EPA United States Environmental Protection Agency

EPA 601/R-12/008 | June 2012 | www.epa.gov/research

Homeland Security
STRATEGIC RESEARCH ACTION PLAN 2012-2016

SCIENCE

Office of Research and Development
Homeland Security

EPA 601/R-12/008

Homeland Security

Strategic Research Action Plan 2012 - 2016

"EPA has a vital role in homeland security. The Agency has been called upon to respond to five major disasters and nationally significant incidents in the past seven years. In the coming years, EPA's homeland security roles and responsibilities will continue to be of the utmost importance as the Agency enhances its preparedness."

EPA Administrator Lisa P. Jackson

May 12, 2009

U.S. Environmental Protection Agency
June 2012

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Executive Summary

This document outlines the Homeland Security research plan for EPA's Office of Research and Development, and how it will address science and technological gaps and improve the Agency's ability to carry out its responsibilities associated with preparing for, and responding to, terrorist attacks and other disasters.

Although the United States has not experienced a large scale chemical, biological or radiological-based terrorist attack since 2001, many experts agree that more attacks are inevitable. The sustainability of U.S. communities requires that they be resilient to such disasters. The U.S. Environmental Protection Agency (EPA) has a responsibility to help communities prepare for and recover from disasters, including acts of terrorism. EPA's role includes helping to protect water systems from attack, assisting water utilities to build contamination warning and mitigation systems, and leading remediation of contaminated indoor and outdoor settings and water infrastructure. Critical science gaps exist in all these areas.

EPA's Homeland Security Research Program (HSRP) was established to conduct applied research and provide technical support that increases the capability of EPA to achieve its homeland security responsibilities. The HSRP helps build systems-based solutions by working with Agency partners to plan, implement and deliver useful science and technology products. HSRP maintains robust coordination efforts with other federal agencies including the U.S. Department of Homeland Security, the U.S. Department of Defense, and the Centers for Disease Control and Prevention, among others. HSRP's research is conducted and science products are constructed to address "all hazards," filling science gaps associated with chemical, biological and radiological contamination intentionally released by terrorists or caused by natural disasters or accidents.

The HSRP is organized into three Research Themes: two themes align with each of EPA's main homeland security responsibilities (water security and environmental cleanup), and a third cross-cutting theme addresses issues common to both of these responsibilities.

The themes are as follows:

Theme A: Securing and Sustaining Water Systems

Theme B: Characterizing Contamination and Determining Risk

Theme C: Remediating Indoor and Outdoor Environments.

This research action plan describes the mission and design of the HSRP, its strategic directions, and the critical scientific and technical questions it is addressing. The research action plan is a high-level strategic document that will be revised every three to four years.

Introduction

In 2001, an act of bioterrorism—when anthrax-tainted letters were mailed to two U.S. Senators and several news media offices—resulted in at least 17 buildings being contaminated with anthrax spores, five deaths, and 17 injured people, and required an immense characterization and cleanup effort by EPA and others. The reported cost of the response and clean up of anthrax contamination totaled about $1 billion. The incident happened only a little more than a month after terrorists flew airplanes into the World Trade Center and the Pentagon. Although no chemical, biological and radiological (CBR)-based terrorist attacks have succeeded in the United States since, many experts believe more attacks, and the associated costs to human life and the economy, are inevitable. In 2008, a Congressionally-created commission concluded that "it is more likely than not that a weapon of mass destruction will be used in a terrorist attack somewhere in the world by the end of 2013" (Graham, 2008).

At the same time, natural and accidental disasters are common. Federal disaster declarations have ranged from 42 to 80 per year during the last decade (Federal Emergency Management Agency, 2011). Recent major disasters include Hurricanes Katrina and Rita in 2005, the Deepwater Horizon oil spill in 2010, and the Mississippi River flood and tornados in the Midwest and Southeast in 2011. Such incidents will continue to challenge the United States in the future.

Human lives can be at stake when people are exposed to hazardous chemicals, microbial pathogens, and radiological materials purposely released into the environment by terrorists or by unintentional releases resulting from industrial accidents or natural disasters. Such events also can result in economic turmoil. Our communities and country can recover more quickly and cost effectively from these events if effective tools, methods, information, and guidance are developed and successfully delivered to local, state, and federal decision-makers.

An essential element in building sustainable communities is the capability to successfully prepare for, respond to, and recover from disasters. This element of sustainability is often termed "community resilience." A community's state of resiliency can be expressed as its level of competency in governance, risk assessment, knowledge and education, risk management and vulnerability reduction, and disaster preparedness and response (Twigg, 2009). EPA plays an essential role in helping build several of these resiliency components, namely, the human health and environmental components of "risk management" and "disaster preparedness and response".

President Obama recently emphasized the commitment by the federal government to help communities become more resilient to disasters (Office of the President of the United States, 2010):

> *"We are building our capability to prepare for disasters to reduce or eliminate long-term effects to*

people and their property from hazards and to respond to and recover from major incidents. To improve our preparedness, we are integrating domestic 'all hazards' planning at all levels of government and building key capabilities to respond to emergencies. We continue to collaborate with communities to ensure preparedness efforts are integrated at all levels of government with the private and nonprofit sectors."

EPA's work to support community resilience often highlights scientific and technological gaps that, if filled, would improve EPA's guidance and tools for a variety of national, state, and local decision-makers. EPA established HSRP to lead efforts at filling critical gaps associated with EPA's homeland security responsibilities. Figure 1, in simple terms, illustrates the relationship between HSRP's efforts and the goal of enhancing the resiliency and sustainability of water systems and communities.

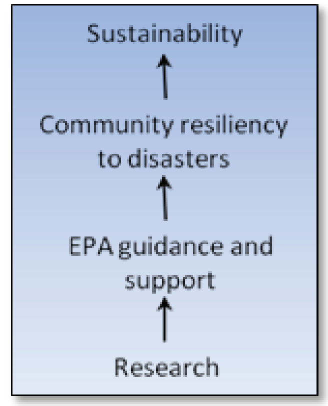


Figure 1.

HSRP was established in 2002 with the formation of EPA's Office of Research and Development's (ORD) National Homeland Security Research Center to tackle scientific issues associated exclusively with terrorism. Over the years, the research program has developed many products that address critical terrorism-related issues while having applicability to other natural and manmade disasters. Currently, as the Agency views the preparation for and recovery from disasters more holistically), EPA's HSRP has evolved to a broader focus reflecting the Agency's all hazards scientific needs.

Research Supports EPA Priorities

Statutory and Policy Context

EPA is embracing the all hazards approach to preparing for and recovering from both natural and manmade disasters. The Agency now defines the term "homeland security" to be not only related to acts of terrorism, but to be:

> *"…a concerted and collective national effort to reduce the United States' vulnerability to terrorism, natural disasters and other emergencies, as well as to minimize the damage and recovery from these events when they do occur."* (U.S. EPA, 2011)

EPA holds clearly defined responsibilities associated with responding to disasters or acts of terrorism. These responsibilities are established through a set of laws, Homeland Security Presidential Directives and Executive Orders, and national strategies. The document, *Refining EPA's Strategic Approach to Homeland Security* (U.S. EPA, 2011) describes these drivers and the resulting Agency responsibilities. EPA's disaster-related responsibilities can be summarized into three areas:

1. **Water systems**: (1) protect water systems from terrorist attacks and natural disasters and (2) detect and recover from the effects of attacks and disasters by leading efforts to provide States and water utilities with guidance, tools and strategies.

   EPA is the federal government Sector Specific Agency) lead for water infrastructure.

2. **Indoors/outdoors**: Remediate contaminated environments including buildings and outdoor areas impacted by terrorist attacks or disasters by leading efforts to establish clean-up goals and remediation strategies.

3. **Laboratories:** Develop a nationwide laboratory network with the capability and capacity to analyze for CBR agents during routine monitoring and in response to terrorist attacks and other disasters.

These responsibilities are coordinated by EPA's Office of Homeland Security and carried out by many of the Agency's Program Offices (U.S. EPA, 2011). Primary partners include the Office of Water and the Office of Solid Waste and Emergency Response, with critical contributions by the Office of Chemical Safety and Pollution Prevention, the Office of Air and Radiation, and each of the Agency's ten Regional Offices around the country.

Within EPA's ORD, HSRP actively coordinates its efforts with EPA's other five national research programs. Ongoing communication

EPA's Priorities:

- Taking action on climate change
- Improving air quality
- Assuring the safety of chemicals
- Cleaning up our communities
- Protecting America's waters
- Expanding the conversation on environmentalism and working for environmental justice
- Building strong state and tribal partnerships

Collaborating Across Research Programs

between the programs' leadership, laboratory and center management, and research staff ensures that HSRP's work: (1) is informed by synergistic projects and tasks in other programs and (2) does not duplicate other research within ORD. Synergistic relationships between ORD research programs will continue to build.

Research areas with ongoing coordination include:

> HSRP Theme 1, "Securing and Sustaining Water Systems" has complementary elements in the Safe and Sustainable Water Resources (SSWR) Research Program related to managing drinking water infrastructure to produce safe and sustainable water resources from source to drinking water tap to receiving waters
>
> HSRP Theme 3, "Remediating Indoor and Outdoor Environments," benefits from the work in the Sustainable and Healthy Communities Research Program projects devoted to "Contaminated Sites" and "Materials Management and Sustainable Technologies."

Research on homeland security issues is carried out in a number of federal departments and agencies. Because the mission of the HSRP is to help build EPA's capability to carry out its homeland security functions, and EPA has unique responsibilities related to disasters, there is no duplication of work performed by EPA and other agencies. Other agencies, however, are carrying out relevant research, results from which inform HSRP efforts. In the federal community, the Department of Homeland Security and the Department of Defense conduct research that is complementary to HSRP efforts. Together with EPA, these two departments have signed the "TriAgency" Memorandum of Understanding, which promotes active coordination among the three organizations' science and technology programs for chemical and biological defense.

Six Integrated Research Programs of EPA's Office of Research and Development

- *Homeland Security Research*
- *Chemical Safety for Sustainability*
- *Air, Climate, and Energy*
- *Safe and Sustainable Water Resources*
- *Sustainable and Healthy Communities*
- *Human Health Risk Assessment*

Developing Partnerships From the Start

HSRP identifies its primary Agency partners to be the Office of Solid Waste and Emergency Response, Office of Water, and each of EPA's ten Regional Offices around the country, based on the critical roles that these offices play in implementing EPA's homeland security program. Other EPA program offices and federal agencies also influence the direction of the program. Appendix 1 lists HSRP's primary partners and stakeholders.

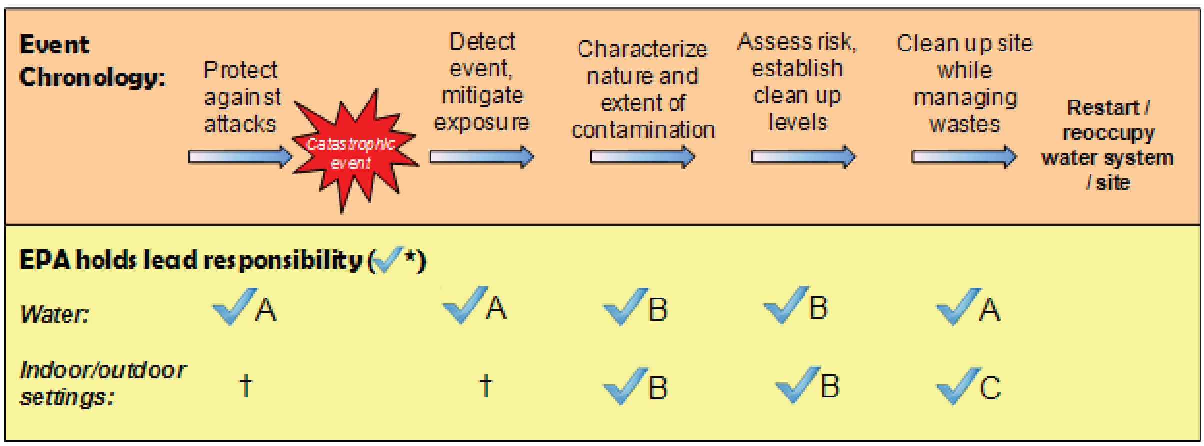
HSRP has established deliberate processes to engage its primary partners in planning the research portfolio. For research addressing indoor and outdoor contamination, a process called "PARTNER" was created to facilitate regular interactions between HSRP and its customers. The foundation of this process is the principle that the research program must engage its partners, the people, and organizations who need HSRP's work, through the complete life cycle of research, from planning to conducting the work and delivering the products. It is through such continuous interaction that customers for the program's research obtain the scientific information and tools that they need to make important decisions when responding to natural and manmade disasters. The PARTNER process is conducted through an annual cycle of engagement that includes an annual fall meeting with all participants.

HSRP's water security research is planned in a separate process in collaboration with the Agency's Office of Water. HSRP maintains monthly communications with this Office's Water Security Division and holds an annual meeting for reporting on progress and planning for the future. Through ongoing stakeholder consultations and EPA's participation on the Water Sector Coordinating Council, input on research needs is gathered from water utilities. The HSRP's Research Action Plans are built on the *Water Security Research and Technical Support Action Plan* (U.S. EPA, 2004), which guided this research through Fiscal Year 2011.

HSRP Program Design

HSRP is built on a systems-based approach to prepare for and recover from CBR disasters. Figure 2 illustrates this approach by showing the alignment of EPA's homeland security responsibilities (see √) with a generic chronology of a catastrophic event, coupled to the themes of the HSRP. This illustration emphasizes that EPA's role is somewhat broader for water sector issues than for indoor and outdoor contamination. The larger role in water is driven by EPA's designation as the federal lead for water infrastructure (HSPD-7, 2003).

The event chronology (Figure 2, top row, adapted from National Science and Technology Council, 2009) can be thought of as a system where all five actions are considered simultaneously due to their interdependence. For example, choosing the most sustainable, cost-effective, rapid and health protective approach to cleanup is dependent on how contamination is monitored, waste is managed, and clean-up goals are set. Alternatively, clean-up goals are dependent on the ability to measure contamination to the level of those goals. The strategies to protect



* The letters A, B and C following the check marks indicate the associated research theme (see Section III below).
† Other federal departments or agencies hold primary responsibilities for these areas

Figure 2. EPA's responsibilities aligned with preparing for and responding to a catastrophic event and the associated HSRP research themes. (This chronology accounts for the portions of response and recovery for which EPA holds a leadership role – many other steps should be anticipated post-event including the immediate emergency response by local responders).

water systems from attack should be viewed in the holistic context of how to respond to and recover from attacks. HSRP is designed to support this systems-based approach to decision-making by the Agency and its state and community stakeholders.

HSRP's strategic direction is determined by homeland security priorities established by Congress, the White House, and EPA's Administrator, and influenced by EPA programmatic science needs and external expert review by, for example, the Science Advisory Board, Board of Scientific Counselors. The Agency's efforts to address disasters are captured in the *EPA Strategic Plan* (U.S. EPA, 2010) under the goals, "Assuring the safety of chemicals, "Protecting America's waters," and "Cleaning up communities." HSRP's current strategic focus is described below, including the most pertinent elements of the research program.

Responding to a wide-area anthrax attack—risk assessment and dose-response data, clearance goals, sampling and analytical methods, risk management and communication, and clean-up strategies.

Responding to the detonation of a radiological dispersion device—sampling and analytical methods and clean-up strategies.

Responding to an attack on a water distribution system—protective measures, containment and mitigation methods, risk assessment and communication, decontamination of infrastructure, and treatment of contaminated water.

The following emerging issues are likely to influence the future strategic direction of the HSRP:

The Food Safety Modernization Act (2010)—This recently passed legislation provides EPA with the primary responsibility to: "…provide support for, and technical assistance to, State, local, and tribal governments in preparing for, assessing, decontaminating and recovering from an agriculture or food emergency."

The emergence of classes of chemical warfare agents not yet addressed by EPA but needing attention because of their nature and characteristics.

The increased attention to managing nuclear contamination in light of the Fukushima nuclear power plant disaster.

The *Strategic Research Action Plan for EPA's Homeland Security Research Program* guides research for the next 3 to 4 years. It has been designed with the flexibility needed to leverage scientific breakthroughs, address the emerging priorities and threats, and meet the needs of decision makers, shifting resource availability, and other considerations. As such, it is a "living document" that will be updated as needed.

Below, each theme is introduced followed by the critical science questions and the associated outcomes that are expected if these questions are addressed successfully. The program's research, however, is not planned or conducted as themes isolated from each other; rather, research is planned and executed in a holistic manner across the entire event chronology (Figure 2).

Research Themes and Priority Science Questions

Theme A: Securing and Sustaining Water Systems

HSRP conducts research to increase the capabilities of EPA in carrying out its responsibilities as the federal lead for water. HSRP science products assist states, local municipalities, and utilities in designing and operating water systems so that they are more resilient to intentional attacks or natural disasters.

Theme 1 includes research that addresses scientific gaps in: preparing the Nation's water systems to detect and respond to a contamination event, cleaning up the system and treating contaminated water, and retrofitting current systems or building new systems that are inherently more secure and resilient.

Some terrorist attacks are intended to spread fear in the civilian populace in the form of large, loud explosions, whereas others are clandestine actions. Detecting clandestine events is challenging, making it difficult for emergency responders to identify and mitigate adverse health effects or property damage. The Government Accountability Office concluded (GAO, 2003) that the most vulnerable element of a drinking water utility is the distribution system, and without an effective contamination warning system, intentionally-introduced contamination could remain "virtually undetectable until it has affected consumers." In recognition of this vulnerability, a Homeland Security Presidential Directive (HSPD-9, 2004) directed EPA to "develop robust, comprehensive, and fully coordinated surveillance and monitoring systems...for...water quality that provide early detection and awareness of disease, pest, or poisonous agents."

There are many CBR agents that if introduced into a distribution system would be harmful to water users. Therefore, deploying a system that can detect all known agents of concern is technologically and economically impractical. In addition, there may be some agents that have not been studied before. Thus, EPA's Office of Water is leading the deployment of a detection system that does not depend on monitoring for specific agents but indirectly detects the presence of contamination: the Water Security Initiative (U.S. EPA - WSI). The goal of the Initiative's pilot deployments at water utilities is to test the following contamination warning system components:

- Online monitoring of distribution system water quality.
- Regular water quality sampling and analysis in distribution systems.
- Enhanced security monitoring of the utilities' physical components.
- Surveillance of consumer complaints about their water.
- Surveillance of public health trends at hospitals, doctors' offices, and pharmacies.

HSRP has supported the Water Security Initiative by conducting research to fill science gaps in several of the components listed above and by developing approaches to integrate the information generated from each component so that events can be effectively detected. Field and handheld sensors have been tested and evaluated by HSRP, and performance information has been provided to water utilities. Software tools to enable the optimal placement of water quality sensors and the interpretation of data have been developed by the HSRP and are currently being tested as components of the contamination warning system architecture in a number of large water utilities. Future research in this area will include improving existing software tools based on field experiences, testing the performance of improved sensors for water contamination, and investigating the feasibility of using these tools and technologies to provide multiple benefits to water systems.

Once harmful contamination is detected in a water system, exposure of the population to contaminated water must be minimized, the water treated to inactivate or remove the contaminant, and the infrastructure decontaminated. Water utilities need tools to quickly estimate the extent of contamination in a system so that contaminated zones can be isolated and the source of contamination located. HSRP is developing real-time models of the fate and transport of contaminants in distribution systems to meet this challenge.

Contaminated water likely will need to be treated before release and the infrastructure decontaminated before service can be resumed. HSRP research priorities in water treatment and system decontamination are refinements of the recommendations published in *Water Sector Decontamination Priorities* (Critical Infrastructure Partnership Advisory Council, 2008).

The interconnectedness of distribution systems is a result of the incremental construction of systems across many decades. This approach provides redundant pathways of water supply for fire protection and reliability. These distribution systems, however, were not designed and built to take into account the need for *in situ* monitoring and cleanup. HSRP is investigating innovative systems designs and real-time monitoring and modeling for retrofitting existing systems or designing new systems so that water systems are inherently safer.

Science Questions

> *How can water security technologies for drinking water distribution systems be improved to be faster, more reliable, less expensive, more sustainable and better integrated into daily operations?*
>
> *What approaches are most effective, timely and sustainable for returning water and wastewater infrastructure to service following a contamination incident?*
>
> *What innovations and new methods are needed to fill technical and knowledge gaps in water infrastructure security and sustainability?*

Example: Water system monitoring and security

EPA researchers are developing a suite of tools to advance water monitoring technology and protect the nation's drinking water supply.

Example output: Water monitoring technologies and software that work together to provide system-wide, real time monitoring of water supplies and distribution systems.

Research products contributing to this output:

- Updated **Threat Ensemble Vulnerability Assessment and Sensor Placement Optimization Tool** (commonly known as TEVA-SPOT) and **CANARY event detection software** for use by utilities to design and operate contamination warning systems. Update is based on experiences from the Water Security Initiative pilot in five major U.S. cities.

- **Reports on performance testing of commercially-available water**

detection technologies, thereby improving the information utilities have when making decisions on investments in detection technology.

- **Water Sample Concentrator** and Software to enhance detection of hazardous biological contaminants in large volume samples of drinking water.

- **Real-time water distribution system modeling software** (EPANET-RTX) for use by utilities in making real-time decisions, including forecasting where contamination has been and will be following detection of a contamination incident.

Expected outcome of the research: Water utilities, EPA's Office of Water, and other partners will have the technology and tools needed to monitor water distribution systems, and to clean up and decontaminate water systems following a contamination incident.

Impacts

The resilience of water systems to terrorist attacks or other manmade and natural disasters will be improved by addressing the key science questions outlined above. Utilities will have improved contamination warning systems, tools, and strategies to manage contaminated systems and approaches to make these systems inherently safer via innovative designs and monitoring approaches. The results of research addressing these questions, integrated with results from other HSRP themes, will provide the Agency with systems-based approaches to managing risk to water systems.
Such integrated approaches will provide communities with cost-effective and timely options that have minimal environmental and economic impact. Proven detection and clean-up approaches will be a deterrent to terrorist activities.

In addition, the results of this work will be applicable to cleanup of contamination caused by accidents or natural disasters. Collectively, the availability of this information will increase the resiliency of the water sector and, therefore, the ability of communities to respond to and recover from numerous types of system disturbances.

Theme B: Characterizing Contamination and Determining Risk

Following a chemical, biological, or radiological attack, EPA will be charged with site characterization and remediation of water systems and indoor and outdoor areas. Characterization involves defining the degree and extent of contamination, which informs the remainder of the site clean-up activities, including risk assessment, choice of remediation approach, disposal of waste and wastewater, and clearing the site for resumed use by individuals or organizations. EPA's Office of Solid Waste and Emergency Response is building the Environmental Response Laboratory Network (U.S. EPA - ERLN) to establish the capability and capacity for conducting sampling and analysis programs in support of site characterization and remediation.

The HSRP supports the implementation of the Laboratory Network by filling gaps in the science needed to: (1) improve the *capability* by standardizing and verifying sampling, sample preparation, and analytical methods for CBR agents, and (2) increase the *capacity* by enhancing the efficiency of these methods. Additionally, the program will develop innovative sampling strategies that maximize information from a limited a number of samples.

Upon characterization of the contaminated areas, the risk to human health associated with contamination inside buildings, on urban outdoor surfaces, or in water distribution systems can be assessed. This site-specific assessment informs decisions on what areas require remediation and factors into determining the levels to which the contamination must be reduced so that the site can be used once again.

The HSRP conducts risk assessment research that addresses science gaps, ranging from applied information gathering and sharing tools, to strengthening existing risk assessment approaches and developing new assessment methodologies.

Recovery from a catastrophic event requires effective communication among affected stakeholders as well as sound science on which to base decisions. For example, recovery is most successful when the public understands the risks of contamination, has confidence in the clean up approach, and, upon successful remediation, reoccupies the site or uses the utilities' water. In addition, communication of information from scientific and technical experts to decision makers must be effective so that the most informed decisions are made.

Science Questions

What site characterization methods are needed to inform cleanup decisions and how can methods be optimized to increase laboratory capacity response and recovery?

How can characterization of exposure pathways and health risks from contamination be improved to better inform risk assessment and risk management decisions?

How can the effectiveness of communicating risk to decisions-makers and other stakeholders, including the public, be improved?

Example: Science to support site characterization following a contamination event

EPA researchers are working to provide the science, data, and tools needed to inform and support site characterization activities following a chemical, biological, or radiological event.

Example Output: Accessible and understandable protocols and methods that first responders and laboratories can use to take appropriate actions and make informed decisions in the aftermath of a contamination event.

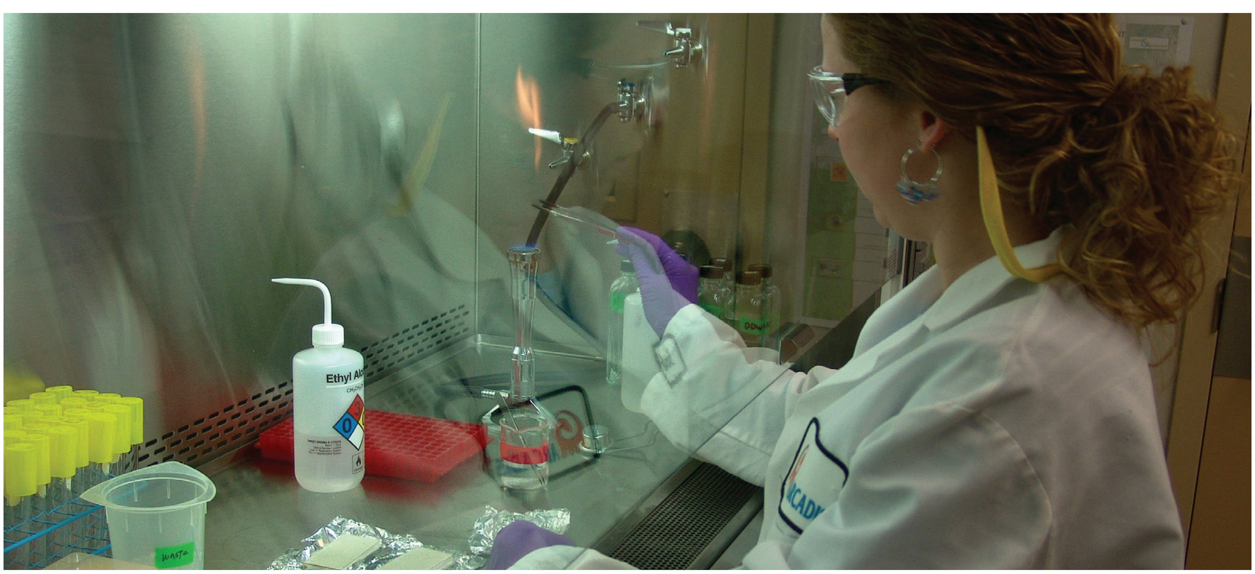
Research products contributing to this output:

- **Rapid viability analytical method for measuring anthrax in soils**—improving the capacity of the Environmental Response Laboratory Network thereby supporting timely decision making during a response to an anthrax attack.
- Updates to ***Selected Analytical Methods***—a report giving responders the most current set of the best analytical methods to characterize a site contaminated with chemical, biological, or radiological materials and to monitor cleanup activities.
- **Sample collection procedures** for swipes, soil and air filters, improving the capacity of the Environmental Response Laboratory Network thereby supporting timely decision making during a response to a contamination incident.

Impacts

The Agency and other interested organizations will have the methods needed to properly sample, ship, and analyze priority homeland security contaminants in various environmental media. When an attack or other disaster occurs, the Nation will recover more quickly and with more confidence because scientifically- sound methods have been adopted by EPA.

At the heart of nearly all EPA responses to contamination is human health risk. By developing science products and approaches based on the above questions, the Agency will be better able to protect the health of humans during the clean up and long after. Reliable risk assessment tools support decisions on clean up goals for a particular site. These goals often drive the selection of a cleanup approach, and therefore, the timeliness and cost of cleanup. The methods and approaches developed and delivered by EPA researchers will improve the resiliency of the Nation's communities when faced with disasters.



Theme C: Remediating Indoor and Outdoor Environments

Following risk assessment and establishment of clean up goals, the clean up process begins. Often this process involves multiple steps including consideration of clean up approaches, conducting the cleanup operation and monitoring its progress, treating and disposing of contaminated materials or residuals, confirmation of successful cleanup, and communication with the public as the cleanup progresses. The HSRP is filling critical gaps in the science and technology needed to accomplish each of these steps effectively.

EPA has a long history and extensive expertise in cleaning up contamination associated with accidental spills and industrial accidents. Remediating CBR contamination released intentionally into buildings, public spaces such as airports and sports facilities, and wide areas such as outdoor urban centers, is a relatively new responsibility for which the Agency lacks substantial experience or a research history to support it. The U.S. Department of Defense has expertise in the tactical decontamination of equipment in battlefield situations, but this expertise is not directly applicable to the decontamination of public facilities and outdoor areas that have a variety of porous surfaces and, potentially, must meet more stringent clean-up goals for public re-occupation.

The HSRP activities associated with site cleanup (or decontamination) aim to fill the most critical scientific gaps in the capabilities of EPA's response community so that, when needed, EPA can make the most informed clean-up decisions. Several elements that must be studied to support the best, holistic choice for cleanup are:

- Determining the environmental fate of CBR contaminants (i.e., effect of natural processes and re-suspension of spores);
- Measuring the performance of commercially ready decontamination technologies;
- Building a broader base of knowledge on the effectiveness of technologies for homeland security application by studying their efficacy under diverse, realistic environmental, and operating conditions, as well as cleanup of process variables;
- Developing and improving decontamination engineering and processes to facilitate appropriate technology selection, the decontamination strategy, and field implementation; and
- Enhancing the ability to rapidly increase the capacity of effective decontamination methods in response to wide-area application.

Successful cleanup must include management of contaminated material residuals: 14 of the 15 scenarios of the Homeland Security Council's *Planning Scenarios: Executive Summaries (DHS, 2007)* anticipate a significant waste disposal component.

EPA effectively manages common cleanup of waste and debris using existing regulatory infrastructure and pre-negotiated contracts for waste management, treatment, and/or disposal services. However, the treatment and disposal of CBR contaminated waste can be problematic for several reasons: sampling and analytical methodologies are not well established; the waste may not fit within existing waste categories defined in the regulations; the behavior of the materials while being processed by various disposal technologies is not well understood; and the disposal facilities have expressed resistance to accepting these materials because of unease about possible contamination of their business assets and concern over community relations. Although licensed disposal facilities exist for radiological waste, an event involving a radiological dispersion device could produce greater quantities of waste than current disposal capacity can absorb.

Science Questions

After initially settling, will contamination continue to spread?

What clean up technologies are most effective and how are their efficacies changed by real world variations in environmental, process and agent characteristics?

How can wide area contamination be remediated in the most cost effective and expedient way while still protecting human health and the environment?

How are contaminated residuals of clean up operations best managed?

Example: Cost-effective waste management of residuals from the decontamination of urban environments.

EPA researchers are working to provide the science, data, and tools needed to inform and support waste management of the residuals generated during decontamination of chemical, biological, or radiological contamination of an urban area.

Example output: Technical briefs, standard operating procedures, and tools to help responders make decisions about waste management strategies and approaches for waste minimization.

Research products contributing to this output:

- **Wash Aid Technology for Cesium on Urban Surfaces** to help remove contaminants from the waste stream prior to disposal.
- **Online I-WASTE Tool** to assess the quantity of residuals that will be produced during the decontamination process.
- **Waste Sampling Strategies** that can be used by responders to support site characterization and clearance sampling while minimizing waste and managing laboratory capacity.
- **Management of Chemical, Biological, and Radiological Wastes,** technical briefs to help inform responders about the fate and transport of contaminants in landfills, mobile waste treatment devices, incinerators, composters, and other devices.
- **Standard Operating Procedures for Minimization of Wastes from Radiological Incidents,** including use of combustion, screening and segregation technologies, and other methods to minimize radiological waste.

Impacts

Addressing the science questions under this theme will, coupled with answering the questions in Themes A and B, provide the Agency with systems-based approaches to site characterization, risk assessment, clean up and waste management. Such information will help federal, state and community decision makers select cost-effective, timely options that have minimal environmental impact.

Proven clean up approaches will also be a deterrent to terrorist activities since timely, effective response minimizes the overall impact of an incident. In addition, the results of this work will be applicable to the cleanup of contamination caused by accidents or natural disasters. Collectively, the availability of this information will increase the resiliency of our communities.

Conclusions

This document outlines how the EPA's Office of Research and Development (ORD) is addressing the scientific and technological gaps in EPA's ability to carry out its responsibilities associated with preparing for and responding to terrorist attacks and to other disasters. ORD operates the Homeland Security Research Program (HSRP) to develop scientific data, tools, models and technologies that enhance the capabilities of EPA's Office of Water, Office of Solid Waste and Emergency Response, and the Agency's Regional Offices. HSRP works closely with these offices, and other stakeholders within the Agency and across the country, to understand their scientific and technological needs, to design research that addresses these needs, and to develop and deliver science products that are relevant to their needs, are responsive to their homeland security mission, and delivered when needed.

Through this close engagement, the HSRP is designed so that its products will be used by the Agency to:

- Better prepare water systems for terrorist attacks and other disasters thereby minimizing the impact of such events and developing inherently safer systems.
- Give water systems scientifically sound approaches to monitor their systems for contamination, so that the impacts of intentional or accidental risks are minimized.
- Build the capability and capacity of the Agency's Environmental Response Laboratory Network and the Water Lab Alliance with enhanced sampling and analytical methods, thereby improving the quality and timeliness of EPA's response to disasters.
- Conduct site-specific risk assessments with associated clean up goals to protect human health and the environment.
- Better communicate risk and clean up options to decision makers and the public.
- Make more informed choices about clean up approaches for water systems, buildings, and outdoors areas, including considerations such as efficacy, timeliness, and cost, while accounting for the management of contaminated waste materials.

The EPA plays a critical role in the federal government's homeland security program. Other agencies conduct homeland security research that addresses the needs and responsibilities of those agencies. The HSRP recognizes that efforts in these agencies, particularly within the Department of Homeland Security and the Department of Defense, are complementary, and therefore, must be understood and well coordinated with efforts in the HSRP. Several Memoranda of Understanding have been established between EPA and other agencies to facilitate this coordination.

Research that the HSRP conducts, by improving the capabilities of the Agency, assists the Agency in addressing its strategic goals, particularly “Assuring the Safety of Chemicals,” “Protecting America’s Waters,” and “Cleaning Up Communities and Advancing Sustainable Development.” Successfully addressing these goals improves the sustainability of social, environmental, and economic systems. In particular, improvement of the ability to prepare for and recover from disasters, such as terrorist attacks improves the resiliency of our communities, thereby contributing to the sustainability of the Nation.

Summary Tables of Outputs and Outcomes

The following tables list the expected outputs from the homeland security research program along with the associated partner outcomes. Although each output is listed under a single theme and science question, many of them serve to answer multiple questions. The column title "Relevance to Other Science Questions" lists other science questions as indicated in the third column.

Theme A. Securing and Sustaining Water Systems

Science Question 1: How can water security technologies for drinking water distribution systems be improved to be faster, more reliable, less expensive, more sustainable, and better integrated into daily operations?		
Outcomes: Improved resilience of U. S. water systems to terrorist attacks or natural disasters; enhanced detection capabilities; effective systems-based approaches to protecting water systems in a cost-effective, timely way that minimizes environmental and economic impacts.		
Output	**Output Year**	**Relevance to Other Science Questions**
Sensor Development and Testing Report	2014	Theme A SQ2, SQ 3
Technology Testing and Evaluation Program Performance Reports	2012, 2013, 2014	Theme A SQ2, SQ 3
CANARY Event Detection Software and User Manual Updates	2012, 2013, 2014	Theme A SQ2, SQ 3
TEVA-SPOT Software and User Manual Updates	2012, 2013, 2014	Theme A SQ2, SQ 3
Improved Water Sample Concentrator and Software	2013	Theme A SQ2, SQ 3

Science Question 2: What approaches are most effective, timely, and sustainable for returning water and wastewater infrastructure to service following a contamination incident?		
Outcomes: Improved resilience of U. S. water systems to terrorist attacks or natural disasters; enhanced treatment, decontamination and response management capabilities; effective systems-based approaches to protecting water systems in a cost-effective, timely way that minimizes environmental and economic impacts.		
Output	**Output Year**	**Relevance to Other Science Questions**
Microbial Inactivation Data Package for Update to Water Contaminant Information Tool (WCIT)	2014	Theme A SQ1, SQ 3
Treatment Data Package for Update to Water Contaminant Information Tool (WCIT)	2014	Theme A SQ1, SQ 3
Decontamination Data Package for Update to Water Contaminant Information Tool (WCIT)	2014	Theme A SQ1, SQ 3; Theme C SQ1
Water Security Response Toolkit Software and User Manual	2013	Theme A SQ1, SQ 3

Science Question 3: What innovations and new methods are needed to fill technical and knowledge gaps in water infrastructure security and sustainability?		
Outcomes: Improved resilience of U. S. water systems to terrorist attacks or natural disasters; enhanced detection, treatment, decontamination and response management capabilities; new inherently safer water system designs for the future; effective systems-based approaches to protecting water systems in a cost-effective, timely way that minimizes environmental and economic impacts.		
Output	**Output Year**	**Relevance to Other Science Questions**
Real-time water distribution system model (EPANET-RTX) Software and User Manual	2014	Theme A SQ1, SQ 2

Theme B. Characterizing Contamination and Determining Risk

Science Question 1: What site characterization methods are needed to inform clean up decisions and how can methods be optimized to increase laboratory capacity response and recovery?		
Outcomes: Improved resilience of the U. S. to terrorist attacks and natural disasters; Improved analytical methods for chemical, biological, and radiological contaminants; improved sampling and shipping methods for contaminants in various environmental media; improved protection of public health.		
Output	**Output Year**	**Relevance to Other Science Questions**
RV-PCR Method for Anthrax and Surrogates	2013	Theme B SQ2, SQ 3
Selected Analytical Methods (SAM) for Environmental Remediation and Recovery, Website, and Sample Collection Procedures	2012, 2014	Theme B SQ2, SQ 3

Science Question 2: How can characterization of exposure pathways and health risks from contamination be improved to better inform risk assessment and risk management decisions?		
Outcomes: Improved resilience of the U. S. to terrorist attacks and natural disasters; improved analytical methods for chemical, biological, and radiological contaminants; improved sampling and shipping methods for contaminants in various environmental media; improved understanding of the health risks of priority contaminants; improved protection of public health.		
Output	**Output Year**	**Relevance to Other Science Questions**
Provisional Advisory Levels (PALs) for 12 Chemical Contaminants	2012, 2013, 2014	Theme B SQ1, SQ 3
Water Exposure Assessment of Microbial Pathways and Doses (Tech Brief)	2012	Theme B SQ1, SQ 3; Theme A SQ1, SQ 2, SQ 3
SERRA Database Update	2013	Theme B SQ1, SQ 3
Dose Response Research to Support Risk Based Decisions Following an Anthrax Attack (Tech Brief)	2012	Theme B SQ1, SQ 3
National and regional Maps of Biothreat Agent Distribution	2012, 2013, 2014	Theme B SQ1, SQ 3

Science Question 3: How can the effectiveness of communicating risk to decision makers and other stakeholders, including the public, be improved?		
Outcomes: Improved resilience of the U. S. to terrorist attacks and natural disasters; improved risk communication strategies; improved protection of public health.		
Output	**Output Year**	**Relevance to Other Science Questions**
Tools to enhance knowledge of community information needs during long term decon-tamination and clearance	2014	Theme B SQ1, SQ 2; Theme A SQ 2

Theme C. Remediating Indoor and Outdoor Environments

Science Question 1: After initially settling, will contamination continue to spread?		
Outcomes: Improved resilience of the U. S. to terrorist attacks and natural disasters; improved systems-based approaches to clean up and waste management; improved understanding of contaminant fate and transport in indoor and outdoor environments.		
Output	**Output Year**	**Relevance to Other Science Questions**
Re-aerosolization of Particulate-Based Contaminants in an Urban Environment (Tech Brief)	2015	Theme C SQ2, SQ 3, , SQ 4
Technical Solutions for Management of Contaminated Wastewater (Tech Brief)	2015	Theme C SQ2, SQ 3, SQ 4; Theme A SQ 2

Science Question 2: What clean up technologies are most effective and how are the efficacies changed by real world variations in environmental, process, and agent characteristics?		
Outcomes: Improved resilience of the U. S. to terrorist attacks and natural disasters; improved systems-based approaches to clean up; improved understanding of decontamination approaches, efficacy, and costs.		
Output	**Output Year**	**Relevance to Other Science Questions**
Environmental Persistence of Biological Agents (Tech Brief)	2015	Theme C SQ1, SQ 3, SQ 4
Efficacy of Decontamination Technologies for Biological Agents (Tech Brief)	2013, 2015	Theme C SQ1, SQ 3, SQ 4
Efficacy of Decontamination Technologies for Radiological Agents (Tech Brief)	2013, 2015	Theme C SQ1, SQ 3, SQ 4
Efficacy of Decontamination Technologies for Chemical Agents (Tech Brief)	2013, 2015	Theme C SQ1, SQ 3, SQ 4
Enhanced Biological Indicators for Fumigant Performance Assurance (Tech Brief)	2015	Theme C SQ1, SQ 3, SQ 4
Performance and Economics of Decontamination Technologies Tested by BOTE	2012	Theme C SQ1, SQ 3, SQ 4

Science Question 3: How can wide area contamination be remediated in the most cost effective and expedient way while still protecting human health and the environment?		
Outcomes: Improved resilience of the U. S. to terrorist attacks and natural disasters; improved systems-based approaches to clean up and waste management; improved understanding of decontamination approaches, efficacy, and costs.		
Output	**Output Year**	**Relevance to Other Science Questions**
Wash Aid Technology for Cesium on Urban Surfaces	2013	Theme C SQ1, SQ 2; Theme A SQ 2
Decontamination Selection Tool	2013	Theme C SQ1, SQ 2, SQ 4
Online I-WASTE Tool, User Manual, and Training Materials	2013	Theme C SQ1, SQ 2, SQ 4
Stand-alone Tool to Include Waste Sampling Strategies in an Overall Remediation Approach	2014	Theme C SQ1, SQ 2, SQ 4

Science Question 4: How are contaminated residuals of clean up operations best managed?		
Outcomes: Improved resilience of the U. S. to terrorist attacks and natural disasters; improved systems-based approaches to clean up and waste management; improved understanding of decontamination residuals.		
Output	**Output Year**	**Relevance to Other Science Questions**
Management of Chemical, Biological, and Radiological Wastes (Tech Brief)	2015	Theme C SQ1, SQ 2, SQ 3; Theme A SQ 2
SOP: Sorbent Injection for Capture of Cesium from Combustion of Contaminated Biomass	2013	Theme C SQ1, SQ 2, SQ 3
SOP: Adaptation of Existing Waste Screening Methodologies for Minimization of Waste from Radiological Incidents	2013	Theme C SQ1, SQ 2, SQ 3

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Appendices

A. Research Program Partners and Stakeholders

Below, HSRP's partners and stakeholders are identified. The organizations in parentheses indicate the most relevant subgroups.

Primary EPA Partners:

- Office of Solid Waste and Emergency Response (Office of Emergency Management, Office of Resource Conservation and Recovery)
- Office of Water (Water Security Division)
- EPA Regions (Lead Homeland Security Region is currently Region 8)

Other Key EPA Partners

- Office of Homeland Security
- Office of Air (Office of Radiation and Indoor Air)
- Office of Chemical Safety and Pollution Prevention (Office of Pesticide Programs)

Stakeholders

- Water utilities (AWWA and many individual utilities)
- Department of Homeland Security (S&T Division)
- Department of Defense

B. Definitions

Outputs are synthesized and/or translated from Products into the format needed by the End User. Outputs should be defined, to the extent possible, by Partners/Stakeholders during Problem Formulation.

Product - A deliverable that results from a specific Research Project or Research Task. This may include (not an exhaustive list) journal articles, reports, databases, test results, methods, models, publications, technical support, workshops, best practices, patents, etc. These may require translation or synthesis for inclusion as an Output.

Partner/Stakeholder Outcome - The expected results, impacts, or consequence that a Partner or Stakeholder will be able to accomplish due to ORD research.