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An Inventory of EPA's Tools for Enhancing Community Resilience to Disasters

Office of Research and Development
National Homeland Security Research Center

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An Inventory of EPA's Tools for Enhancing Community Resilience to Disasters

U.S. Environmental Protection Agency
National Homeland Security Research Center Office of
Research and Development
Washington, D.C. 20003

Disclaimer

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List of Acronyms and Abbreviations

BMP	Best Management Practices
CERI	Community Environmental Resiliency Index
E.O.	Executive Order
EPA	U.S. Environmental Protection Agency
EXAMS	Exposure Analysis Modeling System
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System
HUD	U.S. Department of Housing and Urban Development
I-WASTE	Incident Waste Assessment and Tonnage Estimator
LID	Low Impact Development
MMSOILS	Multimedia Contaminant Fate, Transport, and Exposure Model
NDRF	National Disaster Recovery Framework
NHSRC	National Homeland Security Research Center
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
PPD	Presidential Policy Directive
TEVA-SPOT	Threat Ensemble Vulnerability Assessment Sensor Placement Optimization Tool
WNTR	Water Network Tool for Resilience

1. Introduction

Disasters have widespread implications and cascading consequences. Communities can be and have been severely impacted by all types of hazards that cause significant and lasting harm to people, property, and the environment. Improving resilience is key in the effort to ensure that communities reduce hazard risks, mitigate impacts, and continue to thrive in the face of disasters. The general concept of resilience, as defined by a number of public and private organizations, is the capacity of a system to anticipate risk and potential harm, prepare, plan for, and absorb impacts, and bounce back and recover from adverse, disruptive events (NRC 2012, CARRI 2014). To safeguard human health and the environment, all human and natural systems within a community need to be considered in disaster planning and management processes.

A number of resources are available for communities to enhance their resilience to disasters, such as resilience indices, scholarly articles, and mitigation and recovery grants. This report inventories a subset of those resources, in the form of tools available through the U.S. Environmental Protection Agency (EPA), which together can be directly applied for purposes of preparing for, mitigating, preventing, responding to, recovering from, and improving overall community resilience to all-hazards, including both natural and man-made disasters. These tools include online mapping systems, guidance documents and publications, and many others. Several of the tools were originally developed for recovering from chemical, biological, radiological, or nuclear events but can be used for recovering from other events as well. This inventory is intended to provide researchers and practitioners with information about available resiliency tools that they may distribute and use to help communities protect their resources and become more resilient to all-hazards. It also addresses further research needs and opportunities to continue advancing the science and practice of community resilience.

This report is a product of the EPA National Homeland Security Research Center's (NHSRC's) Community Environmental Resiliency Index (CERI) project. The CERI project began as an effort to consider how communities can safeguard their environmental and ecological systems before, during, and following a disaster. The CERI project has worked to identify and assess potential indicators of environmental resilience and recovery and integrate these efforts into existing public and private organizations and partnerships. The tools in this report were retrieved through web searches on EPA networks, from EPA webpages and documents, and through communication with EPA researchers. They were then reviewed to determine how they could be applied for purposes of strengthening community resilience to future disasters. A table included in Appendix A lists each tool and its potential resilience application(s). Though a number of tools are included in this report, the list is by no means exhaustive. Many other potential tools have been identified and the current list may continue to be updated as more tools are released.

2. Disasters and Resilience

Over the past several decades, the number of natural disasters impacting U.S. communities has increased dramatically, as has the number of people affected by these disasters. Globally, about 70 disasters were catalogued annually in the 1970s. Since 2000, more than 300 have been reported every year, with half of those years experiencing 400 or more (Guha-Sapir et al., 2014). Not only are natural disasters increasing in frequency, but they are also becoming more destructive as well. Despite increasing knowledge of disaster impacts and mitigation practices,

the ten most economically damaging disasters in the United States since 1900 have occurred in the last two decades (Guha-Sapir et al., 2014). With climatic changes tending to further increase the frequency and intensity of extreme weather events, coupled with increasing technological and manmade threats, communities are at even greater risk (Walsh et al., 2014). Preventing further damages and addressing vulnerabilities requires new approaches to planning, management, and recovery from all-hazards.

Whereas human and natural systems have experienced the effects of disasters for millennia, research into hazard mitigation planning and resilience to disasters has only recently begun to attract widespread attention. Hazard mitigation planning involves concerted efforts to reduce risks and potential losses associated with disasters through both policy and action. Strengthening a community's resilience involves this planning process and more. As defined in Executive Order (EO) 13653 addressing climate change and Presidential Policy Directive (PPD) 21 addressing critical infrastructure, resilience means "the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions." (Exec. Order No. 13653, Presidential Policy Directive 21, 2013). Building resilience involves continual preparedness, response, recovery, and adaptation efforts (Figure 1).

Figure 1. Continuous Cycle for Improving (Community) Resilience to All-Hazards
[*Adapted from USEPA. 2015.*]

There are several other interpretations of resilience in the literature. Some researchers consider resilience to be a return to normalcy following a disturbance, but others tend to agree that resilience entails recovering and improving upon prior conditions, a view that has increased in recent years (Jordan and Javernick-Will, 2012). Several public and private organizations have conducted assessments, created indices, and published reports in an effort to inform stakeholders about how they may improve the resiliency of their community systems. Community groups have partnered with local, state, and federal agencies and researchers to conduct resiliency studies and provide tools to plan for and recover from disaster impacts.

Federal agencies play a central role in disaster recovery research and management and in supporting state and local entities following a federal disaster or emergency declaration (Robert T. Stafford Act 2013). As part of its mission to protect human health and the environment, EPA works to ensure that communities and environmental and ecological systems thrive. When these systems experience a natural disaster or other hazard, EPA assists in responding to events by identifying risks and deploying personnel and technology to address impacts to both people and the environment. EPA has long been a lead agency in responding to oil spills and releases of hazardous chemicals under the National Oil and Hazardous Substances Pollution Contingency Plan and the National Response Framework (40-CFR-300, 1994). More recently, EPA's role in disaster recovery is being identified and defined under the National Disaster Recovery Framework (NDRF) and Presidential Policy Directive 8 (PPD-8). This directive discusses how federal agencies and departments can help communities reach preparedness goals. The NDRF, along with other frameworks for prevention, protection, mitigation, and response, provide guidance for identifying roles and responsibilities, improving coordination, and enhancing the overall process of building disaster resilience.

3. EPA Disaster Response and Recovery

The environmental risks associated with disasters are numerous, and impacts can be severe as disasters routinely interrupt critical environmental services and ecosystem function. Environmental systems like drinking water and wastewater systems can flood, rupture, be contaminated, or lose power due to hazards such as earthquakes, hurricanes, tornadoes, or intentional events. Ecosystems alike can be eroded, stripped of trees and other vegetation, littered with debris following a disaster, and further affected by contaminants released from impacted facilities. Disasters may also cause extensive pollution, both in air and water, and have implications for human health. Hurricane Sandy alone caused over $4 billion in damages to water infrastructure. More than 10 billion gallons of untreated and partially treated sewage spilled into waterways, wetlands, and even city streets (Climate Central, 2013). Structures affected by flooding grew mold and homes and industries unintentionally released hazardous wastes and chemicals, exposing people and wildlife to dangerous materials and prompting broad cleanup actions.

EPA has assisted state and local communities following many types of disasters. In response to the Deepwater Horizon oil spill in 2010, EPA mobilized available technologies to provide air monitoring data, implement sampling plans for areas affected by the oil and cleanup operations, and advise the U.S. Coast Guard and state and local agencies on potential risks of the spill to human health and aquatic life (USEPA 2013a). With five state governors and other federal agencies, EPA now co-chairs the Gulf Restoration Commission that manages the distribution of funds for Gulf Coast recovery efforts. Immediately following the major tornado that struck Joplin, Missouri, in 2011, EPA responded similarly. EPA deployed personnel to address critical human health and environmental hazards, helped coordinate the removal of hazardous waste from impacted areas, and conducted air monitoring for the presence of particulate matter and asbestos that may have been released (USEPA 2014a).

Response efforts like these usually last for several weeks following an event and are intended to identify and provide for the immediate health and safety needs of the affected communities. Traditionally, EPA has filled this role as an emergency response agency. With the issuance of

PPD-8 addressing national preparedness, security, and resilience, along with the NDRF, EPA and other federal agencies have responsibilities that go beyond response into the recovery phase. Though EPA does not coordinate efforts for recovery, it plays a significant supporting role in each of six Recovery Support Functions (Federal Emergency Management Agency, FEMA 2011a) outlined in the NDRF:

- Community Planning,
- Housing,
- Infrastructure,
- Health and Social Services,
- Economic Recovery, and
- Natural and Cultural Resources

Designated offices and programs within EPA work with other federal agencies and departments under these Functions to address long-term economic, social, and environmental recovery. EPA has continued to support efforts through the recovery phase by providing air and water monitoring, soil sampling, funding, and advising on remediation and rebuilding projects for both Deepwater Horizon and the Joplin tornado disasters.

Like its response capabilities, EPA's recovery actions began with a focus on remediating contamination, pollution, and chemical releases. EPA has since expanded its capabilities to engage in an "all-hazards approach" (Figure 2), committing resources for recovery and resilience to all types of disasters or emergencies that require long-term remediation (most often disasters of national significance when states request federal assistance). Recovery operations, in contrast to response efforts, last months or years following a disaster. They may involve actions such as providing funds for long-term risk and vulnerability assessments, sampling, analysis, and remediation efforts (as was done in Joplin), or supporting management of disaster debris. In many cases, repairing and upgrading damaged infrastructure is also necessary. These recovery projects, rather than returning the community to its previous state, should enhance community resilience to and assist in preparing for and mitigating the effects of the next disaster.

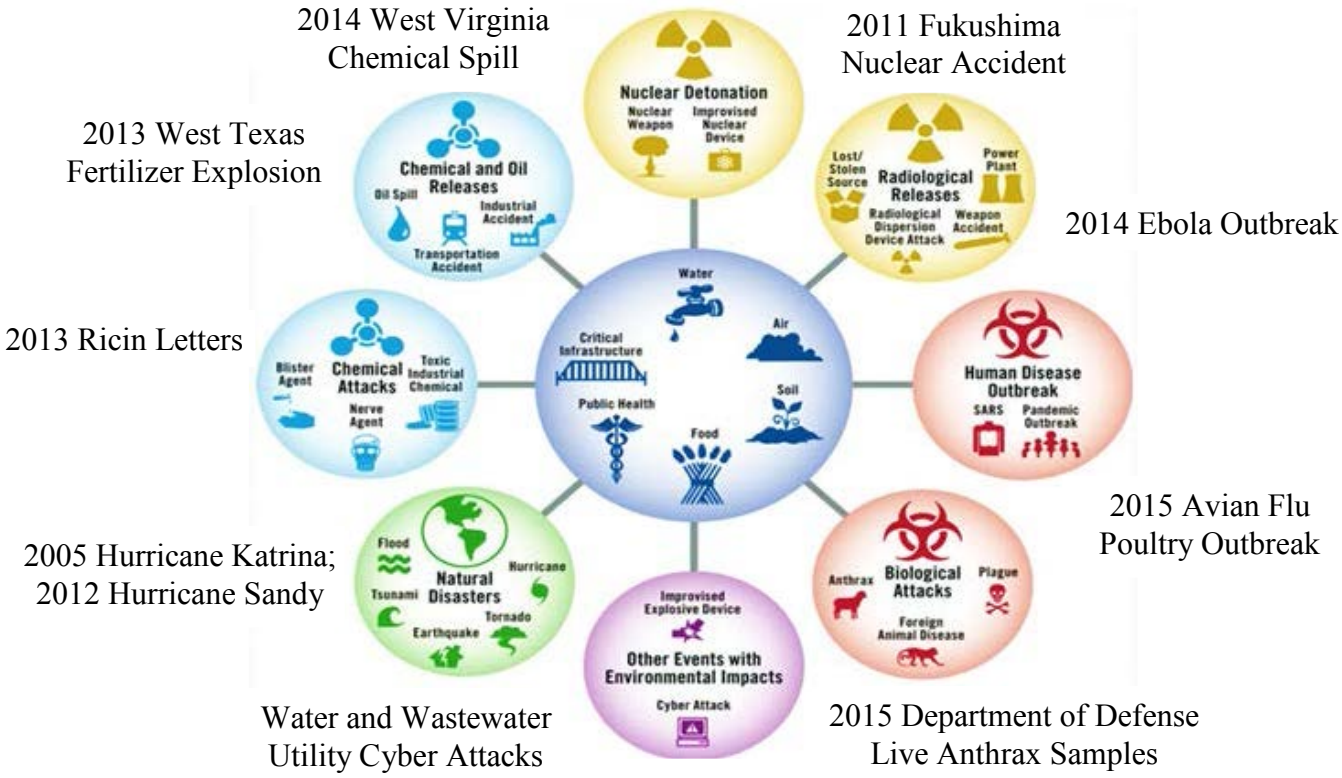

Figure 2. All-Hazards Threats to Health and Environment
Adapted from U.S. EPA. 2011. Refining EPA's Strategic Approach to Homeland Security

As evidenced by the Deepwater Horizon Oil Spill, disasters can have lasting, widespread effects. Under PPD-21, EPA is the sector-specific agency for addressing the security and resilience of critical water and wastewater systems and infrastructure. After Hurricane Sandy devastated much of New Jersey and New York in 2012, EPA helped with a number of response efforts, including screening and monitoring air for hazardous chemicals, sampling water and assessing contaminated sites, and managing debris (USEPA 2013b). Many drinking water distribution networks and wastewater treatment plants were severely damaged due to flooding, contamination, or power loss. Due to releases of untreated wastewater, surrounding habitats were polluted and many people were exposed to pathogens. Even today, several water systems continue to require repairs. To support these repairs and further recovery-phase efforts, EPA agreed to provide more than $500 million in grants to the states of New York and New Jersey for improving their water and wastewater facilities (USEPA 2013c). These projects must build resilience into their systems and may include incorporating green infrastructure practices or supplying and protecting backup renewable energy technologies and resources.

While beginning to address resilience, EPA also continues to promote sustainability. Sustainability is the concept and process that creates and maintains the conditions under which humans and nature can exist in productive harmony and that permits fulfilling the social, economic, and other requirements of present and future generations (USEPA). Resilience supports sustainability. Communities must be resilient to disasters to maintain or rapidly regain

proper functioning, protect human health and environmental and economic resources, and mitigate disaster impacts. Preparing for and recovering more quickly from disasters can allow communities to better protect and sustain their resources and achieve their sustainability goals. Rebuilding following an event then becomes a process of adjusting to "new normals" that make communities more sustainable and resilient to future disruptions.

Not all resilience projects may promote sustainability, however, and vice versa. For example, building levees may enhance resilience by protecting against flooding, but building levees can be detrimental to achieving sustainability by disturbing natural habitat or disrupting ecological processes. Alternatively, designing communities to be more interconnected can help them achieve sustainability by reducing resource burdens and pollution, but such action may not be resilient if communities build in areas with high flooding risks. Still, there are opportunities to develop and implement plans that provide complementary resilience and sustainability benefits. Renewable energy facilities can be built to withstand potential storm surges or power outages, or wetlands can be restored to act as natural buffers to flooding and to provide ecosystem services like storm water filtration. Enhancing aquatic resources can attract economic activities which in turn drive sustainability. Projects such as these that enhance both the resiliency and sustainability of a system should be considered and prioritized whenever possible.

To support resilience efforts when responding to natural and man-made disasters, EPA has deployed a number of tools and technologies to support state and local agencies, utilities, and local communities in addressing their environmental concerns. In addition to tools such as mobile laboratories and modeling software, EPA also maintains guidance documents, databases, and other tools that were developed for a range of applications and stakeholders. During recovery operations, EPA has partnered with other federal agencies and communities to provide knowledge, expertise, and tools for managing air quality, drinking water, and green infrastructure. Many of these tools, though not designed specifically for resiliency purposes, have been applicable to disaster management and recovery; other tools may be applicable, as well.

4. Inventorying Resilience Tools

This report reviews many of the tools EPA has available for federal partners, state and local governments, utilities, communities, and individuals that may be applied to help prevent, prepare for, protect against, respond to, and recover from natural disasters, hazardous chemical, biological, radiological, or nuclear events, or other incidents that pose threats to human health and the environment. Tools and technologies that were developed for responding to and recovering from chemical, biological, radiological, and nuclear incidents may also be successful when used in recovering from natural disasters and other types of hazards. This effort is meant to respond to, in part, *The Hurricane Sandy Rebuilding Strategy*, which was issued to help provide information and highlight further research needs for disaster recovery following Hurricane Sandy in 2012. The *Rebuilding Strategy* specifically calls for "packag[ing] the variety of existing Federal resources and tools related to disaster recovery to… streamline access to recovery expertise needed by impacted communities" (p. 138), as well as "ensuring that personnel have the appropriate skills and tools related to... recovery planning" (p. 129). The purpose of this review is to present an inventory of available EPA tools, consider how these tools may be

utilized in real-time to help communities enhance their resiliency and recover more quickly from disturbances, and identify future resiliency research and technology needs.

Within EPA's Office of Research and Development, the National Homeland Security Research Center (NHSRC) organized an innovative research team to consider concepts, applications, and audiences for developing a Community Environmental Resilience Index (CERI). As part of this effort, the CERI team defined "community environmental resilience" as "minimizing environmental risks associated with disasters, quickly returning critical environmental and ecological services to functionality following an event, and applying this learning process to reduce vulnerabilities and risks to future incidents." Other public and private research entities such as the National Academy of Sciences and the National Institute of Standards and Technology have begun programs focused on community and disaster resilience, but comparatively little attention has been paid specifically to environmental resilience (National Institute of Standards and Technology, NIST 2015; NRC 2012). This report is designed to support CERI team research and provide information regarding tools that can help improve environmental resilience and address this research gap.

Hereafter referred to as tools, all materials referenced in this report, including databases, guidance documents, models, software, programs, and applications were all developed wholly or in part by EPA for a variety of purposes. A table summarizing each tool and a potential resilience application is provided. Information for each tool was gathered from EPA websites and documents or through collaborations and partnerships with EPA personnel who have experience developing, maintaining, or deploying the tools for use. Some of the tools require training, registration, or other prior experience to be fully understood and effectively applied. Tools were included in this report if it was determined, in consultation with developers and owners, that it could be applied for purposes of building environmental resilience of communities. There may be other EPA materials and tools not present in this report such as Geographic Information System (GIS) maps or fate and transport models that may be used directly or indirectly to support other aspects of disaster preparedness, response, and recovery.

4.1. Tool Identification and Collection

Tools were collected through extensive searches of EPA websites and through cooperation and consultation with members of other EPA regional offices and programs. These tools are designed to provide a wide range of end-users such as individual community members, water utilities, and emergency planners, managers, and responders with information and guidance regarding many issues. Some issues include levels of chemical exposure and corresponding human health effects, waste management planning methods, detecting and remediating drinking water system contamination or disruption, planning for natural and man-made disasters, sustainability projects, and modeling environmental conditions across scales and regions. Since few tools were developed with a specific focus on environmental resilience, but instead were created for these more general environmental management purposes, only those tools identified as sufficiently addressing the criteria included in the environmental resilience definition were considered as potential "resilience tools" for this project.

The Environmental Protection Agency offers hundreds of tools for public use. Over 400 were considered for this report, including tools addressing exposure, toxicity, air quality, and many

other environmental issues. Some were developed specifically to aid in improving resilience, while others address broader aspects of the environment, infrastructure, and human health. EPA also hosts webpages with general information, tips, and processes for building mitigation plans and other resilience-related endeavors.

After determining which tools are specific to the criteria within the definition of environmental resilience, assist in long-term recovery actions or bouncing back from a disaster, and assist in planning, preparing for, and/or mitigating the next event, 90 are included in this report.[1] These tools include guidance documents for developing emergency response and recovery plans, models for soil deposition and groundwater transport, and tools for integrating waste management and green infrastructure practices into response and recovery operations. Some are purely informational, while others describe specific actions for users to take. Each may apply to environmental resilience in some way, whether by informing preparedness and hazard mitigation or by guiding response and recovery actions.

4.2. Guidance Documents

Guidance documents developed by EPA include guidelines, frameworks, manuals, "how-to" guides, reports, and handbooks that inform or provide step-by-step approaches for identifying and addressing potential environmental harms and conducting recovery efforts. One such report is "*Planning for an Emergency Drinking Water Supply*" (USEPA 2011). This report reviews actions utilities may take to ensure they can obtain, maintain, and provide treated water to customers if there is a disruption in service due to a natural or man-made disaster. The report also addresses alternative methods of supplying water and how to do so in an emergency. "*Planning for Natural Disaster Debris*" is another document that provides steps to plan for community management of debris prior to the incident, which is a critical element in building community resiliency. In future updates, "*Planning for Natural Disaster Debris*" will also include elements of resilience specifically, as well as climate-related adaptation information.

The guide entitled "*Enhancing Sustainable Communities with Green Infrastructure*" is designed to help local communities consider green infrastructure practices. It details strategies for organizing stakeholders, developing a community sustainability plan, and monitoring and evaluating progress toward both sustainability and resilience goals. The guide suggests green infrastructure practices that have a host of benefits. Mitigating stormwater runoff and pollution while also improving resilience to flooding and climate change impacts are two outcomes of these efforts that also allow for many other economic, environmental, health, and social benefits. Other guidance documents for water utilities address emergency response plans, proper disposal of contaminated water, and disaster recovery funding opportunities.

4.3. Tools

Software, applications, computer programs, and toolkits (collections of tools) are all considered "tools" in this report. EPA has continued to develop and update a number of tools for use by communities, utilities, and others for a variety of purposes. The tools collected for this report address issues such as contaminant detection in drinking water systems and estimating

[1]The other tools reviewed but not included in this report may still apply to resilience in other contexts.

concentrations of chemical releases to air, water, and land. These tools may include such systems as CANARY (USEPA 2012) and the Threat Ensemble Vulnerability Assessment Sensor Placement Optimization Tool (TEVA-SPOT) that work to rapidly detect abnormal conditions in water quality that may point to infrastructural issues like pipe damages or incidents of contamination.

Other tools available for disaster planning, response, and recovery efforts include some tools for procuring funding, managing waste, and monitoring pollutant discharges and watershed impacts. *Fed FUNDS* is a tool available to state and local utilities that allows utilities to obtain information about federal disaster and mitigation funding during all stages of planning for and recovering from a disaster. The *Incident Waste Assessment and Tonnage Estimator (I-WASTE)* tool, though designed generally to assist waste managers in determining how to handle, transport, treat, and dispose of the waste and debris generated by a disaster, can also be used prior to an event. Emergency responders, planners, utilities, all levels of government, or other decision-makers can register and use I-WASTE (USEPA 2013d) to pre-designate waste disposal sites and transportation routes. This can serve to better prepare recovery personnel for managing the debris that can result from a disaster before it occurs.

4.4. Models

Models allow users to incorporate environmental information to simulate real world systems. Users may input and alter values of environmental conditions, such as land cover type or rainfall amount, to obtain different results that may better fit their needs or address a specific scenario. The models presented here can be used to address disaster scenarios, and all have been developed and are maintained by US EPA. One model, the *Multimedia Contaminant Fate, Transport, and Exposure Model (MMSOILS)*, can be used as a tool for hazard identification and evaluation as well as recovery. MMSOILS estimates human exposure to hazardous waste site contamination releases through different exposure pathways (i.e., ingestion, inhalation, or consumption) and associated health risks. After using the model to showcase these risks and hazards, users can compare remediation activities across sites. Experts then can use the results of the model to inform their long-term cleanup methods.

The *Exposure Analysis Modeling System (EXAMS)* is another such model that can be used to measure and track the release of chemical contaminants. It can also determine how long it will take for an affected aquatic ecosystem to be purified naturally following contamination. If a community experiences a synthetic chemical spill or incident involving pesticides or industrial materials, EXAMS may be used to evaluate hazards by examining exposure, fate, and transport of the chemical. Technical leaders of recovery efforts may use EXAMS to investigate chronic (long-term) exposure and follow up with actions that may be necessary if natural persistence of the contamination poses any risks to human or environmental health.

4.5. Databases

The databases maintained by US EPA allow users to search for environmental information such as chemical toxicity data and human health effects of environmental contaminants. These data can be used to predict risk and exposure and inform decision-making about remediation and recovery efforts following a disaster. The *Drinking Water Treatability Database (DTB)* contains referenced information on a number of potential water contaminants as well as treatment

information for each contaminant. Users can either select a contaminant of concern or a treatment process to determine how they can prepare for, respond to, and recover from a water contamination event. Another database, the *International Stormwater Best Management Practices (BMP) Database*, is a collaborative effort among EPA and other research organizations, federal agencies, and technical associations. The BMP Database houses studies, tools, guidance documents, and other publications that provide information on designing, improving, and utilizing stormwater best management practices. Communities can use the database and its resources to implement stormwater mitigation projects and reduce vulnerabilities associated with flooding and stormwater events.

4.6. GIS Mapping Tools

Mapping tools, those that give users the ability to map environmental information, may also be used to support community resilience. These tools can map demographic and health data, air and water quality conditions, regulated facility locations, and other information across scales from local to national. Community-level GIS tools, such as the *MyEnvironment* application, allow users to select a location and subsequently view air, water, energy, health, and land data. Reports on local environmental conditions are also available, as is the ability to "shout out" and promote community environmental projects that are underway. Such actions can help users become more familiar with and advance recovery efforts at the community level following a disaster. *EnviroAtlas* is another GIS application with interactive tools and resources that combine maps, fact sheets, analysis tools, and data. *EnviroAtlas* can be used to analyze interactions between ecosystems and the communities that depend on them and determine potential impacts of various planning decisions.

5. Current Use of EPA Tools

Many of the tools presented in this report have been used for addressing disaster scenarios and recovery, and others can be used as well. One general modeling tool that simulates surface water jets and plumes, the *Visual Plumes* modeling system, was used following Hurricane Katrina. Water from flooded regions of New Orleans had been pumped into surrounding lakes, and simulations made through this modeling system helped to evaluate the impact of water and sediment discharges from these lakes into surrounding areas (USEPA 2014b). After heavy rains flooded the state of Vermont during Hurricane Irene, EPA worked with local communities to develop the guide "*Planning for Flood Recovery and Long-Term Resilience in Vermont*" and identified how improving collaboration among agencies and implementing smart growth strategies within the guide can enhance resilience and recovery.

EPA has also helped respond to hazardous chemical releases by informing decision-makers about exposures and health risks of hazardous chemicals. Chemical exposure information was provided to emergency responders for use following incidents of ricin contamination in Washington D.C., releases of toxic industrial chemicals in Texas, and sulfur mustard gas exposures during and following a Massachusetts incident. Such exposure information might also be applied in forward-looking exercises to identify exposure levels that would help emergency responders protect themselves and residents of an affected area from potential hazards in the event of a future incident.

Communities have used other tools as well in all stages of the resilience process. Both prior to and after recovering from events, users have applied the *Storm Water Management Model (SWMM)* to thousands of systems throughout the world, using the tool to map flood plains, design flood control measures, and investigate water quality and pollutant levels. In response to the release of pollutants and contaminants, EPA's *Portable High-throughput Integrated Laboratory Identification System (PHILIS)*, a network of mobile laboratory units, has been deployed in exercises to aid in sampling and analyzing affected areas. PHILIS can operate in response to all-hazards and facilitate more efficient site assessment and cleanup operations. EPA's "*Planning for Natural Disaster Debris"* document has been used by many communities to develop Debris Management Plans that allow them to respond and recover from natural disasters more effectively. The document contains case studies of actual disasters and integrates the experiences of the communities that have used the document into the recommendations section. "*Planning for Natural Disaster Debris"* continues to be distributed to state and local communities to enhance their disaster preparedness and response capabilities.

The use of these tools demonstrates their capabilities to enhance the resilience of communities to disasters. Still, opportunities are available for further research and application of all the tools in this inventory.

5.1 Using Tools to Strengthen Community Resilience

As the sector-specific agency for protecting water infrastructure, EPA hosts several tools for managing drinking water and wastewater systems. Some tools specifically encourage water and wastewater security and resilience activities, like the *Community-Based Water Resiliency Tool (CBWR)*. Other tools focus on contaminants, model water flow and distribution, or inform decisions about mitigating effects of climate change on water infrastructure, like the *Climate Ready Water Utilities Toolbox*, which hosts the *Climate Resilience Evaluation and Awareness Tool (CREAT)*. CANARY and TEVA-SPOT are two water infrastructure tools that can be used together at all stages of the resilience process to help protect against, prevent, mitigate, respond to, and recover from disasters. Both are designed for use by water utilities, whether public or private. TEVA-SPOT informs optimal placement of water quality sensors, and CANARY monitors data from these sensors and alerts operators of data anomalies that may indicate potential contamination.

Prior to a disaster, a drinking water utility operator can use CANARY and TEVA-SPOT as early warning and contaminant detection systems. Using tools like EPANET-RTX and the Water Security Toolkit further enable water utilities to design and evaluate response plans and actions relative to contamination events in near real-time. Testing these plans and their effectiveness will help better prepare managers and first responders as well. Taken together, these actions help mitigate potential effects to the water distribution system and to the community at large if an event does occur. Following the event, managers can execute a more rapid, practiced, and targeted response that can limit the extent of the damage. Continuous monitoring during long-term recovery following a disaster, such as during cleanup and repairs of affected infrastructure, can help utilities better address water quality issues, apply their knowledge to design more resilient systems, and continue to provide adequate service to customers.

Designing a more resilient water system means developing a more resilient community. Utilities can use the "*Planning for an Emergency Drinking Water Supply*" guidance to prepare for disturbances in drinking water distribution, respond to these disturbances efficiently, and recover from them quickly. By following the steps in this guidance document, utilities can better plan for supplying potable water during an emergency. The guidance shows how to develop a response plan that considers how a disruption may occur, how alternative sources of water will be secured, and how, where, and when that water will be treated, stored, and distributed (Figure 3, *adapted from "Emergency Drinking Water Supply"*). The guidance also suggests that utilities consider when they might need outside assistance. If a community's water needs cannot be met following an event, then the utility needs to implement a plan that addresses what types of resources they might require and how to communicate such a request to potential supporting agencies.

Key to an effective emergency drinking water supply plan is identifying the assets, roles, and responsibilities of these supporting agencies. The tool helps to identify which utilities and local, state, federal, or nongovernmental agencies may become involved following an event. If an event is extensive enough that local resources are exhausted, then it may warrant state or federal action. The "*Emergency Drinking Water Supply*" guidance contains information on how the utility can liaise with these external supporting groups to effectively execute their response. For long-term recovery efforts, the guidance notes how utilities can request that a governor seek Stafford Act funding. These funds are targeted primarily for immediate emergency response efforts, but they may also be provided for long-term infrastructure repair and recovery as well. CANARY, TEVA-SPOT, and the "*Emergency Drinking Water Supply*" guidance are just a few examples of the many tools and guidance documents EPA has developed to address water sector emergency planning, disaster response and recovery funding, and contaminant identification and cleanup.

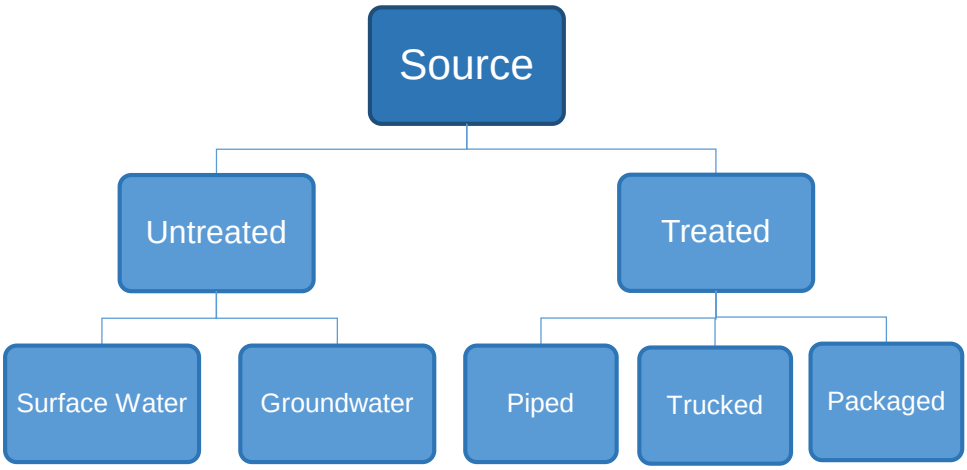

Figure 3. Sources, Types, and Methods of Distribution for Emergency Drinking Water

6. Opportunities for Partnerships in Resilience

Whether to secure water resources in the face of flooding risks or properly and efficiently dispose of hazardous waste following a disaster, communities can use these resilience tools to aid their efforts. Partnering with stakeholders is essential for applying these tools, testing their efficacy, and ensuring communities have access to and successfully use them. EPA Regional disaster recovery personnel can help work with their communities and promote these tools. Outside of EPA, other federal agencies and departments, nonprofit organizations, and institutions can begin and have begun programs and conducted outreach efforts to address community resilience needs.

After experiencing hurricanes, floods, tornadoes, and other disasters, a number of regional offices throughout EPA have expressed interest in field testing tools that can help improve their resilience. In EPA Region 1, Vermont suffered tremendous harm as a result of Tropical Storm Irene and associated flooding in 2011. Bridges were destroyed, hundreds of miles of roadways were damaged, hazardous chemicals were released into waterways, and the drinking water supply in many areas was compromised. Total damages were estimated at $175-250 million (Vermont Agency of Natural Resources 2012). As a result of Irene, Vermont communities have begun to consider their vulnerabilities to disasters, how green infrastructure practices may reduce flooding impacts, and how they can better mitigate and recover from the next storm. EPA has already been offering technical assistance for recovery efforts. There are additional opportunities to help these communities prepare for future flooding. Using the *Emergency Drinking Water Supply* guidance, Vermont communities can plan for disruptions in their water infrastructure, as occurred with Irene. This guidance can inform communities about how they can secure other sources of clean and safe drinking water in the face of disaster.

Flooding similarly devastated many areas of Colorado in EPA Region 8 in September 2013, with deluges of precipitation amounting to more than ten times average levels in some areas (National Oceanic and Atmosphere Administration, NOAA 2013). Just over one year later, communities in Colorado are still recovering from the flooding and working to become more resilient to all-hazards. EPA's *Flood Resilience Guide* is an interactive tool for utilities that can be helpful to Colorado towns and cities, such as Boulder, that have identified community risks and needs to further address how they can prepare for floods, mitigate impacts, and recover quickly (City of Boulder 2013). The guide walks users through a process for increasing a utility's resilience to flooding that includes completing worksheets and watching informational videos (USEPA 2014c). The process includes convening relevant stakeholders to discuss responsibilities, identify threats and assets, evaluate mitigation options, and create a plan to implement flood mitigation measures. A number of potential mitigation measures for drinking water and wastewater utilities are documented along with their relative costs.

The guide also highlights resources that communities can take advantage of for resilience. In addition, it provides an example of a pilot project. By using the approach outlined within the guide, a small drinking water utility in the Northeast successfully implemented a plan for flood resilience. Although the guide specifically addresses flooding, the authors note that the process it lays out can be useful for enhancing resilience to other hazards as well. As evidenced by the pilot project, using the guide to address flood risks will allow for observable progress toward more resilient communities that improve essential functions and reduce potential harm.

Hurricane Sandy prompted widespread action on disaster preparedness, response, and recovery due to the extent of its damage throughout communities along the East Coast. As part of the Hurricane Sandy Rebuilding Task Force, EPA has supported response and recovery efforts in impacted cities and states. Following sewage overflows and the flooding of residences, water utilities, and commercial facilities, both New York and New Jersey issued boil water advisories for millions of residents, some lasting more than three weeks after the Hurricane struck (New York State Department of Health 2012; New Jersery Department of Environmental Protection 2012). EPA Region 2 immediately conducted sampling of potentially contaminated areas, helped pump out flood waters, and assessed a number of drinking water and wastewater facilities for damages, helping to restore power and repair equipment. Some water systems continue to need repairs, and the many tools EPA has that are related to building resilience into drinking water infrastructure can provide a host of benefits to utilities and the communities they serve. EPA tools such as the *All-Hazards Preparedness, Mitigation, Response, and Recovery Checklist* address what actions state drinking water programs should consider before, during, and after an event. EPA's guidance documents and tools such as these can assist communities in incorporating flood management, green infrastructure practices, and sustainability into community and utility planning and action.

The tornado that struck Joplin, Missouri, in 2011 destroyed thousands of structures and scattered more than 1.5 million cubic yards of hazardous waste and debris across the city (FEMA 2011b). How to dispose of this large amount of waste, transport it, and handle the hazardous materials and contaminated areas properly was one of many issues Joplin faced for months after the disaster. EPA and Region 7 worked with Joplin to designate hazardous waste sites and provide funding for ongoing soil sampling and remediation activities (USEPA 2014a). I-WASTE, hosts waste management information that can help local officials and state agencies create incident response plans. I-WASTE assists users with waste management by granting access to available waste treatment and disposal facility databases, guidance documents, and debris and waste estimators. To mitigate and recover quickly from potential future events, Joplin and other communities can use I-WASTE to consider waste disposal options and locations ahead of time (Figure 4, *adapted from I-WASTE report*).

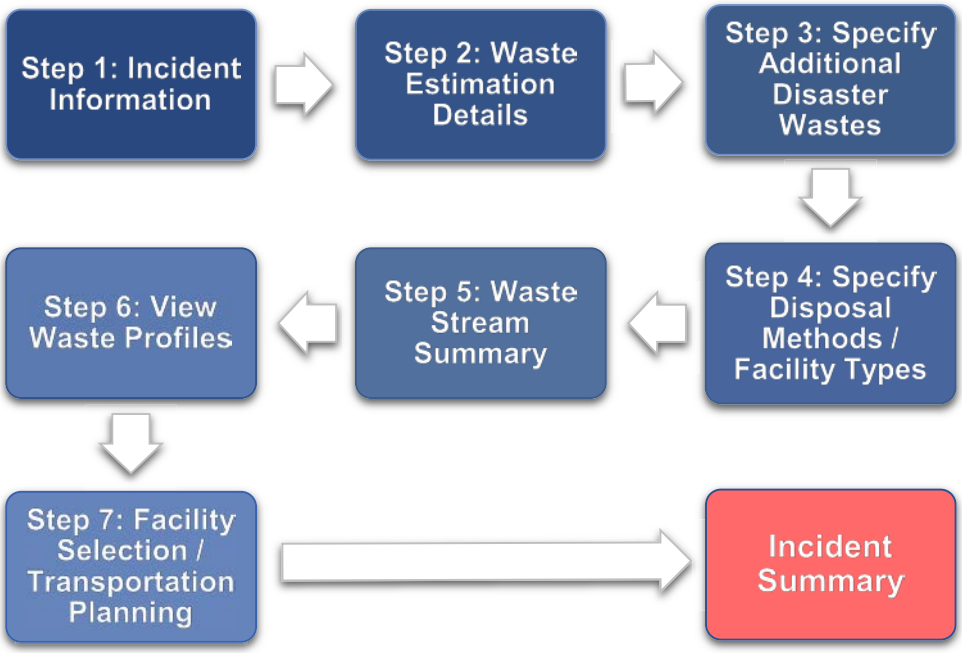

Figure 4. I-WASTE Natural Disaster Incident Planning Scenario Process

EPA has already taken advantage of opportunities for partnering with organizations outside the agency. Through a Memorandum of Understanding, EPA has partnered with the Rockefeller Foundation's *100 Resilient Cities* program. Cities selected by this project receive funding for a Chief Resiliency Officer, technical assistance to develop a strategy for resilience, and access to innovative tools (The Rockefeller Foundation 2014). EPA is working towards this effort by sharing knowledge, innovations, and tools for resilience with member cities so that they may meet their sustainability and resilience goals. EPA has also partnered with the United Nations Office for Disaster Risk Reduction's R!SE initiative to support creating more resilient communities. Across federal agencies and departments, efforts such as the Department of Housing and Urban Development's (HUD's) National Disaster Resilience Competition offer similar benefits. Providing tools to the 67 states, districts, territories, and cities that are eligible for the competition can help them create innovative plans for resilience that better prepare them for future events and improve their capacity to recover as well. Partnering with environmental justice communities, those communities that are particularly vulnerable to environmental and health hazards or experience them disproportionately, offers another opportunity to apply these tools in the areas that need them most.

7. Further Research Needs

As described in this report, many tools exist to help communities enhance their resilience. Still, many are not recognized or put into practice because they are yet to be distributed or are generally unknown to the communities who can utilize them. For instance, the tools currently maintained by EPA are located on different web pages throughout the epa.gov site, making them more difficult to locate. Expanding outreach and communication is essential for ensuring that city planners, community officials, emergency responders, and recovery personnel know what

tools are available and what issues they can address. Expansion of outreach can be done through workshops, education programs, and collaborations with local organizations. Generally categorizing tools, clearly communicating the required level of expertise, and hosting them in one centrally located website or database can make the tools easier to access and explore as well. Efforts to do so are already underway at the federal level, as the recent launch of disasters.data.gov shows. This website hosts links to disaster resilience tools, data sets, and challenges innovators to consider new ideas, tools, and solutions to disaster issues. Many more tools are available to be showcased, and new partners can contribute innovations as well. With further developments, the website could become an essential database for disaster resilience information from all types of organizations. EPA is also engaging in efforts to offer training and develop a network of EPA regional disaster recovery contacts and specialists who will apply these and other tools and help further resilience research and applications.[2]

With regard to creating new tools and improving upon existing tools, developers should consider how they can address community needs. They should involve communities before, during, and after the development process. This way, communities can inform tool designers about the types of issues they are facing and the types of tools that would be most suitable to their needs. Making these tools openly accessible, distributable, and understandable to the general public will allow more users to take advantage of their benefits. When using the tools, communities should also provide feedback on their effectiveness, ease of use, and how they might be updated to address other salient issues the community faces. Through these collaborations and by listening to community concerns, developers can create even more valuable tools for disaster resilience that communities can comprehend and easily apply.

For measuring the success of these available tools and their applications, measuring resilience is key. However, the data on community and environmental resilience topics are relatively sparse and neither consistent nor systematic. There are technical and research gaps that still need to be addressed with regard to how to measure resilience, what types of resilience metrics and indicators are appropriate, and how these metrics can be applied across different temporal and spatial scales (McAllister 2013). Though indicators for risk reduction are available, recovery metrics specifically are lacking (Jordan and Javernick-Will 2012). Researchers need to consider how to measure the ability of critical infrastructure to recover from an event, how natural systems are impacted, how social factors might influence recovery, and how applying tools for resilience actually enhances a community's ability to prevent, mitigate, respond to, and recover from a disaster (NRC 2012). EPA's NHSRC is responding to this gap in resilience indicators in part by working to identify indicators of environmental resilience and develop quantitative metrics for drinking water system resilience to disasters, which will be included in their Water Network Tool for Resilience (WNTR).

8. Conclusion

Tools for enhancing resilience are being developed by federal and state agencies and departments, private organizations and utilities, community groups, and others. Further research following this report could be to collect these tools and identify which are most useful to communities, how they can gain access to the tools, and how they can best apply the tools to fit

[2] http://www.epa.gov/homeland-security/epas-role-disaster-recovery

their needs. Some organizations like Rockefeller and HUD have taken steps to collect these tools and put them into practice in partnership with communities. Though beyond the scope of this report, determining what resources are available across the federal government is perhaps a next step in detailing further opportunities for resilience research and assessment at the federal level. This determination can also help inform what actions to take regarding the development and application of new tools for resilience. Collaborating with stakeholders is essential to this process.

Preparing for and recovering from disasters requires many different efforts at the community, state, regional, and federal level. The tools presented in this report address a variety of topics and are meant to serve as a sample of the EPA resources available to users to improve local capacity and enhance their environmental resilience to all-hazards. Some focus on specific disasters, such as floods or chemical contamination, or address general issues of waste cleanup, infrastructure repair, and environmental conditions prior to or following any type of disaster. Others serve as guidance for how to implement protection and response plans and receive funding for recovery efforts. Field testing these tools, some of which have been developed for homeland security or other purposes, may prove to be useful when applied in an all-hazards context. Tools created specifically for emergency response and recovery may also be used for planning and better preparing communities for future disasters. Communities most in need can utilize these tools, serving to broaden their applicability and offer additional benefits as well. Though addressing issues individually can be effective, considering a more comprehensive approach to tool development may prove to be more beneficial. Enhancing resilience to all types of hazards requires concerted efforts to research, consider options, take action, apply the tools presented here and elsewhere, and measure community progress throughout long term disaster recovery and sustainability efforts.

Appendix A

Table 1: EPA resilience tools, access link, and resilience application

Tool Name	Access Link	Description or Potential Resilience Application
Contamination, Exposure, and Contaminant Cleanup		
Aggregated Computational Toxicology Online Resource (ACTOR)	http://actor.epa.gov/actor/faces/ACToRHome.jsp	Inform decisions on chemical toxicity, contaminants, and their health and environmental effects by reviewing data
ASPECT (Airborne Spectral Photometric Environmental Collection Technology)	http://www.epa.gov/emergency-response/aspect	Detect and map chemical and radiological contamination through airborne remote sensing
CAMEO (Computer-Aided Management of Emergency Operations)	http://www.epa.gov/cameo/what-cameo-software-suite	Help plan for and respond to chemical emergencies by providing emergency managers a suite of tools to access, store, and evaluate information for developing emergency plans
EcoToxicology Database (EcoTox)	http://cfpub.epa.gov/ecotox/	Inform decisions about chemical toxicity and effects on aquatic life, terrestrial plants, and wildlife
Environmental Response Laboratory Network (ERLN) [including Water Laboratory Alliance]	http://www.epa.gov/emergency-response/environmental-response-laboratory-network	Support response and recovery efforts following Chemical, Biological, and Radiological (CBR) events by providing laboratory testing capabilities and capacity
EPA-Expo-Box (Exposure Toolbox)	http://www.epa.gov/expobox	Learn about and assess exposure by accessing exposure assessment tools, guidance documents, models, etc.
Exposure Analysis Modeling System (EXAMS)	http://www.epa.gov/exposure-assessment-models/exams-version-index	Examine and evaluate fate, transport, and short-long term exposure and persistence of certain chemical contaminants in the environment
Integrated Risk Information (IRIS) Database	http://www.epa.gov/iris	Inform decisions for risk, exposure, and health effects of over 500 chemicals within database
Interim Clearance Strategy for Environments Contaminated with Anthrax	http://www.epa.gov/emergency-response/epacdc-interim-clearance-strategy-environments-contaminated-anthrax	Inform decisions and approaches for remediating indoor and outdoor areas contaminated with anthrax
Multimedia Contaminant Fate, Transport, and Exposure Model (MMSOILS)	http://www.epa.gov/exposure-assessment-models/mmsoils	A screening tool that can be used to analyze movement of chemicals through the environment and routes that may result in human exposures
Portable High-throughput Integrated Laboratory Identification System (PHILIS)	http://www.epa.gov/emergency-response/chemical-biological-radiological-and-nuclear-consequence-management#PHILIS	Mobile lab that can conduct rapid on-site analysis of contaminated environments and detect chemical warfare agents and toxic industrial chemicals in samples
Provisional Peer Reviewed Toxicity Values (PPRTVs)	http://hhpprtv.ornl.gov/	Inform decisions for risk related to certain chemicals at Superfund sites
Risk-Screening Environmental Indicators (RSEI)	http://www.epa.gov/rsei	Analyze data about toxic substance releases from facilities in an area and identify situations that may pose threats to human health and require further evaluation and action

Selected Analytical Methods for Environmental Remediation and Recovery (SAM) 2012	http://www.epa.gov/homeland-security-research/sam	Determine which analytical methods to use on environmental samples following a contamination event
TAGA: Trace Atmospheric Gas Analyzer buses	http://www.epa.gov/ert/environmental-response-team-trace-atmosphere-gas-analyzer-taga	A screening tool that can conduct instant-result monitoring of air quality to help inform air quality assessments and response actions
Drinking Water and Wastewater		
Adaptation Strategies Guide	http://www.epa.gov/crwu/climate-adaptation-strategies-guide-and-toolbox-training-water-utilities	Prepare utility facilities for climate-related impacts and incorporate sustainable practices into adaptation measures
Alarm Estimation Tool (AET)	http://www.epa.gov/waterqualitysurveillance/customer-complaint-surveillance-resources	Develop alarm thresholds for the customer complaint surveillance component of a surveillance and response system
All-Hazard Consequence Management Planning for the Water Sector	http://www.awwa.org/portals/0/files/legreg/security/allhazard.pdf	Develop response plans that can reduce the public health and economic consequences of both natural and man-made threats that may impact water facilities
Better Assessment Science Integrating point & Non-point Sources (BASINS)	http://www.epa.gov/exposure-assessment-models/basins	Determine action steps by assessing the effects of different climate change scenarios on streamflow and water quality
Bridging the Gap: Coordination between State Primacy Agencies and State Emergency Management Agencies	http://www.epa.gov/communitywaterresilience/collaboration-between-state-water-primacy-agencies-and-emergency-management	Assist in preparing for emergency response to incidents that require state involvement by coordinating and collaborating with the public water and emergency management sectors
CANARY	https://software.sandia.gov/trac/canary	Monitor water quality, detect contaminants and alert operators to water quality changes in water distribution networks
Climate Ready Water Utilities Toolbox	http://www.epa.gov/crwu	Integrate climate mitigation and adaptation efforts into long-term planning and review models, tools, and other resources for climate change preparedness and response
Climate Resilience Evaluation & Awareness Tool (CREAT)	http://www.epa.gov/crwu/assess-water-utility-climate-risks-climate-resilience-evaluation-and-awareness-tool	Assess climate change threats and risks, explore long-term impacts, and evaluate & implement mitigation and adaptation strategies
Collaborative State-Level Water Sector Emergency Response Exercises 2009-2011: Lessons Learned	http://www.epa.gov/waterresiliencetraining/learn-state-water-emergency-response-exercises	Prepare for emergency response by reviewing lessons learned from EPA-sponsored water sector emergency response exercises
Community-Based Water Resiliency Tool (CBWR)	http://www.epa.gov/communitywaterresilience/community-based-water-resiliency-tool	Gauge current preparedness efforts, utilize tools and resources for resilience, and increase community awareness of including the water sector in emergency planning

Containment and Disposal of Large Amounts of Contaminated Water: A Support Guide for Water Utilities	http://www.epa.gov/watertilityresponse/containment-and-disposal-large-amounts-contaminated-water	Provides recommendations for containment, treatment, and disposal of contaminated water within water systems
Decontamination and Recovery Planning - Water and Wastewater Utility Case Study	http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P1001KL7.txt	Provides a case study based on how a utility coordinates, plans, and prepares for response and recovery from a contamination event
Drinking Water Advisory Communication Toolbox	http://www.cdc.gov/healthywater/emergency/dwa-comm-toolbox/index.html	Plan for, develop, implement, and evaluate drinking water advisories and communications with partners and the public
Drinking Water Treatability Database (DTB)	http://iaspub.epa.gov/tdb/pages/general/home.do	Control drinking water contamination by accessing and applying information on contaminants and methods for treatment
Effective Risk and Crisis Communication During Water Security Emergencies: Report Of EPA Sponsored Message Mapping Workshops	http://cfpub.epa.gov/si/si_public_record_report.cfm?subject=Homeland%20Security%20Research&dirEntryId=165863	Effectively communicate risks and properly answer questions prior to and following an incident by applying message mapping methods
Effective Utility Management: A Primer for Water and Wastewater Utilities	http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P10053BJ.txt	Assess utility system performance and develop, implement, and evaluate plans for improvements in stability, sustainability, and operational resiliency
Emergency Response Plan Guidance for Small and Medium Community Water Systems	http://www.epa.gov/watertilityresponse/emergency-response-plan-guidance-small-and-medium-community-water-systems	Develop, revise, and update effective emergency response plans for various major events
Emergency Response Plan Guidance for Wastewater Systems	deq.mt.gov/wqinfo/pws/security/EmergencyPreparedness/VA_ERP/WastewaterERPguidance04.pdf	Support the development of wastewater system emergency response plans by providing information regarding content, structure, training, and evaluation
EPANET-MSX (multi species extension)	http://www.epa.gov/water-research/epanet	Help maintain and improve water quality, model fate, transport, and reactions of chemical and biological species, and enhance overall resilience by modeling drinking water distribution systems
EPANET-RTX (real time extension)	http://www.wateranalytics.org/epanet-rtx/	Help maintain and improve hydraulic and water quality performance by performing real time model simulations of hydraulic and water quality behavior in drinking water distribution networks
Federal Funding for Utilities – Water/Wastewater – in National Disasters (Fed FUNDS)	http://www.epa.gov/fedfunds	Obtain information about taking advantage of federal disaster and mitigation funding before, during, and after a disaster
Flood Resilience: A Basic Guide for Water and Wastewater Utilities	http://www.epa.gov/watertilityresponse/flood-resilience-basic-guide-water-and-wastewater-utilities	Understand flooding threats, identify vulnerable assets, and evaluate mitigation options

Incident Command Tool For Protecting Drinking Water (ICWATER)	http://ofmpub.epa.gov/sor_internet/registry/systmreg/resourcedetail/general/description/description.do?infoResourcePkId=11956	Assist incident commanders in modeling drinking water contamination in real-time for a rapid, effective emergency response after a source water contamination event
Large Water System Emergency Response Plan Outline: Guidance to Assist Community Water Systems in Complying with the Bioterrorism Act	http://www.epa.gov/wateutilityresponse/emergency-response-plan-guidance-large-community-water-systems	Prepare emergency response plans and identify plans, procedures, and equipment to implement or utilize in the event of an attack
Moving Toward Sustainability: Sustainable and Effective Practices for Creating Your Own Water Utility Roadmap	http://www.epa.gov/crwu/sustainable-practices-water-utilities	Develop sustainability plans and follow practices that help utilities become more resilient to disasters and address other environmental, economic, and health challenges
Need to Know: Anticipating the Public's Questions during a Water Emergency	http://cfpub.epa.gov/si/si_public_record_report.cfm?address=nhsrc/&dirEntryId=240476	Help improve emergency response by providing information on effectively communicating risks and properly answering questions prior to and following an incident
PIPELINENET	http://ofmpub.epa.gov/sor_internet/registry/systmreg/resourcedetail/general/description/description.do?infoResourcePkId=11893	Simulate and model fate and transport of contaminants in water distribution systems and help estimate risk and respond to a water contamination event
Planning for an Emergency Drinking Water Supply	http://cfpub.epa.gov/si/si_public_record_report.cfm?address=nhsrc/&dirEntryId=235197	Plan for and respond to disruptions in drinking water services
Planning for Sustainability: A Handbook for Water and Wastewater Utilities	http://www.epa.gov/crwu/sustainable-practices-water-utilities	Integrate sustainable practices into water utility planning that also help improve operational resilience
Public Assistance for Water and Wastewater Utilities in Emergencies and Disasters	http://www.epa.gov/waterresilience/public-assistance-water-and-wastewater-utilities-emergencies-and-disasters	Learn how to procure funding for disasters under FEMA's Public Assistance Grant Program
Reimbursement Tips for Water Sector Emergency Response and Recovery	http://www.epa.gov/fedfunds/reimbursement-tips-water-sector-emergency-response-and-recovery	Learn how your utility can be reimbursed for costs associated with a disaster
Resource Guide to Effective Utility Management and Lean	http://permanent.access.gpo.gov/gpo53052/eum-lean-guide.pdf	Reduce waste, improve service, and enhance resilience to environmental and safety risks
Drinking Water Utility Response Protocol Toolbox (DWRPTB)	http://www.epa.gov/wateutilityresponse/drinking-water-and-wastewater-utility-response-protocol-toolbox	Includes six interrelated modules designed to help drinking water utilities to plan for, investigate, and respond to distribution system contamination incidents

Rural and Small Systems Guidebook to Sustainable Utility Management	http://www.epa.gov/small-and-rural-wastewater-systems/rural-and-small-systems-guidebook-sustainable-utility-management	Create plans for improving management, performance, and resilience by following the ten key management areas of sustainably managed utilities
State Drinking Water Program All-Hazard Preparedness, Mitigation, Response and Recovery Checklist	http://www.epa.gov/communitywaterresilience/state-drinking-water-program-all-hazard-preparedness-mitigation-response	Support and sustain preparedness, response, and recovery by reviewing actions to be considered before, during, and after an emergency
Tabletop Exercise Tool for Water Systems: Emergency Preparedness, Response, and Climate Resiliency (TTX Tool)	http://www.epa.gov/waterresiliencetraining/develop-and-conduct-water-resilience-tabletop-exercise-water-utilities	Plan, conduct, and evaluate tabletop exercises addressing an all-hazards approach to emergency preparedness and response as well as climate change
Threat Ensemble Vulnerability Assessment - Sensor Placement Optimization Tool (TEVA-SPOT)	https://software.sandia.gov/trac/spot	Perform contaminant consequence assessments and optimize sensor placement to detect, evaluate, and mitigate impacts of water distribution system contamination incidents
Threshold Analysis Tool (TAT)	http://www.epa.gov/waterqualitysurveillance/customer-complaint-surveillance-resources	Detect water quality anomalies or contamination events using customer complaint surveillance as an alert mechanism
Top Ten List for Small Ground Water Suppliers	http://www.epa.gov/wateutilityresponse/top-ten-list-small-ground-water-suppliers-security-and-emergency-response	Provides tips to protect facilities from contamination incidents and to prepare for emergencies
Vulnerability Self-Assessment Tool (VSAT)	http://www.epa.gov/waterriskassessment/conduct-drinking-water-or-wastewater-utility-risk-assessment	Determine utility vulnerabilities to natural and man-made hazards and evaluate options to enhance system resilience
Wastewater Response Protocol Toolbox (WWRPTB)	http://www.epa.gov/wateutilityresponse/drinking-water-and-wastewater-utility-response-protocol-toolbox	Provides emergency response planning tools that are designed to help in protecting wastewater systems from contamination events and incidents
Water Contamination Information Tool (WCIT)	http://www.epa.gov/waterlabnetwork/access-water-contaminant-information-tool	Plan for and respond to contamination events by using database information on chemical, biological, and radiological contaminants of concern for water security
Water Health and Economic Analysis Tool (WHEAT)	http://www.epa.gov/waterriskassessment/find-out-about-health-and-economic-impacts-water-utility-emergencies	Assist utility owners and operators in quantifying an adverse event's public health consequences (i.e. injuries and fatalities, utility-level financial consequences, direct and indirect regional economic consequences, and downstream impacts

Water Quality Surveillance and Response Systems	http://www.epa.gov/waterqualitysurveillance	Enhance a drinking water utility's capability to quickly detect and respond to water quality incidents that occur in distribution systems with this framework designed to support monitoring and management of distribution system water quality
Water Resiliency Action Planner Kit	http://www.epa.gov/communitywaterresilience/community-based-water-resiliency-tool	Enhance response capabilities by discussing roles & responsibilities for hospitals, emergency services, major water users, public officials and stakeholders during water service interruptions
Water Security Toolkit	https://software.sandia.gov/trac/wst	Reduce the impact of water contamination incidents by aiding in identifying the contamination injection location and informing decision making for response, remediation, and recovery
Water/Wastewater Agency Response Networks (WARN)	http://www.epa.gov/waterutilityresponse/mutual-aid-and-assistance-drinking-water-and-wastewater-utilities	Provides an avenue for water/wastewater utilities to receive emergency assistance in the form of personnel, equipment, materials or other associated services as necessary from other water/wastewater utilities while responding to or recovering from an emergency
Water/Wastewater System Generator Preparedness	http://www3.epa.gov/region1/eco/drinkwater/pdfs/WaterWastewaterSystemGeneratorPreparedness.pdf	Prepare for a disaster or loss of service by learning how to run and maintain backup generators
Ecosystem and Human Health		
Database of Sustainability Indicators and Indices (DOSII)	E-Database in development	Identify specific indicators for measuring sustainability and may provide information on indicators of hazard and disaster vulnerability or resilience for community decision-making
EJSCREEN	http://www.epa.gov/ejscreen	Identify communities potentially overburdened with environmental issues and support decision-making for human health and environmental wellbeing
EnviroAtlas	http://www.epa.gov/enviroatlas	Access, view, and analyze data, tools, and other resources, and information about ecosystem services and their human health benefits and explore how decisions can affect ecological and human health outcomes
Envirofacts	http://www3.epa.gov/enviro/	Inform mitigation efforts by applying database information on toxic air releases, water discharge, hazardous waste, and other environmental activities affecting air, water, and land
Integrated Climate and Land-Use Scenarios (ICLUS) Online	http://cfpub.epa.gov/ncea/global/recordisplay.cfm?deid=257306	Inform decision-making and facilitate vulnerability assessments by providing national projections of future housing density, population and impervious surface consistent with global, peer-reviewed scenarios of climate and demographic change.
MyEnvironment	http://www.epa.gov/enviro/myenvironment-how-use-page	Integrate environmental and health data at the community level using maps based on a user's location and use "Shout out" function to report on local environmental efforts

Stormwater and Flood Management		
Enhancing Sustainable Communities with Green Infrastructure	http://www.epa.gov/smartgrowth/enhancing-sustainable-communities-green-infrastructure	Enhance community resilience by helping communities better manage stormwater to achieve environmental, public health, social, and economic benefits
Green Long-Term Control Plan-EZ Template: A Planning Tool for Combined Sewer Overflow Control in Small Communities	http://www.epa.gov/green-infrastructure/green-infrastructure-modeling-tools	Control combined sewer overflows and manage stormwater in communities by applying recommended green infrastructure practices
International Stormwater Best Management Practices Database	http://www.bmpdatabase.org	Investigate and apply best practices for managing stormwater using available guidance documents, tools, and reports
National Stormwater Calculator (SWC)	http://www.epa.gov/water-research/national-stormwater-calculator	Determine which Low Impact Development (LID) controls support stormwater management under different environmental conditions and climate scenarios
Planning for Flood Recovery and Long-Term Resilience in Vermont: Smart Growth Approaches for Disaster-Resilient Communities	http://www.epa.gov/smartgrowth/planning-flood-recovery-and-long-term-resilience-vermont	Enhance flood resilience and disaster recovery capabilities by following outlined approaches and strategies
Sanitary Sewer Overflow Analysis and Planning (SSOAP) Toolbox	http://www.epa.gov/water-research/sanitary-sewer-overflow-analysis-and-planning-ssoap-toolbox	Design focused field investigation plans for sanitary sewer condition assessment, assess the effectiveness of sewer rehabilitation programs, and support wastewater infrastructure improvements
Storm Water Management Model (SWMM)	http://www.epa.gov/water-research/storm-water-management-model-swmm	Determine which LID and green infrastructure projects are effective in managing stormwater and combined sewer overflows
System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN)	http://www.epa.gov/water-research/system-urban-stormwater-treatment-and-analysis-integration-sustain	Evaluate alternatives for stormwater management and select stormwater best management practices in urban watersheds
Waste and Debris		
Guide for Industrial Waste Management	http://www3.epa.gov/epawaste/nonhaz/industrial/guide/index.htm	Assess risks associated with and become knowledgeable of industrial waste and waste management processes
Incident Waste Assessment & Tonnage Estimator (I-WASTE)	http://www2.ergweb.com/bdrtool/login.asp	Provides access to technical information, regulations, and guidance on waste characterization, treatment, and disposal options, and how to incorporate waste management into planning, response and disaster recovery activities
Municipal Solid Waste Decision Support Tool (MSW-DST)	https://mswdst.rti.org/	Evaluate costs and environmental aspects of integrated waste management strategies and can be used to evaluate options for reducing air pollution and environmental releases to water and land

Planning for Natural Disaster Debris	http://www3.epa.gov/epawaste/conserve/imr/cdm/pubs/pndd.pdf	Contains recommendations, debris management options, available resources, and community case studies to help communities develop or revise disaster debris management plans
RDD Waste Estimation Support Tool (W EST)	http://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=246738&fed_org_id=1253&address=nhsrc/&view=desc&sortBy=pubDateYear&showCriteria=1&count=25&searchall=Disposal%20OR%20landfill%20OR%20leachate	Generate estimates of quantity and characteristics of waste following a wide-area radiological event and evaluate strategies for decontamination and disposal
Watershed and Water Modeling		
Automated Geospatial Watershed Assessment Tool (AGWA)	http://www.epa.gov/water-research/automated-geospatial-watershed-assessment-agwa-tool-hydrologic-modeling-and-watershed	Identify problem areas in watersheds where mitigation measures can be focused, and provide decision support for watershed planning efforts based on variable scenarios and conditions prior to or following an event
Handbook for Developing Watershed Plans to Restore and Protect Our Waters (and Supplemental Documents)	http://www.epa.gov/polluted-runoff-nonpoint-source-pollution/handbook-developing-watershed-plans-restore-and-protect	Create and implement plans for protection or remediation of watersheds
Sea Level Rise Coastal Property Model	http://ofmpub.epa.gov/sor_internet/registry/systmreg/resourcedetail/general/description/description.do?infoResourcePkId=11967	Estimate the response to and economic impacts of sea level rise and storm surge on coastal properties in the lower 48 states
Visual Plumes	http://www.epa.gov/exposure-assessment-models/visual-plumes	Simulate surface water movement and evaluate impact of discharge flows on water quality
Water Erosion Prediction Project Climate Assessment Tool (WEPPCAT)	http://cfpub.epa.gov/ncea/global/recordisplay.cfm?deid=153583	Evaluate the effectiveness of different strategies for managing impacts of climate change on erosion and sediment loading to streams
Watershed Management Optimization Support Tool (WMOST)	http://www2.epa.gov/exposure-assessment-models/wmost-10-download-page	Evaluate the environmental and economic costs, benefits, trade-offs and co-benefits of various watershed planning and management options (prior to or following an event, e.g. flood or drought)
Watershed Plan Builder	http://java.epa.gov/wsplanner/#	Create plans for recovering and restoring polluted or impaired watersheds

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