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Report to Congressional Committees

January 2010

COMBATING NUCLEAR TERRORISM

Actions Needed to Better Prepare to Recover from Possible Attacks Using Radiological or Nuclear Materials

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GAO-10-204

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Highlights

Highlights of GAO-10-204, a report to congressional committees

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Actions Needed to Better Prepare to Recover from Possible Attacks Using Radiological or Nuclear Materials

Why GAO Did This Study

A terrorist's use of a radiological dispersal device (RDD) or improvised nuclear device (IND) to release radioactive materials into the environment could have devastating consequences. GAO was asked to examine (1) the extent to which the federal government is planning to fulfill its responsibilities to help cities and their states clean up contaminated areas from RDD and IND incidents, (2) what is known about the federal government's capability to effectively clean up these contaminated areas, and (3) suggestions for improving federal preparedness to help cities and states recover from these incidents. The report also discusses recovery activities in the United Kingdom. GAO reviewed federal laws and guidance; interviewed officials from the Department of Homeland Security (DHS), Federal Emergency Management Agency (FEMA), Department of Energy (DOE), and Environmental Protection Agency (EPA); and surveyed emergency management officials from 13 cities at high risk of attack, their 10 states, and FEMA and EPA regional offices.

What GAO Recommends

GAO recommends that, among other things, FEMA prepare a national recovery strategy that clarifies federal roles for cleaning up areas contaminated by attacks using RDDs or INDs, and schedule additional exercises to assess recovery preparedness. DHS and DOE agreed with our recommendations, and EPA did not agree or disagree with them.

View GAO-10-204 or key components.
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What GAO Found

FEMA, the DHS agency responsible for developing a comprehensive emergency management system, has not developed a national disaster recovery strategy, as required by law, or issued specific guidance to coordinate federal, state, and local government recovery planning for RDD and IND incidents, as directed by executive guidance. To date, most federal attention has been given to developing a response framework, with less attention to recovery. Responding to an attack would involve evacuations and providing treatment to those injured; recovering from an attack would include cleaning up the radioactive contamination to permit people to return to their homes and businesses. Existing federal guidance provides limited direction for federal, state, and local agencies to develop recovery plans and to conduct exercises to test recovery preparedness. Of the over 90 RDD and IND exercises to test response capabilities in the last 6 years, only 3 included a recovery component. GAO's survey found that almost all 13 cities and most states believe they would need to rely heavily on the federal government to conduct and fund analysis and environmental cleanup activities. However, city and state officials were inconsistent in views on which federal agencies to turn to for help, which could hamper the recovery effort.

Although DOE and EPA have experience cleaning up localized radiation-contaminated areas, it is unclear whether this federal capability is sufficient to effectively direct the clean up after RDD or IND incidents, and to efficiently address the magnitude of cleanup that would follow these incidents. According to an expert at DOE's Idaho National Laboratory, experience has shown that not selecting the appropriate decontamination technology can generate waste types that are more difficult to remove than the original material and can create more debris requiring disposal—leading to increased costs. Limitations in laboratory capacity to rapidly test potentially millions of material samples during cleanup, and uncertainty regarding where to dispose of radioactive debris could also slow the recovery process. At least two-thirds of the city, state, and federal respondents expressed concern about federal capability to provide the necessary cleanup actions after these incidents.

Nearly all survey respondents had suggestions to improve federal recovery preparedness for RDD and IND incidents. For example, almost all the cities and states identified the need for a national disaster recovery strategy to address gaps and overlaps in federal guidance. All but three cities wanted additional guidance, for example, on monitoring radioactivity levels, cleanup standards, and management of radioactive waste. Most cities wanted more interaction with federal agencies and joint exercising to test recovery preparedness. Finally, GAO's review of the United Kingdom's preparedness to recover from radiological terrorism showed that it has already taken actions similar to those suggested by GAO's survey respondents, such as issuing national recovery guidance, conducting a full-scale recovery exercise, and publishing national recovery handbooks for radiation incidents.

Contents

Figure

Abbreviations

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DHS	Department of Homeland Security
DOD	Department of Defense
DOE	Department of Energy
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FRMAC	Federal Radiological Monitoring and Assessment Center
IMAAC	Interagency Modeling and Atmospheric Assessment Center
IND	improvised nuclear device
NNSA	National Nuclear Security Administration
NRC	Nuclear Regulatory Commission
RDD	radiological dispersal device

GAO
Accountability * Integrity * Reliability

United States Government Accountability Office
Washington, DC 20548

January 29, 2010

The Honorable Bennie G. Thompson
Chairman
The Honorable Peter T. King
Ranking Member
Committee on Homeland Security
House of Representatives

The Honorable Yvette D. Clarke
Chairwoman
The Honorable Daniel E. Lungren
Ranking Member
Subcommittee on Emerging Threats, Cybersecurity,
and Science and Technology
Committee on Homeland Security
House of Representatives

The Honorable Michael T. McCaul
Ranking Member
Subcommittee on Intelligence, Information Sharing, and
Terrorism Risk Assessment
Committee on Homeland Security
House of Representatives

A terrorist's use of either a radiological dispersal device (RDD)—frequently referred to as a dirty bomb—or an improvised nuclear device (IND) to release radioactive materials into the environment could have devastating consequences. However, quickly analyzing and cleaning up contaminated areas from such an incident, particularly from an RDD attack, could speed up the recovery and allow restoration of normal operations of critical infrastructure, services, businesses, and public activities, thus reducing the many adverse consequences from an attack of this kind. Responding to such an attack would involve evacuations, providing medical treatment to those who were injured, and protecting property; recovery would include cleaning up areas contaminated with radioactive materials in order to permit people to return to their homes and businesses. According to a 2008 report of the National Science and Technology Council, which coordinates science and technology policy within the Executive Office of the President, the ability of government to quickly and decisively respond to and recover from an RDD or IND incident is key to national resiliency.[1] Importantly, the council noted that being prepared to recover from these incidents may even provide an element of deterrence if the adversary perceives less potential for long-lasting harm.

The consequences of a terrorist attack using an RDD or IND would include not only loss of life, but also enormous psychological and economic impacts. An RDD would disperse radioactive materials into the environment through a conventional explosive or through other means. Depending on the type of RDD, the area contaminated could be as small as part of a building or a city block or as large as several square miles. Hundreds of individuals might be killed or injured from the RDD explosion or face the risk of later developing cancer due to exposure to radiation and radioactive contamination. An IND is a crude nuclear bomb made with highly enriched uranium or plutonium. It would create an explosion producing extreme heat, powerful shockwaves, and intense radiation that would be immediately lethal to individuals within miles of the explosion, as well as radioactive fallout over thousands of square miles. Nonproliferation experts estimate that a successful IND could produce the same force as the equivalent of the yield of the bomb that destroyed Nagasaki, Japan in 1945; it could devastate the heart of a medium-sized U.S. city. The explosion could cause hundreds of thousands of deaths and injuries, as well as pose long-term cancer risks to those exposed to the radioactive fallout. An RDD is thought to be a more likely terrorist weapon than an IND given the prevalent commercial use of radioactive source material—for example, in some medical and industrial equipment—and the relatively easy way in which this material could be dispersed through conventional explosives, like dynamite, or other means.

If an RDD or IND incident occurred, as part of the recovery process, a number of federal, state, and local government departments and agencies would be involved in the analysis and environmental cleanup of areas contaminated with radioactive materials. Generally, state and local governments have primary responsibility for recovering from disasters, but the federal government may provide assistance when an incident exceeds state and local government resources or when an incident is managed by federal agencies under their own authorities or occurs within federal jurisdiction (e.g., on a military base or a federal facility or lands).

[1]National Science and Technology Council, *Roadmap for Nuclear Defense Research and Development: Fiscal Years 2010-2014* (Washington, D.C., July 2008).

The Department of Homeland Security (DHS) is the principal federal agency responsible for domestic incident management. The primary mission of its Federal Emergency Management Agency (FEMA) is to develop a comprehensive emergency management system of preparedness, protection, response, recovery, and mitigation. For an RDD or IND incident, DHS would be the lead agency in coordinating federal assistance to state and local governments. For these incidents, DHS would have responsibility for coordinating the federal response, with the support of other federal agencies, to assist state and local governments in the analysis and environmental cleanup of areas contaminated with radioactive materials. For example, in certain circumstances, the Department of Energy (DOE) would have primary responsibility for coordinating the analysis or characterization of areas contaminated with radioactive materials through its leadership of the interagency Federal Radiological Monitoring and Assessment Center (FRMAC).[2] The Environmental Protection Agency (EPA) would take over leadership of FRMAC for coordinating the long-term monitoring of radiological contamination and supporting the detailed assessment of property contamination in the affected areas to support the cleanup of these areas. The Department of Defense (DOD), along with other agencies, would act in support of FRMAC. Federal agencies, including EPA, DOE, and the Nuclear Regulatory Commission (NRC), as well as state regulatory agencies have set various cleanup standards for areas contaminated with radioactive materials, but not specifically for RDD or IND incidents. The national laboratories have also provided research support assessing methods and technologies for analysis and environmental cleanup activities.

The risk of terrorists using an RDD or IND is, in large part, determined by their ability to gain access to the materials needed to construct these devices. Over the past few years, we have issued a number of reports on the security of nuclear and radiological materials and facilities that house them. Overall, our work has shown that despite investing billions of dollars in new technology to upgrade security procedures, gaps continue to exist in our nation's ability to prevent terrorists from accessing or smuggling dangerous quantities of radioactive material into the country. For example, in 2007, we testified before Congress that our own

[2]FRMAC is responsible for coordinating all environmental radiological monitoring, sampling, and assessment activities for the federal response to a radiological release into the environment.

investigators were able to set up phony businesses and obtain a legitimate NRC license that would have permitted them to obtain dangerous quantities of radioactive material.[3] Our investigators were able to obtain this NRC license just months after NRC had completed a lengthy process to strengthen its licensing procedures. In 2008, we reported that NRC, in developing its security requirements for research reactors, had not fully considered the risks associated with terrorists attacking these facilities—many of which are located on college campuses.[4] Such an attack could involve terrorists sabotaging a reactor in order to disperse radioactive material over neighboring communities—similar to an RDD. We have also reported on DHS's and FEMA's preparedness for, response to, and recovery from disasters in 2007, 2008, and 2009.[5]

We were asked to review the federal government's preparedness to help cities and states recover from possible attacks using an RDD or IND. Accordingly, this report addresses the following: (1) the extent to which federal agencies are planning to fulfill their responsibilities to help cities and states clean up areas contaminated with radioactive materials from RDD and IND incidents, (2) what is known about the federal government's capability to effectively clean up areas contaminated with radioactive materials from RDD and IND incidents, and (3) suggestions from government emergency management officials for improving federal preparedness to help cities and states recover from RDD and IND incidents. In addition, we are providing information on actions taken in the United Kingdom to prepare for recovering from RDD and IND incidents.

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[3]GAO, *Nuclear Security: Actions Taken by NRC to Strengthen Its Licensing Process for Sealed Radioactive Sources Are Not Effective*,GAO-07-1038T (Washington, D.C.: July 12, 2007).

[4]GAO, *Nuclear Security: Action May Be Needed to Reassess the Security of NRC-Licensed Research Reactors,* GAO-08-403 (Washington, D.C.: Jan. 31, 2008).

[5]GAO, *Observations on DHS and FEMA Efforts to Prepare for and Respond to Major and Catastrophic Disasters and Address Related Recommendations and Legislation,* GAO-07-1143T (Washington, D.C.: July 31, 2007); *Actions Taken to Implement the Post-Katrina Emergency Management Reform Act of 2006,* GAO-09-59R (Washington, D.C.: Nov. 21, 2008); and *National Preparedness: FEMA Has Made Progress, but Needs to Complete and Integrate Planning, Exercise, and Assessment Efforts*, GAO-09-369 (Washington, D.C.: Apr. 30, 2009).

This report follows preliminary observations that we provided in testimony at a September 14, 2009, congressional hearing.[6]

To address these objectives, we examined pertinent federal law, presidential directives, and other executive guidance; interviewed cognizant officials from DHS, DOE, EPA, FEMA, NRC, and from both DOE and EPA national laboratories; and conducted a survey of emergency management officials in 13 cities considered to be at high or medium risk for an RDD or IND incident, officials in these cities' states, and federal emergency management officials in FEMA and EPA regional offices.[7] We also reviewed information on the number and type of RDD and IND response and recovery exercises that have been conducted in the last 6 years. Finally, we visited the United Kingdom to review its preparedness to recover from RDD and IND incidents at the suggestion of EPA officials and because it has addressed a fairly recent radiological release incident in a large urban area. Appendix I provides more detail on our scope and methodology.

We conducted this performance audit from October 2008 to January 2010 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

In the aftermath of the terrorist attacks on September 11, 2001, security experts have raised concerns that terrorists may try to smuggle radiological or nuclear materials into the United States to produce either an RDD or IND. These experts have also raised concerns that terrorists could obtain radioactive materials used in medicine, research, agriculture, and industry to construct an RDD, or dirty bomb. This radioactive material

[6]GAO, *Combating Nuclear Terrorism: Preliminary Observations on Preparedness to Recover from Possible Attacks Using Radiological or Nuclear Materials,* GAO-09-996T (Washington, D.C.: Sept. 14, 2009).

[7]The high- and medium-risk cities are Boston, Chicago, Dallas, Denver, Detroit, Houston, Los Angeles, Miami, New York, Philadelphia, San Francisco, Seattle, and St. Louis. While Washington, D.C., is considered a high-risk city, we excluded it from our survey because it is unlike other cities in its reliance on the federal government and the federal agencies that would take over analysis and environmental cleanup activities.

is encapsulated, or sealed, in metal, such as stainless steel, titanium, or platinum, to prevent its dispersal and is commonly called a sealed radiological source. Sealed sources are used throughout the United States and other countries in equipment designed to, among other things, diagnose and treat illnesses, preserve food, detect flaws in pipeline welds, and determine the moisture content of soil. Depending on their use, sealed sources contain different types of radioactive material, such as strontium-90, cobalt-60, cesium-137, plutonium-238, and plutonium-239. While no terrorists have detonated a dirty bomb in a city, Chechen separatists placed a canister containing cesium-137 in a Moscow park in the mid-1990s. Although the device was not detonated and no radioactive material was dispersed, the incident demonstrated that terrorists have the capability and willingness to use radiological materials as weapons of terrorism. In contrast, detonating an IND would require a terrorist group to obtain nuclear weapons material—which is generally heavily secured—and to have highly sophisticated expertise and equipment to fabricate this material into a weapon.

Another form of nuclear terrorism occurred with the dispersal of radioactive materials through a sequence of events in London during November and December 2006. On November 23, 2006, Alexander Litvinenko, a former officer of the Russian Federal Security Service, was poisoned with a milligram of polonium-210—about the size of a grain of salt.[8] The dispersal of the polonium by the perpetrators of the crime and the victim resulted in widespread contamination across London and even abroad. His poisoning was detected only after he was hospitalized for a few weeks and tested for symptoms of radiation exposure because of hair loss. Following the poisoning, forensic investigators examined 47 sites across London for traces of polonium, both resulting from the handling of the polonium by his perpetrators and maybe other attempts to poison him. Of these locations, about 12 showed signs of this radioactive material, including a restaurant, hotel room, soccer stadium, and an eastbound British Airways plane. British investigators also identified over 1,000 people who might have been in various ways exposed to the polonium. Health officials tested 738 of them and found that 137 had reportable levels of this substance, although few of these individuals turned out to have levels that warranted medical attention. The decontamination activities at these sites spanned 19 days, involved a number of methods and

[8] British investigators believe that this pure polonium was probably produced in a Russian research reactor.

technologies, and cost more than $200,000. However, the estimated total cost of managing this incident, including law enforcement investigation, testing individuals, sampling materials, and cleanup, was $4 million.[9]

The Federal Government Has Not Completed Planning to Help Cities and States Clean up Areas Contaminated with Radioactive Materials from RDD or IND Incidents

FEMA has not completed planning to help cities and states recover from RDD or IND incidents as evidenced by not (1) developing a national disaster recovery strategy as required by law and (2) issuing specific guidance to coordinate federal, state, and city planning to recover from RDD or IND incidents. Moreover, federal agencies have conducted few exercises to test recovery plans for these incidents.

FEMA Has Not Developed a National Disaster Recovery Strategy to Help Guide RDD or IND Recovery Planning

FEMA has not developed a national disaster recovery strategy, as required by law and directed by executive guidance, or issued specific guidance to coordinate federal, state, and local government recovery planning for RDD or IND incidents. The Post-Katrina Emergency Management Reform Act of 2006 requires FEMA to develop, coordinate, and maintain a national disaster recovery strategy.[10] Among other things, the strategy is to clearly define the roles, programs, authorities, and responsibilities of each agency that may provide assistance to the recovery from a major disaster. In addition, the *National Strategy for Homeland Security* also called on the federal government to prepare a recovery strategy.[11] The federal government has placed a higher priority on developing a strategy to respond to domestic incidents, including RDD and IND incidents, than it has on developing a comparable strategy for recovering from these

[9]A.C. Perkins, “The London Polonium Poisoning: Events and Medical Implications,” *World Journal of Nuclear Medicine*, Vol. 6, No. 2, (April 2007) 102-106.

[10]The Post-Katrina Emergency Management Reform Act, Pub. L. No. 109–295, § 682, 120 Stat. 1355, 1445-46 (2006). The act also requires FEMA to submit a report to Congress within 270 days of enactment describing the strategy in detail.

[11]Homeland Security Council, *National Strategy for Homeland Security* (Washington, D.C., October 2007).

incidents. For example, the response strategy, captured in the 2008 *National Response Framework*, does not include guidance on long-term recovery activities.[12] The FEMA coordinator for the development of a national disaster recovery strategy told us that while the previous administration had drafted a "white paper" addressing this strategy, the new administration has decided to rethink the entire approach.[13] The FEMA coordinator also told us that FEMA recognizes its responsibility to prepare a national disaster recovery strategy but could not provide a time frame for its completion. This same official did say that in developing this strategy, FEMA plans to seek out opinions of nonfederal stakeholders. Once completed, the official said that the recovery strategy would provide guidance to federal, state, and local agencies in revising their operational plans for recovery activities, including recovery from RDD and IND incidents.

Currently, the limited federal planning guidance related to the recovery from RDD and IND incidents can be found in a number of documents. There are several annexes to the *National Response Framework* that address, in part, federal agency responsibilities and assets to help state and local governments recover from these incidents. For example, a December 2004 emergency support function annex covering long-term community recovery and mitigation, led by FEMA, provides a framework for federal support to localities to enable community recovery from the long-term consequences of events of national significance. While this annex addresses FEMA's responsibilities to coordinate the transition from response to recovery in field operations, it does not provide details on recovery planning for RDD and IND incidents. The January 2003 emergency support annex covering hazardous materials, led by EPA, provides the framework for federal support in response to an actual or potential discharge and release of hazardous materials following a major disaster or emergency. EPA officials informed us that this annex will give them a significant federal role in leading cleanup efforts after RDD or IND incidents, in coordination with affected state and local governments. The June 2008 nuclear and radiological incident annex describes federal

[12]In January 2008, DHS issued the *National Response Framework*, as an update of the 2004 and the 2006 *National Response Plan.* The framework provides a guide for how the nation should conduct all-hazard response, including the roles and responsibilities of federal agencies involved in response efforts.

[13]In our November 21, 2008 report (GAO-09-59R), we found that FEMA had drafted a national disaster recovery strategy but that it was under review at the time with no timeframe for completion.

responsibilities and provides some operational guidance for pertinent response activities and, to a lesser extent, recovery activities in support of state and local governments. DHS is identified as the technical lead for recovery activities, but may request support from other federal agencies—for example, EPA and the United States Army Corps of Engineers—that have cleanup and recovery experience and capabilities. According to this annex, the federal government, upon request of state and local governments, can assist in developing and executing recovery plans, but such plans would not generally be developed until after the incident occurs.

The lack of a national disaster recovery strategy that would include RDD and IND incidents is problematic because, according to survey respondents, most localities would count on the federal government being prepared to carry out analysis and environmental cleanup activities following these incidents. Specifically, emergency management officials from almost all 13 cities and most of their 10 states indicated in our survey that they believe they would need to rely heavily on the federal government to conduct and fund all or almost all analysis and environmental cleanup activities associated with recovering from an RDD or IND incidents of the magnitude described in the national planning scenarios. They indicated that their technical and financial resources would be overwhelmed by a large RDD incident—and certainly by an IND incident. Most of these officials reported that they believe they could adequately address a smaller RDD incident, such as one that is confined to a city block or inside a building. Despite this anticipated reliance on the federal government, we obtained mixed responses as to whether these RDD and IND recovery activities should be primarily a federal responsibility. Almost half of the respondents from the cities (6 of 13), but most of those from states (8 of 10), indicated that these activities should be primarily a federal responsibility. The others stressed the need for shared responsibilities with the federal government. However, when respondents were asked in our survey to identify which federal agencies they would turn to for help in the analysis and environmental cleanup of areas contaminated with radioactive materials from RDD or IND incidents, they provided inconsistent responses and frequently listed several federal agencies for the same activity. These responses seem to indicate that there might be some confusion among city and state emergency management officials regarding federal agency responsibilities to provide assistance to them under these circumstances. In our view, this confusion, if not addressed, could hamper the timely recovery from these incidents and demonstrates the need for development and implementation of a national disaster recovery strategy. In commenting on the draft report, EPA indicated that as no single federal department or agency has the sole requisite technical capacity and capabilities to respond to the scope of RDD or IND incidents, it is expected that numerous federal agencies would need to work together in a single mission, such as through FRMAC. Nevertheless, EPA stated that our survey results underscore the importance having clear communication and notification among federal agencies, which if not addressed, could hamper recovery efforts.

FEMA Has Not Issued Specific Guidance to Coordinate Federal, State, and City Planning to Recover from an RDD or IND Incidents

FEMA has not issued specific guidance describing how federal capabilities would be integrated into and support state and local plans for recovery from RDD or IND incidents,[14] as called for by presidential directive.[15] According to a senior FEMA official, the agency has delayed issuing this guidance pending the reevaluation of its planning approach by the new administration. However, a senior FEMA planning official told us that because FEMA is already aware that its planning system does not fully recognize the involvement of state and local governments, the agency is developing regional support plans—including for RDD and IND incidents—through its regional offices, which will reflect state and local government roles and responsibilities. Moreover, according to FEMA officials, in August 2008, DHS issued stop-gap guidance outside of FEMA's planning guidance framework to provide some immediate direction to federal, state, and local emergency response officials in developing their own operational plans and response protocols for protection of emergency workers after RDD or IND incidents.[16] In regard to recovery, EPA officials informed us that FEMA and other federal agencies worked together on this guidance in an attempt to clarify the processes for providing federal cleanup assistance following such an incident. These officials informed us that DHS's guidance was intended to cover the existing operational

[14]The planning for RDD and IND incidents is based on a national planning scenario for each incident. Scenario 11 represents a radiological attack using an RDD spreading contamination over 36 city blocks, causing hundreds of fatalities, costing billions of dollars in economic impacts, and taking months to years for recovery. Scenario 1 represents a nuclear detonation using a 10-kiloton IND spreading contamination over approximately 3,000 square miles, causing hundreds of thousands deaths, hundreds of billions of dollars in economic impacts, and taking years for recovery.

[15]Homeland Security Presidential Directive 8, Annex 1 (December 2007), titled National Planning, is intended to further enhance the preparedness of the United States by formally establishing, developing, and maintaining a standard and comprehensive approach to national planning.

[16]DHS, *Planning Guidance for Protection and Recovery Following Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) Incidents*, 73 Fed. Reg. 45,029 (Aug. 1, 2008).

guidelines for implementing the protective action guides and other response actions, and to encourage their use in developing specific response protocols. In responding to a draft of this report, EPA informed us that DOE had convened an interagency workgroup to address gaps in DHS's guidance and had issued a preliminary report, for comment by September 30, 2009, containing additional operational guidelines to respond to an RDD incident.[17] Moreover, these officials indicated that EPA has also worked with other federal agencies to examine its own 1992 protective action guides to address shortcomings and to incorporate more recent guidance.[18] However, according to EPA officials, much work remains to convert the new guidance into operational guidance. In addition, DOD has established operational plans for consequence management following terrorist incidents, including RDD and IND attacks.[19]

Without federal guidance for coordinating federal, state, and local planning for recovery from RDD or IND incidents, cities and states lack a framework for developing their own recovery strategies. Emergency management officials representing all 13 cities and their states in our survey indicated that while their jurisdictions had prepared emergency response and recovery plans for domestic incidents, few of these plans specifically addressed RDD and IND recovery activities, particularly for the analysis and environmental cleanup of areas contaminated with radioactive materials. For example, few city respondents (3 of 13) indicated that their recovery plans included preparations for an RDD incident, although respondents from two cities indicated that their cities were drafting these plans. In regard to IND preparation, all city respondents informed us that recovery planning was still important despite the magnitude of such events, but none of them had prepared such plans. Respondents from all states in our survey indicated that they had prepared emergency response plans for domestic incidents, and most of

[17] C. Yu et al., *Preliminary Report on Operational Guidelines Developed for Use in Emergency Preparedness and Response to a Radiological Dispersal Device Incident,* DOE/HS-0001, prepared for DOE, Office of Health Safety, and Security, February 2009.

[18] EPA, *EPA Guidance on the Optimization Process Following a Radiological Dispersal Device or Improvised Nuclear Device Incident* (Draft), and *Revisions to the Protective Action Guides Manual for Radiological Incidents* (Draft).

[19] We provided testimony on this DOD initiative in GAO, *Homeland Defense: Preliminary Observations on Defense Chemical, Biological, Radiological, Nuclear, and High-Explosive Consequence Management Plans and Preparedness,* GAO-09-927T (Washington, D.C.: July 28, 2009).

them (8 of 10) indicated that these plans included a recovery component. However, we were told that few of these recovery plans address an RDD incident, or specific analysis and environmental cleanup activities following such an incident, although respondents from 8 states mentioned that they planned to prepare such plans. The lack of recovery planning for RDD and IND incidents may be due, in part, to the relatively low priority given to preparing for them by city and state emergency management officials that we surveyed when compared with other types of risks facing their jurisdictions. For example, the majority of city respondents indicated that natural disasters, such as severe weather and infrastructure failure, were the most significant risks facing their jurisdictions.

Federal Agencies Have Conducted Few Exercises to Test Recovery Plans for RDD or IND Incidents

Federal agencies and local jurisdictions have used existing federal guidance as a basis for planning RDD and IND response exercises and, to a much lesser extent, recovery exercises to test the adequacy of their plans and level of preparedness. According to DHS guidance, preparedness is the foundation of a successful national incident management system involving all levels of government and other nongovernmental organizations as necessary.[20] The cycle of preparedness for prevention, protection, response, and recovery missions ends with adequate exercising, evaluation, and improvement. Our search of FEMA's National Exercise Schedule—a scheduling system for federal, state, and local exercises—revealed 94 RDD or IND response exercises planned and carried out by these authorities from May 2003 through September 2009. These exercises were identified as either full-scale, tabletop, workshop, seminar, functional, or a drill, and some locations have conducted several of them over a period of time. While many of these exercises listed both response and recovery objectives, as well as other exercise objectives, officials with FEMA's National Exercise Division told us that only three of them actually included a recovery component that exercised activities associated with environmental cleanup. However, our survey of city, state, and federal regional office emergency management officials found that many response and a few recovery exercises were conducted over the last 6 years that do not appear in FEMA's National Exercise Schedule. We previously reported that information in the National Exercise Schedule database was unreliable.[21] Nevertheless, for the purpose of this report, it is clear that very few RDD and IND response exercises have included a

[20] DHS, *National Preparedness Guidelines* (Washington, D.C., September 2007).

[21] GAO-09-369.

recovery component. According to National Exercise Division officials, a recovery discussion following an RDD or IND response exercise has typically not occurred because of the time needed to fully address the response objectives of the exercise, which are seen as a higher priority.

While two response exercises in 2003 and 2007 included brief follow on recovery discussions, a more recent exercise set aside more time for this discussion. The most recent RDD response exercise, based in Albany, New York, set aside 2 days (June 16-17, 2009) for federal, state, and local agencies to discuss operational recovery issues. One unresolved operational recovery issue discussed during this exercise pertained to the transition of the leadership of FRMAC from the initial analysis of the contaminated area, led by DOE, to the later cleanup phase, led by EPA. For example, there are unresolved operational issues regarding the level and quality of the monitoring data necessary for EPA to accept the leadership of FRMAC from DOE. According to EPA officials, while this transitional issue has been discussed in exercises dating back to the development of the *Federal Radiological Emergency Response Plan* in 1984, it has only recently been discussed in RDD or IND response exercises. Another unresolved operational recovery issue discussed during this exercise pertained to the distribution of responsibilities for the ownership, removal, and disposal of radioactive debris from RDD or IND incidents. According to EPA exercise planning documents, both of these operational issues are to be addressed again in the first full-scale RDD recovery exercise—Liberty RadEx—set to take place April 26-30, 2010, in Philadelphia, Pennsylvania. According to an EPA coordinator for this event, this exercise is to focus on a few technical recovery issues involving intergovernmental coordination, such as setting environmental cleanup priorities and levels, as well as managing radioactive waste staging and disposal. Appendix II contains a brief summary of three national-level exercises, since May 2003, which contained a recovery component, along with the exercise objectives for the planned April 2010 RDD exercise, which is to contain a recovery component. In addition to this RDD recovery exercise, the National Exercise Schedule has listed two planned IND response exercises in 2010 that are to have some recovery components.

Uncertainty about Federal Capability to Effectively Clean up Areas Contaminated with Radioactive Materials from RDD or IND Incidents

It is uncertain whether federal capability is sufficient to effectively clean up from RDD or IND incidents because federal agencies have only carried out environmental cleanup of localized areas of radioactive materials, and some limitations exist in federal capabilities to help address the magnitude of the cleanup that would follow these incidents.

Effectiveness of Environmental Cleanup Methods and Technologies Following RDD or IND Incidents Are Untested on a Large Scale

Some federal agencies, such as DOE and EPA, have substantial experience using various analysis and environmental cleanup methods and technologies to address localized areas contaminated with radioactive materials, but little is known about how these methods and technologies might be applied in recovering from the magnitude of RDD or IND incidents. For example, DOE has invested hundreds of millions of dollars in research, development, and testing of methods and technologies for cleaning up and decommissioning contaminated structures and soils—legacies of the Cold War. In addition, since the passage of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), which established the Superfund program,[22] EPA has undertaken significant efforts to study, develop, and use technologies that can address radioactive contamination. DOD has also played a major role in studying potential applications for innovative technologies for its Superfund sites.

As a result of federal agencies' experience with radioactive materials, there is evidence that the agencies could effectively carry out the analysis and environmental cleanup of localized areas contaminated by these materials. In regard to analysis, DOE's National Nuclear Security Administration (NNSA) has developed operational plans, orders, and publications on how to respond to a radiological or nuclear incident. NNSA has developed various FRMAC manuals to guide operational, assessment and monitoring activities. In addition, EPA's National Decontamination Team has published guidelines that provide a framework

[22]Comprehensive Environmental Response, Compensation, and Liability Act, 42 U.S.C. §§ 9601-9675. CERCLA gives the federal government the authority to respond to releases or threatened releases of hazardous substances (including radionuclides) that may endanger public health or the environment.

for how to develop sampling plans to support decontamination efforts after a radiological release. In regard to environmental cleanup, EPA has published inventories of radiological methods and technology guidance for contaminated sites, surfaces, and media.[23] The cleanup technologies are generally grouped into chemical and physical technologies. During the initial response phase to an incident, responders might rely on fairly simple cleanup approaches, such as washing down exposed people and surfaces, mowing grass, pruning trees, and sweeping up affected areas. The latter recovery phase might require no additional action or use of complex decontamination technologies depending on the level of desired cleanup. EPA has also published guidance for its On-Scene Coordinators at each regional office to aid in their response to a radiological incident.[24] This guidance covers the full range of radiological incidents, but its focus is primarily on the early to intermediate phases of an RDD incident, as this incident is expected to present a challenge for these coordinators. This guidance addresses possible decontamination approaches for eight types of radionuclides that experts believe are most likely to be used in an RDD.

As previously mentioned, federal agencies' current approaches to analysis and environmental cleanup have only been applied in localized areas, as an RDD or IND incident has not occurred; however, decontamination research is currently under way to gain a better understanding of potential applications of current and experimental methods and technologies for primarily RDD incidents. According to decontamination experts at DOE's Lawrence Livermore National Laboratory, current research has focused on predicting the effects of radiation release in urban settings through simulation, small-scale testing, and theory. In addition, researchers at EPA's National Homeland Security Research Center informed us that while there are available methods that have proven successful for cleaning up various types of contamination, more research is needed to develop standard national guidance for their efficacious application in urban areas

[23]EPA, *Inventory of Radiological Methodologies for Sites Contaminated with Radioactive Materials,* EPA-402-R-06-007 (Washington, D.C., October 2006); *Technology Screening Guide for Radioactively Contaminated Sites,* EPA-402-R-96-017 (Washington, D.C., November 1996); *Technology Reference Guide for Radiologically Contaminated Surfaces,* EPA-402-R-06-003 (Washington, D.C., March 2006); and *Technology Reference Guide for Radioactively Contaminated Media,* EPA-402-R-07-004 (Washington, D.C., October 2007).

[24]EPA, *OSC Radiological Response Guidelines* (Washington, D.C., October 2006). The EPA On-Scene Coordinators direct and coordinate the agency's response at the scene of an incident through the local incident command system in accordance with the *National Oil and Hazardous Substances Pollution Contingency Plan* and the *National Response Framework*.

and to other RDD or IND incident scenarios. According to a decontamination expert at DOE's Idaho National Laboratory, experience has shown that without guidance and discussion early in the response phase, a contractor might use a decontamination technology during this phase for no other reason than it was used before in an unrelated situation. The expert told us that this situation might lead to selecting environmental cleanup technologies that generate waste types that are more difficult to remove than the original material and that create more debris requiring disposal—leading to increased costs. For example, the Lawrence Livermore National Laboratory decontamination experts told us that the conventional use of high-pressure hosing to decontaminate a building is effective under normal conditions but could be the wrong cleanup approach for an RDD using cesium-137. In this case, the imbibing (absorbing) properties of some porous surfaces such as concrete would actually cause this soluble radioactive isotope to penetrate even further into surfaces making subsequent decontamination more difficult and destructive.[25] A senior EPA official with the Office of Radiation and Indoor Air told us that the agency has studies under way to determine the efficacy of high-pressure hosing for removing contamination from porous urban surfaces that would result from the terrorists' use of an RDD using certain radioisotopes.

Limitations in Federal Capabilities to Address Magnitude of Cleanup Following RDD or IND Incidents

There are also limitations in federal capabilities to help address, in a timely manner, the magnitude of cleanup that would be associated with RDD or IND incidents. For example, we found that limitations in federal capabilities to complete some analysis and environmental cleanup activities might slow the recovery from an incident, including (1) characterizing the full extent of areas contaminated with radioactive materials, (2) completing laboratory validation of contaminated areas and levels of cleanup after applying decontamination approaches, and (3) removing and disposing of radioactive debris and waste.

Characterizing Areas Contaminated with Radioactive Materials

There are some limitations in the capability of federal agencies to efficiently characterize the full extent of the areas contaminated with radioactive materials in the event of RDD or IND incidents. For example, the current predictive capability of various plume models is not sufficient,

[25]The experts also said that decontamination costs can dramatically increase depending on the selection of an initial approach and the length of time before remediation actions are taken.

and may never be sufficient to reduce the time necessary to fully characterize the extent of contaminated areas after RDD or IND incidents.[26] According to a senior official at the Lawrence Livermore National Laboratory's Interagency Modeling and Atmospheric Assessment Center (IMAAC), the predictive capabilities of existing plume models are not at the resolution necessary to produce this added value for urban areas, as modeling for this purpose is only theoretical at this point. This official told us while there are data about debris dispersal from building demolition and weapons testing, there is little research data on the likely dispersal patterns of concrete, asphalt, and glass that would result from use of an RDD or IND. However, some federal agency officials question the need to improve the predictive capabilities of these plume models. For example, the DHS IMAAC director told us that the current state-of-the-art and plume modeling approach is sufficient for its primary purpose in directing the protective actions of first responders. Nevertheless, NNSA officials informed us they are working with FEMA on a multiyear program to improve federal capabilities to model the release of material during a radiological or nuclear incident. However, they contend that plume modeling will never replace the need for actual measurements for radioactive contamination. In commenting on a draft of this report, EPA agreed that characterization of areas contaminated with radioactive materials from RDD or IND incidents would be challenging because existing plume models are not entirely applicable to urban areas. Moreover, EPA added that other types of contamination, such as in the drinking water and wastewater infrastructure, would also involve very complex systems that would be difficult to model.

Completing Laboratory Validation of Areas Contaminated with Radioactive Materials

There are some limitations in federal capabilities to complete laboratory validation of contaminated areas and levels of cleanup after applying decontamination approaches. Moreover, FEMA's proposed process for determining cleanup standards during the recovery phase for RDD and IND incidents has not been fully exercised, although there was a tabletop discussion among government officials in a June 2009 exercise. EPA has conducted an examination of federal, state, local, and private laboratory capabilities to conduct environmental sampling and testing in order to determine the nationwide laboratory capacity required to support environmental monitoring and decontamination of chemical, biological,

[26]Information from plume models—mathematical or computer equations—is intended to provide first responders with early estimates of potentially contaminated areas to help guide field sampling of sites, that data from which will in turn be used to update plume predictions in a cyclical process until the affected area has been accurately characterized.

and radiochemical-nuclear agents. EPA determined that there was a significant capacity and competency gap in efficiently meeting the laboratory evaluation needs for an RDD scenario. In addition, while EPA did not conduct a detailed assessment of the national planning scenario for an IND incident, it determined that such an incident could contaminate 3,000 square miles and require potentially millions of samples for laboratory analysis. According to EPA documentation, the gap in laboratory capacity would result in the lack of timely, reliable, and interpretable data, which would delay national and local response and recovery activities. EPA has documented that it is currently establishing an all-media Environmental Response Laboratory Network, and it is also conducting a demonstration project to enhance the capacity and capability of public laboratories.

A related environmental cleanup issue pertains to the process for determining the cleanup standards that would be applied to urban areas contaminated with radioactive materials in recovering from RDD or IND incidents. According to a decontamination expert at the Idaho National Laboratory, an important consideration in decontamination is the starting level of radioactivity and desired ending level. This official told us that no technology removes all of the contamination all the time; some technologies are more efficient than others at removing certain kinds of contamination. The current DHS planning guidance for RDD and IND incidents recommends a framework for incident cleanup and recovery using a process called "site-specific optimization" for determining the level of environmental cleanup after RDD or IND incidents. The guidance recommends that this process include potential future land uses, technical feasibility, costs, cost-effectiveness, and public accountability. In commenting on a draft of this report, EPA informed us that draft guidance intended to outline the structure of, and responsibilities for the conduct of the optimization process as they pertain to EPA's involvement in RDD or IND incidents is under review by the new Administrator.[27] EPA added that it looks forward to the lessons to be learned from the upcoming Liberty RadEx exercise in 2010, which officials believe should provide significant insights into the issues under discussion in this report.

[27]EPA, *EPA Guidance on the Optimization Process Following a Radiological Dispersal Device or Improvised Nuclear Device Incident* (Draft).

Storing and Disposing of Waste from Areas Contaminated with Radioactive Materials

There are also limitations in federal capabilities to help state and local governments address the interim storage and eventual disposal of the radioactive waste that would arise from RDD or IND incidents. The National Science and Technology Council's 2008 report found gaps in our nation's capabilities to effectively remove and dispose of radioactive debris in the event of an RDD or IND incident. This is due, in part, to current restrictions on accessing possible disposal facilities for the radioactive debris stemming from such incidents. According to NNSA officials, DOE's disposal sites currently can only accept low-level and mixed low-level radioactive waste from its own and DOD facilities under certain circumstances. Moreover, according to an EPA decontamination expert, EPA is concerned about access to commercial radioactive waste disposal sites in the event of such an incident. Currently, there is only one low-level radioactive waste disposal site located in Utah that could be used by most states for radioactive debris disposal, although a limited number of states have access to low-level radioactive waste disposal facilities for waste generated by users of radioactive materials in their states. Another issue is paying for waste disposal. In the Superfund program, EPA can bill the responsible party, if known. However, covering the cost of waste disposal would be complicated in the case of RDD or IND incidents. One additional complicating factor would be the mixing and problematic separation of radioactive, biological, and chemical materials in the debris that would stem from such incidents. According to a recent research paper on disposal issues, the proper characterization of the quantity, properties, and level of debris contamination and decontamination residue from an RDD or other radiological incidents can have significant impacts on cleanup costs and restoration timelines.[28] In commenting on a draft of the report, EPA officials informed us that its Office of Research and Development is currently developing a suite of decision support tools for the management of waste and debris from a variety of different events, including radiological incidents.

Concerns about Federal Capabilities from Survey Respondents

Concerns about limitations in these federal capabilities were expressed by many city, state, and federal regional office emergency management officials who responded to our survey. Respondents representing most of the cities (9 of 13), states (7 of 10), FEMA regional offices (6 of 9), and almost all EPA regional offices (9 of 10) expressed concerns about the

[28] P. Lemieux et al., "Updated Decision Support Tool for the Management of Waste and Debris from Radiological Incidents," (conference paper presented at Waste Management 2009 Conference, Phoenix, Ariz., March 1-5, 2009).

capabilities of federal agencies to provide the assistance needed to complete the necessary analysis and environmental clean up activities in the event of RDD or IND incidents. For example, respondents from several cities told us that they were concerned about how rapidly the federal government could provide this assistance, despite the strengthening of some capabilities since the terrorist attack of September 11, 2001. Respondents from most states expressed the same expectations of the federal government. For example, one state was particularly concerned about current federal capabilities to handle multiple and simultaneous RDD incidents across the country.

The National Science and Technology Council's 2008 report also found that cities and states would need to rely heavily on a strong federal response to a radiological incident. This report identified similar limitations in federal capabilities to rapidly characterize an incident site and contaminated critical infrastructure, contain and control contaminant migration, decontaminate and cleanup affected areas, and remove and dispose of the waste to facilitate long-term recovery. Moreover, the report claimed that catastrophic effects of RDD or IND incidents could be reduced and the path to recovery shortened with more effective decontamination, mitigation, and rapid recovery operations.

City, State, and Federal Emergency Management Officials Provided Suggestions to Improve Federal Recovery Preparedness for RDD and IND Incidents

City and state emergency management officials responding to our survey, as well as emergency management officials at EPA and FEMA regional offices across the country, provided a number of suggestions for ways to improve federal recovery preparedness for RDD and IND incidents, particularly with the environmental cleanup of areas that would be contaminated with radioactive materials from such incidents. Respondents from nearly all the cities and states expressed the need for a national disaster recovery strategy to address gaps and overlaps in current federal guidance in the context of RDD and IND incidents. This is important because, according to one city official, "recovery is what it is all about." In developing such a recovery strategy, respondents from the cities, like those from their states, want the federal government to consult with them in the initial formulation of a recovery strategy through working and focus groups, perhaps organized on a regional basis. Respondents representing most cities (10 of 13) and states (7 of 10) also provided specifics on the type of planning guidance necessary, including integration and clarification of responsibilities among federal, state, and local governments. For example, respondents from some of the cities sought better guidance on monitoring radioactivity levels, acceptable cleanup standards, and management of radioactive waste. Most respondents from cities expressed the need for greater planning interactions with the federal government and more exercises to test recovery plans. One city respondent cited the need for recovery exercises on a regional basis so the cities within the region might better exchange lessons learned. Respondents from most cities (11 of 13) and their states (7 of 10) said that they planned to conduct RDD and IND recovery exercises in the future. Finally, emergency management officials representing almost all cities and states in our survey offered some opinions on the need for intelligence information on RDD and IND threats. They generally said that sharing information with law enforcement agencies is necessary for appropriate planning for RDD or IND incidents and that the law enforcement fusion centers were a step in the right direction. However, only half of the respondents indicated that they were getting sufficient intelligence information from law enforcement sources.

The EPA and FEMA regional office emergency management officials that responded to our survey also offered a number of suggestions on ways to improve federal preparedness to recover from RDD and IND incidents, generally concurring with the suggestions of the city and state respondents. The majority of the EPA regional offices (6 of 10) and FEMA regional offices (7 of 9) indicated that a national disaster recovery strategy was needed to address overlaps and gaps in current government responsibilities in the context of RDD and IND incidents. Almost all of them stressed the need to reach out and involve state and local governments in developing this recovery strategy. The majority of the EPA regional office (7 of 10) and FEMA regional office (5 of 9) respondents indicated that additional guidance was needed on the distribution of government responsibilities for the recovery phase of RDD or IND incidents, including the transfer of FRMAC responsibilities and the process for determining acceptable cleanup levels. Many of the federal regional office respondents mentioned the need to conduct recovery exercises that involve state and local governments. Finally, EPA and FEMA regional office respondents differed somewhat on the need for standard national guidance on the application of approaches for environmental cleanup of areas contaminated with radioactive materials. While about half of the EPA regional office respondents expressed the need for guidance on the application of existing approaches for RDD or IND incidents, most FEMA regional office respondents (7 of 9) indicated that it would be beneficial to synchronize existing guidance from multiple and disparate sources to ensure that they are complementary and not competing.

The United Kingdom's Handling of the 2006 Polonium Incident and Subsequent Actions Provide Information That May Help U.S. Federal Agencies Prepare for RDD and IND Incidents

While it was more limited in scope than what is usually envisioned as an RDD incident, the aftermath of the 2006 polonium poisoning incident in London had many of the characteristics of an RDD incident, including testing hundreds of people who may have been exposed to radiation and a cleanup of numerous radiation-contaminated areas. Because of its experience in dealing with the cleanup from this incident and from other actions the United Kingdom has taken to prepare for an RDD or IND attack, we met with officials from this country to obtain a better understanding of their approach to recovery preparedness. These officials told us that the attention to recovery in their country is rooted in decades of experience with the conflict in Northern Ireland, dealing with widespread contamination from the Chernobyl nuclear power plant accident, and a national history of resilience—that is, the ability to manage and recover from hardship. We found that actions the United Kingdom reported taking to prepare for recovery from RDD and IND incidents are similar to many of the suggestions for improvement in federal preparedness that we obtained through our survey of city, state, and federal regional office emergency management officials in the United States. For example, we found that the United Kingdom reported taking the following actions:

- *Enacted civil protection legislation in 2004.* This civil protection legislation includes subsequent emergency response and recovery guidance, issued in 2005, to complement the legal framework established for emergency preparedness. This guidance describes the generic framework for multiagency response and recovery for all levels of government. The guidance emphasizes that response and recovery are not discrete activities and do not occur sequentially; rather, recovery should be an integral part of response from the very beginning, as actions taken at all times can influence longer-term outcomes for communities.

- *Established a Government Decontamination Service in 2005.* This organization was created out of recognition that it would not be cost-effective for each entity—national, regional, and local government—to maintain the level of expertise needed for cleaning up chemical, biological, radiological, and nuclear materials, given that such events are rare.[29] The Government Decontamination Service provides advice and guidance to local governments, maintains and builds a framework of specialized analysis and environmental cleanup contractors, and advises the national

[29]The Government Decontamination Service is similar in size and responsibilities to EPA's National Decontamination Team, which became fully operational in August 2007.

government regarding response capabilities. This service implemented its responsibilities by assisting the City of Westminster respond to the analysis and environmental cleanup needs following the November 2006 polonium poisoning of Alexander Litvinenko.

- *Developed online national recovery guidance in 2007.* This guidance reinforces and updates the early emergency response and recovery guidance by establishing, among other things, a recovery planning process during the response phase so that the potential impacts of early advice and actions are explored and understood for the future recovery of the affected areas. Moreover, the guidance—reviewed every 3 months and updated as necessary—emphasizes the need for training recovery personnel on essential roles, responsibilities, and procedures to test competencies, as well as to design and conduct recovery exercises.

- *Updated the recovery handbooks for radiation incidents in 2008 and 2009.* The handbooks are intended to aid decision makers in developing recovery strategies for contaminated food production systems, drinking water, and inhabited areas following the release of radioactive materials into the environment. The handbooks were first published in 2005 in response to the Chernobyl nuclear power plant accident. The current handbooks include management options for application in the prerelease, emergency and longer-term phases of an incident. Sources of contamination considered in the handbooks include nuclear accidents, radiological dispersion devices, and satellite accidents. The handbooks are divided into several independent sections comprising supporting scientific and technical information, an analysis of the factors influencing recovery, compendia of comprehensive, state-of-the-art datasheets for around 100 management options, guidance on planning in advance, a decision-aiding framework comprising color-coded selection tables, look-up tables and decision trees, and several worked examples. The handbooks can also be applied for training purposes and during emergency exercises.

- *Conducted a full-scale RDD recovery exercise in 2008.* This exercise, involving several hundred participants, provided a unique opportunity to examine and test the recovery planning process within the urgency of a compressed time frame. The exercise, which took place 6 weeks after the response exercise, had participants address three scenarios: rural contamination of crops and livestock, contamination of the urban transit infrastructure, and disruption of the water supply. The lessons learned from this exercise were incorporated into the United Kingdom's recovery strategy. One key lesson is the benefit of exercising the handover of government leadership during the response phase to leadership of the recovery phase.

- *Established a national risk register in 2008.* This register provides information on the risks facing the country, including malicious attacks such as with an RDD. This threat information was previously held confidential by the government. The government reported that the release of this information is intended to encourage public debate on security and help organizations, individuals, families, and communities that want to prepare for these emergencies. This register is designed to complement community risk registers that have been published by local emergency planners since passage of the 2004 civil protection legislation. The community risk registers are based on local judgments of risks, as well as from information contained in the national risk assessment—a 5-year planning assessment that is still a classified document. The government has conducted this risk assessment since 2005.

- *Issued specific nuclear recovery planning guidance in 2009.* This guidance, the UK Nuclear Recovery Plan Template, provides a generic recovery strategy and structures needed to address a radiological release from a civil or defense nuclear reactor, as well as incidents involving nuclear weapons and special nuclear materials in transit. It is also considered applicable to recovery from RDD and IND incidents. Among other things, it provides guidance on the formation of a Recovery Advisory Group and Science and Technology Advisory Cell early in the response phase. The Recovery Advisory Group would be charged with identifying immediate and high-level strategic recovery objectives—recorded in templates to keep the process focused and on track—for, among other activities, cleanup levels, management of radioactive waste, compensation arrangements, and recovery costs. This advisory group would transition into a broader Strategic Recovery Coordinating Group during the recovery phase. The guidance requires that all high-risk cities in the United Kingdom prepare recovery plans.

Finally, according to United Kingdom officials, the 2006 polonium incident in London showed the value of recovery planning. In particular, through this incident, United Kingdom officials gained an appreciation for the need to have an established cleanup plan, including a process for determining cleanup levels, sufficient laboratory capacity to analyze a large quantity of samples for radiation, and procedures for handling the radioactive waste. Furthermore, they found that implementing cleanup plans in the polonium poisoning incident and testing plans in the November 2008 recovery exercise have helped the United Kingdom to better prepare for larger RDD or IND incidents. Appendix III contains a more thorough review of the approach to recovering from RDD and IND incidents in the United Kingdom.

Conclusions

Recovering from RDD or IND incidents would likely be difficult and lengthy. Completing the analysis and environmental cleanup of areas contaminated with radioactive materials would be among the first steps in the recovery process after the initial response to save lives. A faster recovery—meaning people can return sooner to their homes and businesses and get back to the routines of everyday life—would help lessen the consequences of RDD and IND incidents. In fact, being fully prepared to recover from such an incident may also serve as a deterrent to those who would do us harm.

However, our work demonstrates that the federal government is not fully prepared to help cities and states with the analysis and environmental cleanup of areas contaminated with radioactive materials from RDD and IND incidents. To date, FEMA has not developed a national disaster recovery strategy, as required by law, which would help guide RDD and IND recovery planning, or issued specific guidance to coordinate federal, state, and city recovery planning for these incidents. Federal agencies have also included only a few recovery discussions in the response exercises to these incidents. The lack of clearly communicated guidance on federal responsibilities and activities has left emergency management officials in the cities and states we surveyed confused about which federal agency to turn to for assistance, and many federal regional office officials we surveyed were not certain about which environmental cleanup methods and technologies would be the most successful in removing radioactive materials from buildings and infrastructure.

As the United States moves forward in recovery preparation, some insights might be gained from the actions already taken by the United Kingdom to increase its preparedness to recover from acts of nuclear and radiological terrorism, many of which are similar to those suggested by the city, state, and federal emergency management officials we surveyed for improving federal preparedness to recover from RDD and IND incidents.

Recommendations for Executive Action

To better prepare federal agencies to coordinate with state and local governments on the analysis and environmental cleanup of areas contaminated with radioactive materials following RDD or IND incidents, we recommend that the Secretary of Homeland Security direct the Federal Emergency Management Agency Administrator to

- prepare a national disaster recovery strategy that would clarify federal responsibilities for assisting state and local governments with the analysis and environmental cleanup of areas contaminated with radioactive materials in the event of RDD or IND incidents;

- issue guidance that describes how federal capabilities would be integrated into and support state and local plans for recovery from RDD and IND incidents; and
- schedule additional recovery exercises, in partnership with other federal, state, and local governments that would, among other things, specifically assess the preparedness of federal agencies and their contractors to conduct effective and efficient analysis and environmental cleanup activities associated with RDD and IND incidents.

Agency Comments and Our Evaluation

GAO provided DHS, DOE, and EPA with a draft of this report for their review and comment. DHS and FEMA concurred with the recommendations in the report. DOE, through NNSA, generally agreed with our report findings and provided technical comments, which we incorporated as appropriate. EPA did not agree or disagree with the report findings, but offered technical comments, which we incorporated as appropriate.

As agreed with your offices, unless you publicly announce the contents of this report earlier, we plan no further distribution until 30 days from the report date. At that time, we will send copies of this report to the appropriate congressional committees as well as to the Secretaries of Homeland Security and Energy; the Administrators of NNSA and EPA; and other interested parties. The report will also be available at no charge on the GAO Web site at http://www.gao.gov.

If you or your staffs have any questions about this report, please contact me at (202) 512-3841 or aloisee@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix IV.

Gene Aloise
Director, Natural Resources
and Environment

Appendix I: Scope and Methodology

In our review, we examined (1) the extent to which federal agencies are planning to fulfill their responsibilities to help cities and states clean up areas contaminated with radiation materials from radiological dispersal device (RDD) and improvised nuclear device (IND) incidents, (2) what is known about the federal government's capability to effectively clean up areas contaminated with radioactive materials from RDD and IND incidents, and (3) suggestions from government emergency management officials for improving federal preparedness to help cities and states recover from RDD and IND incidents. In addition, we are providing information on actions taken in the United Kingdom to prepare for recovering from RDD and IND incidents.

To determine the extent to which federal agencies are planning to fulfill their responsibilities to help cities and states clean up areas contaminated with radioactive materials from RDD and IND incidents, we reviewed pertinent federal law, presidential directives, and other executive guidance; interviewed cognizant officials from the Department of Homeland Security (DHS), Department of Energy (DOE), Environmental Protection Agency (EPA), Federal Emergency Management Administration (FEMA), and Nuclear Regulatory Commission (NRC); conducted a survey of 13 cities considered to be at high or medium risk to such attacks and their states,[1] and all federal FEMA and EPA regional offices; and reviewed information on the number and type of RDD and IND response and recovery exercises that have been conducted from May 2003 through September 2009. More specifically, we reviewed existing planning documents for domestic incidents to determine the extent to which they addressed recovery issues, particularly from RDD and IND incidents. For example, we found limited discussion of recovery planning for these incidents in various annexes to the *National Response Framework*, such as its emergency support function annexes and nuclear and radiological incident annex, as well as other planning documents. In addition, after speaking with emergency management officials in San Francisco and comparable state officials near Sacramento, California, we developed a semistructured telephone survey instrument—pretested in Denver, Colorado—in order to obtain the perspectives of city and state emergency management officials on government responsibilities and plans to fulfill them. We originally selected 13 high- and medium-risk cities and

[1]The high- and medium-risk cities came from a list compiled by an advisory group to the insurance industry that conducts catastrophe event modeling. DHS also maintains a list of high-risk cities. However, DHS considers its list to be sensitive information. Nonetheless, DHS officials agreed that using the insurance industry list for our survey was reasonable.

their 11 states to cover the mostly likely target cities for a terrorist attack and to ensure that we had at least 1 city in each of the 10 EPA and FEMA regions. The cities included Atlanta, Boston, Chicago, Dallas, Denver, Detroit, Houston, Los Angeles, New York, Philadelphia, San Francisco, Seattle, and St. Louis. While Washington, D.C., is considered a high-risk city, we excluded it from our survey because it is unlike other cities in its reliance on the federal government and the agencies that would take over analysis and environmental remediation activities. Emergency management officials representing these cities and their states responded to our survey, except for Atlanta and the states of Georgia and Massachusetts. After repeated attempts to include this city and the two states in our survey, we decided to drop them. We replaced Atlanta and the state of Georgia with Miami and the state of Florida, which are in the same federal region. Because we decided to retain Boston despite receiving no response from Massachusetts, we ended up with 10 states in our survey. We also visited EPA regional offices in San Francisco and Denver, and the FEMA regional office in Oakland, to develop questions to survey all 10 EPA and FEMA regional offices in order to obtain a federal field perspective on this issue. All EPA and FEMA regional offices responded to our survey, except FEMA region 8. We tabulated the yes and no responses to each pertinent question from the city, state, and federal surveys and conducted a content analysis of the explanatory statements accompanying many of the questions. FEMA's National Exercise Schedule database was used to identify the location and types of RDD and IND response and recovery exercises—based on national planning scenarios. Because we determined in our April 2009 report (GAO-09-369) that this database is unreliable, we asked each city, state, and federal regional office in our survey to list RDD and IND response and recovery exercises that had taken place in their jurisdiction, as well as any plans for future exercises to check the accuracy of the federal exercise database. In addition, we attended the first full-scale recovery tabletop exercise—Empire09—based on an RDD incident scenario in Albany, New York that was conducted on June 16-17, 2009, and an interagency planning session held in Philadelphia on October 28-29, 2009, to prepare for the Liberty RadEx recovery exercise scheduled for April 26-30, 2010 in Philadelphia.

To determine what is known about the federal government's capabilities to effectively clean up areas contaminated with radioactive materials from RDD and IND incidents, we reviewed pertinent guidance on available methods and technologies and obtained information from subject matter experts at the federal agencies and national laboratories about their potential application for RDD and IND incidents. More specifically, we spoke with subject matter experts at the National Nuclear Security

Administration, EPA, and FEMA, as well as at DOE's Lawrence Livermore National Laboratory and Idaho National Laboratory and EPA's Andrew W. Breidenbach Environmental Research Center, National Air and Radiation Environmental Laboratory, National Decontamination Team, National Homeland Security Research Center, and the Radiation and Indoor Environments National Laboratory. We also observed a demonstration of the capabilities of the Interagency Modeling and Atmospheric Assessment Center at Lawrence Livermore National Laboratory and some decontamination research projects at the National Homeland Security Research Center. In addition, we reviewed reports and documents from these agencies, national laboratories, and research centers that addressed methods and technologies for analysis and environmental remediation of areas contaminated with radioactive materials as well as some that specifically discussed their potential use for RDD or IND incidents. Moreover, we included questions about the potential use of these approaches in our semistructured phone survey of federal, state, and city emergency management officials.

To identify suggestions from government emergency management officials for improving federal preparedness to help cities and states recover from RDD and IND incidents, we included relevant questions in our semistructured phone survey of federal, state, and city officials. We conducted a content analysis of these questions to identify patterns in the responses, that is, what types of suggestions were most prevalent. We also reviewed past GAO reports and other documents that addressed areas for improvement in federal preparedness.

In addition, to broaden our review of potential areas for improvement in federal involvement in planning and preparing for the recovery from RDD and IND incidents, we included the United Kingdom in our scope. This country has actual experience with recovery from a radiological incident in an urban area and was suggested to us by EPA officials as a country that is one of the leaders in recovery planning. We interviewed selected central and regional government officials responsible for response and recovery planning and preparation, and we visited a decontamination contractor that performed environmental remediation activities in the aftermath of the 2006 radioactive poisoning of Alexander Litvinenko in London. We also reviewed documents provided by these officials and from other sources to obtain a better understanding of this system and how it might apply to the United States. Two officials from the United Kingdom who we interviewed during our site visit reviewed a draft of the information contained in appendix III for content and accuracy.

We conducted this performance audit from October 2008 to January 2010 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: Recovery Exercises

Table 1 provides a brief summary of four RDD exercises, since May 2003, which contained recovery objectives including a planned exercise for April 2010.

Table 1: RDD Exercises Containing Recovery Objectives, May 2003 to April 2010

Name of exercise	Dates of exercise	Lead agency	Locations of exercise	Objectives of recovery exercise	Issues discussed at recovery exercise
National-level exercise (TOPOFF 2)	May 12-16, 2003: RDD response exercise included a large-scale game involving recovery issues	DHS and State Department	Seattle, Wash. and Chicago, Ill.	• To improve incident management capabilities • To collect and coordinate distribution of RDD plume modeling data	• Data collection and coordination • Coordinating the distribution of plume model analysis products • Federal Radiological Monitoring and Assessment Center (FRMAC) transition
National-level exercise (TOPOFF 4)	October 15-19, 2007: RDD response exercise was followed by a long-term recovery tabletop exercise on December 4, 2007	DHS	Phoenix, Ariz., Portland, Ore, and Guam	• To identify gaps in role definitions, authorities, standards, capabilities, etc., for key recovery measures • To determine cost-benefit tradeoffs in defining acceptable risk for long-term exposures as a guide to cleanup and recovery activity • To identify measures and communication strategies for maintaining public confidence	• Sampling and laboratory capacity • Decontamination technologies • Radioactive waste disposal and management • FRMAC leadership transition
Empire 2009	June 1-5, 2009: RDD response exercise was followed by a facilitated discussion recovery exercise on June 16-17, 2009	DOE	Albany, N.Y.	• To establish criteria for the release of public areas • To establish cleanup values, and long-term monitoring, sampling and community recovery plans • To discuss the transfer of FRMAC leadership responsibility	• Cleanup planning and guidance • Implementation of cleanup and optimization process for determining cleanup levels • Data management optimization • Waste disposal • FRMAC leadership transition

Name of exercise	Dates of exercise	Lead agency	Locations of exercise	Objectives of recovery exercise	Issues discussed at recovery exercise
Liberty RadEx 2010	April 26-30, 2010: RDD response exercise is to include recovery related issues	EPA	Philadelphia, Penn.	• To exercise roles for hazardous materials assessment, mitigation, cleanup and FRMAC leadership transition • To apply guidelines for mitigation and short-term cleanup • To review community recovery activities for contamination and long-term cleanup • To utilize the optimization process to prioritize mitigation and cleanup activities in post-emergency phase and to develop long-term cleanup standards	• Coordination between cleanup and public health • Community/stakeholder involvement • Long-term cleanup planning and prioritization • Involvement and coordination with FEMA on long-term community recovery in cleanup planning • Long-term relocation decision making • Waste disposal

Source: GAO analysis of federal agency documents.

Appendix III: Radiological Recovery Experiences in the United Kingdom

The United Kingdom provides an example of another country's efforts to prepare to recover from a terrorist attack using chemical, biological, radioactive, or nuclear materials. This country's attention to recovery needs is reflected in promulgating emergency response and recovery legislation, establishing a government decontamination service, creating online national recovery guidance, updating a recovery handbook for radiation incidents, conducting a full-scale RDD recovery exercise, establishing a community and national risk register system, and preparing specific nuclear recovery planning guidance. The particular emphasis on recovery activities in the United Kingdom has been linked to decades of experience with the conflict in Northern Ireland, widespread contamination from the Chernobyl nuclear power plant accident, and a national history of resilience—that is, the ability to manage and recover from hardship.

Emergency Response and Recovery Framework

The United Kingdom has established a framework for addressing the release of radiological materials that prompted planning for the recovery from these events. This framework was primarily established through the 2001 Radiation (Emergency Preparedness and Public Information) Regulations[1] and the 2004 Civil Contingencies Act, as well as guidance issued pursuant to the Civil Contingencies Act.[2] According to a senior official from the United Kingdom's Health Protection Agency, the radiation regulations were developed in response to a European Union directive following the 1986 Chernobyl, Ukraine, nuclear power plant accident.[3] These regulations require preparation of on- and off-site emergency management plans for release of radioactive materials in the event of a nuclear power plant accident, as well as the conduct of exercises to test preparedness to respond to radiological releases. According to this official, while the radiation regulations did not include directives to prepare for recovery from such accidents, they established a Nuclear Emergency Planning Liaison Group, which formed a Recovery Subgroup to begin addressing this planning need.

[1]The Radiation (Emergency Preparedness and Public Information) Regulations 2001, 2001 No. 2975, August 27, 2001.

[2]Civil Contingencies Act 2004, 2004 Chapter 36, Royal Assent on November 18, 2004.

[3]The Radiation (Emergency Preparedness and Public Information) Regulations 2001, implemented Council Directive 96/29/Euratom on laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionizing radiation.

The 2004 Civil Contingencies Act was enacted following a government consultation exercise that concluded that previous legislation provided an inadequate framework for civil protection against twenty-first century risks, including terrorism. The Civil Contingencies Act established a statutory framework of roles and responsibilities for local responders to address the effects of the most serious emergencies facing the country. Guidance issued pursuant to this legislation established an integrated emergency management system, not unlike that in the United States,[4] comprising six related activities: anticipation, assessment, prevention, preparation, response, and recovery. The November 2005 guidance addressing emergency response and recovery covers the principles, practical considerations, operational doctrine, and examples of good practice for these activities.[5] This guidance describes the generic framework for multiagency response and recovery activities at all levels of government, emphasizing that these activities are not separate activities that occur sequentially. Instead, this guidance contends that recovery considerations should take place early in the response phase, as initial decisions can affect the long-term outcomes for communities. Moreover, because the government recognized that no single approach could meet the needs of every affected area, it did not intend this guidance to be either prescriptive or an operational manual.

Government Decontamination Service

In 2005, the United Kingdom established a special Government Decontamination Service to address issues associated with contaminated land, buildings, open space, infrastructure, and transportation routes from both deliberate and accidental releases of chemical, biological, radiological, and nuclear materials.[6] This service was established because the national government recognized that it would not be cost-effective for each responsible authority—national, regional, and local governments—to maintain the level of expertise needed for the analysis and environmental

[4]In 2004, the United States established its National Incident Management System to provide a consistent nationwide approach for government, private sector, and nongovernmental organizations to prepare for, respond to, and recover from domestic incidents.

[5]HM Government, *Emergency Response and Recovery: Non-Statutory Guidance to Complement Emergency Preparedness* (York: Easingwold, Library and Information Centre, Emergency Planning College, November 2005).

[6]The Government Decontamination Service has been compared to EPA's National Decontamination Team, which became fully operational in August 2007. Both organizations are similar in size and have similar advisory missions to local authorities, but the EPA team does not itself maintain a framework of contractors.

cleanup of affected areas given that the release of such material would be a rare event. The Government Decontamination Service has no statutory powers itself, nor does it directly provide analysis and environmental remediation services. Instead, it provides advice and guidance to local governments, maintains and builds a framework of specialized contractors to conduct these activities, and advises the national government regarding response capabilities.

In regard to advice to local governments, in November 2006, the Government Decontamination Service was requested to respond to an incident involving the poisoning of Alexander Litvinenko with a milligram—about the size of a grain of salt—of polonium-210. This service was asked to assist the City of Westminster, within greater London, given the international nature of the event, even though the incident was classified as a hazardous materials event rather then a terrorist incident. According to the recovery planning process, the city selected a contractor from the Government Decontamination Service list of specialized contractors for the remediation work and used a model contract developed by this service for this purpose. This model contract contains allowable costs per unit, equipment charges, and charge out rates for the emergency response. Under the contract, the selected specialized contractor agrees to start off with nonaggressive, simple, and less expensive decontamination approaches, and then apply more sophisticated approaches, if necessary, to meet the desired cleanup level. The actual payments for these services were made by the owners of properties, such as a hotel where the perpetrators of the crime had stayed, that were contaminated with polonium. However, the cleaning up of public premises was a responsibility of the local government. The national government has established ways to help cover the costs of such incidents. This includes insurance coverage for damages resulting from acts of terrorism. For large commercial concerns, the insurance industry offers terrorist insurance that is underwritten by the government. For smaller companies, terrorist insurance is offered for an additional 20 percent surcharge on an existing policy. Other funding is available for local governments if such an event would overwhelm their financial resources, such as applying for grants from the national government or European Union.

In regard to its framework of specialized contractors, the service has identified three specialized contractors that have capabilities to address various decontamination scenarios, and it certifies their capabilities through testing. A specialized contractor is invited to visit the location, receives a briefing on the incident scenario, and is asked to develop a recommended decontamination strategy. The Government Decontamination Service then assesses the contractor's approach and recommendations to identify issues, strengths, and weaknesses. In addition, the service develops improvement plans, backed with exercises, to address identified performance gaps. For example, in December 2007, the Government Decontamination Service tested and evaluated the capabilities of one of its specialized contractors to analyze and clean up areas contaminated with radioactivity from an RDD event scenario in downtown Birmingham. In Exercise Streetwise, a specialized contractor was fully tested at the venue on its capability to detect and clean up actual radioactive materials. According to a senior official with the Government Decontamination Service, "you cannot get a realistic picture of recovery needs and issues through only tabletop exercises."

Finally, in regard to advice to national government, the Government Decontamination Service participates in efforts to identify, prioritize, and as necessary maintain decontamination-related research projects, and it has established a library of the relevant knowledge and experiences drawn from national and international sources. For example, a Government Decontamination Service official told us that this agency is currently engaged in learning more about how to deal with the disposal of radioactive waste that has no known owner, which might be similar to the radioactive waste stemming from an RDD incident. The issue is not only ownership, but where to put the radioactive debris and how to cover the cost of storage and disposal. In this regard, the United Kingdom has a clearance rule for allowing very low-level radioactive waste to be disposed of in less expensive and more numerous solid and hazardous waste landfill sites without specific regulatory approval or exemption.[7] In addition, the United Kingdom and the United States have agreed to increase the exchange of information and personnel regarding the research, development, testing, evaluation, and development of technical standards

[7]The United States does not have a clearance rule to allow very low-level radioactive waste to be disposed of at more conventional landfill sites. Rather, the Nuclear Regulatory Commission takes a case-by-case approach, which has also been implemented by some Agreement States.

and operations to address chemical, biological, radiological, and nuclear incidents.[8]

Online National Recovery Guidance

While passage of the 2004 Civil Contingencies Act was an important legislative step to further emergency preparedness, the reaction of local responders to several domestic incidents following passage of this act made it clear to the national government that these responders needed more comprehensive guidance than that contained in the 2005 guidance for emergency response and recovery activities. One such event was the July 2005 subway bombing in London by a terrorist group that killed 52 people. This incident, in conjunction with other events in 2005, such as the Buncefield Fire and severe flooding, prompted the government in 2006 to form a National Recovery Working Group to address the need for additional recovery guidance for multiple risk scenarios. This working group was comprised of a wide range of government departments and agencies, as well as other stakeholders who had been involved in the recovery phase following these events. The government charged this working group with, among other things (1) producing national recovery guidance for local responders, (2) identifying gaps in the country's recovery capability with recommendations to address them, and (3) contributing to the ongoing review of the 2005 nonstatutory guidance for emergency response and recovery activities. In 2007, the working group produced a *National Recovery Guidance* document.[9] This guidance establishes a planning process for involving recovery stakeholders during the response phase to ensure that the potential impact of early advice and actions for the future recovery of the area are explored and understood. This online guidance covers 14 generic issues, such as recovery structures and processes, training and exercises, and a lessons learned process, which are reviewed every 3 months and updated as necessary.[10] For

[8] *Agreement Between the Government of the United States of America and the Government of the United Kingdom of Great Britain and Northern Ireland on Cooperation in Science and Technology for Critical Infrastructure Protection and Other Homeland/Civil Security Matters*. There are also 10 annexes attached to this agreement, including joint exercises and training on decontamination approaches.

[9] The *National Recovery Guidance* is a guide to emergency response and recovery maintained by the national government.

[10] The U.S. administration and Congress directed the preparation of a national disaster recovery strategy or framework in *The National Strategy for Homeland Security of 2007* and the Post Katrina Emergency Management Reform Act of 2006, but no action has been taken to date.

example, the *National Recovery Guidance* addresses the need for training recovery personnel on essential roles, responsibilities, and procedures to test competencies, as well as the need to design and conduct recovery exercises. While acknowledging that recovery training and exercises lag behind those for response, the National Recovery Working Group found that many organizations had already conducted small-scale recovery exercises and had applied lessons learned from them. One of the lessons identified was the need to exercise the shift from the response phase to the recovery phase.

Updated Recovery Handbooks for Radiological Incidents

The 2009 version of the *UK Recovery Handbooks for Radiological Incidents* is considered relevant to radiological releases—accidental and intentional—from the nuclear and nonnuclear industry sectors.[11] The handbooks, first published in 2005 by the United Kingdom's Health Protection Agency, were developed in response to the need for further recovery guidance following the Chernobyl nuclear power plant accident. The development of these handbooks was sponsored by six government departments and agencies representing national and local governments. According to a senior official from the Health Protection Agency, the European Union also supported the development of a series of generic recovery handbooks for use by other countries based on the structure, format, and content of the handbook developed for the United Kingdom. This official told us that member countries of the European Union are currently customizing their handbooks for use at national, regional, and local levels. The current handbooks, updated from the 2008 version, include management options for application in the prerelease, emergency and longer-term phases of an incident. Sources of contamination considered in the handbooks include nuclear accidents, radiological dispersion devices, and satellite accidents. The handbooks are divided into several independent sections comprising supporting scientific and technical information, an analysis of the factors influencing recovery, compendia of comprehensive, state-of-the-art datasheets for around 100 management options, guidance on planning in advance, a decision-aiding framework comprising color-coded selection tables, look-up tables and decision trees, and several worked examples. The handbooks can be applied as part of the decision-aiding process to develop a recovery

[11] A. Nisbet et. al., *UK Recovery Handbooks for Radiation Incidents 2009,* version 3, prepared for the Radiation Protection Division, Centre for Radiation, Chemical and Environmental Hazards, Health Protection Agency (Chilton, Didcot, Oxfordshire, U.K., December 2009).

strategy following an incident, for training purposes, and during emergency exercises. An example of a datasheet for one of the management options—high pressure hosing—contained in the *UK Recovery Handbooks for Radiation Incidents*: 2009, is provided in figure 1.

Figure 1: Example of a Datasheet on High Pressure Hosing for Cleaning Contaminated Surfaces in the *UK Recovery Handbooks for Radiation Incidents: 2009*

DATASHEETS OF MANAGEMENT OPTIONS

Back to list of options

7 High pressure hosing	
Likely Category	C
Objective	To reduce external gamma and beta doses and inhalation doses from contamination on external walls and roofs of buildings within inhabited areas.
Other benefits	Will remove contamination from external building surfaces.
Management option description	Pressure-washing equipment can be used to loosen contamination from a surface and wash it off. A continuous water flow is applied at high pressure of about 150 bar (2000 psi). Washing must start at the top of walls and roofs and it is particularly important to avoid lifting roof tiles by forcing water upwards. A pump is mounted on the ground and hoses are fed to a platform or scaffolding. Use of high pressure jets at pressures significantly above 150 – 200 bar is not advisable on roofs as this may lead to lifting of the tiles. **Roofs:** it should be practicable to collect the water used for high pressure hosing. Collection of water from roofs can be aided by modifying guttering and drainpipes, so that the collected waste is fed into collection tanks, where it may be filtered (most of radioactivity will be associated with the solid phase). If no active means are adopted to collect the water, some of the waste water may soak into the ground and the rest will pass directly into the drains or to soak-aways via gutters and drainpipes. It may be necessary to apply a surface treatment to roofs to ensure protection against future water penetration. **Walls:** it is unlikely to be practicable to collect the waste water and associated contamination. **Ground:** The implementation of options to the surrounding ground surfaces should also be considered after high pressure hosing has been implemented, if run-off to ground surfaces has occurred. If the implementation of any other options to the surrounding ground surfaces is planned, high pressure hosing of walls and roofs should be implemented first.
Target	External walls and roofs of buildings (highly contaminated).
Targeted radionuclides	All long-lived radionuclides. Not short-lived radionuclides.
Scale of application	Any size building.
Time of application	Maximum benefit if carried out soon after deposition when maximum contamination is still on the surfaces. However, high pressure hosing of external walls and roofs of buildings can be effective up to 10 years after deposition.
Constraints	
Legal constraints	Liabilities for possible damage to property (e.g. flooding). Ownership and access to property. Disposal of contaminated water via public sewer system. Use on listed and other historical buildings.
Environmental constraints	Severe cold weather (water would need to be heated). Walls must be waterproof. Roof constructions must resist water at high pressure.
Effectiveness	
Reduction in contamination on the surface	A decontamination factor (DF) of between 1.5 and 5 can be achieved if it is implemented soon after deposition. A higher DF can be achieved following dry deposition rather than wet deposition. In the case of plutonium, a DF of between of 10 and 2 can be achieved. For elemental iodine and tritium, thorough hosing of impermeable surfaces will lead to virtually full removal of contamination. The effectiveness of high pressure hosing decreases with time elapsed since contamination occurred, especially in areas with high rainfall rates. Repeated application is unlikely to provide any significant increase in DF.
Reduction in surface dose rates	External gamma and beta dose rates from decontaminated external walls and roofs of buildings will be reduced by a factor similar to the DF. Reductions in external doses received by a member of public living in the area will depend on the number of buildings in the area and the time spent by individuals close to these buildings (see below).
Reduction in resuspension	Resuspended activity in air will be reduced by the value of the DF.
Technical factors influencing effectiveness	Water pressure. Type, evenness & condition of surface, including the amount of moss on roofs. Time of operation: the longer the time between deposition and implementation of the option the less effective it will be due to fixing of the contamination to the surface. Consistent application of water over the contaminated area (ie operator skill). Care in application: care needed to wash contamination from walls and roofs and not just move the contamination around the surface; lower part of walls need to be cleaned very carefully as this is the surface that will provide the greatest dose to an individual in the vicinity of the building; special care needed to clean roof gutters and drain pipes. Whether the ground surrounding the building and other surfaces onto which run-off may

Version 3 49

Back to list of options

7 High pressure hosing

<table>
<tr><td></td><td colspan="8">have occurred have been decontaminated after treating the building (if waste was not collected).
Number of buildings in the area.
Time of implementation: weathering will reduce contamination over time so quick implementation will improve effectiveness.</td></tr>
<tr><td>Social factors influencing effectiveness</td><td colspan="8">Public acceptability of waste treatment and storage routes.</td></tr>
<tr><td colspan="9">Feasibility</td></tr>
<tr><td>Equipment</td><td colspan="8">The equipment used will depend on whether the waste water is filtered prior to disposal.
The equipment used for high pressure hosing can include:
2000 psi pressure washer
7.5kW generator
Filter
Spate pump
Gully sucker
Scaffolding with roof ladders for additional roof access
Transportation vehicles for equipment and waste</td></tr>
<tr><td>Utilities and infrastructure</td><td colspan="8">Roads for transport of equipment and waste.
Water supply.
Public sewer system.</td></tr>
<tr><td>Consumables</td><td colspan="8">Fuel and parts for generators and transport vehicles.
Surface treatment for roofs (if required).</td></tr>
<tr><td>Skills</td><td colspan="8">Skilled personnel essential to operate high pressure hoses and gully suckers.</td></tr>
<tr><td>Safety precautions</td><td colspan="8">For tall buildings: lifeline and safety helmets.
Water-resistant clothing should be recommended, particularly in highly contaminated areas.
Personal protective equipment (PPE) should be considered to protect workers from contaminated water spray.
Precautions are needed to ensure that people making connections to mains water supplies do not inadvertently contaminate the water supply, e.g. by back-flow from vessels containing radioactivity or other contaminants, or operate hydrants in a way that disturbs settled deposits within the water main system.</td></tr>
<tr><td colspan="9">Waste</td></tr>
<tr><td>Amount</td><td colspan="8">$2\ 10^{-1} – 4\ 10^{-1}$ kg m^{-2} solid and 20 l m^{-2} water.</td></tr>
<tr><td>Type</td><td colspan="8">Dust and water.</td></tr>
<tr><td colspan="9">Doses</td></tr>
<tr><td rowspan="5">Averted dose</td><td colspan="4">Cs-137
(% reduction in external dose)</td><td colspan="4">Pu-239
(% reduction in resuspension dose)</td></tr>
<tr><td colspan="2">Over 1st year</td><td colspan="2">Over 50 years</td><td colspan="2">Over 1st year</td><td colspan="2">Over 50 years</td></tr>
<tr><td>Dry</td><td>Wet</td><td>Dry</td><td>Wet</td><td>Dry</td><td>Wet</td><td>Dry</td><td>Wet</td></tr>
<tr><td><5</td><td><5</td><td><5</td><td><5</td><td>0</td><td><5</td><td><5</td><td><5</td></tr>
<tr><td colspan="8">The dose reductions are for illustrative purposes only and are for a person living in a typical inhabited area. The estimated dose reductions do not include any potential future doses that may arise if contaminated water enters the drainage system and subsequently the wider environment (see Appendix C for further information).</td></tr>
<tr><td>Factors influencing averted dose</td><td colspan="8">Consistency in effective implementation of option over a large area
Care in application. Care needed to wash contamination from walls and roofs and not just move the contamination around the surface; lower part of walls need to be cleaned very carefully as this is the surface that will provide the greatest dose to an individual in the vicinity of the building; special care needed to clean roof gutters and drain pipes.
Whether the ground surrounding the building and other surfaces onto which run-off may have occurred have been decontaminated after treating the building (if waste was not collected).
Population behaviour in the area.
Number of buildings in the area, i.e. environment type/land use.
Time of implementation. The impact of cleaning the surfaces on the overall doses will be reduced with time as there will be less contamination on the surfaces due to natural weathering.</td></tr>
<tr><td>Additional doses</td><td colspan="8">Relevant exposure pathways for workers are:
• external exposure from radionuclides in the environment and contaminated equipment
• inhalation of radioactive material resuspended from the ground and other surfaces (may be enhanced over normal levels)</td></tr>
</table>

Back to list of options

7 High pressure hosing

	• inhalation of dust and water spray generated • *inadvertent ingestion of dust from workers' hands* Contributions from pathways in italics are will not be significant and doses from these pathways can be controlled by using PPE. Exposure routes from transport and disposal of waste are not included. No illustrative doses are provided as they will be very specific to the type of contamination, environmental conditions, the tasks undertaken by an individual, controls placed on working and the use of PPE.	
Intervention costs		
Operator time	Work rate (m^2/team.hr)	30 – 60 (excludes setting up scaffolding, if required)
	Team size (people)	Up to 3 (depends on equipment used for access to buildings. More people needed if water is collected and filtered prior to disposal)
Factors influencing costs	Weather. Building size. Type of equipment used. Access. Proximity of water supplies. Use of personal protective equipment (PPE).	
Side effects		
Environmental impact	High pressure hosing will create contaminated waste water. However, this should be minimised through the control of any disposal route and relevant authorisations. If waste water is not collected, some of it will run onto other surfaces (roads, soil, grass etc), resulting in a transfer of contamination which may require subsequent clean-up, generating more waste. It is important that high pressure hosing of buildings is implemented before the implementation of any recovery options to surrounding ground surfaces.	
Social impact	Acceptability of active disposal of contaminated waste water into the public sewer system. High pressure hosing of buildings will make an area look clean; implementation may give public reassurance. Repair work on some walls and roofs may be required.	
Practical experience	Tested on realistic scale on selected walls and roofs in the Former Soviet Union and Europe after the Chernobyl accident.	
Key references	Andersson KG (1996). Evaluation of early phase nuclear accident clean-up procedures for Nordic residential areas. NKS Report NKS/EKO-5 (96) 18, ISBN 87-550-2250-2. Andersson KG, Roed J, Eged K, Kis Z, Voigt G, Meckbach R, Oughton DH, Hunt J, Lee R, Beresford NA and Sandalls FJ (2003). *Physical countermeasures to sustain acceptable living and working conditions in radioactively contaminated residential areas.* Risø-R-1396(EN), Risø National Laboratory, Roskilde, Denmark. Andersson KG and Roed J (1999). A Nordic preparedness guide for early clean-up in radioactively contaminated residential areas. *Journal of Environmental Radioactivity*, 46, (2), 207-223. Brown J and Jones AL (2000). Review of decontamination and remediation techniques for plutonium and application for CONDO version 1.0. NRPB, Chilton, NRPB-R315 Brown J, Charnock T and Morrey M (2003). DEWAR – Effectiveness of decontamination options, waste arising and other practical aspects of recovery countermeasures in inhabited areas. Environment Agency R&D Technical Report P3-072/TR Hubert P, Annisomova L, Antsipov G, Ramsaev V and Sobotovitch V (1996). *Strategies of decontamination.* Experimental Collaboration Project 4, European Commission, EUR 16530 EN, ISBN 92-827-5195-3. Roed J and Andersson KG (1996). Clean-up of urban areas in the CIS countries contaminated by Chernobyl fallout. *Journal of Environmental Radioactivity*, 33 (2), 107-116. Roed J, Andersson KG and Prip H (ed.) (1995). *Practical means for decontamination 9 years after a nuclear accident.* Risø-R-828(EN), ISBN 87-550-2080-1, ISSN 0106-2840, 82p.	
Version	2	
Document history	See Table 3.2.	

Source: A. Nisbet et. al., UK Recovery Handbooks for Radiation Incidents 2009, version 3, prepared for the Radiation Protection Division, Centre for Radiation, Chemical and Environmental Hazards, Health Protection Agency (Chilton, Didcot, Oxfordshire, U.K., December 2009).

RDD Recovery Exercises

In November 2008, Exercise Green Star tested government capabilities to recover from a terrorist attack based on RDD scenarios.[12] This was the first time that complex recovery issues had been considered in a national-level exercise. In this exercise, several hundred participants were wholly focused on recovery issues. About 6 weeks after an initial RDD tabletop response exercise, which set the scene for the participants, a 2-day recovery exercise took place involving three scenarios: rural contamination of crops and livestock, contamination of the urban transit infrastructure, and disruption of the water supply. On day one of the exercise, participants looked at immediate cleanup issues, including resource priorities and management responsibilities. On day two, participants considered the longer-term issues of environmental contamination, monitoring strategies, and financial considerations. The use of a real radioactive isotope within the exercise scenario ensured that participants were able to investigate their own and wider mechanisms for obtaining scientific advice during an incident. A scientific advisory group was put in place to expedite the recovery process by helping to manage scientific input into the decision-making process. An after-action report was prepared following this exercise to capture lessons learned.[13] One observation was that this exercise provided a unique opportunity to develop remediation policies within a compressed time frame, resulting in the development of a sound framework for recovery.

Community and National Risk Registration System

The United Kingdom has developed a comprehensive program to ensure an effective response to a range of disruptive emergencies that might affect the country. The country uses the term “resilience” as the ability of organizations, like individuals, to withstand or recover easily and quickly from hardships, such as major flooding or a terrorist attack. Community risk registers have been published by local emergency management planners since passage of the 2004 Civil Contingencies Act. These community risk registers address specific risks identified by representatives from local emergency services and public, private, and voluntary organizations. Local resilience forums are required to develop

[12]The United States plans to conduct its first full-scale recovery exercise, Liberty RadEx, in April 2010.

[13]In the United States, the implementation plan for the national exercise program provides that after-action reports should be completed in 6 months or less following an exercise. In our April 2009 report (GAO-09-369), we found that FEMA had not ensured that after-action reports for Tier 1 exercises were completed in a prompt manner.

and maintain these registers that include a description of potential outcomes, likelihoods, impacts, and ratings for various risk categories and subcategories of events. One of the risk categories is an actual terrorist attack using an explosive device. The national government does not expect communities to directly track these risks, but rather to improve their own preparedness based on information from the national risk assessment, which is a classified document. In 2008, the government published a national risk register, which is based on this classified assessment and discusses the likelihood and potential impacts of a range of risks facing the country, including attacks using chemical, biological, radiological, and nuclear materials. This national risk register contains information that was previously held confidential within government but was published to encourage public debate on security and to help organizations, individuals, families, and communities prepare for encountering threats. The government reports that while there have been very few examples of attacks such as the 1995 release of Sarin gas in a Tokyo subway, it still recognizes the need to prepare and plan for them.

Specific Nuclear Recovery Planning Guidance

In March 2009, the Nuclear Emergency Planning Liaison group published a *UK Nuclear Recovery Plan Template* based on the *National Recovery Guidance and Recovery Plan Guidance Template*.[14] This document provides generic guidance for a recovery strategy and structures needed to address a radiological release from a civil or defense nuclear reactor accident, as well as from incidents involving nuclear weapons or special nuclear materials in transit. This guidance is based on examples from existing local government recovery plans and experiences. While not specific to malicious use of radiological and nuclear materials, according to a senior government official with the Health Protection Agency, this guidance and associated monitoring templates would have potential application for recovery from RDD or IND incidents.

The *UK Nuclear Recovery Plan Template* considers recovery to be more than simply the replacement of what has been destroyed and the rehabilitation of those affected—it is a complex social and developmental process rather than just a remediation process. The manner in which recovery processes are undertaken is thus critical to their success and, therefore, best achieved when the affected community is able to exercise a

[14] Nuclear Emergency Planning Liaison Group, *UK Nuclear Recovery Plan Template* (United Kingdom, March 10, 2009).

high degree of self-determination. As such, this document provides that during the initial response phase, a Strategic Coordinating Group, which manages this phase of the process, would receive input from a Recovery Advisory Group and a Science and Technology Advisory Cell. The Recovery Advisory Group would be charged with identifying immediate and high-level strategic objectives for recovery early in the response phase, including, among other actions, determining remediation levels and when to stop remediation, managing radiation-contaminated waste, and managing compensation arrangements and recovery costs. These objectives would be accompanied by targets and milestones that the community would use as a basis to track recovery progress—for example, cleanup activities—with the aid of various predesigned templates. The Science and Technology Advisory Cell would include experts to advise on health and welfare, environment and infrastructure, and monitoring response and recovery activities. On transition to the recovery phase of an incident, the Strategic Coordinating Group would be replaced by a Strategic Recovery Coordinating Group.

The Strategic Recovery Coordinating Group would be supported by specific subgroups. These subgroups would include ones for finance and legal, communications, business and economic recovery, health and welfare, environment and infrastructure, and monitoring. For example, the subgroup on environment and infrastructure would identify viable options for remediation of food production systems, drinking water, and inhabited areas, including identifying options for the restoration and cleanup of the physical infrastructure and natural environment. The guidance suggests that this subgroup consider forming task groups to, among other things, address waste management and disposal, criteria to determine when remediation can cease, evaluate feasibility, and recommend remediation options for defined affected areas.[15] The templates would be referred to throughout the recovery to ensure that the work of the Strategic Recovery Coordinating Group is focused and on track.

[15]In the United States, DHS's *Planning Guidance for Protection and Recovery Following Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) Incidents* (August 2008) describes a process for establishing late-phase cleanup criteria through a site-specific optimization process that should include potential future land uses, technical feasibility, costs, cost-effectiveness, and public acceptability.

Appendix IV: GAO Contact and Staff Acknowledgments

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Staff Acknowledgments

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