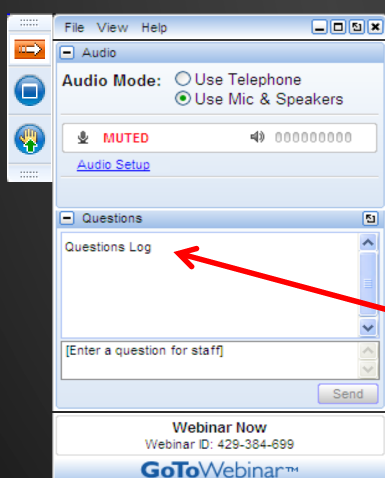
How to Participate Today



- **Audio Modes**
  - Listen using Mic & Speakers
  - Or, select “Use Telephone” and dial the conference (please remember long distance phone charges apply).
- **Submit your questions using the Questions pane.**
- **A recording will be available for replay shortly after this webcast.**

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Smart Water Technologies: An Overview of Real World Applications

Thursday July 12 2018
1:00 – 3:00 PM ET

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Today's Moderator

Elkin Hernandez

dc water is life®

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Today's Speakers

- Joshua Cantone & Jack Chan
  - MWRDGC's Outcome Driven Approach to Stormwater Planning
- Prateek Joshi
  - Operational Analytics for Water Treatment Plants
- Reese Johnson
  - Smart Sewers: Using Technology to Improve Wet Weather Operations

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Our Next Speakers

Joshua Cantone, Ph.D.

Optimatics PLAN SMARTER

Jack Chan, Ph.D., P.E.

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MWRDGC's Outcome Driven Approach to Stormwater Planning

Joshua Cantone, Ph.D.
Jack T.P. Chan, Ph.D., P.E.

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Demystifying Artificial Intelligence

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An industry word jumble

- Artificial Intelligence
- Smart Networks
- Intelligent Systems
- Black Box
- Decision Support System
- Big Data
- Data Analytics
- Predictive Analytics
- Optimization
- Smart Water

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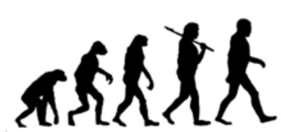
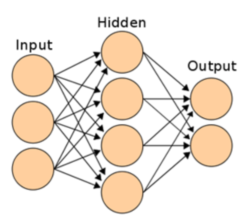
Demystifying AI…

- Artificial intelligence is perhaps the best overarching term – optimization is a part of that
- Two types of AI – narrow (weak) and strong
  - Narrow: non sentient machine intelligence used for a narrow task
  - Strong: sentient machine intelligence with consciousness and mind

“STRONG AI”





“NARROW AI”

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Real world examples

- Artificial Neural Networks

- Fuzzy Logic

- Evolutionary Algorithms

FedEx

SOUTHWEST

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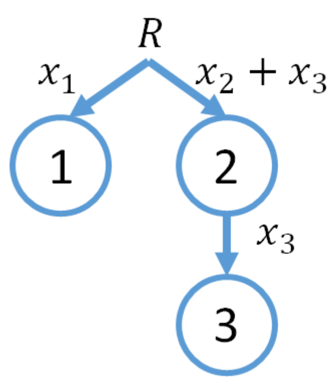
In the water industry…

- Partial Enumeration
  - Best engineering judgement
- Linear, Non-linear, or Dynamic Programming
  - Linear equation to be maximized or minimized
  - Linear constraints
  - Examples: Water resources allocation



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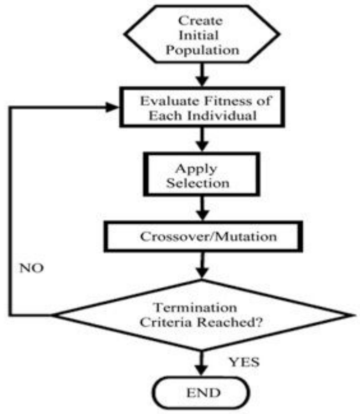
In the water industry…

- Evolutionary Algorithms
  - Based on nature, population based approach
  - Examples: Off-line planning for water distribution systems and wastewater collection systems
- Artificial Neural Networks
  - Learn from big data in order to predict or detect events
  - Examples: pipe breaks, flow prediction, etc.



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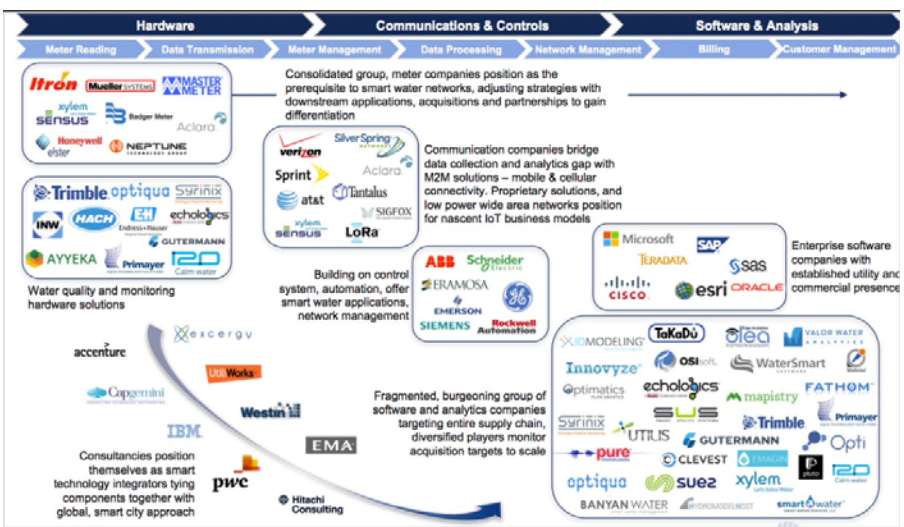
A burgeoning space…



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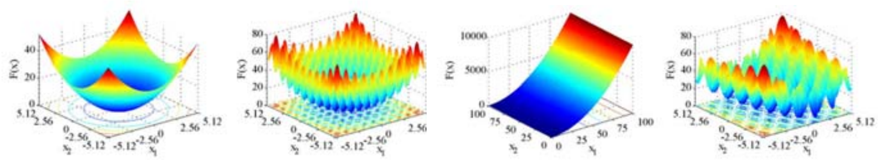
AI (Optimization) for Smart Planning

- Optimization is…
  - applying an analytic process to find the best solution to a problem that has many possible solutions
  - transparent, unbiased and adaptive approach
- Optimization is <u>not</u>…
  - black box



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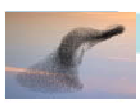
Meta-heuristics Inspired by Nature



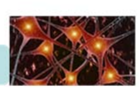
Particle swarm optimization

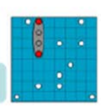
Shuffled frog leaping algorithm

Ant colony optimization

Genetic algorithm optimization

Artificial neural networks





Monte Carlo methods

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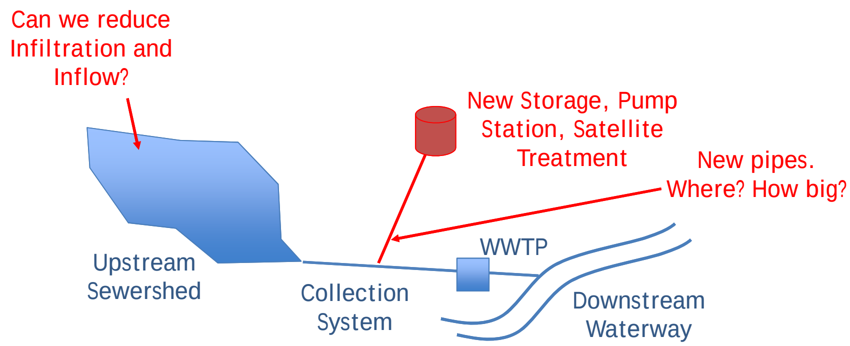
Simple Example



Design Criteria
- Surcharge
- Velocity
- Overflow

Costs
- Capital costs
- Operating costs
- Lifecycle Costs

Scenarios
- Existing/future demands
- Storm events
- Limited options

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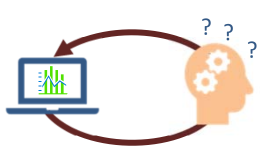
Optimization

Find the best solutions to a problem that has many possible outcomes

Traditional Planning Approach

Trial and error process to develop CIP and operating plans.

Only limited number of alternatives can be evaluated and vetted



Frustrating

Optimizer™ Approach

Planner sets capital improvement and operating options and objectives to be met

Creates and evaluates thousands of trial solutions

Evaluate Costs

Evaluate Hydraulic Performance and Key Criteria (e.g Risk, Environmental, Social)

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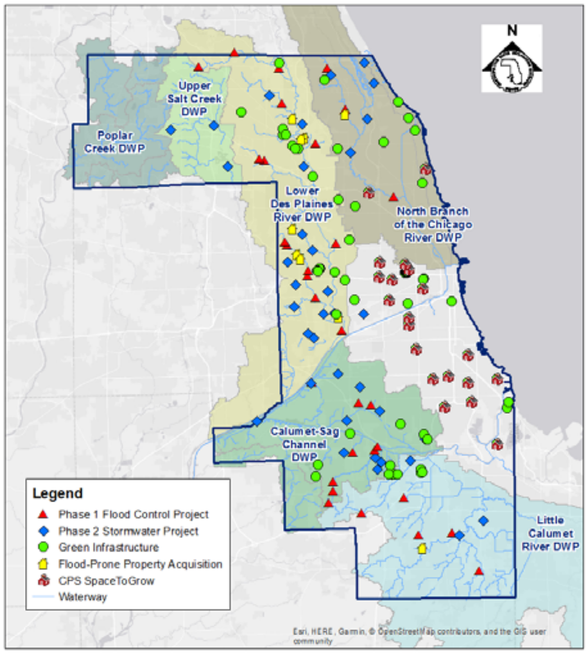
MWRDGC's Outcome-Driven and Adaptive Approach to Stormwater Planning

MWRDGC Background

- 2004 the authority for general supervision of stormwater management in Cook County was conveyed to the District by the Illinois State legislature.
- 2011 Detail Watershed Plans (DWPs) completed for the 6 major watersheds of Cook County – Cal-Sag Channel, Little Calumet River, Lower Des Plaines, North Branch of the Chicago River, Poplar Creek, and Upper Salt Creek.
- Phase I projects were identified from the DWPs to address overbank flooding "riverine flooding"
- 2014 the District's authority was amended to allow for flood-prone property acquisition and to plan, implement, finance, and operate local stormwater management projects.
- Phase II projects involves working with local communities and agencies to address local drainage problems.



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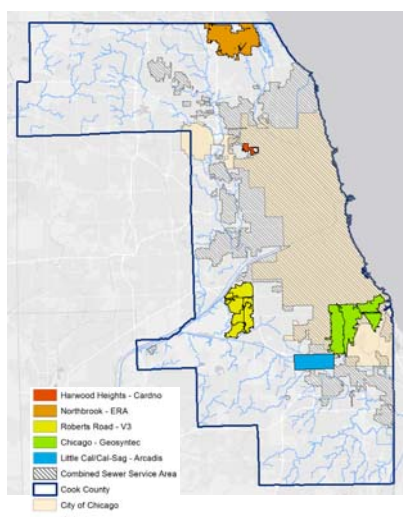
Stormwater Masterplan Pilots

- Pilot study areas identified by four Councils of Government and the City of Chicago
- Study areas comprised of both separate or combined sewer areas
- Goal was to identify solutions to flooding of structures experienced in storms up to and including a 100-year event



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Approach of the Studies

- Analysis of existing overland flooding and basement backup issues, including detailed (H&H) modeling of flooding issues and alternative solutions
- Minimize basement flooding and surface flooding by:
  - Balancing gray and green infrastructure
  - Implementing backflow prevention
  - Outcome driven
- Sought input from local municipalities, other stakeholders, and general public through questionnaires, public workshops, and other outreach tools to get full understanding of flooding impacts, and to identify preferences for green, gray, and/or private property solutions
- Public outreach effectiveness was also measured to evaluate the change in public attitude and willingness to participate in stormwater solutions

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City of Chicago (Southeast Side) Pilot - GEOSYNTEC

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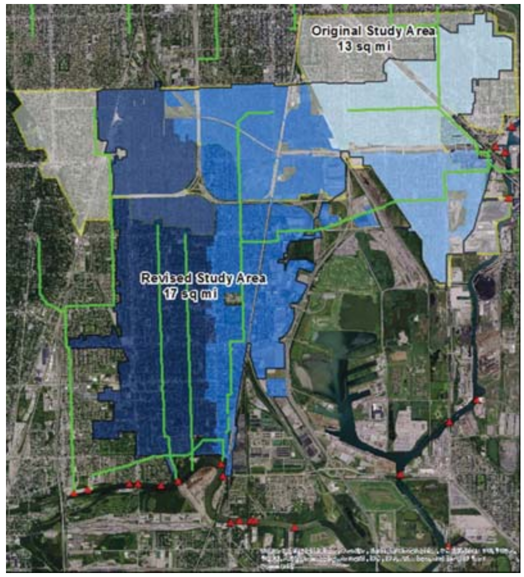
Study Area

- 17 square miles
- 493 catchments
- 4 major sewersheds
- 44,053 structures (excludes garages)

Structures flooded:

- 5 yr: 25,466 (58%)
- 25 yr: 32,610 (74%)
- 100 yr: 41,188 (93%)



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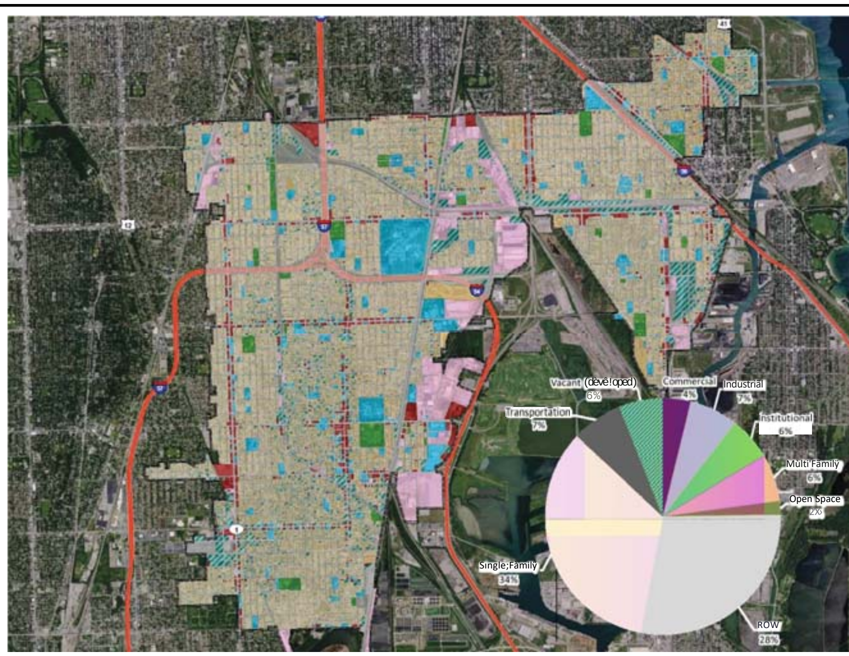

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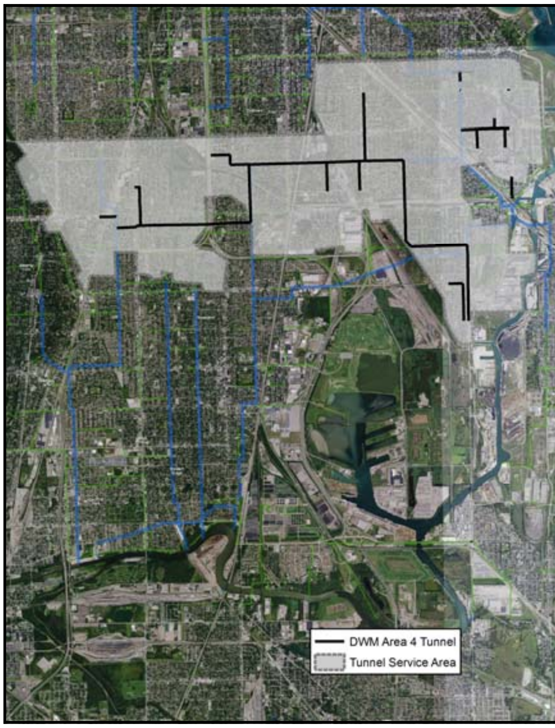

Conceptual Tunnel Alternative

- 5 year level of service (only)
- Northern portion of Area 4 (only)
- Structures removed: 27,131
- Preliminary estimate: $255M +

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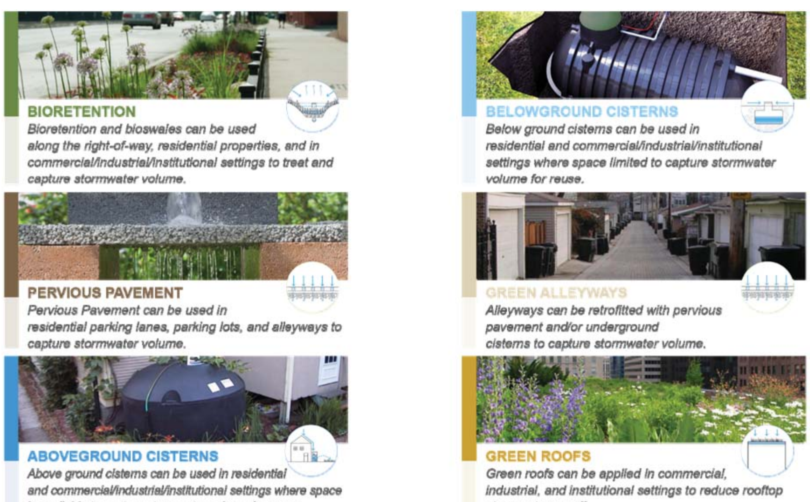
GI Tool Box



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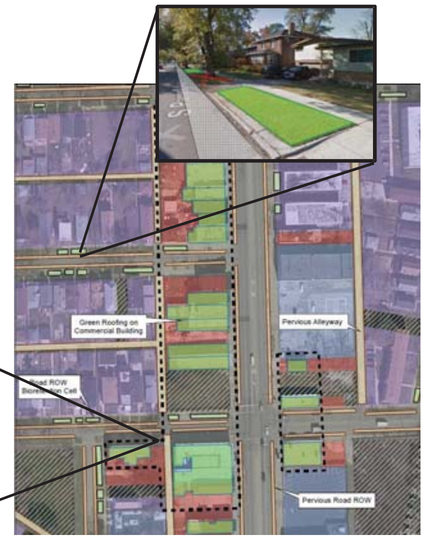
Screening

- Performed intense screening of GI applicability within the study area
  - Identify viable GI practice alternatives for urban landscape of Chicago
  - Determine maximum extent of GI implementation
- Associated GI practices with each land use category (defined in model)



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Summary of Unit Cost Estimates and Model Input Unit Costs

	GI Practice	Units	Low (-30%) Cost Estimate	**Model Input Cost Estimate**	Actual Cost Estimate	High (+50%) Cost Estimate
P1	Pervious Pavement (Commercial, Industrial, and Institutional)	SF	$21	**$25**	$34	$46
P2ƒP3	Pervious Pavement (Roadway ROW and Residential Alleys)	SF	$20	**$24**	$32	$45
B1	Bioretention (ROW)	SF	$29	**$35**	$45	$62
B2	Bioretention (Commercial, Industrial, and Institutional)	SF	$18	**$22**	$27	$38
B3	Bioretention (Residential)	SF	$19	**$23**	$31	$43
C1	Aboveground Cisterns on Residential Properties	CF	$55	**$66**	$85	$117
C1	Below-Ground Cisterns on Residential Properties	CF	$75	**$90**	$100	$150
C1	Alleyway Concept #1—Below-Ground Aluminized CMP with Asphalt Pavement	CF	$62	**$74**	$97	$132
C1	Alleyway Concept #2—Below-Ground ChamberMaxx Storm Arch with Asphalt Pavement	CF	$30	**$36**	$47	$65
C1	Alleyway Concept #3—Below-Ground ChamberMaxx Storm Arch with Pervious Pavement	CF	$35	**$42**	$55	$75
C1	Alleyway Concept #4—Below-Ground StormTrap with Asphalt Pavement	CF	$44	**$53**	$69	$94
C2	Cisterns (Commercial)	CF	$13	**$16**	$20	$28
G1	Green Roof (Commercial, Industrial, and Institutional)	SF	$8	**$20**	**$10**	$16

**Unit cost of $20/square foot was selected for green roofs based on information provided by local green roof installation companies—Omni Ecosystems and LiveRoof.

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Modeling Approach

- Direct representation of GI in combined sewer model
  - Converted City's trunk sewer model from InfoWorks to SWMM and incorporated GI into the SWMM model
  - Allowed direct comparison of green vs gray performance
- Optimization of GI types, coverage, and placement locations
  - 70,000+ combinations (comparing performance & cost)
  - Evaluated targeted scenarios (implementation strategies)

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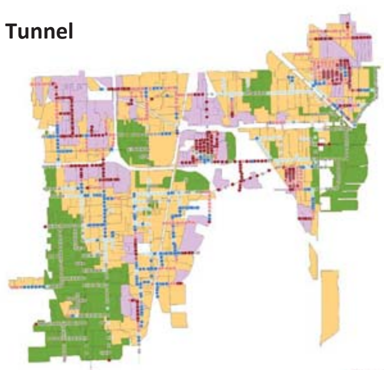
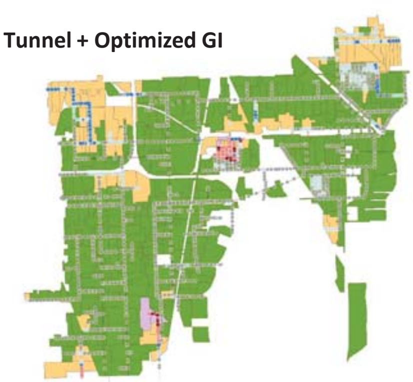
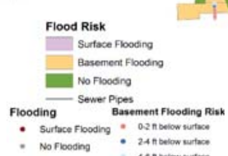
25-Year Storm Event

Tunnel



Tunnel + Optimized GI





Total Structures: 44,053
Structures flooded: 73%
Cost: $255M

Structures flooded: 11%
Cost: $1,114M
$255M (tunnel) + $809M (GI) + $50M (back flow)

53

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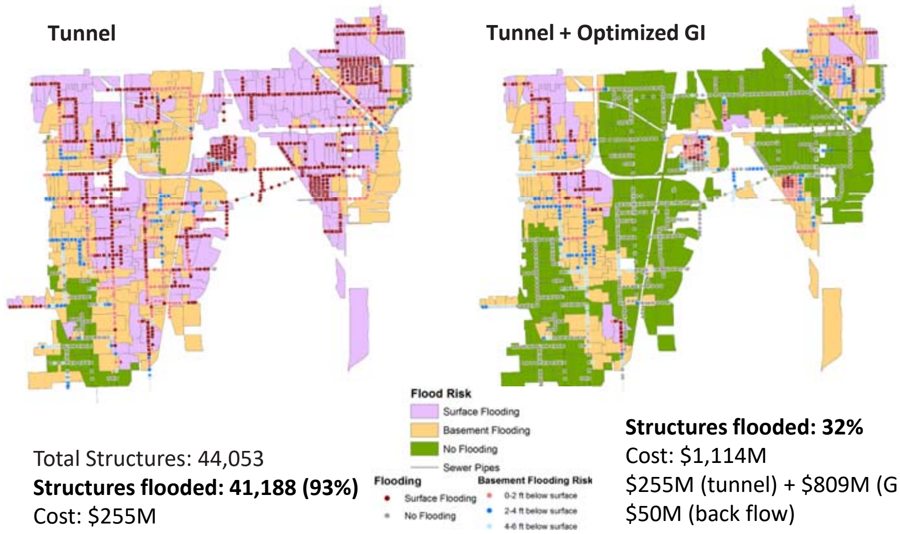
100-Year Storm Event



Total Structures: 44,053
Structures flooded: 41,188 (93%)
Cost: $255M

Structures flooded: 32%
Cost: $1,114M
$255M (tunnel) + $809M (GI) + $50M (back flow)

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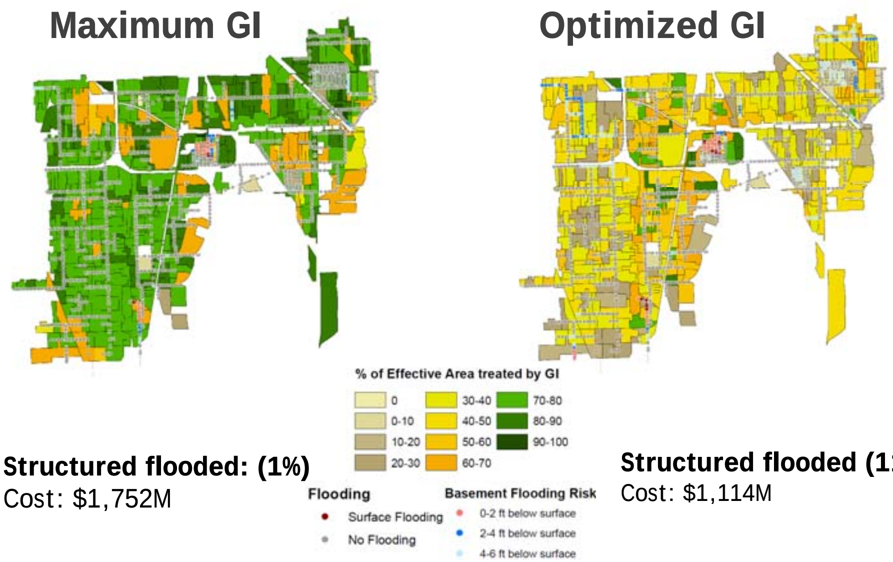
Optimizing GI Placement – 25 year



Structured flooded: (1%)
Cost: $1,752M

Structured flooded (11%)
Cost: $1,114M

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Findings

- Traditional solutions can lack resiliency
- GI is effective & placement can be optimized

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Next Steps – Stormwater Master Planning

- Evaluate Master Planning needs throughout Cook County
- Develop outcome-driven but adaptive approach, centered on managing local stormwater issues with multi-disciplined teams
- Establish logical watershed/sewershed based study areas and prioritization
- Create a guidance document to guide master planning for each study area

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Our Next Speaker

Prateek Joshi

Operational Analytics for Water Treatment Plants

Prateek Joshi
CEO, PLUTO AI
prateek@plutoai.com

Who am I?

Founder of **PLUTO AI**. Launched in Mar 2016.

Author of **8 books** on Artificial Intelligence

Affiliations: **WEF, WE&RF, AWWA, LIFT, TAG**

Problem

Energy is the largest expense of operating a treatment plant. No access to data intelligence to reduce the energy consumption.

Why is it a problem?

Operating reactively as opposed to proactively

No info on the **future operating conditions** of the plant

Compliance requirements force treatment plants to make **conservative decisions**, leading to higher operating costs.

Solution

Real-time operational analytics that can provide operational parameters to maximize throughput and minimize compliance risk, thereby increasing energy efficiency.

What can AI do?

Extract wisdom from treatment plant data in real time

Perform scenario planning based on future conditions

Provide **step-by-step operational insights**

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How does AI do that?

It learns the behavior of the plant using **historical data**

It predicts the **future conditions**

It **forecasts the values** of key operational parameters

It **performs scenario planning** to choose the best path

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Terms (mis)used in the field

Artificial Intelligence is the goal

Machine Learning is a vehicle to get there

Deep Learning is a type of vehicle that's fast, winged, and self-driving.

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Data requirements for AI

AI needs **historical data** to learn about the plant's behavior and build a model

AI needs **real-time data** to predict the future behavior based on the above model

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Deploying AI at a plant

Operators need information that's **actionable**

The information needs to be **accurate**

Always need to be **compliant**

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Data-centric simulations

Simulations built on static equations only work under ideal conditions. What about real world scenarios?

Need to use data-centric simulations to understand all the future possibilities and pick the best one.

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Digital Twin

Digital equivalent of a physical asset or a process

Digital Twin can be used for **scenario planning**

It enables us to visualize multiple future scenarios by **varying key input variables**

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More water with less energy

Key metric: Energy spent per gallon produced

Need to correlate data to this metric and build models

Computational modeling of energy systems is critical

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Reducing energy footprint

Finds key performance indicators by sifting through data

Can find the right values for the parameters to reduce energy footprint for that process

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Membrane analytics

Membrane systems like RO Membranes and MBR are **energy intensive**

AI can find the **optimal values** for operational parameters like driving pressure, permeability, cleaning schedule, lifecycle impact, and more.

AI can provide **operational oversight** to help the operators ensure that there are no shocks in the system

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AI vs. Excel

Excel can’t predict future conditions

Excel can’t build simulations

Excel can’t learn and adapt

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Predict. Forecast. Simulate.

Predict the occurrence of an event

Forecast the future values of parameters

Simulate various events for scenario planning

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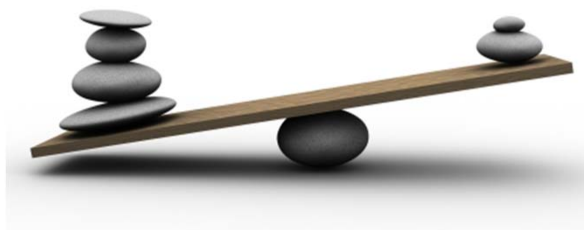
Generic AI vs. water AI

One-size-fits-all approach doesn't work in water. We need AI models that are specifically trained to understand the behavior of water treatment systems



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Key takeaways

AI takes real-time plant data and **converts it to wisdom**

AI finds **optimal values** for key operational parameters

AI does **scenario planning** using data-centric simulations

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THANK YOU

Prateek Joshi
CEO, PLUTO AI
prateek@plutoai.com

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Our Next Speaker

Reese Johnson, PE, PMP

METROPOLITAN SEWER DISTRICT of greater CINCINNATI

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Smart Sewers: Using Technology to Improve Wet Weather Operations

Reese Johnson, PE, PMP
Metropolitan Sewer District of
Greater Cincinnati

emnet · Intelligent Platforms · GRAY MATTER SYSTEMS · CDM Smith listen. think. deliver. · JACOBS

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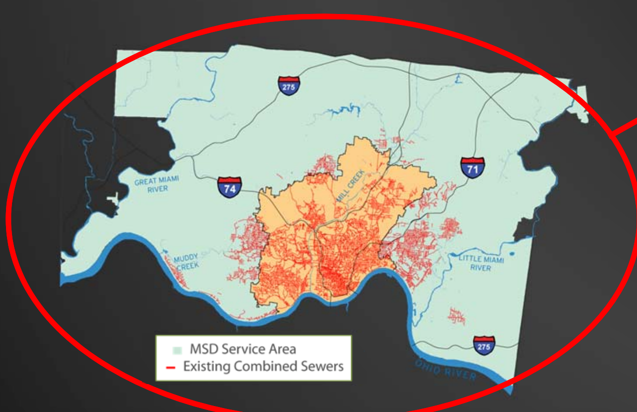
Metropolitan Sewer District of Greater Cincinnati, Ohio



- 800,000+ Residents of Cincinnati and Hamilton County
- 290 Square Miles
- 7 Treatment Plants
- 100+ Pump Stations
- 3,000 Miles of Sewers, Both Sanitary and Combined
- 184 MGD on Dry Days

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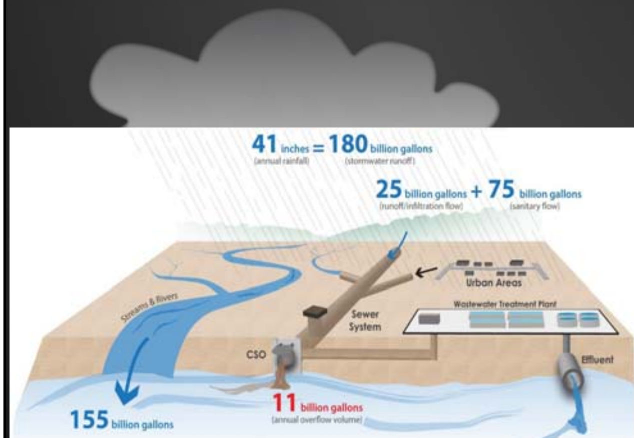
The Challenge of Wet Weather



Southwest Ohio receives
41 inches of rain
per year…

Results in approximately
11 billon gallons of overflow in a typical year

Led to a $3.2B Consent Decree to address the 200+ overflow points through:

- Pipe Upsizing, Storage
- Strategic Separation
- Green Infrastructure
- Dedicated WW Facilities

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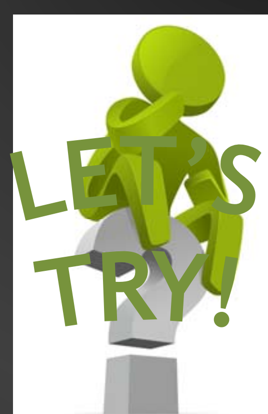
What if…

… we could use *all* the conveyance capacity in our pipes before we had a combined sewer overflow?

….we could use a remote storage tank to reduce overflows many miles away?

….we could use real-time information to prioritize treatment?



Could we achieve the same, or better, environmental benefit and build less new infrastructure?

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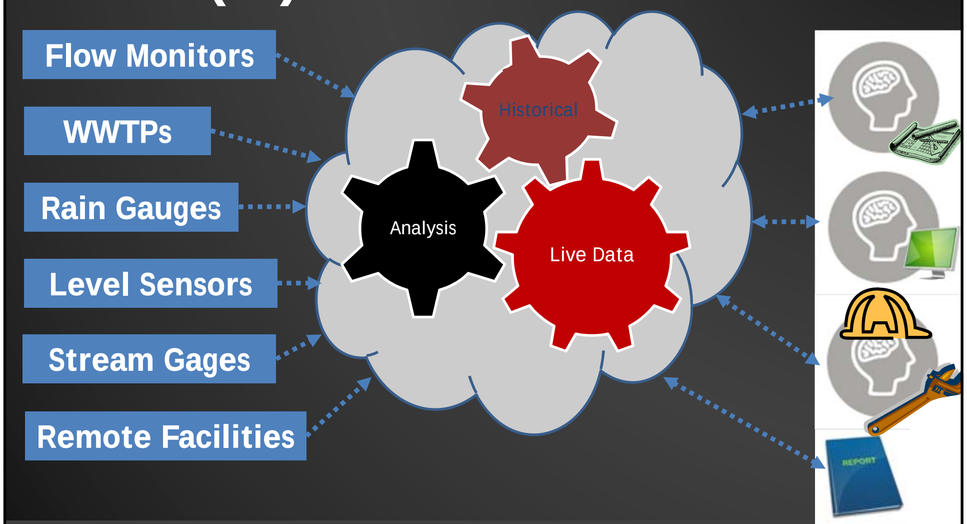
Cloud-based SCADA Enables a Smart(er) Sewer



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"Smart Sewer" Achieves Results Without Additional Construction

- Improves Treatment Plant Operations
- Reduces Overflows from the Collection System
- Improved Watershed Protection

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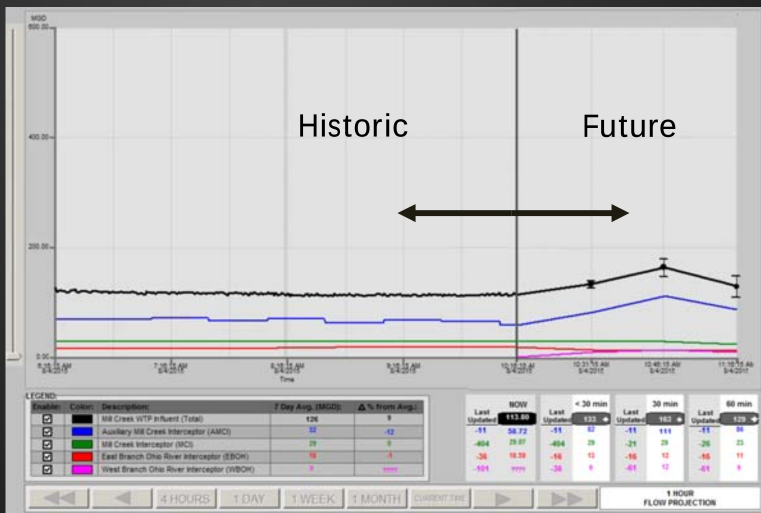
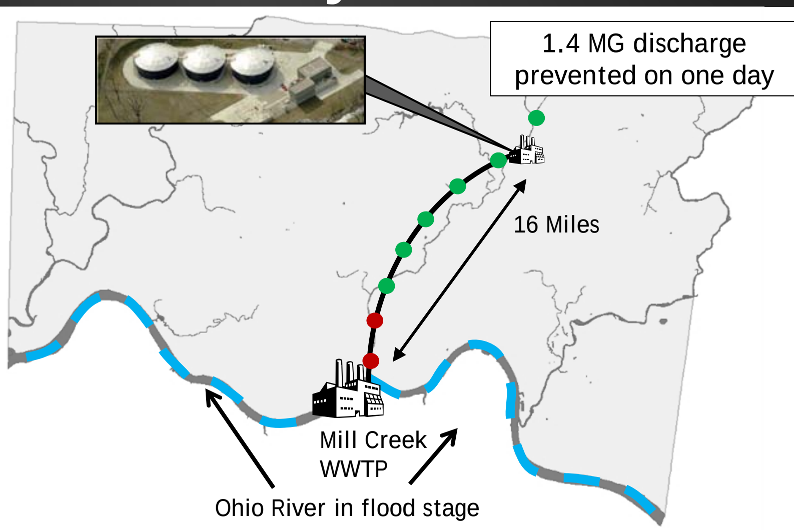
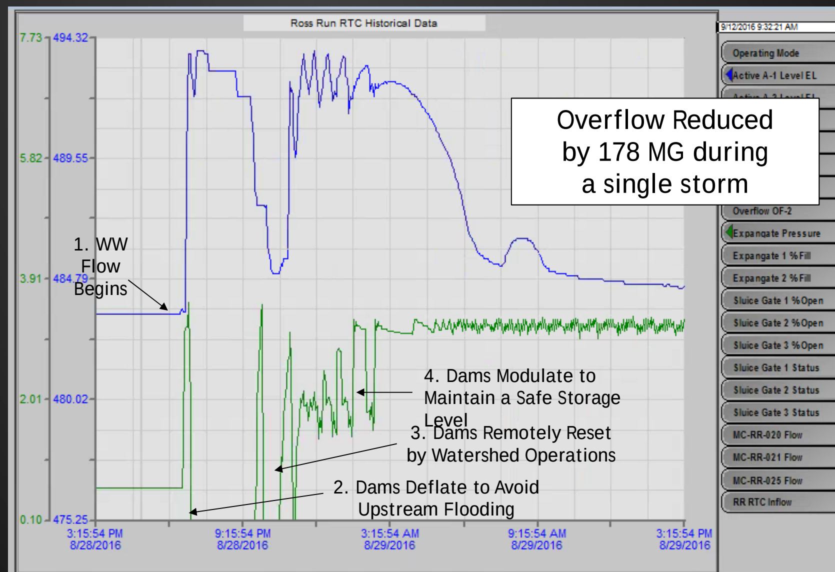
Improved Ops by Projecting Future Flows to WWTP



Reduced Overflows using a Distant Facility



…And through Remote Control



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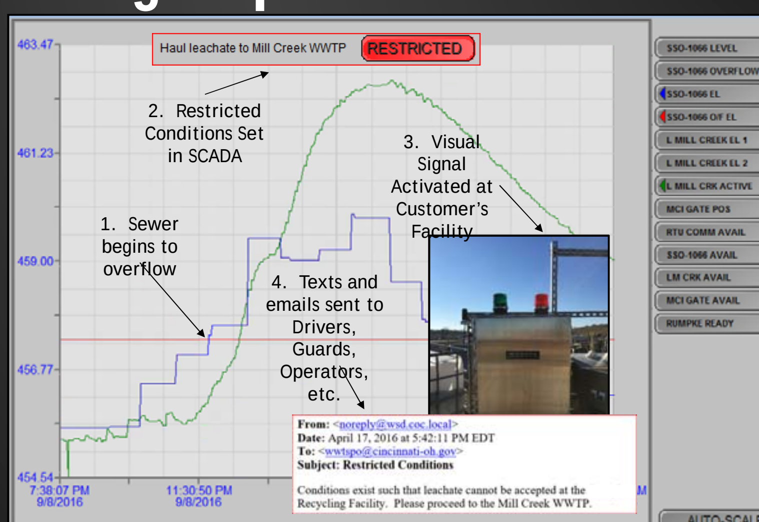
Prohibiting High Strength Discharge Upstream



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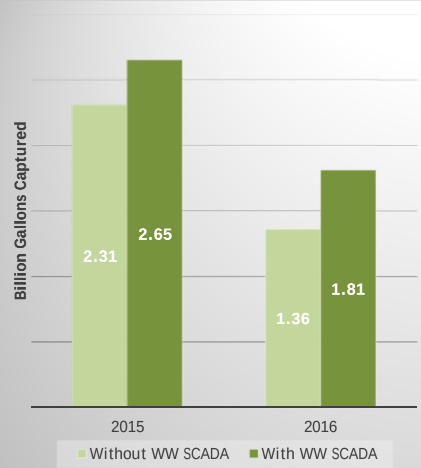
Quantified Early Benefits of the Wet Weather SCADA System



2-year study of 4 Wet Weather Facilities:

- **15% improvement** with addition of real-time monitoring capabilities
- **33% improvement** with real-time

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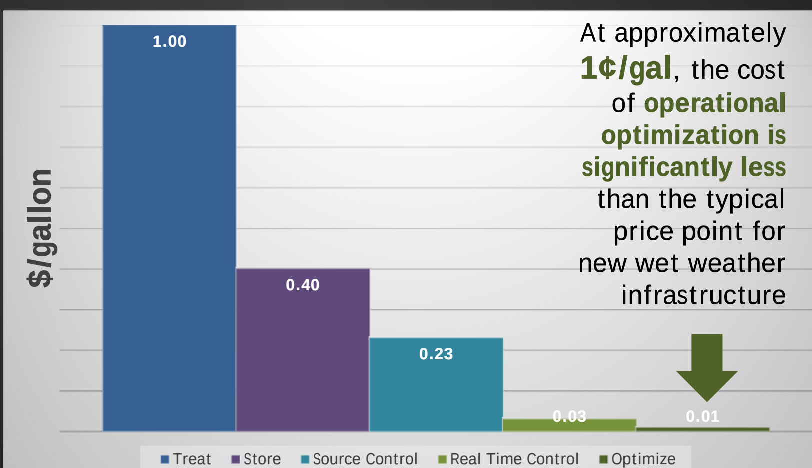
Smart Sewers Make Dollars and Sense



At approximately **1¢/gal**, the cost of **operational optimization is significantly less** than the typical price point for new wet weather infrastructure

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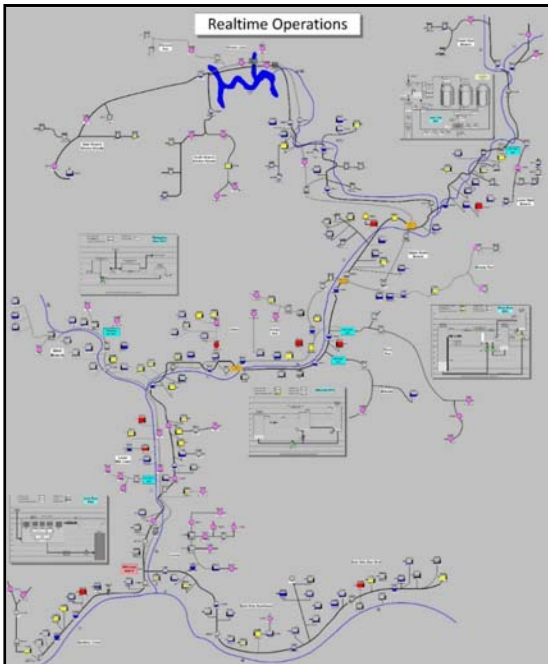

Cincinnati's Smart Sewers

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Questions?

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