Explicit Simulation of Green Infrastructure for Flood Control Using Two-Dimensional Surface Routing

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Image: US EPA

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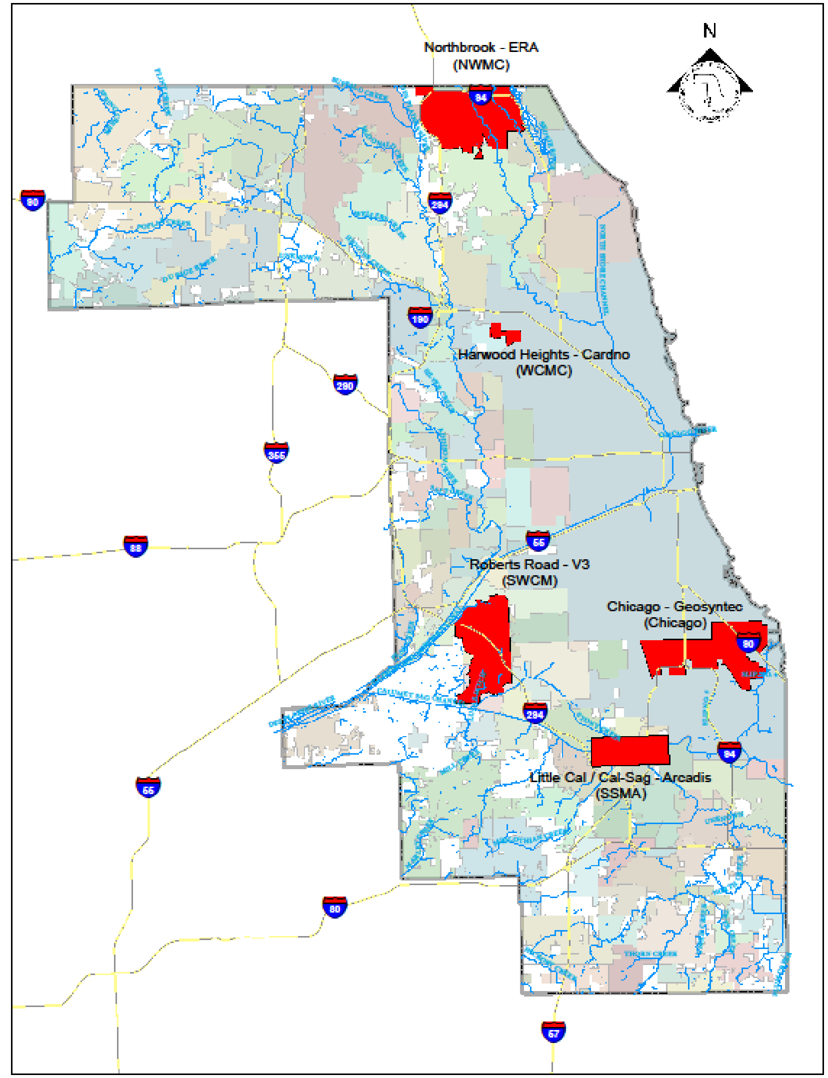
5 MWRD Stormwater Master Plans

1. Study Areas
   - One per Council of Government (4)
   - One in City of Chicago
2. Purpose
   - Investigate urban flooding issues
   - Evaluate conceptual solutions, especially green-gray infrastructure
   - Develop community-based and supported plans to address local flooding

MWRD STORMWATER MASTERPLAN STUDY AREAS



Stormwater Master Planning

- **Main goal: estimate improvements necessary to mitigate flooding to the 100 year level**
  - First on public land,
  - Then if necessary, private land
  - GI investigated as a major component of this work
    - 4th reservoir : Storing stormwater on private land, all contributing to the solution
- **Problem evaluation:**
  - Where is it flooding: 311 calls, models, surveys and public outreach
- **Solutions evaluation: modeling, cost-estimating, master planning**
  - Optimatics: quickly evaluating many combinations of solutions
- **Geosyntec is the prime consultant managing this work, other consultants for other master plans**

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Study Components, Modeling GI

- **Study is investigating green infrastructure at a planning/conceptual level**
  - Optimized combinations of gray and green infrastructure


Image: 3 Rivers Wet Weather

- **Typically modeled with a broad approach in the past**
  - Gross adjustment of curve number
  - Blanket adjustment of initial abstractions
  - Surface storage at a loading node
  - Could we do better? Explicitly model the GI elements → MWH

Experimental 2-D Study

- **Integrated Catchment Modeling**
  - Platform for simulating hydraulically linked urban and riverine catchments
  - Includes all sewer modeling functionality with added ability to simulate overland flows across a 2-D surface
- **ICM can simulate direct-to-mesh rainfall**
  - Rainfall applied directly, then concentrates and finds its own flow path
- **Experimental study**
  - Explicitly modeling each individual GI installation
  - Sheet or shallow concentrated flow vs. non-uniform surface routing
- **Goal: To investigate the ability of ICM to simulate GI explicitly**

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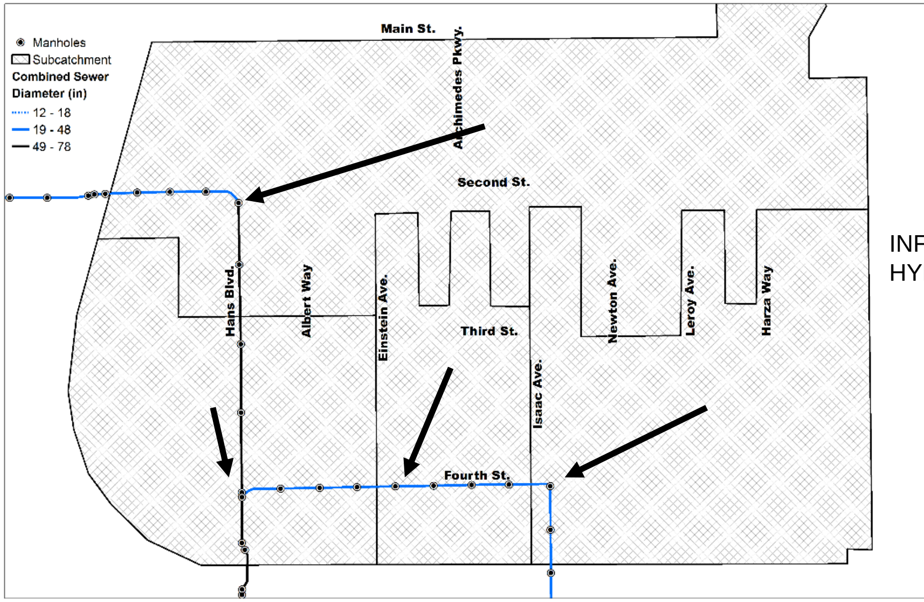
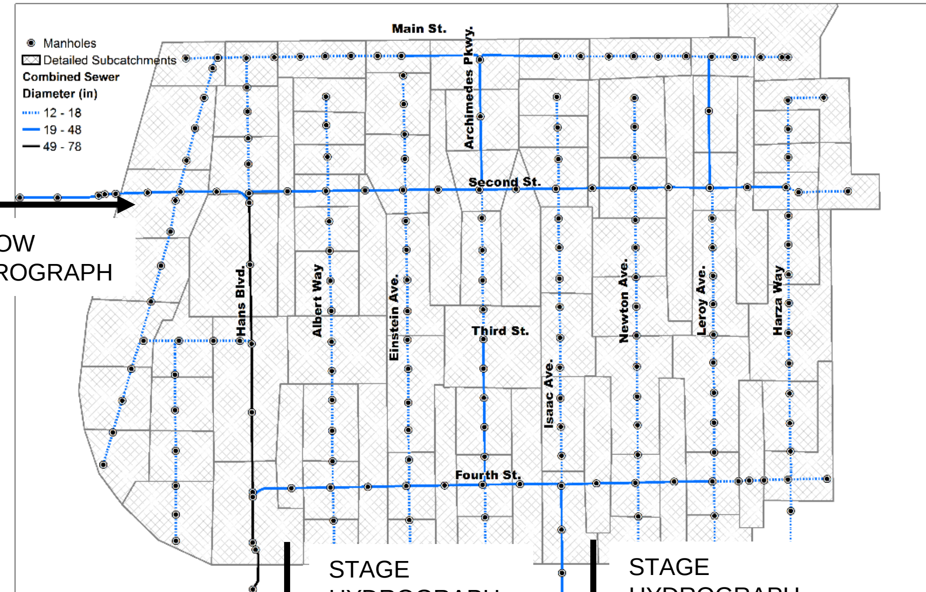
Hydrology of Study Area

Coarse Trunk Sewer Hydrology



INFLOW HYDROGRAPH

Detailed ICM Hydrology



STAGE HYDROGRAPH

STAGE HYDROGRAPH

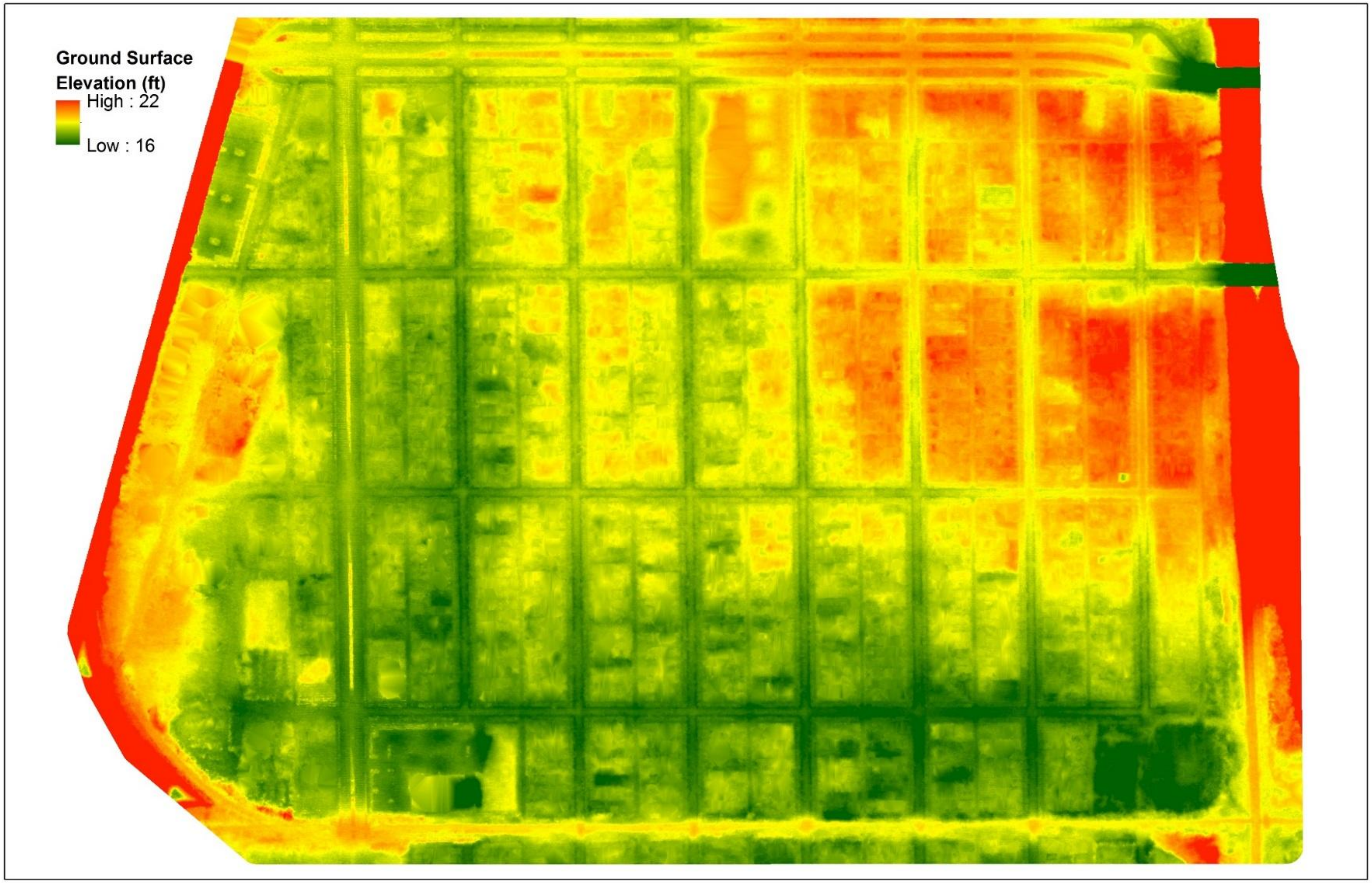
- Network Refinement
  - 1% variance at outlets
- Adding detail to sewer network allows inflows to sewer to be more evenly distributed

	Outlet	Hans Blvd.	Isaac Ave.
	Diameter	6.5-ft	3-ft
Volume (MG)	CS	9.43	1.35
	ICM	9.43	1.35
	Variance	-0.05%	-0.03%
Peak Flow (cfs)	CS	150	18.0
	ICM	149	17.8
	Variance	-0.35%	-1.2%

Topography of Study Area

Surface Hydraulics

- Sources
  - High ground
- Pathways
  - Roadways
  - Surface slope
- Sinks
  - Ponding areas
  - Sewer system



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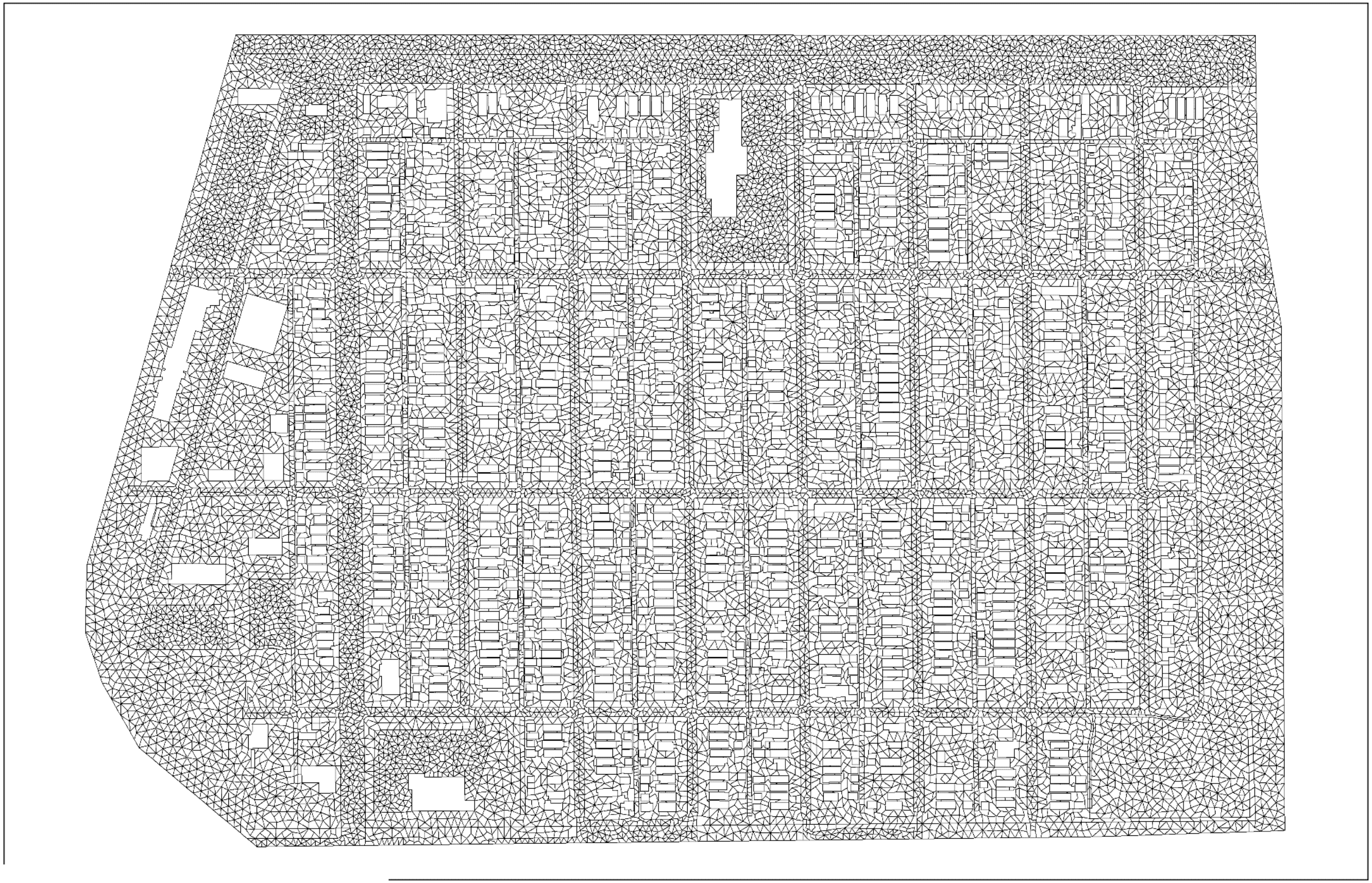
Ground Surface – TIN Creation



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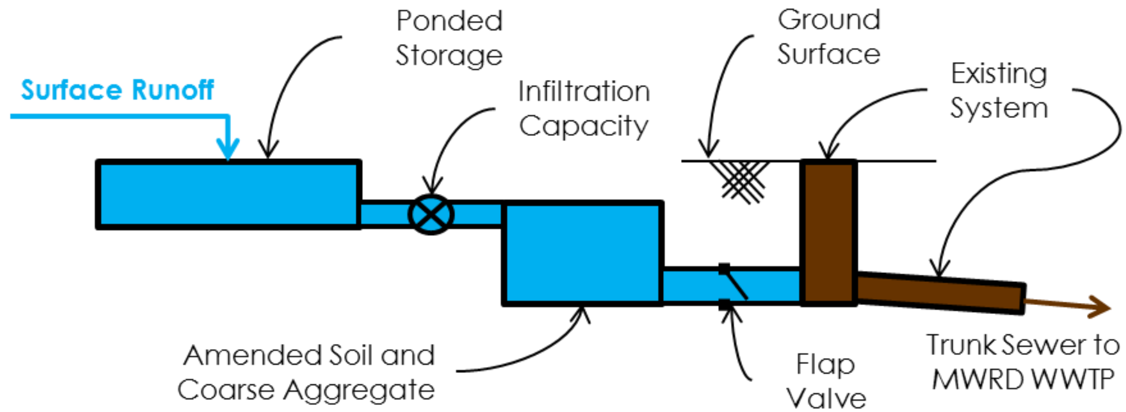
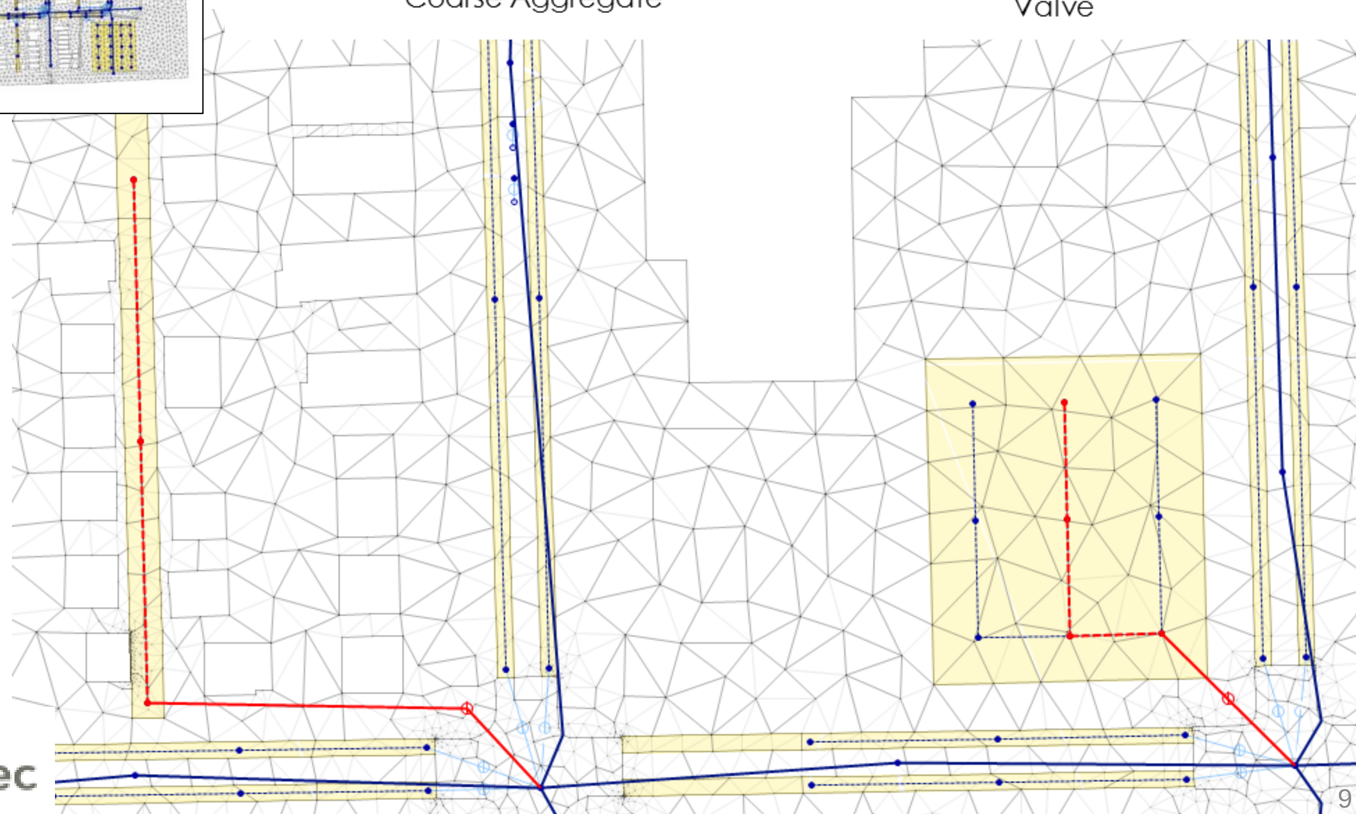
Bioretention / Permeable Pavement



Type	Bioretention (rain garden)	Permeable Pavement
Ponded Storage Depth	12-inch	3-inch
Infiltration Capacity	2-in/hr	5-in/hr
Porosity	30%	30%
Depth of Void Storage	38-inch	27-inch



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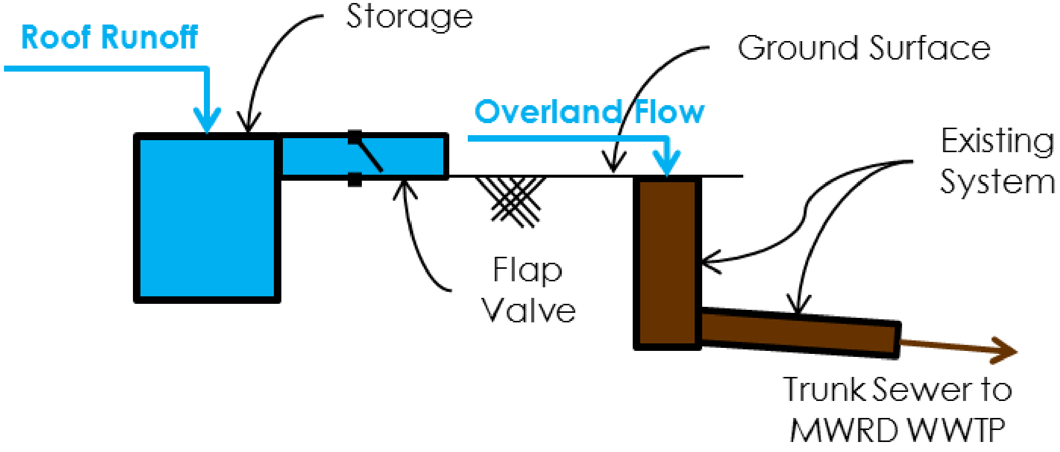
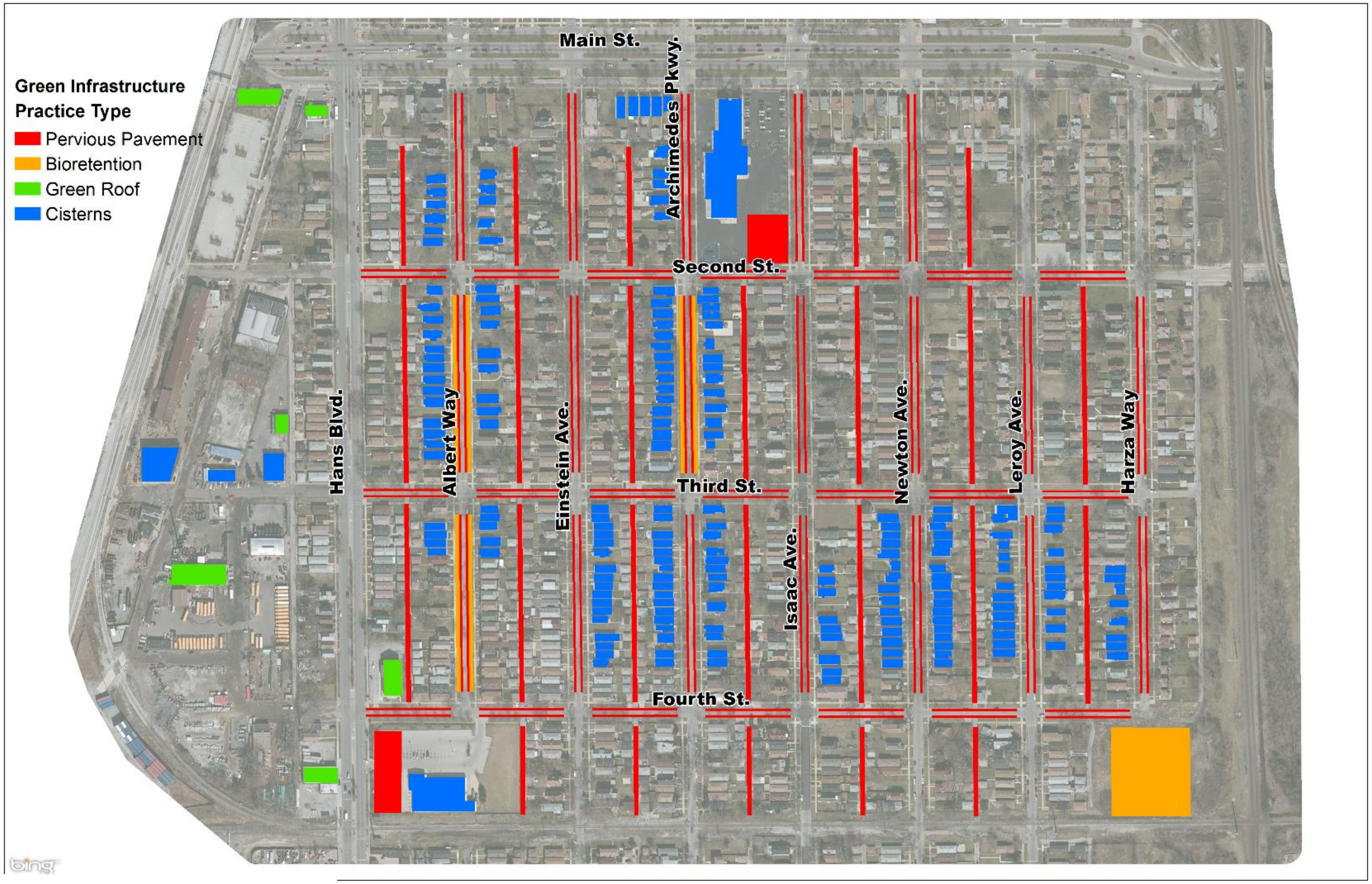
Cisterns / Green or Blue Roofs



Type	Green Roof	Cistern
Ponded Storage Depth	n/a	n/a
Infiltration Capacity	> Peak Rainfall Intensity	n/a
Porosity	30%	n/a

Optimized Green Infrastructure Scenario

- **Level of implementation optimized for sewershed**
  - Square feet or storage volume/land use type/subcatchment



5-Year Max Ponding Depth - Existing

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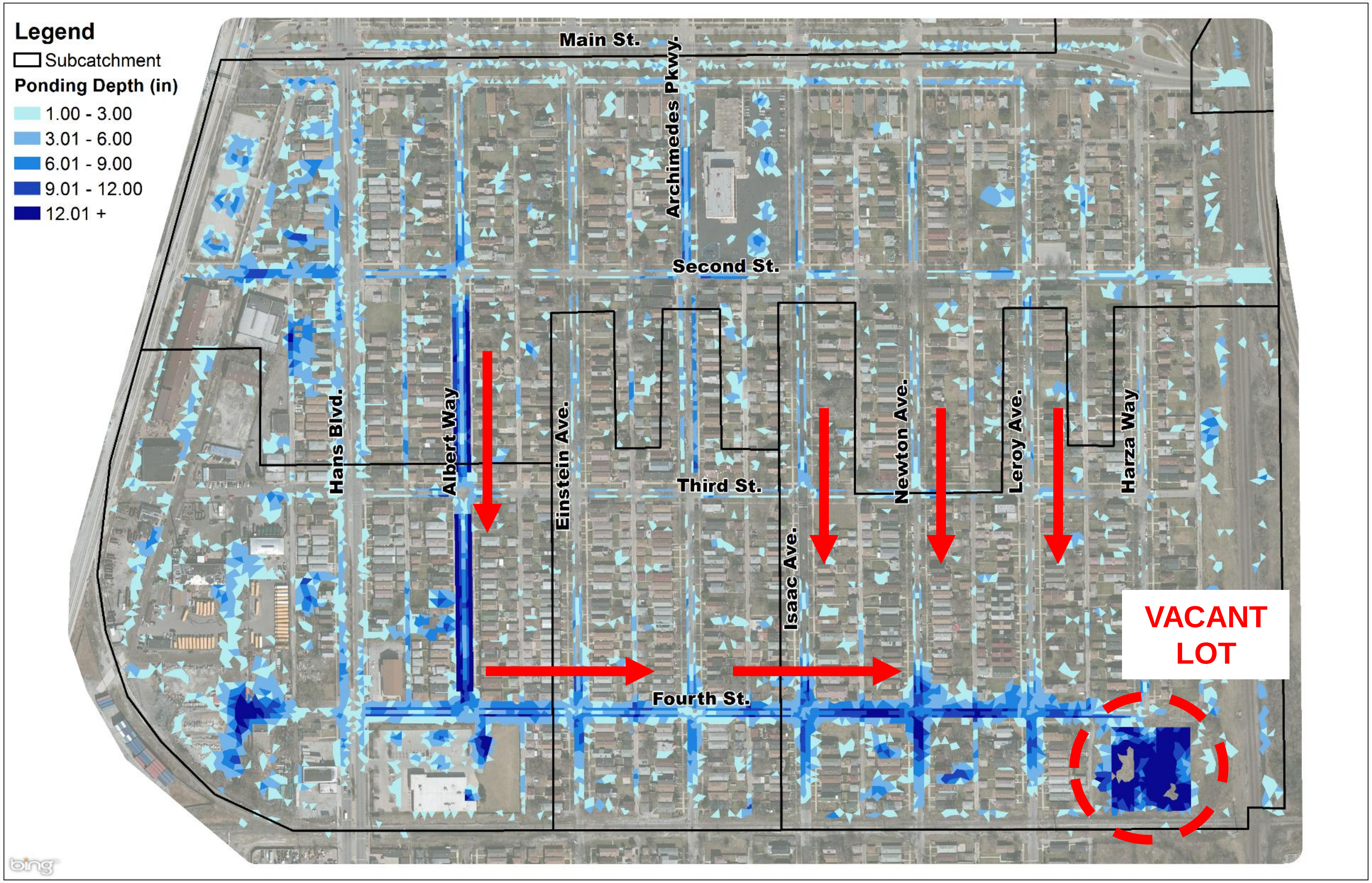
5-Year Max Ponding Depth – Optimized GI



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Conclusions

- **Integrated catchment modeling can be used to explicitly model GI elements for a realistic evaluation of their role in the overall drainage system**
  - Heavily surcharged - target GI projects
  - Surcharging reduced - evenly distribute GI projects
  - Effectiveness of each type of GI varies with level of surcharge
- **GI has a limited benefit to surface flooding with a surcharged collection system**
- **GI should be part of a solution integrated with grey infrastructure**

Opportunities for Future Investigation

- Real Data Validation
  - Simulate historical storms and validate flooding extents to photos or anecdotal evidence of flooding.
- Extension of Model Duration
  - A 5-hour duration was simulated to capture event peaks within sewer system. Longer duration simulations could be run to understand the effects of long-term storage recovery and predict the ultimate volume of runoff
- Infiltration
  - Future studies could assess the effect of infiltration on modeling results and determine a realistic value for the existing ground surface.
- Detailed Inlet Network/Mesh Size refinement
  - Inlet capacity was concentrated at manholes in this study. Inclusion of all catch basins, inlets, and leads in the network to model inlet capacity would add more detail.

Study Applications

- District message : 4th reservoir, “Recovering Resources, Transforming Water”
- We can use these results and modeling methods for future Stormwater projects
- After the study, we can better understand the impact of GI on flood reduction
  - “first flush” contains contaminants, but also reduces rainfall depth for secondary systems
  - Majority of storms in a year are under 1.5” and this is easily captured by GI (ref: EPA, Dr. Krishna Pagilla’s presentaiton at IWEA)
  - So it does reduce the impact of stormwater on combined sewer systems and our reclamation plants
  - Some areas give better opportunities than others, so we can evaluate and locate GI in the most effective areas
- Better understand the impact of implementing GI on a neighborhood scale

Thank You

Questions welcome!

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