U.S. EPA Office of Research and Development

Homeland Security Research Program
Research Framework

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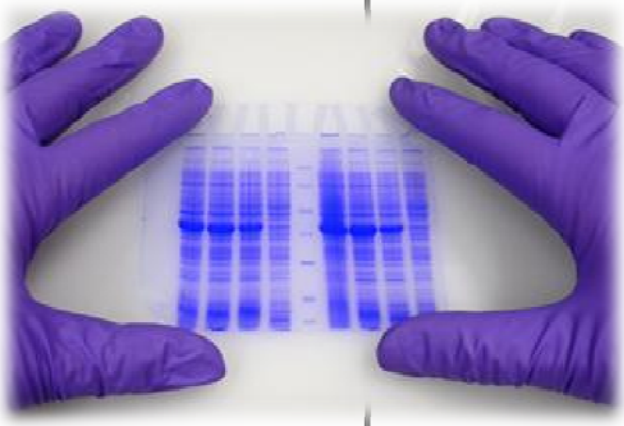

I. EXECUTIVE SUMMARY

Although the United States has not experienced a successful chemical, biological or radiological-based terrorist attack since 2001, many experts agree that such attacks are inevitable. The sustainability of our communities requires that communities are resilient to disasters. EPA holds specific responsibilities to help communities prepare for and recover from disasters including acts of terrorism. EPA's role includes helping protect water systems from attack, assisting water utilities build contamination warning and mitigation systems, and leading cleanup of contaminated indoor and outdoor settings and water systems. Critical science gaps exist in these areas of EPA responsibility. The Homeland Security Research Program (HSRP) was established to conduct research that will increase the capability of EPA to carry out its homeland security responsibilities. The HSRP helps build systems-based approaches to addressing these environmental problems, working with Agency clients to plan, implement and deliver useful science products. The HSRP maintains robust coordination efforts with other federal agencies including the Department of Homeland Security, the Department of Defense, and the Centers for Disease Control and Prevention, among others. The HSRP research is conducted and science products constructed so that the results, primary aimed at homeland security issues. can be applied to a broad set of environmental disasters.

II. INTRODUCTION

In 2001, an act of bioterrorism resulted in at least 17 buildings being contaminated with anthrax spores, killing 5 people, and requiring an immense characterization and cleanup effort by the Environmental Protection Agency (EPA) and others. Although, no chemical, biological or radiological (CBR)-based terrorism has succeeded in the United States since then, many experts believe such attacks 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 inadvertent disasters are, unfortunately, common. For example, in the last decade, the U.S. has experienced Hurricanes Katrina and Rita (2005), the Deepwater Horizon oil spill (2010), and, recently, the Mississippi River flood and tornados (2011). We would be naive to believe such events would not continue to challenge the United States in the future.

An essential element in building sustainable communities is the capability to successfully prepare for, respond to, and recover from disasters. This element of sustainably 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 component of "risk management" and "disaster preparedness and response" (including recovery).

Assigned by laws, Presidential Directives, and the National Response Framework, the U.S. EPA fulfills this role by providing guidance, tools and technical support to communities. These responsibilities are consistent with the National Security Strategy (Office of the President of the U.S., 2010) including its goal to effectively manage emergencies:

> *"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."*

The Agency's work in support of community resilience to disasters often highlights science and technological gaps that, if filled, would improve EPA's guidance and tools for national, state, and local decision makers. EPA has established the Homeland Security Research Program (HSRP) to lead efforts at filling critical gaps associated with EPA's homeland security responsibilities. The program's products are often useful to EPA offices and regions, and states and communities in building competency to address inadvertent and natural disasters as well. Figure 1, in simple terms, shows the logical relationship between the HSRP's work and supporting resiliency and sustainability.

Figure 1. Logic relating Homeland Security Research and community sustainability

The mission of the HSRP is to conduct research resulting in science and technology products that increase the Agency's capability to meet its homeland security responsibilities, thereby assisting communities' build their resilience. The program's goal is to plan, execute and produce these products in close concert with our Agency partners so that the results of this program are used by these partners in implementing their homeland security programs. A secondary goal of the program is to design research and it products so that they address natural and inadvertent disasters to the greatest extent possible. This second goal stresses the multiple benefits of the HSRP.

The HSRP is built on a systems approach to preparing for and recovering from chemical, biological or radiological (CBR) attack, and is directly associated with EPA's legislated and administrative responsibilities. Figure 2 illustrates this system by showing the alignment of EPA's homeland security responsibilities 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 issues than for indoor and outdoor contamination. The larger role in water is driven by EPA's designation as the federal sector-specific lead agency (SSA) for water infrastructure. (HSPD-7, 2003) Thus, EPA is responsible for providing leadership to water utilities in protecting water systems from attacks and other disasters, and helping utilities enhance their capabilities to detect and mitigate exposure associated with intentional contamination events. For both water infrastructure and indoor/outdoor contamination, EPA

holds the lead federal role in cleaning up the systems/sites including: determination of the nature and extent of contamination, assessment of risk, establishment of clean up goals, and remediation of the contaminated systems/sites including management of wastes.

The event chronology (top row, Fig. 2) should be viewed as a system where addressing all issues should be considered simultaneously due to their interdependence. For example, choosing the most sustainable (cost-effective, rapid, health protective) approach to clean up is dependent on how contamination is monitored; waste is managed and the clean up goals that are set. Alternatively, the clean up goals are dependent on the ability to measure contamination to those goals. The strategies to protect water systems from attack should be viewed in the holistic context of how to respond to and recovery from attacks. The HSRP is designed to support this systems-based decision making by the Agency and our state and community stakeholders.

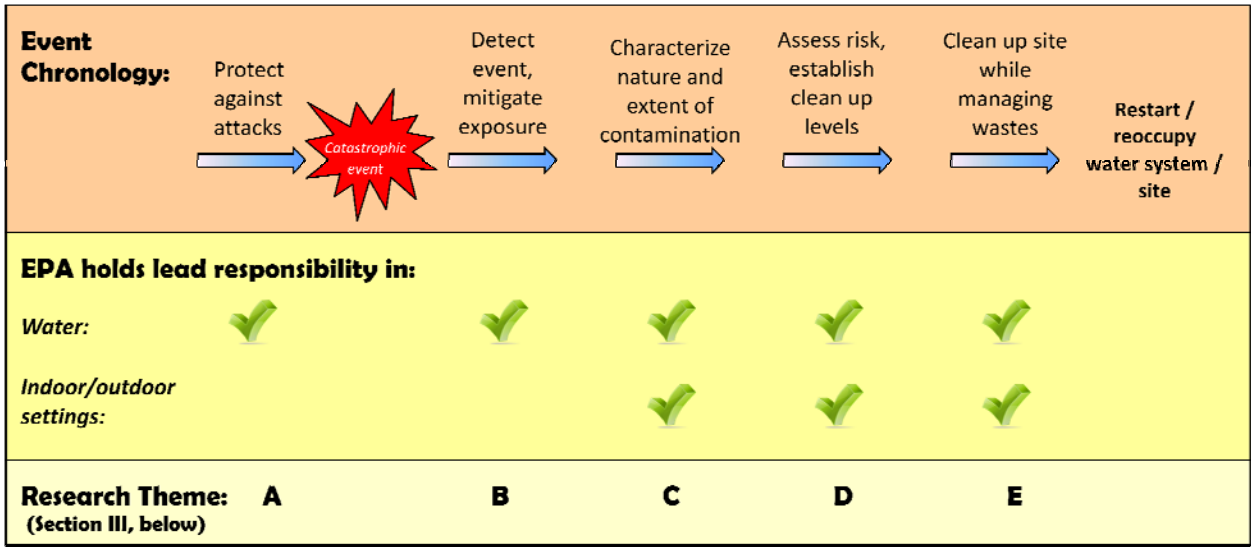

Figure 2. EPA's responsibilities aligned with preparing for and responding to a catastrophic event. (This chronology accounts for the portions of response and recovery for which EPA holds a leadership role – many other steps should be anticipated post-event including the immediate emergency response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

The HSRP's strategic directions are determined by homeland security priorities established by the White House and EPA Administrator, and influenced by EPA programmatic science needs and external expert review (e.g., Science Advisory Board, Board of Scientific Counselors). The Agency's effort to address disasters is captured in the EPA Strategic Plan (U.S. EPA, 2010) Goal 2, "Protecting America's Waters," and Goal 3, "Cleaning Up Communities and Advancing Sustainable Development." The program's current strategic directions are listed below including the elements of the research program most pertinent to addressing that direction:

- *Responding to a wide-area anthrax attack* – dose-response, clean up goals, sampling and analytical methods, risk assessment and communication, and clean up strategies
- *Responding to the detonation of a radiological dispersion device (RDD)* – sampling and analytical methods, and clean up strategies

- *Responding to an attack on a water distribution system* – modeling tools to contain the spread of contamination and locate the source, risk assessment and communication, decontamination of infrastructure, and treatment of contaminated water

Currently, the following emerging issues will likely influence future strategic directions of the HSRP:

- *The Food Safety Modernization Act (2010)* – This recently passed legislation gives EPA 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." Implementation of EPA's responsibilities will likely result in new research in the program.
- The recent emergence of classes of chemical warfare agents not yet addressed by EPA or the HSRP.
- The increased attention to managing nuclear contamination in light of the Fukushima nuclear power plant disaster.

III. RESEARCH THEMES

Figure 2 above presents the logical design of the HSRP research themes (A – E). Below, each theme is introduced followed by its critical science questions and associated outcomes that are expected if these questions are addressed successfully. However, the program's research s not planned or conducted as isolated themes; rather, research is planned and executed in a holistic manner by considering the entire event chronology (Fig. 2) as an inter-connected system.

A. Research to Help Protect Water Infrastructure against Attacks

Effective protection of water infrastructure can reduce the risk and impacts of an attack, thereby safeguarding human health and the critical infrastructure of the United States. EPA is the SSA lead for water and, in cooperation with water utilities, is responsible for enhancing protection of water systems from terrorist attack. The program is addressing the following science questions regarding protecting water systems:

What security measures can be developed or adopted from methodologies used by other stakeholders to improve:

a) physical security of water supplies and systems,

b) vulnerability assessment methodologies, and

c) incorporation of security measures into the design or retrofit of water systems?

Research products resulting from addressing these questions will provide EPA and water utilities tools to better prepare for attacks on the utilities' critical infrastructure by supporting scientifically-sound, proactive design changes to infrastructure. Better preparation will result in minimization of the impact of an attack, and, arguably, discourage attacks. In addition, these changes in infrastructure can reduce the impact of natural or accidental disasters.

B. Research to Improve Detection of Contamination and Mitigation of Exposure in Water Systems

Terrorism can come in the form of large, loud explosions or quiet, clandestine actions. When quiet and clandestine, determination of when an event has occurred is challenging, making it difficult for emergency responders to mitigate significant 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 (CWS), intentionally-introduced contamination could remain "virtually undetectable until it has affected consumers." In recognition of this vulnerability, HSPD-9 directed EPA, as the SSA for water, 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 can be introduced into a distribution system and are known to be harmful to water users. Therefore, deploying a system that can detect many or 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 development of a detection system that does not depend on monitoring for specific agents: the Water Security Initiative (WSi). (U.S. EPA - WSI) The goal of the WS initiative is to develop a CWS for drinking water utilities built on integration of data from:

- 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

The HSRP is supporting the WSi by conducting research to fill science gaps in several of the five WS initiative components above, and by developing approaches to integrate the information generated from each component so that events can be effectively detected.

a) What monitoring technologies and surveillance information can adequately detect relevant contamination in a distribution system?

b) Can tools be developed to help design optimal monitoring networks?

c) Can software tools be developed to optimize monitoring efforts, contaminant detection, and sensor placement in water distribution systems?

d) Can real-time software tools be developed to aid utilities in making real-time decisions on how to minimize exposure to contaminated water?

Science products from this work will assist water utilities improve their response to intentional contamination by providing a systems of sensors and software tools. Better response will reduce the impact of the attack on human health. Such systems may also discourage terrorist from attempting attacks. Finally, the contamination detection and mitigation systems can be used by utilities for routine monitoring of water quality and to respond to inadvertent contamination events (e.g., cross-contamination or main break events).

C. Research to Improve Characterization of the Nature and Extent of Contamination

Following a CBR attack, EPA will be charged with site characterization and remediation of water systems and indoor and outdoor areas. Characterization includes defining the degree and extent of contamination and informs the remainder of the site cleanup activities including risk assessment, choice of remediation approach, disposal of solid waste and wastewater, and clearing the site for resumed use by the public. OSWER is building the Environmental Response Laboratory Network (ERLN) (U.S. EPA - ERLN) to establish the capability and capacity to conduct sampling and analysis programs in support of site characterization and remediation.

The HS Research Program supports the implementation of the ERLN by filling gaps in the science needed to (1) increase the *capability* of the ERLN by standardizing and validating sampling, sample preparation, and analytical methods for CBR agents, and (2) increase the *capacity* of the ERLN by increasing the efficiency of the methods. The following science questions are being addressed in this theme:

a) What sampling and analytical methods are needed to confirm an attack, characterize contaminated water systems and indoor and outdoor areas (and associated residues), and confirm that cleanup levels have been achieved following remediation efforts?

b) Can more rapid methods be developed to increase laboratory capacity?

Science products addressing these questions provide the Agency (and any other interested laboratory) with methods to properly sample, ship and analyze the priority homeland security agents in various environmental media. When an attack occurs, the nation will recover more quickly and with more confidence because scientifically-sound methods have been adopted by the EPA. In addition, these methods may be useful in response to accidental contamination events.

D. Research to Improve Risk Assessments and Communication

Upon characterization of the contaminated areas, the risk to human health associated with contamination at all locations - inside buildings, on urban outdoor surfaces, in water distribution systems - can be assessed. This site-specific assessment informs the decision on what areas require remediation and factors into determining the levels to which the contamination must be removed so that the site can be reused. The HS Research Program 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. The Program also studies how to improve communication with the public about risks associated with the contaminated site, water or water systems, and the proposed approach to cleaning it up.

a) What levels of exposures of the public to contaminants are acceptable?

b) How can uncertainties in risk assessments be reduced?

c) Can methods to assess risks associated with biological agents be developed?

d) How can communication with stakeholders (including the public) regarding risk, including the nature and extent of contamination and associated risk and clean up goals, be improved?

At the heart of nearly all EPA responses to contamination is addressing risk. By developing science products and approaches based on the questions above, the Agency will be better ability to protect the health of humans, while the site is contaminated and long after cleanup activities have concluded. 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.

E. Research to Improve Cleanup of Contamination

Following risk assessment and establishment of cleanup goals, the cleanup process can begin. Often this process will involve multiple steps including consideration of cleanup approaches, conducting the cleanup operation including monitoring its progress, treating and disposing of contaminated materials or residuals, confirmation of a successful cleanup, and communication with the public about the cleanup progress. The HSRP is filling critical gaps in the science needed to accomplish these tasks successfully.

EPA has a long history and deep expertise in cleaning up contamination associated with accidental spills and industrial sites. Remediating CBR contamination released intentionally into buildings and wide areas (airports, outdoor urban centers, and sports facilities) 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 cleanup goals.

The HS Research Program 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 best possible cleanup decisions. Several elements that must be considered when attempting to make the best, holistic choice of cleanup approaches:

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

Successful completion of a cleanup must include management of its residuals: 14 of the 15 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/disposal of CB 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 waste licensed disposal facilities exist for radiological waste, an RDD event could produce greater quantities of waste than current disposal capacity could absorb.

The key science questions in clean up of contamination are:

a) Will contamination continue to spread? Will weather, human or other factors cause microbial spores to resuspend after initially settling? How might spreading/resuspension affect the efficacy of clean up technologies?

b) Will natural processes clean up contamination promptly?

c) What clean up technologies are efficacious and how is their efficacy affected by real world variations in environmental and process factors or by the ability of contamination (especially spores) to resuspend?

d) What aspects of process engineering and monitoring are important to success of these technologies?

e) How are contaminated residuals of clean up operations best managed?

f) How can communication with stakeholders (including the public) regarding decision-making about clean up approaches and site clearance be improved?

The results of research addressing these questions, integrated with tackling questions housed in other themes, will provide the Agency with systems-based approaches to site characterization, risk assessment, clean up and waste management. Such integrated approaches can provide communities cost-effective, timely, options that have minimal environmental impact. Proven clean up approaches can be a deterrent to terrorist activities. In addition, the results of this work will be applicable to clean up of contamination caused by unintentional actions or natural disasters. Collectively, the availability of this information will increase the resiliency of our communities.

Research Theme Summary Tables

Theme A: Research to Help Protect Water Infrastructure against Attacks

Outcomes	Science Questions	Outputs
Research products resulting from addressing these questions will provide EPA and water utilities tools to better prepare for attacks on the utilities' critical infrastructure by supporting scientifically-sound, proactive design changes to infrastructure. Better preparation will result in minimization of the impact of an attack, and, arguably, discourage attacks. In addition, these changes in infrastructure can reduce the impact of natural or accidental disasters.	What security measures can be developed or adopted from methodologies used by other stakeholders to improve: a) physical security of water supplies and systems, b) vulnerability assessment methodologies, and c) incorporation of security measures into the design or retrofit of water systems?	Reports, software tools and journal articles giving EPA and water utilities information and tools to improve vulnerability assessments, better protect against attacks including explosions, and develop distribution designs strategies that can minimize the impact of an attack

Theme B: Research to Improve Detection of Contamination and Mitigation of Exposure in Water Systems

Outcomes	Science Questions	Outputs
Science products from this work will assist water utilities improve their response to intentional contamination by providing a systems of sensors and software tools. Better response will reduce the impact of the attack on human health. Such systems may also discourage terrorist from attempting attacks. Finally, the contamination detection and mitigation systems can be used by utilities for routine monitoring of water quality and to respond to inadvertent contamination events (e.g., cross-contamination or main break events).	What monitoring technologies and surveillance information can adequately detect relevant contamination in a distribution system? Can tools be developed to help design optimal monitoring networks? Can software tools be developed to optimize monitoring efforts, contaminant detection, and sensor placement in water distribution systems? Can real-time software tools be developed to aid utilities in making real-time decisions on how to minimize exposure to contaminated water?	Reports, software tools, technology evaluations and journal articles for EPA and water utilities that describe the efficacy of sensors and scientific tools needed to implement a contamination warning and mitigation system

Theme C: Research to Improve Characterization of the Nature and Extent of Contamination

Outcomes	Science Questions	Outputs
Science products addressing these questions provide the Agency (and any other interested laboratory) with methods to properly sample, ship and analyze the priority homeland security agents in various environmental media. When an attack occurs, the nation will recover more quickly and with more confidence because scientifically-sound methods have been adopted by the EPA. In addition, these methods may be useful in response to accidental contamination events.	What sampling and analytical methods are needed to confirm an attack, characterize contaminated water systems and indoor and outdoor areas (and associated residues), and confirm that cleanup levels have been achieved following remediation efforts? Can more rapid methods be developed to increase laboratory capacity?	Analytical and sampling methods for CBR agents that improve the capability and capacity of the EPA's ERLN; and updates to the Selected Analytical Methods (SAM) document providing the best methods currently available for homeland security applications.

Theme D: Research to Improve Risk Assessments and Communication

Outcomes	Science Questions	Outputs
At the heart of nearly all EPA responses to contamination is addressing risk. By developing science products and approaches based on the questions above, the Agency will be better ability to protect the health of humans, while the site is contaminated and long after cleanup activities have concluded. 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.	What levels of exposures of the public to contaminants are acceptable? How can uncertainties in risk assessments be reduced? Can methods to assess risks associated with biological agents be developed? How can communication with stakeholders (including the public) regarding risk, including the nature and extent of contamination and associated risk and clean up goals, be improved?	Reports, databases, methods and journal articles for EPA and other stakeholders communicating Provisional Advisory Levels, approaches to microbial risk assessment including responses to low-dose exposures, and improved approaches to communicating risk to the public and others.

Theme E: Research to Improve Cleanup of Contamination

Outcomes	Science Questions	Outputs
The results of research addressing these questions, integrated with tackling questions housed in other themes, will provide the Agency with systems-based approaches to site characterization, risk assessment, clean up and waste management. Such integrated approaches can provide communities cost-effective, timely, options that have minimal environmental impact. Proven clean up approaches can be a deterrent to terrorist activities. In addition, the results of this work will be applicable to clean up of contamination caused by unintentional actions or natural disasters. Collectively, the availability of this information will increase the resiliency of our communities.	Will contamination continue to spread? Will weather, human or other factors cause microbial spores to resuspend after initially settling? How might spreading/resuspension affect the efficacy of clean up technologies? Will natural processes clean up contamination promptly? What clean up technologies are efficacious and how is their efficacy affected by real world variations in environmental and process factors or by the ability of contamination (especially spores) to resuspend? What aspects of process engineering and monitoring are important to success of these technologies? How are contaminated residuals of clean up operations best managed? How can communication with stakeholders (including the public) regarding decision-making about clean up approaches and site clearance be improved?	Reports, decision support tools, technology evaluations and journal articles for EPA and other stakeholders describing the importance of spore resuspension, the efficacy of various clean up approaches and how to conduct them effectively, best approaches to managing contaminated waste materials, and improvement in approach to communicate with stakeholders about clean up approaches and clearance.

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V. APPENDIX: 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)