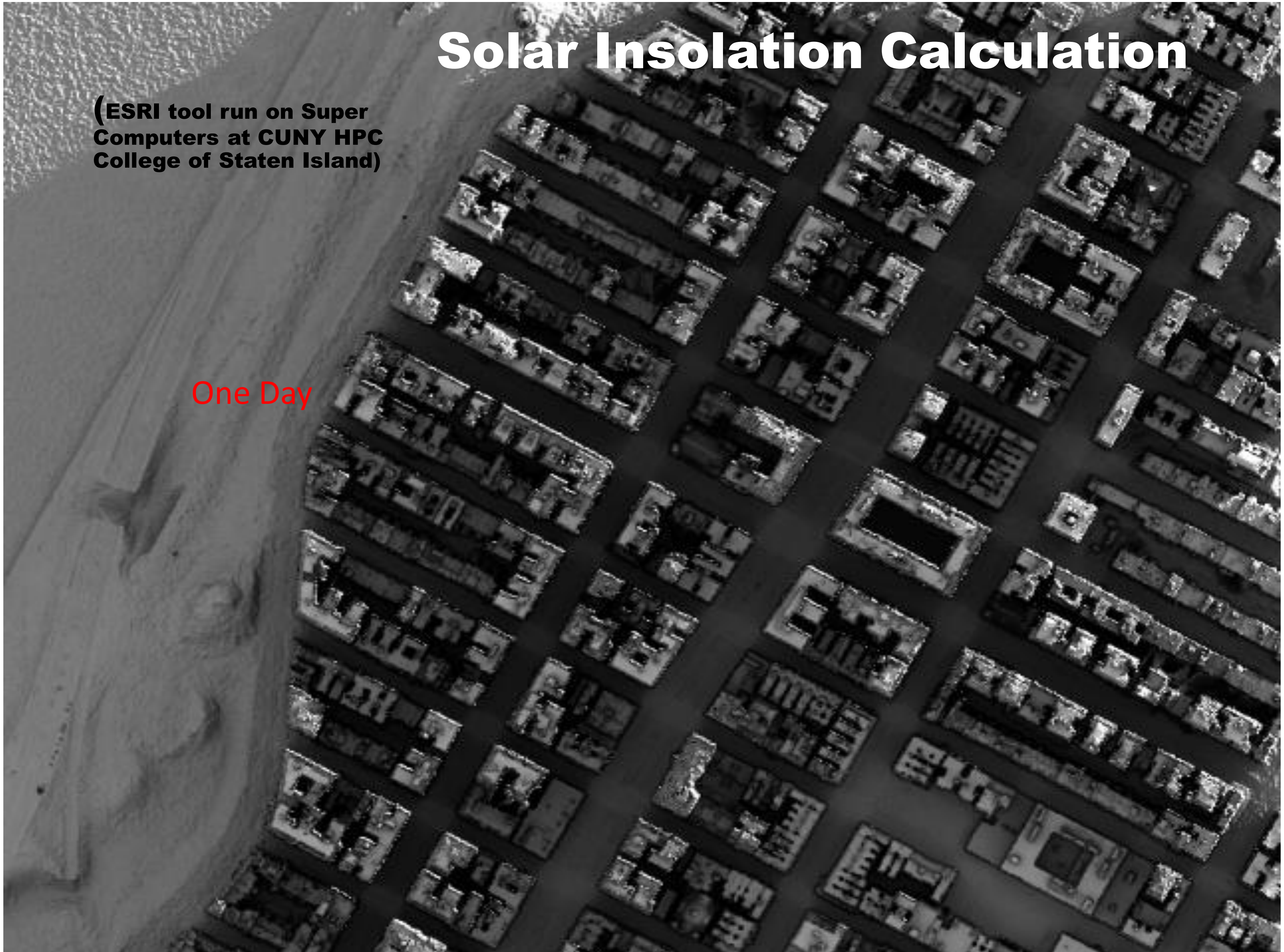


027200
219Q
(Preliminary)
WILLOW LAKE
QUEENS BL
Forest Hills Gardens
(Private Community)
LEGEND:
ANNOTATION GRAPHIC:
NOTES:
LOCATION MAP
NYC Department of Environmental Protection
Bureau of Water and Sewer Operations
Engineering
Queens Sewer Map
Grid No.
027200
Datum:
NAD, 1983
Queens Borough Sewer and Highway Datum
Map Updated:
12/03/2009
Baker Engineering NY, Inc.
1 inch equals 100 feet
SHEET 219Q OF 584Q

# Digital Twin Applications

- Solar
- Planning
- Agent models – gaming environments
- Flooding  - visualizaiton
- Augmented reality

# Solar Insolation Calculation

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Solar animation:
one day

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# The Solar Map and Calculator

( https://nysolarmap.com).


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# Redevelopment

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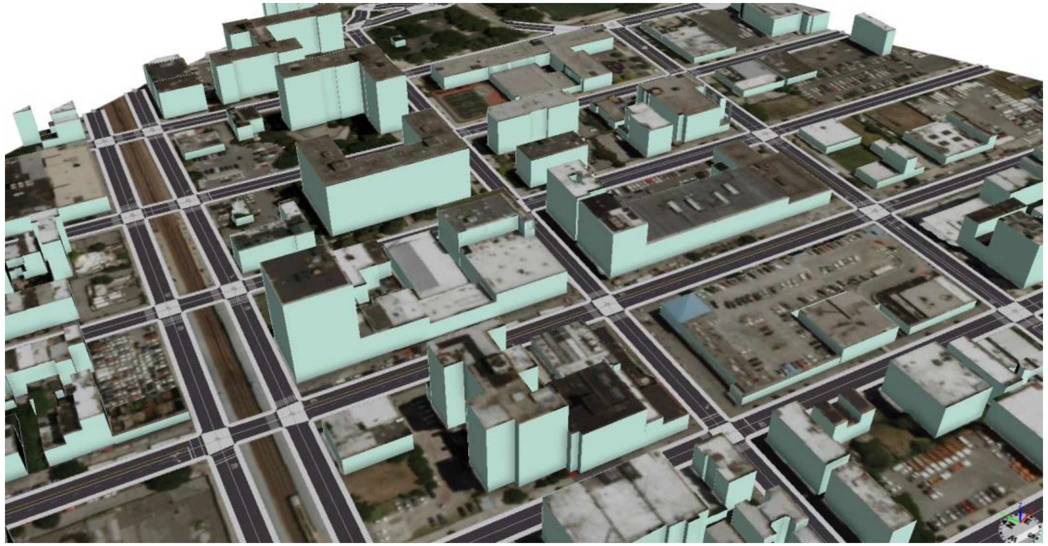
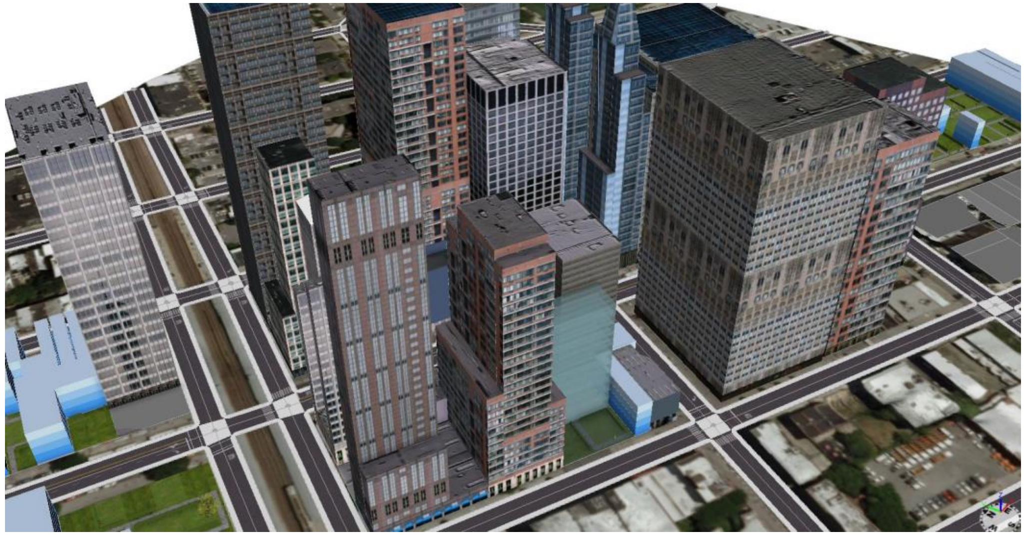


Before



After

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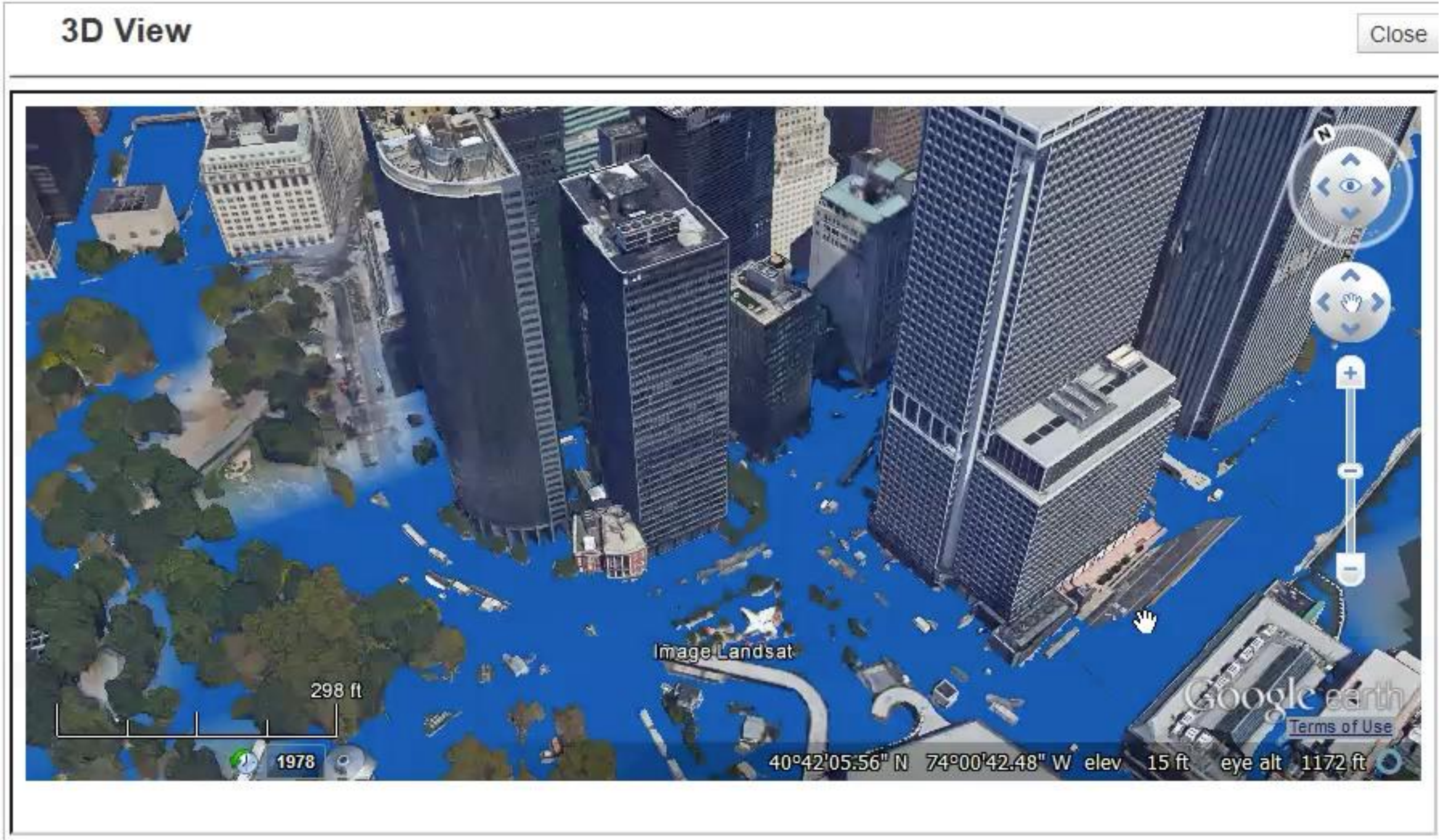
# Flooding: visualization and response



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# AR Example*: Parcel data


*Matthew Ward, MS GeoInformatics thesis

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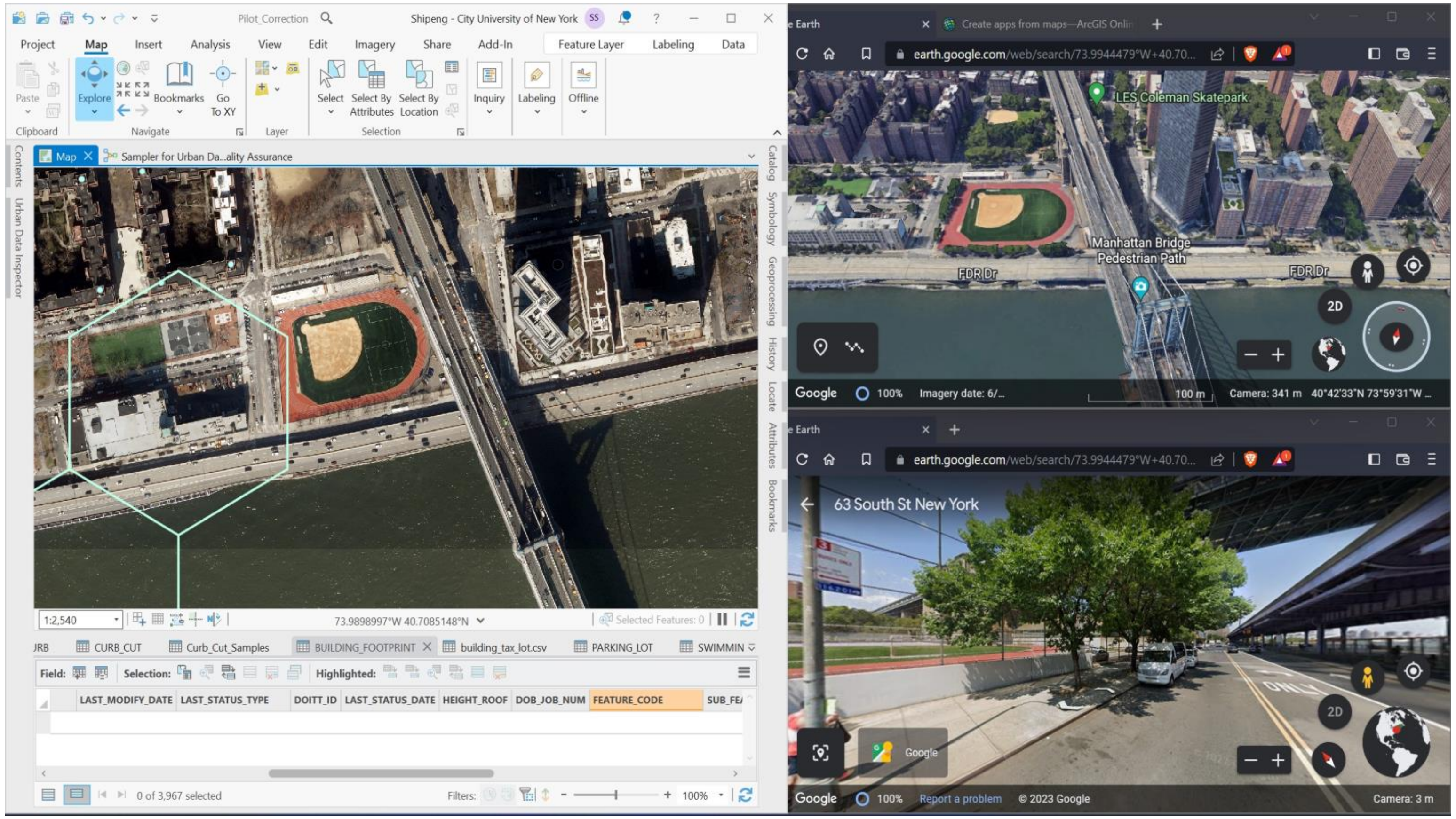
# Planimetric Update: Quality assurance* using acceptance sampling




| Feature | Collection Scope |
|---|---|
| Boardwalk | Update |
| Building_Footprint | Update |
| CSCL Street Centerlines | Edge-of-Pavement ID Transfer |
| Deleted_Line | New (to be used for tracking feature changes) |
| Deleted_Point | New (to be used for tracking feature changes) |
| Deleted_Polygon | New (to be used for tracking feature changes) |
| Elevation | Update |
| Hydro_Structure | Update |
| Hydrography | Update |
| Median | Update, new feature code |
| Misc_Structure_Poly | Update |
| Open_Space | Update |
| Park | Update |
| Parking Lot | Update |
| Pavement Edge | Update, new attribute and feature instructions |
| Plaza | Update , new feature code |
| Railroad | Update |
| Railroad_Structure | Update |
| Retaining Wall | Update |
| Roadbed | Update |
| Shoreline | Update |
| Sidewalk | Update |
| Sidewalk Centerline | Update |
| Street Furniture | Update |
| Swimming Pool | Update |
| Transport_Struct | Update |
| Water Tank | New feature class addition |
| Under_Construction_Unknown | New |
| Updated_Line | New (to be used for tracking feature changes) |
| Updated_Point | New (to be used for tracking feature changes) |
| Updated_Poly | New (to be used for tracking feature changes) |

Topology 100%, feature ID & drafting, 95% CI, feature omission 95% CI

* Design by Sean Ahearn & Shipeng Sun; Application Shipeng Sun

# The NYC Digital Twin

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- **High degree of verisimilitude**: data quality, data models, representation, and systems
- **Real time** (e.g. sensors), **persistent** environment
- **Real time feedback** from DT to physical world and back
- Computational/Modeling Platform for **simulation and scenario testing**
- **AR/VR** enabled

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# NYC Digital Twin Conceptual Model