



The BLUX logo is centered in the middle of the image. It consists of the word "BLUX" in a bold, white, sans-serif font. The letter "X" is stylized with a long, horizontal bar extending to the right, which then curves downwards and back to the left, forming a shape reminiscent of a DNA double helix or a stylized 'X'.

Intelligent Urban Watersheds™

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President and CTO, EmNet, LLC

A Symposium in Honor of Dr. Panos Antsaklis
October, 2018

The Problem: Wet Weather Management



772 cities with 46 million people

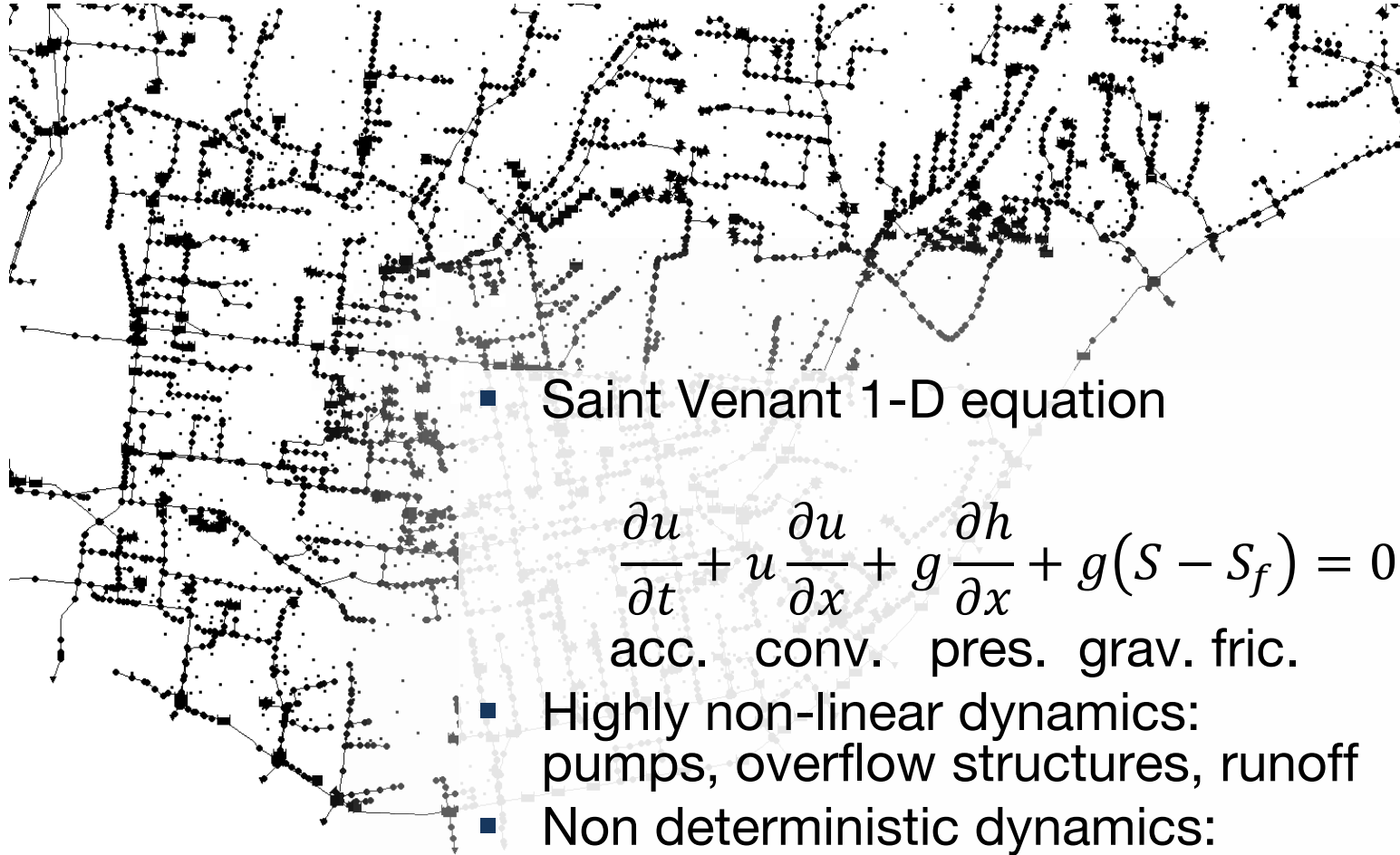




Traditional Solutions

Chicago Tunnel and Reservoir Plan
Tunnel: 100 miles, 400 ft. deep, 33 ft. diameter
\$3.5 Billion

Problem Characteristics



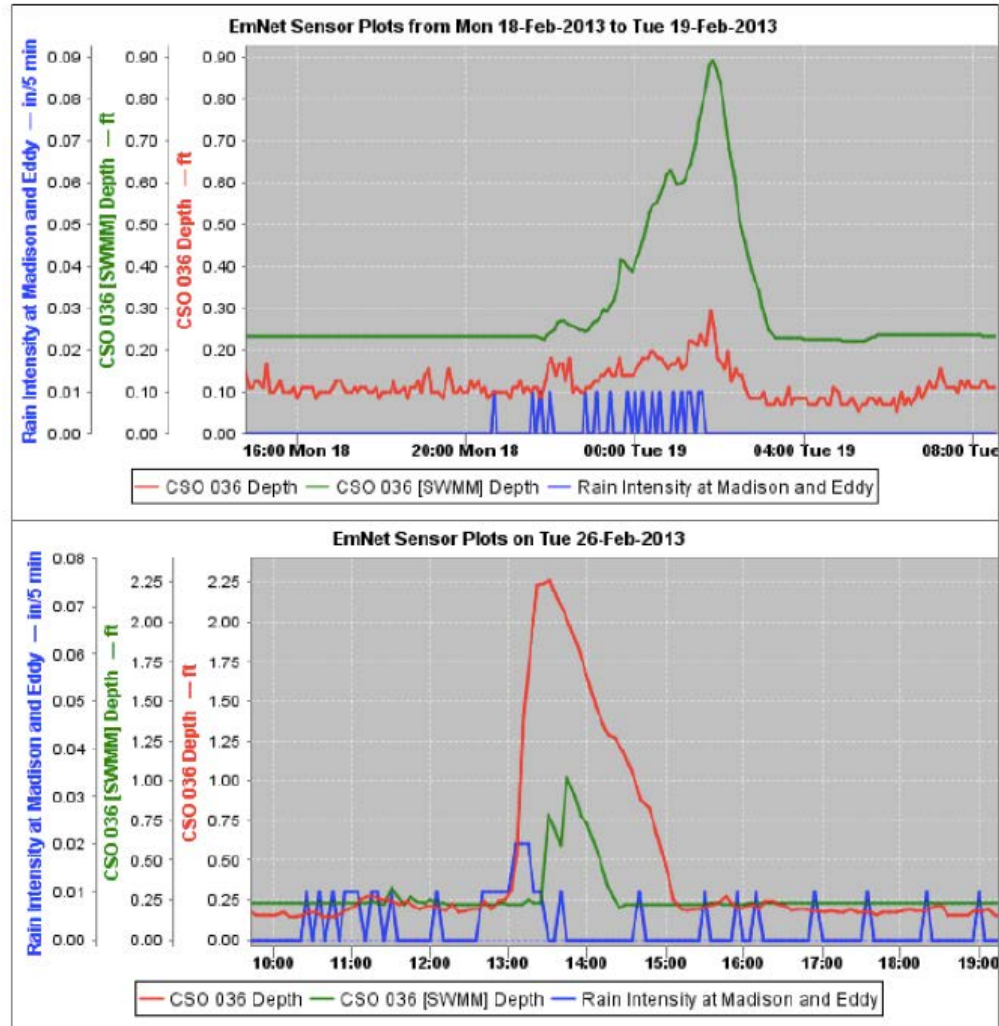
- Saint Venant 1-D equation

$$\frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} + g \frac{\partial h}{\partial x} + g(S - S_f) = 0$$

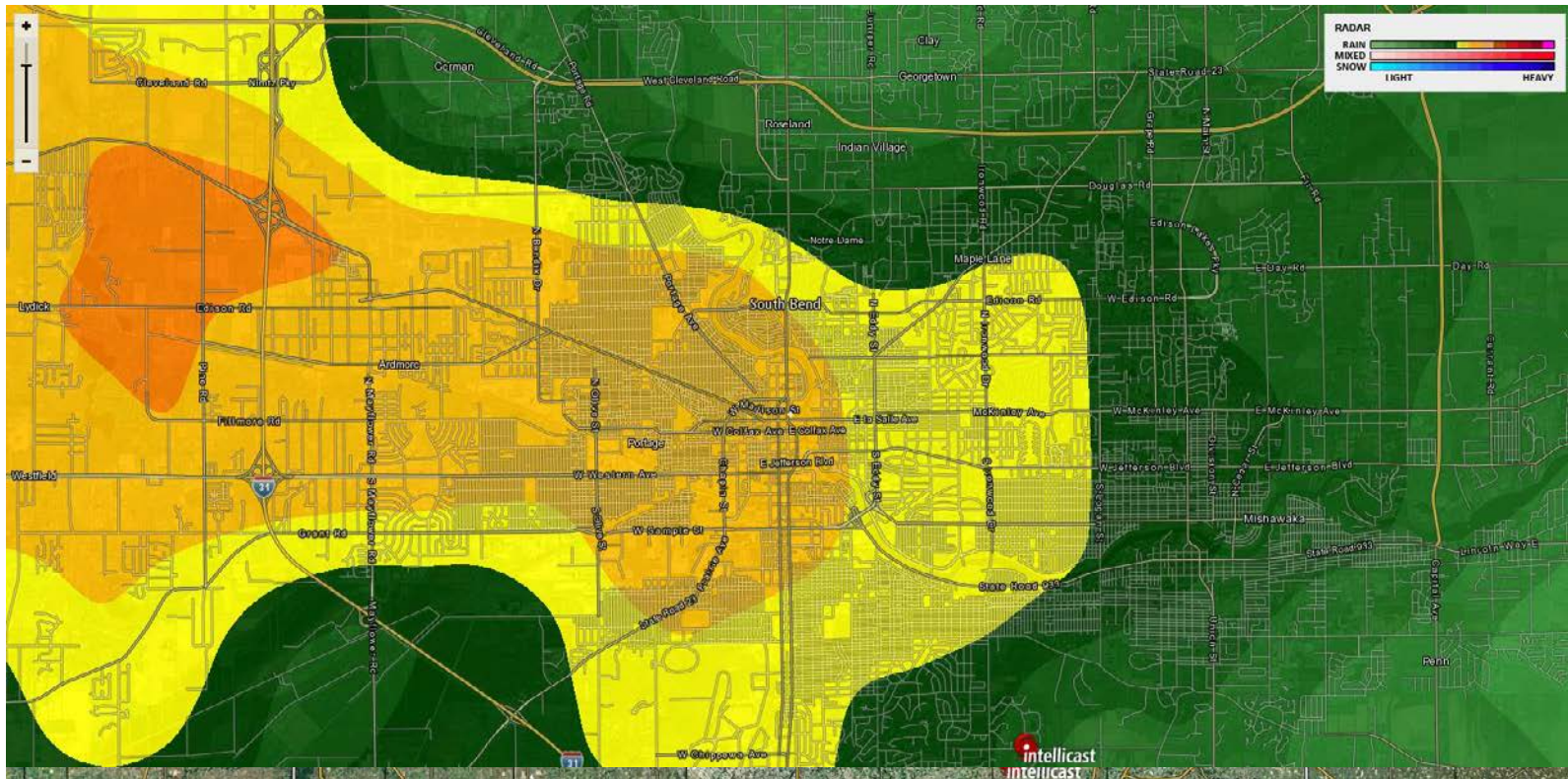
acc. conv. pres. grav. fric.

- Highly non-linear dynamics: pumps, overflow structures, runoff
- Non deterministic dynamics: manual operation, precipitation

Problem Characteristics



Problem Characteristics



Problem Characteristics



Blue Infrastructure:

Control the urban watershed to improve the environment while saving ratepayers money



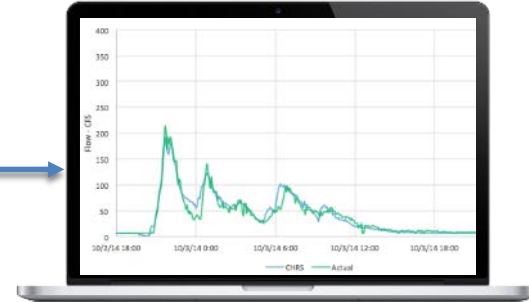
Tier 3: Operate the watershed

Implement and run Global RTC
Empower operations with RT-DSS
Maximize Performance and Resiliency



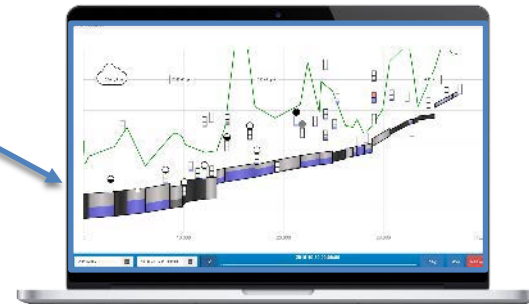
Tier 2: Create Digital Copy

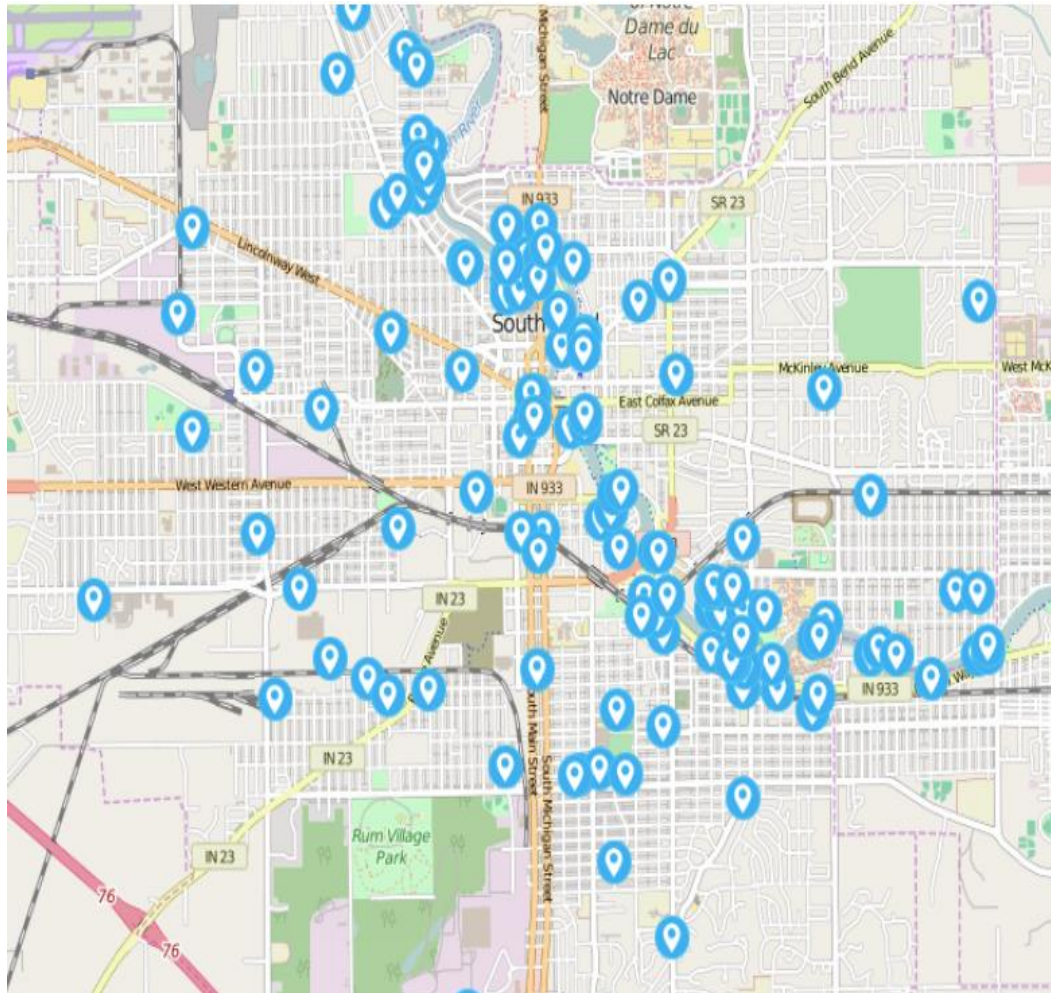
Cognitive Hydraulic Models
Host and run real time models
Compare/contrast sensor and model data



Tier 1: Turn On the Lights™

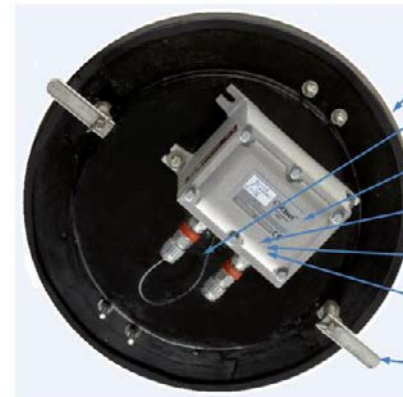
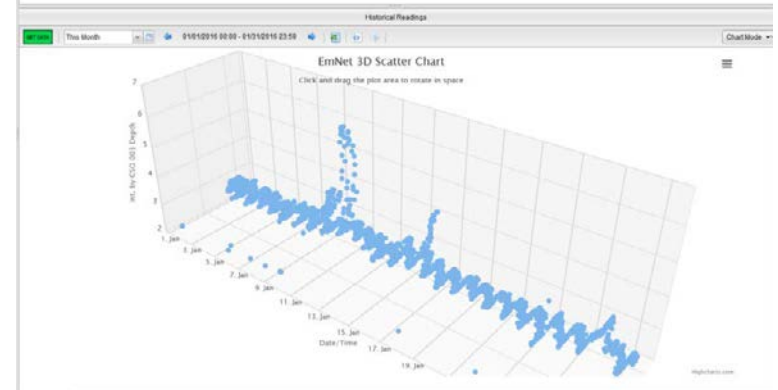
Data Collection Software
Database & Data Analytics Tools
Full SCADA Integration



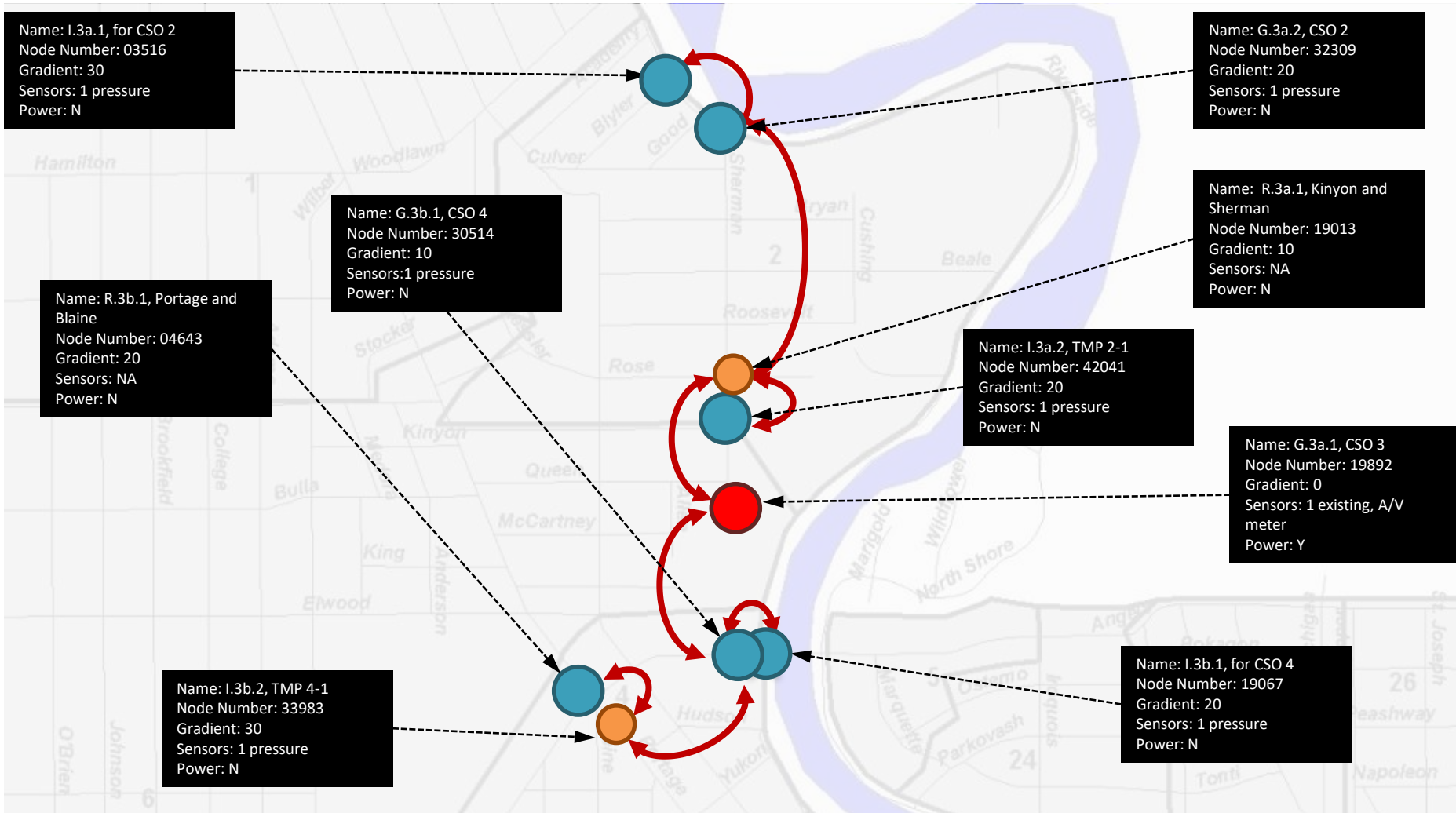


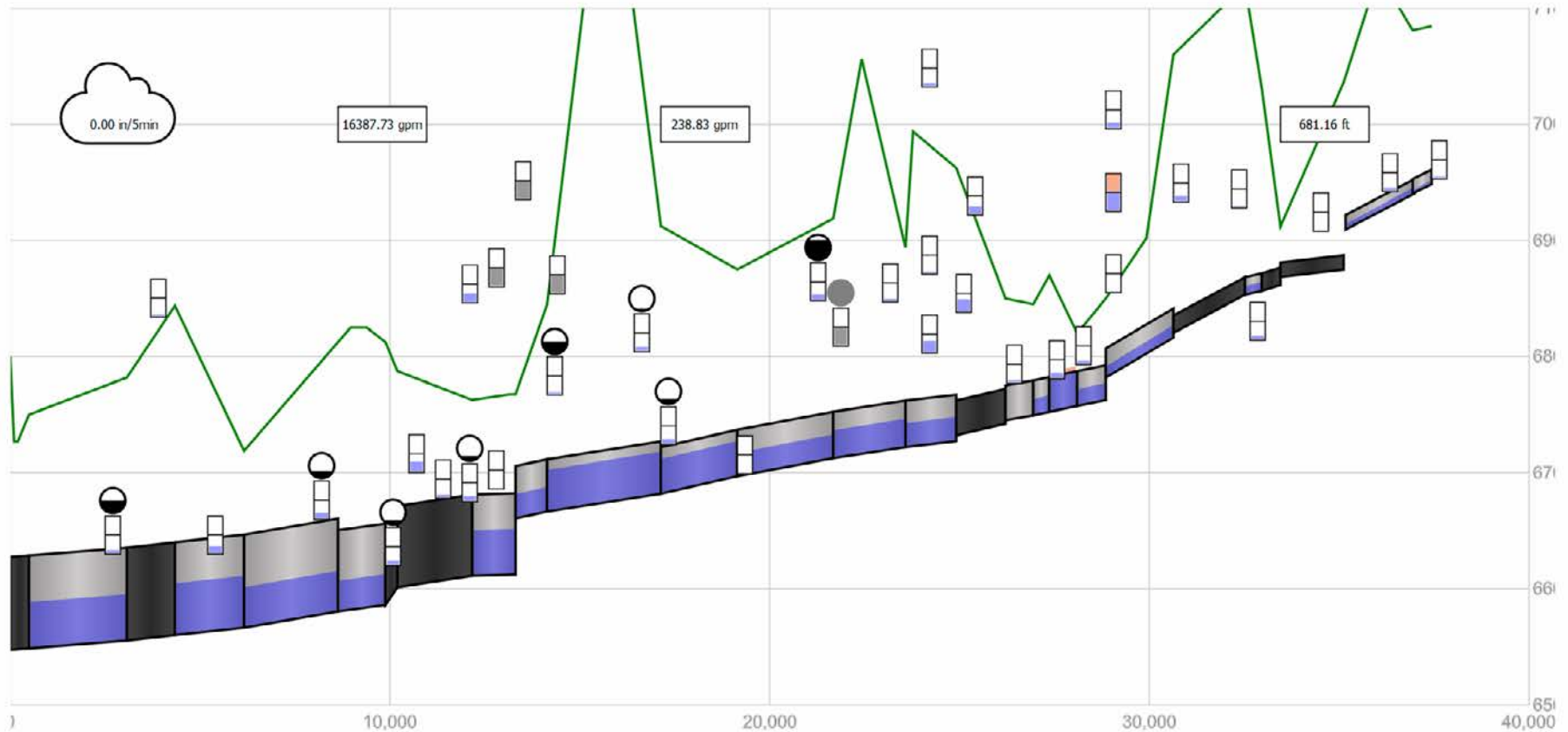
Current Readings

ID#	Sensor Type	Critical Low	Critical High	Reading	Utilization	Last Collected	Latitude	Longitude	Percent Utilization
SR by CSD 1031 Depth	DR	0 ft	7 ft	2.6 ft @ 8	34.24%	01/07/2016 18:32	41.68815444732	-86.2642214176	
SR by CSD 1031 Velocity	Velocity	-1 fpm	10 fpm	1.6700 fpm	16.73%	01/07/2016 18:32	41.68815444732	-86.2642214176	



- Composite Manhole Cover**
HS20 rated, corrosion resistant
- Embedded Antenna**
Radiate signal out of manhole cover
- Explosion Proof Box**
Class 1 Div 1 Safe, corrosion resistant
- Chasqui Processor**
Mica2-based, rugged IO, 2ppm RTC
- 4 D-size Lithium Battery**
1 Yr Life, Temperature Resistant
- 900MHz Radio / Cellular**
1 Watt, 900MHz SS, 115kbps
- Cam Lock Mechanism**
Prevent cover from popping out





2016-11-23 12:00



2016-11-24 03:45



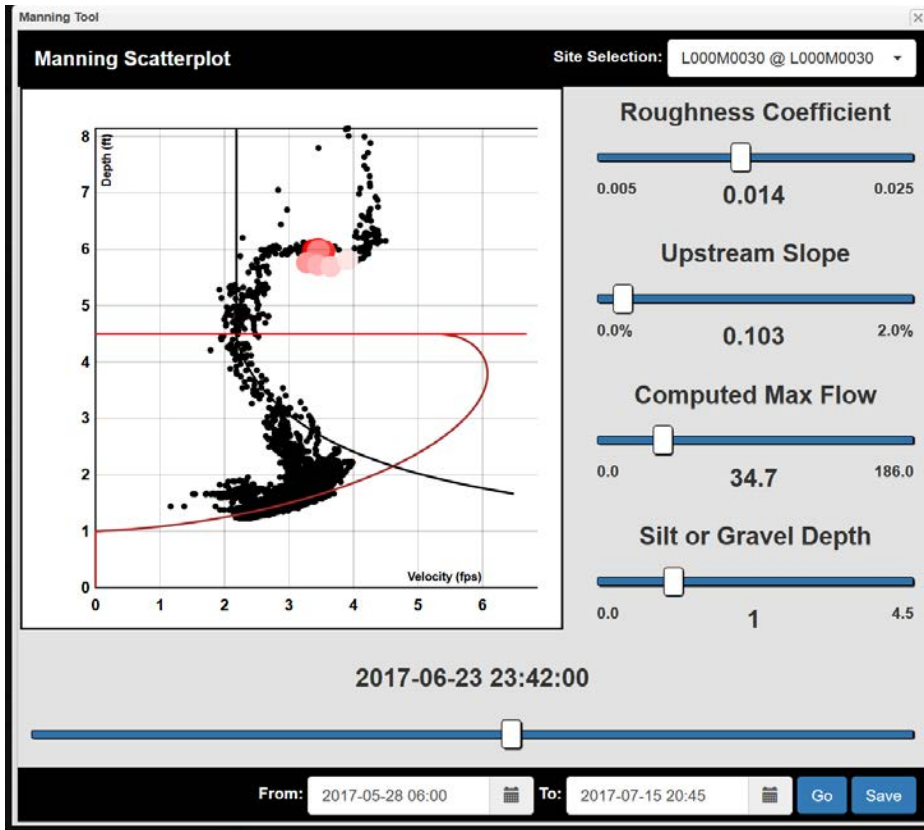
Go

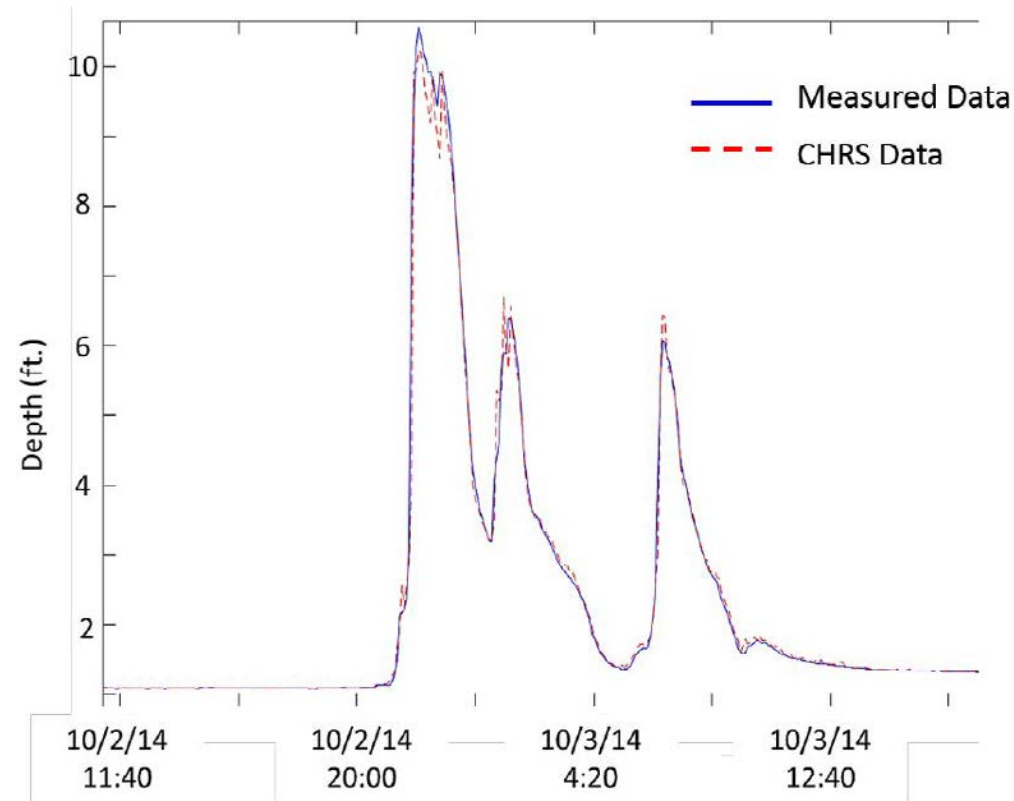
2016-11-23 12:35:00

Pause

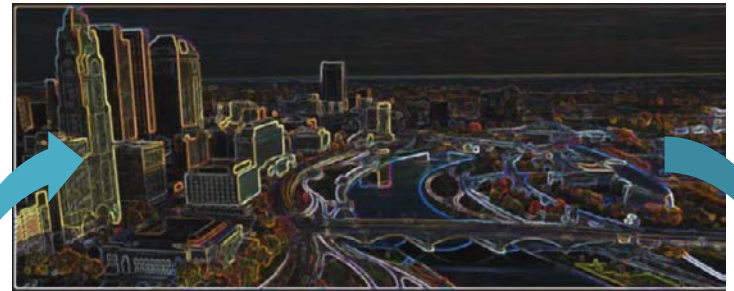
Stop

Real-time

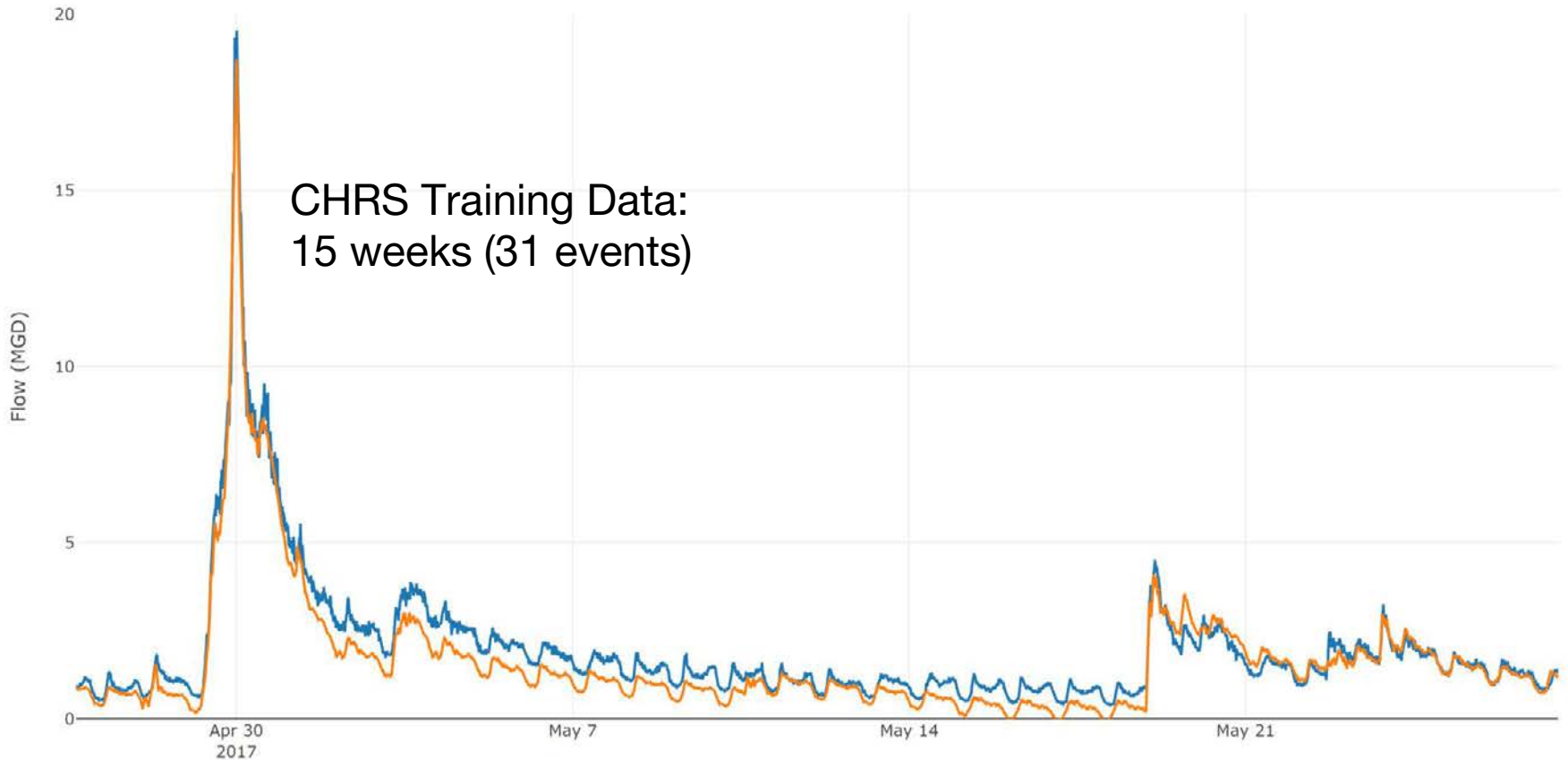


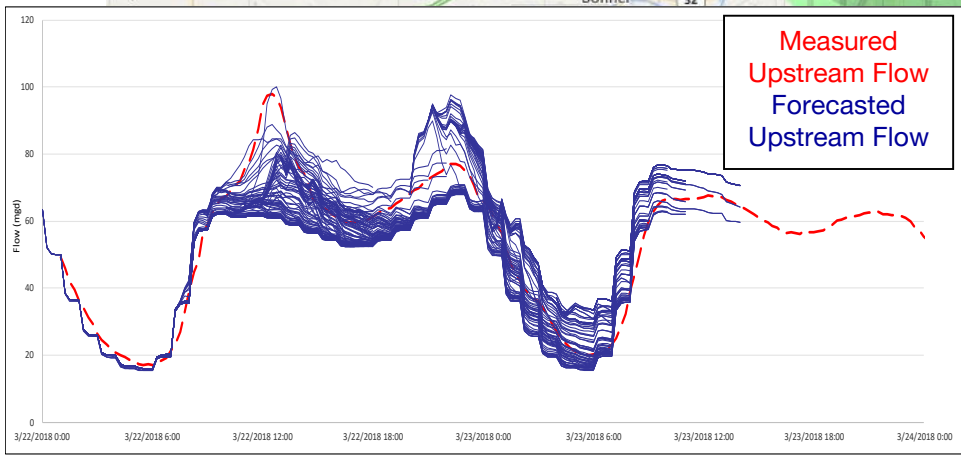
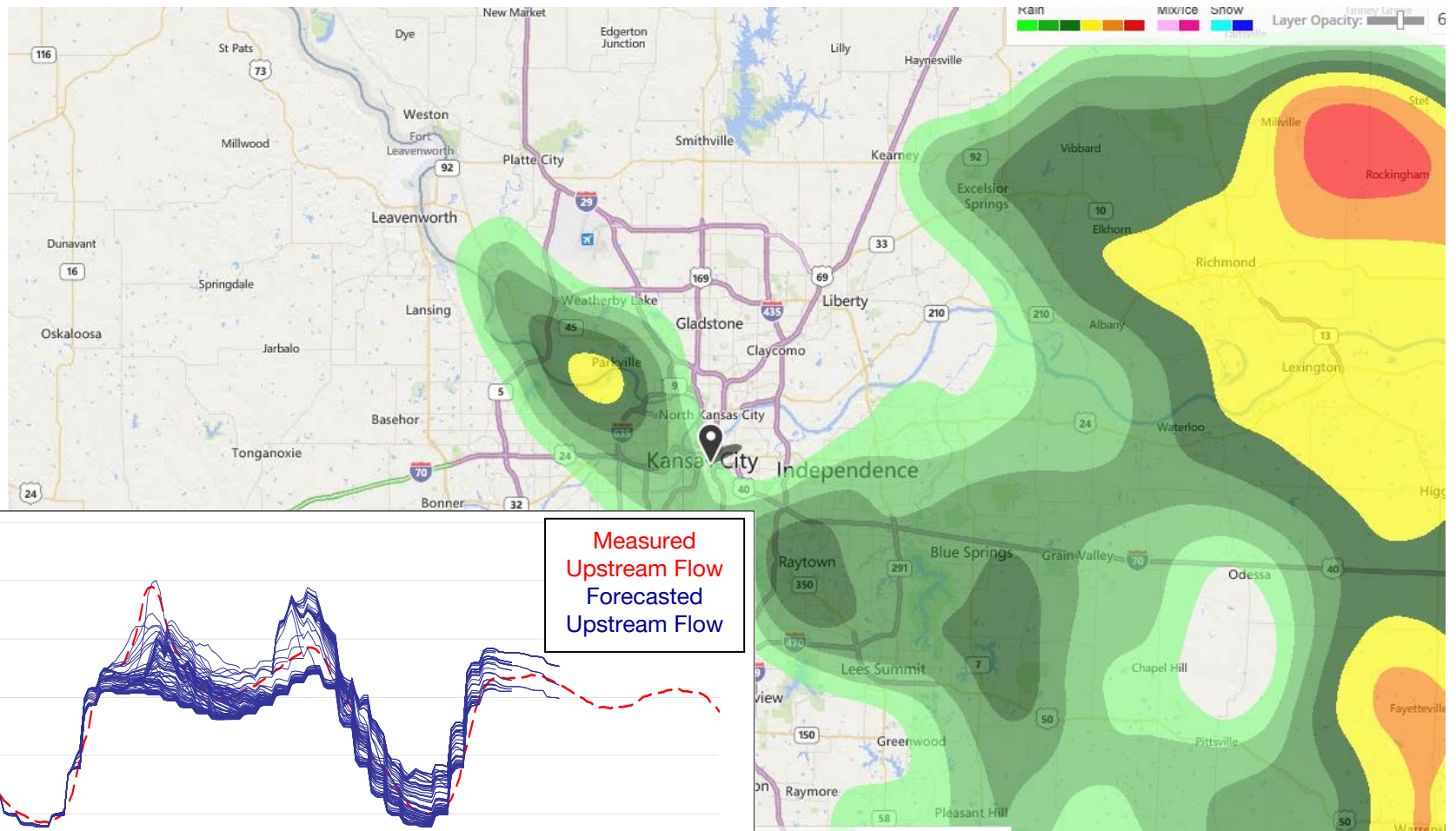


digital copy



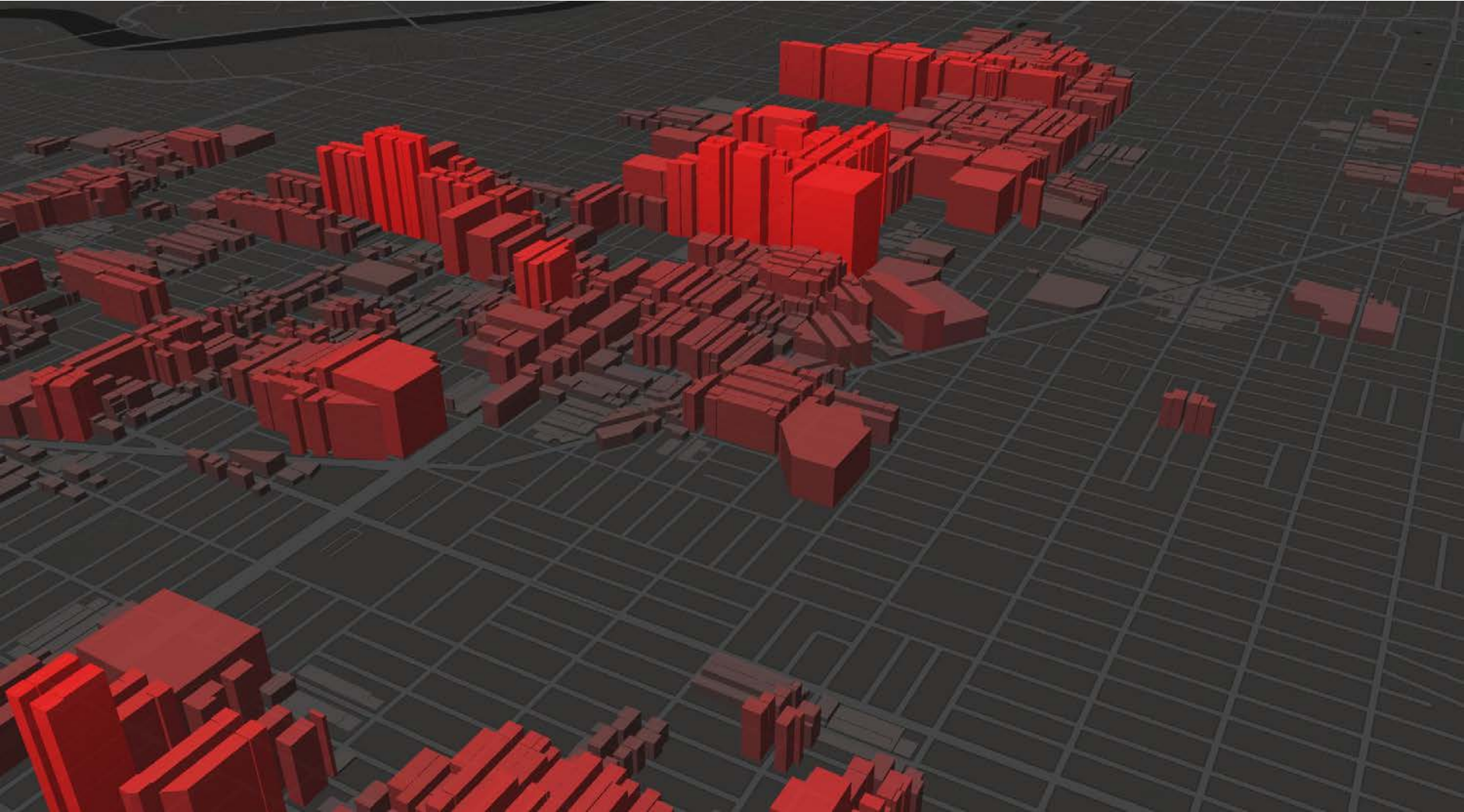
real world





BLU

Predict: Cognitive Hydraulic Response System



Basin 003:
“Increased flows!
Need to buy capacity.”

WWTP 2:
“I have plenty
of capacity.”

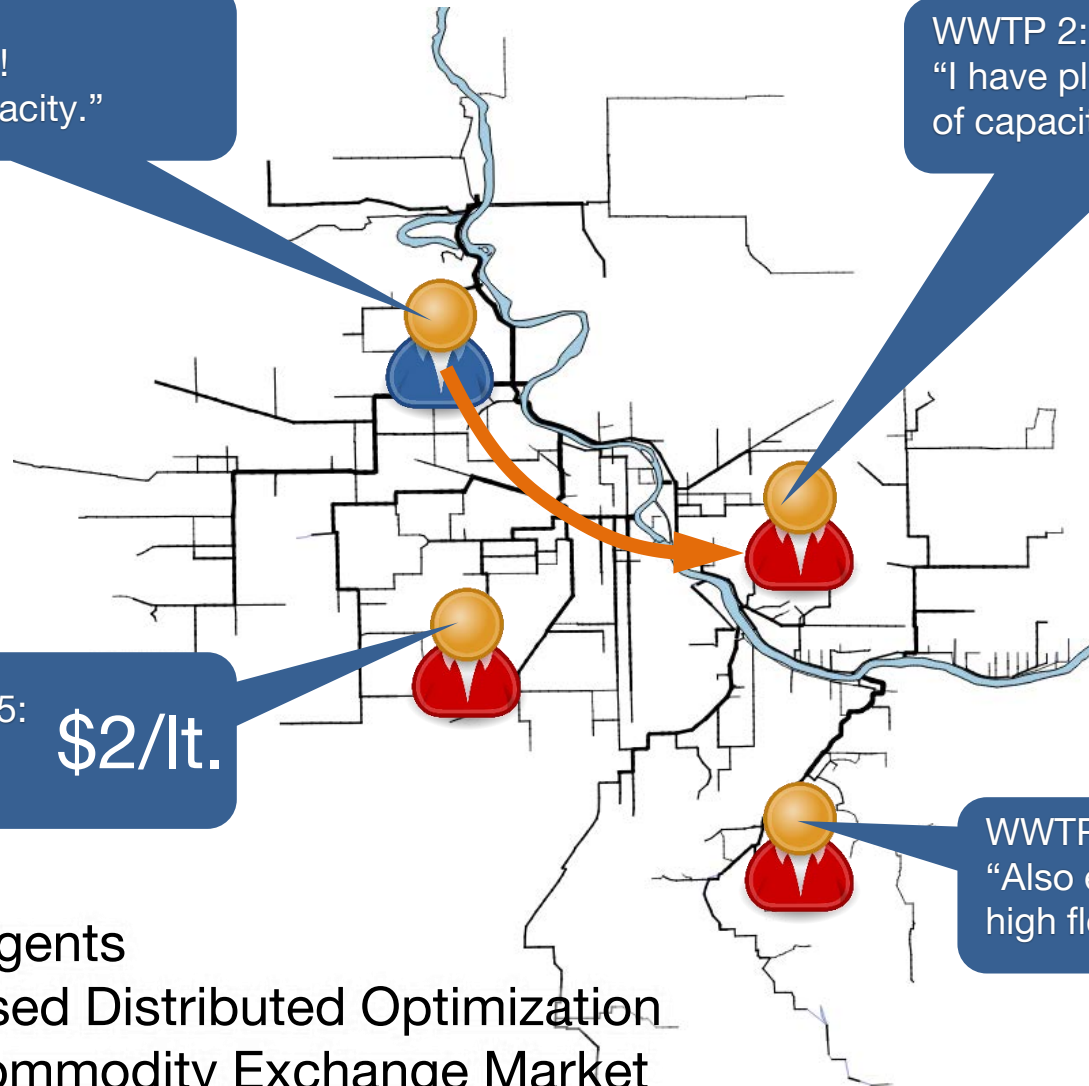
\$1/lt.

Storage Tank 005:
“I’m half full.”

\$2/lt.

WWTP 1:
“Also experiencing
high flows.”

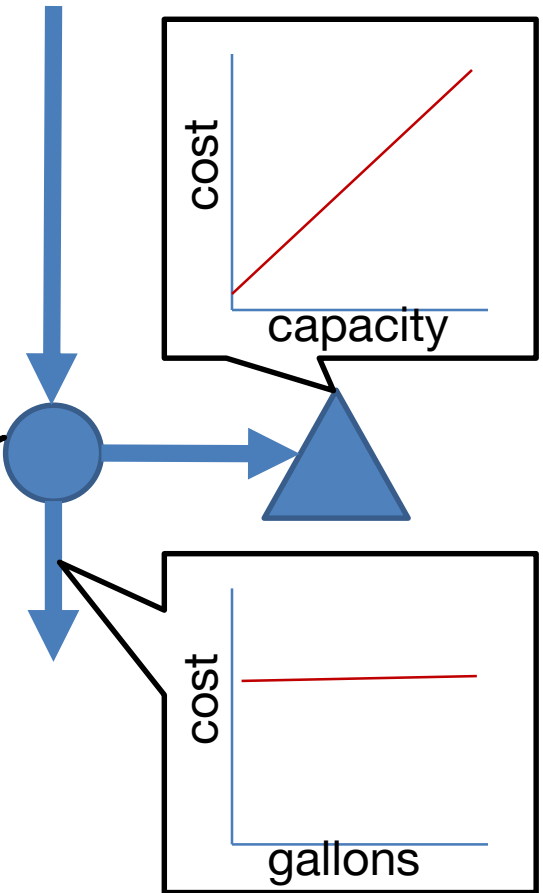
\$5/lt.



- Software Agents
- Market-Based Distributed Optimization
- Emulate Commodity Exchange Market

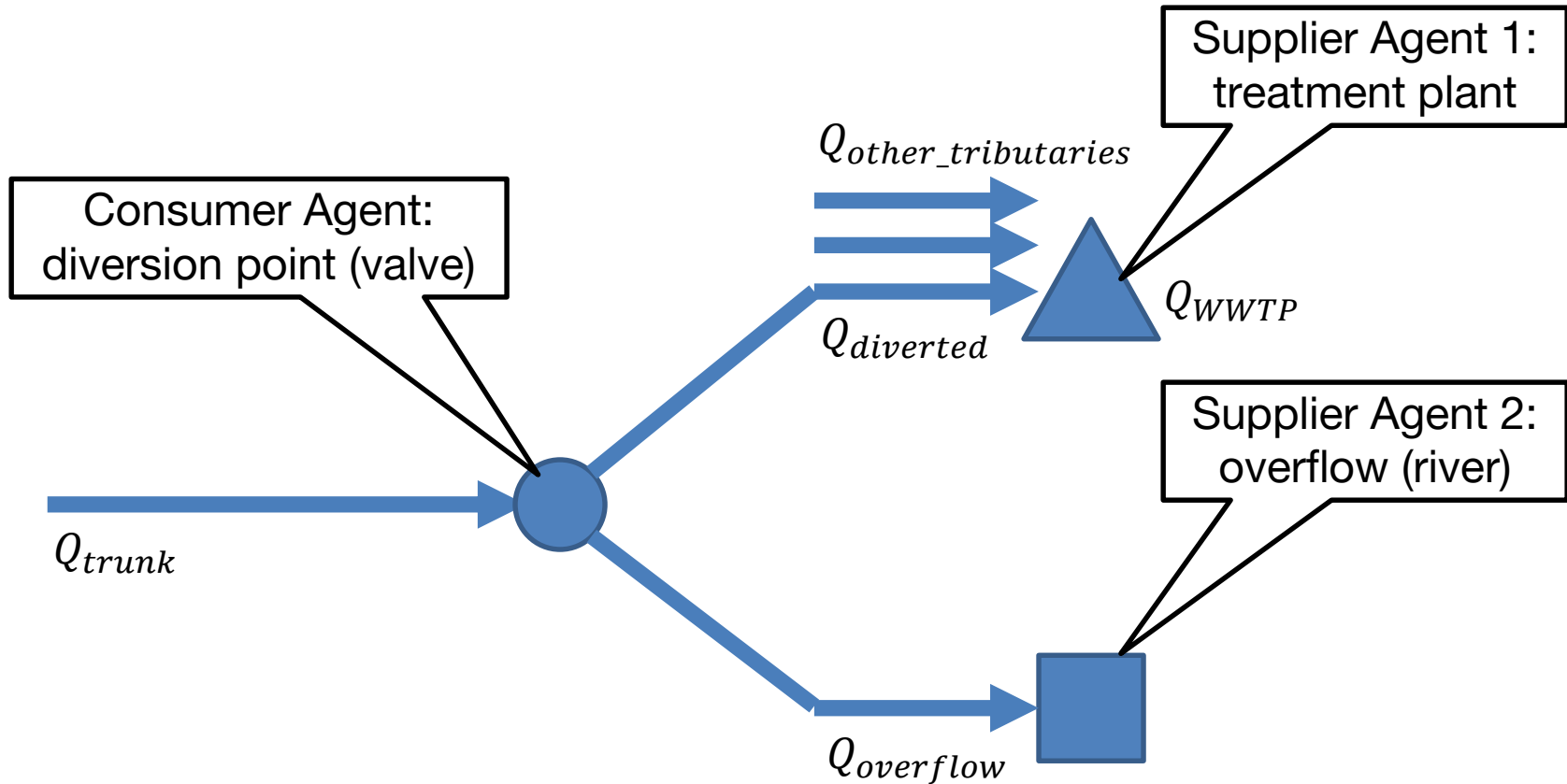
- Agent-Based control
- Network nodes trade capacity
- Downstream nodes are suppliers
- Upstream nodes are consumers
- Consensus problem

Local Optimization
Minimize cost
Compete for WWTP

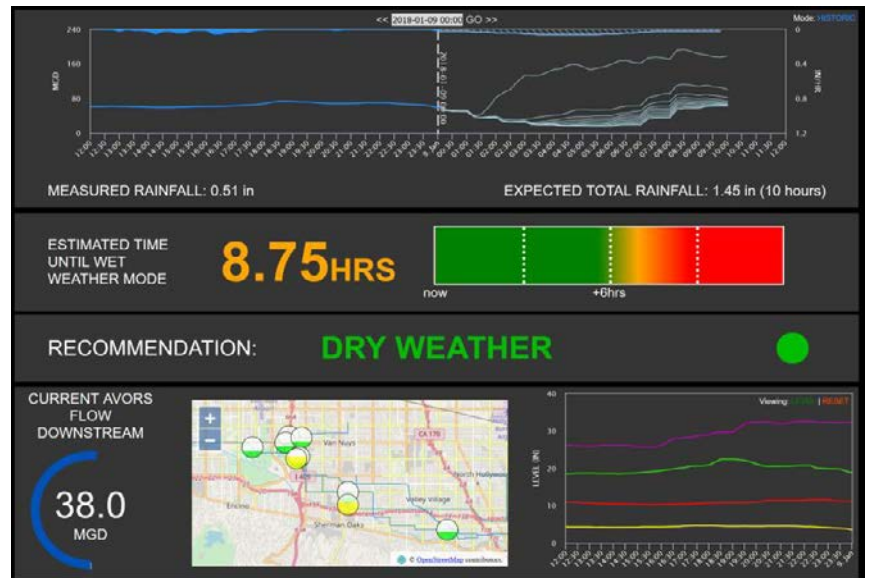
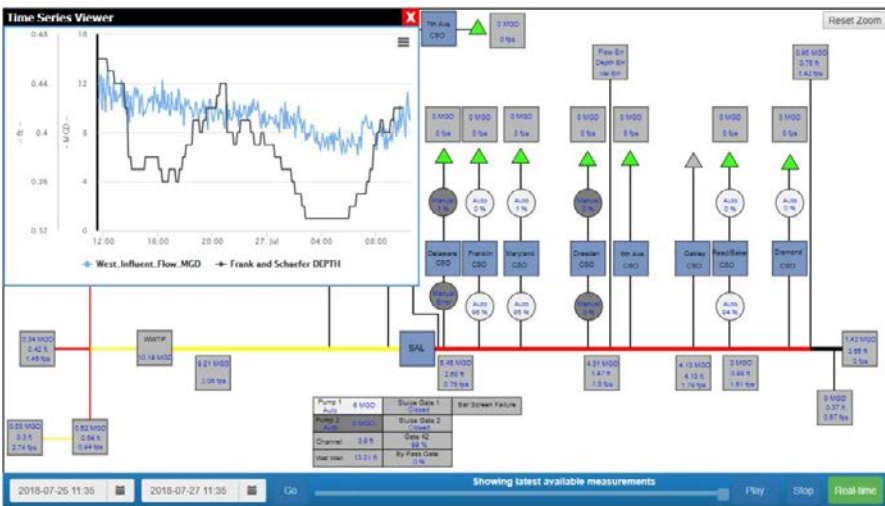
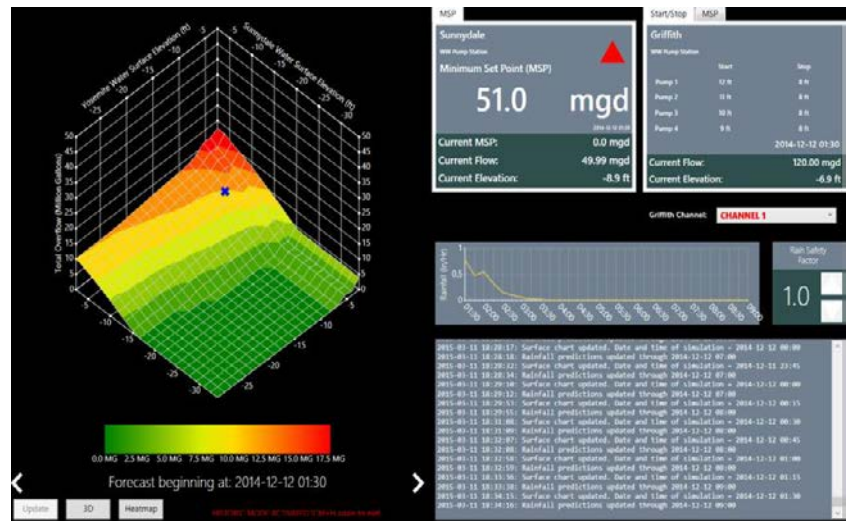
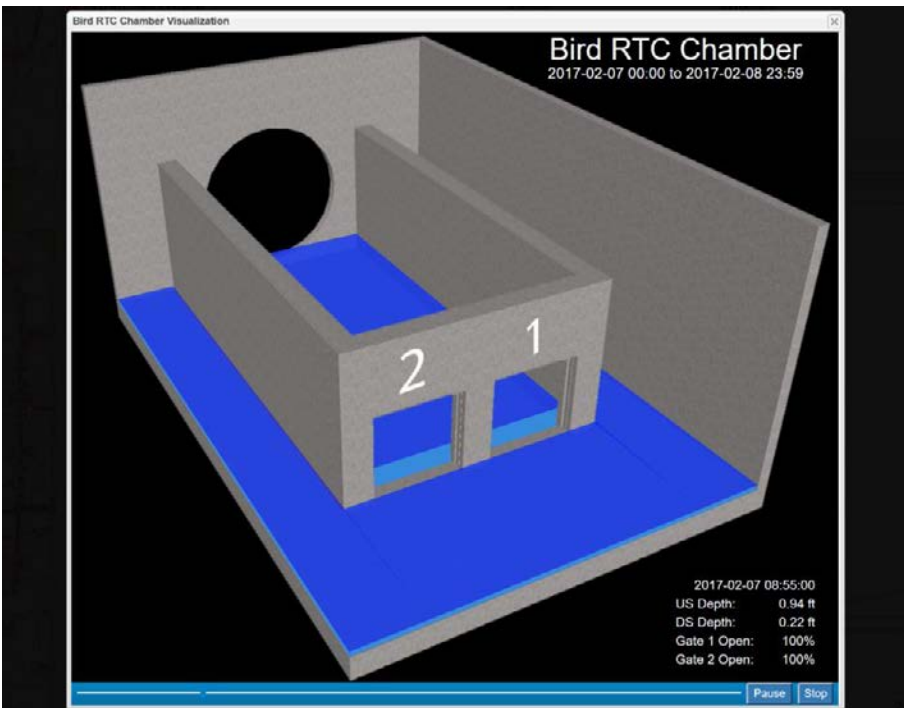


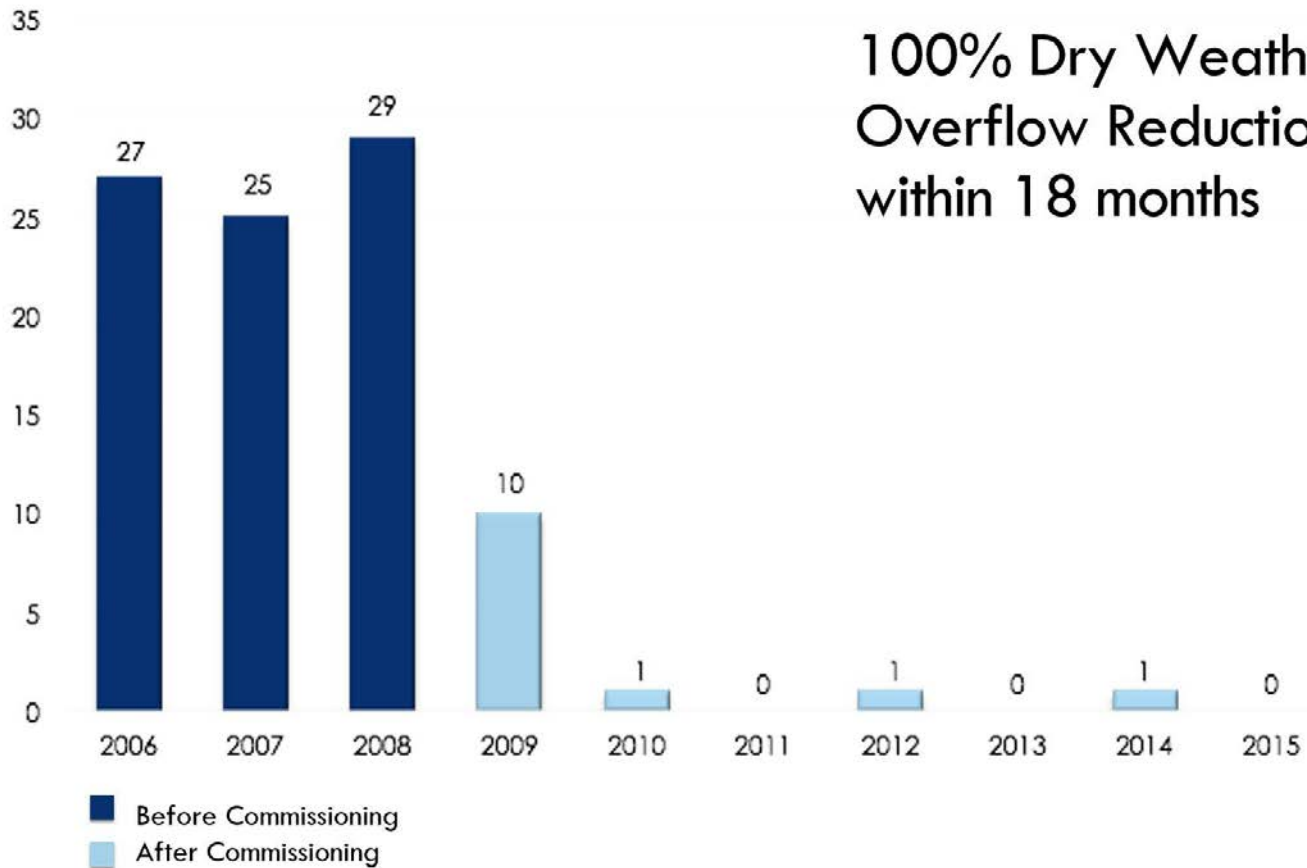
$$Q_{WWTP} = \sum_{i=0}^N Q_{Ii}, \bar{Q}_{WWTP} = \sum_{i=0}^N \bar{Q}_{Ii}$$

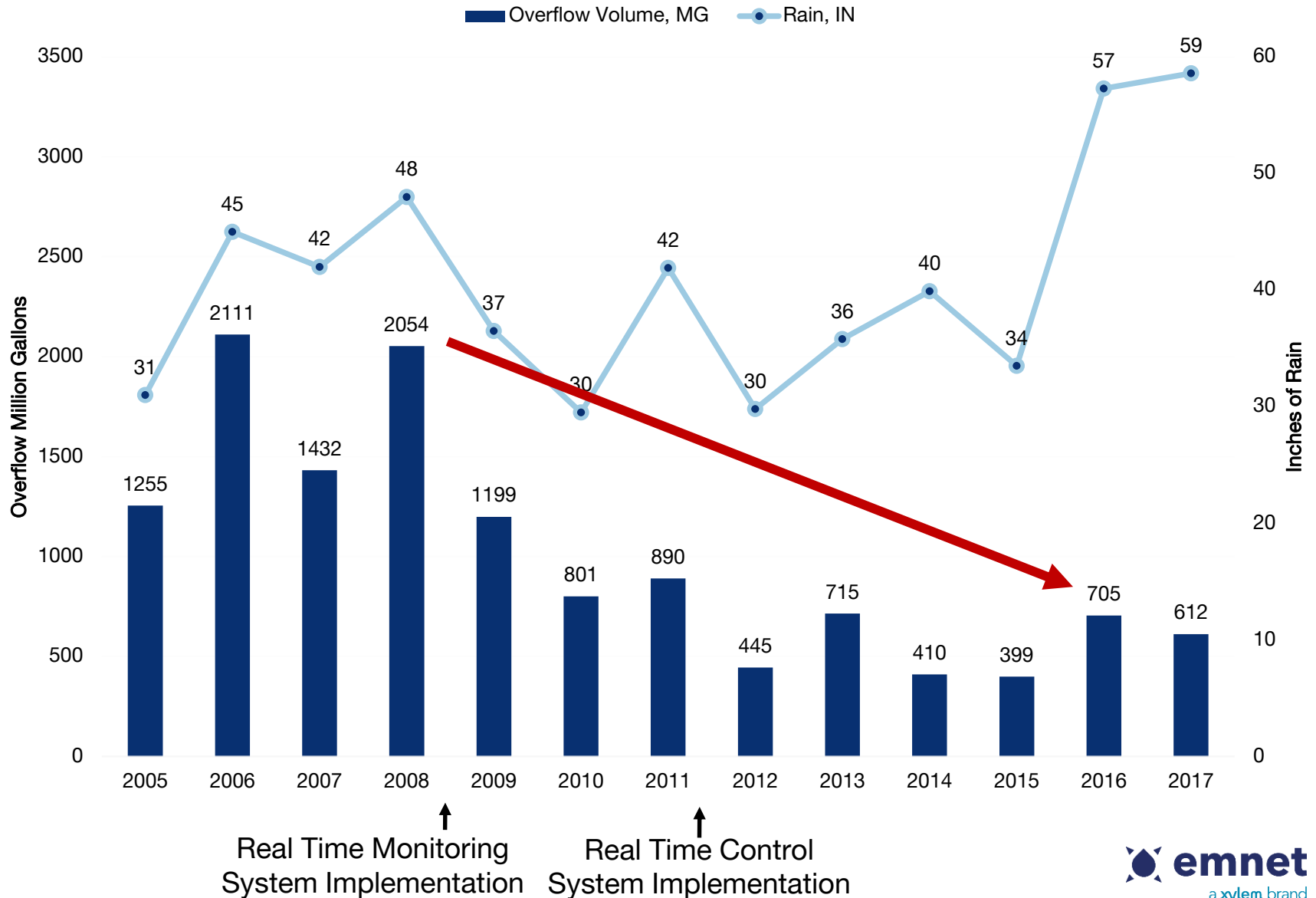
$$Q_{CSOi} = \begin{cases} 0, & Q_{Ti} < \bar{Q}_{Ii} \\ Q_{Ti} - \bar{Q}_{Ii}, & O.W. \end{cases}$$



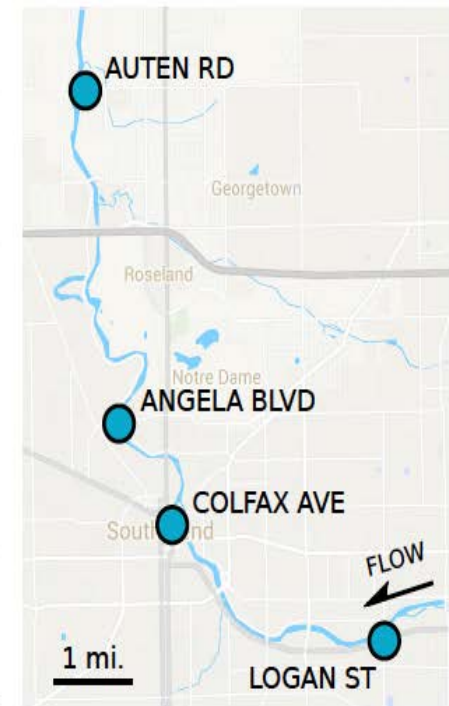
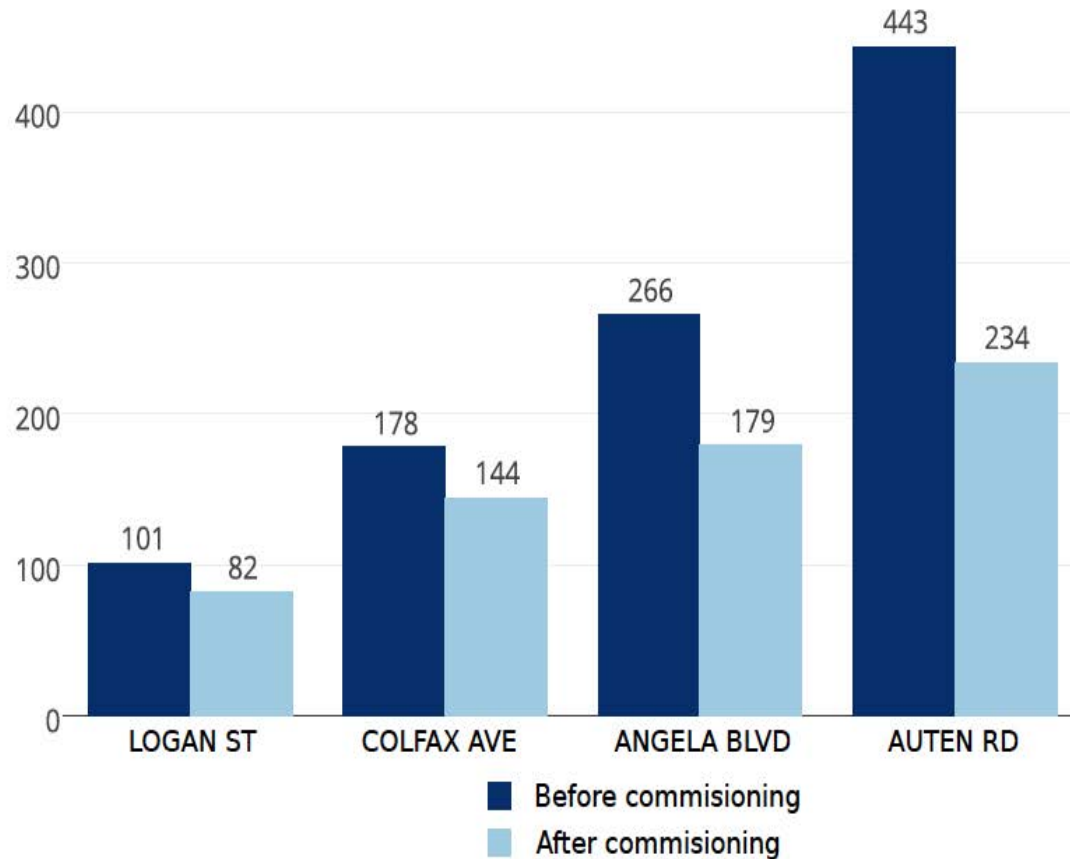
$$\min(Q_{overflow}) \text{ subject to } Q_{WWTP} \leq \overline{Q_{WWTP}}$$







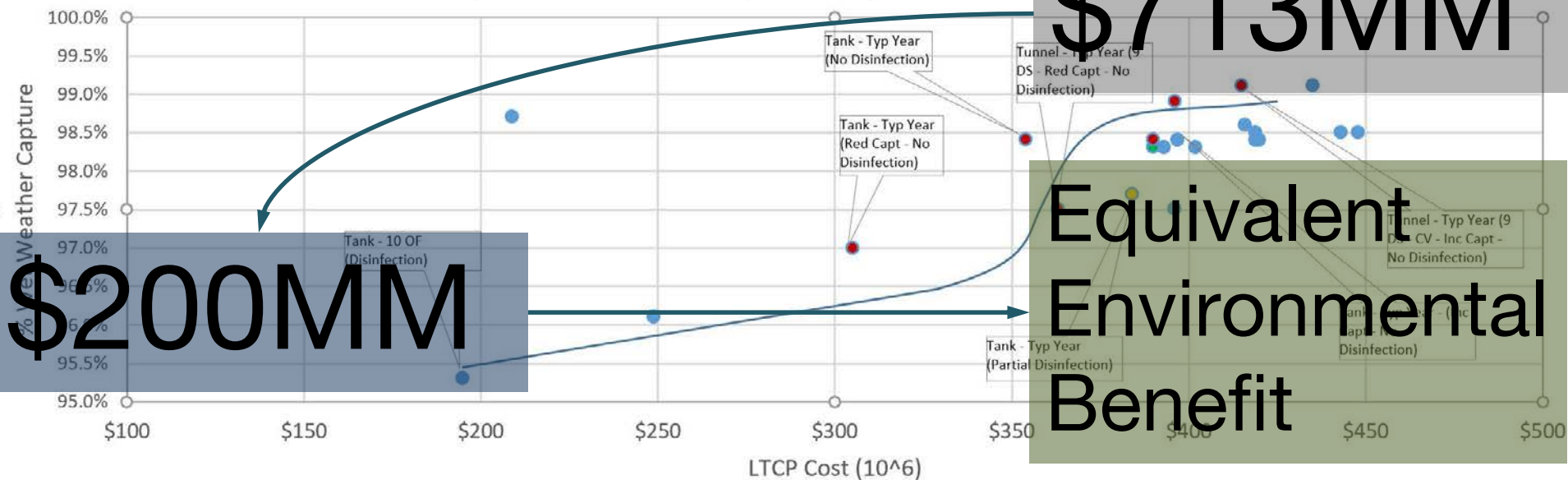
Median E. coli concentration [cfu/100 mL]



55% reduction in E. coli contribution

Use the cloud to try every possible grey, green, and smart infrastructure option.

% Wet Weather Capture vs LTCP Cost (Millions)



\$713MM

\$200MM

**Equivalent
Environmental
Benefit**



Intelligent Urban Watersheds

Thank You!