Homeland Security
Strategic Research Action Plan, 2016-2019
(Revised Draft – July 2015)

Table of Contents

I. Executive Summary

EPA's Office of Research and Development's (ORD) Homeland Security Research Program (HSRP) aims to help increase the capabilities of EPA and communities to prepare for and respond to chemical, biological, and radiological disasters. Enhancing these capabilities will lead to improved resiliency of our nation to environmental catastrophes. Disasters resulting in environmental threats to public health and the ecosystems may be manmade or naturally occurring incidents including, for example, terrorist use of anthrax spores in 2001, the Deepwater Horizon oil spill in 2010, and Hurricane Katrina in 2005.

The *Homeland Security Strategic Research Action Plan, 2016-2019* (StRAP FY16-19) is a four-year research strategy designed to meet the following objectives:

- Improve water utilities' abilities to prepare for and respond to incidents that threaten public health; and
- Advance EPA's capabilities to respond to wide-area contamination incidents.

EPA's homeland security research is organized into three topic areas that support these objectives: characterizing contamination and assessing exposure, water system security and resilience, and remediating wide areas. Short- and long-term aims within the topics outline a strategy for addressing the objectives.

HSRP carries out applied research that aims to deliver relevant and timely methods, tools, data, and technologies to those who carry out EPA's homeland security mission. To accomplish this aim, we engage our Agency customers throughout the research life cycle – identifying scientific capability gaps, performing research to address the gaps, and formulating and delivering the products that fill the gaps.

HSRP scientific products will improve the resilience of water systems to terrorist attacks or other manmade and natural disasters. Specifically, utilities will have improved tools and strategies to manage contaminated systems and approaches to make these systems inherently resilient. HSRP products also provide the EPA with systems-based approaches for site characterization, risk assessment, and clean up, including waste management. Such information will help Federal, State and local decision makers select cost-effective, timely options while minimizing the impact to the environment.

II. Introduction

The *Homeland Security Strategic Research Action Plan, 2016-2019* (StRAP FY16-19) is a four-year strategy to deliver research results and solutions needed to support EPA's overall mission to protect human health and the environment, fulfill the EPA's legislative mandates, and advance the cross-Agency priorities identified in the *FY 2014-2018 EPA Strategic Plan.* This strategy outlines how EPA's Office of Research and Development's Homeland Security Research Program (HSRP) aims to meet the homeland security science needs of EPA partners and stakeholders.

As the science arm of the EPA, EPA's Office of Research and Development (ORD) conducts leading-edge research to provide a solid underpinning of science and technology. The HSRP StRAP is one of six research plans, which each support one of EPA's national research programs in ORD. The six research programs are:

- Homeland Security (HSRP)
- Safe and Sustainable Water Resources (SSWR)
- Air, Climate, and Energy (ACE)
- Chemical Safety for Sustainability (CSS)
- Sustainable and Healthy Communities (SHC)
- Human Health Risk Assessment (HHRA)

EPA's six strategic research action plans are designed to guide a comprehensive research portfolio that delivers the science and engineering solutions the Agency needs to meet its goals and objectives, while also cultivating a new paradigm for efficient, innovative, and responsive government and government-sponsored environmental and human health research.

Historically, HSRP has focused on filling science gaps associated with EPA's work on terrorist attacks involving chemical, biological, radiological, and nuclear (CBRN) contamination. EPA, along with other Federal government agencies, now recognizes that the activities associated with preparing for a response to non-terror disasters (e.g., chemical accidents, hurricanes) and acts of terror (e.g., ricin or anthrax spores in the mail, contamination of a water system) are often the same. Thus, although terror-related research remains its core, HSRP is beginning to address a broader set of disasters, including how communities can build resilience to disasters.

In this way, HSRP carries out work in the core areas of EPA's disaster response mission. These areas include developing standardized sample collection, analysis methods, and strategy options for characterization of contamination so that risk can be assessed and cleanup approaches considered; developing approaches for preparing water systems for disasters and successfully responding to catastrophes so that access to drinking water by the public and business operations are maintained or restored quickly; and developing approaches for cleanup of outdoor areas and buildings so that the impact of disasters on commerce and personal lives is minimized. Finally, following a disaster, the program provides expert technical advice and hands-on assistance as needed by the response community.

III. Environmental Problems and Program Purpose

HSRP's mission is to conduct research and deliver scientific products to improve EPA's capability to carry out its homeland security responsibilities. Since the 2001 attack on the World Trade Centers and subsequent mailing of letters containing anthrax, EPA's homeland security efforts have focused on preparing for and responding to purposeful use by terrorists of toxic CBRN substances. HSRP has supported the agency by conducting a broad program of CBRN research for over a decade.

The U.S. Government has recognized that preparing for and responding to most disasters, manmade or natural, have common elements (The White House, 2011). Recent major disasters in the United States (the Deepwater Horizon oil spill in 2010, Superstorm Sandy in 2012, the Oklahoma tornados in 2013, the West Virginia water contamination incident in 2014, and the avian flu outbreak in the poultry industry in 2015) and abroad (Fukushima Nuclear Power Plant accident in 2011) illustrate the critical need for rapid recovery after all types of disasters. The Federal government's view of homeland security now includes "all hazards" as described in Presidential Policy Directive 21:

"The Federal Government shall…take proactive steps to manage risk and strengthen the security and resilience of the Nation's critical infrastructure, considering all hazards that could have a debilitating impact on national security, economic stability, public health and safety, or any combination thereof." (The White House, 2013)

Communities, therefore, call on EPA to assist them in preparing for and recovering from the environmental aspects of "all hazards" or "all disasters." The HSRP embraces this broader view of EPA's homeland security mission and is evolving its program from strictly addressing terrorism incidents to the broader set of all disasters.

HSRP supports EPA's responsibilities to prepare for and respond to acute disasters by conducting short-term, applied scientific research. The base of the program focuses on CBRN contamination resulting from intentional or unintentional incidents; however, the HSRP also works to find multiple uses of its research by applying, when appropriate, its products to gaps in EPA's ability to effectively respond to all hazards. Finally, "all hazards" capability gaps exist that are not addressed by HSRP's core program. HSRP will collaborate with other ORD research programs and with other Federal agencies to address the most pressing of these gaps. Figure 1 illustrates this strategic approach, emphasizing that terrorism-related work is the foundation of the program and the "all hazards" efforts are built on that foundation.

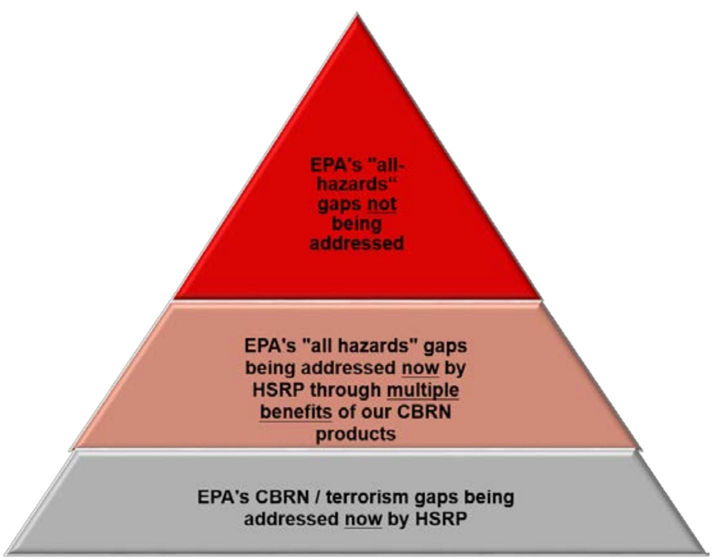

FIGURE 1. HSRP'S APPROACH TO ADDRESSING ALL HAZARDS CAPABILITY GAPS.

Ultimately, EPA's efforts to improve communities' ability to face and recover from disasters helps build resilience in these communities. Improving community resilience is especially critical for populations that have greater exposure to disasters and are more vulnerable to their impacts. Developing resilience at the community level is a critical aspect of building sustainability. Communities that "prepare for, absorb and recover" (NRC, 2012) from disasters will, in turn, have more sustainable economic, environmental, and social systems. Developing and transitioning effective tools and guidance to community decision makers, including water utility owners and operators, enables communities to prepare for and more rapidly recover from these incidents. Figure 2 illustrates how EPA research related to resilience ultimately supports sustainability.

FIGURE 2. HOW EPA RESEARCH SUPPORTS SUSTAINABILITY.

The following Problem Statement and Program Vision guide the research program:

III.A. Problem Statement

Natural or manmade disasters often result in environmental pollution that can threaten the health of populations and the ecosystems and commerce on which they rely. The United States is regularly affected by natural disasters and industrial accidents. It is very difficult for communities to be resilient in the face of such acute environmental catastrophes, especially if scientifically sound information to make difficult decisions is not readily available.

III.B. Program Vision

EPA and communities, including water utilities, have the scientiifc tools they need to prepare for and respond to disasters, thereby helping communities achieve resilience to catastrophes.

IV. Program Design

The HSRP StRAP 2016-2019 provides a vision and blueprint for advancing homeland security research in ways that meet legislative mandates, while addressing the highest priorities of Agency partners and stakeholders. Accordingly, it was developed with considerable input and support from EPA Program Offices and Regions, as well as outside stakeholders including sister Federal agencies, State and local agencies, and colleagues across the scientific community.

IV.A. Building on the 2012-2016 Research Program

The current HSRP builds on the 2012-2016 StRAP (U.S. EPA, 2012). StRAP FY12-16 introduced the idea that EPA's homeland security responsibilities are comprised of interconnected systems of activities: actions taken for one activity could impact, negetively or positively, another activity. Thus, a "systems approach"[1] requires consideration of these interdependencies prior to making decisions and taking action. This "systems" view is furthered in the StRAP FY16-19 and continues to guide research so that products maximize response and cleanup efforts and minimize unintended conequences of decisions. This in turn minimizes the overall cost and recovery time. Figure 3 illustrates a simplified systems diagram for the preparedness – response – decontamination/waste management cycle asscociated with a CBRN incident. The red explosion indicates the beginning of the incident and the text boxes indicate the various activities conducted pre- and post-incident.

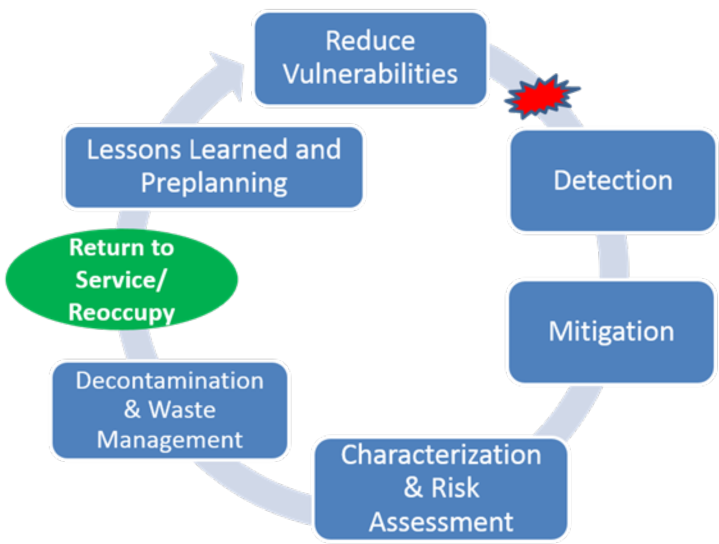

FIGURE 3. SYSTEMS DIAGRAM FOR RESPONSE AND REMEDIATION AFTER A CBRN INCIDENT.

The 2012-2016 StRAP outlined the HSRP's initial focus for its water-system-related research, supporting Homeland Security Presidential Directive/HSPD-9 (The White House, 2004). This directive established a national policy to defend the agriculture and food system (including water systems) against terrorist attacks, major disasters, and other emergencies. For this reason, a significant portion of the program focused on development of contamination warning strategies for water systems. HSRP developed software tools for sensor placement and evaluated sensors to support contamination monitoring

[1] Systems approaches, including systems-based solutions, aim to understand a system in totality through analyzing its various components while still understanding how these components interact. These approaches also aim to understand the system at many levels. In this context, the "system" here is the incident response and recovery efforts composed of many interconnected activities such as constructing a sampling strategy, selecting a cleanup technology, and managing wastes.

systems. These tools were piloted in five cities and some are now used in many other cities (http://www2.epa.gov/homeland-security-research/water-system-security-and-resilience-homeland-security-research). As the contaminant warning system program has matured, the HSRP has moved its focus towards methods for response to contamination incidents and science to support development of resilient water systems. This is reflected in the current StRAP.

Initial efforts related to building community resilience to disasters, including indoor/outdoor cleanup research outlined in the previous StRAP, were focused on remediation of buildings contaminated with traditional chemical, biological, and radiological (CBR) agents. Recently, the program completed a full-scale evaluation of three decontamination methods for remediation of a facility contaminated with anthrax surrogate spores (US EPA, 2013). The results from this evaluation were incorporated into a facility remediation decision support tool (US EPA, 2014a).

Remediation and recovery exercises (e.g., U.S. DHS, 2012), however, have highlighted that incidents impacting large portions of cities or entire communties will require remediation of numerous outdoor and semi-enclosed areas (e.g., subways) in addition to buildings. The research program is now examining clean up methodologies and strategies for these wide areas.

In addition, because the EPA is designated by the Food Safety Modernization Act (FSMA) as a Support Agency to the Department of Agriculture for response to a food or agriculture emergency, the HSRP is developing methods for cleanup (including carcass disposal) after these incidents (FSMA, 2011).

Lastly, in support of the Agency's broadened definition of homeland security, the program is also looking to assist in addressing the needs related to other environmental disasters through application of its research products to a broader set of incidents. Because of additional needs articulated by the program's partners and declining resources, field scale demonstrations of remediation of indoor/outdoor areas are limited and research on chemical warfare agent remediation (including characterization of contamination) is decreasing in scope over the period of this StRAP.

IV.B. EPA Partner and Stakeholder Involvement

Numerous Agency Program Offices and Regions carry out EPA's homeland security responsibilities while EPA's Office of Homeland Security coordinates the activities. The primary partners for the HSRP include the EPA's Office of Water (OW), the Office of Solid Waste and Emergency Response (OSWER), and each of the Agency's ten Regional Offices across the country. In addition, other stakeholders of the HSRP also provide critical contributions to the program, including the Office of Chemical Safety and Pollution Prevention (OCSPP), the Office of Air and Radiation (OAR), the Office of Enforcement and Compliance (OECA), the Office of Policy's Office of Sustainable Communities, State and local laboratories, and water utilities.

The HSRP believes that the end users of our research will receive the scientific products they need only if they are closely involved with the research program. The HSRP-partner engagement involves working together diligently on each step of product development: identifying and prioritizing research needs, implementing research studies, and designing and delivering useful products. To succeed in these efforts, staff and management in HSRP work together continuously with partner organizations.

HSRP collaborates extensively with the other Federal agencies whose missions support response to environmental disasters. HSRP works closely with Department of Homeland Security (DHS), Department of Defense (DOD), Department of Health and Human Services (DHHS), Department of Agriculture (USDA) and others to leverage their homeland security/environmental disaster science efforts. These interactions range from high strategic level planning and coordination managed by theWhite House's National Science and Technology Council (NSTC)[2] to staff-to-staff collaboration on individual research efforts. Figure 4 shows these agencies and their response roles in dark blue and light blue boxes, respectively. Directly below, the white boxes describe the areas of research collaboration with these agencies (described in more detail in the Topics section). HSRP also leverages DOD's research to support the warfighter, specifically their CBRN decontamination and fate and transport research.

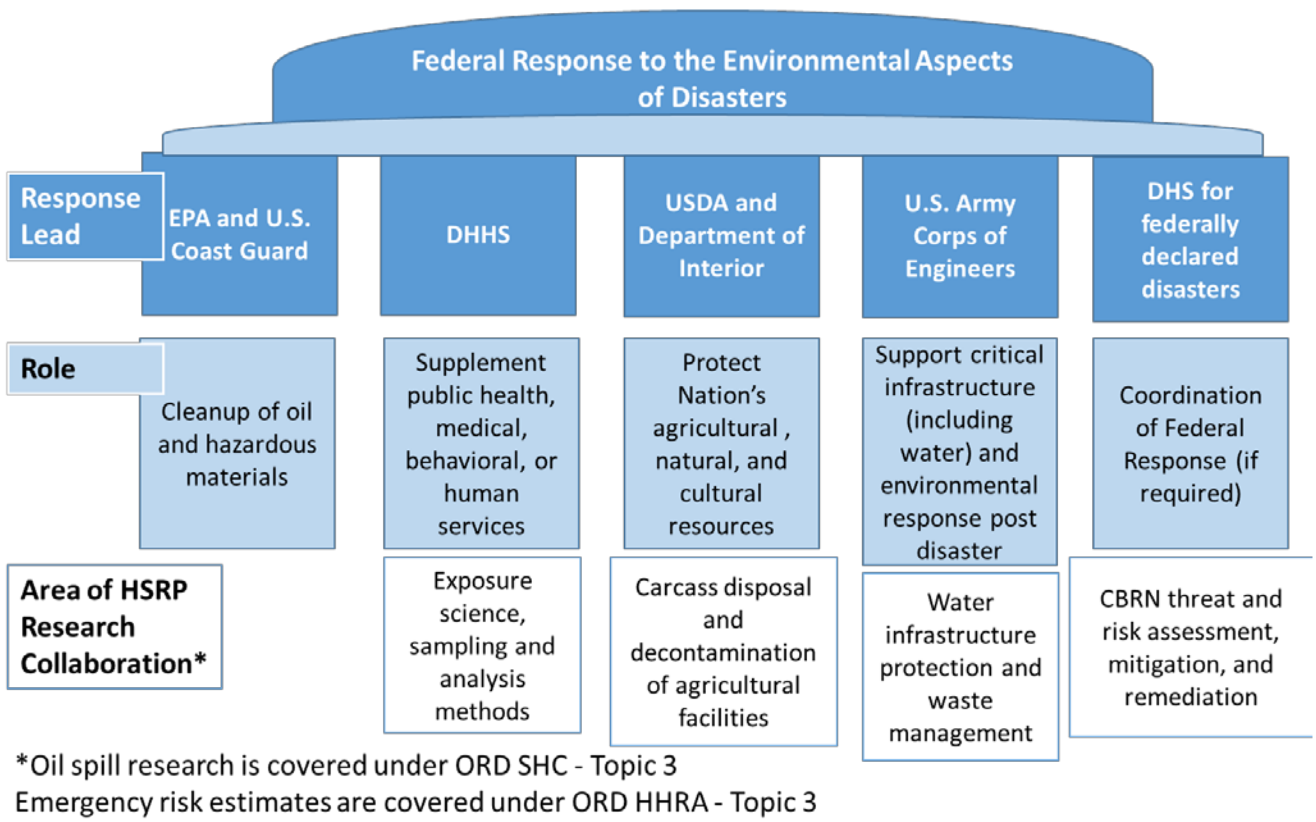

FIGURE 4. HSRP RESEARCH COLLABORATIONS WITH FEDERAL PARTNERS IN THE ENVIRONMENTAL RESPONSE CONTEXT.

[2] ORD HSRP participates in both the Environment, Natural Resources, and Sustainability and Homeland and National Security Committees under the NSTC.

Using the systems understanding of disaster preparedness and response, and identifying high priority research needs, the program is organized by topics, under which there are specific research areas or projects. The work in the projects produces bodies of data, tools, models, and technologies ("Outputs") to address the capability needs expressed by our partners. The anticipated FY16-19 Outputs, organized by project area, are listed in Appendix A.

IV.C. Integration across Research Programs

Because many of the other ORD programs conduct research that can be leveraged to support homeland security research, the HSRP works closely with the other five programs on topics that support the needs of its partners. Figure 5 shows the research areas that the program leverages in the other five programs. Specific research activities are discussed further in the Research Topics section, and they range from information sharing to conducting integrated research efforts.

To accomplish formal integration of research on significant cross-cutting issues at a high level, EPA developed several research "roadmaps" that identify both ongoing relevant research and science gaps that need to be filled. The roadmaps serve to coordinate research efforts and to provide input that helps shape the future research in each of the six programs. Roadmaps have been developed for the following areas:

- Nitrogen and Co-Pollutants
- Children's Environmental Health
- Climate Change
- Environmental Justice

Fig. 6 indicates that HSRP has research activities and interest in identified science gaps within the Climate Change and Environmental Justice Research Roadmaps. Specific research integration activities are described in the Research Topics section.

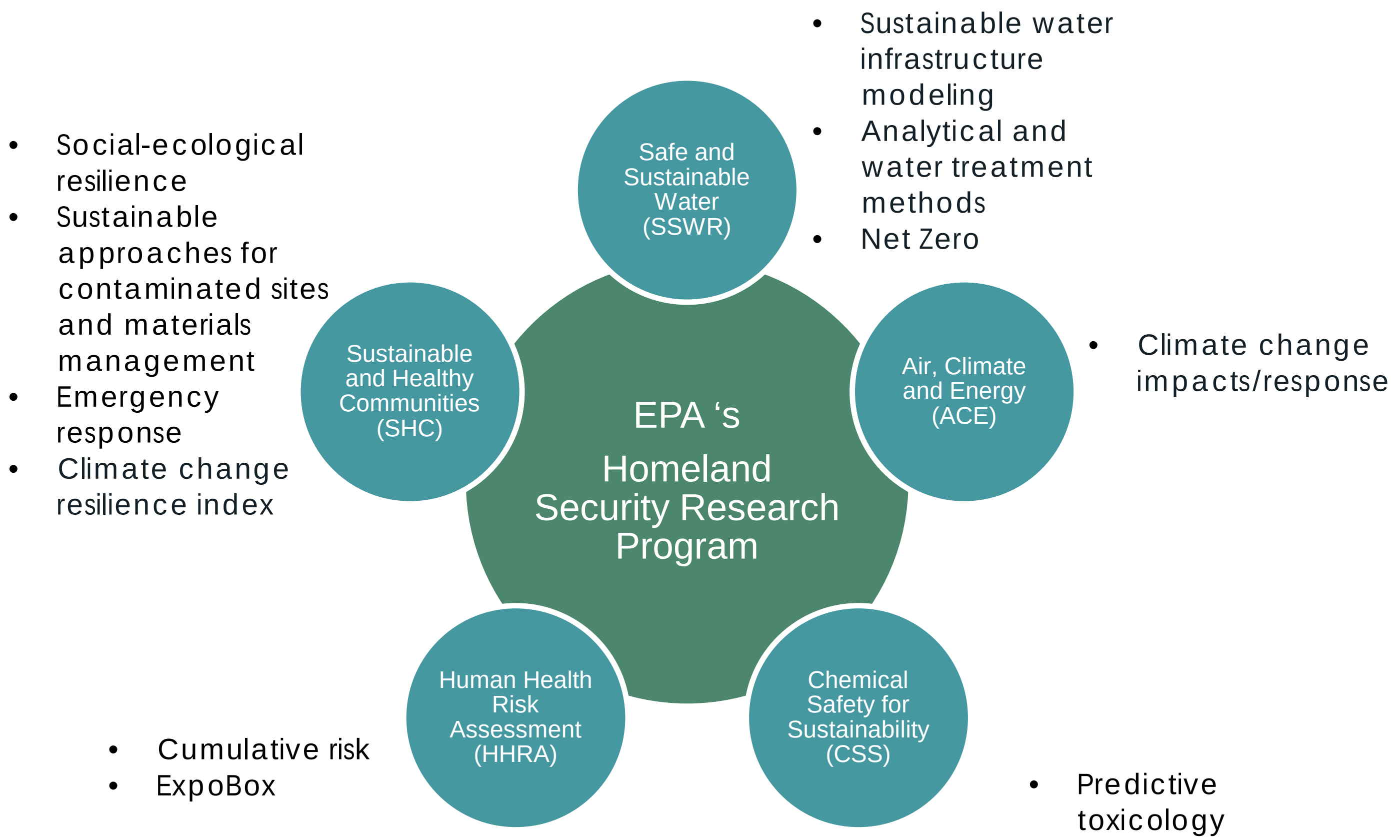

FIGURE 5. AREAS OF RESEARCH IN OTHER ORD PROGRAMS THAT ARE LEVERAGED BY HSRP.

ORD Roadmap	HSRP Topic Area		
	Characterizing Contamination and Assessing Exposure	Remediating Wide Areas	Water System Security and Resilience
Climate Change		✓	✓
Environmental Justice		✓	
Children's Health			
Nitrogen & Co-Pollutants			

FIGURE 6. HOMELAND SECURITY RESEARCH PROGRAM CONTRIBUTIONS TO CRITICAL NEEDS IDENTIFIED BY ORD ROADMAPS. CHECKMARKS INDICATE A LARGER CONTRIBUTION OF HSRP ACTIVITIES AND INTEREST IN THE IDENTIFIED SCIENCE GAPS OF THE ROADMAPS THAN A SINGLE CHECKMARK; A BLANK INDICATES NO SUBSTANTIVE ROLE. AS INDICATED, HSRP IS NOT THE LEAD RESEARCH PROGRAM FOR ANY OF THE ORD ROADMAPS BUT ITS TOPIC AREAS PROVIDE SIGNIFICANT CONTRIBUTIONS TO EACH OF THEM.

IV.D. Research to Support EPA Strategic Plan

In support of EPA's mission to protect human health and the environment, the EPA Strategic Plan identifies five strategic goals and four cross-agency strategies (Figure 7). Homeland Security Research significantly supports Goal 2, "Protecting America's Waters," and Goal 3 "Cleaning Up Communities and Advancing Sustainable Development." Under Goal 2, HSRP's research supports the "Protecting Human Health"

Supporting FY 2014-2018 EPA Strategic Plan, Goals and Cross-Agency Strategies

EPA Strategic Goals

Goal 1: Addressing Climate Change and Improving Air Quality
Goal 2: Protecting America's Waters
Goal 3: Cleaning Up Communities and Advancing Sustainable Development
Goal 4: Ensuring the Safety of Chemicals and Preventing Pollution
Goal 5: Protecting Human Health and the Environment by Enforcing Laws and Assuring Compliance

Cross-Agency Strategies

- **Working Toward a Sustainable Future**
- **Working to Make a Visible Difference in Communities**
- Launching a New Era of State, Tribal, Local, and International Partnerships
- Embracing EPA as a High-Performing Organization

FIGURE 7. SUMMARY OF EPA STRATEGIC PLAN: GOALS AND CROSS-AGENCY STRATEGIES.

objective by providing scientific products that help communities "protect and sustainably manage drinking water resources." The HSRP supports the Goal 3 objective to "Promote Sustainable and Livable Communities and Restore Land" by providing tools and information to help communities "prepare for and respond to accidental or intentional releases of contaminants and clean up."Homeland security research is cataloged in this Strategic Plan under Goal 4, "Ensuring the Safety of Chemicals and Preventing Pollution." Its research also supports the cross-agency strategies within this plan, specifically "Working Toward a Sustainable Future" and "Making a Visible Difference in Communities" through research that will "advance sustainability science, indicators, and tools" (U.S. EPA, 2014b).

IV.E. Statutory and Policy Context

EPA has 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, Presidential Policy Directives, Executive Orders, and national strategies.[3]

EPA's disaster-related responsibilities can be summarized into three areas:

1. Water systems: (a) Protect water systems from intentional or unintentional contamination and (b) Detect and recover from attacks and the effects of disasters by leading efforts to provide States and water utilities with guidance, tools and strategies to enhance resilience, detect disruptions (including contamination), mitigate impacts and efficiently return the systems to service;
2. Indoors/outdoors: Remediate environments contaminated with CBRN agents or materials, including buildings and outdoor areas impacted by terrorist attacks or by inadvertent disasters by leading efforts to establish clean-up goals and remediation strategies; and,
3. Laboratories: Develop a nationwide laboratory network with the capability and capacity to analyze for CBRN agents during routine monitoring and in response to terrorist attacks and other disasters.

The HSRP provides the scientific basis for these strategies, tools, guidance, and cleanup levels, as well as a continual effort to provide laboratories with verified analytical methods.

V. Research Program Objectives

The HSRP StRAP FY16-19 is aligned around two major research objectives as were described briefly above: (1) improve water utilities' abilities to prepare for and respond to incidents that threaten public health; and (2) advance EPA's capabilities to respond to wide area contamination incidents. These objectives are directly in line with the EPA's primary homeland security responsibilities and overall

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[3] Bioterrorism Act, Presidential Policy Directive-8 *National Preparedness*, Presidential Policy Directive-21 *Critical Infrastructure Security and Resilience*, Homeland Security Presidential Directive-7 *Critical Infrastructure Identification, Prioritization, and Protection*, Homeland Security Presidential Directive-9 *Defense of United States Agriculture and Food*, Homeland Security Presidential Directive-22 *Domestic Chemical Defense*, Executive Order-13636 *Improving Critical Infrastructure Cybersecurity*, National Response Framework, and elements of Comprehensive Environmental Response, Compensation and Liability Act, Emergency Planning and Community Right-to-Know Act, Clean Water Act, Safe Drinking Water Act, Oil Pollution Act, Clean Air Act, Resource Conservation and Recovery Act

strategic directions (U.S. EPA, 2014b). These objectives also allow the program to determine the needs of its EPA partners related to these responsibilities.

Objective 1: Improve water utilities' abilities to prepare for and respond to incidents that threaten public health.

Disasters, manmade or natural, can impact water utilities' ability to function. To support disaster preparedness, the HSRP develops modeling tools that support the design and operation of water systems to decrease their vulnerability to disasters. HSRP also builds tools, technologies, and data to support post-incident responses. Following an incident, HSRP research helps water utilities detect contamination, take mitigative actions, determine extent of contamination, assess risk, treat water, and decontaminate infrastructure. Collectively, these efforts help improve the resiliency of water systems faced with inevitable disasters.

The research that is striving to meet this objective can be summarized to address the following science questions:

Can water systems models be designed to enable utilities to be more resilient to disruptions while enhancing daily operations?

What technologies, methods, and strategies for detection and mitigation of contamination in water systems best minimize public health consequences?

What are the standardized sample collection and analysis methods and strategies for characterization of contamination that allow a water utility to quickly return to service?

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

What methodologies and strategies are most effective (minimize cost while protecting human health and the environment) for water infrastructure decontamination and water treatment?

How can HSRP place its research in a decision-maker-friendly format for use by EPA water partners and water utilities?

Objective 2: Advance EPA's capabilities to respond to wide area contamination incidents.

Terrorist incidents or natural disasters can result in wide area contamination with CBRN agents or materials. EPA needs effective and affordable cleanup strategies and methods to enable successful recovery by affected communities. After a wide-area contamination incident occurs, HSRP products can be used to assist in determining the nature and extent of the problem, assessing risk, choosing the best cleanup approach, and managing the resulting contaminated wastes. Communities are also looking for ways to holistically assess their environmental resilience to disasters.

The research that is striving to meet this objective can be summarized as work to address the following science questions:

What social & environmental variables affect a community's environmental resilience? What are indicators & metrics of resilient communities?

What are the standardized sample collection and analysis methods and strategies for characterization of contamination that enable an expedient remediation?

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

What technologies, methods, and strategies are effective for mitigating the impacts of the contamination and for reducing the potential exposures?

What technologies, methods, and strategies are best suited (minimize cost while protecting human health and the environment) for cleanup of indoor and outdoor areas (including management of waste)? How can HSRP place its research in a decision-maker-friendly format for use by EPA partners and State and local decision makers?

Because this program supports time-critical response to disasters, our results must be available in quickly accessible, usable, and concise formats for decision makers. As evidenced by the science challenges within each of the three objectives outlined above, HSRP aims to deliver science synthesis products into the hands of end users by making this information available through existing, widely used information databases and supporting this work with technical assistance. The primary metric of the program's success is the use of its research in databases, guidance, and training developed by its EPA partners and external stakeholders.

VI. Research Topics

The Research Objectives described above serve as the overarching framework for more focused research *topics* that guide specific research and development activities. The research topics are:

Characterizing Contamination and Assessing Exposure
Develop sample collection and analysis methods that increase the capability and capacity of the Agency's Environmental Response Laboratory Network (ERLN) (which includes the Water Laboratory Alliance (WLA))[4] to respond to both water-related and wide area contaminations. Provide the science needed to establish sampling strategies for indoor and outdoor areas that provide the maximum amount of information regarding the extent of contamination while minimizing the sampling and laboratory resources required. Develop methods to assess exposure pathways and utilize exposure modeling for CBRN contaminants to support risk assessment.

Water System Security and Resilience
Develop water systems models that enable utilities to design and operate their water systems so that they are more resilient to intentional attacks or natural disasters including understanding the implications of various operational and design decisions on the overall resilience of the system. Develop approaches for detecting and responding to a water system contamination event or other system disruptions. Develop methods to decontaminate water systems and treat contaminated water. Includes drinking water and wastewater systems.

[4] A nationwide laboratory network with the capability and capacity to analyze for CBRN agents during routine monitoring and in response to terrorist attacks and other disasters. The WLA includes water utility laboratories.

Remediating Wide Areas
Fill critical gaps in science and technology to inform selection and implementation of contamination mitigation and cleanup technologies, remediation monitoring approaches, treatment and disposal tactics for contaminated wastes, and strategies for confirmation of successful cleanup.

Each of the three research topics and corresponding science questions are listed in Table 1 along with their related near- and long-term aims.

Table 1. Research topics, science questions, near term aims, and long-term aims for the Homeland Security Research Program.

HSRP Research Topics	Science Question	Near-Term Aim	Long-Term Aim
Characterizing Contamination and Assessing Exposure	What are the standardized sample collection and analysis methods and strategies for characterization of contamination?	Innovative sample strategy options, sample collection methods, and analytical protocols. Improved understanding of sampling data management and interpretation.	Verified sampling strategy options to maximize needed characterization information and methods that improve laboratory capability and capacity.
	Can exposure pathways and models be improved to better inform risk assessment and risk management decisions for water-related exposures?	Evaluation/modification of existing exposure models for water-related exposures.	Exposure assessment models incorporated into water security and resilience tools.
	Can exposure pathways and models be improved to better inform risk assessment and risk management decisions after a wide area contamination incident?	Evaluation/modification of existing exposure assessment models for CBRN contaminants for inclusion into modeling tools.	Modeling tools to support exposure assessment for biological and chemical contaminants.
	How can the program place its research in a decision maker-friendly format for use by EPA partners, water utilities, and State and local decision makers?	Incorporation of research results into widely used databases and guidance documents.	Use of HSRP developed models and methods by the ERLN and EPA.

Water System Security and Resilience	Can water systems models be designed to enable utilities to be more resilient to disruptions while enhancing daily operations?	Water systems models that allow water utilities to evaluate their security and operational resilience.	Water systems models for water utilities to improve their security and operational resilience.
	What technologies, methods, and strategies for detection and mitigation of contamination in water systems best minimize public health consequences?	Evaluations of detection and mitigation technologies and methods for water systems.	Effective technologies and methods for detection and mitigation for water systems.
	What methodologies and strategies are most effective for water infrastructure decontamination and water treatment?	Assessments of methodologies and strategies for water infrastructure decontamination and water treatment.	Verified customizable approaches for water infrastructure decontamination and water treatment.
	How can the Program place its research in a decision maker-friendly format for use by EPA water partners and water utilities?	Incorporation of research results into widely used databases and guidance documents (e.g., Office of Water's Water Contaminant Information Tool).	Use of HSRP water security and resilience tools and data by EPA partners and water utilities.
Remediating Wide Areas	What are indicators of community environmental resilience and how can existing tools incorporate these indicators?	Determination of the coupled human and natural system variables that affect community environmental resilience.	Tool to support community resilience to risks from environmental disasters.
	What technologies, methods, and strategies are effective for mitigating the impacts of the contamination and for reducing the potential exposures?	Evaluations of mitigation methods.	Effective methods for mitigation.
	What technologies, methods, and strategies are most effective (minimize cost while protecting human health and the environment) for cleanup of indoor and	Development of effective cleanup methodologies and strategies (including waste management) for complex environments.	Informed decision support tools for wide area response and remediation (including waste management).

	outdoor areas (including management of waste)?	Improving capability, capacity, and scalability of remediation methods.	
	How can the program place its research in a decision maker-friendly format for use by EPA partners and State and local decision makers?	Incorporation of research results into widely used databases and guidance documents.	Use of HSRP tools and data by EPA partners and State and local planners.

VI.A. Topic: Characterizing Contamination and Assessing Exposure

Following a chemical, biological, or radiological incident, EPA will oversee site characterization and remediation of contaminated water systems and indoor and outdoor areas. Additional contamination characterization may be required during the cleanup operations to assess progress and to characterize waste streams, and may inform clearance decisions. EPA's OSWER constructed the ERLN to establish the capability and capacity for site characterization and remediation after national scale incidents.

Because site characterization data informs decisions regarding remediation, including determining the efficacy of the cleanup efforts, it is important to understand how to relate these data to risk assessment. Using these data in risk assessment is not straightforward, particularly for microbial contamination. This is due to the uncertainty and variability in the field data as well as how to estimate exposure.

In this topic, the HSRP develops standardized sample collection and analysis methods and strategies for characterization of contamination to support the ERLN and other Agency partners. Specifically by filling gaps in the science needed to: (1) improve the capability by developing, standardizing, and verifying sample collection, sample preparation, and analytical methods for CBRN agents; and (2) increase the capacity by enhancing the efficiency of these methods. Additionally, the program conducts research that assists in establishing sampling strategies and data management options for indoor and outdoor areas that provide the maximum amount of information regarding the extent of contamination while minimizing the sampling and laboratory resources required. Research also supports risk assessment and risk management decisions, specifically addressing the science questions related to exposure pathways and models. Over time, this topic will evolve to focus more on science to inform sampling strategies, a key challenge for wide area contamination incidents. This topic also addresses optimal approaches for translating research to enable urgent decision making by EPA's response community. Priorities in this area are identified through discussions with EPA and external partners who are part of the ERLN.

Some specific areas of research are:

- **Sampling Strategy for Anthrax**– Sampling strategies that employed probabilistic and/or judgmental sampling exist to support site cleanups ofchemical and radiological contaminants in the U.S. and abroad. Previous interagency efforts have discussed these strategies at length as well as potential new options. Research conducted under this StRAP reviews these traditional sampling strategies, assesses these strategies for estimating exposure to *B. anthracis*, and develops innovative sampling strategy options. This includes evaluating composite sampling approaches and existing EPA modeling tools to support judgement-based air sampler placement after a wide area outdoor release *of B. anthracis*.

Assessment of existing exposure assessment methodology for microbial data - connecting exposure assessment to sampling data

After an anthrax release, the potential for human exposure will be considered when response and remediation decisions are made. Research is underway to determine how sampling data can be related to human exposure and if existing exposure assessment methods (developed for chemical contaminants) are appropriate.

- **Data management and usability** – Data management during response to a wide area contamination incident can be daunting and the usability of microbiological data is not throughly understood, particularly at low concentrations. The HSRP assesses and modifies existing software systems that will integrate characterization data and its geospatial metadata to meet the needs of Agency partners. In addition, a standardized approach for assessing the usability of microbial data is being developed.
- **Development and testing of sampling and analysis methods and update of the Selected Analytical Methods (SAM) and Sample Collection Information Document (SCID)** – These documents are intended to provide EPA responders and the ERLN with the most current sample collection and analytical methods to characterize a site contaminated with CBRN materials and to monitor cleanup activities. HSRP ensures that SAM and SCID include methods for the highest priority contaminants and are updated with the most recent methods. To support these documents, the program develops novel sample collection techniques and evaluates existing sample collection and analysis methods for traditional environmental matrices (air, water, soil, and surfaces). In addition, sample collection and analysis methods for solid waste media and matrices relevant to wastewater systems are being developed.
- **Exposure modeling tools to support site-specific responses**– Exposure-based modeling is a mature field for traditional chemical contaminants like pesticides, but modeling efforts for biological agents to help plan sampling strategies are not available. Research conducted under this StRAP develops or modifies existing exposure-modeling tools to support development of these strategies. Models for water-based exposures are also being developed and incorporated into systems modeling consequence estimation tools.

Integration and Leveraging

Beyond the ERLN and EPA partners, the interagency workgroup, Scientific Program on Reaersolization and Exposure (SPORE)[5], continues to inform the work in this topic related to biological agent exposure. Additionally, analytical methods developed by EPA ORD's SSWR (Topic 4 - Water Systems) and CSS (Topic 1 - Chemical Evaluation) are examined for their applicability to CBRN contaminants. HSRP also leverages DHS-funded analytical method development, which is primarily focused on biological agents and emerging chemical threats. Lastly, as HSRP moves further toward addressing all hazards, it will begin to explore integration of its applications in cumulative risk assessment methods, in collaboration with HHRA (Topic 3 – Community and Site-specific Analysis), to the impacts of disaster-related chemical contamination and non-chemical stressors on the environment and public health. These approaches, once mature, will be incorporated into the cross-ORD resilience research activities and tools discussed under the Remediating Wide Areas topic section below.

VI.B. Topic: Water System Security and Resilience

The public can be seriously harmed by ingesting contaminated drinking water caused by accidental or intentional introduction of harmful substances into our water systems. Contamination of drinking water can occur through the direct introduction of CBRN substances into the distribution infrastructure, through compromises in the integrity of the distribution lines, or via contaminated raw water supply entering a treatment plant. Direct distribution system contamination can result from acts of terror or inadvertent distribution system disruptions such as main breaks or cross connections. Accidental or natural contamination can enter drinking water supplies via contaminated stormwater runoff, wastewater and industrial outfalls, or transportation or industrial incidents.

EPA supports water utilities by providing tools and guidance that help harden their infrastructure to respond to and recover from contamination incidents and other disasters. Priorities in this area are determined through conversations with the EPA's OW, OECA, and Regional Offices. The water utilities convey their needs through the water sector's Critical Infrastructure Protection Advisory Committee (CIPAC), managed out of the DHS and co-led by EPA's OW. This group periodically releases research priorities and these also inform HSRP's research in this topic.

This topic includes development of tools that (1) enable water systems to detect and respond to a contamination event and other system disruptions; (2) assess the vulnerabilities of the systems to contamination; and (3) understand the implications of operational and design decisions on the overall system resilience. HSRP also develops methods for decontaminating water infrastructure and treating contaminated water. Decision-support tools for response to source water contamination and for assessing vulnerabilities due to critical infrastructure interdependencies are also within this topic.

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[5] Scientific Program on Reaerosolization and Exposure aims to understand the degree to which *B. anthracis* spores reaerosolize from surfaces, ways to mitigate this reaerosolization and the potential exposures resulting from this reaerosolization. This research informs public health decisions and sampling, mitigation, and decontamination strategies. DOD, HHS, and DHS participate in this group.

This research supports the science questions related to: 1) design of water systems models; 2) technologies, methods, and strategies for detection and mitigation of contamination in water systems; 3) water infrastructure decontamination and water treatment; and 4) delivering research in an user-friendly format for use by EPA water partners and water utility owners and operators. As the research in this area progresses, the focus will move towards more field-scale assessments and additional focus on improving the overall resilience of water systems to disasters. Some specific examples of this research are:

- **Support innovative design and operation of water systems and technologies for resiliency.** To reduce the vulnerabilities of their systems to contamination and other disasters, water utilities need to better understand their system's vulnerabilities and operational conditions. The research that supports this need includes:
  - Examining the effectiveness of cybersecurity standards,
  - Developing systems modeling tool that allows utilities to use their supervisory control and data acquisition (SCADA) data to model their system in real time, allowing them to assess operational conditions (including identifying disruptions) and model the spread of contamination in their system; and,
  - Developing a framework that allows the study of operational and design decisions on overall system resilience to disasters. Because this includes disasters resulting from climate change, this research is covered under the Climate Change Roadmap.

Homeowner Decontamination of Post-Service Connection Plumbing and Appliances

The persistence of high priority contaminants on home plumbing infrastructure are studied as well as the effectiveness of flushing as a decontamination method. As evidenced by the West Virginia water contamination incident in 2014, this information is needed for response to a water system contamination incident.

- **Fate and transport of contaminants and by-products in water and wastewater systems.** Understanding the fate and transport of contaminants and their degradation or decontamination by-products provides information that is relevant to sampling, mitigation, and decontamination methods and strategies. Experimental data is collected and predictive models are developed to address fate and transport for a range of potential contaminants and infrastructure design features.
- **Detection and mitigation methods and strategies.** Detecting contamination in water is critical for mitigating its impacts. Research efforts in this area include testing emerging water contaminant sensors and developing ways to quickly mitigate iimpacts. Water systems modeling efforts in this area aim to inform mitigation strategies (e.g., flushing and isolation).
- **Decontamination of water infrastructure.** Once a water system is contaminated, it is important to have effective, scalable decontamination methodologies for the infrastructure. HSRP collects data on the persistence of priority CBR contaminants on

water infrastructure (including wastewater infrastructure and premise plumbing[6]) and develops effective decontamination procedures to remove persistent contamination.

- **Treatment, disposal, minimization and handling of contaminated water.** A contaminated water system may be flushed or decontaminated, generating large volumes of contaminated water. Indoor/outdoor area decontamination activities may generate large volumes of decontamination wash water. Containment and treatment technologies exist, but these activities will likely result in volumes of water that cannot be easily handled with existing capabilities. Existing approaches for collecting, minimizing, treating, and disposing of large volumes of contaminated water are being modified and assessed.
- **Development and enhancement of decision-making tools.** The HSRP is developing an Emergency Management Decision Support Tool that allows utilities to identify upstream hazards (e.g., barges, railroad infrastructure adjacent to drinking water sources) and model spills from these or above-ground storage tanks to determine time of travel to downstream drinking water intakes as well as the leading edge, peak, and trailing edge contaminant levels. This modeling will provide guidance on emergency response sampling locations, methods, and drinking water utility options to treat the contaminant, close the intakes, or provide alternative sources of water. In addition, an operational and design-decision support tool for water systems is being developed that factors in the interdependencies between different critical infrastructure and water systems.
- **Systems analysis and demonstration of approaches for response to a contaminated or disrupted water system.** Approaches developed and tested at the laboratory and pilot scale require testing at the field scale in real time to understand their true cost and performance under real-world operating conditions. For these reasons, full-scale distribution system evaluations of cyber-based disruptions, in-line contaminant detectors, decontamination methodologies (including automatic flushing), wash water treatment methodologies, and the water system modeling tools are being

FIGURE 8. AERIAL PICTURE OF THE WATER SECURITY TEST BED.

[6] The customer's portion of the potable water distribution system, which is connected to the main distribution system via the service line.

conducted at a full-scale simulation of a municipal water system (the Water Security Test Bed).

- **Inform Agency tools and standards.** Information developed in this topic are being included in widely available databases such as OW's Water Contaminant Information Tool (WCIT). HSRP's water systems modeling tools can potentially inform OW's tools for utilities, including the Vulnerability Self-Assessment Tool (VSAT).

Integration and Leveraging

The Climate Change Roadmap integrates HSRP's research on resilience of water systems with other climate-related research. As a part of this integration, ACE and HSRP will partner to develop a set of the scenarios for water systems resilience research. The program also continues to collaborate with SSWR (Topic 4 - Water Systems) on sustainable water infrastructure modeling as well as on methods for communities to achieve Net Zero conditions[7], specifically treatment of decontamination wash water. In addition, HSRP leverages findings from SSWR studies of technologies for the collection and treatment of water after a water system contamination incident (Topic 4 - Water Systems). The program is also working with DOD's Army Corp of Engineers to develop and operationalize water treatment technologies at the full scale. Lastly, to ensure that the capabilities of the Water Security Test Bed are fully realized and used, the program collaborates with federal partners (DOE, DHS, DOD) and water utilities to plan and execute research at this Test Bed.

VI.C. Topic: Remediating Wide Areas

EPA has a long history and extensive expertise in cleaning up contamination associated with accidental spills and industrial accidents. Remediating CBR contamination released into wide areas, such as outdoor urban centers, is a responsibility for which the EPA lacks substantial experience. 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 in this topic 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 mitigation and remediation (decontamination and waste management) decisions.

The ultimate aim of EPA's tools, methods, and technologies for disaster preparedness and response is to improve our communities' ability to recover from a disaster successfully. Therefore, EPA and communities need tools to assess their current state of resilience to environmental disasters. HSRP aims to address science gaps related to community environmental resilience assessment. Priorities in this area are determined through interactions with EPA's OSWER, OCSPP, OAR, OW, and Regional Offices.

[7] By definition, this means "consuming only as much energy as produced, achieving a sustainable balance between water availability and demand, and eliminating solid waste sent to landfills."

The research in this topic addresses the science questions related to indicators of community environmental resilience; technologies, methods, and strategies for mitigating the impacts of the contamination and for cleanup of indoor and outdoor areas; and providing research into decision maker-friendly formats for use by EPA partners and other stakeholders. Over the period of this plan, the research in this topic will evolve to focus on scalability of cleanup methods and application of the research to additional hazards outside of the CBRN paradigm. Some specific examples of this research are:

- **Environmental fate and transport of CBR contaminants** – Understanding the fate and transport of these contaminants is critical for informing risk reduction, sampling, and remediation activities. Examples of research in this area include examining *B. anthracis* transport to inform risk reduction, sampling, and decontamination.
- **Gross Decontamination[8] and Containment for Biological and Radiological Contamination** – After a wide area contamination incident, responders will need gross decontamination and other mitigation technologies in order to enable movement into and between contaminated zones. Such zones may include critical infrastructure that is essential to keep on-line or get back on-line as a priority. Mitigation technologies that are appropriate to wide-area contamination incidents are being assessed. This includes the study of methods for gross decontamination and inhibiting the spread of contamination.

FIGURE 9. PICTURE OF A FIREFIGHTER DEMONSTRATING GROSS DECONTAMINATION OF A VEHICLE.

- **Identification, development, and assessment of decontamination methods for improved efficacy and capacity** – The ability to decontaminate CBR agents is a function of many factors (e.g., agent, surface type). Even where efficacious decontamination methods exist, the capacity needed for a wide incident does not. New decontamination methods that are widely available, user friendly, economical, and ideally have low human and environmental impact are identified, modified, and evaluated. This work is done under process variables that include diverse, realistic environmental and operating conditions for a variety of surfaces, including complex materials such as soil and dirty concrete.
- **Implementation of decontamination technologies over the wide area** – Wide areas can present many complex environments, from open spaces with soil/vegetation to

[8] Gross decontamination is decontamination that is conducted with the goal of reducing contamination levels. This reduction may not meet final cleanup levels, but may be useful to mitigate some public hazard or contain contamination.

skyscrapers. These environments, as well as the prospect of many square miles of contaminated area, dictate the need for scalable technologies. In addition, many decontamination technologies may include use of chemicals such as disinfectants which can be toxic if used inappropriately. It is critical to have engineering controls to protect responders and the general public, as well as to ensure proper decontamination conditions. HSRP develops and improves decontamination engineering processes to facilitate implementation of technologies in the field and provide information to assist in scale up of these methodologies. After the Fukushima Daiichi incident, it also became apparent that effective risk reduction and self-help remediation methods are needed after a wide area contamination incident. The program is developing methods for risk reduction and self-help (e.g., owner/occupant or their contractors) remediation after a wide area anthrax or radiological contamination incident.

Methodologies to Apply Biocides for Biological Agent Containment and Decontamination on Outdoor Surfaces

Methodologies for applying biocides are being developed to maximize containment and decontamination efficacy. Specifically, the influence of spraying parameters on containment and decontamination are being studied for the most effective decontaminants. After a wide area biological incident, these methodologies will enable continuity of response operations and potentially reduce the size of the impacted area.

- **Waste minimization, treatment, and disposal** – As evidenced by previous incidents (US EPA, 2013) waste management dictates the remediation cost and timeline. Methods to minimize and treat waste are critical components of an effective waste management strategy. Critical for wide area remediation is treatment of chemical, biological, and radiological decontamination washwater, which is covered under the water systems topic. Under this topic, the behavior of contaminants in a variety of solid waste treatment processes (e.g., incineration, autoclave) is studied, the effectiveness of commercially available and novel treatment methods (including on-site technologies) is evaluated, methods for the minimization of solid waste are developed, and scientific information to support waste staging recommendations (e.g., appropriate areas for staging, packaging of waste during staging) is generated.
- **Development and enhancement of decision-making tools and information to support a systems approach to response and remediation** – Making decisions regarding response to and remediation of wide area contamination is difficult due to the complexity of the situation. Tools that allow the decision maker to better understand the options for response and remediation as well as the consequences of each decision are critical for effective decision making. HSRP develops and enhances computer-based decision-support tools, which can be used to quickly evaluate the efficacy and impacts of potential response and remediation options from single facility to wide area scale. These tools, as well as other previously developed tools, are being evaluated for their ability to assess resilience to environmental disasters beyond traditional CBRN threats.
- **Community environmental resilience to disasters –** Resilience to acute shocks and disasters is a necessary underpinning of long-term sustainability. Currently, while there are indicators for communities to assess their social and geographic vulnerability and

resilience to natural disasters, there is not a way for communities to assess their environmental resilience to natural disasters or CBRN incidents. HSRP develops indicators for communities to enhance their environmental resilience, which will be tested in communities to develop a community environmental resilience self-assessment tool. HSRP is also developing a framework to integrate environmental and social indicators of community resilience. The framework gives explicit attention to environmental and ecological variables, and includes socioeconomic and cultural variables. Because communities that have greater exposure to disasters are more vulnerable to their impacts, they are of particular interest in this research effort. This framework is integrated with other resilience research in the Environmental Justice Research Roadmap.

- **Inform Agency guidance** – Information generated under this topic is being included in response and remediation preparedness documents (e.g., tactical guides, guidance) that are being developed by the EPA (Program Offices and Regions), State and local agencies.

Integration and Leveraging

Increasing the resilience of communities, including their ecosystem services, to the changing climate and to acute disasters is an area of interest for almost all of the EPA National Research Programs. The HSRP is facilitating the coordination of the research in this area as it continues to grow.

The community environmental resilience research is an integrated research area (with SHC and ACE) under the Environmental Justice Roadmap. Specifically, this research leverages SHC's development of indicators of ecological resilience (SHC Topic 2 - Community Well-Being: Public Health and Ecosystem Goods & Services), using these indicators within its framework to integrate environmental and social indicators of community resilience to disasters. When these indicators are tested in communities, HSRP will partner with SHC.

HSRP will also explore SHC's community assessment tools as venues for the indicators, with these tools potentially serving as the community environmental resilience self-assessment tool. In addition, HSRP is collaborating with SHC on development of the Climate Change Resilience Index, which examines the vulnerabilities of communities to the impacts of the changing climate. The program also continues to exchange information with SHC on their research related to cleanup of contaminated sites (SHC Topic 3 - Sustainable Approaches for Contaminated Sites and Materials Management), which deals with ground water and soil contaminated with traditional chemical and radiological contaminants,. and sustainable materials management, which is critical for dealing with waste after environmental disasters. Lastly, HSRP and DHS collaboratively conduct projects addressing remediation resulting from the release of biological agents in underground transportation environments and remediation of outdoor areas after biological and radiological incidents.

> ***Environmental resilience:***
> *"Minimizing environmental risks associated with disasters, quickly returning critical environmental & ecological services to functionality after a disaster while applying this learning process to reduce vulnerabilities & risks to future incidents."*

VII. Anticipated Research Accomplishments and Projected Impacts

HSRP work is designed to address the critical gaps in EPA's capabilities to carry out its homeland security mission. However, this relevant research may not have its intended impact unless the products are formed and delivered in a manner most useful toAgency partners. ORD products specifically designed to be useful in the hands of partners are termed "outputs." The HSRP will produce a number of outputs from FY16 to FY19. The titles of the proposed outputs for this time period can be found in the Appendix. To give a better sense of the impacts of the research program, examples of anticipated research accomplishments are given below by topic area:

Characterizing Contamination and Assessing Exposure

Research on characterizing contamination and assessing exposure will improve the ability of EPA responders and laboratories to characterize environmental samples after disasters. Specifically, the program is producing a compendium of the methods for sample collection, processing, and analysis (*Selected Analytical Methods (SAM) and the Sample Collection Information Documents (SCID) 2017)* which provide selected sample collection and analytical methods for EPA responders and laboratories during EPA response and remediation efforts following a homeland security incident. This compendium includes recently developed innovative sample collection methods and analysis protocols. Additional accomplishments in this topic area support development of sampling strategies after a wide area biological agent incident, a critical remediation activity because sampling and analysis can be very costly and time consuming. Sample strategy options are being developed through evaluation of biological agent composite sample collection techniques and strategies to inform what is selected during an actual response. These techniques and strategies must incorporate temporal and spatial aspects of agent fate and transport in urban settings, sample collection efficiencies, sampling approach representativeness, and be able to be deployed over large spatial scales with minimal time and resources. These evaluations will provide input into various sampling approaches and strategies that can potentially reduce the cost and overall timeline.

Water System Security and Resilience

Anticipated accomplishments in this topic will improve the resilience of water systems (both drinking and wastewater systems) through the holistic assessment of resilience indicators for water systems and the field-scale evaluation of drinking water infrastructure decontamination. Specifically, a framework is being developed which allows the impact of design and operational decisions on overall system resilience to be studied. It is critical to assess how these decisions influence the overall resilience of water systems so that findings from the use of this framework can inform the J-100 standard and OW's Vulnerability Self-Assessment Tool. Other anticipated accomplishments in this area include the evaluation of infrastructure decontamination methodologies and water treatment technologies at the full scale. These studies allow understanding of the applicability of these methodologies and a system's view of how these activities would tie together during an actual incident.

Remediating Wide Areas

The ability to remediate after a wide area biological and radiological incident will be improved through additional development of decontamination methods for outdoor areas and decontamination methods that can be employed by owners/occupants or their contractors. In addition, tools that enable a systems approach to remediation will be available, improving EPA's ability to remediate the wide area. For example under this topic, the state of the capabilities, as determined by laboratory and field efforts, for outdoor decontamination after a wide area *B. anthracis* incident are being assessed. This assessment will help inform selection of decontamination methods for these large outdoor areas, which are critical for making substantial progress in remediating the wide area. Another example accomplishment is the release of a trade-off analysis tool, which employs a GIS-based approach, for mitigation, decontamination, and waste management decisions after a biological incident. For emergency planners and Federal responders to scope out the waste and debris management issues resulting from a biological response and recovery effort, it is critical to understand not only the quantity, characteristics, and level of contamination of the waste, but also the implications of response and cleanup decisions on subsequent waste generation. This tool will allow planners and responders to understand these implications.

VIII. Conclusion

The entire Homeland Security Research Program, from the community environmental resilience self-assessment tool to the methods and tools for cleanup, enhances community resilience. Systems-based approaches are captured in the program's decision support tools. These methods and tools, along with Federal, State, and local preparedness activities, enable rapid recovery after acute disasters.

Specifically, the resilience of water systems to terrorist attacks or other manmade and natural disasters will be improved by the research outlined above and its incorporation into widely used EPA tools and standards. Utilities will have improved tools and strategies to manage contaminated systems and approaches to make these systems inherently resilient. In addition, the results of research will provide EPA with systems-based approaches to managing risk to water systems, including reliable exposure assessment tools to 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 characterization strategies and methods needed to properly sample, ship, and analyze priority contaminants in various environmental media, and waste media will also be available. When an attack or other disaster occurs, the United States will recover more quickly and with more confidence because scientifically sound methods have been adopted by EPA.

Such integrated approaches provide water utilities with cost-effective and timely options that have minimal environmental and economic impact. 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.

This program will also provide the EPA with systems-based approaches and tools for site characterization, risk assessment, and clean up including waste management. Such information will help Federal, State and community decision makers select cost-effective, timely options while minimizing the impact to the environment. Proven characterization, risk assessment, and clean up approaches are a deterrent to terrorist activities because timely, effective responses minimize the overall impact of an incident (Kroenig and Pavel, 2012). In addition, the results of this work will be applicable to the cleanup of contamination caused by accidents or natural disasters.

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Appendix

Table of Anticipated Outputs, Homeland Security Research Program FY16-19

Project Area	**Output**	**Anticipated Completion Date**
Topic: Characterizing Contamination and Assessing Exposure		
Sampling and Analysis	Sample Processing Approach for Post Bleach-Decontamination Ricin Sample Analysis	FY16
	Protocol for detection of *Y. pestis* in environmental matrices	FY16
	Selected Analytical Methods (SAM) 2017	FY17
	Sample Collection Information Document (SCID) 2017	FY17
	Building Material Collection Procedure and Sample Collection Strategy for Radionuclides	FY17
	Technical Brief: Ultra-Dilute Chemical Warfare Agents Use for Reference Standards	FY17
	Technical Brief: Evaluation of Commercially Available PCR Assays for *Bacillus anthracis* for Wide Area Releases	FY18
	Updated/Modified Field Sample Collection and Lab Analytical Data Management Tool	FY18
	Summary Technical Evaluation: Biological Agent Composite Sample Collection Techniques and Strategies	FY19
Exposure Assessment	Updated Tool: TEVA SPOT Consequence Estimation Module - Determines site-specific public health consequences from intentional or unintentional contamination events in drinking water systems	FY17
	Technical Brief: Outdoor Human Activity Forces for Reaerosolization of *Bacillus anthracis* Spores	FY17
Topic: Water Systems		
Support innovative design and operation of water systems and technologies for resiliency	Revised Real-time Analytics and Modeling Software in the Water Community	FY16
	Security Design and Operational Resilience Evaluation Framework for Water Distribution System	FY17
	Technical Brief: Recommendations for Protecting Water and Wastewater Utilities' SCADA Systems from Cyber Intrusions	FY18
Fate and transport of contaminants and by-products in water and wastewater systems	Technical Brief: Predicting Fate and Transport of CBR Contaminants During Water Treatment and Decontamination Processes	FY19

Detection and mitigation methods and strategies	Software: Evaluation of Response Strategies in Water Distribution Systems Using Simulation Studies	FY19
Water infrastructure decontamination	Technical Brief: Homeowner Decontamination of Post Service Connection Plumbing and Appliances	FY19
	Technical Brief: Water Infrastructure Decontamination Methods for Chemicals from Pilot Scale Studies	FY19
Treatment, disposal, minimization, and handling of contaminated water	Technical Brief: Bio-Contaminated Wash-Down Water Management Technologies and Procedures	FY18
	Technical Brief: Management of Cesium- Contaminated Water	FY18
Development and enhancement of decision-making tools	Ohio River Basin Vulnerability and Emergency Management Decision Support Tool	FY18
Systems analysis and demonstration of response and remediation approaches	Technical Brief: Lessons Learned from Systems Evaluations of Response and Return to Service after a Water System Contamination Incident	FY19
Remediating Wide Areas		
Environmental fate and transport of CBR contaminants	Decision-Support Tool: Radiological Agent Fate and Transport Supporting Remediation Activities	FY19
Gross decontamination and containment	Technical Brief: Impact of Washdown and Rain on Urban Surfaces Contaminated with *B. anthracis* Spores	FY18
	Technical Specification Datasheet and Brief: Technical Information on Gross Decontamination and Containment for Inclusion in OSWER/OEM/DHS Rad App for Responders	FY19
Identification, development, and assessment of decontamination methods for improved efficacy and capacity	Technical Brief: Effectiveness of Liquid Decontamination Technologies for Surfaces Contaminated With Blister Agents	FY16
	Technical Brief: Summary of Ricin Decon Methods	FY18
Implementation of decontamination technologies over the wide area	Technical Brief: Effectiveness of Decontamination Options for Critical Infrastructure (Efficacy And Material Compatibility)	FY17
	Technical Brief: Assessment of Self-Help Methods and Their Potential Uses and Precautions for Wide Area Anthrax Contamination Incidents	FY18
	Technical Brief: Assessment of Self-Help Methods, Their Potential Uses And Precautions For Radiological Incidents	FY19
Treatment, disposal, minimization, and handling of contaminated waste	Summary of On-Site Waste Treatment and Staging Approaches for CBR	FY18
	Technical Brief: Methods for Waste Volume Reduction for Radiological Incidents	FY19

Development and enhancement of decision-making tools	Decision Support Module for Early Phase Containment, Decontamination, and Waste Disposal Actions after a Radiological Incident	FY17
	Waste Estimation Support Tool (WEST) to Address Wide Area Biological Response	FY18
	Decontamination Support Tool (DeconST) Adapted to Support Chemical Agent Incidents in Facilities	FY18
	Carcass Disposal Technology Selection Tool	FY19
Community environmental resilience to disasters	Environmental and Ecological Metrics Framework for Measuring Community Resilience and Community Environmental Resilience Self-Assessment Tool	FY19