# Research Overviews

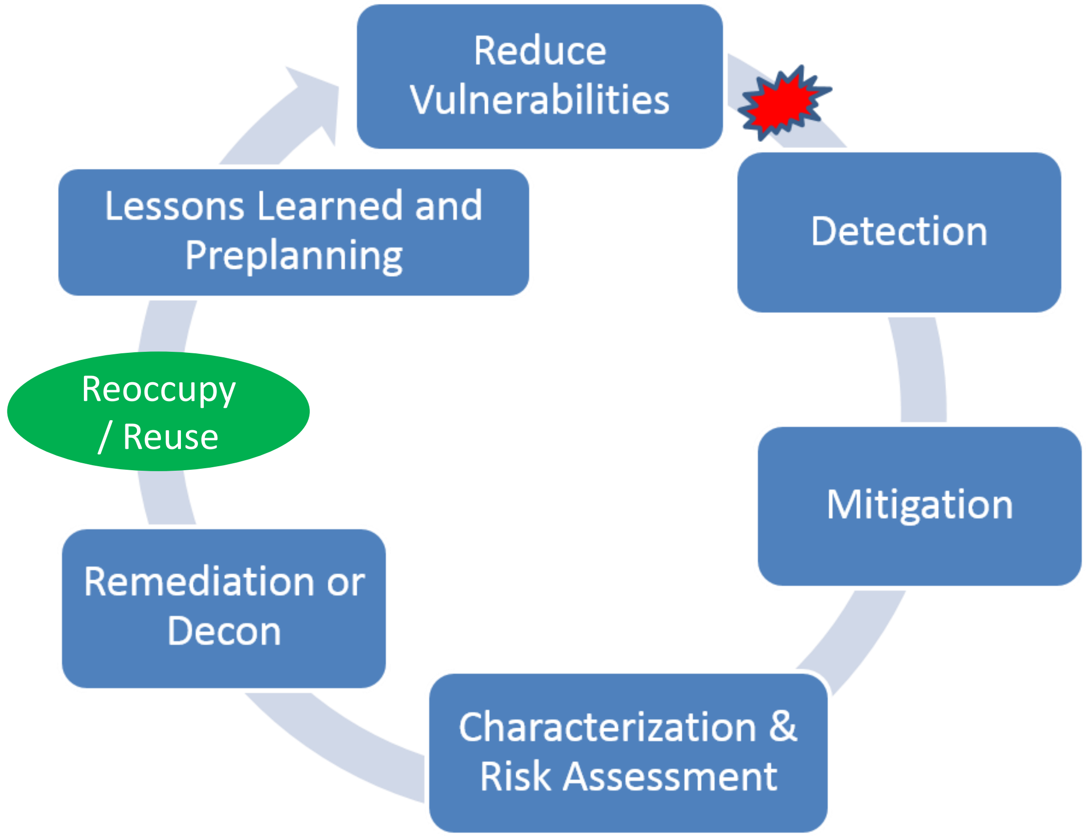
**BOSC Homeland Security Research Subcommittee**
**August 25, 2015**

# Presented by Strategic Research Action Plan Topics

- Characterizing Contamination and Assessing Exposure
- Water System Security and Resilience
- Remediating Wide Areas

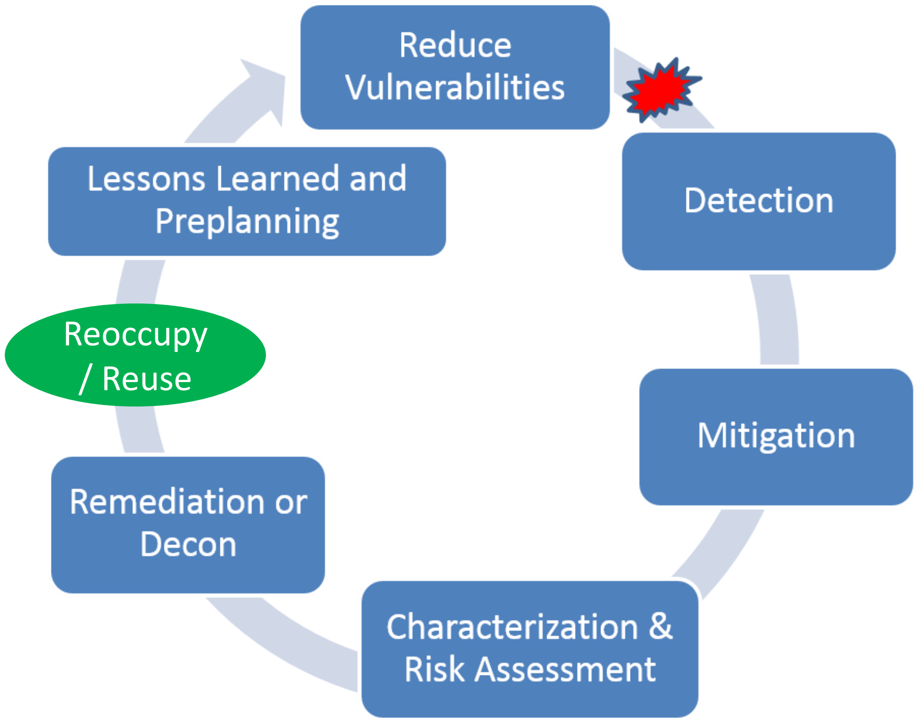
# Incident Response is Complex –

## Research needs to account for these interconnected activities



# Research program is designed and implemented to mirror response activities

- Projects cross Topics, integrate across media
- Encourages transdisciplinary collaborations on research efforts
- Leverages related research efforts
- Eliminates silos and encourages program unity



# ORD's Homeland Security Research Program



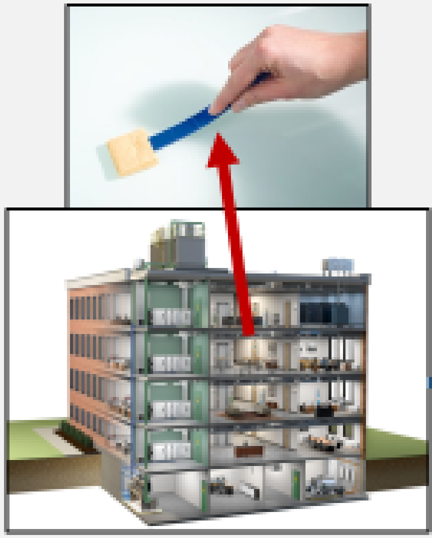
| Project Title | StRAP 2016-2019 Topics | | |
|---|---|---|---|
| *Coral rows indicate posters on this Project presented in Session 1*<br>*Light blue rows indicate posters on this Project presented in Session 2* | Characterizing Contamination and Assessing Exposure | Water System Security and Resilience | Remediating Wide Areas |
| Community environmental resilience | | | X |
| Development of sample collection methods, analysis protocols and strategy options for known contaminants (chem & biotoxin, rad, & bio) | X | | |
| Evaluating potential exposure to contaminants and by-products | X | | |
| Innovative design and operation of water systems and technologies for resiliency | | X | |
| F&T of contaminants and by-products in water and wastewater systems | | X | |
| F&T of contaminants and by-products in indoor and outdoor environments | | | X |
| Detection and mitigation methods and strategies | | X | X |
| Development, identification & efficacy of decontamination methods | | X | X |
| Engineering application considerations for decontamination methods | | X | X |
| Treatment, disposal, minimization & handling of contaminated water and waste | | X | X |
| Decision-making tools & info to support a systems approach to R & R | | X | X |
| Systems analysis and demonstration of remediation approaches | | X | X |
| Research to real world | X | X | X |

# Overview of StRAP Research Questions:

## Characterizing Contamination and Assessing Exposure

- What are the standardized sample collection and analysis methods and strategies for characterization of contamination?
- Can exposure pathways and models be improved to better inform risk assessment and risk management decisions for water-related exposures?
- Can exposure pathways and models be improved to better inform risk assessment and risk management decisions after a wide area contamination incident?

# Characterizing Contamination and Assessing Exposure



## HSRP Exposure Assessment Research

***What is the environmental concentration?***
*Water, air, surfaces, soil...*

→

***What are the potential exposure pathways?***
*Showering, walking, driving...*

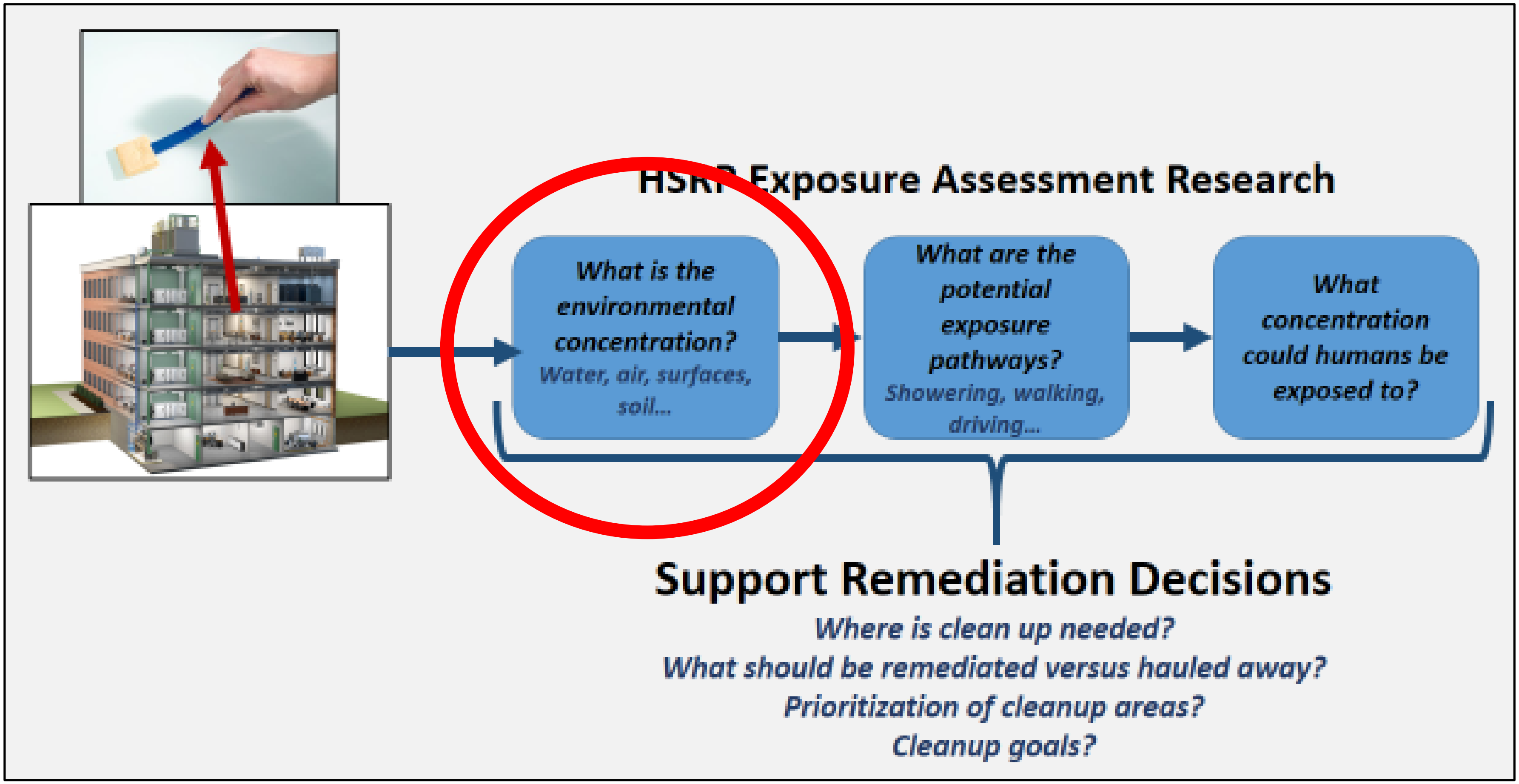
→

***What concentration could humans be exposed to?***

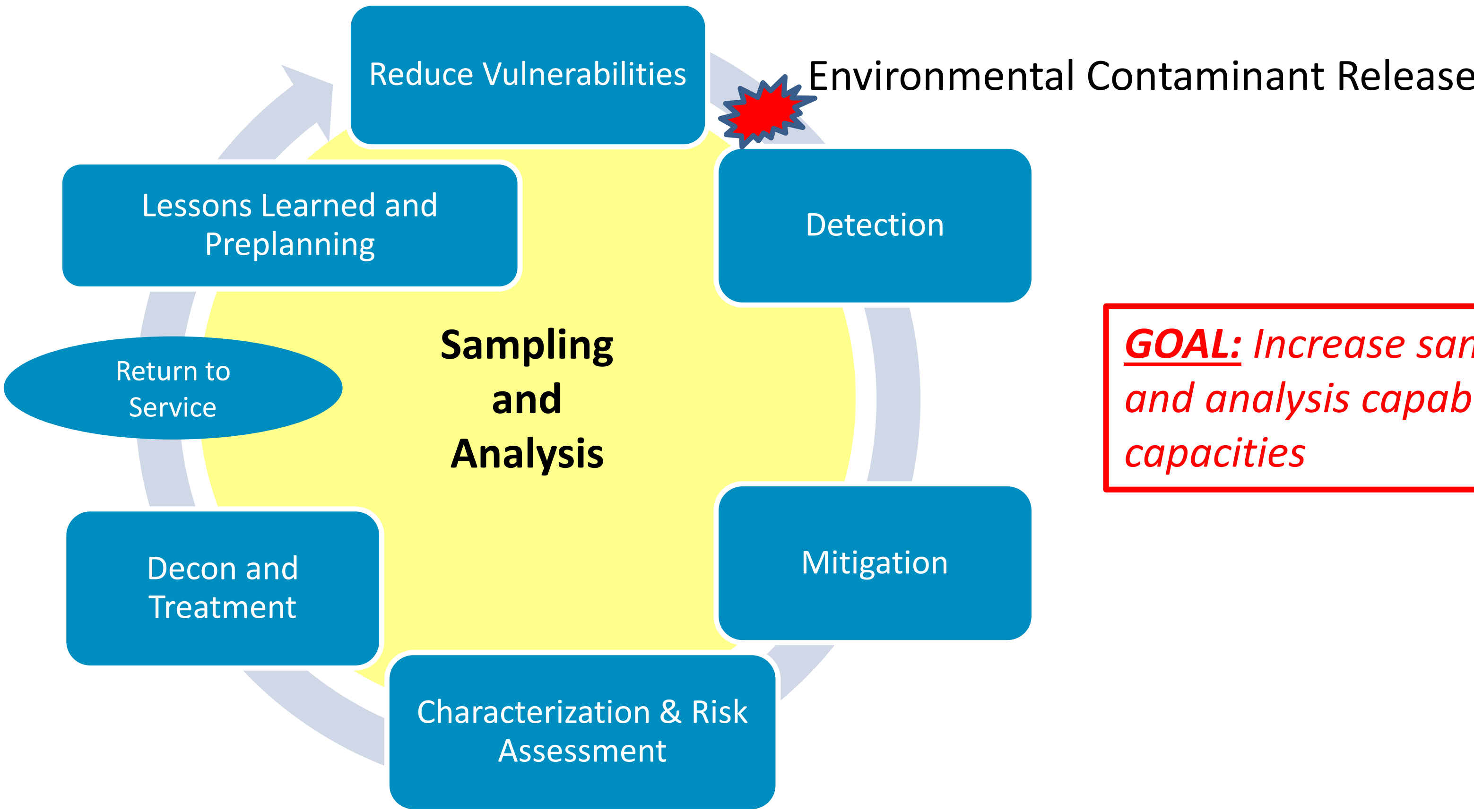
## Support Remediation Decisions

*Where is clean up needed?*
*What should be remediated versus hauled away?*
*Prioritization of cleanup areas?*
*Cleanup goals?*

# Characterizing Contamination and Assessing Exposure



# What are the standardized sample collection and analysis methods and strategies for characterization of contamination?




***GOAL:*** *Increase sample collection and analysis capabilities and capacities*

# What are the standardized sample collection and analysis methods and strategies for characterization of contamination?

Sampling and Analysis Needs Change during the Response Timeline

EPA

What is it?

Where is it?

Is the agent still present (at harmful levels)?

| **Response Phase ( Duration)** | Forensics Health (Hours) | Identification (Days) | Extent of Contamination (Weeks) | Remediation (Days to Months) | Clearance (Weeks) | Surveillance (Years) |
|---|---|---|---|---|---|---|

# What are the standardized sample collection and analysis methods and strategies for characterization of contamination?

Sample Collection

Sample
Transport

Sample Analysis

Field Responders:
- On-Scene Coordinators (OSCs)
- Response Teams (CMAT, ERT, RRT)

Laboratories:
- Environmental Response Laboratory Network (ERLN)
- Water Laboratory Alliance (WLA)
- National Analytical Radiation Environmental Laboratory (NAREL)

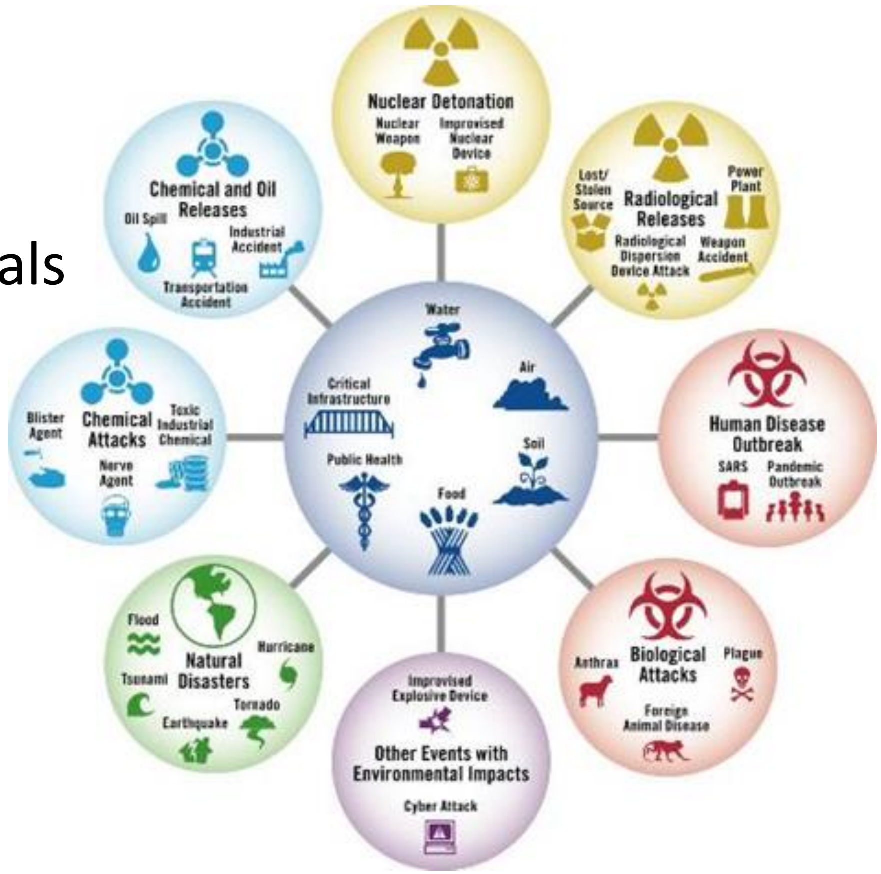
# What are the standardized sample collection and analysis methods and strategies for characterization of contamination?

## Sampled Matrices

- Water
- Surfaces
  - Porous
  - Non-porous
- Air
- Soil
- Waste
- Wastewater
- Building materials

## Sampled Agents

- Biologicals
- Chemicals
- Biotoxins
- Radiologicals



https://wcms.epa.gov/homeland-security-research/sam

Homeland Security Research

# Selected Analytical Methods for Environmental Remediation and Recovery (SAM) – Home

EPA's *Selected Analytical Methods for Environmental Remediation and Recovery (SAM)* identifies analytical methods to be used by laboratories performing analyses of environmental and building material samples following a contamination event. Laboratories may use this information to evaluate the nature and extent of contamination and assess decontamination efficacy. In addition to providing the SAM document in its entirety, this site contains a tool that allows users to easily query the SAM methods.

## Query the Selected Analytical Methods Now!

Due to the complexity of some tables and graphics, some of our information is not amenable to a screen reader. If you have trouble accessing information contact Kathleen Nickel (nickel.kathy@epa.gov) and accommodations will be made.

Select your type of analyte to begin your query:

- Chemical Methods Query
- Radiochemical Methods Query
- Pathogen Methods Query
- Biotoxin Methods Query

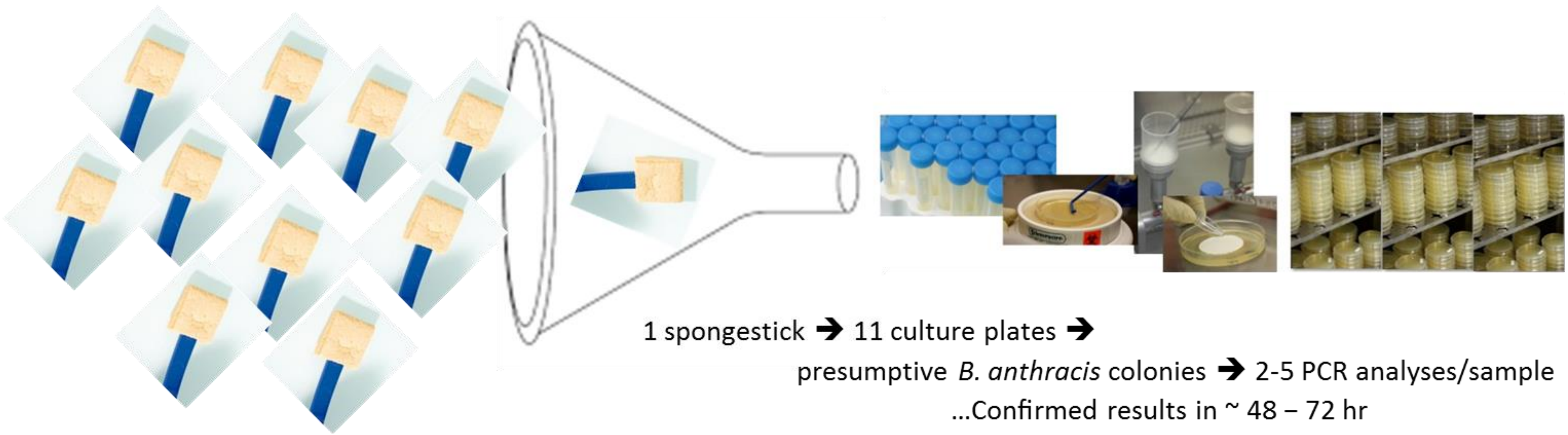
## SAM 2012 in PDF Format

Selected Analytical Methods for Environmental Remediation and Recovery (SAM) 2012

## SAM Resources

- SAM Technical Contacts
- SAM Method Sources

# Sample Collection Example:



1 spongestick ➔ 11 culture plates ➔
presumptive *B. anthracis* colonies ➔ 2-5 PCR analyses/sample
...Confirmed results in ~ 48 – 72 hr

**Spongestick:**
preferred method of environmental surface sampling for biological agents

Time to result for 100 samples is 4-5 days for a lab with 2-3 technicians.

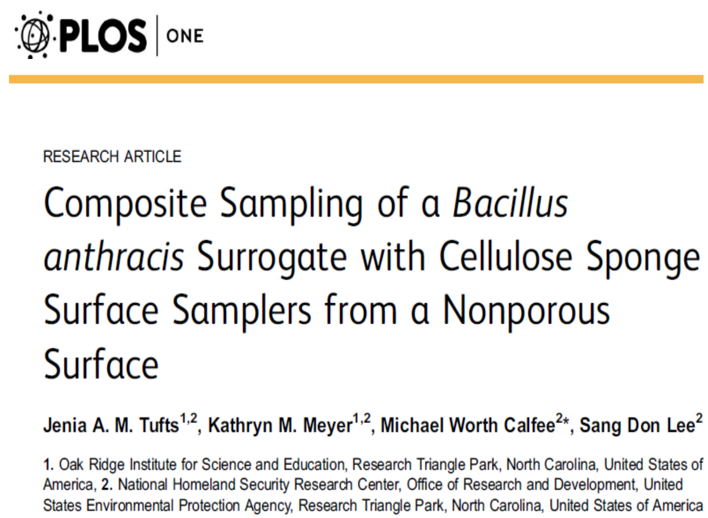
## Bottleneck is LAB CAPACITY

# Example of HSRP Research addressing Sample Collection:

Can environmental sampling personnel use one spongestick to sample larger or multiple areas (a procedure which is outside of what the standard CDC method recommends)?

HSRP study suggests:

- composite surface sampling, by either the standard CDC method or the HSRP modified method can increase the amount of surface area sampled without an increase in laboratory processing time, labor, and consumables



PLOS | ONE

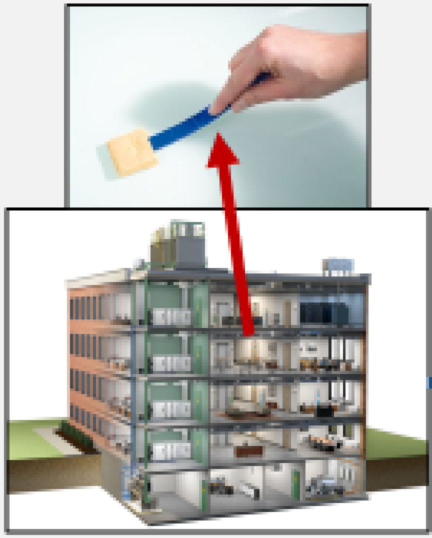
RESEARCH ARTICLE

Composite Sampling of a *Bacillus anthracis* Surrogate with Cellulose Sponge Surface Samplers from a Nonporous Surface

**Jenia A. M. Tufts[1,2], Kathryn M. Meyer[1,2], Michael Worth Calfee[2*], Sang Don Lee[2]**

**1.** Oak Ridge Institute for Science and Education, Research Triangle Park, North Carolina, United States of America, **2.** National Homeland Security Research Center, Office of Research and Development, United States Environmental Protection Agency, Research Triangle Park, North Carolina, United States of America

# Characterizing Contamination and Assessing Exposure



**HSRP Exposure Assessment Research**

***What is the environmental concentration?*** *Water, air, surfaces, soil…*

→ ***What are the potential exposure pathways?*** *Showering, walking, driving…*

→ ***What concentration could humans be exposed to?***

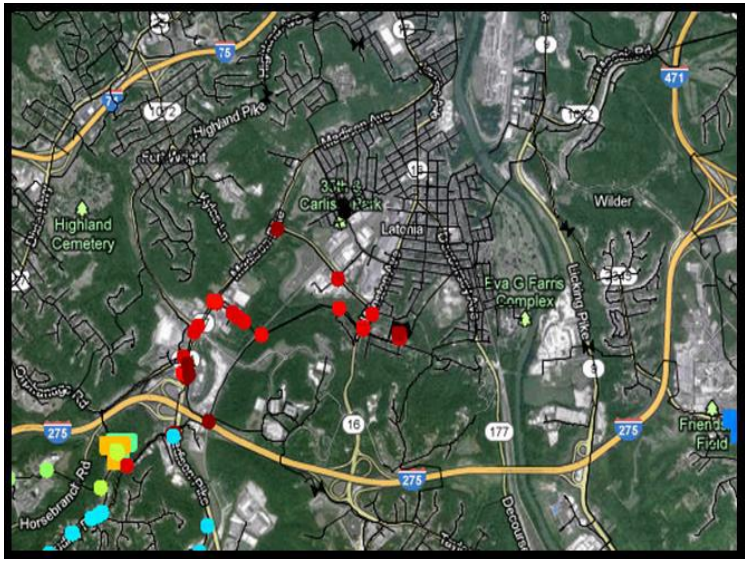
## Support Remediation Decisions

*Where is clean up needed?*
*What should be remediated versus hauled away?*
*Prioritization of cleanup areas?*
*Cleanup goals?*

# Can exposure pathways and models be improved to better inform risk assessment and risk management decisions for water-related exposures?

- Developing models to assess the consequences of CBRN contaminant introduction into water systems to support vulnerability assessments

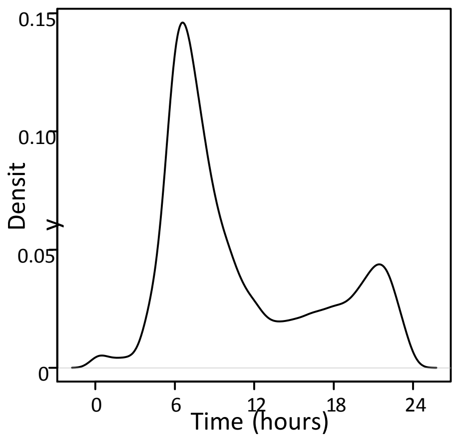
- Informing where physical security or other measures are best applied to reduce these vulnerabilities



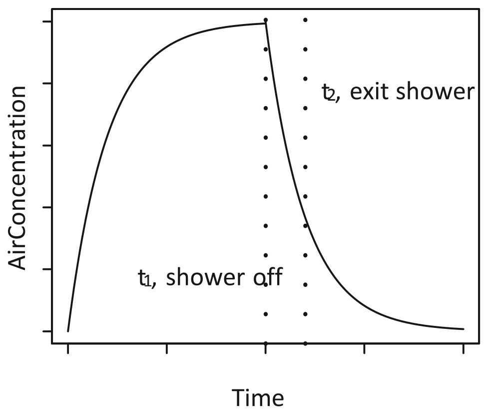

View Consequences

# Example of HSRP Research addressing Potential Water Exposures:

- Building models to evaluate and improve response options - exposure, dose, and consequences from inhalation during showering




U.S. Census data used to develop starting times for timing of showering events each day




Time variability of air concentration of a contaminant during showering

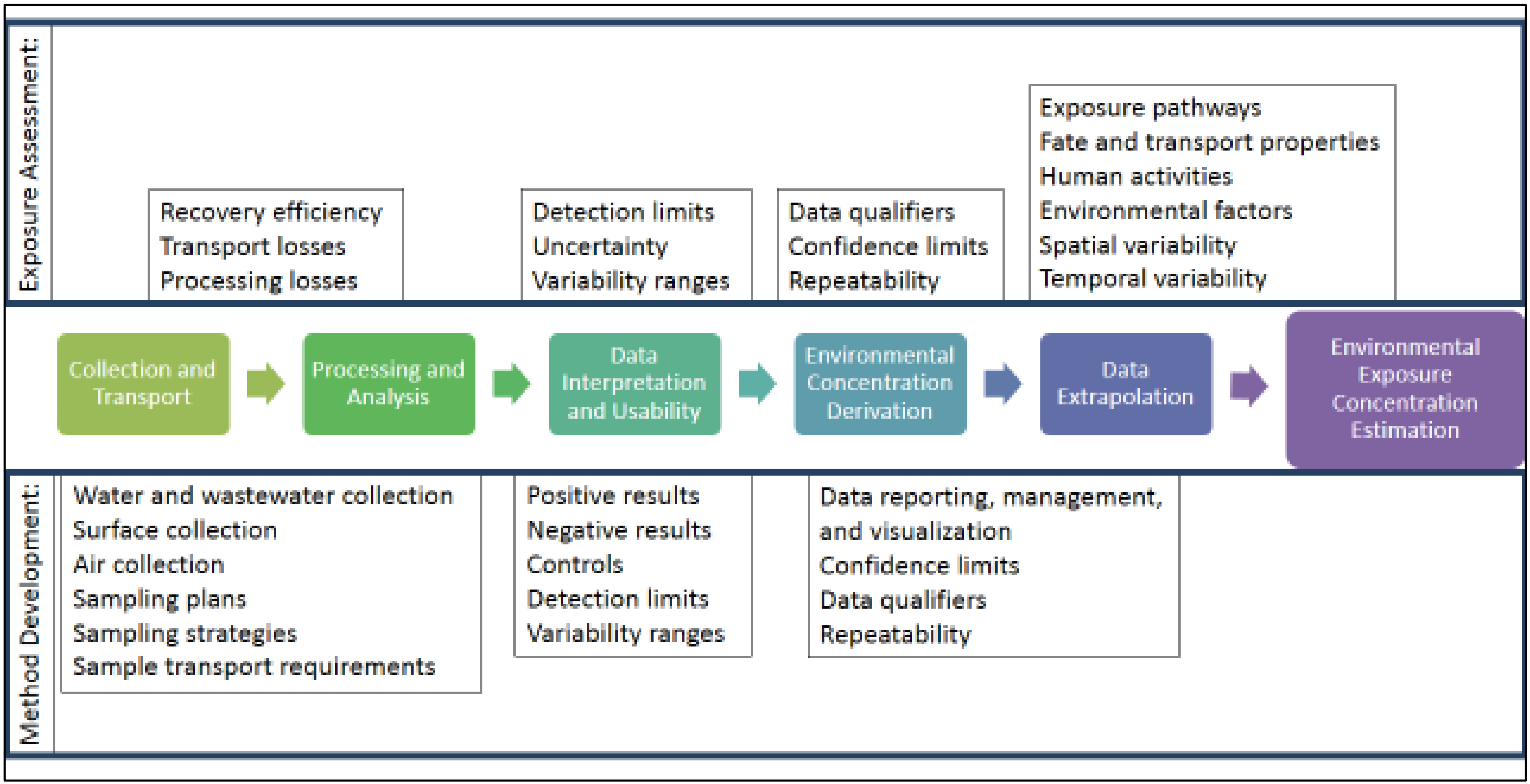
# Can exposure pathways and models be improved to better inform risk assessment and risk management decisions after a wide area contamination incident?

- Evaluating existing exposure assessment methodologies to connect microbial field sampling data to determining potential environmental exposures

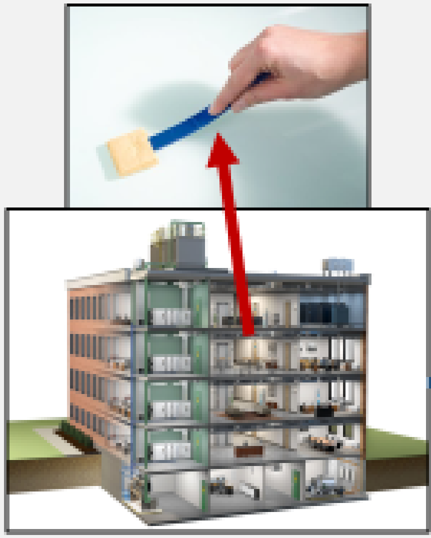
- Estimating *B. anthracis* exposure to humans from reaerosolized spores on outdoor urban surfaces

- Assessing of exposure modeling for predicting population distributions of exposures following an outdoor release due to variability in human activity patterns, building characteristics, and population demographics

# Exposure Example: Connecting Field Sampling Data to Potential Exposure Concentrations



# Characterizing Contamination and Assessing Exposure



## HSRP Exposure Assessment Research

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## Support Remediation Decisions

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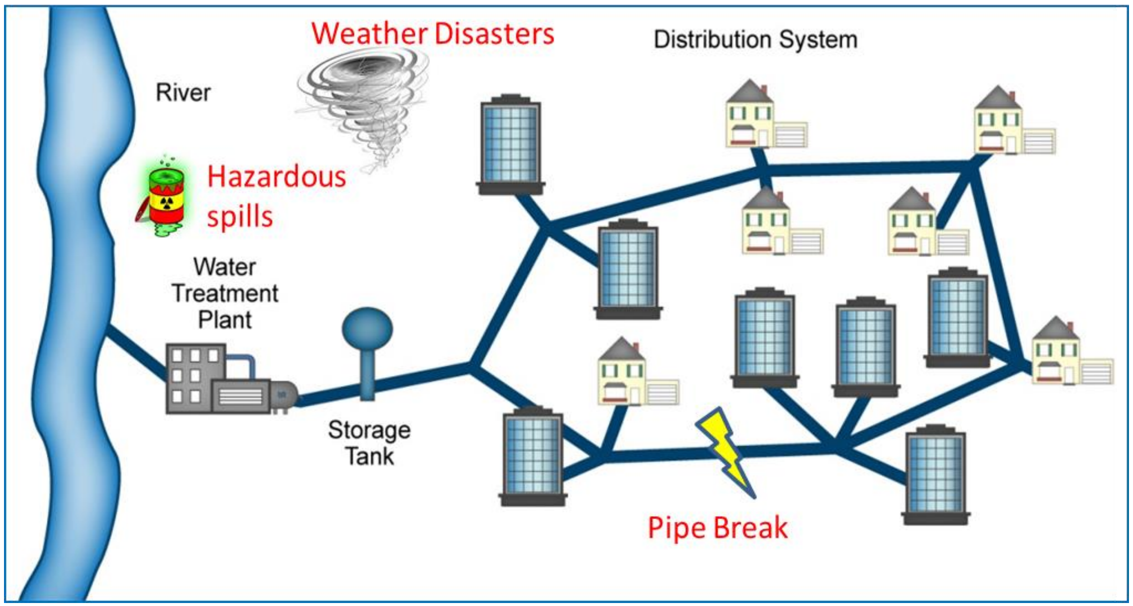
Please visit…

# Poster Session – Day 1

- Evaluate Potential Exposure to Contaminants and By-Products
- Bio Sampling and Analysis
- Chem and Biotoxin Sampling and Analysis
- Rad Sampling and Analysis

# Water System Security and Resilience

| Detection | Mitigation | Cleanup | Resilience |
|---|---|---|---|
| Contamination warning system data and tools | Flushing strategies | Infrastructure decon, wash water treatment | System designs, vulnerability tools, treatment indicators |




***EPA is the federal government sector specific lead agency for water infrastructure protection***

# StRAP Research Questions

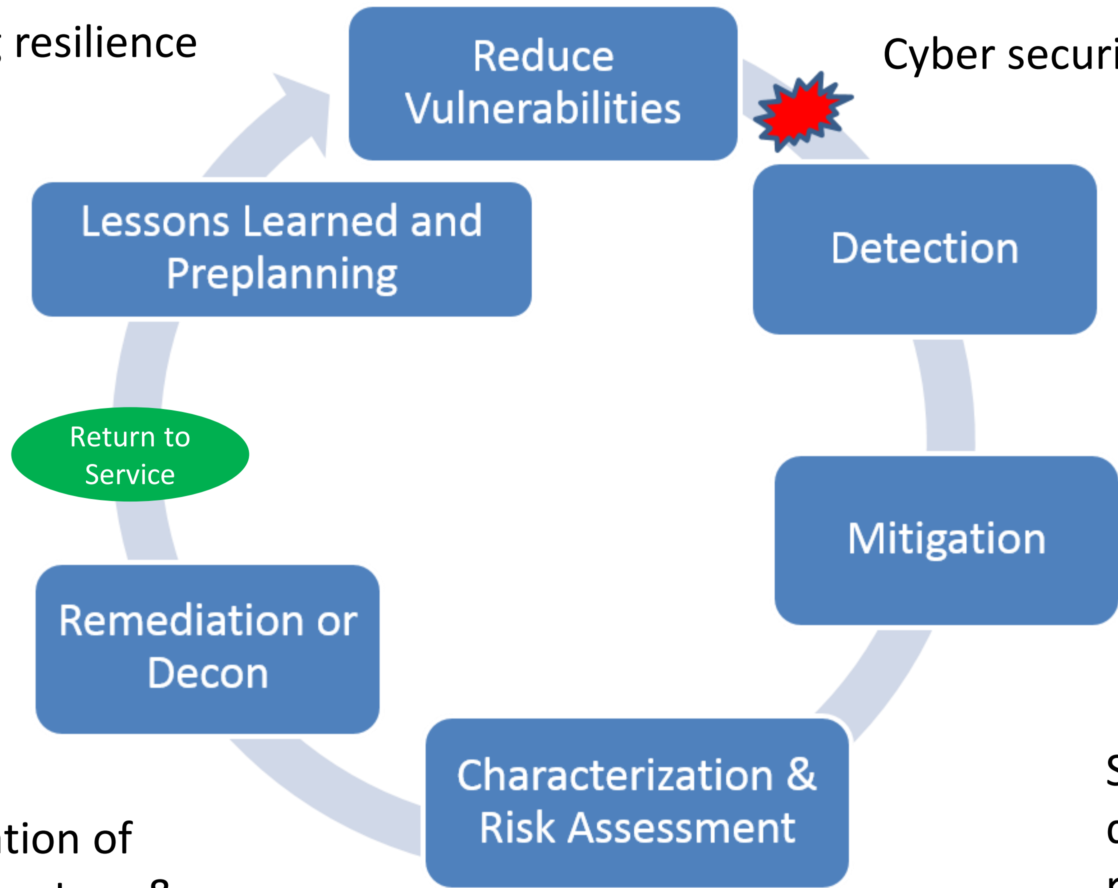
## Water System Security and Resilience

- Can water systems models be designed to enable utilities to be more resilient to disruptions while enhancing daily operations?
- What technologies, methods, and strategies for detection and mitigation of contamination in water systems best minimize public health consequences?
- What methodologies and strategies are most effective for water infrastructure decontamination and water treatment?
- How can the Program place its research in a decision maker-friendly format for use by EPA water partners and water utilities?

# Program Design: A Systems Approach to Incidents

Increasing resilience

Cyber security for water systems




On-line monitoring of contaminants in drinking water systems

Contaminant fate and transport

Self help decontamination and risk reduction measures

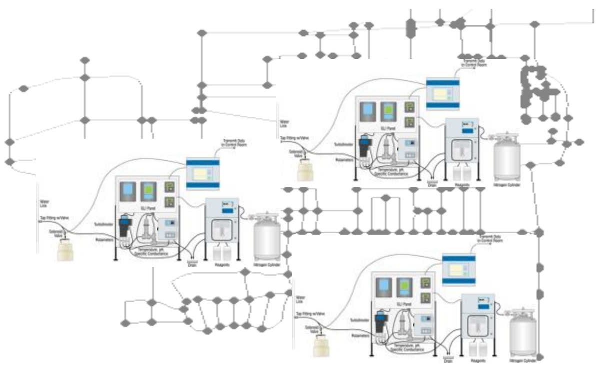
Sampling and analysis for water and waste water

Decontamination of water infrastructure & water treatment

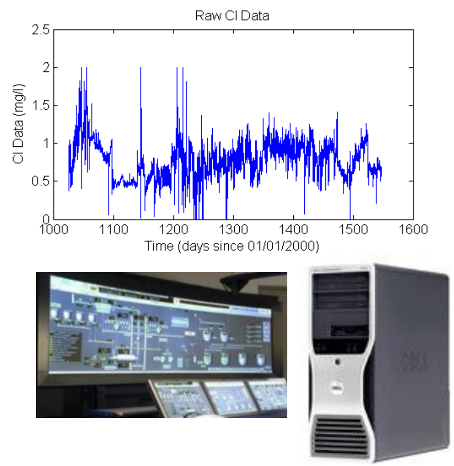
Wastewater treatment

# Vision for the Future

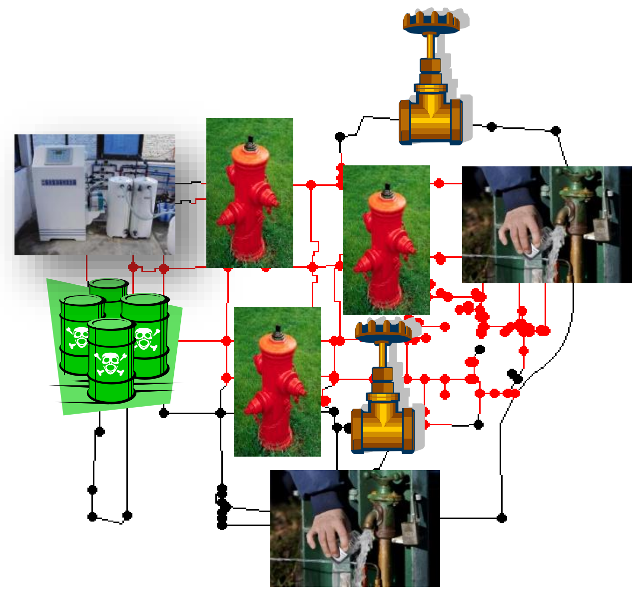
Water utilities rely on advanced tools to automatically detect water quality problems, identify and evaluate potential response actions, thereby integrating security with daily operations



**Contamination Warning System**

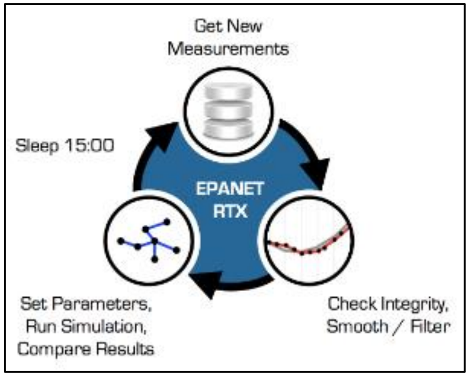



**Data Analytics & RT Modeling**



**Evaluation of Response Actions**

# Innovative Design and Operation of Water Systems for Resiliency




- Real-time analytics tool (EPANET-RTX) to fuse real-time field (SCADA) data with infrastructure models
- Continued advancement of EPANET software
- Systems modeling tools to measure resilience of water systems to natural disasters, terrorist attacks, and other emergencies
- Effectiveness of cybersecurity standards and identifying cybersecurity gaps and needs


Contamination identification & response

**Impact**

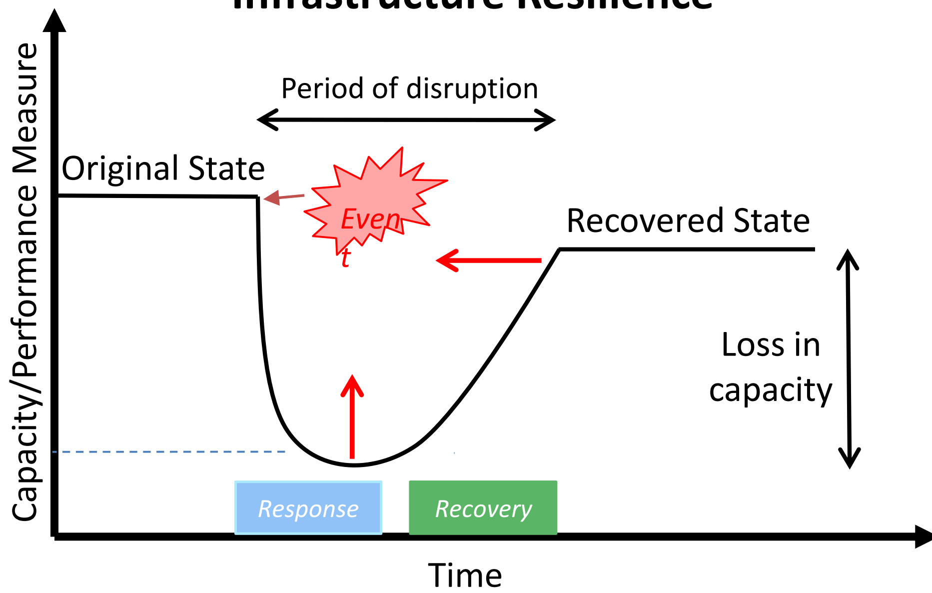
- Improve the resilience of water and wastewater systems
- Provide water systems with the tools and technologies to
  - Mitigate intentional and accidental contamination
  - Respond to natural disasters
  - Improve operations

# Innovative Design and Operation of Water Systems for Resiliency

***Infrastructure Resilience***

- Water sector is tightly linked to the energy sector
- Natural disasters may result in power outages affecting the operation of water critical infrastructure
- Develop new and advanced simulation capabilities for drinking water and wastewater resilience
- Use system analysis to examine the consequences of disasters, improve resilience and mitigation strategies

**Infrastructure Resilience**

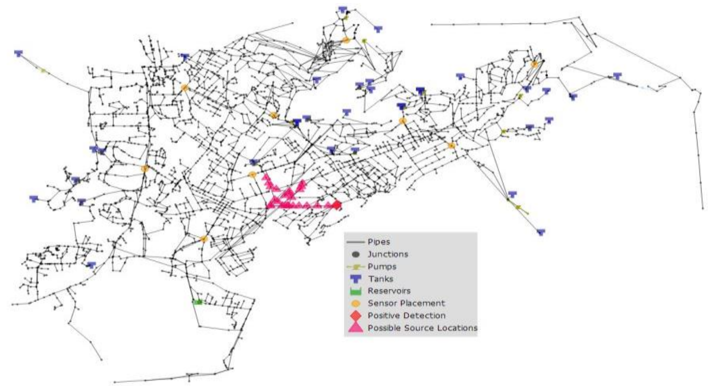



Infrastructure resilience is the reduction of the magnitude and/or duration of disruptive events.

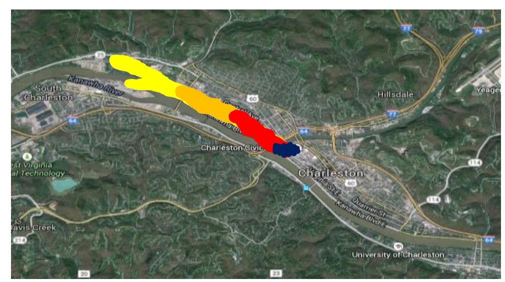
# Decision-Making Tools and Information to Support a Systems Approach to Response and Remediation

- **WST (Water Security Toolkit)** – a hydraulic and water quality modeling, simulation and optimization software to develop response options by identifying:
  - possible contaminant injection locations
  - hydrants for flushing
  - locations for decontamination

- **RSMS (Ohio Riverine Spill Modelling System)** – river modeling software updated with the US Army Corp of Engineer's Hydraulic Engineering Centers - River Analysis System (HEC-RAS) data for emergency spill response and planning



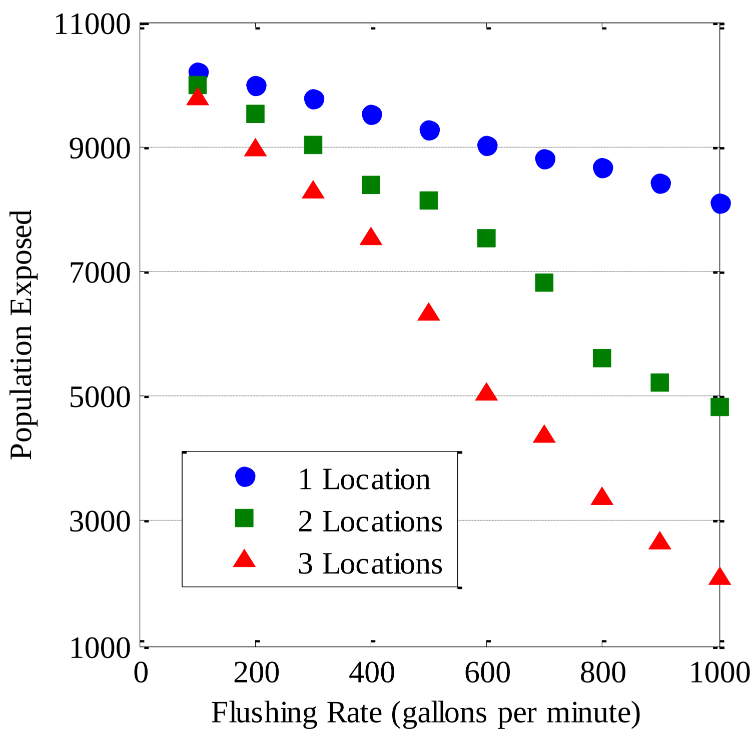

Possible Contamination Injection Locations in Water Distribution System

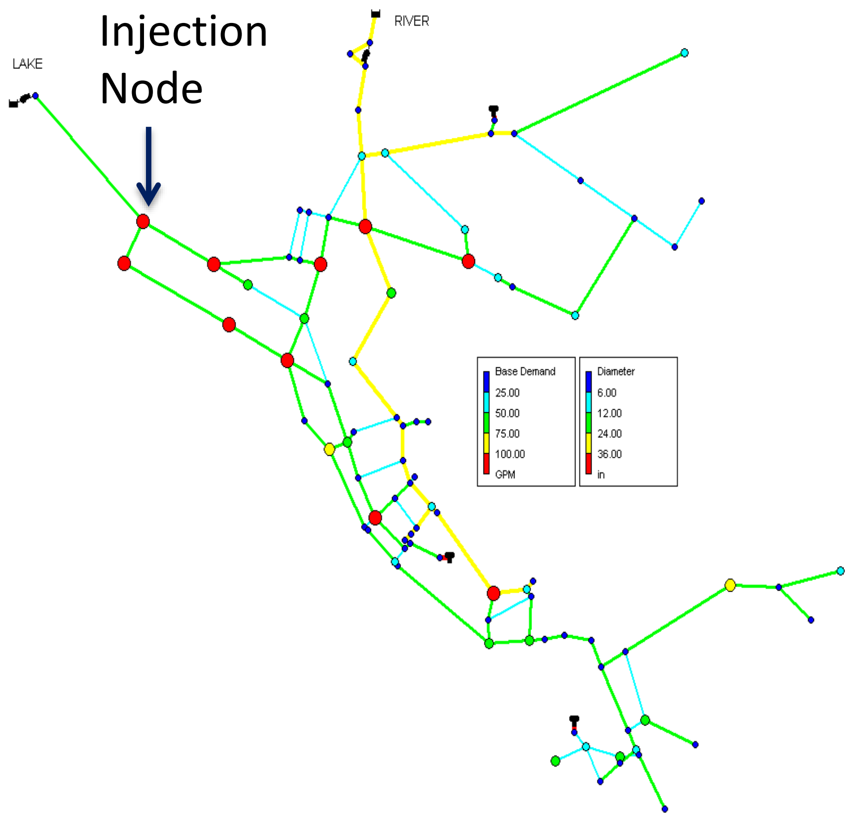



River Spill Concentration Plume

# Decision-Making Tools and Information to Support a Systems Approach to Response and Remediation

***Responding to Water Incidents – Water Security Toolkit Capabilities***



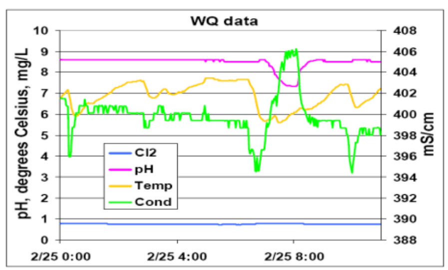



# Detection and Mitigation Methods and Strategies

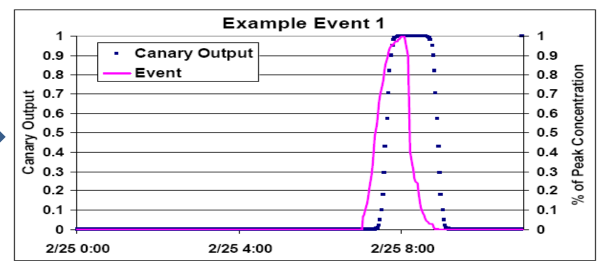

- Rapid detection of contamination in drinking water distribution systems
- On-line water quality monitoring and development of sensors (Rad detectors)
- Supported by software tools to optimally place sensors and detect deviation from baseline water quality readings

**<u>Impact</u>**: Water systems are better prepared to detect intentional and unintentional contamination


Sensor Station



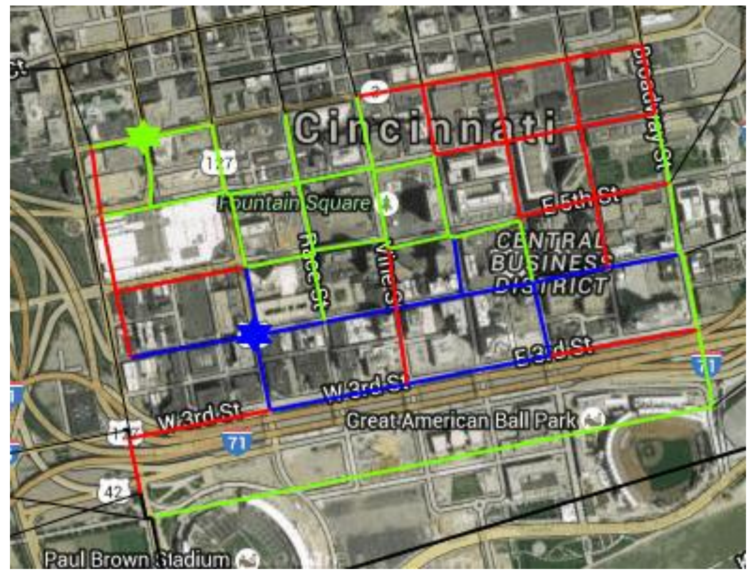

Raw Data




CANARY Event Detection

# Real World Applications

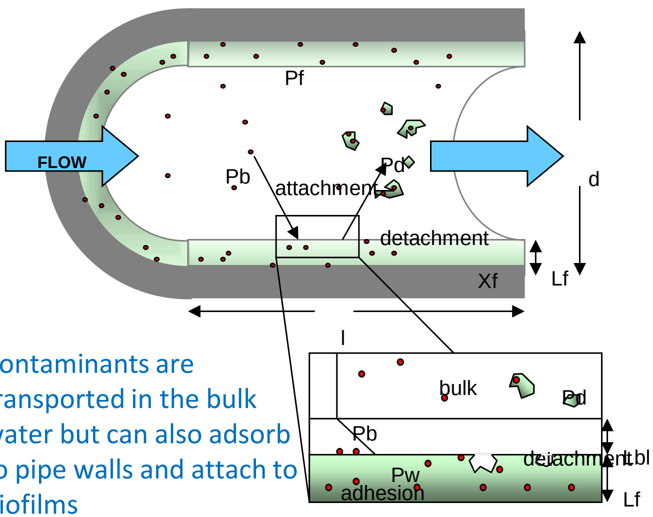

- **Greater Cincinnati Water Works (GCWW), Cincinnati, Ohio**
  - Optimal monitoring and placement of water sensors for the 2015 All-Star game
- **City of Milford, Ohio**
  - Adapting the utility model to a SCADA driven real time model using EPANET-RTX
  - Improve system operation: water quality and a better understanding of water losses in the system
- **Montreal Water Utility, Montreal, Canada**
  - Use models to support response to *E. coli* detection in the system
  - TEVA-SPOT backtracking algorithm to identify upstream critical facilities and inform vulnerable zones




Optimal placement of sensor monitoring stations in downtown area

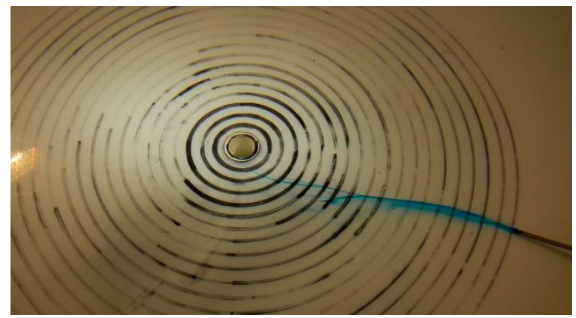
# Fate and Transport of Contaminants and By-products in Drinking Water and Wastewater systems

- Experimental investigation of chemical, biological, and radiological (CBR) contaminant fate and transport
- Prediction and modeling of CBR fate and transport
- Strategies to minimize contamination of distribution systems due to contaminated tank sediments




Contaminants are transported in the bulk water but can also adsorb to pipe walls and attach to biofilms

Pilot-scale facility for contaminant fate through waste water treatment, especially activated sludge. systems



Tracer test during draining of a tank designed to study sediment removal and resuspension. Small changes in design have great impact.

# Contaminant Adherence to Sediments



Tank cleaning company collecting sediments

Sediments from different tanks can vary a lot!

Lab contaminant adherence studies

# Engineering Application Considerations for Decontamination Methods

Decontamination of *B. anthracis* surrogate spores adhered to common drinking water infrastructure

Clear PVC pipe with sampling ports and fire hydrant

- Cement mortar and corroded iron coupons
- Evaluation of 6 disinfectants (varying concentration, holding time, and pH)
- Flushing alone and following each disinfectant application
- Data tables on the decontamination effectiveness of common drinking water disinfectants and flushing

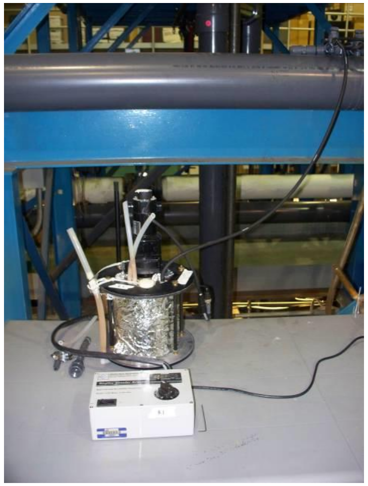
**Impact**: Improved water and wastewater infrastructure decontamination approaches for the water sector

# Treatment, Disposal, Minimization and Handling of Contaminated Water

- Managing CBR agent contaminated drinking water and wastewater
- Pilot scale demonstration of mobile water and wastewater treatment
- Impact of washdown activities involving biological agents on wastewater treatment
- Treatment and disposal options for large volumes of contaminated drinking water and wastewater




# Applied Research Solutions Approach



Bench-Scale

Pilot-Scale

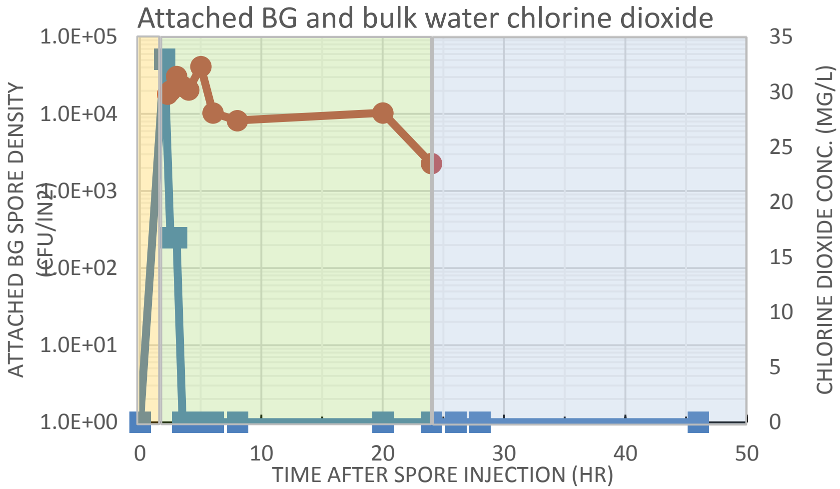
Full-Scale

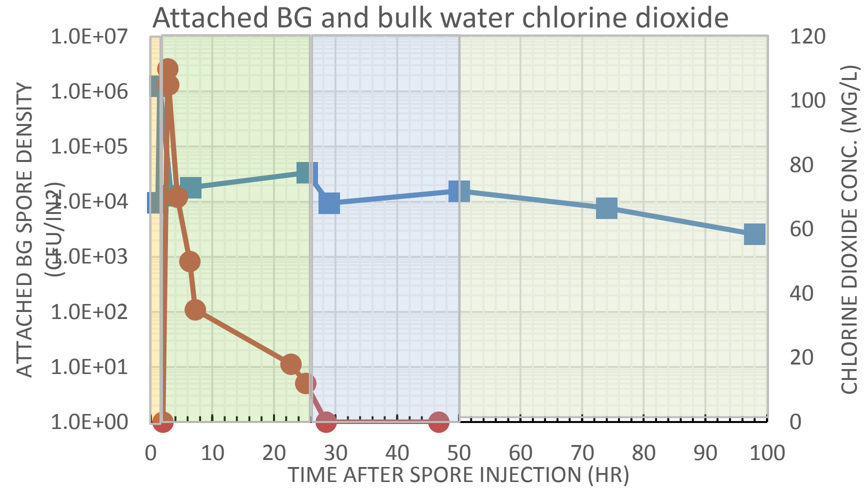
# Systems Analysis and Demonstration of Remediation Approaches

U.S. Water Sector identified full-scale testing of water security tools, sensors, methods, with real contamination, a MAJOR gap

- Evaluation of contamination detection methods, water treatment technologies, and drinking water infrastructure decontamination methods at full-scale
- Simulates intentional and inadvertent distribution system contamination (chem, bio, rad) and disruptions (cyber-attacks)
- Providing training and simulation opportunities for utilities and responders to practice implementation of resilient technologies and prepare for and mitigate for potential service interruptions.

# Comparison of Pilot- & Full-Scale Results



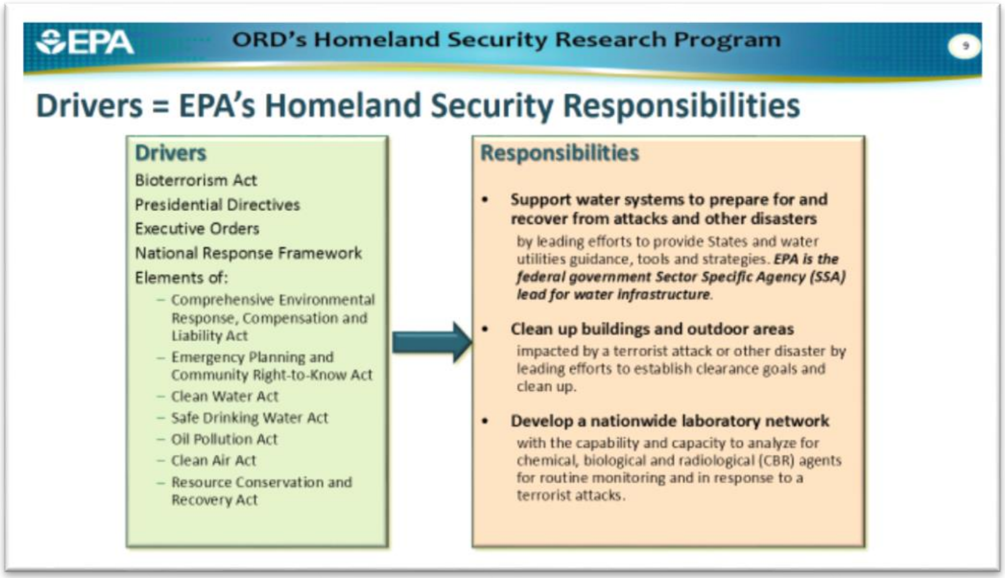




- Data from the pilot scale decontamination loop at EPA's T&E facility
- No spores detected on cement-mortar after treatment with 25-30 mg/L $CL0_2$

- Data from the WSTB at INL
- Spores persisted on cement-mortar in the presence of up to 100 mg/L $Cl0_2$
- Pipe demand, temperature fluctuation and dead end spaces impacted decontamination

*Preliminary Results: Full-scale decontamination and wash water treatment results less effective than pilot and bench-scale*

# Remediating Wide Areas




- Support water systems to prepare for and recover from attacks and other disasters
- Clean up buildings and outdoor areas

- Amerithrax incidents in 2001, highlighted capability gaps for response and remediation
  - Natural "anthrax" responses demonstrated limited capabilities
- Interagency studies further highlighted capability gaps for wide area remediation
- Additional "all hazard" incidents highlighted relevance of research and the capability gaps
  - Ebola outbreak - low-tech, readily available methods especially for porous materials
  - Ricin contamination and "anthrax" lab contamination – methods for sensitive equipment and materials
  - Burkholderia incident – methods for outdoor areas, particularly soil

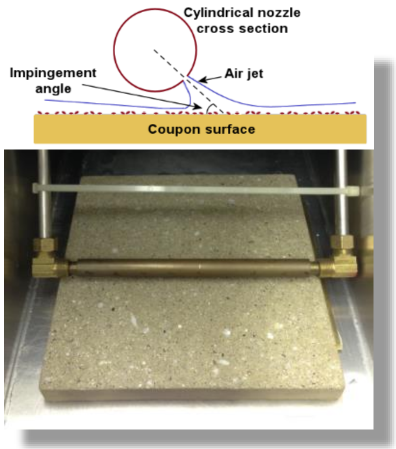
# StRAP Research Questions

Remediating Wide Areas

- What are indicators of community environmental resilience and how can existing tools incorporate these indicators?
- What technologies, methods, and strategies are effective for mitigating the impacts of the contamination and for reducing the potential exposures?
- What technologies, methods, and strategies are most effective (minimize cost while protecting human health and the environment) for cleanup of indoor and outdoor areas (including management of waste)?
- How can the program place its research in a decision maker-friendly format for use by EPA partners and State and local decision makers?

# Fate and Transport of Contaminants and By-products in Indoor and Outdoor Environments

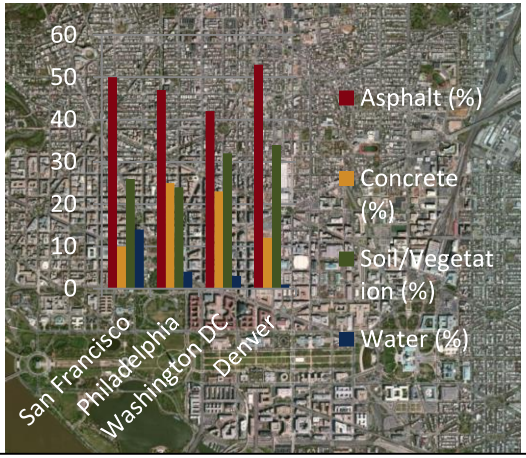
- Understanding persistence of non-spore forming biological agents
- Developing an understanding of the transport mechanisms of *Bacillus anthracis* spores to inform mitigation, sampling and remediation decision making
- Assessing the fate of persistent chemical agents, such as mustard lewisite, and VX, on environmental matrices
- Determining how radioactive contaminants (cesium) behaves in the urban environment

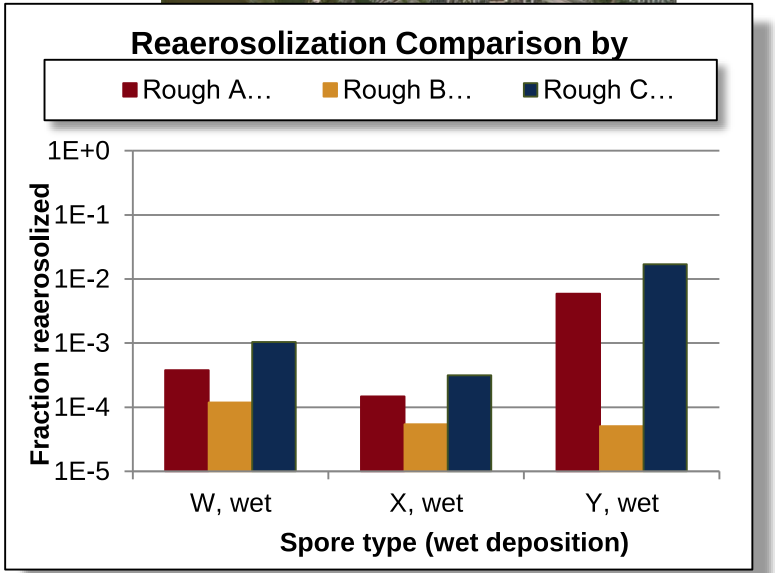



- Literature reviews to determine gaps and important transport mechanisms based upon historical data
- Lab tunnel-based studies to understand the transport of biological particulates as a function of environmental conditions, forces, and mitigation measures
- Lab chamber based studies to assess fate/persistence as a function of environmental conditions and matrices

# Fate and Transport of Contaminants and By-products in Indoor and Outdoor Environments

- Impact – inform mitigation and remediation decisions, including containment, sampling, decontamination, and waste management
- Example: Understanding reaerosolization of *B. anthracis* spores to inform mitigation/remediation decisions
  - Dry > Wet
    - Dry-deposited spores reaerosolize more and with less applied force
  - Ba = Btk
    - Results for spore W and spore Y were not significantly different from each other
  - Bg ≠ Ba or Btk
    - Results for spore X were significantly different



# Detection and Mitigation Methods and Strategies


- Mitigation methods
  - Reduce the risk of exposure by the public and responders at the release site
  - Contain the contamination preventing spread beyond the release site.
  - Readily available hazard mitigation methods support early phase response, remediation activities, and continuity of operations.

- Rapid detection is important component to mitigation, particularly in drinking water distribution systems

- This project addresses gaps such as:
  - On-line monitoring for rapid detection of contaminants
  - Gross decontamination methods for biological and radiological agents

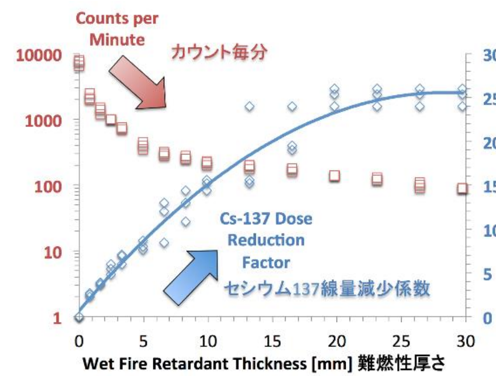
# Detection and Mitigation Methods and Strategies

- Examples:
  - Use of existing and readily available materials allow for faster deployment – can they be used effectively to reduce exposure or spread of contamination?
  - Can mitigation methods be derived from locally and readily available materials?
  - What is the filed-scale applicability of specifically designed materials for mitigation?

T1: Fire-fighter materials (those commonly available to fire-fighters, immediately available)

T2: Locally available materials (those commonly found at large hardware stores or local suppliers, or commonly used by city, county or state public works within 12-24 hrs)

T3: Rad-specific commercially available materials (those demonstrated to be effective in stabilizing radiological contamination, not typically available locally or quickly, >24hrs)

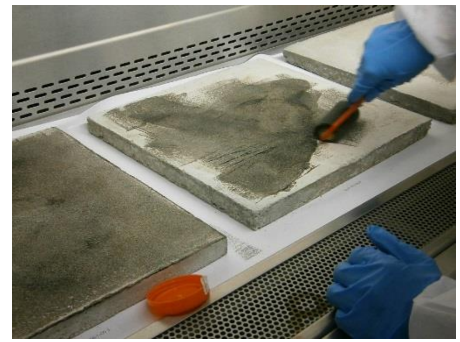



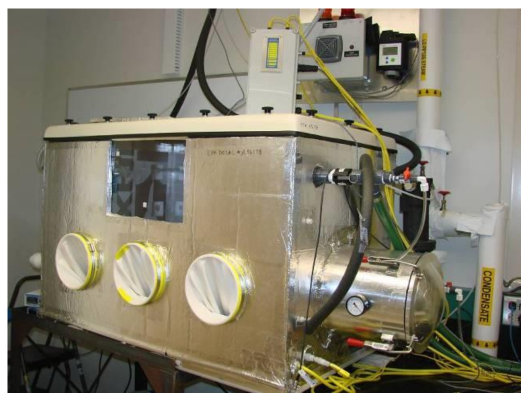
# Decontamination is a critical aspect of remediation

- 2001 Amerithrax incidents
- residences contaminated with naturally occurring *Bacillus anthracis*
- ricin contamination in postal facilities and residences
- support to USDA/APHIS on decon/disposal in agricultural settings
- radiological contamination in the UK and Japan
- misuse of chemical pesticides.

# Development, Identification and Efficacy of Decontamination Methods

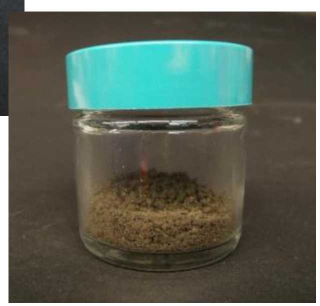
- The specific focus is on finding decontamination methods for surfaces
  - materials contaminated with biological, radiological or persistent chemical agents, with a focus on porous or permeable materials
  - water and wastewater infrastructure
  - critical infrastructure and sensitive materials/equipment
  - self-help methods (easy implementation without specialized training or equipment), for homes, pets, vehicles, etc.

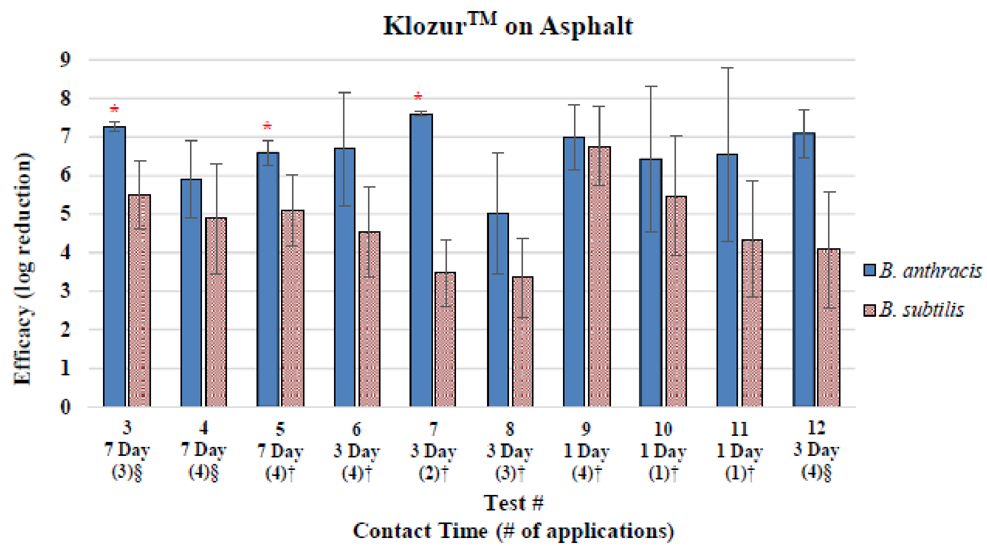




# Development, Identification and Efficacy of Decontamination Methods

- Example: Application of methods used for other purposes
  - Focus on assessing products/methods intended for other applications
  - For example:
    - Sodium persulfate: soil decontaminant for organic chemicals
    - Chloropicrin: soil pesticide





# Engineering and Application Considerations for Decontamination Methods

- Purpose – Inform decision making on pros, cons, and practical application considerations of decontamination methods

- Project builds on Development, Identification and Efficacy of Decontamination Methods
  - Assessing promising decontamination efforts in more applied settings
  - Determine operational-relevant information such as cost, time, waste generation, and impacts

# Engineering and Application Considerations for Decontamination Methods

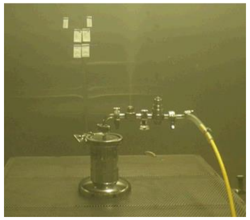
- Some of the critical knowledge gaps being addressed in this project include:
  - Effective decontamination methods for drinking water and wastewater infrastructure decontamination
  - Increase capability and capacity for remediating environments resulting from a wide area release
  - Effective decontaminants for outdoor areas, including soil, and are applicable to wide areas
  - Decontamination methods that reduce waste generation
  - Decontamination methods for sensitive equipment and materials, including critical infrastructure

# Engineering and Application Considerations for Decontamination Methods

- Research done at numerous scales
  - large chambers and pipe loops
  - Surrogates for chemical, biological or radiological agents are generally used
- Example:  Efficacy of Sporicidal Wipes for Decontamination of Mid-Size Surfaces
  - efficacious (6 log kill) on a 1 ft x 1 ft surface
  - Average log reduction down to 3.4 – 4.3 (depending on wipe type) on glass when applied over larger area
  - Cross contamination into areas that were not inoculated








# Treatment, Disposal, Minimization and Handling of Contaminated Water and Waste

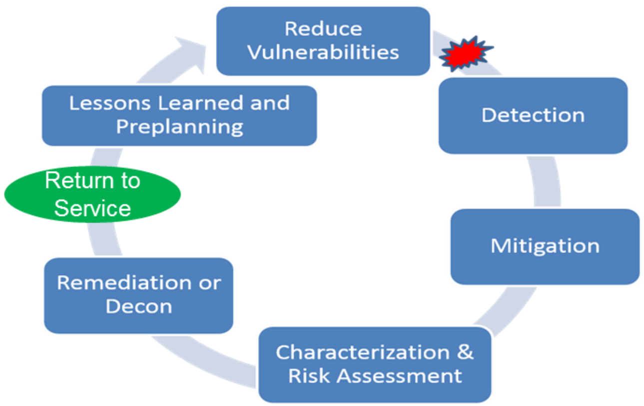
- Waste management is a critical aspect of all remediation efforts, as all efforts from initial site entry to final sampling generate waste.
  - Handling CBR agent contaminated drinking water and wastewater, including the acceptance of wastewater wastewater treatment facilities
  - Impact of washdown activities involving biological agents on wastewater treatment plants, including understanding the fate of biological agents in the treatment system
  - Best approaches for managing waste/debris from biological incidents
  - Treatment and disposal options for large volumes of contaminated drinking water and wastewater
  - Informing options for staging/storing and selection of treatment/disposal pathways for waste/debris from radiological incidents

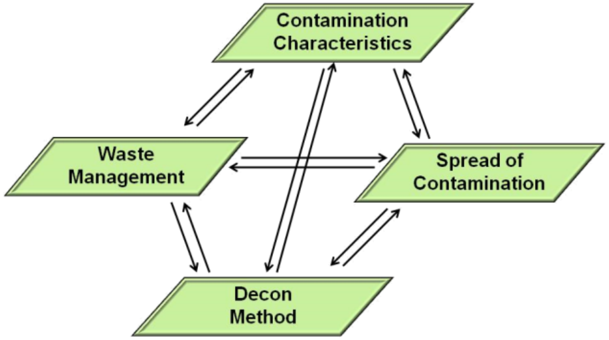
# Treatment, Disposal, Minimization and Handling of Contaminated Water and Waste

- Waste treatment and disposal for chemical and biological incidents
  - Effectiveness of on-site waste treatment using low tech methods
  - Autoclaves to treat waste contaminated with chemical agents
- Field scale effectiveness of water treatment equipment
  - Novel portable treatment devices for treatment of chemical contaminants
  - Pilot scale demonstration of mobile water and wastewater treatment
- Bio-contaminated washdown water management technologies and procedures
  - Simplified procedure for inactivation of washwater
  - Considerations for acceptance of bio-contaminated wastewater

# Decision-Making Tools and Information to Support a Systems Approach to Response and Remediation

- Responding to incidents involves a system approach, activities are intricately tied together
- Decision support tools (DSTs) have been developed to aid in providing information for decision making
- Decision Support Methodologies and Tools for Wide Area Decontamination
  - Incident Waste DST (IWASTE)
    - All hazards incident waste estimation and information on disposal and treatment options
  - Decontamination Selection Tool (DeconST)
    - Ties together scenario specific sampling, decontamination and waste management option
  - Waste Estimation Support Tool (WEST)
    - Developed for wide area radiological incidents



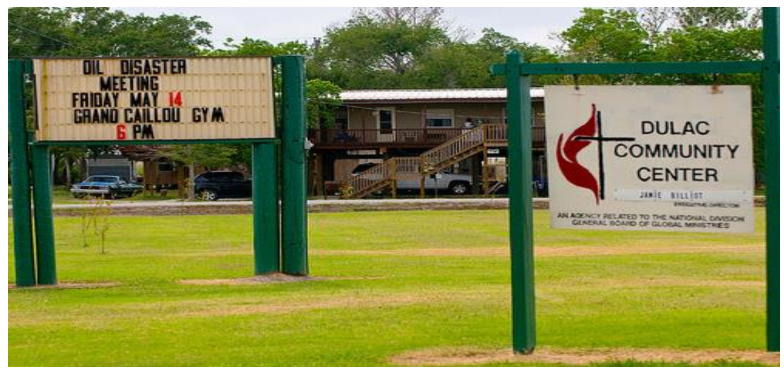



# What are indicators of community environmental resilience and how can existing tools incorporate these indicators?

- Integrating environmental and social science theory, methods, and data to build a community environmental resilience index
- Designing decision support tools that provide scientific information to community stakeholders in a way that incorporates local values and priorities

**Environmental Resilience**

Minimizing environmental risks associated with disasters, quickly returning critical environmental and ecological services to functionality after a disaster, while applying this learning process to reduce vulnerabilities and risks to future incidents.




*Social factors that affect environmental resilience include sense of place & identity, disaster planning & governance, social networks & collective action*

# END OF SLIDES

# Overview of StRAP Research Questions:

Remediating Wide Areas

- What are indicators of community environmental resilience and how can existing tools incorporate these indicators?
- What technologies, methods, and strategies are effective for mitigating the impacts of the contamination and for reducing the potential exposures?
- What technologies, methods, and strategies are most effective (minimize cost while protecting human health and the environment) for cleanup of indoor and outdoor areas (including management of waste)?
- How can the program place its research in a decision maker-friendly format for use by EPA partners and State and local decision makers?

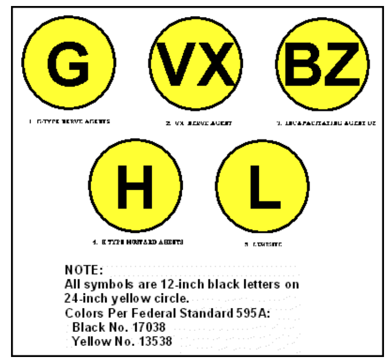
# What are indicators of community environmental resilience and how can existing tools incorporate these indicators?

- Preliminary resilience indicators for waste, organized by factor.

| Waste Resilience Indicator | Factors Affecting Waste Resilience |
|---|---|
| - Invasive species present<br>- Percent green debris disposal | Environmental ecological |
| - Landfill capacity<br>- Time to function: waste management | Infrastructure & built environment |
| - Predesignating debris disposal sites | Disaster governance & planning |
| - Clean-up of key local places (park, school) | Sense of place & identity |
| - Environmental hazards in flood zone<br>- Contaminants in building stock | Health & well-being |
| - Race, class, ethnicity (in disaster & disposal sites) | Demographic |
| - Contracts in place (recycling, waste hauler) | Economic |

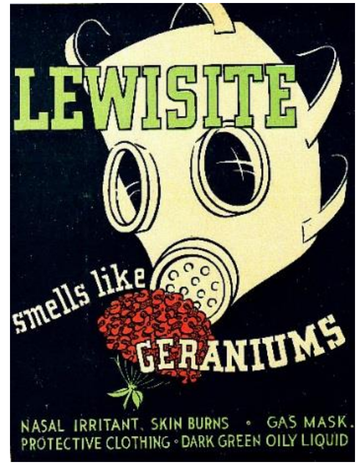
# Example of HSRP Research addressing CWA Sample Analysis:

- Analytical Methods to detect CWA and their degradates
  - CWA persistence is variable and is dependent on chemical composition and environmental conditions
  - Methods developed to identify potentially toxic degradates, which may be more persistent than parent compound
    - Allows sampling/analysis to identify areas of concern when parent compound has degraded either through natural attenuation or remediation

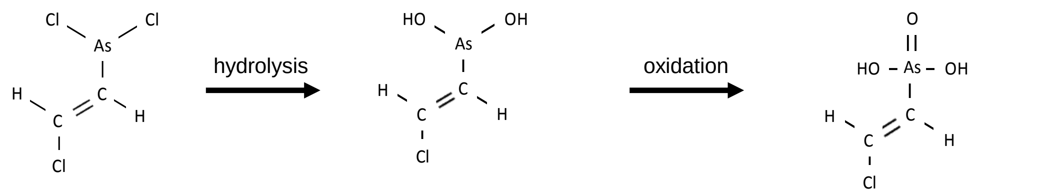



# CWA Sample Analysis Example:

- Lewisite
  - organoarsenic compound that is a blister agent and lung irritant
  - degrades rapidly in the environment




- HSRP developed a LC-MS/MS method for water, surface wipes, and soil for detection of lewisite in the environment
- Analyzes for Lewisite by-products which are more environmentally persistent




**Lewisite I** | **Chlorovinyl arsonous acid (CVAA)** | **chlorovinyl arsonic acid (CVAOA)**

# What are the standardized sample collection and analysis methods and strategies for characterization of contamination?



http://www.epa.gov/sam/


Next versions due 2017