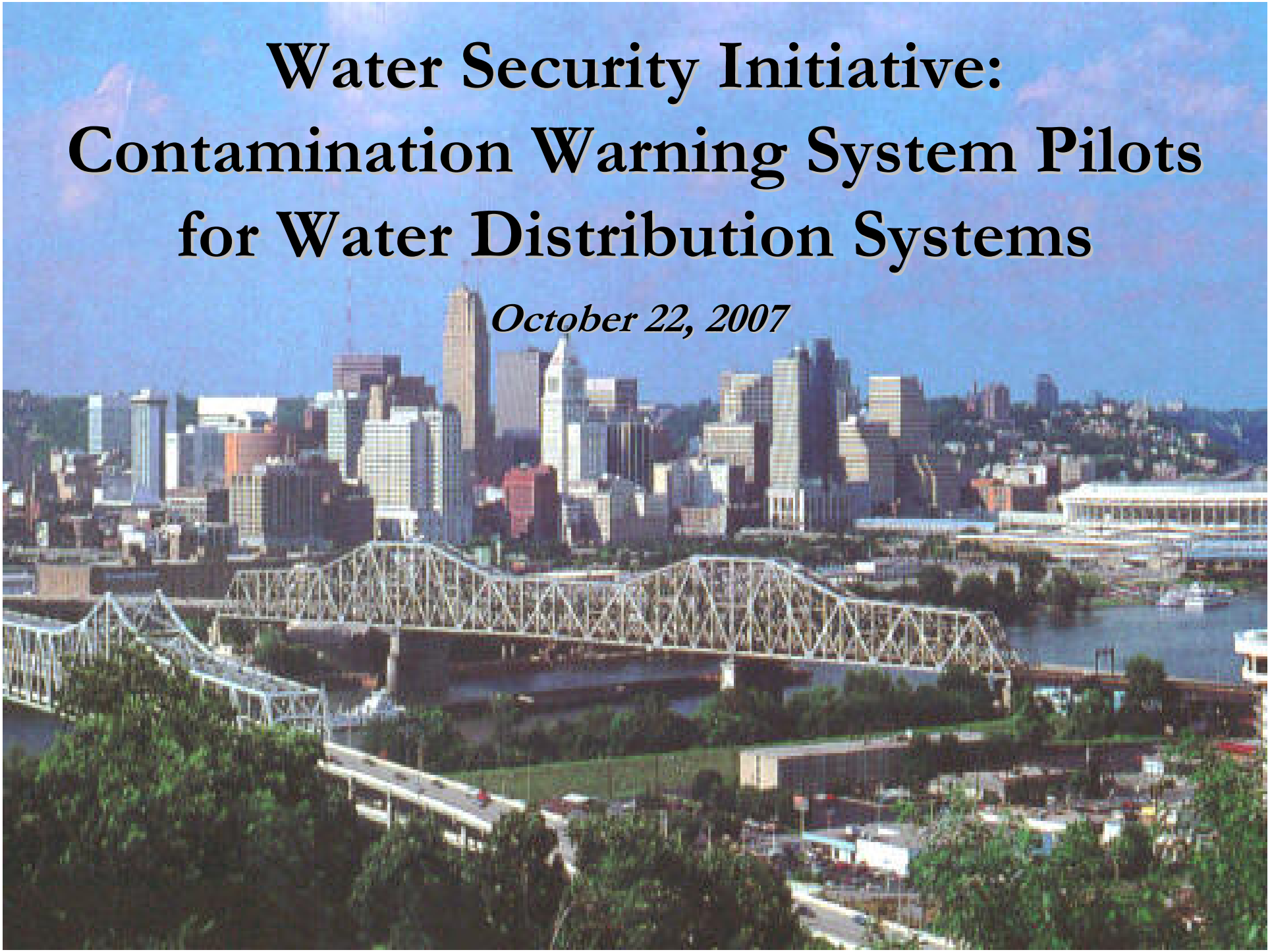
Water Security Initiative: Contamination Warning System Pilots for Water Distribution Systems

October 22, 2007



Overview

- Contamination warning system design.
- Contamination warning system evaluation.
- Expansion of the WSi pilot program.

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Contamination Warning System Design

Developing a Design Basis for a CWS

- Select target contaminants.
- Identify potential detection strategies.
- Find optimal locations for sensors and enhanced security to detect high consequence events.
- Determine timing of detection for different CWS components relative to consequence timeline.

Contamination Selection

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Master List of > 200 Contaminants

Prioritization

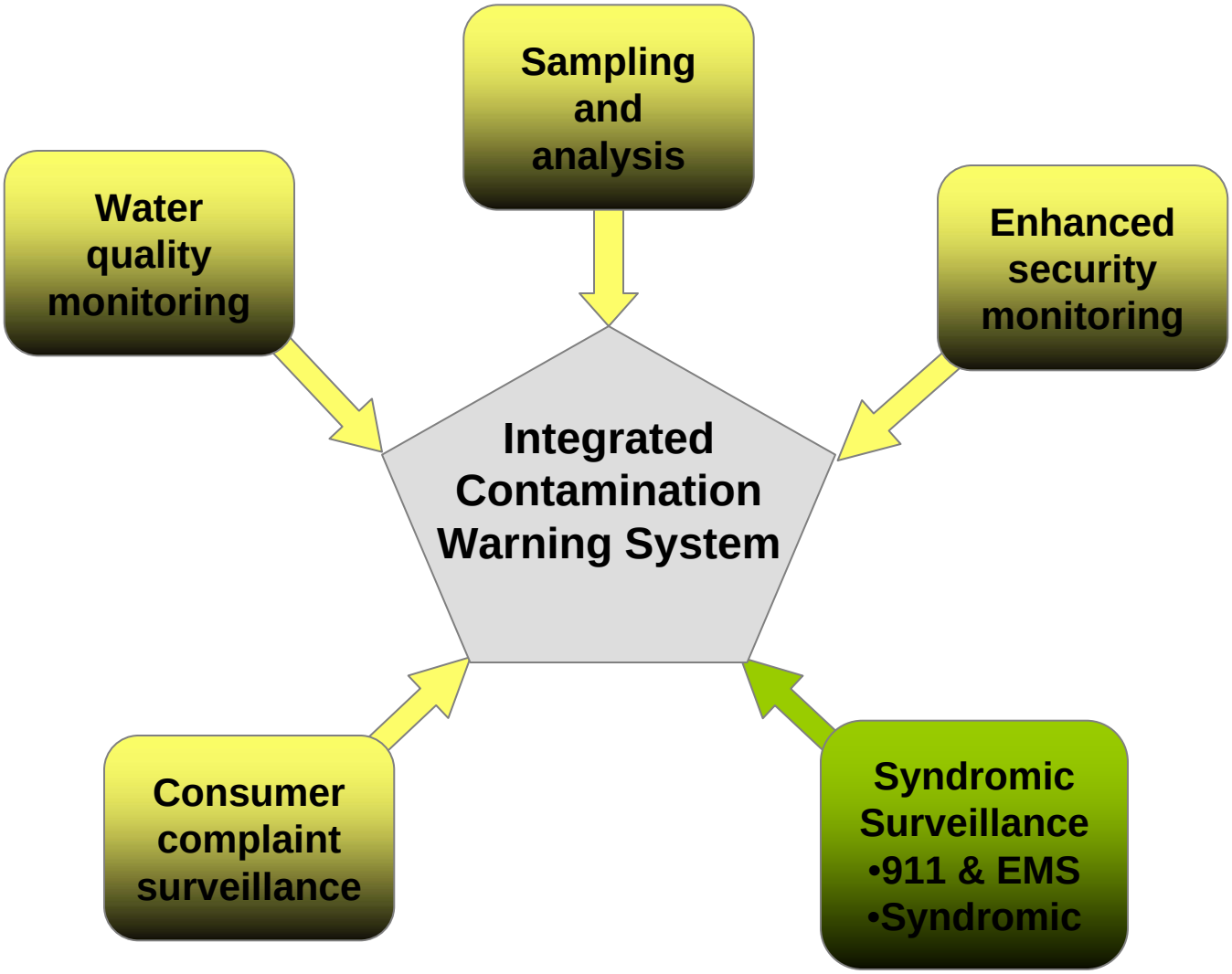
Priority List of 80 Contaminants

Contaminant Selection

- Analytical methods
- Means of detection
- Timely detection

Contaminants for Design Basis

Detection Strategies



Contaminant Detection Classes

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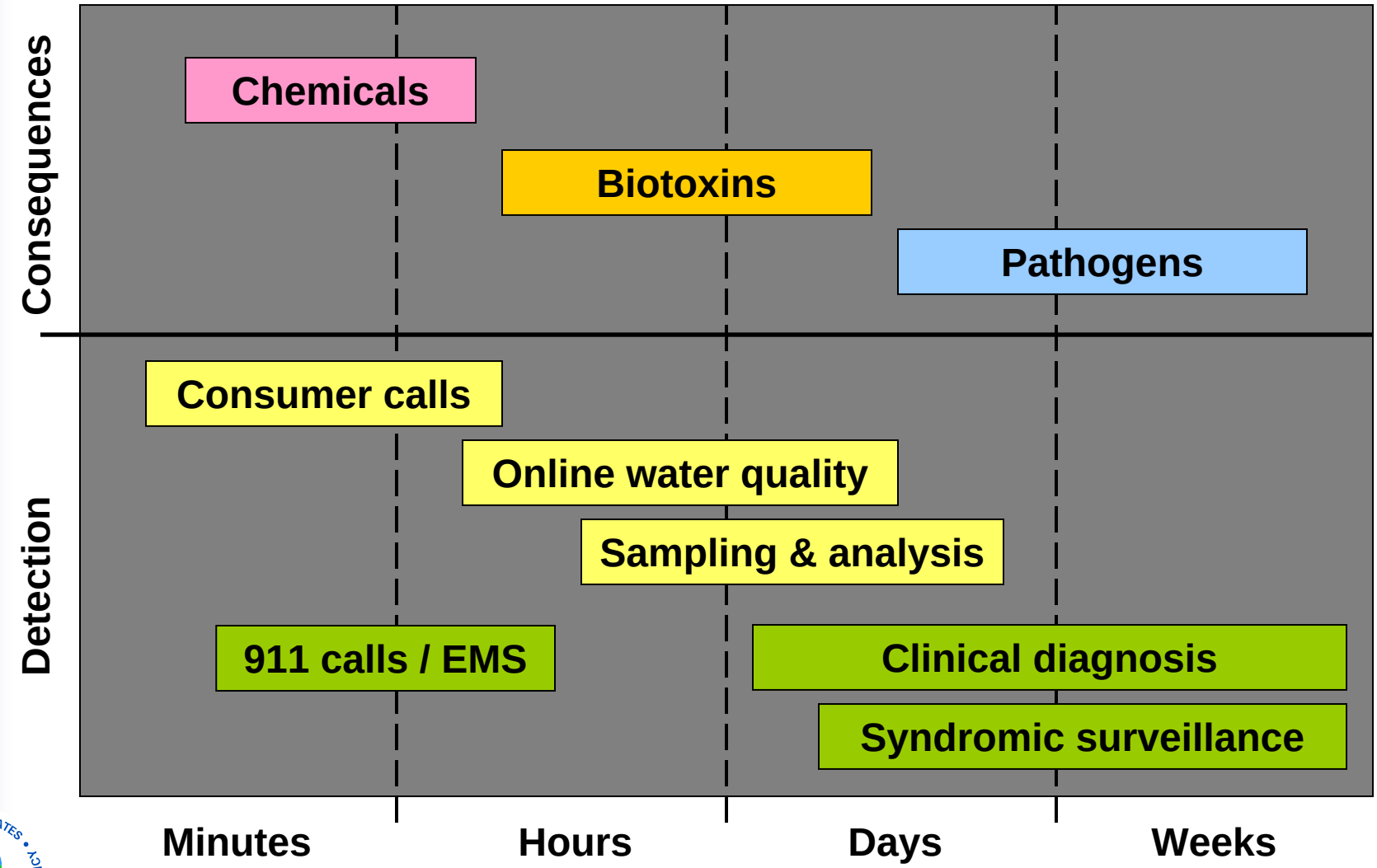
Class	Description	Water quality	Consumer complaints	911 calls / EMS	Syndromic surveillance
1	Petroleum products	√	√		
2	Pesticides (with odor or taste)	√	√	√	
3	Inorganic compounds	√	√	√	
4	Metals	√	√	√	
5	Pesticides (odorless)	√		√	
6	Chemical warfare agents			√	
7	Radionuclides	√		√	
8	Bacterial toxins	√			√
9	Plant toxins	√			√
10	Pathogens causing diseases with unique symptoms	√			√
11	Pathogens causing diseases with common symptoms	√			√
12	Persistent chlorinated organic compounds	√			

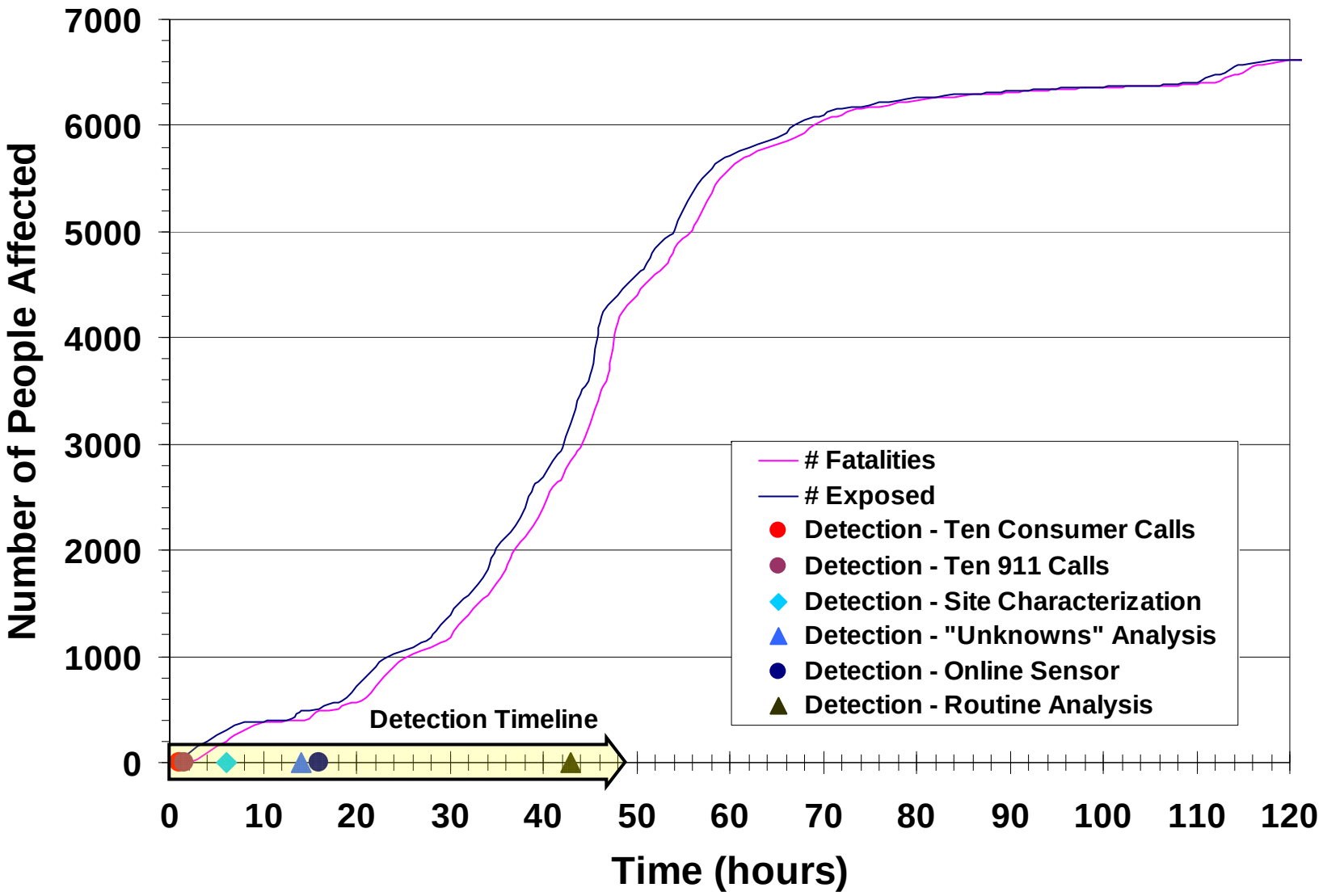
Optimal Locations

- Consequence Assessment:
  - Simulate 1,000s of potential contamination scenarios.
  - Rank scenarios according to consequences.
- Water Quality Monitoring:
  - Sensors placed using an optimization algorithm to minimize consequences over all scenarios.
  - Trade-off analysis considers incremental benefit of additional sensors.
- Enhanced Security Monitoring:
  - Facilities prioritized by relative risk: probability of attack, consequences, and effectiveness of security measures.

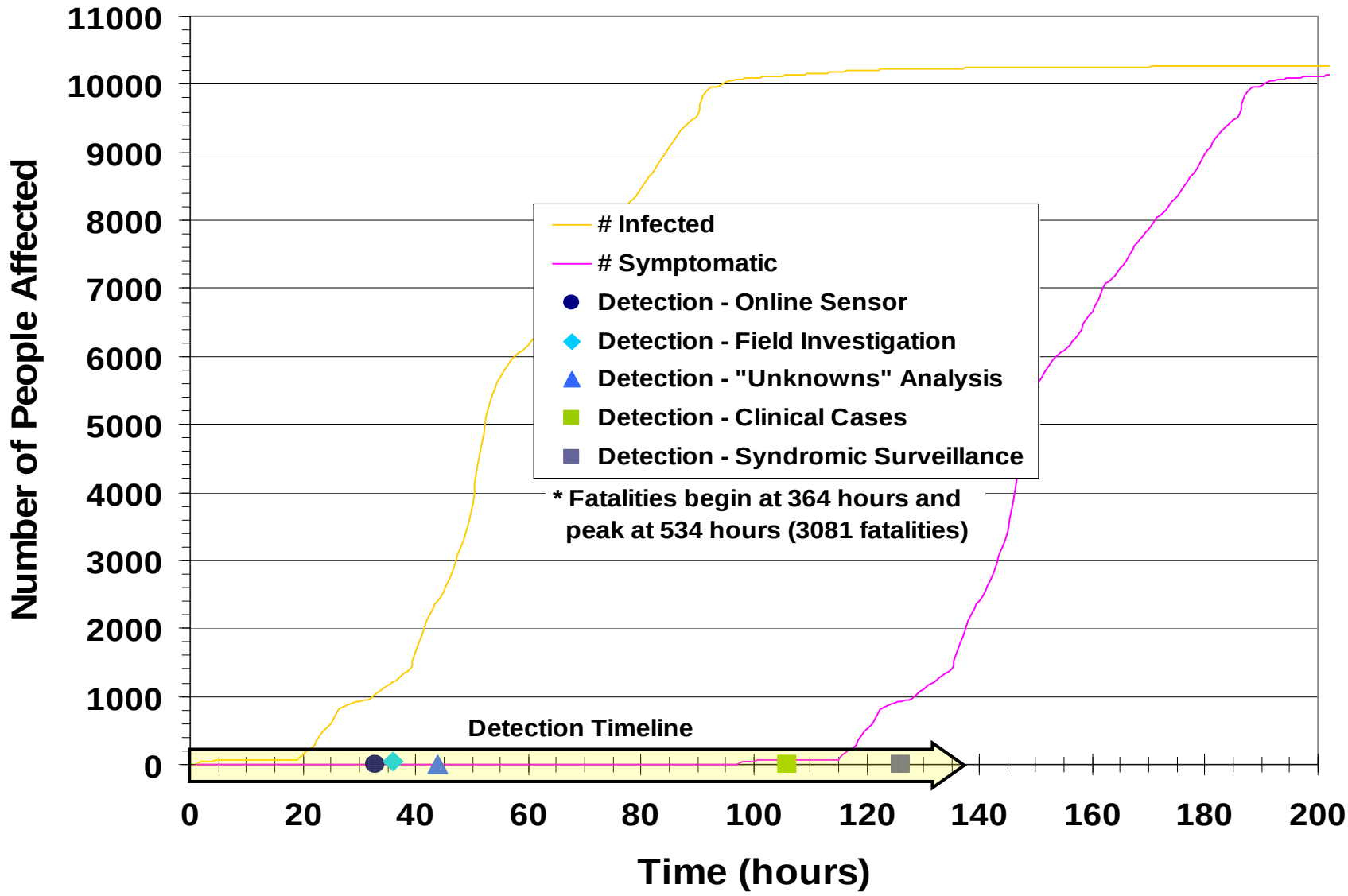
Relative Timing of Detection



Example Contamination Incident Timeline for a Chemical



Example Contamination Incident Timeline for a Pathogen



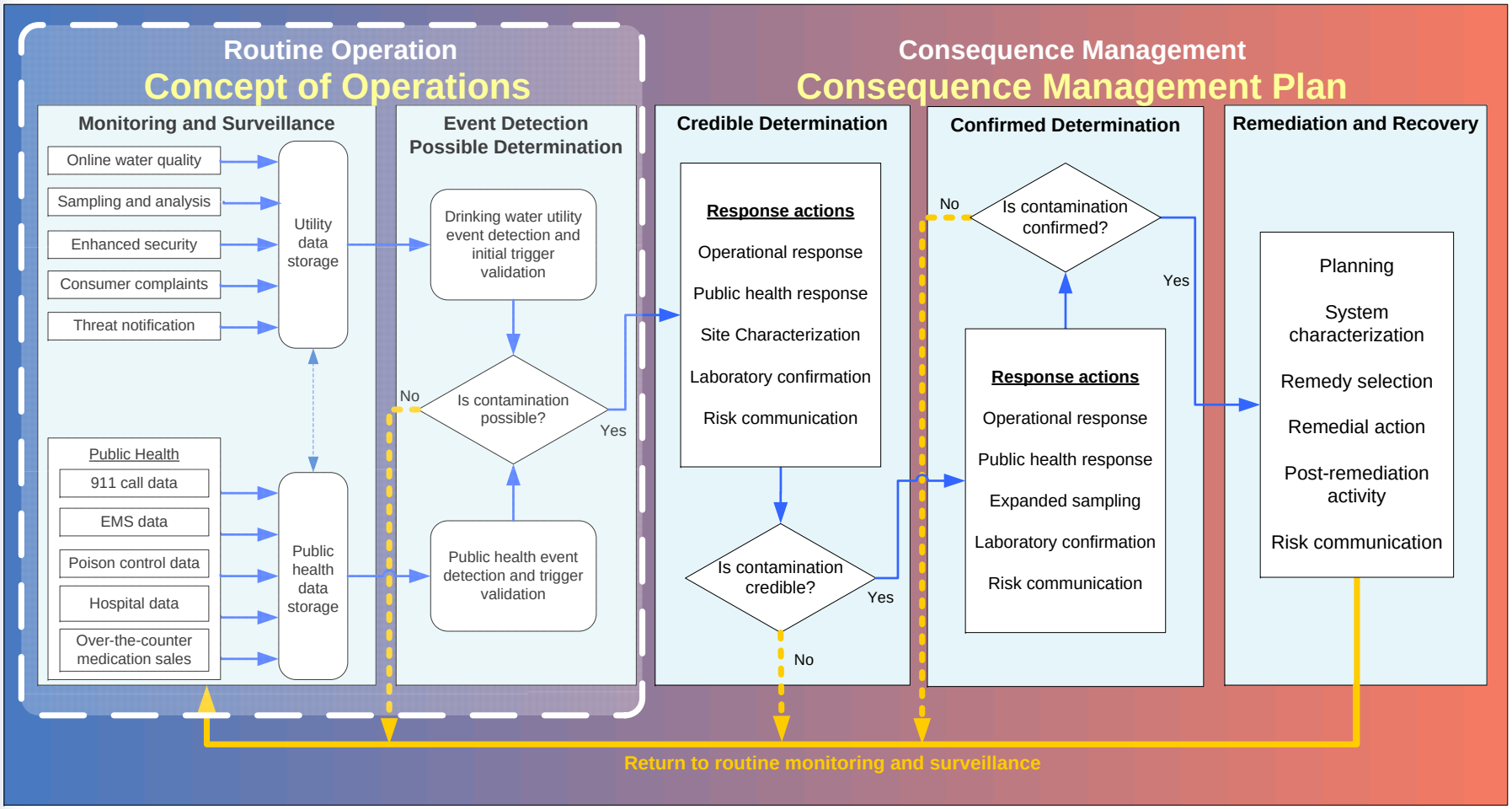
Contaminant Detection Sequence

Class	Description	Initial Detection	Secondary Detection	Tertiary Detection
1	Petroleum products	Consumers	Online WQ	N/A
2	Pesticides (with odor or taste)	Consumers	911/EMS	Online WQ
3	Inorganic compounds	911/EMS	Consumers	Online WQ
4	Metals	911/EMS	Consumers	Online WQ
5	Pesticides (odorless)	911/EMS	Online WQ	N/A
6	Chemical warfare agents	911/EMS	N/A	N/A
7	Radionuclides	911/EMS	Online WQ	N/A
8	Bacterial toxins	Online WQ	911/EMS	PH-Clinical
9	Plant toxins	Online WQ	911/EMS	PH-Clinical
10	Pathogens causing diseases with unique symptoms	Online WQ	PH-Clinical	PH-Syndromic
11	Pathogens causing diseases with common symptoms	Online WQ	PH-Syndromic	N/A
12	Persistent chlorinated organic compounds	Online WQ	N/A	N/A

Summary of Detection Strategies

Component	Contaminant Coverage	Spatial Coverage	Timing of Detection
Enhanced Security Monitoring	Independent of contaminant type	Reservoirs, tanks, and pump stations	Prior to contamination
Online Water Quality Monitoring	Many chemicals and carriers	Limited number of optimal locations	Minutes to several hours
Sampling and Analysis	Target and method specific	Targeted location based on trigger	Hours to days
Consumer Complaint Surveillance	Many toxic industrial chemicals	Throughout entire service area	Minutes to an hour
911 Call and EMS Surveillance	Fast acting toxins and chemicals	Throughout entire service area	Minutes to an hour
Clinical and ED Surveillance	Infectious agents and biotoxins	Throughout entire service area	Days to weeks

CWS Architecture



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Contamination Warning System Evaluation

Three Pillars of CWS Evaluation

- System operation:
  - Percent of system downtime.
  - Data accuracy and completeness.
  - Hours of unscheduled maintenance.
- System performance:
  - Rate of false alarms.
  - Number of undetected contamination incidents.
  - Timeliness of alarms.
- System sustainability:
  - Dual-use applications.
  - Cost-benefit analysis.
  - Comprehensive organizational support.

Performance Evaluation Concepts

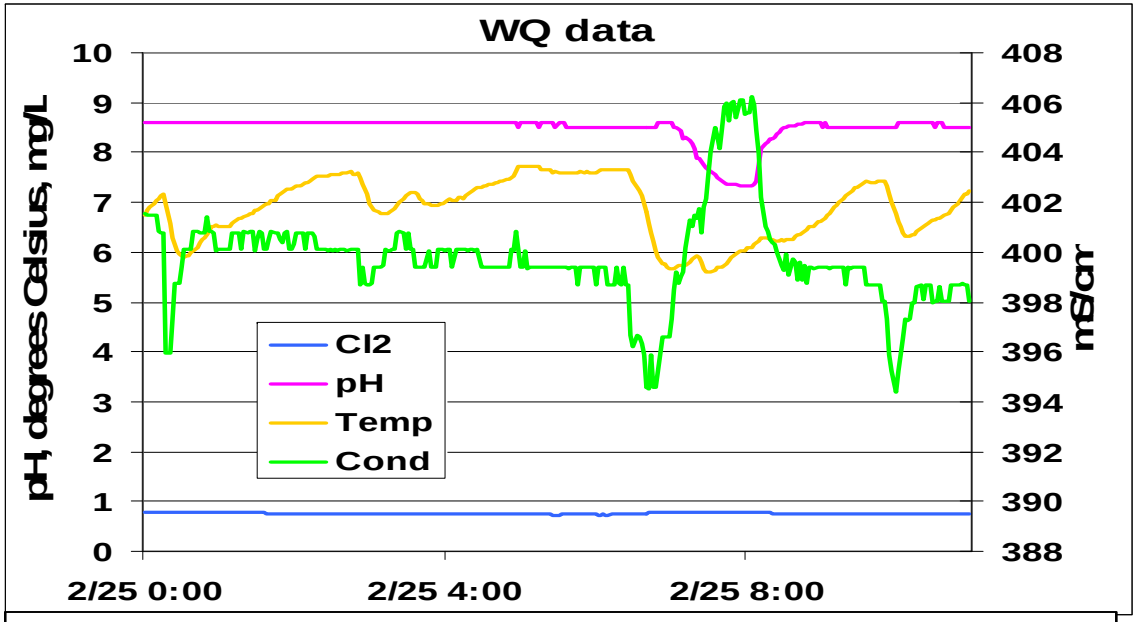
- **Operation**: Does a piece of equipment, IT system, etc. meet basic requirements of functionality?
- **Performance**: Does the component or system meet the design objectives of the integrated contamination warning system?
  - Contaminant coverage: contaminant classes detected.
  - Spatial coverage: number of scenarios detected across the distribution system.
  - Timeliness: time required to detect, confirm, and respond to a contamination incident.
  - False trigger rate: rate at which triggers that lead to an investigation occur when there is no water quality problem.
  - Reliability: extent to which information from the integrated system leads decision officials to the proper conclusion and response.

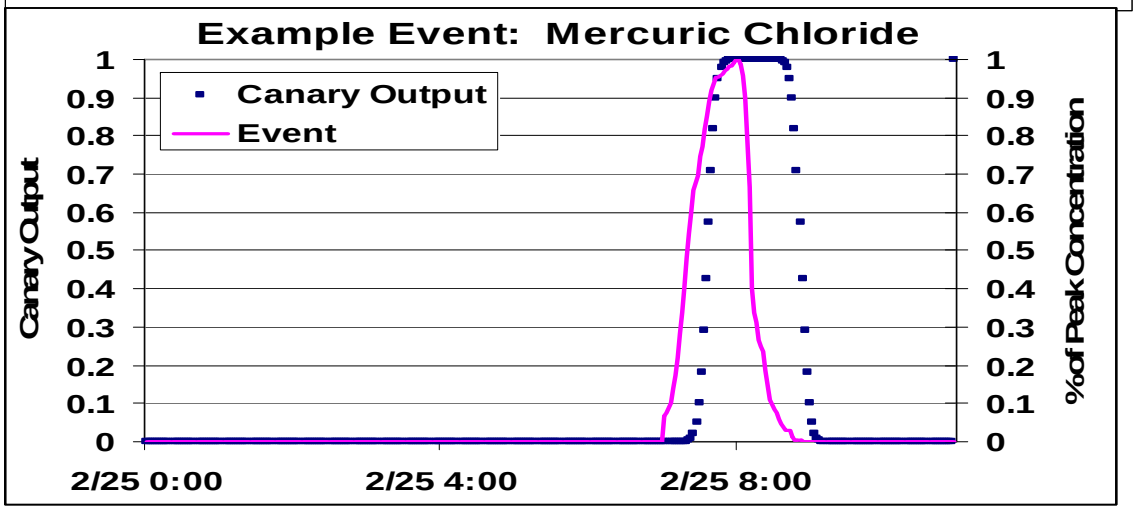
Proper operation is a necessary but insufficient condition for acceptable performance!

System-Level Simulations

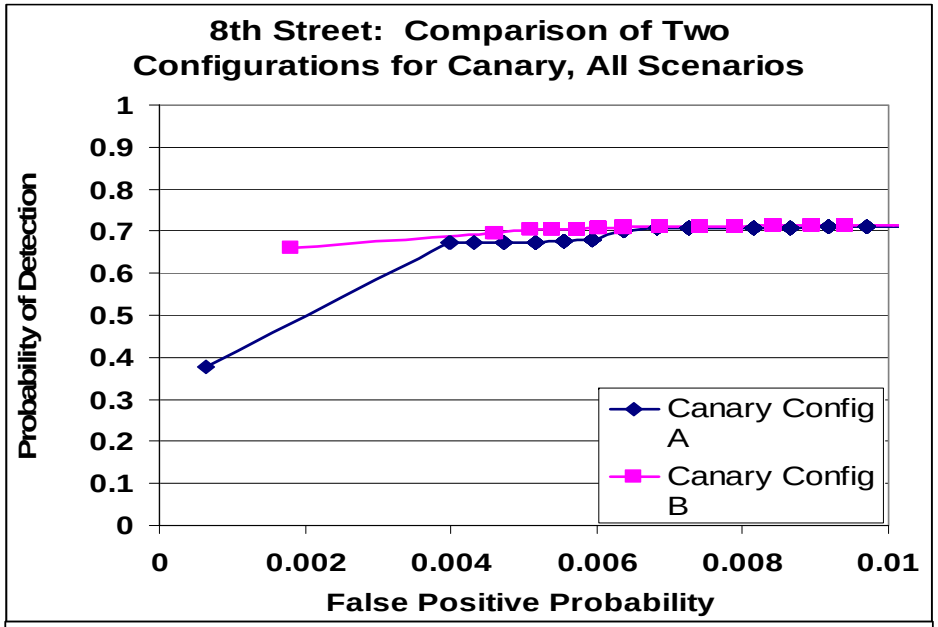
- Develop a robust suite of contamination incidents
- Develop models of each component based on data collected from the CWS pilot
- Develop models for consequence management activities based on data collected from drills and exercises
- Use the distribution system model to simulate
  - The suite of contamination incidents
  - Detection by the monitoring and surveillance system
  - Consequence management activities
  - Reduction in adverse impact
- Ultimate outcome is a quantification of performance metrics for each of the WS design objectives

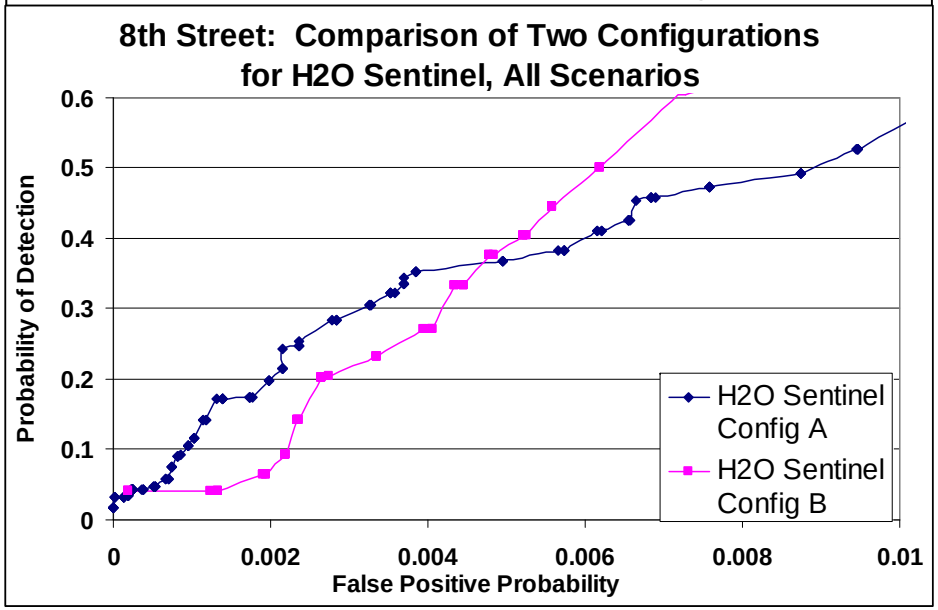
EDS Evaluation Results





EDS Evaluation ROC Curve





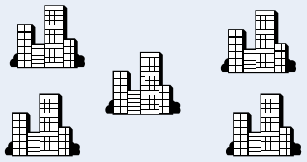
Preliminary Conclusions

- Canary detected 70% of events with one false alarm per day.
- H2O Sentinel detected 35% of event with one false alarm per day.
- Inclusion of operational data will improve performance.
- Sensor maintenance may have the greatest impact on EDS performance.
- Both tools undergoing re-training, and performance has already improved.

Expansion of the WS Initiative

Goals of WS Initiative

- **Design** system for timely detection and appropriate response to drinking water contamination incidents
- **Demonstrate** contamination warning system through deployment and testing at drinking water utilities
- **Prove** concept for water utilities nationally

Phase	Design	Initial Pilot	Expansion	National Guidance
Approach	Conceptual design → Apply to *single* pilot utility → Evaluate → Refine and enhance → Applied by *multiple* utilities → Evaluate → Refine and enhance → Convert to guidance for *any* utility			
Scope	Not applicable			
Design Specificity	Low	High - Applies to pilot utility only	High – Applies to each pilot utility	Medium – Applies to range of utlities

Additional Pilots

- Up to 4 additional WSI contamination warning system pilots in large drinking water utilities.
- To be funded with cooperative agreements awarded through a competition:
  - Request for Applications closed on September 10, 2007.
  - Anticipate issuing awards in February 2008.
- Pilots must include:
  - All five WS monitoring and surveillance components.
  - Consequence management plan.
  - Evaluation plan.
- Three-year project period.

WSi Guidance

- **USEPA is currently developing CWS guidance:**
  - ***Water Security Initiative: Overview of EPA's Contamination Warning System Guidance (2007)***
  - ***Water Security Initiative: Interim Guidance on Planning for Contamination Warning System Deployment (2007)***
  - ***Water Security Initiative: Interim Guidance on Developing a Contamination Warning System Concept of Operations (2008)***
  - ***Water Security Initiative: Interim Guidance on Developing a Consequence Management Plan (2008)***
- **For more information, visit:**

  http://cfpub.epa.gov/safewater/watersecurity/initiative.cfm

Summary and Conclusions

- The WS-CWS conceptual design relies on integration of multiple information streams to:
  - Provide broad coverage of priority contaminates.
  - Provide coverage of the entire distribution system.
  - Detect contamination in time for effective response.
  - Improve the overall reliability of the system.
  - Provide opportunities for dual-use application.
- However, the concept is currently unproven, and will likely deviate from expected performance.

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Issues and Challenges

- The time from initial detection of contamination to response must be minimized.
- Most currently available event detection systems are poorly characterized at best.
- The rate of false alarms produced by a CWS designed according to the WS model is unknown.
- Meaningful spatial and temporal integration of different data streams will be a difficult.
- The ability of an integrated CWS to detect water contamination requires further demonstration.
- Sustainability of the CWS must be demonstrated.