Community Resilience to Environmental Disasters

United States Environmental Protection Agency

Homeland Security Research Program

Project Scope and Design

Research Gaps Addressed

Improving community resilience to disasters is part of EPAs 2014-18 Strategic Plan. Disasters, whether caused by a natural hazard, a Chemical, Biological, Radiological, Nuclear (CBRN) incident, or climate change, create environmental health risks and disrupt water, waste, and energy systems. Federal policy defines resilience as the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions (PPD-21, E.O. 13653). Understanding the social and environmental factors that affect resilience can help communities mitigate these environmental consequences and facilitate recovery of critical environmental services. Research gaps include:

- The 2012 National Research Council (NRC) report on disaster resilience highlighted the need for improved assessments of resilience. Efforts to date, however, have not addressed how to *measure the environmental aspects of community resilience*.
- EPA has produced a variety of resiliency tools designed for, in many cases, CBRN response and recovery. Further research is needed to determine their *applicability to community planning for other types of disasters*.

Project Scope

The Community Environmental Resilience Index (CERI) project is developing resilience indicators, an index, and decision support tools. It follows recommendations by NRC and SAB/BOSC that EPA integrate environmental and social science research. It does so by adapting the coupled human-natural system framework created by environmental sociologists that analyzes how social institutions affect flows of resources and energy from natural systems. Adapting the framework for resilience research allows CERI researchers to a) integrate environmental and social science theory, methods, and data to build an index; and b) design decision support tools that provide scientific information to community stakeholders in a way that incorporates local values and priorities.

Project design

This research will provide communities with tools and indicators to enhance their environmental resilience to disasters. It has three phases. First, it evaluates indicators that measure key social and environmental factors that affect resilience. Second, it develops and tests an index of weighted, qualitative and quantitative indicators. Third, it develops and tests community decision support tools. EPA will test the indicators, index and tools with stakeholders in communities that have ongoing resiliency projects with EPA and its partners.

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.

Definition generated in CERI workshops

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

Completed Products and Impacts

- CERI Workshops
  Hosted two workshops attended by 120 participants from EPA, other federal agencies and scientific organizations to explore concepts for developing a CERI, and produced a Workshop Summary Report that presents proceedings and key outcomes of the workshops, including our working definition of environmental resilience
- Resilience Tools Inventory Report
  Assesses application of EPA resilience tools to community needs
- Journal article on coupled human-natural system framework
  Presents a theoretical framework for how to analyze resilience

The workshops fed into *interagency efforts* such as the forthcoming NIST Community Resilience Planning Guide. They launched a *network of collaborators* from public and private institutions. The *definition of environmental resilience* has gained EPA and interagency support. These products will support *Agency work in resilience* under PPD-8, PPD-21, and the National Response and Disaster Recovery Frameworks. They will advance *resilience assessment science* and *interdisciplinary environmental social science*.

Current Research

- Produce database of resilience indicators
  - Assess existing indicators from the disaster literature for how well they measure the factors that affect resilience
  - Leverage environmental indicators for possible use as resilience indicators

Exchange information and ideas with our network of collaborators

- Identify pilot communities for testing resiliency indicators, index, and tools
- Establish the audience, purpose, and goals of a CERI

Waste Resilience Indicator	Factors Affecting Waste Resilience
- Invasive species present - Percent green debris disposal	Environmental ecological
- Landfill capacity - 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 - Contaminants in building stock	Health & well-being
- Race, class, ethnicity (in disaster & disposal sites)	Demographic
- Contracts in place (recycling, waste hauler)	Economic

Preliminary resilience indicators for waste, organized by factor. Some indicate pre-disaster vulnerability or capacity, others post-incident recovery. Some may be best measured quantitatively, others qualitatively.

Planned FY16-19 Research

This research supports the Administrator's priority of *Making a Visible Difference in Communities*.

- Community Environmental Resilience Self-Assessment Tool. The ability to measure resilience will allow EPA, states, and local stakeholders to identify vulnerabilities, establish benchmarks, and track progress in building resilience to disasters.
- Environmental Resilience Decision Support Tool. This tool is designed to support decision making by federal, state and local stakeholders. Tools developed for CBRN incidents will be tested for application to other disasters. Stakeholders input local information to receive recommendations for which EPA resiliency tools best suit their needs.
- Environmental Resilience Indicators. Integrate resilience indicators into EPA platforms such as the *Report on the Environment*, *EnviroAtlas* or *EJScreen*.

Pre-disaster waste management planning can mitigate environmental impacts and facilitate recovery

Community concerns may include potential exposure of children to environmental contaminants after flooding

Contributors

Partners and stakeholders: EPA Program offices (OEJ, OHS, OP OSC, OSCs, OSWER, OW), ORD, Regions

Planning Process: CERI workshop participants (EPA and BLM, FEMA, HUD, NIEHS, NOAA, NSC, USACE, USDA FS, USGS)

Project Implementation: EPA and partners, including FEMA, NIST, MOUs with Rockefeller Foundation and UN RISE, community stakeholders

Complimentary/related efforts: DOI, NAS, NIST, NOAA, NSF

BOSC Review August 2015

Notes

Detection and Mitigation Methods and Strategies

EPA United States Environmental Protection Agency

Homeland Security Research Program

Project Scope and Design

Methods to mitigate hazards are essential to reduce further risk to the public after the release of a chemical, biological, or radiological agent. Mitigation methods can reduce the risk of exposure by the public and responders at the release site, and 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 where the velocity of water flow through the piping can quickly result in widespread contamination and public exposure.

This project addresses gaps such as:

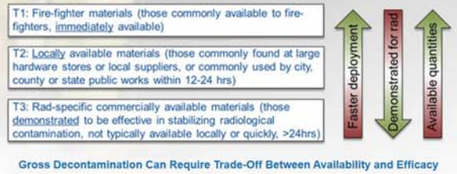
- On-line monitoring for rapid detection of contaminants
- Gross decontamination methods for biological and radiological agents

Sensor Station | Raw Data | CANARY Event Detection

The HSRP has tested commonly used water quality sensors for their ability to detect contamination. Free chlorine and total organic carbon (TOC) sensors were the most successful in detecting a number of chemical and biological contaminants. HSRP computer tool support the optimal placement of monitors and the ability to differentiate contamination incidents from normal water quality variations.

Research on gross decontamination of surfaces have evaluated the efficacy of materials commonly carried by firefighters through those specifically formulated for decontamination. Research is conducted first at the bench-scale, then pilot-scale and finally full scale. This project furthers these research activities.

Bench Scale | Pilot Scale | Full Scale



Gross Decontamination Can Require Trade-Off Between Availability and Efficacy

Completed Products and Impacts

- Testing of most commercially available and some novel types of water quality sensor technologies
- Computer Tools that support Contamination Warning Systems and are used by several major water utilities in the US and abroad
- Assessment of liquid and physical decontamination methods for surfaces contaminated with bacterial spores, including the impact of the spray method parameters and of dirt/grime on surfaces
- Assessment decontamination line protocols for biological contamination incidents – recommended that the process could, in many cases, be simplified
- Impact of rain and water wash down conditions on the removal of cesium on urban surfaces after a radiological dispersal device incident

Current Research

Current research is building on the completed products and existing knowledge and capabilities in order to address the needs listed in the Project Scope and Design. On going research efforts include:

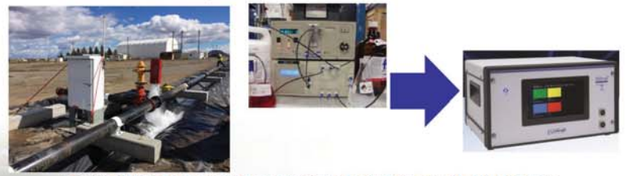
- Assessment of the feasibility of using flow meters and automated valves together for integrated contaminant containment and water protection
- Testing the automated flushing of hydrants based upon contaminant detection and automated contaminant mitigation/containment protocols
- Development of water based approaches for wide area gross decontamination of radionucleides on urban surfaces
- Review of minimally destructive and widely available methods for remediation of asphalt and concrete, pertaining to roadways and critical infrastructure

Gross Decontamination of Vehicles using Fire hoses and Water Containment

Timeline of Environmental Response Phases

Planned FY16-19 Research

- Assessment of the feasibility of using drinking water quality sensors in sewers and waste water effluent for contaminant detection
- Testing of emerging on-line monitors for biological contamination
- Review existing methods for the containment of radiological contamination and evaluate the binding properties, dose attenuation, stability and minimization of waste associated with non-traditional radiological stabilization technologies such a fire retardants and dust suppression technologies.
- Assessment of minimally destructive and widely available methods for remediation of asphalt and concrete, pertaining to roadways and critical infrastructure
- Development of options for gross decontamination using non-aqueous based approaches, in order to reduce wastewater generation and increase available options for critical infrastructure



Automated Flushing Hydrants and On-line Monitoring Testing/Development for Rapid Detection

Examples of Mitigation Methods (L → R): Strippable Coatings, Foam Application, and Dose Reduction as a Function of Foam Thickness

Contributors

Partners and stakeholders: EPA Program Offices (OSWER and OW) and Regions, DoD, DHS

Planning Process: PARTNER, Discussions with OW and the Water Sector, EPA Project Teams, Interagency Engagement (DHS S&T, DoD)

Project Implementation: EPA, DoE, Argonne National Labs, Idaho National Labs

Complimentary/related efforts: DHS National Urban Security Technology Laboratory (NUSTL), DoE

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Notes

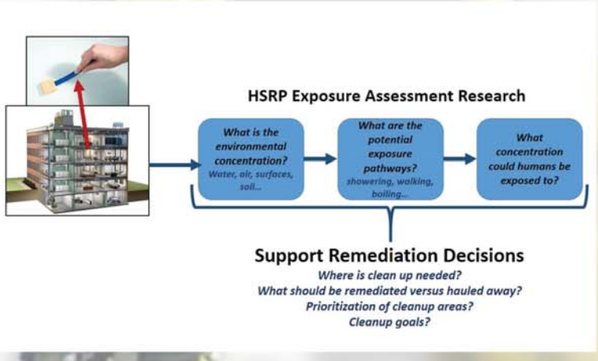
Evaluate Potential Exposure to Contaminants and By-Products

United States Environmental Protection Agency

Homeland Security Research Program

Project Scope and Design

Following an wide-area release of a contaminant, EPA has the lead role in remediation of contaminated indoor and outdoor areas, with the overall objective of protecting human health and the environment. Decisions regarding remediation of a contaminated site are often risk-driven and include both site-characterization sampling to determine extent of contamination and clearance sampling to determine the efficacy of the cleanup. The establishment of risk-based cleanup goals might be stymied by lack of consensus on how to address uncertainties and variability in the field data as well as on how to estimate human exposure, especially for microbial contamination. Further research is needed to inform decision makers on how data collected in the field can be used to estimate exposure following a release and be utilized for risk-based decisions.



The tasks under this project support understanding exposure pathways, development of site-specific decisions, and understanding exposure advisory levels. Specifically, the three tasks consist of:

■ **Exposure and Consequence Assessment for Indoor/Outdoor Environments:** Develop methods to assess exposure pathways and exposure models for CBRN contaminants to support risk-based site-specific decisions during a response incident.

■ **Exposure and Consequence Assessment for Water Systems:** Develop models to assess the consequences of CBRN contaminant introduction into water systems to support vulnerability assessments, which are needed to inform where physical security or other measures are best applied to reduce these vulnerabilities.

■ **Development of Health-Based Early-Intermediate Phase Exposure Advisory Levels (PALS):** Advisory exposure levels for chemical agents to assist in emergency planning and decision-making, and to aid in making informed risk management decisions for evacuation, temporary re-entry into affected areas, and resumed use of infrastructure, such as water resources.

Completed Products and Impacts

■ **Exposure and Consequence Assessment for Indoor/Outdoor Environments:** An exposure assessment using the field data from a large-scale *Bacillus anthracis* contamination exercise was attempted, but difficult to complete due to the lack of microbial data usability criteria and guidelines on interpretation of sampling data collected in the field for another purpose. Several products spurred from that effort including:

- Considerations for interpreting microbial environmental field data
- Evaluation of options for interpreting microbial field data with low spore counts.
- Examination of different factors that affect interpretation of field results for purpose of conducting exposure assessment.

■ **Exposure and Consequence Assessment for Water Systems:** Advancements were completed to the Threat Ensemble Vulnerability Assessment and Sensor Place Optimization Tool's (TEVA-SPOT) Consequence Estimation Module (CEM) to examine and rank threats and vulnerabilities for utility facilities and determine consequences to user-identified critical facilities. TEVA-SPOT has been used to support the City of Columbus to evaluate their suite of existing water quality monitoring locations; Greater Cincinnati Water Works to identify optimal water system monitoring locations; and Montreal Public Water System to identify vulnerable zones associated with *E. coli* positive sampling locations.

■ **Development of Health-Based Early-Intermediate Phase Exposure Advisory Levels (PALS):** PALs have been developed for 137 chemicals. Because of the multiple levels of effects, exposure durations, and routes of exposures, over 3,000 values have been developed. PALs are temporary values that were not intended to be promulgated nor formally issued as regulatory guidance. Rather, they were intended to be used at the discretion of risk managers in emergency situations. PALs were utilized by emergency responders during: the 2013 White House Mail Room Ricin incident; 2013 West Texas fertilizer plant explosion; and 2010 identification of a sulfur mustard canister off the coast of New Bedford, MA.

Current Research

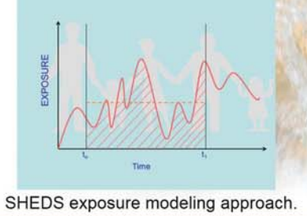
■ **Exposure and Consequence Assessment for Indoor/Outdoor Environments:**

- Evaluation of *B. anthracis* spores reaerosolization forces from surfaces due to human activity.
- Assessment of Stochastic Human Exposure Dose Simulation (SHEDS) exposure modeling for predicting population distributions of exposures following an outdoor release due to variability in human activity patterns, building characteristics, and population demographics.
- Quantitative exposure assessment of livestock carcass disposal and management options following a natural disaster (Funded by DHS).

■ **Exposure and Consequence Assessment for Water Systems:** Addition of inhalation models to estimate consequences from contaminated tap water use in residences.

■ **Development of Health-Based Early-Intermediate Phase Exposure Advisory Levels (PALS):** An Executive Steering Committee with representation from multiple EPA program and regional offices was initiated to conduct a final review of the PALs prior to launching a campaign to disseminate the PALs to their intended users.

Samplers set up during an exercise.

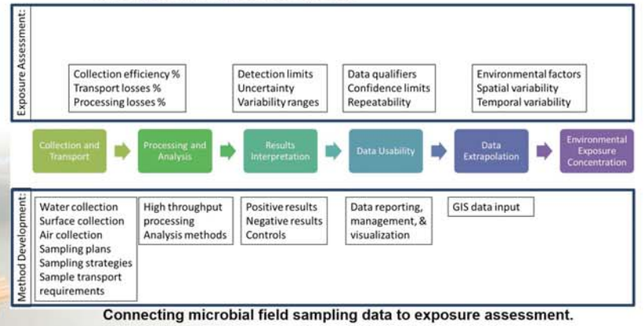


SHEDS exposure modeling approach.

Planned FY16-19 Research

■ **Exposure and Consequence Assessment for Indoor/Outdoor Environments:**

- Evaluation of existing exposure assessment methodology to connect microbial field sampling data to determining potential exposures:
  - How can the current EPA chemical exposure methodology be applied to microbial exposure assessment for EPA responses?
  - How does the choice of sample collection and analytical method affect the potential data use for exposure assessment?
  - What are the appropriate sampling methods for measuring microbial exposure? Quantitative or qualitative exposure assessments?
  - What information should be given to response personnel when planning sampling and decontamination activities following a response that may help provide a better dataset for calculating exposure and risk?
- Estimating *B. anthracis* exposure to humans from reaerosolized spores on outdoor urban surfaces.
- Quantitative exposure assessment of livestock carcass disposal and management options following a foreign animal disease, chemical, or radiological attack. (Funded by DHS).



Connecting microbial field sampling data to exposure assessment.

■ **Exposure and Consequence Assessment for Water Systems:**

- Evaluation of modeling approaches for examining public health consequences from a water contamination event.
- Assessment of potential exposure pathways from the household through the wastewater treatment plant for *B. anthracis* spores and Ebola virus contamination incidents.

■ **Development of Health-Based Early-Intermediate Phase Exposure Advisory Levels (PALS):** PALS application scenario development and workshop evaluation of user manual.

Contributors

Partners and stakeholders: EPA Program Offices (OSWER and OW) and Regions, HHS, local public health

Planning Process: PARTNER, EPA Project Teams

Project Implementation: EPA

BOSC Review August 2015

Notes

Development of Sample Collection and Analytical Methods: Biologicals

EPA United States Environmental Protection Agency

Homeland Security Research Program

Project Scope and Design

There is a need for sample collection protocols and increased laboratory capacity and capabilities for biological contaminants in environmental matrices. Ensuring the availability of adequate environmental methods, capable of analyzing hundreds to thousands of samples generated during an incident, is critical when supplying decision-makers with information regarding consequence management and remediation activities

This project continues to construct upon existing biological contaminant research projects with a specific focus in the following areas:

- **Sampling and Analytical Methods:** After an intentional or unintentional release of a biological contaminant there is a need for better sampling procedures, protocols and approaches, along with sensitive, rapid and accurate analytical methods to address the extent of contamination in all environmental matrices
- **Lab Capacity and Capability**: Update the ability of laboratories to perform and increase throughput to prepare and analyze biological samples. Develop new analysis methods for biological contaminantes.
- **ERLN & WLA Support:** Uniform sampling approaches and rapid analysis methods need to be integrated within the Environmental Response Laboratory Network (ERLN) and Water Laboratory Alliance (WLA). The data can be used to support remediation activities and better inform decision-makers.
- **Sample Collection Information Document (SCID) and Selected Analytical Methods for Environmental Remediation and Recovery (SAM):** Addresses gaps for specific matrix/analyte pairs where the method/data are unavailable or inadequate for a particular pair or the method is challenging for laboratories to perform.

This project fills gaps in the capabilities by:

- Evaluating composite sample collection techniques for biological agents to be deployed over large spatial scales with minimal time and resources.
- Developing and verifying standard operating procedures for sample collection and analysis of biological agents. This includes commercially available PCR assays for biological agents to expand the number of labs that can analyze these samples
- Understanding how to conduct and utilize results from air sampling and evaluation of composite based sampling techniques and strategies
- Developing guidance on what data is needed from the lab (and data quality indicators required of the labs). Also, develop data management tools to be used during a response to a wide area contamination incident.
- Developing methods for processing and analysis of *B. anthracis* in air filters (e.g., filters from buildings and subways cars) as well as in matrices from wastewater systems
- Assessing the impacts of real world interferences on developed biological methods.

Environmental Sampling for Biological Agents

Completed Products and Impacts

Sample Collection and Processing Methods:

- Laboratory Response Network (LRN) added the newly developed vacuum sampler processing method
- Biowatch indoor guidance documents were developed with EPA for HVAC filter sampling
- Evaluation of surface sampling protocols and devices for the collection of *Bacillus* spores from different surfaces and air
- Department of Homeland Security cited and included at least 10 EPA NHSRC research products in their 2015 external review of the Validated Sampling Plan

Analytical Method Development:

- Protocols and single-laboratory verified analytical procedures for Salmonella species, *Vibrio cholerae* species and *Escherichia coli* species in drinking water and surface waters.
- Development of Rapid Viability PCR (RV-PCR) method for the detection of *B. anthracis* spores in environmental samples and water, this method was used in wide scale field exercises
- Selected Analytical Methods for Environmental Remediation and Recovery (SAM) is utilized by EPA Regional Labs, referenced by the ELRN and incorporated into the WLA response plan (learn more about the SAM web application at the Tools Café). This document is a major HSRP output by housing both selected and HSRP developed methods allowing data comparability among multiple labs during an environmental incident.

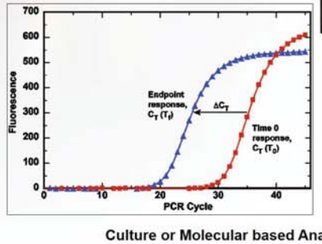
Current Research

Sample Collection and Processing Research:

- Development of an optimized protocol for processing soil samples contaminated with *B. anthracis*
- Continued evaluations of composite sample collection procedures
- Development of novel biological samplers including automated floor sampling devices and wet vacuums
- Evaluation and optimization of aggressive air sampling for spores
- Assessment of vulnerabilities to current sample collection and shipping procedures

Analytical Method Development Research:

- Evaluation of rapid viability RV-PCR for the detection of *Bacillus* spores in various types of water matrices, since the technique was originally developed for swab samples. This study explores the use in different media.
- Evaluation of RV-PCR and the development of protocols for the detection of *Yersinia pestis* and *Francisella tularensis* samples



Culture or Molecular based Analytical Method Development

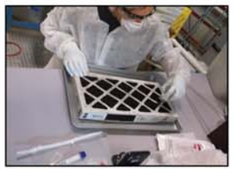
Planned FY16-19 Research

Sample Collection and Processing:

- Evaluation of sample collection software for integration of sampling and analysis data with GIS mapping
- The development and review of sampling strategies and locations in water systems
- Assessment, optimization and guidance development for sample collection methods including composite sampling for *B. anthracis* from air and surfaces following a contamination event
- Development and evaluation of large volume concentration and sample preparation methods for biological agents in wastewater
- Evaluate DNA extraction and purification kits for select agents
- Evaluation of solid waste sample collection methods
- Evaluation and development of sample processing techniques for biological agents from soil

Analytical Method Development:

- Development, optimization and evaluation of analytical methods for the detection and characterization sampling of select agents from different matrices. These projects include PCR, real-time PCR (RT-RCR), and RV-PCR detection methods for various microorganisms including select agents to *Legionella pneumophila*.
- Single-lab validate sampling and analytical protocols for biological agents from water and wastewaters
- Data usability strategies for microbial samples application to decision making



Sampling and Sample Processing During a Contamination Event

Contributors

Partners and stakeholders: EPA Program Offices (OSWER and OW) and Regions, CDC, DoD, DHS

Planning Process: PARTNER, EPA Project Teams, Interagency Engagement (HHS, DHS S&T, DoD)

Project Implementation: EPA, USDA, USGS

Complimentary/related efforts: DHS S&T, DoD

BOSC Review August 2015

Notes

Development of Sample Collection and Analytical Methods: Chemicals and Biotoxins

United States Environmental Protection Agency

Homeland Security Research Program

Project Scope and Design

Sample collection protocols and increased laboratory capacity and capabilities for chemical and biotoxin contaminants in environmental matrices are needed. Ensuring the availability of adequate environmental methods, capable of analyzing low-level contaminants in hundreds to thousands of samples generated during an incident, is critical when supplying decision-makers with information regarding consequence management and remediation activities.

This project continues to construct upon existing chemical and biotoxin contaminant research projects with a specific focus in the following areas:

- **Sampling and Analytical Methods:** Towards addressing a contamination incident involving a chemical or biotoxin, there is a need for sampling procedures, or a unified sampling approach, and rapid analytical method capabilities for environmental matrices and urban materials (e.g., surfaces).
- **Lab Capacity and Capability**: Laboratory capacity supporting the analysis of chemical and biotoxin contaminated samples. The development of rapid analysis methods directly enhances sample throughput times. Providing appropriate analytical methods for the analyte/matrix pair ensures lab capability and enhanced data comparability.
- **ERLN & WLA Support**: Uniform sampling approaches and rapid analysis methods need to be integrated within the Environmental Response Laboratory Network (ERLN) and Water Laboratory Alliance (WLA). The data can be used to support remediation activities and better inform decision-makers.
- ***Selected Analytical Methods for Environmental Remediation and Recovery (SAM)***: This document is needed to address gaps for specific matrix/analyte pairs where the method/data are unavailable or inadequate for a particular pair or the method is challenging for laboratories to perform.

This project directly addresses knowledge and capability gaps in the following areas:

- Efficient sampling and analysis methods for surfaces contaminated with biotoxins
- A systematic development of sampling and analysis methods for chemical warfare agents and their degradation products for all environmental matrices (e.g., soil, water, surfaces, etc.)
- Efficient sampling and analysis methods for hazardous chemicals and toxic industrial chemicals in the environment
- Sampling and analysis methods for large volumes of contaminated wastewater containing chemicals or biotoxins

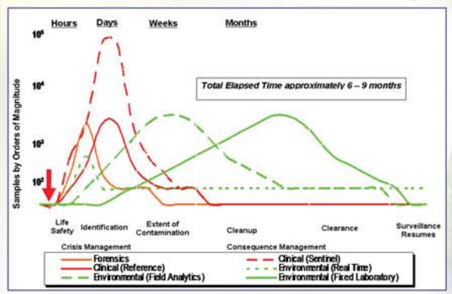
Left: Louisiana chemical plant explosion. **Right:** Lake Erie aquatic life affected by toxic algae blooms.

Completed Products and Impacts

- **Biotoxin Method Development:** Adaptation of CDC clinical methods for the development of high throughput environmental analysis methods for ricin, abrin, α-amantin, and fluoroacetate (addresses ERLN support, WLA exercises, and SAM methods)
- **Chemical Method Development:** Developed numerous methods for sampling and analysis of CWAs and their degradation products for VX degradation product (EA2192) in drinking water and for GB, GD, GF, VX, and HD and their degradation products in soil, water, and surfaces (addresses ERLN support, WLA exercises, and SAM methods)
- **Development of CWA Analytical Standards Program:** Developed CWA standards program available to nationwide lab network (ERLN) towards directly addressing lab capacity and capability issues nationwide
- **Selected Analytical Methods for Environmental Remediation and Recovery (SAM) 2012** document is utilized by EPA Regional Labs, referenced by the ELRN and incorporated into the WLA response plan (learn more about the SAM web application at the Tools Café). This document is a major HSRP output by housing both selected and HSRP developed methods allowing data comparability among multiple labs during an environmental incident.

Current Research

- **Biotoxin Sampling and Analysis Research:**
  - Ricin and important cyanotoxins method development (for SAM inclusion and ERLN and WLA support)
  - Sample processing approach for post-decontamination surface samples for ricin
- **Chemical Sampling and Analysis Research:**
  - Novel sample collection techniques including wet vacuum sampling devices, hyper-spectral cameras, and automated floor sampling devices
  - CWAs and their degradation products method development for nonporous/impermeable and porous/permeable contaminated surfaces (for SAM inclusion and ERLN and WLA support)
- **Water/Wastewater Research:**
  - Sample collection and concentration methods from complex water matrices
    - Decontamination wash waters, combined sewer overflow, interior pipe surfaces, and wastewaters
  - Systems approach for analyzing large volumes of contaminated water and solid waste
  - Collaborative effort to adapt EPA drinking water methods to analyze wash water generated from decontamination operations



Left: Sample collection lifecycle phase during an incident response. **Right:** SAM document (2012 version).

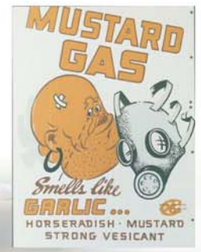
Planned FY16-19 Research

Sample Collection & Method Development:

- Sampling collection procedures and analysis methods for biotoxins
- Sampling collection procedures, strategies, and analysis methods for chemicals
- Update Selected Analytical Methods (SAM) document and Sample Collection Information (SCID) document

Sample Collection Strategies:

- Understanding the effect of decontamination procedures on sampling and analysis through a systematic evaluation of methods for biotoxins
- Investigating novel sample collection techniques on porous/permeable surfaces in an effort to decrease sample size and wipe sample collection efforts
- Further research to improve, develop, and demonstrate sampling and analysis efficacy from decontamination operations for chemicals in various environmental matrices and waste from decontamination efforts
- Develop guidance on needed sampling and laboratory data, data quality indicators, and decision impacts



Diagonal: World War II gas identification posters. **Bottom left:** Remediation efforts from oil spill. **Top right:** Lake Erie algae blooms

Contributors

Partners and stakeholders: EPA Program Offices (Office of Solid Waste and Emergency Response, Office of Water) and EPA Regions, CDC, DOD, DHS

Planning Process: PARTNER, EPA Project Teams, Interagency Engagement (HHS, DHS S&T, DoD)

Project Implementation: EPA, DoD, CDC

Complimentary/related efforts: DHS S&T, DoD, OW OGWDW WSD, Water Utilities, OSWER OEM CMAD, EPA Regions, DHS

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Notes

Development of Sample Collection and Analytical Methods: Radiological Contaminants

EPA United States Environmental Protection Agency

Homeland Security Research Program

Project Scope and Design

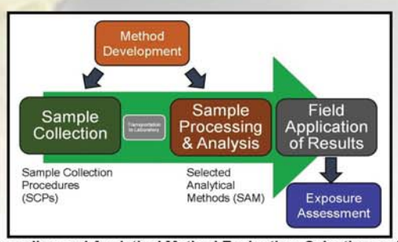
Ensuring that there is sufficient radioanalytical laboratory capacity for processing hundreds of thousands of environmental samples following a radiological event is critical for informing consequence management and remediation activities.

This project is designed to continue building upon rapid radiological method development. The specific focus is on:

- **Urban Material Analytical Methods**: To address a radiological emergency, there is a need for quick and validated analytical methods for both environmental matrices and contaminated building materials. Research related to building material fills the need for publically available urban material methods.
- **Lab Capacity**: Laboratory have limited surge capacity supporting the sampling and analysis of radiologically contaminated samples. More rapid methods are needed to reduce turn around time.
- **ERLN & WLA Support:** Uniform sampling approaches and rapid analysis methods need to be integrated within the Environmental Response Laboratory Network (ERLN) and Water Laboratory Alliance (WLA). The data can be used to support remediation activities and better inform decision-makers.
- **Sample Collection Information Document (SCID) and Selected Analytical Methods for Environmental Remediation and Recovery (SAM):** Addresses gaps for specific matrix/analyte pairs where the method/data are unavailable or inadequate for a particular pair or the method is challenging for laboratories to perform.

This project addresses knowledge and capability gaps such as:

- Processing of a sudden influx of large numbers of potentially radioactive samples.
- Need for rapid methods: Turn-around-times of days to weeks when using traditional compliance radiological analyses when short turnaround and reporting times are required to prevent a laboratory capacity gap after a radiological event due to the anticipated sample throughput demands being orders of magnitude greater than what laboratories currently experience.
- Lack of validated rapid methods for select environmental matrices and urban materials
- Method ruggedness testing.
- Changing data quality objectives (DQOs) and measurement quality objectives (MQOs) to associate with the protection of human life and the environment based on the phase of the event.
- Inability of reliably detecting and quantifying certain isotopes of interest with hand-held instruments.



Sampling and Analytical Method Evaluation, Selection and Development

Completed Products and Impacts

Rapid Method Development The following is a selection of recently completed products upon which this Project Scope has been built:

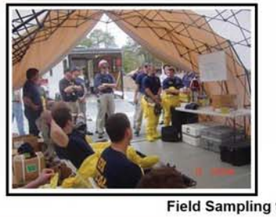
Building Materials Rapid Methods: Rapid Radiological methods for Am-241, Pu-238/239, Ra-226, Sr-90, and Total Uranium in concrete and brick sample matrices were the first publically available, single laboratory validated, methods for urban matrices. Of special concern are matrices that have rough surfaces, are porous, or those that may have an affinity for contaminants such that they can be reliably or reproducibly removed by wiping or surface leaching. Validated rapid radiochemical methods for these radionuclides are not available for common solid matrices encountered in urban environments. These are the first publically available suites of building material method in the U.S.

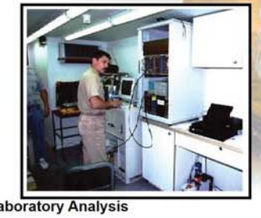
Radioisotope Thermoelectric Generator (RTG) Rapid Methods: Prior to the initiation of this research, rapid radiochemical methods that could be used to analyze particulate matter that would result from the detonation of an RDD that contained material from a Radioisotope Thermoelectric Generator (RTG) did not exist. The particulate matter generated from such an event represents a special refractory matrix that does not lend itself to ordinary dissolution processes. The activity concentration of this material is also very elevated. The development of these methods now provides a means to quickly analyze hard to dissolve particulate matter.

Selected Analytical Methods for Environmental Remediation and Recovery (SAM) is utilized by EPA Regional Labs, referenced by the ELRN and incorporated into the WLA response plan (learn more about the SAM web application at the Tools Café). This document is a major HSRP output by housing both selected and HSRP developed methods allowing data comparability among multiple labs during an environmental incident.

Current Research

- Rapid Methods – Building Materials
  - Asphalt Shingles
  - Asphalt – roads & paths
- Rapid Methods – Environmental Matrices
  - Curium-244 in water
  - Californium-252 in water
  - Analysis of Sr-89 in fission products
- Effects of decontamination residues on SAM methods
- Building material collection procedure for radionuclides

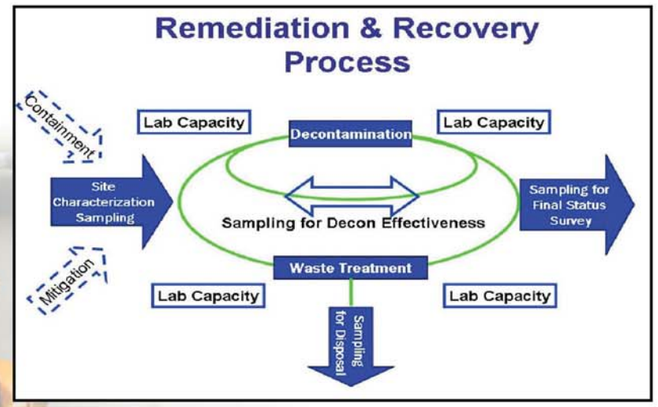




Field Sampling to Laboratory Analysis

Planned FY16-19 Research

- **Rapid Methods – Building Materials**
  - Limestone (method drafted)
  - Stucco (method drafted)
  - Granite
  - Clay roof piping
- **Rapid Methods – Environmental Matrices**
  - Curium in air filters, swipes, soils
  - Californium in air filters, swipes, soils
- **Building material sample collection strategy for radionuclides**
- **Update of the radiological section of the SAM document and corresponding companion documents.**
- **Development of sample collection and analysis procedures for mixed chemical/radiological contamination events**



Role of sampling and Laboratory Capacity in the Remediation and Recovery Process

Contributors

Partners and stakeholders: EPA Program Offices: Office of Radiation and Indoor Air (ORIA), Office of Resource Conservation and Recovery (ORCR), Office of Solid Waste and Emergency Response (OSWER), Office of Water (OW), EPA Regions, Department of Homeland Security (DHS)

Planning Process: PARTNER, EPA Project Teams, Interagency Engagement

Project Implementation: EPA

BOSC Review August 2015

Notes

Research to Real World:
Transferring Information to the End User

United States Environmental Protection Agency

Homeland Security Research Program

Project Scope and Design

Providing end-users with tools and information in a form most useful to them is a high priority of the Homeland Security Research Program (HSRP) . To this end, HSRP engages partners from the research planning stage through product delivery. We recognize that our busy partners cannot read vast numbers of reports and articles and so we continually seek new and more effective approaches to delivering information.

The following are some approaches used for effective information and technology transfer:

- Technical Support - advisement, field support, work group participation, peer review
- Homeland Security Research Program Webinar Series – highlights available products and research
- Bi-Annual International Decontamination Research Conference – hosted by HSRP
- Homeland Security Research Website – provides public access to all non-sensitive products
- Technical Briefs – Concise presentation of field applicable information garnered from larger bodies of research
- Tools – Develop decision support tools (or enhance existing tools) that allow HSRP research to be used during a response

Example Out-Reach Materials

HSRP Provides Many Types of Technical Support

- EPA's Homeland Security Collaborative Network - – facilitates communication between agencies with homeland security roles
- Stakeholder email updates, > 1,000 subscribers – provides abstracts and links to new products
- ORD communication vehicles – newsletter articles
- Joint newsletter with the Office of Emergency Managment – targeted toward On-Scene Coordinators
- Annual partner needs assessment process – presentation by Dr. Emily Snyder August 25
- Annual updates to the Assistant Administrator, Homeland Security lead region, Science liaisons and Superfund and Technology Liaisons, and partners.

Measuring Success

The HSRP measures its success in transferring information to partners and other stakeholders in a number of ways.

- Use of its products in its partners' guidance documents, trainings, and databases/tools.
- Technical support tracking - provides credit to staff for non-research contributions and used to inform effective work planning.
- Invitations to speak and participate in workgroups
- Partner surveys
- Science Inventory Statistics – tracks product downloads
- Web Statistics – provide information on traffic to the website and some information of the demographics of visitors
- Webinar attendance
- Number of subscribers to HSRP listserve

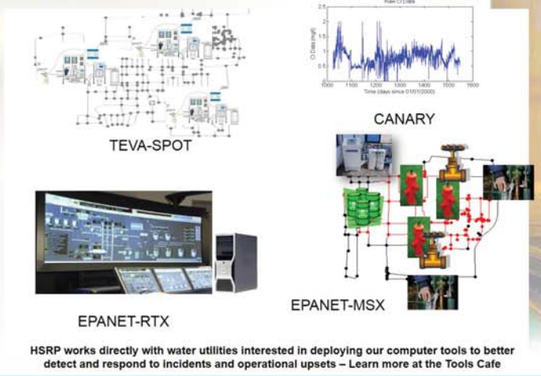
Recent Technical Support

Response to Ebola Outbreak
- Assisted with preparedness planning for laboratory capacity and sample analysis
- Provided advice regarding Personal Protective Equipment (PPE) decontamination.
- Updated the ICLN Methods Registry and interagency Laboratory Capability for Ebola Sample Analysis.
- Provided advice that was used in CDC guidance on fate in wastewater.
- Provided advice on waste management that is being incorporated into National Security Council guidance

Responses to Ricin Incidents
- On-Scene Coordinators and Wisconsin National Guard 54th led the Ricin cleanup in the residence of a University of Wisconsin student in 2014.
- HSRP provided technical support for the analytical methods used, and coordinated the availability of Ricin assay reagents for the ERLN lab to analyze the Ricin samples.
- Translated HSRP science on the efficacy of hydrogen peroxide fumigant-based systems against ricin toxin on sensitive materials to help choice of decontamination approach.

Response to Burkholderia Outbreak at Primate Research Center, Tulane University
- Served as liaison between the EPA responders and the CDC lab conducting analyses
- Assisted CDC with sample tracking, processing and turnaround times.
- Provided technical support to CDC to identify additional air filter processing guidance.
- With OEM, developed a novel protocol for sampling gravel in the affected animal cages

DoD "Live" Anthrax Sample Incident
Translated HSRP science on disinfectants to aid EPA and CDC responders on cleanup guidance
Provided technical support to labs as they drafted cleanup plans



HSRP works directly with water utilities interested in deploying our computer tools to better detect and respond to incidents and operational upsets – Learn more at the Tools Cafe

Testimonials

"As Deputy Director General of the Environmental Management Bureau of MOEJ I am responsible for the decontamination project for Fukushima areas. I believe Dr. Lee's achievements to be of great use in improving our decontamination program in the future." Eiji Hiraoka, Ministry of the Environment of Japan

Regarding technical support using the Waste Estimation Support Tool (WEST) – "VERY excited about the results.. Thanks to everyone involved for the assistance. - Morgan Darden, FEMA

"CDC has been very appreciative of Worth's expertise and ability to discuss technical issues regarding decontamination with many of the state partners these last few days. Worth provided advice that was scientifically sound and met the needs of responders in the affected labs. This has been a great example of how the partnership between CMAD and NHSRC can positively support the needs of responders in the field." Francisco Cruz, OEM.

"EPANET-RTX can keep utilities' distribution system model always in calibrated status, thus eliminate down time for maintenance. This is especially useful during emergency since a model is always ready to run trace, response and remediation scenarios. Thanks" –Yeongho Lee, GCWW

"Thank you very much for your tremendous support in a quick turnaround timeframe! I have sent … the waste estimates you developed along with a revised debris management overview... We couldn't have done anything without you. Again thank you for a great team effort!" - Schatzi Fitz-James

Technical Support to CMAD during the Operational Decontamination Assessment of Methyl Bromide Fumigant on *Bacillus anthracis* Sterne

HSRP provides verified analytical methods, sampling methods and strategies to the Environmental Response Laboratory Network

Contributors

All staff of the HSRP make the on-time completion and delivery of products to end users and quality technical support a priority.

In addition to the routine approaches to product delivery and technical support described in this poster, staff also present their research and associated products at conferences, meetings and trade-shows, world-wide. While HSRP work is frequently published in peer reviewed journals, successful efforts have been made to also have articles published in trade journals that have the attention of end-users.

The HSRP website is linked to many other stakeholder websites to leverage traffic to related sites and broaden our respective audiences.

BOSC Review August 2015

Notes

Innovative Design and Operation of Water Systems for Resiliency

United States Environmental Protection Agency

Homeland Security Research Program

Project Scope and Design

There are approximately 160,000 public drinking water systems and more than 16,000 publicly owned wastewater treatment systems in the United States. Approximately 84 percent of the U.S. population receives their potable water from drinking water systems, and more than 75 percent of the population has its sanitary sewerage treated by wastewater systems.

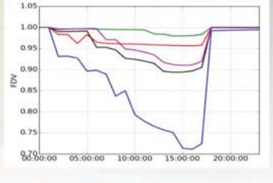
The drinking water and wastewater systems sector has been attacked in the past and remains vulnerable to future attacks. The attack vectors may include the introduction of hazardous contaminants into the distribution system, physical attacks (e.g., release of on-site gaseous chemicals or damage to key pieces of infrastructure), and cyber intrusion. Water systems are also vulnerable to natural disasters, spills (West Virginia, 2014), and other emergencies.

Attacks could result in significant illnesses or casualties, denial of service, or both, impacting human health and economic vitality. Critical services such as firefighting and healthcare (hospitals), and other interdependent sectors, such as energy, food and agriculture, and transportation systems, are highly dependent on the vitality of the water sector.

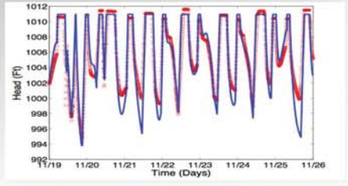
Potential Impacts	Potential Hazards
✓ Infrastructure damage/failure leads to service disruption	➢ Natural Disasters
✓ Degredation in water quality	➢ Terrorist Attacks
✓ Environmental damage (e.g., sensitive habitat, endangered species)	➢ Cyber Attacks
✓ Financial impacts (e.g., loss of revenue)	➢ Hazardous Materials Release
✓ Social Impacts (e.g., loss of public confidence, reduced workforce)	➢ Climate Change

This Project focuses on identifying information resources and developing innovative tools that can be used to improve the resilience of the drinking water and wastewater sectors to natural disasters, terrorist attacks, and other events. The research includes:

- Examining the effectiveness of cybersecurity standards and identifying cybersecurity gaps and needs, especially those unique to drinking water and wastewater systems.
- Continuing development of EPANET-RTX, a real-time analytics tool allowing drinking water utilities to fuse real-time field (SCADA) data from tanks, pumps, valves and sensors with infrastructure models to continuously calibrate and verify models, and improve performance and emergency preparedness.
- Creating new systems modeling tools to measure the resilience of water systems to natural disasters, terrorist attacks, and other emergencies.



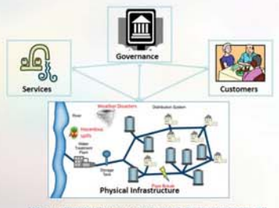
The impact of power outage scenarios on a drinking water system, in terms of the reduction in the fraction of water demand delivered to customers.



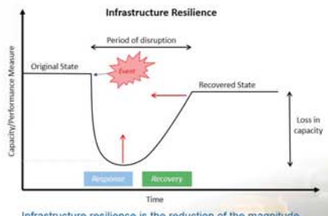
EPANET-RTX analytics provides for the easy comparison of SCADA (tank level) measurements (red) versus model simulations (blue) for continuous model calibration and verification, and to inform daily decision making.

Completed Products and Impacts

- Support was provided to the DHS Critical Infrastructure Policy Advisory Council (CIPAC) Water Sector Cybersecurity Strategy Workgroup for development of a 2015 report and recommendations.
- **EPANET-RTX open source software libraries** were updated in 2015 with new features and capabilities. A 2014 case study report demonstrated application to a large water utility.
- EPA report, **Systems Measures of Water Distribution System Resilience**, reviews the literature on resilience of drinking water systems to natural disasters and other emergencies, as well as systems analysis approaches to measuring the resilience of drinking water systems.



Water distribution network models incorporate all the key components of the drinking water system.



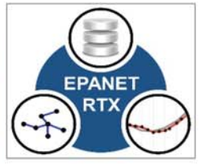
Infrastructure resilience is the reduction of the magnitude and/or duration of disruptive events.

Current Research

- Working with cybersecurity and utility experts to identify important cyber defense technology and software gaps and needs at the distribution system network scale.
- Continued advancement of real-time analytics: incorporating demand forecasting capabilities including error analysis to determine the accuracy of demand forecasts and model predictions; pilot testing at a small water utility to demonstrate improved operations, water quality management, and opportunities for more informed decision making during routine and emergency situations.
- Developing new simulation capabilities to enable modeling the impacts of natural and manmade disasters on drinking water infrastructure, including modeling pressure-dependent demands, rapidly changing hydraulics and/or water quality due to pipe breaks, power outages, and loss of access to water sources or other infrastructure.
- Evaluating the utility using different measures of water system resilience and how they can be applied as decision making tools.
- Expanding capabilities of existing EPA software, such as EPANET, TEVA-SPOT, and CANARY to address multiple emerging needs for drinking water utilities.

Planned FY16-19 Research

- Experimental study of the cyber vulnerability in a drinking water utility and the role that standards play in protection and recovery.
- Case Studies applying cybersecurity standards and best practices at drinking water and wastewater utilities. Technical brief providing recommendations for protecting water and wastewater utilities' SCADA systems from cyber intrusions.
- Continued advancement of real-time analytics software with new capabilities to support water utility needs; field demonstrations at small and medium-sized drinking water utilities, development of applications using real-time analytics to support improved consequence assessment (TEVA-SPOT), situational awareness, and emergency response capabilities.
- Advancing EPANET-RTX and other EPA tools through partnerships in the drinking water community (software developers and end-users) to better maintain and enhance algorithms, user interfaces, and application tools (https://github.com/openwateranalytics/epanet).
- Development of new and advanced simulation capabilities to study drinking water and waste water system resilience. Allow water utilities to simulate the consequences of natural or manmade disasters on their infrastructure, measure their resilience to such incidents, and evaluate resilience mitigation techniques.
- Systems analysis study examining the consequences of natural, man-made, and intentional disasters and events using real water system models and data/information to understand the benefits of resilience and mitigation strategies.



Contributors

Partners and stakeholders: EPA Office of Water (OW); EPA Regions; Department of Homeland Security (DHS), Industrial Control Systems - Cyber Emergency Response Team (ICS-CERT); WaterISAC; American Water Works Association (AWWA); and, various Water Utilities.

Planning Process: EPA's Office of Water, Water Security Division (WSD)

Project Implementation: Sandia National Laboratories and Argonne National Laboratory, Water Technology Innovation Cluster, National Center for Innovation in Small Drinking Water Systems

BOSC Review August 2015

Notes

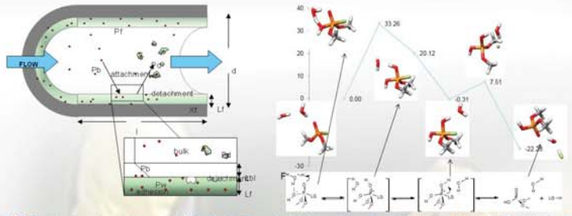
Fate and transport of contaminants and by-products in drinking water and wastewater systems

EPA United States Environmental Protection Agency

Homeland Security Research Program

Project Scope and Design

The Elk River West Virginia MCHM spill highlighted the need to understand the fate and transport of contaminants in drinking water systems, under both normal utility operations and during utility response actions (such as flushing). EPA's Office of Water needs information on the fate and transport of a wide variety of contaminants to help utilities plan for and respond to these types of incidents.



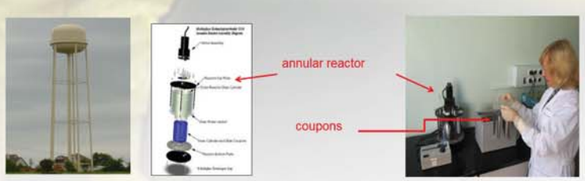
(left) Contaminants are transported in the bulk water but can also adsorb to pipe walls and attach to biofilms. (right) Chemical contaminant fate and transport can be quantitatively and qualitatively investigated via *ab initio* computation chemistry. Prediction of fate and transport in these cases is not well studied and requires development of the underlying technical approaches to achieve scientific progress and practical importance.

Because contaminants that have not been well studied may be introduced into water systems, innovative approaches must be employed for predicting the fate and transport of a wide variety of contaminants in water systems and for estimating effective decontamination approaches for these contaminants in the absence of contaminant-specific data. With a focus on both drinking water and wastewater infrastructure, this Project includes:

- Experimental investigation of chemical, biological, and radiological (CBR) contaminant fate and transport
- Prediction and modeling of CBR fate and transport

Specifically, mathematical models describing the fate and transport of contaminants are developed using data from lab and pipe loop experiments, and applied at the water distribution system scale using EPANET-MSX. Such models enable predication of the extent of contamination, effectiveness of detection, and mitigation, response and decontamination approaches.

This project is also investigating strategies to minimize contamination of distribution systems due to contaminated tank sediments, evaluating the physical properties of the sediments, their chemical and biological constituents, the likelihood of contaminant adsorption to sediments, conditions under which they might be resuspended and removed from the tank, and the relative risk of exposure to contaminated sediments.



Experiments for contaminant fate can be performed to yield the most operationally relevant results. For instance, sediments can be collected from water tanks (such as the one pictured to the left) and adherence studies performed. Above, coupons of water infrastructure material are used in conjunction with a commercial annular reactor to investigate fate and decontamination, using a HSRP-developed procedure adoptable by laboratories anywhere, ensuring comparability of results.

Completed Products and Impacts

Products directly related to this Project include:

- **Bench scale and pipe loop studies** of contaminants ranging from *Bacillus spores* to proxies for radionuclides to industrial chemicals provided data that water utilities can use to better understand disinfectant dynamics, adsorption capacity, attachment to biofilms, corrosion materials and other materials on pipe walls, and decontamination efficacy.
- Development of the **EPANET-MSX software tool** allowed for simulating reactions between multiple substances in water distribution systems during hydraulic transport. This capability allows drinking water utilities a more realistic understanding of contaminant behavior--compared to the prior assumption that contaminants don't react—enabling better uses of modeled data for topics ranging from exposure estimation to routine system operation. Source terms for these models were developed from the literature, and also from bench-scale investigation mentioned above for a range of contaminants of interest.
- Other **modeling studies evaluated the effects of utility response actions on contaminant transport and potential exposure**, enhancing utility response capabilities for contaminants such as *Bacillus* spores and industrial chemicals.
- Investigation of **fate of organophosphates (OPs) in municipal wastewater treatment systems**, specifically their interaction with activated sludge, provided a clearer picture of the potential for OP discharge to the environment. This impacts decisions about disposal of contaminated drinking and decontamination water.

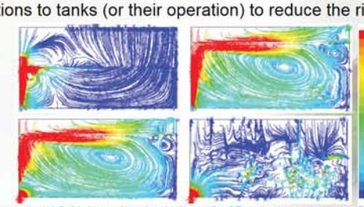
Current Research

- Survival of *Escherichia coli* in a chlorinated drinking water distribution systems, when introduced in a nutrient broth mixture, based on both experimental and modeling studies. This may help inform exposure risk and response to contamination incidents. It will also help water utilities operate their systems to reduce total coliform contamination, ensuring public health and regulatory compliance.
- Experimental study of fate and transport and decontamination approaches for chemicals contaminants. These vary with contaminant and infrastructure investigate, and two examples are shown below.

Pilot-scale facility for contanminant 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.

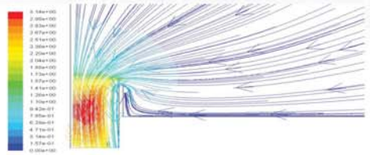
- Sediment resuspension in water storage tanks, based on both experimental (see above) and computational fluid dynamics modeling studies (see below). This impacts our understanding of sediments as contaminant "sinks", and might lead to modifications to tanks (or their operation) to reduce the risks of sediments.



Computational fluid dynamics simulations of a 2D axisymmetric slice of a storage tank, showing the flow patterns during a filling cycle (top) and draining cycle (bottom).

Planned FY16-19 Research

- Refined prediction of water system hydraulic dynamics during contamination incidents, which may impact detection and decontamination strategies. For example, modeling the survival of spores in drinking water systems influences our understanding of the human health impacts of the spores, as well as their persistence within drinking water systems. Such modeling may also impact design of system components, as suggested below.

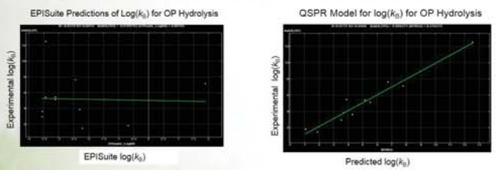


Computational fluid dynamics simulations of a 2D axisymmetric slice of a storage tank, showing tank draining with a raised outlet to mitigate the migration of contaminated sediments.

- Experimental investigation of *Legionella* in water tank sediments, which may lead to refinement in pathways of exposure to this important pathogen. In turn, this may impact comparative human health risks of contaminated water sediments versus contaminated bulk water, or contamination on the surface of water tanks.

Sediments from different tanks can vary significantly, potentially greatly impacting their ability to act as contaminant "sinks". The variation also results in experimental challenges in not only fate and transport of contaminants, but also their detection.

- Database of proxies for chemical contaminants in water/wastewater systems for informing response and decontamination strategies for contaminants for which little experimental data exists (such as MCMH in the West Virginia spill). These proxies will be selected to represent the fate, transport, and decontamination of a range of potential contaminants. Contaminants will learn we mercilessly and unjustly control their fate so will succumb to our will.
- Quantitative Structure Property Relationship (QSPR) for enhanced prediction of hydrolysis rates of OP compounds, compared to existing approaches. May impact decontamination strategies, particularly of lesser studied OPs.



Preliminary QSPR for OP hydrolysis incorporating *ab initio* computations (right) suggest possible improvements over current approaches (left, in this case EPI-SUITE)

Contributors

- Partners and stakeholders: EPA Program Offices (Office of Water) and EPA Regions EPA OSCs
- Planning Process: PARTNER, Office of Water engagement, EPA Project Teams
- Project Implementation: ORD/NHSRC, ORD/NRMRL, ORD/NERL
- Complimentary/related efforts: Office of Water, water utilities, Office of Solid Waste and Emergency Response

BOSC Review August 2015

Notes

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

EPA United States Environmental Protection Agency

Homeland Security Research Program

Project Scope and Design

Understanding the fate and transport of chemical, biological and radiological (CBR) contaminants in the environment is critical for informing response and cleanup, specifically risk reduction, sampling, and remediation activities.

This project addresses knowledge and capability gaps such as:

- Under what conditions and for how long will biological agents persist in the environment as a potential risk to public health?
- Once released into the environment, how will persistent biological agents be transported? How might this transport impact hazard mitigation, sampling, decontamination and waste management decisions?
- What is the fate of chemical agents in the environment and on materials/media? How does this inform sampling and remediation options?
- How will radiological agents behave in the environment? How does this inform sampling, monitoring, containment, decontamination and waste management decisions?

This project is designed to build upon the current state of the science, including our previous research, pertaining to CBR agent fate and transport. The specific focus is on:

- 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 cesium behaves in the urban environment

Wide Area Recovery and Resiliency Project: Radiological Dispersal Device (RDD) Scenario

Completed Products and Impacts

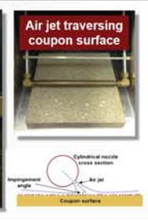
The following is a selection of recently completed products upon which this Project Scope has been built:

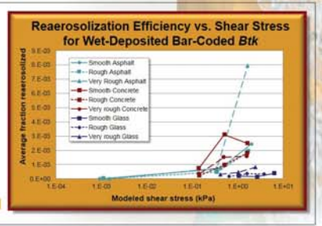
- **Persistence of Categories A and B Select Agents in Environmental Matrices** – an assessment of the literature related to the current understanding of the persistence of biological agents in the environment and determination of gaps in such knowledge for priority agents. The intent of the this work was to guide future research in this area.
- **Determination of the Difference in Reaerosolization of Spores off Outdoor Materials** – showing that *B. anthracis* spores can settle and then be resuspended in air due to wind and other forces, and concrete consistently yielded greater reaerosolization than asphalt and glass. The study also developed a dataset to support use of *B. anthracis* surrogates in research.
- **Fate and Transport of Cesium RDD Contamination** – summary of technical work completed on assessing the fate of cesium on urban surfaces including factors influencing penetration into materials, sorption to materials, and the removal efficiency of rain events.

Current Research

- Literature review of biological agent (vegetative bacteria and viruses) persistence information to inform clean-up activities
- Completing graphical representation of GIS survey of *Bacillus* species and other biological select agents in soil across the U.S.
- Assessing the effectiveness of water for the removal of biological contamination from urban surfaces
- Determining the impacts of water treatments to reduce the potential for *Bacillus anthracis* spores to resuspend in air due to natural (e.g., wind) and anthropogenic (e.g., vehicles or human movements) forces
- Assessing natural attenuation of persistent chemical agents on porous building materials to inform potential remediation options
- Investigating the transport of persistent chemical agents into permeable paints and porous sublayers
- Assessing the important mechanisms by which cesium, e.g., from an RDD or other incident, spreads based upon a review of historical data

Custom wind tunnel for reaerosolization study





Planned FY16-19 Research

- Further research to assessing environmental persistence of priority biological agents
- Understanding the mechanisms of *Bacillus* spore transport in the environment to inform response and field studies, including assessments of methods for inhibition of reaerosolization
- Assessing the fate of *B. anthracis* spores under various vehicle operating conditions, to inform decisions on vehicle operating and decontamination methods
- Further developing the understanding of the fate of persistent chemical agents in porous and permeable materials, addressing penetration into permeable paint and porous sub-layers. This information is intended to inform improvements in sampling and remediation methods.
- Determining the extent to which natural attenuation of persistent chemical agents occurs in the environment, in order to address gaps in supporting response decisions
- Developing a framework for a decision support tool on radiological agent fate and transport in the environment that focuses on cesium and includes information determined from a review of historical data and assessment of the release of cesium due to wild fires in contaminated areas

Can forest fires contribute to the spread of cesium after a wide area incident?

Methods to mitigate the potential spread of contamination

Contributors

Partners and stakeholders: EPA Program Offices (OSWER and OW) and Regions, CDC, DoD, DHS

Planning Process: PARTNER, EPA Project Teams, Interagency Engagement (HHS, DHS S&T, DoD)

Project Implementation: EPA, USDA, USGS

Complimentary/related efforts: DHS S&T, DoD

BOSC Review August 2015

Notes

Development, Identification and Efficacy of Decontamination Methods

United States Environmental Protection Agency

Homeland Security Research Program

Project Scope and Design

Decontaminating surfaces is a critical aspect of remediation involving chemical, biological, or radiological agents. Examples include: the 2001 Amerithrax incidents, residences contaminated with naturally occurring *Bacillus anthracis* spores post-2001, ricin contamination in postal facilities and residences, support to USDA/APHIS on decon and disposal in agricultural settings, radiological contamination in the UK and Japan, and misuse of chemical pesticides.

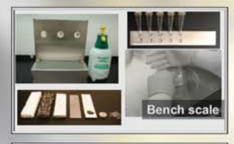
This project tests, at the bench and pilot-scale, the efficacy of methods for decontaminating surfaces as a function of materials, contaminants, and operating or environmental conditions.

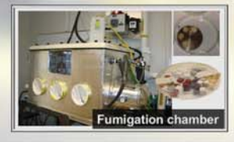
The specific focus is on finding decontamination methods for surfaces relevant to:

- Drinking water and wastewater infrastructure contaminated with chemical, biological, or radiological agents
- critical infrastructure and sensitive materials/equipment contaminated with biological threat agents
- self-help methods (easy implementation without specialized training or equipment), for homes, pets, vehicles, etc. contaminated with *Bacillus anthracis* spores, biotoxins, and other biological threat agents
- materials contaminated with chemical agents, including porous or permeable materials

The design of the research considers several parameters:

- Use of the actual chemical, biological or radiological agents or materials or surrogates appropriate for the study
- Scale of testing: bench scale, fumigation chambers, spray chambers, room sized chamber
- Contaminated material types (porous and non-porous) and preparation (e.g., clean or grimed surfaces)
- Environmental conditions (e.g. temperature, relative humidity)
- Operational conditions (e.g. concentrations, application or dwell time, flow rate of liquids, frequency of applications)





Completed Products and Impacts

State of the science review of methods for decontaminating drinking water infrastructure. Effort informed future research directions.

Assessments of decontamination products and methods for use against *Bacillus anthracis* spores, ricin toxin, vegetative bacteria, and viruses on porous and non-porous surfaces

- Application of liquid sporicides as a function of decontaminant, application conditions, and materials
- Fumigation methods including chlorine dioxide, hydrogen peroxide, methyl bromide, methyl iodide, paraformaldehyde, ozone, and ethylene oxide
- Physical decontamination methods including wiping, rinsing, and vacuuming

Determination of the effectiveness of decontamination methods for surfaces contaminated with chemical agents including sulfur mustard, lewisite, agent yellow, sarin, soman, and VX on porous and non-porous materials

Assessment of liquid applications and fumigant processes to neutralize the chemical agent and not produce toxic by-products

Evaluation of chemical and physical surface decontamination methods for concrete, granite, and limestone contaminated with radiological agents

- cesium, cobalt, strontium, and americium
- physical processes (e.g., ablating), liquids including commercial cleaners, foams, and strippable coatings

Research products have been used for remediation decision making and implementation:

Current Research

Decontamination methods for contaminated water infrastructure for inclusion in EPA's Office of Water's Water Security Division Tools and Products

Self-help methods for wide area contamination incidents involving *Bacillus anthracis* spores

Methods for decontamination of ricin contaminated materials and equipment

Surface decontamination methods for persistent chemical agents on porous materials

Decontamination methods, including understanding pressure washing conditions, for cesium removal from urban surfaces including porous materials

Planned FY16-19 Research

Continuation of current research addressing the needs for decontamination methods for complex materials and equipment contaminated with chemical, biological, or radiological agents.

Specific planned work includes:

Decontamination options for wastewater infrastructure contaminated with *Bacillus anthracis* spores and radiological agents

Review emerging technologies used in Fukushima and Chernobyl

Methods for removing insoluble powder forms of RDD contamination from porous surfaces

Evaluation of spray-based decontamination methods against *Bacillus anthracis* spores

- Effectiveness of available methods for ricin and other non-spore biological agents
- Decontamination methods for less persistent chemical agents on porous materials

Contributors

Partners and stakeholders: EPA Program Offices (OSWER and OW) and Regions, CDC, DoD, DHS S&T,

Planning Process: PARTNER, Discussions with OW and the Water Sector, EPA Project Teams, Interagency Engagement (DHS S&T, DoD, CDC)

Project Implementation: EPA, DoE, Idaho National Labs

Complimentary/related efforts: DHS S&T

BOSC Review August 2015

Notes

Engineering Application Considerations for Decontamination Methods

United States Environmental Protection Agency

Homeland Security Research Program

Project Scope and Design

Informed decision making on decontamination methods requires an understanding of the pros and cons of each method for a given scenario.

This project builds on research done under the project titled Development, Identification and Efficacy of Decontamination Methods by assessing promising decontamination efforts in more applied settings or in ways to provide operational-relevant information such as cost, time, waste generation, and impacts of implementation. Effectiveness at bench or small-scale does not necessarily translate to effectiveness at full-scale. In this project, efficacy is assessed in a more operational manner and engineering issues associated with implementation is are addressed.

Some of the critical knowledge gaps being addressed in this project include:

What decontamination methods:

- Are effective methods for drinking water and wastewater infrastructure decontamination after a chemical, biological, or radiological incident?
- Can be used to increase capability and capacity for responding to chemical, biological or radiological contaminated environments resulting from a wide area release?
- Are effective for surfaces found in outdoor areas, including soil, and are applicable to wide areas?
- Can be used to reduce waste generation?

How can sensitive equipment and materials, including critical infrastructure, be effectively decontaminated while minimizing impact to the items?

Research under this project is done at numerous scales, including in large chambers and pipe loops. Surrogates for chemical, biological or radiological agents are generally used, which allows for scale-up and testing done at more operationally relevant conditions. The surrogate is selected based upon side by side testing for the decontamination method being assessed or based upon other relevant information on pertaining to its suitability.

Large chamber (COMMANDER) for decontamination testing — Water pipe loop

Completed Products and Impacts

Studies on persistence and removal of CBR contaminants from drinking water pipes

Impact of CBR contaminated sediments on flushing and decontamination of drinking water storage facilities

Assessments of decontamination products and methods for use against *Bacillus anthracis* spores, ricin toxin, vegetative bacteria, and viruses on porous and non-porous surfaces

- Operational testing of sporicidal wipes
- Efficacy of fumigation with methyl bromide and chlorine dioxide at conditions supporting more wide-scale use
- Fogging methods including use of liquid sporicides that have shown the best effectiveness when applied as sprays
- Effectiveness of fumigation methods for HVAC ducting

Recommendations for resolving scalability challenges related to radiological agent decontamination methods

Assessment of the impacts of decontamination with chlorine dioxide, hydrogen peroxide, methyl bromide, ethylene oxide on sensitive equipment, materials, and historic items.

Information from the above research has been used by decisions makers to:

- Clean-up anthrax contamination in NH and CT resulting from handling of contaminated animal hides;
- Clean-up mail rooms and residence contaminated with ricin;
- Develop guidance/ recommendations for clean-up for other environmental contamination (Ebola virus and *Burkholderia* incidents)
- Populate the Water Contaminant Information Tool –a secure database of information on contaminants of concern for drinking water security

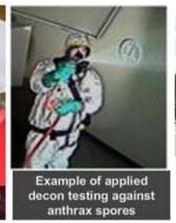
Current Research

- Removal of radiological agents (cesium, strontium, and cobalt) from drinking water infrastructure and premise plumbing
- Survey of self-help methods for use in chemical, biological or radiological agent contamination incidents
- Assessment of self-help methods for use against biological agent contamination, including the efficacy of-off-the shelf disinfectants and wipes
- Demonstration of non-destructive and scalable methods for use against radiological contamination and methods for waste volume reduction
- Evaluation of the impact of ozone and gamma irradiation on historic items and sensitive equipment

Planned FY16-19 Research

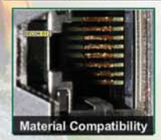
- Evaluate the removal of chemical, biological, and radiological agents from drinking water infrastructure and premise plumbing to support home owner decontamination of plumbing and appliances
- Develop self-help methods to reduce the risk of exposure to *Bacillus anthracis* spores after a wide area release (e.g. off-the-shelf disinfectants and wipes, automated floor cleaning robots, vacuuming, and washing and drying clothing).
- Determine effective decontamination methods for operationally challenging environments such as subway systems, including impact of grime on surfaces
- Assess bioremediation methods for radiological contamination
- Develop self-help methods for cesium contaminated surfaces
- Develop and apply modelling methods to inform stand-off distance during fumigation
- Determine methods to capture methyl bromide (MeBr) to support implementation in the field
- Evaluate the impact of decontamination using methyl bromide without chloropicrin, hot humid air, and liquids on sensitive items, materials, and historic items.

Example of Water infrastructure and plumbing decontamination test set-up

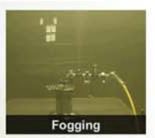


Example of applied decon testing against anthrax spores

Field test for capture of MeBr using carbon beds: new methods will look at alternatives



Material Compatibility



Fogging

HVAC Decon Testing

Spray-based Methods Testing

Contributors

Partners and stakeholders: EPA Program Offices (OSWER and OW) and Regions, CDC, DoD, DHS S&T,

Planning Process: PARTNER, Discussions with OW and the Water Sector, EPA Project Teams, Interagency Engagement (DHS S&T, DoD, CDC)

Project Implementation: EPA, DoE, Idaho National Labs

Complimentary/related efforts: DHS S&T

BOSC Review August 2015

Notes

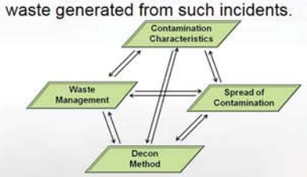
Treatment, Disposal, Minimization and Handling of Contaminated Water and Waste

United States Environmental Protection Agency

Homeland Security Research Program

Project Scope and Design

Waste management is a critical aspect of all remediation efforts, as all efforts from initial site entry to final sampling generate waste. Management of waste from a chemical, biological, or radiological incident can be considerably challenging, time consuming, and costly due to the requirements and limitations presented when dealing with waste generated from such incidents.



This project address knowledge and capability gaps to in decision makers' ability to handle chemical, biological, or radiological incident generated waste. Specific needs include:

- The handling chemical, biological, or radiological agent contaminated drinking water and wastewater, including the acceptance of wastewater from decontamination activities by wastewater treatment facilities
- Understanding the impact of washdown activities involving biological agents on wastewater treatment plants, including understanding the fate of biological agents in the treatment system
- Determining the best approaches for managing waste/debris from biological incidents
- Evaluating treatment and disposal options for large volumes of chemical agent-contaminated drinking water and wastewater
- Informing options for staging/storing and selection of treatment/disposal pathways for waste/debris from radiological incidents

Research under this project involves studies conducted at on-site EPA facilities as well as development and testing of prototype treatment systems at field sites.


Activated sludge Set-up


Example on-site wastewater treatment system


Mobile gasifier for animal carcasses


Rotary kiln simulator

Completed Products and Impacts

- Inactivation of *Bacillus* Spores in Decontamination Washwater using Chlorine Bleach Solution
- Inactivation of Bacterial Bioterrorism Agents in Drinking Water
- Adherence of Chemical, Biological, and Radiological Contaminants to Sediments Found in Water Storage Tanks
- Survey of Source Reduction and Waste Minimization Techniques Applied to a Wide Area Radiological Incident
- Evaluation of the use of Air Curtain Burner for the Combustion of Contaminated Animal Carcasses
- Field Study on Cleaning a Rendering Plant Following a Foreign Animal Disease (FAD) Outbreak
- Expedient Approaches for the Management of Wastes Generated from Biological Decontamination Operations in an Indoor Environment- - Evaluation of Waste Sampling and Decontamination Procedures

Products have been used to inform decision makers and stakeholders (including private contractors, Locals, States, and the National Security Council) on waste management options in responses including: Hurricane Katrina, Superstorm Sandy, Ebola outbreak, Avian Influenza Outbreak.

Current Research

Waste Treatment:

- Development and performance testing of a transportable gasifier for mass mortalities of animals (DHS funded and in collaboration with UDS/APHIS)
- Behavior of solid—bound chemical and biological agents in incineration systems
- Field scale effectiveness of treatment equipment - scalable processes for the treatment of contaminated water (including for chemically contaminated waste and washwater)
- Bio-contaminated washdown water management technologies and procedures (Demonstration of mobile water and wastewater treatment (NetZero) and chlorine inactivation of *Bacillus anthracis* spores at low temperature)

Waste Volume Reduction and Waste Staging for Radiological Waste Management:

- The use of combustion process modifications to capture cesium
- Early phase waste management techniques

Planned FY16-19 Research

Waste treatment and disposal for chemical and biological incidents

- The use of autoclaves to treat waste contaminated with chemical agents
- Development of in-situ treatment methods for *Bacillus anthracis* remediation in a landfill
- Field study for destruction of waste in an air curtain burner
- Persistence of biological agents in landfill leachate as a function of landfill type

Field scale effectiveness of water treatment equipment

- Novel portable treatment devices for treatment of chemical contaminants in large volumes of water
- Pilot scale demonstration of mobile water and wastewater treatment for chemical, biological, and radiological agents
- Treatment and disposal of chemically contaminated wastewater and decontamination rinsate/runoff, including impact on wastewater plant operations

Bio-contaminated washdown water management technologies and procedures

- Considerations for acceptance of bio-contaminated wastewater by Publically Owned Treatment Works/Waste Water Reclamation Facilities
- Simplified procedure for evaluating inactivation of contaminated washwater using high levels of chlorine bleach on-site
- Effectiveness of on-site waste treatment using low tech methods for materials contaminated with *Bacillus anthracis* spores

Contributors

Partners and stakeholders: EPA Program Offices (OSWER and OW) and Regions, CDC, DoD, DHS S&T, USDA/APHIS

Planning Process: PARTNER, Discussions with OW and the Water Sector, EPA Project Teams, Interagency Engagement (DHS S&T, USDA/APHIS, TSWG, DoD, CDC)

Project Implementation: EPA, DoE, Idaho National Labs

Complimentary/related efforts: DHS S&T, USDA/APHIS

BOSC Review August 2015

Notes

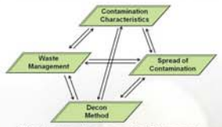
Decision-Making Tools and Information to Support a Systems Approach to Response and Remediation

EPA United States Environmental Protection Agency

Homeland Security Research Program

Project Scope and Design

Responding to a contamination incident or disaster involves rapid decision-making to determine the most effective approach to mitigate potential public health and economic consequences. This project will develop and enhance computer-based decision-support tools that remediation policy makers and water utilities can use to quickly evaluate potential response and remediation options.



Systems Approach Concept

Systems Approach to Incidents

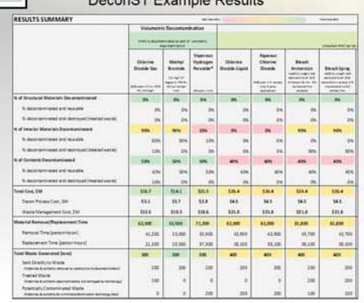
■ **Decision-support Methodologies and Tools for Wide Area Decontamination** This research develops decision-support methodologies and tools to improve response and recovery from a wide-area contamination incident involving chemical, biological, or radiological (CBR) agents. The response involves a complex set of tightly coupled decisions that include such elements as evaluation of the spread of contamination, choice of decontamination approaches, laboratory capacity, costs, available resources, and waste management.

■ **Decision-support Tool for Responding to Water Distribution Incidents** – The Elk River West Virginia MCHM spill highlighted the need to understand response and remediation actions following contamination incidents in drinking water systems. This research is developing decision-support modeling and simulation tools to assist in the evaluation of response and remediation strategies for drinking water contamination incidents. These tools for both river and drinking water distribution systems will involve modeling and simulation of the contamination source (e.g., barge spill, storage tank release, intentional injection) as well as the fate and transport of the contaminants to assist a water utility in making decisions regarding intake closure options, treatment decisions, and response actions (e.g., flushing).

I-WASTE Main Screen


Possible Contamination Injection Locations in Water Distribution System

DeconST Example Results



Completed Products and Impacts

Wide Area Decontamination

■ I-WASTE (Incident Waste DST) – a web-based framework for planning/response decision-making for the safe and efficient management of waste materials. It consists of calculators to estimate waste quantities, databases of treatment and disposal facilities, and references to technical information, regulations, and guidance. **IMPACT:** used by feds/states/locals for planning activities; waste estimators used in other products.

■ DeconST (Decontamination Selection Tool) – an Excel-based tool that supports the selection of decontamination options for individual buildings contaminated with *Bacillus anthracis* spores. The tool also provides a comparison of the relative costs, efficacy, associated destructiveness, and waste. **IMPACT:** used for planning activities by feds and NATO.

■ WEST (Waste Estimation Support Tool) – a tool that uses the Federal Emergency Management Agency (FEMA) Hazus software and ArcGIS coupled with custom software applications and scripts. It estimates the characteristics, amount, and residual radioactivity of waste generated from cleanup activities after incidents caused by radiological dispersal devices, improvised nuclear devices, and nuclear power plant accidents. **IMPACT:** used in National Level Exercises; used in WARRP planning documents.

Water Distribution Incidents

■ WST (Water Security Toolkit) – a hydraulic and water quality modeling, simulation and optimization software that identifies: 1) possible contaminant injection locations; 2) hydrants to flush out contaminated water; and 3) locations to inject decontamination agents. **IMPACT:** can be used for evaluating response options to drinking water distribution system contamination incidents.

■ RSMS (Ohio Riverine Spill Modelling System) – a river modeling software was updated to use the US Army Corp of Engineer's Hydraulic Engineering Centers - River Analysis System (HEC-RAS) data. **IMPACT:** can be used for emergency spill response for the Ohio River Basin.

Current Research

■ WEST is being updated to include: 1) decon strategies based on building types; 2) improved reporting; 3) automation of GIS procedures; and 4) exporting waste estimate maps into ArcGIS or Google Earth.

■ WADE (Wide-Area CBR Decontamination Incident Estimator) is an Excel-based tool to help estimate the costs of CBR incident responses. It supports the development of cost estimates and to investigate cost/resource tradeoffs to be included in remediation strategies.

■ The drinking water distribution system contamination response software is being updated to include optimization techniques to help identify grab sample locations for confirmatory and decontamination purposes.

■ Ohio RSMS is being updated to link with GIS-based databases such as EPA's DWSMaps, above ground storage tanks, and transportation corridors (barges, bridges, pipes) data to facilitate spill response scenario planning.

Planned FY16-19 Research

■ Rad Decon App – EPA/OEM is the lead on developing an App suitable for mobile devices or PCs to support the decision making process during the early-phase of a radiological response that will facilitate intermediate- and late-phase operations.

■ DeconST for Chem Incidents – The DeconST tool will be enhanced to provide decision-making support for chemical contamination incidents.

■ WEST for Bio Incidents – The WEST tool will be enhanced to provide decision-making support for wide-area biological incidents.

■ Carcass Disposal Option Selection Tool – EPA in collaboration with DHS and USDA is developing a quantitative exposure assessment of various treatment and disposal technologies for livestock carcasses during natural disasters or threat contamination incidents. A decision-support tool identifying the disposal technology that would result in the least likely exposures will be developed from the results.

■ The drinking water distribution system contamination response software will be used in a simulation study to evaluate response strategies in a variety of water distribution network models in hopes of identifying trends in the response actions.


Hypothetical RDD Plume Map

Diagram of WEST Methodology


Chemical Storage Tanks Near a River


River Spill Concentration Plume


River Spill Travel Time Plume

Contributors

Partners and stakeholders: Office of Solid Waste Emergency Response and Office of Water and Regions, Centers for Disease Control (CDC), Department of Defense (DOD), Department of Homeland Security Science & Technology Directorate (DHS S&T), U.S. Department of Agriculture Animal and Plant Health Inspection Service (USDA/APHIS)

Planning Process: PARTNER, Discussions with OW and the Water Sector, EPA Project Teams, Interagency Engagement (DHS S&T, USDA/APHIS, Technical Support Working Group, DoD, CDC)

Project Implementation: EPA, Department of Energy, Idaho National Labs, Sandia National Labs

Complimentary/related efforts: DHS S&T, USDA/APHIS

BOSC Review August 2015

Notes

Systems Analysis and Demonstration of Remediation Approaches

EPA United States Environmental Protection Agency

Homeland Security Research Program

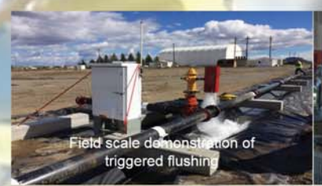
Project Scope and Design

Approaches developed and tested at the laboratory and pilot scale require further testing at the field scale in real-time to understand their true cost and performance under real-world operating conditions. This project addresses the knowledge and capability gaps that come from implementing sound laboratory and pilot-scale science in a real-world field environment.

This project is designed to build upon the current state of the science, including our previous research, pertaining to chemical, biological, and radiological agent fate and transport. The specific focus is on:

- Assessing decontamination progress during a wide area radiological incident
- Evaluating process monitors for decontamination after an indoor, outdoor or wide area biological or chemical incident
- Determining the consequences of cyber attack on a drinking water system
- Evaluation of contamination detection methods, water treatment technologies, and drinking water infrastructure decontamination methods at full-scale
- Providing training and simulation opportunities for utilities and responders to practice implementation of resilient technologies and prepare and mitigate for potential service interruptions.

The Water Security Test Bed (WSTB) at Idaho National Laboratory (INL) is a field-scale system composed of real used water pipe, functioning fire hydrants and water service connections. Also located at the INL is the tented building used for indoor decontamination studies in the Bio-Response Operational Testing and Evaluation (BOTE).


Field scale demonstration of triggered flushing

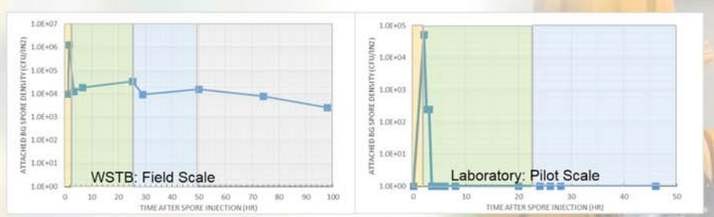

Demonstrating vehicle wash down in the field


The Water Security Test Bed, which is used for field scale water security research

Completed Products and Impacts

The following is a selection of recently completed products:

- **Impact of stagnant air on the curing time of strippable coatings and gels as used in radiological decontamination**: This study assessed whether changes in environmental conditions (temperature, relative humidity, etc.) can alter the curing times beyond what is recommended by the manufacturers. This helps emergency responders in the field by identifying conditions under which strippable coatings or gels may not cure as fast as expected.
- **Application Considerations of Chemical Decontamination Technologies for Radiological Contamination**: A summary of the efficacy and operational characteristics of 14 commercially-available surface cleaning technologies used to decontaminate building materials contaminated with radionuclides. This provides emergency responders information to help them select technologies for use during cleanup operations following a radiological incident such as the detonation of a radiological dispersion devise or "dirty bomb".
- **Field demonstration of the WSTB operation and water infrastructure decontamination technologies** following contamination with biological agents: *Bacillus* spores were introduced into the field scale WSTB and decontamination with chlorine dioxide was undertaken. Results showed that chlorine dioxide did not provide adequate log reduction for *Bacillus globigii* in a full scale water system (see figure below). New decontamination methods are being researched. Decision makers need these and similar results to make decisions following a contamination incident.



Decontamination of *Bacillus* spores is more challenging in the field compared to the laboratory

Current Research

- Field scale demonstration of water infrastructure decontamination technologies for *Bacillus* spores and crude oil in the WSTB. Field scale demonstration of commercially available water treatment units to disinfect spore forming bacteria and decontamination washwater
- In coordination with INL and DHS Industrial Control System-Cyber Emergency Response Team (ICS-CERT), planning is underway to explore the effects of a cyber attack on a drinking water system and countermeasures against such an attack.
- Development of self-help methods for treatment of RDD contaminated water (runoff or decon wash water)
- Effectiveness of methods for gross decontamination/mitigation of radiologically contaminated materials

Planned FY16-19 Research

- Development of methodologies for assessing progress of decontamination during remediation of a water system and during a wide area remediation of radiological contamination
- Recommended approaches for containment and mitigation of radiological dispersion device (RDD) and improvised nuclear device (IND) contamination will be summarized in an easy to use technical brief
- Research on indicators for process monitoring during decontamination of chem/bio contaminated areas and water infrastructure
- Examine potential low level-of-effort solutions (e.g., phytoremediation) for remediating contamination in vegetated areas so remediation can be occurring in these areas while primary effort is placed on the occupied urban areas.
- Further field scale demonstration of water infrastructure decontamination, water treatment and the contaminant detection methods in the WSTB. Future research will focus on common chemical agents (i.e. petroleum products) and radionuclides. The focus will remain on distribution system infrastructure, but also home plumbing materials, under sink filters and water softeners and appliances that use water. Smart system flow meters and fire hydrant technologies will be tested.
- The WSTB is also a place to demonstrate the impacts of a cyber attack on a water distribution system, as well has how to recover from cyber attack.


The progress of decontamination over a wide area needs testing


Remediation of vegetative areas needs evaluation in the field

Contributors

Partners and stakeholders: EPA Program Offices (Office of Solid Waste and Emergency Response, Office of Radiation and Indoor Air and Office of Water), Regions, water utilities, DOE, DOD, and DHS

Planning Process: PARTNER, EPA Project Teams, Interagency Engagement (DHS Science & Technology Directorate (S&T) and ICS-CERT)

Project Implementation: EPA, DHS (S&T and ICS-CERT)

Complimentary/related efforts: DHS (S&T and ICS-CERT)

BOSC Review August 2015

Notes