Planning Guidance for Responding to and Recovering from Radiological Dispersal Device (RDD) Incidents

After the Initial Response

December 2023

FEMA

Acknowledgements and Disclaimers

The research supporting the development of this document was conducted with the U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T) under contract 70RSAT22KPM000038.

FEMA extends its appreciation to the National Urban Security Technology Laboratory (NUSTL), a component of DHS S&T, for its extensive collaboration in the development of this document. NUSTL is a federal laboratory that provides testing and evaluation services and products to the national first responder community. Its mission is to test, evaluate, and analyze homeland security capabilities while serving as a technical authority to first responder, state, and local entities protecting our cities. NUSTL services and products help first responders prepare, protect, and respond to homeland security threats. As a federal government-owned, government-operated lab, NUSTL uniquely provides independent technology evaluations and assessments for first responders, thereby enabling informed acquisition and deployment decisions and helping to ensure that responders have the best technology available to use in homeland security missions.

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Introduction

Background

In 2017, the Department of Homeland Security (DHS) National Urban Security Technology Laboratory (NUSTL) collaborated with the Department of Energy (DOE) National Nuclear Security Administration (NNSA) and FEMA to publish the *RDD Response Guidance: Planning for the First 100 Minutes*[1] (hereafter referred to as the *First 100 Minutes Guidance)*. The *First 100 Minutes Guidance* provides emergency planners and first responders with essential information on the initial response to an explosive RDD incident. It focuses on lifesaving and incident characterization actions initiated during the immediate minutes and hours following an RDD detonation. These actions include identifying that a radiation emergency has occurred, determining the direction and extent of any radioactive material release, making initial public warnings and notifications, and delivering official guidance to keep people out of immediate harm.

This *Planning Guidance for Responding to and Recovering from Radiological Dispersal Device (RDD) Incidents: After the Initial Response* (hereafter referred to as the *RDD Response and Recovery Guidance*) picks up where the *First 100 Minutes Guidance* leaves off and provides planners with a framework for the sustained response to and recovery from an RDD incident. Many activities initiated during the initial response as described in the *First 100 Minutes Guidance* will carry forward into and/or provide the baseline for sustained response and recovery.

Like the *First 100 Minutes Guidance*, this *RDD Response and Recovery Guidance* uses a timeline to assist planners with identifying when certain response and recovery activities should occur post-detonation. In this case, the timeline is based on the “early,” “intermediate,” and “late” protective action phases established in EPA guidance[2]. However, planners should recognize that there will likely be no clear, distinct line of separation between these phases of the response during an actual emergency. Even the total time involved – from the RDD detonation to full recovery – may vary from months to many years, depending on specific situational factors at time of the detonation and the complexity of the response and decisions made during recovery. In essence, every RDD incident will be unique to some degree. The information presented in this guidance is designed to inform, rather than prescribe, priorities and strategies for the challenges associated with RDD incident response and recovery.

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[1] NUSTL (2017) *Radiological Dispersal Device (RDD) Response Guidance, Planning for the First 100 Minutes*. Available online at:www.dhs.gov/sites/default/files/publications/nustl_rdd-responseplanningguidance-public_28oct2021-508-revised.pdf.

[2] EPA (2017) *Protective Action Guide Manual, Protective Action Guides and Planning Guidance for Radiological Incidents.* EPA-400/R-17/001, PAG Manual. Available online at: www.epa.gov/sites/default/files/2017-01/documents/epa_pag_manual_final_revisions_01-11-2017_cover_disclaimer_8.pdf.

Purpose

This *RDD Response and Recovery Guidance* provides the framework needed to plan for the sustained response to and recovery from an explosive RDD incident occurring anywhere within the United States (U.S.), its territories, or in tribal nations.[3]

This guidance is intended as a starting point to enable emergency planners, responders, and jurisdictional leaders to identify, prioritize, and implement response and recovery strategies tailored to specific RDD scenarios they may face. For example, this guidance includes how to best determine and select protective measures, remediation options, and incident objectives, as well as a socio-economically responsible long-term recovery effort. It also is intended to help emergency planners and leaders formulate timely, effective, and equitable decisions in the face of incomplete data and high levels of uncertainty, as is often the case in the early phases of an incident involving radiological materials.

Scope

The Strategies and Focus Areas detailed in this guidance comprise a flexible framework that planners can be adapted to a wide range of potential RDD scenarios and response and recovery lines of effort. This framework is intended to be adaptable to any level or size of jurisdiction or geographic area – large or small, urban, or rural – that may be impacted by an RDD incident. It also can serve as both a starting point for RDD incident response and recovery planning, or as a resource to benchmark existing jurisdictional and/or agency specific RDD incident response and recovery plans. While this guidance focuses specifically on scenarios involving *explosive* RDDs that produce a contaminated plume, most of the Strategies and Focus Areas described herein can be adapted to inform response and recovery planning for other types of radiation hazards, including non-explosive RDDs or the unintentional dispersion of radioactive material.

This guidance augments existing national doctrine and plans for all-hazards incident response and recovery, including but not limited to:

- The National Incident Management System (NIMS) and its Incident Command System (ICS);
- National Response Framework (NRF);
- National Disaster Recovery Framework (NDRF);
- Response and Recovery Federal Interagency Operational Plan (FIOP); and
- Nuclear Radiological Incident Annex (NRIA) to the Response and Recovery FIOP.

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[3] Per the NRIA, an RDD is any device that disperses radioactive material or emits radiation by conventional explosive or other mechanical means, such as a spray, at a harmful level without a nuclear detonation occurring. The harm caused by an RDD can include radioactive contamination, increased public fear of radioactive contamination, and denial of use of the contaminated area, perhaps for many years, which would also have an economic impact and require costly remediation. An RDD that uses explosives for spreading or dispersing radioactive material is called an "explosive RDD," sometimes also referred to as a "dirty bomb." For an explosive RDD, the explosion adds an immediate threat to human life and property.

Planning guidance and best practices discussed in this document are intended to support the multiple command, control and coordination structures set forth in federal statutes (e.g., the Comprehensive Environmental Response, Compensation and Liability Act [CERCLA], 42 U.S.C. 9601 et seq.), as well as state and local laws and ordinances relative to radiological incidents.

This *RDD Response and Recovery Guidance* is one of many resources available in a planner's toolkit. It does not provide an exhaustive account of every activity or operation that will be necessary to respond to and recover from an RDD incident. Instead, it focuses on prioritizing the critical activities that are either specific to the radiation hazard itself (such as characterizing contamination spread) or all-hazard activities that are complicated significantly because of radiological contamination (such as organizing a no-notice wide-area evacuation). Planners should use this guidance as a framework and, where operational details are not provided in sufficient detail, they should consult external guidance and other resources which are provided throughout this document in green-colored call-out boxes per the example provided below.

Recommended Resources:

- *These call-out boxes, provided throughout the Focus Areas, direct planners to additional resources they should review.*
- *Most often, those resources provide not just background information, but also detailed technical guidance on how to plan for and/or execute a particular activity.*
- *The Focus Areas provide a high-level review of response priorities and actions. Planners should consult the resources referenced in these green callout boxes for information on how to fully execute the activities described.*

Finally, in addition to understanding best practices for recovery from radiation emergencies, planners should also be familiar with general long-term disaster recovery, the components of which are discussed in various Focus Area descriptions below. Planners should begin by familiarizing themselves with the NDRF and other foundational guidance produced by FEMA. These resources include the Community Recovery Management Toolkit[4], which guides local governments in preparing for all-hazards recovery. The resources in this toolkit are geared towards helping community leaders through the long-term disaster recovery process and are intended to be useful for any phase of recovery.

Audience

The primary audience for this guidance includes emergency planners, responders and leaders representing a variety of multi-jurisdictional emergency management, public safety/first responder (e.g., law enforcement, fire, emergency medical services and hazardous materials), environmental

[4] See Community Recovery Management Toolkit | FEMA.gov

protection, engineering, public health, public works, crisis communications, disaster recovery, and other organizations that plan, conduct, oversee and/or are legally responsible for RDD incident response and recovery.

Document Organization

This document is organized into three (3) major sections:

- **Introduction***:* Provides information on document background, purpose, scope, audience, and organizational structure.
- **Critical Considerations and Planning Factors***:* Discusses operational and protective action phasing for RDD incident response and recovery, core RDD scenario considerations that planners should include in their plan development, and other important factors that can contribute to effective RDD preparedness planning.
- **Strategies and Focus Areas***:* Describes the five (5) "Strategies" and ten (10) supporting "Focus Areas" that comprise the overarching framework for RDD incident response and recovery presented in this document. Strategies represent high-level outcomes that the responding jurisdiction(s) should strive to accomplish throughout RDD incident response and near-term recovery. Focus Areas refer to operational response activities that must be executed to achieve a strategic objective.

Additional references, background information, and supplementary materials corresponding to various key aspects of RDD incident response and recovery are provided in the annexes to this document as described below:

- **Annex A** contains a glossary of key terms used in this document along with their corresponding definitions.
- **Annex B** highlights critical information and key data needs by individual Focus Area. This annex includes what information needs to be collected, why it is important, and how it can inform the response and recovery process. Annex B is organized based on a checklist format for ease of use by planners or individuals managing RDD incident response and recovery.
- **Annex C** provides a compendium of readily available radiological incident communications tools and user guides, along with relevant trainings.
- **Annex D** provides an overview of the key concepts, methods, and techniques for decontamination and demolition of environments affected by radiological materials.
- **Annex E** includes a summary of available software tools and resources that can assist planners and emergency responders in managing various aspects of RDD incident response and recovery (e.g., incident characterization, protective action guidance, decontamination operations, etc.).

Critical Considerations and Planning Factors

This section briefly describes operational and protective action phasing for RDD incident response and recovery, core RDD scenario considerations, and other factors that planners should account for in their plan development.

RDD Incident Operational Phases

The DHS NRIA to the Response and Recovery FIOP divides incident operations into Phase 1: Pre-incident, Phase 2: Coordinated Response and Recovery, and Phase 3: Recovery and Restoration, as shown in Figure 1. The Strategies and Focus Areas described in this *RDD Incident Response and Recovery Guidance* align with Phases 2a-c and 3a of the NRIA. This guidance does not describe prevention and interdiction missions, except briefly in the context of potential additional radiological or non-radiological threats following an initial RDD incident.

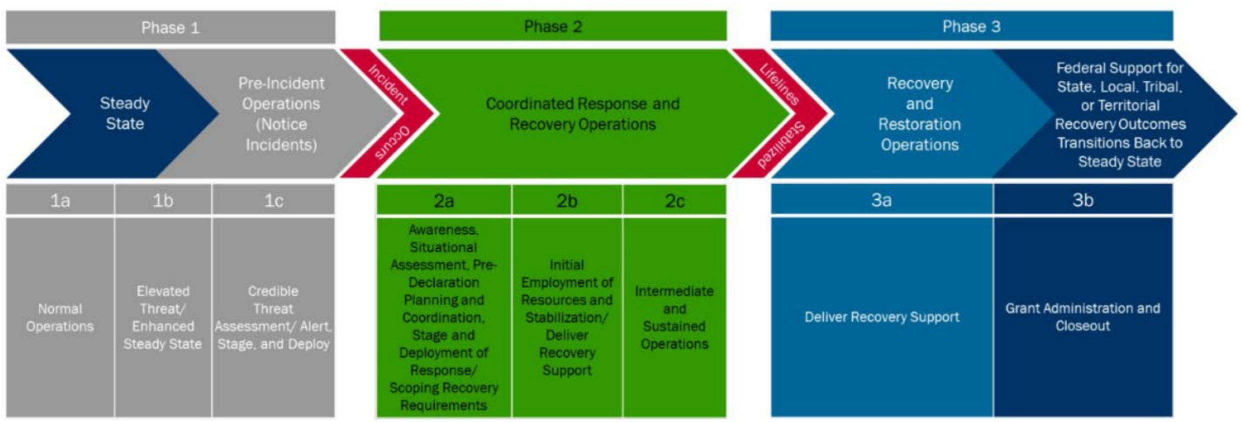

Figure 1: NRIA Incident Operational Phases

RDD Protective Action Phases

The EPA's *Protective Action Guidance (PAG) Manual*[5] divides protective action decision making into three phases that are common to all radiological incidents. These phases represent non-precise time periods in which response officials would be issuing important public health protection decisions

[5] Definitions from p. 5 in EPA (2017) *Protective Action Guide Manual, Protective Action Guides and Planning Guidance for Radiological Incidents.* EPA-400/R-17/001, PAG Manual. Available online at: www.epa.gov/sites/default/files/2017-01/documents/epa_pag_manual_final_revisions_01-11-2017_cover_disclaimer_8.pdf.

(e.g., shelter-in-place, evacuation, food, and water safety, etc.). Certain protective actions may overlap more than one phase.

Protective Action phases are categorized in the EPA's *PAG Manual* as follows:

- Early Phase: The period at the onset of an RDD incident when immediate decisions regarding protective actions are required. Decisions in this phase are based primarily on the magnitude, location, type of radioactive material involved, and the likelihood for worsening atmospheric and climatic conditions. Predictions of radiological conditions based on the type of RDD (explosion or other dispersal method), initial measurements of the radiation levels by first responders, and weather conditions typically inform protective action guidance in this phase. In the worst case, there may be little or no information available on actual releases or via field measurement data. Protective actions in this phase are aimed at avoiding inhalation of gases or particulates in a plume and minimizing external exposure.

- Intermediate Phase: Begins after the incident source and releases have been brought under control (or no longer pose a significant threat to human health) and more precise protective action decisions can be made based on reliable measurements of exposure and radioactive materials that have been deposited. This phase may overlap with and/or follow the early phase response within as little as a few hours and can last for weeks or months. Protective actions in the intermediate phase are intended to reduce or avoid radioactive exposure to the public, control worker exposures and the spread of contamination, and set the stage for late-phase cleanup.

- Late Phase: Represents the period when actions designed to reduce radiation levels in the environment to acceptable levels are conducted. This phase entails final cleanup decisions and implementation of remediation strategies, and generally overlaps with the Intermediate Phase to some degree. For major RDD incidents, this phase could last for years.

Table 1: provides a comparison of NRIA Incident Operations Phases and Protective Action Phases for an RDD incident. The table demonstrates where in the NRIA incident timeline the bulk of the Focus Area-specific activities described in this guidance would occur. However, it is important to recognize that this timeline is notional and that some Focus Area-specific activities (e.g., evacuation and waste management) may initiate earlier or extend later than what is depicted in Table 1: depending on the situation. Additionally, some Focus Area-specific activities may be repeated iteratively over more than one phase.

Table 1: Comparison of NRIA Incident Operations Phases and EPA Protective Action Phases

NRIA Incident Operations Phases:	Phase 2a 1 – 24 Hours	Phase 2b 24 – 72 Hours	Phase 2c 72 hours – 30 Days	Phase 3 30 Days+
EPA Protective Action Phases:	Early	Intermediate		Late
1 – Characterize, Map, and Model	X	X	X	X
2 – Implement Rad Exposure Mitigation	X	X	X	X
3 – Public Communications	X	X	X	X
4 – Conduct Phased Evacuation	X	X	X	
5 – Screen and Decontaminate	X	X	X	X
6 – Restore and Sustain Critical Infrastructure and Select Buildings		X	X	X
7 – Remediate			X	X
8 – Manage and Dispose of Waste			X	X
9 – Reopen				X
10 – Enable Long-Term Recovery				X

RDD Incident Scenario Considerations

Emergency planners should consider a number of potential scenario variations as they develop their RDD incident response and recovery plans. Typical RDD scenarios could include additional complicating factors depending on the mode of the threat as well as the nature of the radioactive material involved. These variations, in turn, may pose a range of distinct challenges for emergency planners in terms of the timing and conduct of specific response and recovery actions, the quantity and type of resources required, strategies for communicating incident information and protective actions, managing phased evacuation and remediation actions, etc.

Specific factors to consider include:

- **Mode of dispersal.** An RDD could be employed either passively or actively. For example, radioactive sources or other radioactive material could be clandestinely dispersed in one or more locations. In this scenario, it may take some time to identify that an intentional release of radioactive material has occurred, thus potentially complicating emergency response and recovery efforts. On the other hand, an explosive RDD could be either a standalone detonation or associated with an active threat situation (such as a complex, coordinated terrorist attack). Additionally, one or more RDDs could be employed in conjunction with other conventional explosives and non-radiological improvised explosive devices (IEDs). The presence of an active threat could also complicate matters in terms of how long it takes to first determine that an RDD has been employed and, second, in delays in gathering critical information needed to plan follow-on emergency response and recovery efforts.

- **Amount of material involved.** The potential harm posed by radiological material does not necessarily always correlate with the amount or size of material involved. For example, one gram of Cobalt-60 (Co-60) has about 1,000 times as much radioactivity as one ton of depleted uranium. Rather, the activity and specific properties of the material itself determine its potential harmfulness to human life. On the other hand, for longer-term recovery purposes, the gross amount of material involved does matter in terms of how much may be distributed across a given area. A larger amount of material could potentially be present in a Vehicle-borne Improvised Explosive Device (VBIED) than in a smaller device, carried by hand. If actively dispersed, such as via an explosive event, a larger explosion involving a greater amount of material would create a larger area of contamination than a smaller explosion with a lesser amount of radioactive material. Additionally, a very large area could potentially be contaminated with a low-hazard material in one scenario, while a very small area could likewise be contaminated with a high-hazard material in another.

- **Isotope Involved.** The specific isotope of the radioactive material used will shape planning for response and recovery. Based on the type of radiation they emit – i.e., gamma, beta, or alpha radiation, or a combination thereof – radioactive materials pose threats to human life in very different ways. For instance, a gamma emitting source may pose a threat at a distance, whereas alpha and beta emitting sources pose more of a threat when inhaled or ingested. Similarly, the detectability of different materials varies by the type of radiation emitted. Identifying the presence of airborne materials and the isotope involved is critical to determining appropriate PPE and detection equipment. For example, if the primary radiation type is beta radiation, responders should prioritize PPE that keeps the material from contacting the skin. Alpha radiation cannot hurt the skin, so it is more important to prioritize PPE that prevents inhalation or ingestion. Meanwhile for gamma emitters, the most effective method to avoid harmful exposure will be to monitor exposure with detection equipment and minimize the total time of that exposure, and if there is a risk of airborne material, responders should don respiratory PPE. The differences in how these radioactive materials may affect the response are summarized in Table 2:. It is worth noting that many isotopes emit more than one type of radiation (e.g., Americium-241 and Radium-226 emit both alpha and gamma radiation, Cesium-137 and Iodine-131 emit both beta and gamma radiation).

Table 2: Summary of Radiation Types and How they Affect the Response

Radiation Emitted	Harm to Humans	Ease of Detection	Example Isotopes
Gamma	Can cause harm at a distance, protective clothing largely ineffective. Respiratory PPE is critical.	Easy to detect with common personal detectors.	Cesium-137, Cobalt-60, Iridium-192
Beta	Most dangerous if ingested or on skin or clothes, but also represents an inhalation hazard.	Moderately difficult to detect, requires Geiger-Mueller (GM) detector of personal beta detection equipment.	Strontium-90, tritium (Hydrogen-3)
Alpha	Only dangerous if inhaled or ingested.	Difficult to detect, requires specialized equipment and potentially sample processing.	Americium-241, Uranium-238, Radium-226

- **Particle Size of the radioactive material.** The ease with which radionuclides can be dispersed into the environment has significant effects both on the response and longer-term decontamination efforts. Readily inhalable or ingestible material is likely to spread further and pose a larger risk of internal contamination and require prompt medical assessment. On the other end of the scale, ballistic fragments – large chunks or pieces thrown from a detonation – will not pose any internal hazards (unless there is penetration beyond the skin surface) and will not move dramatically in wind or rain, but they may pose extreme external gamma or beta hazards due to the large amount of radioactive material concentrated in one place. Additionally, the geographical extent of decontamination operations will increase for certain materials that are more easily dispersed through the environment via wind, water, and mechanical means (such as fine particles being further dispersed by people walking through an affected area).

- **Solubility of the radioactive material.** The solubility of the radioactive material involved will have significant impacts on the potential for human harm, movement in the environment, and in decontamination or remediation efforts. Soluble material will absorb more readily in the lungs, or in the digestive tract, making it more important to prevent accidental inhalation or ingestion of the material by responders or the public. Containment of a soluble material will be complicated during rain or other precipitation, which may wash radioactive material into the soil, storm drains, or local waterways. This same solubility potentially makes gross decontamination easier: if contaminated water can be properly captured, most of the contamination from roads and building exteriors may be easily removed by hosing with water. Further treatment to remove fixed contamination may still be needed.

- **Nature of area(s) potentially contaminated.** Emergency response and recovery efforts will be complicated by the size of the area involved. Larger areas will require larger numbers of resources to isolate the area, survey the hazard, conduct evacuation operations (if necessary), and otherwise undertake response and recovery actions. For example, a release contained to an area within a building would be less complex than a release affects multiple buildings. Likewise, the type and nature of buildings, the heating and ventilation configuration, surrounding geography, vegetation, and other variables will all impact the complexity of response and recovery efforts.

- **Number of people in the potentially affected area.** For purposes of shelter-in-place and evacuation decision making, the number of people in the potentially affected area is a key variable. If a release occurs in a highly populated area, more resources will be required. If a release occurs in an area with a small or contained population (e.g., an industrial site), the need for direct engagement in large-scale operations involving the public may be less crucial.

- **Geography and weather.** One of the key factors for planners to consider is the geography of the area(s) involved and the weather and climatic conditions at the time of the release. Some key questions to consider: 1) Are waterways nearby? If so, containment of additional contamination may become an urgent priority. For example, in urban areas, stormwater drainage and similar systems are likely to capture contaminated run-off and funnel it to nearby surface waterways. 2) If snow is involved, will it melt and create runoff causing further distribution of the material? 3) How soon will rain occur before remediation and cleanup activities can be completed, and is it likely to move materials in a way that will expand the identified hazard area? For large-area contamination, it is unlikely decontamination will be completed before some type of precipitation occurs. In this case, responders' early focus should be on minimizing migration instead of decontamination. It is important for planners to be cognizant of the potential movement of materials throughout the environment, as this movement could change the nature of the known hazard area, as well as the response and recovery variables associated with the incident.

Other Considerations

Concurrent Response, Recovery, and Law Enforcement Investigative Operations

The aftermath of an RDD incident will involve concurrent response, recovery, and law enforcement investigative operations. These various activities will need to be fully coordinated via the incident command structure established for the incident. Additionally, it is possible that a single RDD attack may represent the start of a more widespread series of follow-on threats or attacks, or that secondary devices may have been placed at or near the scene or along likely routes to the scene. Thus, prevention operations focused on potential follow-on threats or concurrent incidents (e.g., cyber-attacks) also will need to be coordinated with ongoing emergency response and recovery operations, including life-saving activities.

Resources and Capability Gaps

The response to an RDD incident likely will require substantial, specialized emergency response resources, such as technical hazmat capabilities, beyond what is immediately available to most local jurisdictions. While state and federal resources will be a critical source of support, it may take several hours to days for them to become fully operational in the impacted jurisdiction. Planners should account for this probability during the planning process and leverage that process to identify gaps in their response and recovery capabilities. Gaps and capabilities should be mapped against the external resources that likely will be provided, starting with those local, state, and federal resources that are available through mutual aid, remotely, and/or on an expedited mobilization timeline. For federal resources, the NRIA to the Response and Recovery FIOP is a good place to start.

Remediation/Clean Up

Since an RDD has the potential to spread radioactive material over a wide area, a central part of recovery from an RDD involves the remediation – or clean up – of areas where radioactive material has settled into the environment. From the remediation perspective, recovery is successful when these areas can be returned to their original use (e.g., as a residence, business, or recreation center), or are beneficially repurposed (e.g., a residential area re-zoned for industrial use). A comprehensive RDD recovery plan must also ensure all aspects of the recovery – from public health monitoring to reopening procedures to community rebuilding – allow for the continuation or restoration of services critical to supporting the physical, emotional, and financial well-being of impacted community members, while strengthening the key systems and resource assets that are critical to the economic stability, vitality, and long-term sustainability of the communities themselves. These include health and human services capabilities and networks, public and private disability support and service systems, educational systems, community social networks, natural and cultural resources, affordable and accessible housing, infrastructure systems, and local and regional economic drivers.[6]

Specialized Subject Matter Expertise

Specialized technical subject matter expertise will be needed to plan, execute, and provide key advice throughout the RDD incident response and recovery process. Responsible jurisdictions should identify individual subject matter experts (SMEs) and operational technical working groups (TWGs) comprised of multi-disciplinary SMEs who can advise incident leadership on technical aspects of the response and recovery effort. Such expertise could include radiation safety professionals such as health physicists and experts in radiological decontamination, as well as issue-specific experts to inform key remediation strategies and techniques. Examples of SME support and other specialized resources are provided in the Focus Area descriptions that follow below.

[6] DHS (2016) *National Disaster Recovery Framework. Second Edition.* Available online at: https://www.fema.gov/emergency-managers/national-preparedness/frameworks/recovery

TWGs can also serve as an interface between planners and responders and the wide array of federal technical expertise that is available remotely and in-person. It is also possible that the affected jurisdiction(s) would be best served by establishing several TWGs, which could be mobilized as necessary to provide advice on specific technical aspects of the response and recovery effort (e.g., an TWG for proposing a cleanup level and another for reviewing safety plans). A critical component of RDD incident planning is identifying the TWGs/SMEs available to both responsible jurisdictions and external partners (e.g., state, federal, private sector, academia, etc.), and determining their role and integration into the response and recovery effort.

Sample of the Variety of Disciplines Required for RDD Recovery

- **Health physicist(s)** for determining occupational controls for health and safety, dose calculations of people exposed to radioactive material, and supporting environmental sampling plan design and execution and evaluating sampling and survey results.
- **Environmental chemists** for assessing the movement of radioactive material in the environment.
- **Geographic information systems experts** who can map and gather diverse types of data including– building type, contamination levels, critical infrastructure., etc.
- **Communication specialists** who can discuss radiation risk with responders and the public.
- **Food, water, and animal feed safety experts** who can help prevent the public's ingestion of radioactive material.
- **Public health and medical professionals** to advise, monitor, assist, and care for affected people and animals, including behavioral health professionals to support first responders and affected members of the public.
- **Structural engineers** who can enter contaminated areas to conduct building inspections.
- **Solid waste managers** who can identify infrastructure and equipment that may be available to use for the response, and to coordinate waste management activities related to the response and routine waste management activities in the areas outside the hot zone (HZ).

Planning Assistance

Local jurisdictions should contact state agencies with core capabilities in emergency response and radiological protection to initiate and coordinate emergency response and recovery planning and operations. Additionally, regional representatives from federal agencies are available to assist in the development of local radiological response and recovery plans.

Why Plan for RDD Recovery?

- **Enable effective and efficient decontamination and remediation efforts.** Decontamination and remediation involve comprehensive and inclusive engagement of public and private stakeholders, which should begin as part of a comprehensive planning process. Without such engagement, response and recovery will be more expensive, involve longer timelines, and possibly involve loss of public trust.

- **Allow for more efficient use of resources.** RDD response and recovery will be multi-agency, multi-jurisdictional, and multi-disciplinary. An effective planning process builds an understanding of authorities, resources, and capabilities among various engaged partners and helps identify where capacity must be built and/or filled using a combination of internal and external resources.
- **Improve the safety and efficacy of response and recovery activities:** Generally speaking, emergency workers, planners, and the public do not have sufficient understanding of radiation hazards and related risk. Effective planning details how risk and protective action information will be communicated to affected audiences.

Coordination Opportunity: FEMA Office of Emerging Threats (OET)

FEMA OET Office and FEMA Regional OET Coordinators can support RDD plan development. Both can be contacted via FEMA-OET@fema.dhs.gov

Strategies & Focus Areas Overview

This *RDD Response & Recovery Guidance* is organized into five strategies, which focus on high-level objectives that the responding jurisdiction should be striving to accomplish throughout RDD incident response and recovery. These strategies are summarized below.

- **Strategy 1: Characterize, Map and Model** radiological hazards to establish the maximum extent of contamination spread, provide data for remediation activities, and determine the potential risk radiation poses to people and the environment within the contaminated area.
- **Strategy 2: Communicate** radiation exposure risks to the public and first responders to give them the information they need to protect themselves, their families, and community, enabling long-term recovery and reoccupation.
- **Strategy 3: Monitor and Assist** affected populations to reduce their radiation exposure and enable continuity of disaster services amid a contaminating incident.
- **Strategy 4: Restore the Environment** by reducing and removing radioactive hazards to the public, including radiological waste generated by the incident and cleanup activities.
- **Strategy 5: Reopen and Recover** impacted areas to enable public reoccupation and re-use and equitable rehabilitation of communities.

Within each Strategy are one or more Focus Areas, which describe operational response activities that must be executed to achieve the strategy objective. Focus Areas also provide information that can help a responding jurisdiction to develop/prioritize their objectives for the response. While the Focus Areas are numbered, they are not necessarily sequential. Each Focus Area contains activities that span multiple incident phases, ranging from hours and days (early phase) to months or even years (late phase); many of the earlier activities will inform later ones. Strategies, Focus Areas, and activities are summarized in Table 3: below.

The annexes provide supplementary material to aid the reader. Annex B highlights critical information and key data needs by Focus Area. It identifies what information needs to be collected, why it is important, and how it can inform the response and recovery process. Annex B serves as a checklist-type aid for a planner or those managing the response to and recovery from an RDD incident.

Table 3: Strategies, Focus Areas, and Activities Overview

Strategy 1: Characterize, Map, and Model		
Focus Area 1: Survey Radiological Hazards	1.1	Conduct a Wide Area Radiation Survey to Establish the Contaminated Area Boundary
	1.2	Collect Samples and Measurements for Field and Laboratory Analysis
	1.3	Conduct a Detonation Site Risk Assessment and Near-Field Grid Survey
	1.4	Implement Data Quality Practices
	1.5	Establish and Revise Incident Boundaries
	1.6	Conduct Monitoring/Surveillance to Detect Spread of Contamination
Focus Area 2: Implement Radiation Exposure Mitigation	2.1	Conduct Exposure Pathway and Dose Assessment
	2.2	Implement an Exposure/Dose Record Process for Emergency Workers, Remediation Workers, and Essential Employees
	2.3	Determine Personal Protective Equipment Requirements for the Contaminated Area
	2.4	Mitigate Spread of Contamination
Strategy 2: Communicate		
Focus Area 3: Public Communications	3.1	Provide Updated and New Early-phase Emergency Messaging
	3.2	Identify and Develop Intermediate and Late-Phase Communication Strategies
	3.3	Assess and Improve Communications
Strategy 3: Monitor and Assist		
Focus Area 4: Conduct Phased Evacuation	4.1	Identify Areas Where People Will Require Evacuation, Release from Shelter-in-Place (SIP), or an Extended Period of SIP
	4.2	Mobilize and Execute a Phased Evacuation Over the Next Few Days
	4.3	Conduct Search, Rescue, and Canvassing Operations

Focus Area 5: Screen and Decontaminate	5.1	Screen and Decontaminate Responders and their Equipment
	5.2	Consolidate Screening/Decontamination Activities and Provide Comprehensive Population Monitoring Services to the Public
	5.3	Screen and Decontaminate Personal Belongings and Civilian Vehicles Removed from Contaminated Areas
Strategy 4: Restore the Environment		
Focus Area 6: Sustain Critical Infrastructure	6.1	Gather Information on Impacted Buildings and Infrastructure
	6.2	Decontaminate Critical Infrastructure
	6.3	Establish Restoration/Sustainment Task Forces
	6.4	Conduct Restoration/Sustainment Operations
Focus Area 7: Remediate	7.1	Execute the Optimization Process for Defining Remediation Zones and Cleanup Levels
	7.2	Develop Remediation Plans
	7.3	Perform Remediation/Clean up
	7.4	Verify Cleanup Levels
	7.5	Release the Area/Site
Focus Area 8: Manage and Dispose of Waste	8.1	Conduct Early-Phase Waste Management and Containment Operations
	8.2	Estimate the Volume of Waste and Establish Waste Management Goals
	8.3	Establish Temporary Waste Staging, Long-Term Waste Disposal Sites, and Inter-Jurisdiction Transportation Requirements
Strategy 5: Reopen & Rebuild		
Focus Area 9: Reopen	9.1	Establish Reopening Criteria for Structures in Remediation Zones
	9.2	Conduct Repairs and Prepare for Reopening

Focus Area 10: Enable Long Term Recovery	10.1	Transition from Incident Response and Lifeline Stabilization to Recovery
	10.2	Execute Existing Disaster Recovery Plans and Identify a Recovery Coordinating Structure
	10.3	Engage Stakeholders Representing Recovery Core Capability Groups
	10.4	Manage Recovery Efforts by Leveraging the Recovery Support Functions

Strategy 1: Characterize, Map, and Model

Focus Area 1: Survey Radiological Hazards

Guidance: *Review and complete the preliminary 10-point Monitoring Survey and begin leveraging advanced radiological response assets to conduct a comprehensive survey of the contaminated area. Results from the additional surveys are used to define the boundaries of contamination, characterize radiological hazards, implement exposure mitigation techniques described in Focus Area 2, and inform other response and recovery actions.*

Recommended Planning Partners:

- Emergency management
- Fire/HAZMAT teams
- Law enforcement
- Public Safety Bomb Technicians / FBI Special Agent Bomb Technicians
- Public health
- Environmental protection
- State/Local Radiation Control Program

Key Terminology: Hazard Control Areas

The Contaminated Area: The "contaminated area" consists of any place where radionuclides are present above some baseline or threshold on a surface or in the environment because of a release. This measurement baseline or threshold, above which an area would be considered contaminated, should be determined in advance, and then reassessed following an actual release. Development of a baseline or threshold could be done by using a value above background (e.g., 10% above background) or a fraction of other hazard control threshold (e.g., 10% of hot zone threshold or turn-back limit). Jurisdictions should develop appropriate levels in collaboration with radiological subject matter experts. Identification of the contaminated area will help identify areas that may require remediation and exposure mitigation actions (see Focus Area 2) to protect people living or working in those areas.

Hot Zone (HZ): The Hot Zone is an area where radiation levels exceed 10 mR/h and additional controls are warranted to reduce exposure to prevent long-term radiation risks.

Dangerous Radiation Zone (DRZ): The Dangerous Radiation Zone is an area where radiation levels exceed 10 R/h and additional controls are warranted to reduce exposure to prevent short-term radiation risks.

Warm Zone: The warm zone is a transition area between contaminated areas and uncontaminated areas where responders don and doff protective gear and decontamination activities take place.

Introduction

The *First 100 Minutes Guidance* outlines a 10-point monitoring survey designed to inform responders of the direction and extent of contamination spread and the general scale of hazard control areas (e.g., hot zone).[7] As the 10-point survey is being completed, responders will need to begin planning to conduct a more comprehensive radiological survey and hazard characterization to achieve a complete picture of the radiological, chemical, and physical hazards created by the incident. Through these additional surveys and characterization activities, responders should be able to confirm the radionuclide(s) involved and identify the **contaminated area** boundary and radiological conditions within it. This information will be essential for instituting radiation exposure mitigation efforts to protect the public and responders (see Focus Area 2) and designating and prioritizing areas that will require radiological remediation (see Focus Area 7).

Coordination Opportunity: Law Enforcement - Evidence Collection

The federal government will coordinate with and support state, local, tribal, and territorial (SLTT) authorities during incidents involving nuclear/radiological weapons, materials, or devices. Federal law enforcement (e.g., Federal Bureau of Investigation [FBI]) investigative activities will be coordinated and deconflicted with SLTT survey and sampling activities as well as with SLTT law enforcement activities to ensure that samples collected do not interfere with the preserving and collecting of evidence.

A comprehensive radiological measurement survey will require appropriate personnel support and technical expertise. During the planning process, jurisdictions should document the advanced radiological survey and analysis resources that are directly available to them as well as those available through regional partners, the private sector, and the federal government. FEMA's *Nuclear/Radiological Incident Annex* to the Response and Recovery FIOP includes a summary of the federal assets that are available for request by a state government, some on an expedited timeline.[8]

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[7] p.28 in NUSTL (2017) *Radiological Dispersal Device (RDD) Response Guidance, Planning for the First 100 Minutes.* Available online at: https://www.dhs.gov/sites/default/files/publications/nustl_rdd-responseplanningguidance-public_28oct2021-508-revised.pdf.

[8] See "Appendix 1" in FEMA (2016) *Nuclear/Radiological Incident Annex to the Response and Recovery Federal Interagency Operational Plans*. Available online at: https://www.fema.gov/sites/default/files/2020-07/fema_incident-annex_nuclear-radiological.pdf.

Since few jurisdictions will have the resources to fully conduct all the surveys described in this focus area, response and recovery plans should clearly document what survey requirements will be fulfilled by available external assets.

There are four key radiological surveys that should be conducted to fully characterize an incident:

- **Wide-area surveys (see Activity 1.1)** to determine with more granularity the extent of contamination spread to establish hazard control area boundaries – including the HZ and DRZ – as well as a general understanding of the conditions within the contaminated area.
- **Field and laboratory analysis of samples (see Activity 1.2)** to determine the nuclide and the chemical and physical properties of the material released (including the degree to which radioactive material is loose or bound to surfaces) which will directly inform exposure mitigation (see Focus Area 2) and remediation (see Focus Area 7).
- **Radiological risk assessment of the release site (see Activity 1.3)** to identify short-term exposure mitigation actions necessary for personnel who may need to access the site as part of the initial crime scene investigation and during initial lifesaving, site stabilization and remediation activities.
- **Grid survey[9] (see Activity 1.3)** to develop a detailed understanding of the conditions (e.g., distribution of contamination) within the contaminated area to provide critical data necessary to initiate remediation planning.

Additional systematic (e.g., grid-based) surveys (before and after remediation) will be necessary in the weeks and months following a radiological release as part of the remediation process. These systematic surveys and their specific requirements likely will be designed and executed by private-sector resources, such as remediation contractors tasked with conducting the cleanup, rather than first responders. Remediation contractors will document this information in their remediation work plans (see Focus Area 7).

The remaining sections of this Focus Area describe key considerations for designating the boundary of the contaminated area and developing guidance for establishing data quality objectives. The **contaminated area** boundary will consist of the entire area where contamination is discovered above a threshold determined during planning as the result of a release. It will not necessarily be synonymous with a hazard control area (e.g., hot zone) or the specific areas requiring remediation (i.e., "remediation zones," introduced in Focus Area 7). State and local public health officials, with the support of federal expertise, will need to assess the relative hazard to the public and responders in areas where contamination is discovered, as discussed in Focus Area 2. Table 28: found in Annex

[9] The "near-field" is defined in the *First 100 Minutes Guidance* as the area between the detonation site and the 1 km transect. See p. 27 in NUSTL (2017) *Radiological Dispersal Device (RDD) Response Guidance, Planning for the First 100 Minutes.* Available online at: https://www.dhs.gov/sites/default/files/publications/nustl_rdd-responseplanningguidance-public_28oct2021-508-revised.pdf.

B describes the information objectives and significance of key data for making recovery decisions for Strategy 1: Characterize, Map, and Model.

Recommended Resources: RadResponder

RadResponder is a web-based tool and iPhone/Android app managed by FEMA[10] that enables organizations to rapidly and securely record, share, aggregate, and visualize radiological survey data. Users may also manage their detection instrumentation, personnel, interagency partnerships, and multijurisdictional event space. RadResponder is provided free to federal, state, local, tribal, and territorial (FSLTT) responders and organizations. For more information see: https://www.radresponder.net/
RadResponder is also available through CBRNResponder: https://www.cbrnresponder.net/

[10] Product of collaboration between Federal Emergency Management Agency (FEMA), Department of Energy (DOE) / National Nuclear Security Administration (NNSA), the Environmental Protection Agency (EPA), the Defense Threat Reduction Agency (DTRA), and the Department of Homeland Security's Science and Technology Directorate (DHS S&T)

Table 4: Summary of Focus Area 1 Activities

	Activity	Phase
1.1	Conduct a Wide Area Radiation Survey to Establish the Contaminated Area Boundary	Early to Intermediate (Hours to Days)
1.2	Collect Samples and Measurements for Field and Laboratory Analysis	Early to Intermediate (Hours to Days)
1.3	Conduct a Release Site Radiological Risk Assessment and Grid Survey	Intermediate to Late (Days to Weeks)
1.4	Implement Data Quality Practices	Intermediate (Days to Weeks)
1.5	Establish and Revise Incident Boundaries	Intermediate to Late (Days to Months)
1.6	Conduct Monitoring/Surveillance to Detect Spread of Contamination	Intermediate to Late (Days to Months to Years)

Activity 1.1: Conduct a Wide Area Radiation Survey to Establish the Contaminated Area Boundary

- Review data from the 10-point monitoring survey, executed as part of the *First 100 Minutes Guidance* activities, to identify anomalies or major gaps in survey data coverage or data quality. A data verification and validation process should be initiated per the *First 100 Minutes Guidance* to support decision making (see Annex 4); however, it is unlikely that there will be time to rigorously assess data quality until more resources are available. This review can be executed by a highly trained first responder, radiation safety professional including a Radiological Operations Support Specialist (ROSS), emergency manager, or public health official. The review could also be supported remotely with experts reviewing the information using RadResponder. Preliminary data should be assessed to identify:
    - Readings that are unusually high or low relative to other nearby data points.
    - Readings that are inconsistent with the hazard or radionuclide, if identified.
    - Inconsistent units and/or incomplete data sets (e.g., exposure rates recorded in counts per minute, not milliroentgens per hour [mR/hr]). See Activity 1.4.

Risk of Secondary Devices

Survey teams which encounter a radiological signature emanating from inside any package or container in suspicious or unusual locations should assume that source could be another RDD.

Survey teams will immediately cease survey operations and contact a Public Safety Bomb Technician/FBI Special Agent Bomb Technician.

- Continuously compare new survey results against revised dispersion models, such as those provided by the FEMA-managed Interagency Modeling and Atmospheric Assessment Center (IMAAC), which have been updated based on previous survey results. If needed, prioritize completing or expanding the 10-point monitoring survey in areas where models or elevated readings from outlying points indicate the potential for contamination but have not been surveyed yet.

- Once the likely direction of contamination is established, conduct a wide-area survey to establish the boundaries of the contaminated area. Table 5: provides a list of the advantages and disadvantages of different wide-area survey techniques available to jurisdictions, or that may become available as the response evolves. Ideally, this survey should use a combination of ground and aerial techniques, executed simultaneously, leveraging state and federal resources with more advanced equipment and expertise.

    - **Conduct an aerial survey of the areas identified as contaminated by the 10-point survey.** An aerial survey will be especially helpful for identifying contamination on rooftops and in hard-to-reach areas, and for confirming that ground surveys did not miss significant pockets of contamination. Since aerial surveys are commonly taken at an altitude of several hundred feet (particularly in areas with densely packed high-rise buildings), their resolution is low and can only detect gamma-emitting radionuclides.

    - **Conduct a ground survey of the areas identified as contaminated by the 10-point survey.** Ideally, use ground vehicle-mounted detection equipment to survey the contaminated area boundaries, as this approach will be most efficient and minimize exposures. However, if ground and aerial vehicular-mounted survey resources are not available and responders must take these measurements on foot:

        - Measure gamma exposure rates at 1 meter (~3 feet) above ground.

        - Measure beta-gamma total surface contamination (include alpha values based on radionuclides of concern).

    - **Refine identification of the plume centerline.** Send a radiological monitoring team to the farthest point where contamination was detected, and perform transects – that is, cut across the plume centerline to measure on either side - approximately every kilometer, moving towards the release site:

        - Take and record gamma exposure rate measurements at 1 m (~3 ft) above ground (annotate highest result and any readings ≥10 mR/hr (0.1 mGy/hr) (the typical threshold for the hot zone). If all values are less than or equal to 10 mR/hr (0.1 mGy/hr), then move to the midpoint of next transect toward the release site.

- Take beta-gamma total surface contamination measurements (include alpha values based on radionuclides of concern). If the midpoint of highest values is more than 250 m (820 ft) from the centerline of the initial plume estimate, adjust the next transect's midpoint, as necessary.
- Ideally, measurements should be taken until the contamination falls below the contaminated area threshold, however, if teams are limited, measurements should be taken at least until the exposure level is below 10 mR/hr (0.1 mGy/hr). The area above 10 mR/hr (0.1 mGy/hr) is critical because it will define hazard and evacuation zones (see Activity 1.5: and Activity 4.2:). Transect measurements should be taken for at least 250 m from the centerline of the initial plume estimates.

Coordination Opportunity: Federal Support

- IMAAC: A federal interagency coordination element responsible for the production, coordination, and dissemination of federal atmospheric dispersion modeling and hazard predictions for the airborne portion of a hazardous material release. The IMAAC provides the single federal consensus on atmospheric predictions of hazardous material concentration to all levels of the Incident Command and national response organizations. Through plume modeling analysis, the IMAAC provides emergency responders with predictions of hazards associated with atmospheric releases to aid in the decision-making process to protect the public and environment. IMAAC support can be requested directly at IMAAC@fema.dhs.gov or 703-767-2003. For general inquiries or more information, email IMAAC at IMAACinquiries@fema.dhs.gov.
- Aerial Measuring System (AMS), Provides rapid assessment of radioactive contamination on the ground over large areas using highly sensitive detection systems mounted on fixed-wing aircraft and helicopters. AMS reach back provides external aerial assets the ability to collect data utilizing their own assets and have it analyzed via consistent and proven methods for interpretation.[11] AMS is a National Nuclear Security Administration (NNSA) Nuclear Emergency Support Team (NEST) asset. NNSA is a semi-autonomous agency within the DOE.
- Airborne Spectral Photometric Environmental Collection Technology (ASPECT): Managed by EPA's CBRN Consequence Management Advisory Team to provide remotely sensed

[11] FEMA (2016) *Nuclear/Radiological Incident Annex to the Response and Recovery Federal Interagency Operational Plans.* Available online at: https://www.fema.gov/sites/default/files/2020-07/fema_incident-annex_nuclear-radiological.pdf.

chemical/ radiological (gamma and neutron) data and imagery (situational awareness). ASPECT can identify, quantify, and map chemical plumes and radioactive material deposited on the ground. It is also capable of collecting high-resolution digital photography and video products. Data products are transferred to ground base support within minutes of collection through satellite communications, while in flight.[12]

- Regional Render Safe Teams (RRSTs): Led by the FBI and trained by DOE, RRSTs are positioned in all 56 FBI Field Offices. They are led by an FBI Special Agent Bomb Technician and consist of Public Safety Bomb Technicians from local Public Safety Bomb Squads, RRSTs are capable of identifying, isolating, and defeating the full spectrum of RDD devices. RRSTs can assist response and recovery personnel with explosive hazard mitigation, isotope identification, and clearing of suspicious packages during radiological surveys. While conducting RDD defeat operations, RRST personnel can provide response and recovery planners with device-specific information regarding its potential to cause harm (to include effects modeling based upon observed/assessed data from the actual RDD), pace of their operations, and expected outcome.
- Radiological Assistance Program (RAP): First responder program for assessing and characterizing radiological hazards from seven regional offices at DOE sites throughout the U.S. Each region has a minimum of three teams with a standard composition of eight personnel. Teams can be augmented with other specialists and will be tailored to the specific mission. The team conducts field monitoring and sampling measurements and provides radiological advice to protect the health and safety of responders and the public.[13] For more information on RAP regional offices, see: https://www.nnss.gov/pages/programs/frmac/ERAssets.html.
- Weapons of Mass Destruction (WMD) Civil Support Team (CST): Assesses suspected WMD attacks or potential CBRN incidents, advises civilian responders on appropriate actions, provides expert medical and technical advice, and facilitates the arrival of additional State and Federal military forces.[14]

[12] Ibid.
[13] Ibid.
[14] Ibid.

Table 5: Advantages and Disadvantages of Rapid Survey Methods Potentially Available to SLTT Jurisdictions

Survey Approach	Advantages	Disadvantages
Land Vehicle Mounted	▪ High-resolution survey (if GPS-labeled) ▪ Fast geographical coverage	▪ Typically, not useful as a contamination survey approach ▪ Cannot survey rooftops
Marine Vehicle Mounted	▪ Survey waterfront locations (e.g., marinas, bridges) that may be difficult to reach from land	▪ Limited to surveys on water and waterfront areas and structures
Aerial Vehicle Mounted (Fixed Wing or Helicopter)	▪ Rapid, wide-area survey ▪ Can easily identify hot spots missed in ground surveys ▪ Can survey hard-to-reach areas (e.g., rooftops, off-roads, areas blocked by debris or hazards)	▪ Low-resolution survey ▪ Typically, not useful as a contamination survey approach ▪ Tall buildings and inclement weather can inhibit survey
Handheld Personal Radiation Detector (PRD) Survey, Vehicle Assisted	▪ High-resolution survey (if GPS-labeled) ▪ Equipment widely available ▪ Low technical expertise required	▪ Less geographical coverage per time ▪ Hard to access rooftops or areas not accessible by road ▪ Less-precise data (due to use of PRD)
Handheld Survey Meter, Vehicle Assisted	▪ High-resolution survey (if GPS-labeled) ▪ Contamination survey possible ▪ Wipe/sample survey possible	▪ Less geographical coverage per time ▪ Hard to access rooftops or areas not accessible by road

Activity 1.2: Collect Samples and Measurements for Field and Laboratory Analysis

- Identify the gamma-emitting nuclide(s) released by collecting in-situ gamma ray spectroscopy (or by collecting a reading that is less than 1 mR/h on contact and performing field gamma-ray spectroscopy of the sample) and reviewing any information that may indicate the source of the radioactive material. These details will directly inform exposure mitigation (see Focus Area 2) and remediation techniques (see Focus Area 7). These activities will primarily occur in the near field, and should accomplish the information objectives for Focus Area 1 that are described in Appendix B.
    - Gather gamma spectroscopy, using a high purity germanium (HPGe) detector, if possible, (or other radionuclide identification device [RIID]) at several locations in which the radiation dose rate is < 500 μR/hr (5 μGy/hr), as well as a background measurement in a non-contaminated area as close to the incident area as possible.

Each sample should be 10-minutes (minimum) and the spectrometer should be placed nominally 1 meter above the ground where the dose rate at 1 meter is less than 1 mR/h. If an HPGe detector is not available, use a RIID to acquire the gamma-ray spectrum. The spectra and dose rate information should be communicated to the Federal Radiological Monitoring and Assessment Center (FRMAC) for additional analysis and confirmation of the nuclide(s) present.

  – If the CBRNResponder tool is used for data collection, consider toggling on the "Share with FRMAC" setting to facilitate data sharing.

- If beta- or alpha-emitting radionuclides are present, obtain samples of the contamination/material, conduct a field screening to determine alpha, beta, and gamma radioactivity present, and send the samples to a laboratory with the capability to perform analysis and nuclide identification.
- If the radioactive material that was dispersed was a regulated source, such as from an industrial or medical device, there may be remnants of shipping papers or container markings that will indicate the nuclide(s) and activity present. This material may be of evidentiary value and should be reported to the investigating agency (likely the FBI); chain of custody or other specialized handling techniques may be required.

▪ Identify areas where additional samples should be collected or spot surveys should be conducted to recognize or rule-out hazards that could impact other components of the response (e.g., protective actions) or create cascading emergencies (e.g., drinking water contamination). Typical examples include wastewater treatment plants, stormwater run-off exit points, water inlets for water treatment plants, subterranean areas (underground buildings, subway systems), and air intakes for buildings.

▪ Evaluate soil samples taken inside the contaminated area to determine the extent that radioactive material will leach from the soil. These tests will help define the extent to which ground water or storm runoff may become contaminated by contaminated soil. As these tests may take a while to complete, until results are available responders should assume soil and dust are both carriers of contamination either through water or through air (as resuspended dust).

Coordination Opportunity: Federal Support

▪ EPA's Radiological Emergency Response Team (RERT) provides advice on assessments of dose and impact of release to public health and the environment; monitoring, sampling, laboratory analyses, and data assessments to assess and characterize environmental impact.

▪ EPA's National Center for Radiation Field Operations (NCRFO) can provide support for field sampling operations. NCRFO field operations include soil, vegetation, water, and airborne monitoring and sampling of radioactive materials in the environment.

- The EPA's National Analytical Radiation Environmental Laboratory (NAREL) can also provide support fixed laboratory testing (based out of Montgomery, AL) and, potentially, mobile laboratory testing.

Activity 1.3: Conduct a Radiological Risk Assessment and Grid Survey of the Release Site

- Conduct a radiological risk assessment of the release site by sending a two-person team (ideally with a vehicle to reduce exposure time) with low and high-range (>10 R/hr [>100 mGy/hr]) dose rate instruments to perform a release site[15] risk assessment. This assessment is conducted to identify radiation and contamination hazards and more thoroughly map the hot zone and dangerous radiation zone. This assessment will be used to determine if there is a need for risk mitigation (e.g., shielding, fixatives, ground cover), establish an approach for high dose rate fragment recovery, and air sampler placement. Since this survey is not a lifesaving priority, it should only be initiated once adequate worker safety protections and dose monitoring are in place.
    - Survey for exposure rate and removable contamination utilizing unmanned vehicles, extension tools, or telescoping detectors. This survey likely will need to be conducted quickly due to the high exposures in/near the release site if it cannot be performed remotely.
- Conduct a grid survey, starting by designating a grid (see Figure 2 for an example in an urban environment) to enable the conduct of systematic surveys of the contaminated area. The grid initially should be focused on the near-field area, as described by the *First 100 Minutes Guidance*, but may need to be expanded further to obtain an understanding of the dose rates and level of contamination throughout the contaminated area. This grid survey should be conducted by radiation safety professionals and responders with experience in conducting radiological surveys. Since this survey is not a lifesaving priority, it should only be initiated once adequate worker safety protections and dose monitoring are in place.
    - Note: The purpose of the near field survey conducted as part of the *First 100 Minutes Guidance* (Tactic 8) is to rapidly identify the initial Hot Zone boundary and general radiological conditions. The purpose of the grid survey in this document, which builds on the initial survey from the First 100-Minutes Guidance, is to provide a detailed understanding of the conditions (e.g., distribution of contamination) within the contaminated area to support the risk assessment and mitigation (above) and initiate remediation planning.

[15] The "detonation site" is defined in the *First 100 Minutes Guidance* as the area 360 degrees around the area immediately surrounding (~20m [~65 ft]) the detonation point (it does not include the detonation point). Non-explosive RDDs may not involve a detonation, so 'release site' is used here to address a wider range of threats.

- Initially extend the grid approximately 250 m (~820 ft) around the release site and 1 km in the direction of contamination towards the transect identified in the 10- point monitoring survey.

- Perform radiation exposure rate surveys every 50-100 m (165-330 ft) when possible or, at a minimum, at intersections and the mid-block. At each measurement location, measure the following:

  - Gamma exposure rate at 1 m (~3 ft) from the ground, with ion chamber or energy compensated Geiger Mueller (GM) detector preferred (e.g., units in mR/hr).

  - Beta-Gamma total surface contamination (include alpha values if appropriate), preferably with 100-square-centimeter probes (e.g., dpm/100 cm^2).

- If resources permit, consider obtaining rooftop radiation dose rate measurements and at street corners and mid-block where possible. Rooftop measurements will help determine the amount of material released but will be less critical for informing health and safety decisions during the early and intermediate phases of the response.

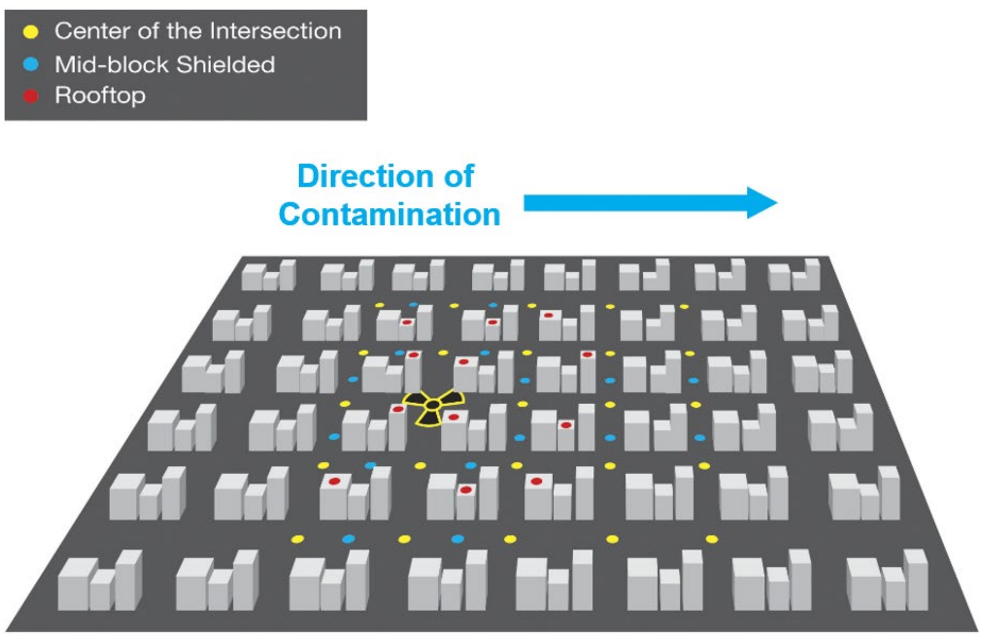

Figure 2: Notional Grid-based Survey Strategy[16]

[16] Stephen Musolino, Frederick T. Harper, Brooke Buddemeier, Michael Brown, and Schlueck. (2013) "Updated Emergency Response Guidance for the First 48 Hours after the Outdoor Detonation of an Explosive Radiological Dispersal Device." *Health Physics,* vol. 105 no.1: 65-73. Available online at: https://doi.org/10.1097/HP.0b013e31828a8fb1.

Coordination Opportunity: Law Enforcement - Technical Support

- Law enforcement and counterterrorism operations will be taking place as the risk assessment process is underway. FBI Special Agent Bomb Technicians lead the FBI Field Office response to all improvised explosive devices, suspicious packages, and weapons of mass destruction (WMD) devices. Additionally, they lead the Field Office Regional Render Safe Team in conducting WMD device defeat and mitigation actions for WMD devices and materials, while also serving as a point of contact for public safety bomb squad coordination[17]. Radiological survey personnel who encounter a suspicious package must immediately cease operations and contact an FBI Special Agent Bomb Technician or a Public Safety Bomb Squad/Technician. Only FBI Special Agent Bomb Technicians, supported by DOE, may evaluate the threat of a known or suspected RDD.
- The FBI has a WMD Coordinator assigned to each of its field offices. Among other things, WMD Coordinators are responsible for the FBI's WMD investigative and countermeasures program and may serve as the point of contact for emergency responders and public health at the state and local level in the event of a threat or incident potentially involving a WMD.
- The FBI Evidence Response Team Unit (ERTU): The Hazardous Evidence Response Team (HERT) provides training, leadership, and subject matter expertise in hazardous evidence collection, as well as in the management and processing of forensic evidence in CBRN crime scenes. ERTU also provides coordination and oversight for operational response and activities of FBI field office HERTs.

Activity 1.4: Implement Data Quality Practices

- Initiate the data assessment process, which is part of the data lifecycle throughout all phases of emergency response and recovery. This process involves (1) reviewing the objectives of data collection; (2) gathering new, current, or historical data (e.g., aggregate survey data); (3) data verification and validation (V&V) and flagging potential issues; and (4) assessing data quality.
    - As discussed in the *First 100 Minutes Guidance,* first responders may not have time to rigorously assess data during the initial response phase since decisions will need to be made quickly to protect the public, responders, and the environment. However, as the response progresses, and more resources become available, incomplete, or suspicious data will need to be reconciled through a data assessment process that includes V&V of data. This process will help decision-makers avoid drawing false conclusions and basing important and costly decisions on incomplete or incorrect

[17] FEMA (2016) *Nuclear/Radiological Incident Annex to the Response and Recovery Federal Interagency Operational Plans.* Available online at: https://www.fema.gov/sites/default/files/2020-07/fema_incident-annex_nuclear-radiological.pdf.

data. Applying data quality practices adds confidence and defensibility to the data that inform decisions (e.g., determining the contaminated area, shelter versus evacuation).

- Figure 3 provides a high-level, condensed overview of the major steps of the data assessment process. Planners should refer to the Radiological Data Assessment Guidance for Emergency Response for an in-depth introduction to Data Quality Assessment (DQA).[18]

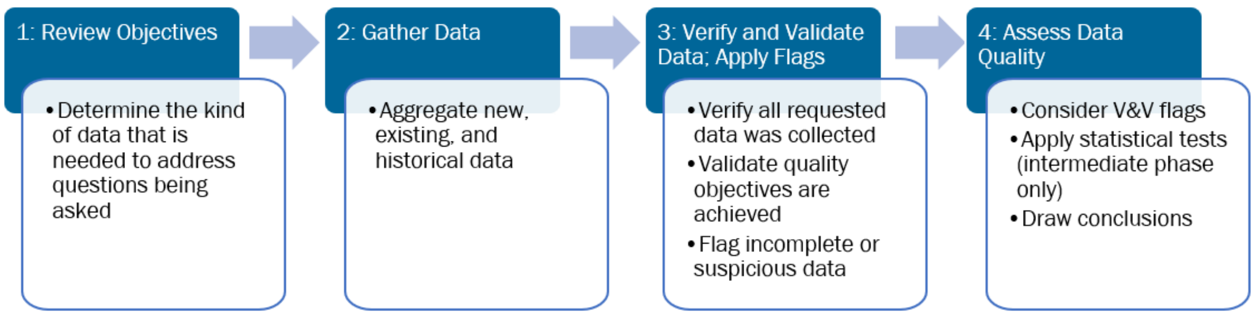

Figure 3: Data Assessment Process (Condensed Overview)

- Review the objectives of data collection: Determine the type of data that needs to be collected to answer the questions that are asked. For example, these data could be data to support a decision (e.g., shelter-in-place or evacuate) or data to estimate what the dose rate is in a particular area. The objective will inform what information is requested for each measurement. For example, for the objective of determining whether radioactive contamination is present, multiple measurements will be required along with the measurement value and units, the location, the background radiation level at the location of interest, and the time and day of the measurement, among other things.

- Gather new, current, and/or historical data (i.e., aggregate data):

  - An immediate challenge to conducting data assessment is that a considerable volume of data will be collected and, if that data is hand-written or manually recorded on individual spreadsheets, the process for reviewing data will be cumbersome and inefficient. First responders can mitigate this challenge by using software platforms tailored specifically for radiological data collection, sharing, and mapping, such as CBRNResponder.[19] Using CBRNResponder will enable response organizations to

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[18] DOE (2022) *Radiological Data Assessment Guidance for Emergency Response*. Available online at: https://www.cbrnresponder.net/app/index#resources/documents/download/2308.

[19] Information about using RadResponder during RDD incident responses, along with information regarding evaluating, validating, and analyzing data is also available in the *First 100 Minutes Guidance*, Annex 5.

create a common operating picture and begin verification and validation (V&V) of radiological data.

- Ideally, each contamination and dose rate measurement should have the information identified in the callout box below to the extent it is available. If responders are using CBRNResponder, much of this information can be pre-populated before an incident occurs or auto-populated when a measurement is recorded. While some of these data may not be available early in the response, emergency responders should take steps as early as possible to ensure all appropriate information is collected for each measurement as the response unfolds. Radiation experts will use this data to assess measurements collected and plan future data collection objectives.

Information for Radiological Emergency Response and Recovery Data

Data collected during radiological emergency response and recovery operations should ideally record the following information. If not, all information is available, as much information as possible should be collected to enable an effective data quality review.

- **Measurement units.**
- **Background measurement and any background adjustments.**
- **Full name, agency-affiliation, and contact information of individuals performing the measurement.** This information is critical to enable follow-up and to answer questions. Information such as instrument brand and model number, for example, can be collected later if necessary.
- **Instrument or measurement type (e.g., Pancake probe, smear sample).** Instrument brands and model numbers (e.g., Ludlum 2360 w. 43-93 alpha-beta, 100cm^2 probe). Calibration information for each instrument (including nuclide efficiencies for contamination instruments). This information is critical to fully assessing the quality of data collected but may be collected later if not immediately available.
- **Date, time, and description (e.g., distance above ground for a dose-rate, sample area) of measurement.** Global Positioning System (GPS) coordinates for measurement location.

- Initiate V&V of data and apply flags.
  - Verification: Assess if all the requested data for the objective was collected (e.g., information fields in the blue box above).

   - Validation: Assess if the measurement quality objectives were achieved for each measurement. Like verification, measurement results are compared to a list of quality objectives (e.g., precision, accuracy, representativeness, completeness)?[20]

   - Apply V&V flags: If a measurement does not satisfy V&V requirements, a data assessor may apply a "flag" to the measurement (or the flag may automatically be applied in CBRNResponder) to indicate the particular issue, such as suspicious or incomplete information.

     – If information about a measurement is missing, but that information (e.g., name or agency) has no influence on the public protection or safety objective currently being addressed, the data assessor may choose not to apply a flag.

- Quality Assessment: Determine if the available information will/could be used to address the data collection objective and what conclusions can be drawn. Use the results of the V&V steps and consider all flags to determine if the data can be used as is and draw conclusions with the information available, or if follow up is needed to fill in information gaps prior to drawing any conclusions. This step may involve statistical tests to determine confidence levels and false negative and positive error rates.

Coordination Opportunity: Federal Support

Consequence Management Home Team (CMHT): Provides analytical and operational support to DOE's Nuclear Emergency Support Team (NEST), which includes the analysis and interpretation of the initial release based on early data. The CMHT also provides map products, coordination of laboratory assets, and situational awareness of response teams deployed to an incident and can be accessed remotely at all times to support radiological data analysis.

Recommended Resources: DOE's Radiological Data Assessment Guidance

DOE (2022) *Radiological Data Assessment Guidance for Emergency Response.* Available online at: https://www.cbrnresponder.net/app/index#resources/documents/download/2308.

Activity 1.5: Establish and Revise Incident Boundaries

- Adjust boundaries for hazard zones identified during the preliminary 10-Point Monitoring Survey, such as DRZs, HZs, and warm zones, as well as the crime scene perimeter, if appropriate.

[20] For more information about precision, accuracy, representativeness, completeness, comparability, and sensitivity (PARCCS) parameters, refer to the DOE (2022) *Radiological Data Assessment Guidance for Emergency Response.* Available online at: https://www.cbrnresponder.net/app/index#resources/documents/download/2308.

Continue mapping and physically marking hot spots or ballistic debris. Should explosive hazards remain, coordinate with Public Safety Bomb Technicians/FBI Special Agent Bomb Technician.

- Define and map boundaries for the contaminated area. These boundaries will determine public access limitations, responder protective actions, and will serve as a starting point for identifying remediation zones (see Focus Area 7). Boundaries should be drawn by taking into consideration two factors:
    - The location and nature of radiological hazards in the area: the actual extent and magnitude of contamination levels, determined through the wide-area and grid-based surveys, and whether the contamination source is fixed, removable, or a combination of both, will determine where boundaries are drawn. This consideration may also incorporate exposure pathway analysis conducted in Focus Area 2.
    - Physical, geographical, or geopolitical boundaries: pre-existing organizational units (e.g., municipal borders or township lines) and physical features of the incident area topography (e.g., buildings, structures, streets, intersections, utilities) may be helpful for defining boundaries where preventing physical access to an area is required.
- Establish perimeter access controls to the contaminated area. Access points will likely be the checkpoints identified in Focus Area 4.
    - To control access to the hot zone, the perimeter of the contaminated area may be considerably larger than the safety perimeter that was established during initial response operations as described in the *First 100 Minutes Guidance* (see Figure 4 below). Initially, use law enforcement personnel to secure access, but prepare to transition to longer-term perimeter control that reduces the first responder personnel footprint (e.g., physical barriers, alarming sensors, cameras, signage, private security, and existing terrain to prevent unauthorized access to these areas). Access to the designated crime scene area within the contaminated area will need additional coordination with law enforcement.
    - Review your local legal authorities for access control. Not all jurisdictions have legal authority to exclude access to an area and, depending on the release site and material, federal authorities, such as a National Defense Area (NDA) or National Security Area (NSA), may or may not apply.[21]

[21] FEMA (2016) *Nuclear/Radiological Incident Annex to the Response and Recovery Federal Interagency Operational Plans.* Available online at: https://www.fema.gov/sites/default/files/2020-07/fema_incident-annex_nuclear-radiological.pdf.

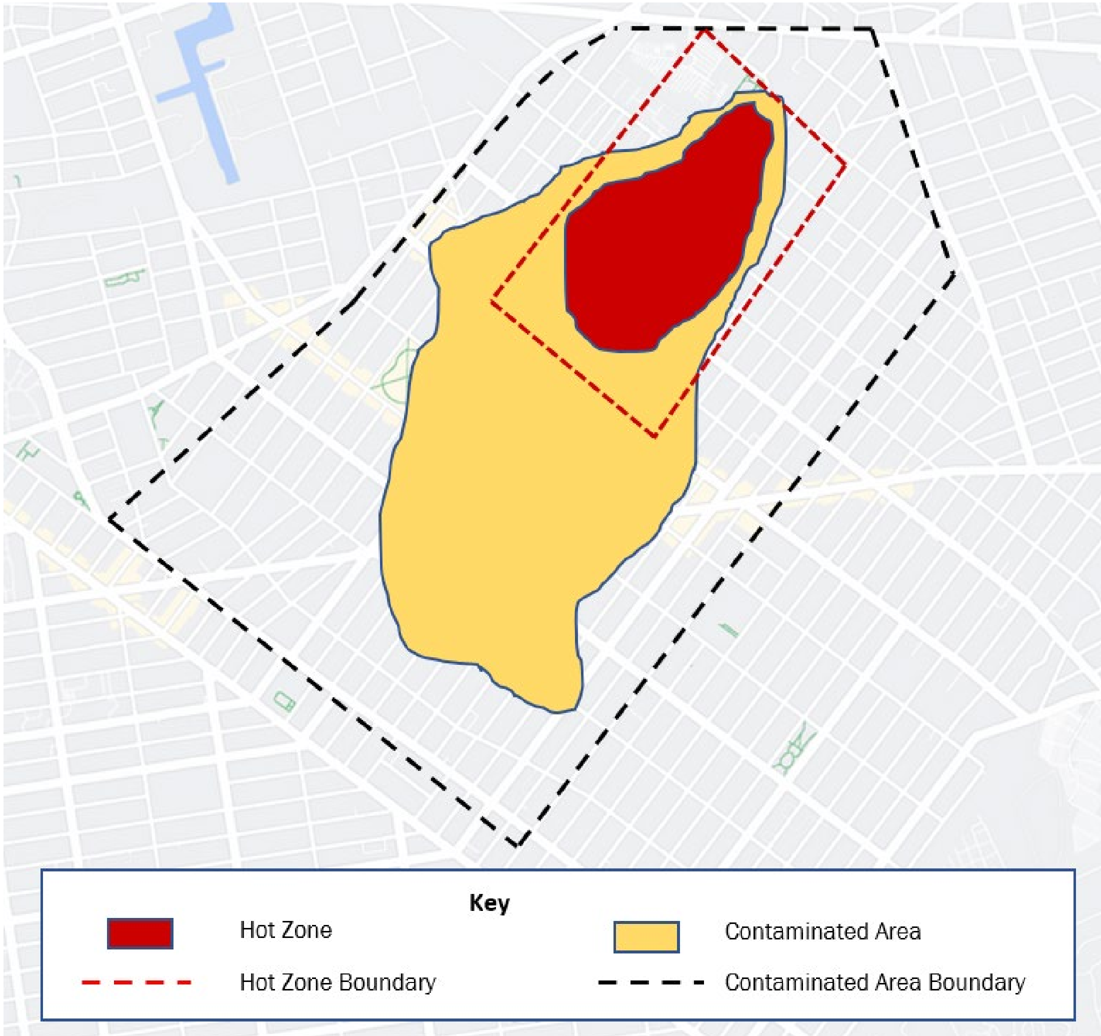

Figure 4: Example map showing a notional hot zone and contaminated area as well as boundaries selected to make communicating and managing of boundaries easier.

Activity 1.6: Conduct Monitoring/Surveillance to Detect Spread of Contamination

- If airborne radioactivity (such as a contaminating plume) is detected, acquire, and deploy static continuous air monitor (CAM) samplers near the boundary of the contaminated area and other work areas. These should be networked into a remote detection system to monitor migration of radioactive material throughout the area.

- Conduct periodic re-surveys (daily, if possible) of contaminated area boundaries to detect the spread of contamination or change in radioactivity over time due to changing environmental conditions (e.g., rain and wind), radioactive decay, and/or human activity (e.g., during evacuation or remediation). The contaminated area boundary may change as a result of these activities.

  - As people, vehicles, or equipment entering and leaving the contaminated area are likely to spread contamination, the boundaries of the contaminated area need to be controlled and monitored to prevent inadvertent spread (see the *First 100 Minutes Guidance* Tactic 7 for more information on securing the scene). Decontamination activities will similarly need to be controlled and monitored to prevent runoff or other decontamination waste from spreading material outside the defined boundary.
  - Note that vehicle traffic, especially heavy vehicles such as dump trucks or bulldozers, operating in contaminated areas may disturb settled radioactive material, creating secondary dust plumes, which could represent an inhalation hazard. Remediation activities in contaminated areas should be accompanied by additional boundary monitoring to ensure radioactive material does not escape the established boundary.

- Monitor waterways close to but outside of the contaminated area to confirm they are not contaminated above an action level. Samples collected from waterways are most important if the radionuclide is soluble but should be collected for all incidents. For urban areas, storm runoff drainage outlets and wastewater treatment plants should be monitored as well. For rural areas, this monitoring should include both drinking water wells and groundwater, though contamination may not appear in these samples for a long time – potentially years - after the incident, depending on the local geology. Early sample collection of drinking water from wells and groundwater will provide information on naturally occurring material in the water to improve assessments later.

- While agricultural contamination may be unlikely for RDD incidents, local agricultural activities should be monitored for radioactivity as well, particularly if airborne contamination was present or local waterways were contaminated. This monitoring program will help prevent disruption of agricultural activities or concern over the safety of those products.
  - Leverage the exposure pathway analysis conducted as part of Focus Area 2 activities to determine if there is an ingestion pathway risk for agricultural products in the areas where contamination settled or is projected to spread over time.
    - If there is ingestion risk for agricultural products, the appropriate Derived Response Levels (DRLs) can be calculated by the FRMAC. These DRLs can then be used by responders to determine which products may not be safe for consumption. If there is concern that food and/or water will continue to be significantly contaminated beyond the first year, the long-term circumstances need to be evaluated to determine whether the recommended DRLs or other guidance would be most appropriate.
  - The State Radiation Control Program may be consulted as part of this effort. Additionally, the Advisory Team for Environment, Food, and Health (A-Team) is a federal radiological emergency response asset that is available through the FRMAC to provide recommendations on protective actions to minimize contamination of milk,

food, and water; disposition of contaminated livestock, poultry, and food; and health and safety advice for the public.

- The Food Emergency Response Network (FERN) utilizes a network of food-testing laboratories at the local, state, and federal levels to support a response to biological, chemical, or radiological contamination of food. Federal partners include Health and Human Services (Food and Drug Administration, Centers for Disease Control and Prevention), U.S. Department of Agriculture, U.S. Customs and Border Protection, Department of Defense, FBI, EPA, and DHS.

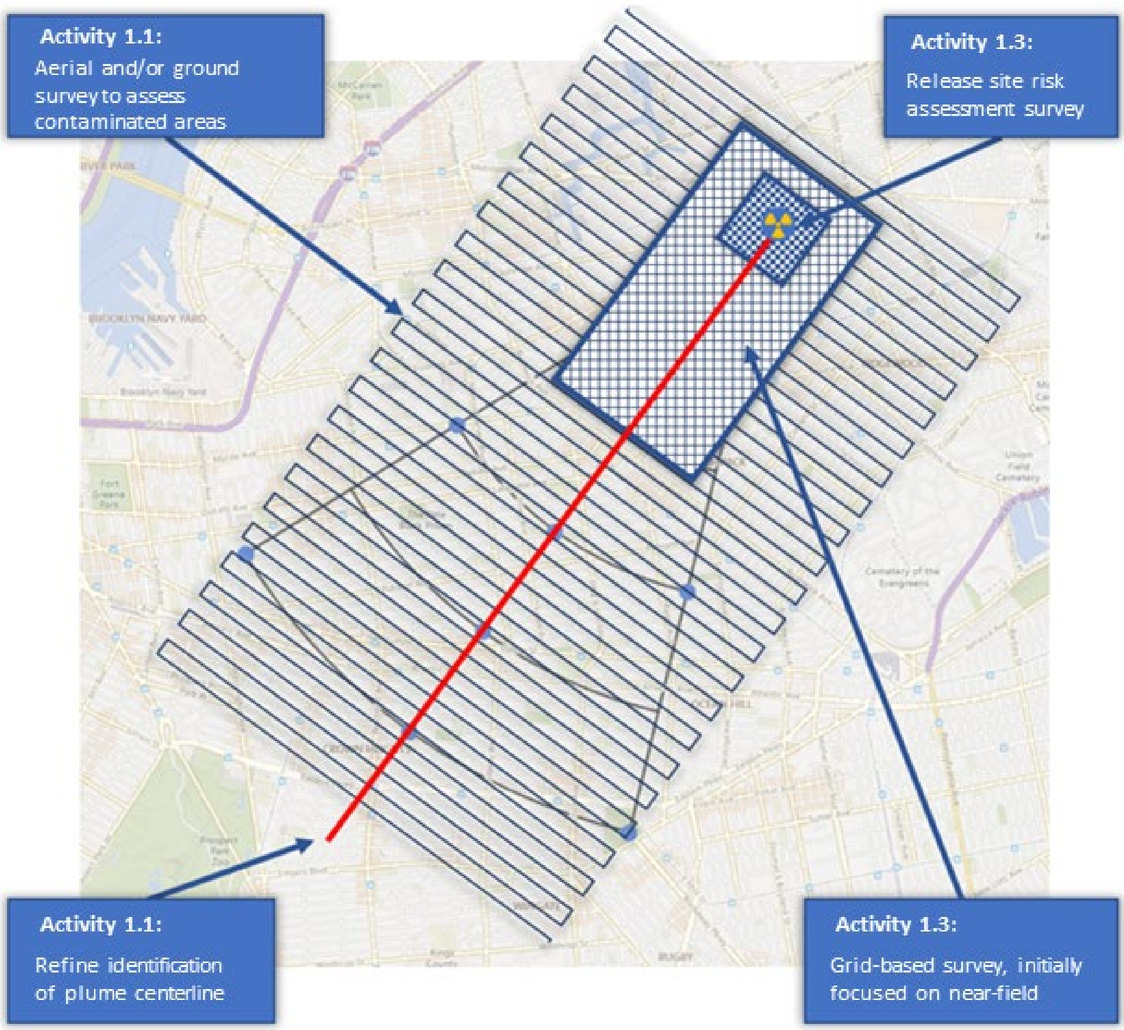

Figure 5: Summary of surveys discussed in Focus Area 1

Recommended Resources:

- Conference of Radiation Control Program Director (2006) *Handbook for Responding to a Radiological Dispersal Device: First Responders Guide – The First 12 Hours.* Available online at: https://www.crcpd.org/resource/resmgr/docs/rdd/rdd-handbook-forweb.pdf.
- Musolino, Stephen, Frederick T. Harper, Brooke Buddemeier, Michael Brown, and Richard Schlueck. (2013) "*Updated Emergency Response Guidance for the First 48 Hours after the Outdoor Detonation of an Explosive Radiological Dispersal Device.*" *Health Physics.* Vol.105 no.1: 65-73. Availble online at: https://doi.org/10.1097/HP.0b013e31828a8fb1.
- DHS (2012) *Key Planning Factors for Recovery from a Radiological Terrorism Incident.* Available online at: https://www.hsdl.org/?abstract&did=756119.
- FEMA (2023) *Nuclear/Radiological Incident Annex (NRIA) to the Response and Recovery Federal Interagency Operational Plans (FIOPs)*. Available online at: https://www.fema.gov/sites/default/files/documents/fema_incident-annex_nuclear-radiological.pdf.
- EPA (2017) *PAG Manual: Protective Action Guidance and Planning for Radiological Incidents.* Available online at: https://www.epa.gov/radiation/protective-action-guides-pags.

Focus Area 2: Implement Radiation Exposure Mitigation

***Guidance**: Assess exposure pathways and conduct dose assessments to determine the potential health risks for the public and responders in contaminated areas. Develop and implement exposure mitigation actions.*

Recommended Planning Partners:

- Emergency management
- Fire/HAZMAT teams
- Law enforcement
- Public health
- Radiation protection
- Radiation safety/safety officers
- Occupational health and safety
- Environmental protection

Introduction

Focus Area 2 is underpinned by two overarching objectives:

- Identify the exposure pathways and conduct dose assessments for people in contaminated areas and determine exposure mitigation controls to protect the public and response personnel, inform phased evacuation operations (Focus Area 4), and set the basis for the Optimization Process for remediation operations (Focus Area 7).
- Implement radiation exposure mitigation (reduction) activities, such as preventing contamination spread and minimizing public health risks, identifying PPE requirements (type and quantity), and establishing a dose monitoring and tracking system for responders and various categories of emergency and recovery workers.

Responding to a radiological emergency will expose emergency workers[22] and recovery workers to a variety of hazards, including radiation and radioactive contamination. Because of this exposure, an immediate priority during any RDD response is to identify and deploy to the scene qualified safety officers who also have sufficient knowledge and experience in radiation safety to weigh the radiological risks and other risks that are present against the work taking place. The term "Radiation

[22] *NCRP Report No. 179: Guidance for Emergency Response Dosimetry* discusses the definition of emergency workers and how that term differs from other workers.

Health and Safety Officer (RHSO)”[23] has been suggested as a term for this type of personnel, since the term “Radiation Safety Officer (RSO)”[24] has a specific regulatory definition that applies only to radioactive materials licensees. The term RHSO is used in this guidance to communicate when a safety officer (SO) should have radiation protection expertise; the term RSO is used specifically in situations where radioactive materials licensees are involved, such as the contractors who conduct radioactive remediation operations (Focus Area 7).

The complexity of the tasks expected to be performed within this Focus Area, along with the number and type of personnel required to execute them, will vary with the size, type, and nature of the incident. For smaller-scale RDD incidents, key tasks may be performed with personnel available from local and state public health and other relevant agencies, supported by a radiation health and safety officer. For larger-scale incidents requiring the coordination and support of a larger number of agencies and technical contractors, alignment of these tasks, as well as the distributed nature of the work required to perform ongoing assessment operations, will entail substantial planning and coordination across agencies and additional radiological subject matter expertise.

During the initial phases of the response to the incident and for small-scale events, hazardous materials teams with personnel trained and equipped to deal with radiological hazards should be able to perform the minimum essential tasks with assistance from public health radiation safety officials. Depending on the size and scale of the incident, the quantity and type of radiation detection and monitoring equipment (such as personal radiation dosimeters) available may immediately become critical limiting factors impacting responder and worker health and safety.

The threat posed by radiological materials released or distributed into the environment in an RDD incident will vary over time based on factors such as radioactive decay and movement of contimination through the environment. See the RDD Incident Scenario Considerations section for more information.

It is important for planners to consider that the dose assessment and monitoring processes which begin with the radiological release will continue over an extended period of time, perhaps lasting years if not decades. Responder health registries from the World Trade Center attacks in 2001, for example, are still active today.[25] The initial priorities set and actions taken for this monitoring process during the early phase of the response will transition to more structured and widely coordinated efforts over the following weeks and months. Planners should consider a comprehensive dosimetry program as part of pre-incident planning to ensure their local jurisdiction is prepared to capture and warehouse dosimetry data both to inform response and recovery activities and provide long-term records to facilitate health and wellness follow-up for responders and the general public. Without adequate pre-incident planning, the dosimetry data management process

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[23] See the *Field Guide for Health and Safety Officers: Radiological Incidents*, NYC Dept. of Health and Mental Hygiene, 2014. https://remm.hhs.gov/fieldguide.htm

[24] The term “radiation safety officer” has a specific, regulatory definition provided in 10 CFR 35.2.

[25] CDC (2023) *9.11 World Trade Center Health Program*. Available online at: https://www.cdc.gov/wtc/

(including the who, what, when, and where exposure has occurred) likely will be vague or uncertain and ultimately impact the effectiveness of response and recovery operations.

Recommended Resources: Data Collection Templates

While not designed for responders, emergency response registry tools developed by the Agency for Toxic Substances and Disease Registry (ATSDR) and the CDC can serve as templates for data collection for responders.

- ATSDR Rapid Response Registry: https://www.atsdr.cdc.gov/rapidresponse/
- CDC Community Reception Center Electronic Data Collection Tool (CRC eTool): https://www.cdc.gov/nceh/radiation/emergencies/crcetool.htm
- CDC Epi CASE Toolkit https://www.atsdr.cdc.gov/epitoolkit/index.html

EXPOSURE MITIGATION OVERVIEW

Exposure mitigation (reduction) starts with the application of "as low as reasonably achievable" (ALARA)[26] radiation safety principles and is based on minimizing radiation doses while limiting the release of radioactive materials into the environment by employing all "reasonable methods." ALARA is not only a sound safety principle, but also a regulatory requirement for all radiation protection programs. Implementing ALARA can help prevent unnecessary exposure and limit accidental overexposure.

Applying the ALARA principle involves three essential factors that can help limit external, whole-body radiation exposure: **time**, **distance**, and **shielding**. These three factors are familar to most first responders trained to deal with radiological contamination as well as other hazardous materials.

Key Terminology: Time, Distance, and Shielding

Time: Minimizing exposure time to radioactive sources reduces the radiation dose received.

Distance: Increasing the distance from the radiation source lowers exposure. Radiation exposure decreases by a factor of four when the distance is doubled and by a factor of nine if the distance is tripled.

Shielding: Lead or lead-equivalent shielding for gamma rays can effectively reduce radiation exposure.

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[26] In the 2017 EPA Protective Action Guides (PAG), ALARA is defined as "making every reasonable effort to maintain exposures to radiation as far below the dose limits as is practical consistent with the purpose for which the activity is undertaken."

In addition to time, distance, and shielding considerations, other mitigation techniques may include using proper PPE (e.g., disposable contamination control clothing, gloves, safety glasses, and respirators) to reduce the risk of ingestion, absorption, and inhalation of radioactive material. Similarly, covering the released material (shielding) or fixing it in place may prevent further spread of the material. Most common techniques for reducing exposure—such as using lead bricks to block external radiation (shielding) or limiting time spent in the contaminated area—will not mitigate the risk of internal exposure due to inhalation of particulates, which may occur in the context of a smoke-producing RDD or a release in which the disturbance of deposited material causes resuspension of radioactive dust.

RADIATION HEALTH AND SAFETY PLAN (R-HASP)

Many of the activities that comprise this focus area should be incorporated into a dedicated Radiation Health and Safety Plan (R-HASP) or radiation-focused supplement to the HASP for emergency workers, remediation workers, and essential employees. The R-HASP is a technical document that outlines many different safety factors and procedures for personnel working in or near a radioactive hazard. An R-HASP typically includes a discussion of radiological hazards and an analysis of risks to human health and safety, an organizational structure for safety operations, requirements for safety training, and an exposure control and monitoring program.

It is also important to remember that radiation is only one hazard that may be encountered during the response and recovery to an RDD, so radiation safety, along with other occupational health and safety programs, should follow the appropriate hierarchy of controls.

Whenever possible, an R-HASP template should be developed beforehand and then adapted to incident-specific radiation hazards and work activities required once an incident occurs. At a minimum, it should be reviewed by and coordinated with the Incident Commander, Radiation Technical Working Group (R-TWG), and/or applicable regulatory agencies (e.g., state/local health departments and labor/occupational health departments). R-HASP implementation should be overseen by RHSOs if possible and adhered to by anyone entering the contaminated area. While an R-HASP will help protect workers, each agency and employer holds the ultimate responsibilty for ensuring the health and safety of their own workers.

Recommended Resources: Field Guide for Health and Safety Officers

The *Field Guide for Health and Safety Officers: Radiological Incidents* guidance issued by the New York City Department of Health and Mental Hygiene is available in the Radiation Emergency Medical Management (REMM) site as an example resource. This document can be utilized as an expedient resource for personnel functioning in the radiation health and safety officer role in the initial phases of an RDD incident. The Field Guide includes useful information and templates for safety briefings, dose assessment, and other important safety activities.

Additional site-specific R-HASPs or HASP supplements should be developed to cover other types of personnel, including contracted workers, accessing the site for specific purposes like conducting remediation operations. These supplemental plans should be consistent with the approach and processes detailed in the overall incident HASP, as supplemental plans typically are limited to the internal procedures, equipment, and training specific to particular groups with access to a contaminated site (e.g., a specific contractor organization). Information collected by safety personnel under safety plan requirements are also a part of recordkeeping for long-term health surveillance purposes.

Table 6: Summary of Focus Area 2 Activities

	Activity	Phase
2.1	Conduct Exposure Pathway and Dose Assessment	Early to Intermediate (Hours to Days)
2.2	Implement an Exposure/Dose Record Process for Emergency Workers, Remediation Workers, and Essential Employees	Early to Intermediate (Hours to Days)
2.3	Determine Personal Protective Equipment Requirements for the Contaminated Area	Early to Late (Hours to Weeks)
2.4	Mitigate Spread of Contamination	Intermediate to Late (Days to Years)

Activity 2.1: Conduct Exposure Pathway and Dose Assessment

- **Identify groups** of people who may be at higher risk of radiation exposure (such as those who are pregnant, immunocompromised, etc.) and who will require an exposure pathway assessment, starting with the groups identified in Table 8: below. Further tailor pathway and dose assessment to special at-risk groups (e.g., children or pregnant people).

- **Conduct an exposure pathway analysis** to assess the routes by which radiation or radioactive materials can reach humans and cause exposure, resulting in radiation dose. The exposure assessment process should be detailed in the HASP; it should also be used to determine protective action guidance for the public in terms of limiting further exposures. It is important to assess both retrospective (past) and prospective (current/future) exposure pathways. Pathway assessments should consider:

    - The exposure pathways described in Table 7: below. Principal exposure pathways include ingestion, inhalation, and direct (external) exposure. An assessment of these pathways is used to estimate the total radiation exposure that would result in a dose that a person will receive from both external and internal sources. Dose can then be used to determine the risk – or probability – of injury, disease, or death from such exposure.

- The specific properties of radionuclides, such as the energy emissions, half-lives, retention in the body, physical and chemical form, etc. The radionuclide identification conducted through the monitoring and sampling activities in Focus Area 1 will inform this part of the dose assessment. For example, if the radionuclide released is a gamma emitter (e.g., Cs-137), the exposure pathways of primary concern will be external exposure; however, for an alpha emitter (e.g., Am-241), internal and ingestion pathways would be the primary pathways of concern (see Table 2: in Critical Considerations and Anticipated Challenges above).

Table 7: Exposure Pathways in the Early vs Intermediate/Late Phases

Exposure Pathway	Early Phase	Intermediate/ Late Phases
Inhalation of radioactive materials in the plume	**Yes**	No
Direct exposure from radioactive materials in the plume (immersion)	**Yes**	No
Inhalation of ground-deposited radionuclides resuspended into the breathing zone	**Yes**	**Yes**
Direct exposure from “groundshine” from depositied radioactive material	**Yes**	**Yes**
Ingestion of contaminated food and drinking water	Yes*	**Yes**
*Unintentional ingestion of contaminated food and water may occur during the early phase if people are unaware of the release of radioactive material (such as might occur during an undetected or slow-to detect release) or if protective actions were not issued regarding the safety of food and water supplies in and around the impacted area.		

Table 8: Categorization of Groups of People for Exposure Pathway and Dose Assessments

Group	Description
Emergency Workers	Emergency workers are individuals (e.g., firefighters, police officers, public health, EMS, public health workers, emergency managers, etc.) who respond to the scene of the incident and/or are involved in the field activities described in the *First 100 Minutes Guidance*. Hospital-based "first receivers" and responders supporting decontamination activities also fall into this category. Due to the type of work performed, this group may have the highest risk for exposure to radiation and is a priority for retrospective dose assessment. Finally, the emergency worker category may also include government personnel who conduct short-term mitigation activities, such as cleaning surfaces or handling radioactive material, in furtherance of extended stabilization of the contaminated site. The nature of the exposure for this group should decrease once the scene is stabilized and longer-term response and recovery operational planning begins.
Essential Employees	This category consists of essential workers assigned specific roles and responsibilities within critical facilities located within a contaminated area, or those who may encounter contamination through execution of their regular duties. This could include workers who provide essential functions for the community (e.g., utility workers, building maintenance, safety and security, and key continuity of operations personnel), transit workers assisting with evacuation of potentially contaminated populations to CRCs or other locations, and sanitation workers at facilities outside the contaminated area (e.g., wastewater treatment plants). Usually, workers categorized within this group are not assigned radiological remediation tasks as part of their normal job responsibilities. Although their risk and exposure during an RDD incident will be significantly lower than that of remediation workers, they may be considered "radiological workers," and subject to the corresponding occupational dose limits and radiation worker safety and awareness training requirements. They also likely will need to be part of a dosimetry and PPE management program to enable monitoring of their external exposure while working in contaminated areas.
Remediation Workers	Personnel tasked to conduct remediation cleanup activities in the later phases of the incident. Such personnel enter contaminated areas and work with equipment and machinery to reduce the amount of radioactivity present. Remediation workers will require significant radiation safety and other hazmat training. From a regulatory standpoint, such personnel would likely be covered under 29 CFR 1910.1096 and, thus, occupational dose limits would apply, in addition to any other relevant regulatory restrictions or guidance. Exposure/dose assessments for this group are not necessary until at least the intermediate phase of the response.
General Public	Members of the public are individuals who do not fit in the other three categories and are not considered part of the emergency response or cleanup operations. Members of the public outside of radiologically contaminated areas are likely to have different exposure pathways than those inside such areas, or those near the site of the explosion/release. Within this category, there are several important sub-groups that may require tailored risk assessments, such as people that are pregnant, children, people with disabilities, and people with certain pre-existing conditions. Responders should work with R-TWGs to identify relevant sub-groups and perform risk assessments based on the specifics of the incident.

- **Conduct a dose assessment** for the various groups of people identified. These should be both retrospective and prospective, where appropriate, and be performed by skilled radiological personnel. Dose assessments combine the exposure pathways identified with the actual or estimated radiological conditions (source term) measured through monitoring and sampling and laboratory analyses described in Focus Area 1. Dose assessment is an ongoing, iterative process.[27]
  - Prospective dose assessments will estimate the projected (future) exposure to emergency workers, remediation workers, essential employees, and members of the public.
    - Assessments for public exposure will inform comparison to PAGs in support of additional short and long-term evacuation, shelter-in-place, or relocation requirements.
    - Remediation workers should be assessed on an ongoing basis at appropriate intervals. Assessments for those working in contaminated areas should be reviewed by the lead jurisdiction's R-TWG and/or the appropriate regulatory agency. These assessments should be outlined in relevant HASPs.
  - Retrospective dose assessment will estimate the exposure already incurred by workers (emergency, remediation, and essential) and the public. Retrospective dose assessment should:
    - Utilize the exposure information collected in Activity 2.2 to estimate exposures for emergency workers and members of the public located or operating within contaminated areas.
    - Rely on registration information for members of the public who are processed through CRCs or other screening/ decontamination locations/facilities, who are seen in a hospital or other healthcare setting as a direct result of the incident, shelters, or who were otherwise registered following exposure.
    - Include information on health effects experienced by any individuals who were potentially exposed to radiological material at or near the incident site. This information should include emergency workers as well as the public. Establish close coordination with medical facilities for monitoring and rapid reporting of any signs or symptoms of radiation exposure since this information will contribute to retrospective dosimetry and could provide important information during the early

[27] ICRP (2006) "The Optimisation of Radiological Protection: Broadening the Process. ICRP Publication 101." Annals of the ICRP 36, no. 3 (2006): 65, 71–104. Available online at: https://doi.org/10.1016/j.icrp.2006.09.007.

phases of an incident regarding radiological sources and the extent of the contamination.

- **Incorporate technical guidance:** As an incident progresses, dose assessment will likely require the inclusion of subject matter expertise from both the private sector and state and federal partners, such as the DOE national laboratory network, the state radiation control programs, or contracted technical consultants. It is important to request and engage the assistance of specialized state and federal resources, such as the FRMAC, CDC Inorganic and Radiation Analytical Toxicology (IRAT) Branch, early in the incident response and recovery process to obtain outside assistance to support dose assessment processes.

Recommended Resources:

- *Field Guide for Health and Safety Officers: Radiological Incidents, Part 1 Operational Guidance and Part 2* Background Information. (New York City Department of Health and Mental Hygiene, June 2014) https://remm.hhs.gov/fieldguide.htm.
- NCRP *Report 161, Management of Persons Contaminated with Radionuclides*. (2008)
- 10 CFR 20 "Standards for Protection Against Radiation".
- *Suggested Training and Experience Qualifications for Health and Safety Officers During a Radiological Incident* - PubMed (nih.gov) https://pubmed.ncbi.nlm.nih.gov/31842135.

Activity 2.2: Implement an Exposure/Dose Record Process for Emergency Workers, Remediation Workers, and Essential Employees

Exposure Information Collection Requirements:

- Identifying information: name, badge number, unit/team
- Specific activity(ies) performed in a contaminated area and location
- Start and end time of activity(ies) in a contaminated area
- List of any PPE worn
- Total dose recorded on responder instrumentation, if available
- Instrumentation type and number, if available
- Highest exposure rate recorded, if available

- **Conduct initial data collection.** For emergency workers or other workers who are completing their duty in the affected area or otherwise demobilizing after the initial incident response, exposure information should be collected to the extent it is available. If no RHSO is available, other personnel may be assigned to oversee collection of exposure data on a contingency basis. The information gathered during this initial data collection effort will be required to perform the dose assessments described in Activity 2.1.

- **Provide monitoring equipment.** Procure and deploy additional radiation dosimeters and/or personal detection equipment that can record total dose. This deployment should be done as soon as possible, especially after life-saving activities have concluded and sustained response activities are underway.
    - Every individual who enters the HZ or DRZ should be issued a personal dosimeter that can provide a dose reading in real-time. Ideally, personnel should also be provided a dosimeter or a personal radiation detector (PRD) that emits an audible alarm triggered by predetermined thresholds. In addition to tracking total received dose for potential health effects, these dosimeters also support a requirement to provide a legal (officially recorded) record of dose received by radiation workers.
    - In situations involving a shortage of PRDs, guidance from the National Council on Radiation Protection (NCRP) provides details on how to use limited PRD resources most effectively.[28,29] Specifically, this guidance entails the use of group dosimetry (issuing a single dosimeter to a group of people who remain in proximity or work in the same area).
- **Set operational goals for radiation exposure.**
    - Operational goals are aimed at preventing people from exceeding regulatory radiation dose limits, described in Table 9:. Operational goals can be a combination of procedural (e.g., wearing dosimetry that is periodically checked) and administrative measures (e.g., assigning stay-times or dose limits).
    - Operational goals are based on two factors:
        - Exposure rate: The intensity of radiation an individual is exposed to expressed as the amount of ionizing radiation in the person's vicinity per hour.
        - Total dose: The total amount of radiation absorbed (dose) for an individual over a given period of time (e.g., total radiation absorbed by the person in a year).

28 NCRP (2017) "Report 179: Guidance for Emergency Response Dosimetry." Available online at: https://ncrponline.org/shop/reports/report-no-179-guidance-for-emergency-response-dosimetry-2017/
29 NCRP. (2019) "Commentary 28, Implementation Guidance for Emergency Response Dosimetry." Available online at: https://ncrponline.org/shop/commentaries/commentary-no-28-implementation-guidance-for-emergency-response-dosimetry/

Table 9: **Guidance on Dose Decision-Point Thresholds (Exposure rate in area (R/hr, Gy/hr))**[30]

Guideline	Activity	Condition
> 10 mR/hr (0.1 mGy/hr)	Work in Hot Zone (HZ)	All personnel working in the HZ should have appropriate training and PPE (including radiation dosimeters) for all hazards they are expected to encounter.
> 10 R/hr (1 Gy/hr) [a, b]	Work in Dangerous Radiation Zone (DRZ) – lifesaving activities	Entry into the DRZ should only be made to conduct life-saving actions or attempting to prevent a catastrophic situation and with the informed consent of those making the entry.
Total dose to the worker (rem, Sv)		
5 rem (50 mSv) [a, c, d, e, f, h, i]	Annual occupational limit for radiation workers under routine circumstances	All reasonably achievable actions have been taken to minimize dose.
5-10 rem (50-100 mSv) [a, b, e, i]	Protecting CI necessary for public welfare (e.g., a power plant)	Exceeding 5 rem (50 mSv) is unavoidable and appropriate actions have been taken to reduce dose. Monitoring is available to project or to measure the dose to individuals.
10-25 rem (100-250 mSv) [a, b, e, h, i]	Lifesaving or protection of large populations	Exceeding 5 rem (50 mSv) is unavoidable and all appropriate actions have been taken to reduce dose. Monitoring is available to project or to measure dose.
25-50 rem (500 mSv) [a, b, e, h, i]	Lifesaving or protection of large populations	All conditions for exceeding a dose of 25 rem have been met and those making the entry are fully aware of the risks involved.

[30] [a] Medical monitoring should be considered for potential doses in excess of 5 rem (50 mSv), [b] In the case of large-scale incidents (e.g., nuclear detonations), the Incident Commander should consider raising the dose guidelines to prevent large-scale loss of life and widespread destruction, [c] EPA Protection Action Guides (2017), [d] NCRP 1993, [e] ICRP 2005, [f] CRCPD 2006, [g] IAEA 2006, [h] DHS 2008, [i] NCRP 2010

- **Perform ongoing data collection.** Establish a routine process for recording and tracking essential information each time a person enters or exits a contaminated area or an area of elevated exposure rate. This process should be outlined in detail in the HASP, and all personnel working on site should be familiar with the purpose and importance of this data collection process.
  - Dose management for contractors conducting remediation work should be documented in a specific HASP or HASP supplement.

Recommended Resources:

- *NCRP Commentary Number 28* includes helpful ICS-oriented worksheets that can be integrated into response plans and protocols to facilitate this process.
- National Council on Radiation Protection and Measurements. (NCRP) *Commentary 19, Key Elements of Preparing Emergency Responders for Nuclear and Radiological Terrorism.* (2005)
- NCRP *Report 165, Responding to a Radiological or Nuclear Terrorism Incident: A Guide for Decision Makers*. (2010)

Activity 2.3: Determine Personal Protective Equipment Requirements for the Contaminated Area

- Identify PPE requirements for:
  - **Emergency Workers:** Emergency workers may require PPE if/when they enter contaminated areas to conduct emergency response work, such as providing emergency medical support, search and rescue, law enforcement activities, firefighting, and gross decontamination. Specific PPE requirements will depend on the type of hazards associated with a specific work activity as well as the radiological hazards posed by the incident. The RHSO should ensure that personnel entering contaminated areas are provided with PPE consistent with the hazards and exposure pathways identified in the contaminated area and the type of work being performed. Note that in some cases no special PPE may be required to perform work in contaminated areas; for example, some sources of penetrating ionizing radiation (such as gamma emitters) will pose a hazard regardless of PPE worn. In such scenarios, protection is ensured through dosimetry, exposure monitoring, and limiting time in the contaminated area rather than by relying on other types of PPE clothing or filtration systems.
  - **Essential Employees:** Workers who must enter the contaminated area to conduct non-radiological work will require PPE guidance specific to the hazards on the site and dosimetry. Depending on the exposure pathways identified, this protection could range from no additional PPE (level D) to PPE including respiratory protection if

resuspension is a concern. This group will also require just-in-time radiation safety training.

  - **Remediation Workers:** Remediation workers will require PPE appropriate for their identified exposure pathways and type of work performed and dosimetry. Required PPE should be documented in the HASP, which should be reviewed by appropriate regulatory bodies (e.g., local and state health departments), safety officer, and/or R-TWG, as appropriate.

  - **General Public:** Members of the public are not expected to require PPE, since access to areas with harmful or potentially harmful levels of contamination should be controlled and limited to those people having a need to enter the area. Members of the public with a need to enter a contaminated area should be provided with dosimetry.

    - If resuspension is a concern, then particulate respiratory protection against dust inhalation may be necessary.

    - If removable (external) contamination is a concern, then either coveralls or a change of clothing may need to be provided at evacuation exit points.

- Conduct just-in-time training on PPE utilization for anyone required to utilize it unless they have previous training that remains up to date.

Activity 2.4: Mitigate Spread of Contamination

- Implement engineering controls, administrative controls, and decontamination techniques to keep contamination as close to the initial source as possible, preventing further spread within and outside of the contaminated area boundary. There are three primary categories of control techniques:

  - To the extent feasible, retrieve and remove large sources of contamination.

    - This technique may be especially important if some or all the radioactive material is in discrete chunks or fragments.

  - Implement **engineering controls** to physically contain contamination in-place. These controls would include:

    - Encapsulating sources and contamination, ideally with dense or thick material (e.g., fixatives, lead bricks, concrete, and other dense barriers) that also provide shielding from gamma or beta radiation.

    - capturing run-off water to prevent transport of material through the environment. This technique may be especially applicable in scenarios in which a fire is involved or where sprinkler systems have been activated by an explosion, but only if berms and dykes can be deployed safely and effectively. Other considerations include limiting runoff from a standoff distance, such as by remotely damming stormwater drainage sewers for later pumping and removal of contaminated runoff.

- Establish **administrative controls** to prevent access to areas with elevated exposure or significant contamination. This includes:
  - Providing just-in-time training to personnel who are working in or near the affected areas to limit any further spread of contamination.
  - Setting up physical boundaries (see Activity 1.5) to control access.
  - Conducting routine and job-specific radiological monitoring.
  - Posting signs that identify hazards (e.g., marking out an HZ boundary or hot spot).
  - Implementing mandatory screening and decontamination checkpoints at designated exits from contaminated areas.
- Conduct expedient environmental **decontamination** intended to reduce exposure to personnel working in the area. These actions do not represent "long term" or "final" decontamination, but rather are intended to address the threat posed by radioactive material in a way that reduces the possible exposure for personnel working in the affected area. Examples include removal of large sources of contamination—such as chunks or fragments, if present—to reduce exposure to people traversing the area. Decontamination techniques supporting short-term mitigation will overlap to some degree with techniques used to complete full remediation (discussed in Focus Area 7 and Annex B). However, these techniques may be appropriate over a shorter time frame and could potentially take advantage of resources that are immediately available.

Recommended Resources: Radiological Recovery Logistics Tool (RRLT)

The RRLT is a web-based tool currently in development to assist federal, and SLTT organizations with identifying appropriate commercial and public works equipment to mitigate, remove, and contain radiological contamination following a large-scale release. It is particularly relevant for preparing early and intermediate-phase mitigation actions before the organized, contractor-conducted remediation operation has begun. The tool provides solutions for five support goals:

- Mitigation of received dose to first responders

- Containment of wastewater
- Decontamination (gross and final)
- Solid waste management
- Survey and monitoring
- The RRLT can be accessed online at: https://cfpub.epa.gov/si/si_public_record_Report.cfm?dirEntryId=357559&Lab=CESER

Recommended Resources:

- Public Health England. *UK Recovery Handbooks Radiation Incidents 2015: Inhabited Areas Handbook.* Version 4.1. (June 2015.) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/775712/inhabited_areas_handbook_2015.pdf.
- Federal Emergency Management Agency. *Nuclear/Radiological Incident Annex to the Response and Federal Interagency Operational Plans.* (U.S. Department of Homeland Security, October 2016.) https://www.fema.gov/sites/default/files/2020-07/fema_incident-annex_nuclear-radiological.pdf.

Strategy 2: Communicate

Focus Area 3: Public Communications

Guidance: *Provide timely emergency messaging in the early and intermediate phases of the incident focusing on protective actions. Identify, develop, and implement communication strategies for long-term concerns, including a focus on building literacy around radiological hazards, and setting expectations for a potentially extended recovery and reoccupation timeline. Utilize* ***trusted sources*** *and coordination mechanisms to ensure messaging is effective and the affected community's issues, concerns, and equities are being addressed appropriately. Include appropriate representation from the affected community in long-term communications strategy development and implementation.*

Recommended Planning Partners:

- Emergency management
- Public Information Officers (PIOs)
- Elected and appointed officials
- Public health departments and stakeholders
- Law enforcement officials
- Public/private partnerships
- Radiological subject matter experts
- Community based organizations/**trusted sources**

Key Terminology: Trusted Sources

Trusted Sources: Trusted sources are members of the community who can serve as nodes for dissemination of information to the public as well as a feedback mechanism to facilitate bidirectional communication. A trusted source will know the history and context of their specific community and how that community likes to receive information both in style/wording and in method of dissemination (e.g., media, social media, printed materials, webinars, townhalls, etc.). Trusted sources may include religious leaders, community organizers, charity organizations, union leadership, etc.

Inclusion of trusted sources will help ensure that credible information reaches and is more likely to be accepted by people and communities that may otherwise have limited access to such information or be untrusting of the official spokesperson(s).

Key Terminology: Misinformation, Disinformation, and Malinformation[31]

Misinformation: False information that was not created or shared with the intention of causing harm.

Disinformation: Deliberately created false information with the intention of misleading, harming, or manipulating a person, social group, organization, or country.

Malinformation: Information based in fact but used out of context to mislead, harm, or manipulate. An example of malinformation is editing a video to remove important context to harm or mislead.

Introduction

Timely, authoritative, and easy-to-understand communication, including for individuals with limited English proficiency and individuals with disabilities, is a key factor underpinning response and recovery actions across all protective action phases. Radiological hazards tend to be unfamiliar, invisible in their manifestation, and potentially frightening to members of the public. Public risk perception may either be overly heightened, with excessive fear regarding any presence or detectable level of radioactivity regardless of the actual radiation hazard, or overly dismissive of a seemingly imperceptible threat. Considering such concerns, messaging will need to explain what happened, as well as corresponding radiation risk and protective actions, in a simple and easy-to-understand way and include reasoning for why the public is being asked to take a particular action. Such messaging should be conducted in partnership with trusted sources within the affected community(ies) to maximize the number of people who follow authoritative protective action guidance. Additionally, as the impacts from a radiological incident are likely to extend well into the late phase, messaging also will need to help set the expectation of a long road to recovery. The public should be made aware that as the situation develops, and more information becomes available, protective actions, cleanup plans, and recovery schedules are likely to change.

The *First 100 Minutes Guidance* describes the immediate public alerts and warnings and messaging that must be disseminated after an RDD detonation. These include an initial announcement of the incident, shelter-in-place and evacuation recommendations/instructions, self-decontamination instructions, and a press release/conference. As the extent of contamination and its impacts are further characterized in the hours and days that follow, PIOs will need to update and expand upon their emergency public safety messaging, while simultaneously combatting misinformation, malinformation, and disinformation, and begin to identify intermediate and late-phase communication priorities and potential community engagement strategies. Due to the importance of timely and accurate messaging that is actionable and linguistically appropriate for all populations, early phase messaging should employ pre-scripted or pre-approved language to the greatest extent

[31] Cybersecurity & Infrastructure Security Agency (CISA). *Foreign Influence Operations and Disinformation*. Available online at: https://www.cisa.gov/topics/election-security/foreign-influence-operations-and-disinformation

possible. There are numerous pre-existing communication guides specific to radiological incidents that include templates for creating messaging materials, Frequently Asked Questions (FAQ) documents, instructional videos and more. Training specific to communicating radiation risks in the aftermath of a radiological or nuclear disaster is also available. A selection of communication resources is provided in Annex C of this guidance.

Coordination Opportunity: Sharing in a JIC

Information sharing between FSLTT agencies and the public in the context of an RDD incident should be consolidated within a Joint Information Center (JIC). A JIC is where PIOs from all relevant agencies can discuss and coordinate public messaging and leverage shared resources, such as GIS specialists producing maps that help provide a visual characterization of an incident. The National Incident Management System (NIMS) describes JIC roles and responsibilities. Coordinated and consistent messaging is particularly important for RDD incidents where there is likely to be a lot of fear and angst among the public and the consequences of misinformation could be severe.

Table 10: Summary of Focus Area 3 Activities

	Activity	Phase
3.1	Provide New and Updated Early Phase Emergency Messaging	Early (Hours)
3.2	Identify and Develop Intermediate and Late-Phase Communication Strategies	Intermediate to Late (Days to Weeks)
3.3	Assess and Improve Communications Efforts	Late (Weeks to Months)

Activity 3.1: Provide New and Updated Early Phase Emergency Messaging

- Release early phase emergency messages to the public. These messages should employ pre-scripted or pre-approved language to facilitate the timely dissemination of critical information and life safety guidance.

- Incorporate radiation experts into the message development and review process in the context of both pre-incident planning and actual incident response and recovery activities. Experts may include SMEs from state radiation protection programs, state and local health departments, or a Radiological Operations Support Specialist (ROSS).

High-Priority Topics for Early-Phase Messaging

- What happened? Include maps of the impacted areas, information on the type of impacts (e.g., infrastructure, services, agricultural embargoes) and areas with access restrictions or relocation needs.
- What actions need to be taken by members of the public? Include information about PPE use, shelter-in-place instructions, relocation information, where to seek contamination screening and medical care, and how to self-decontaminate people, pets, and personal items.
- Provide guidance on whether food, water, and air are contaminated and how to safely consume food and water.
- Who is leading the response? Identify the lead agency or agencies and provide instructions regarding where people can go for information or to ask questions.
- When the next update will be provided.

- Build basic scientific literacy by using easy-to-understand language. The public likely has limited knowledge of radiation-related concepts. Use easy-to-understand visuals such as infographics. Provide basic background information and simplify complex technical information to enhance understanding of the situation and related protective action guidance.
- Manage expectations. As the situation develops, and more information becomes available, protective action recommendations for the public may change. It is important to emphasize that change is expected given the special dynamics of an RDD incident. The public should also be prepared for the likelihood that the timeline of response and recovery for an RDD incident will be significantly longer compared to other types of disasters.
- Pre-identify the best outlets and platforms to facilitate information sharing for both immediate, high-urgency messages (such as evacuation of relocation instructions or PPE use) and lower-urgency messages (such as updates to expected response and recovery timelines). Systems such as FEMA's Integrated Public Alert and Warning System (IPAWS) and Wireless Emergency Alert (WEA) System often have strict character and format limitations, so pre-scripting is especially important. Templated messages should be translated into all languages commonly used in the area and be made accessible to people with access or functional needs.
- Identify or establish liaisons between radiation safety technical working groups and the communications structures supporting incident response and recovery, including the JIC once activated.
- Ensure available means of communications are sufficient to reach community members affected by the RDD incident. Since RDDs do not generate an electromagnetic pulse (EMP), communication infrastructure is unlikely to be affected during an RDD event beyond any physical infrastructure that may be damaged by the blast in the immediate area or saturation of a system

based on a user spike created by the incident. However, jurisdictional communication plans that rely on in-person communication to reach certain populations, particularly those with access or functional needs, may need to be altered for those in and around a contaminated area.

- Develop a communications strategy for first responders, remediation workers, and essential employees as defined and discussed in Focus Area 2. Such individuals may not have hazardous materials training or even a basic knowledge of radiological concepts. However, they may be expected to work in or adjacent to contaminated areas. First responders, remediation workers, and essential employees will need to be reassured and affirmed of their safety, provided the appropriate resources to address their mental health and physical well-being, and be reminded of their critical role in mitigating impacts to the community that they serve.

Coordination Opportunity: Radiological Operations Support Specialist (ROSS)

A ROSS is an individual with radiological expertise and an understanding of the Incident Command System (ICS) available to SLTT emergency managers, responders, and decision-makers. ROSS are FEMA-typed and can be requested through mechanisms such as the Emergency Management Assistance Compact (EMAC). For more information, visit: https://www.fema.gov/sites/default/files/2020-07/fema_cbrn-ross.pdf.

Activity 3.2: Identify and Develop Intermediate and Late-Phase Communication Strategies

- Intermediate and late phase messaging can be more difficult to pre-script than early-phase messaging, since it will be harder to predict the specific needs and concerns of an impacted population days, weeks, months, and years into a recovery effort. However, existing communications resources (listed in Appendix C) can be used to help address many of the questions that are likely to arise during the later phases of an incident.

- Invite community leaders and trusted sources to participate in the development of messages and message deployment strategies. The community should be (and ultimately will be) involved in decision-making, so it is important to craft messages that will be received, understood, and accepted by the impacted public, including those who may not be easily reachable by traditional communication routes or those who may distrust official messaging channels.

Recommended Resources: Medical and Radiation Risk Messaging Resources

Communicating health-related radiation risks is necessary for the public to understand that their actions can protect them from short- and long-term health effects.

Communications should include descriptions of symptoms of radiation injury, what to do and not to do, expected timeframes during which symptoms may appear, and when and where to seek medical care. PIOs can leverage existing resources and messages, such as CDC's public-facing webpages and medical resources.

- FAQ for radiation emergencies: https://www.cdc.gov/nceh/radiation/emergencies/emergencyfaq.htm
- Acute Radiation Syndrome (ARS): A Fact Sheet for the Public: https://www.cdc.gov/nceh/radiation/emergencies/ars.htm
- Preventing and Treating Radiation Injuries and Illness: https://www.cdc.gov/nceh/radiation/emergencies/symptoms.htm
- EPA Communication Resources: https://www.epa.gov/radiation/pag-public-communication-resources

High-Priority Topics for Intermediate and Late-Phase Messaging

- What is happening now? Include updated maps, more details about the incident (as they become available for public dissemination) and key response and recovery activities and timelines, and who is actively responding to/managing the incident. Include maps of areas that are contaminated, under protective action recommendations, or subject safety guidance such as a "Do Not Drink" order, an agricultural embargo, or other lesser restrictions.
- What's happening next? Include what the incident management priorities are for the foreseeable future and provide a timeline (if available) for recovery efforts.
- Explain How to mitigate exposure and personal risk. Include information on decontamination (for people, animals, and property), safety instructions for personal property recovery/retrieval, PPE use, and food/water safety.
- Explain how to recover personal property (including pets, medicines, personal belongings, etc.) or make claims for irretrievable personal effects.
- Include instructions for receiving housing, food, healthcare, and economic assistance. During the recovery phase, include contact information, eligibility requirements, and instructions for accessing available financial aid, including governmental assistance, and/or insurance reimbursement, if applicable.
- Explain how to engage with response and recovery officials. Include information about meetings, hotlines, and other ways that the public can ask questions and/or offer feedback on the recovery process.
- Provide information on cleanup and reoccupation decision-making and progress. Share what will and will not be cleaned up, to what levels impacted areas/structures will be cleaned up, who makes cleanup decisions, cleanup methods, cleanup timelines, and associated information sharing needs for regular updates and unexpected incidents during cleanup. Explain any continued precautions, estimated reoccupation timeline, and any ongoing land-

use restrictions. Describe how the environment will be monitored and what long-term impacts are expected on water supply, wildlife, and agriculture.

Activity 3.3: Assess and Improve Communications

- Assess the impacts and effects of messaging during RDD incident response and recovery. An RDD incident likely will generate a great deal of fear and uncertainty in the community, and it is also a topic about which the public is typically not very knowledgeable. Additionally, background radiation can be present in the environment at levels that are very low and below all thresholds of concern, and for reasons unrelated to the RDD detonation. These factors make communication during and following an RDD incident more challenging and may lead to misunderstanding of important messages and the spread of misinformation, malinformation, and disinformation.

- Involve trusted sources in communications efforts throughout the pre-planning, response, and recovery phases of an incident. Trusted sources (included in Table 11: below) may be able to provide valuable feedback about how messaging is received by certain demographic groups, whether messaging is reaching the targeted audience, and how communications can be improved. Trusted sources can also be powerful allies in combatting misinformation, particularly among groups that are distrustful of official sources.

Table 11: Examples of Trusted Sources

Organization Type	Trusted Source Examples
Healthcare sector	Doctors in private practice, veterinarians, dentists, hospital spokespersons, public health officials
Local businesses	Convenience stores and bodegas, restaurants, pharmacies, retailers
Local media	Local journalists, news platforms
Education institutions	Teachers and professors, school nurses, athletic coaches
Faith-based organizations	Houses of worship, charity organizations
Real-estate sector	Co-op boards, real estate agents, property managers
Academic organizations	Verified experts in radiation, health physics, or public health fields, science communication experts, academic associations
Union/Trade associations	Public and private-sector union leadership
Canvassing organizations	“Get-out-the-Vote” and Census canvassers
Local government	Individual, public-facing employees such as transit workers, homeless outreach, and sanitation staff

- Periodically reassess the reach that partnered organizations, trusted sources, and official communication channels have within the community as the incident progresses. Certain groups, such as essential workers, may require more intensive outreach, the engagement of specific trusted sources (e.g., union organizers, social workers, healthcare providers, etc.), and additional focused messaging.
- Frequently survey for outdated information, misinformation, malinformation, and disinformation, and swiftly address or correct any inaccuracies. As time passes or incident conditions/objectives change, new information vacuums and channels of misinformation, malinformation, and disinformation are likely to develop. Addressing outdated information and misinformation will be especially important as updates become less frequent or less specific during the intermediate and late phases of recovery.

Recommended Resources: Annex C

See Annex C: Radiological Communications Tools.

Strategy 3: Monitor and Assist

Focus Area 4: Conduct Phased Evacuation

Guidance: *Plan for and execute a phased evacuation using geographically defined Evacuation Zones to assist with the prioritization of resources. Implement search and rescue, including canvassing operations to confirm evacuation compliance and assist populations with access and functional needs.*

Recommended Planning Partners:

- Environmental protection
- Emergency management
- Fire/police/EMS
- Public health
- Remediation contractors
- Transportation

Introduction

The activities described in this Focus Area outline the major steps necessary to plan for and execute an evacuation to safely move people who are sheltering in place out of the contaminated area in a timely fashion and in accordance with government-provided guidance. Unlike traditional evacuation planning for events where there are hours or days of advance notice (e.g., special events, coastal storms, and sometimes even nuclear power plant emergencies), an evacuation based upon an RDD incident will occur in an environment where resources have not been pre-staged and the public likely is unaware of any pre-designated evacuation zone or evacuation protocols in advance. Such a scenario requires flexible planning and careful prioritization of resources while balancing the risks of evacuation and potential exposure to radiation hazards versus the risks of prolonged sheltering in place.

Lessons Learned from Fukushima

Fukushima demonstrated that the "assessment of the tradeoff benefits between sheltering and evacuation needs re-emphasis. Evacuation strategies should be based on minimizing risk to the public from all causes." Planners should consult NUREG/CR-7285, "Nonradiological Health Consequences from Evacuation and Relocation" for additional lessons learned about this topic.

https://web.mit.edu/nse/pdf/news/2011/Fukushima_Lessons_Learned_MIT-NSP-025.pdf https://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr7285/index.html.

The first priority for evacuation following an RDD detonation is to remove people out of situations that are immediately dangerous to their life, such as building fires, unstable structures, and very high radiation exposure rates where sheltering is not feasible.

The *First 100 Minutes Guidance* largely addresses this priority. Evacuation of people in these situations should be underway or completed as the Strategies and Focus Areas in this *RDD Recovery Guidance* are initiated. Due to risks associated with evacuation itself, the Fukushima experience taught that it may be advisable to leave people sheltering in place longer until a safe evacuation can take place. All risks, including long-term health risks, should be considered when developing the evacuation plan. In general, conducting a phased evacuation does not mean stopping or delaying necessary medical evacuations out of the area (such as by EMS transport) for any life-threatening conditions or medical emergencies that may emerge.

Recommended Resources: Consequences from Evacuation and Relocation

Evacuation and relocation have inherent risks, ranging from increased risks of anxiety and PTSD to increased rates of diabetes or cardiovascular disease. For more information, see the Nuclear Regulatory Commission's (NRC's) 2021 report on the Nonradiological Health Consequences from Evacuation and Relocation (NUREG/CR-7285), available online at: https://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr7285/index.html.

The *First 100 Minutes Guidance* also describes initial shelter-in-place priorities, such as prompt notification to the public to shelter in place in areas that are 500 meters extending in all directions from the detonation point and 2000 meters in the direction of the contamination plume. Although this area represents a relatively small area compared to other types of major evacuation operations, the possibility exists that the additional characterization conducted as part of the 10 Point Monitoring Survey and Tactics 1, 2, and 8 in the *First 100 Minutes Guidance* will entail a significant expansion of the recommended shelter areas. For a very large radiological release, this expansion could result in multiple neighborhoods – potentially tens of thousands of people in a densely populated area – being advised to remain indoors while responders continue to gather information and plan for a safe evacuation process. It also will be important to communicate the shelter-in-place timeline and expectations to the public (see Focus Area 3).

An RDD-based evacuation operation requires planning and execution tailored to the particular areas affected and the resources available to conduct the evacuation. Communities should plan for and implement phased evacuation with consideration given to the population numbers and density of the area to be evacuated, types of buildings in which people are located (e.g., high-rise condos, apartments, homes), availability of privately owned vehicles (POVs) and public modes of transportation, and time available for evacuation operations to be completed.

A phased evacuation will maximize the safety of the impacted population by prioritizing evacuation of those in the areas of highest radioactivity exposure and those with urgent medical conditions, while controlling the flow of evacuees. This ensures available resources, such as personnel to operate screening and decontamination stations or checkpoints for those exiting the contaminated area, are not overwhelmed.

Focus Area 4 guides planners through the main concepts associated with evacuation planning and implementation, beginning with the designation of evacuation zones based on data collected through activities described in Focus Areas 1 and 2. These are largely determined by the hot zone boundaries and areas where safety guidelines provided in Protective Action Guides (PAGs) are exceeded. From there, planners and responders should match evacuation resources and methods (e.g., vehicle-assisted vs directed self-evacuation) to each zone and determine the order in which evacuation will commence.

Finally, this Focus Area provides guidance for conducting search and rescue, including canvassing operations to determine the success of evacuation and identify people remaining in the area who may require additional assistance to evacuate safely. While canvassing is a common follow-up to any mass evacuation operation, performing such operations in the contaminated area will pose challenges, including ensuring the protection of the health and safety of canvassers. Focus Area 4 activities are informed by specific data requirements (e.g., population density of contaminated area and type of activity in the contaminated area such as office, manufacturing, etc.) further discussed in Annex B.

Table 12: Summary of Focus Area 4 Activities

	Activity	Phase
4.1	Identify Areas Where People Will Require Evacuation, Release from Shelter-in-Place (SIP) or an Extended Period of SIP	Early to Intermediate (Hours to Days)
4.2	Mobilize and Execute a Phased Evacuation Over the Next Few Days	Early to Intermediate (Hours to Days)
4.3	Conduct Search, Rescue, and Canvassing Operations	Early to Intermediate (Hours to Days)

Activity 4.1: Identify Areas Where People Will Require Evacuation, Release from SIP, or an Extended Period of SIP

- **Gather information:** Gather and analyze critical incident information acquired through Strategy 1 activities, including:
    - Radiological monitoring and sampling data/analysis, as described in Focus Area 1 (e.g., maps, aerial and vehicular monitoring data, and responder on-foot monitoring, as well as laboratory analysis of samples, when available).

- Exposure pathway analysis and dose projections for people in areas with significant contamination, as described in Focus Area 2.
  - State and local public health departments should leverage the IMAAC, FRMAC, and A-Team, and other specialized federal assets, as available to conduct this assessment.[32]
  - State and local officials should be prepared to provide updated GIS data to assisting federal agencies, such as 9-1-1 street maps and address point locations. Additionally, FEMA may be able to coordinate with other federal partners to obtain anonymized information from wireless service providers indicating the population concentration within affected areas who have working cellular devices.

Planning Tip: Verify Legal Authority for Mandatory Evacuation and SIP

Statutory authority to compel evacuations and/or restrict movement (such as in an enforced shelter-in-place scenario) varies with state, tribal, and territorial law.

- In some states, only the governor may require evacuation.
- Some evacuation authorities are limited to specific hazard scenarios spelled out in law.
- Local law enforcement and fire departments may also exercise police powers to limit access and/or compel evacuation in some situations.

Check with emergency management officials and legal counsel to determine which authorities govern mandatory evacuation of any designated evacuation and/or relocation zones.

- **Establish zones:** Identify the following three types of areas to inform early and intermediate phase evacuation and SIP decision-making:
  - **HZ and DRZ, where radiological exposures are >10 mR/hr and >10 R/hr, respectively.** These areas may be a priority for timely assisted evacuation during the immediate response; however, rushed evacuations can pose safety and health-risks that exceed those from radiation exposure. Even for areas within the HZ, planners must analyze the risks of conducting an evacuation balanced with the risks of extended temporary shelter-in-place.
  - **Areas with other physical hazards and individuals with access and functional needs.** Other life-safety hazards might prompt the need for evacuation, such as areas

[32] IMAAC support can be requested directly at IMAAC@fema.dhs.gov or 703-767-2003. For general inquiries or more information email IMAAC at IMAACinquiries@fema.dhs.gov. Support from the FRMAC and A-Team can be requested through the DOE (1-202-586-8100) and FDA (1-866-300-4374) emergency operation centers, respectively.

containing non-radiological hazards that may worsen as sheltering time lengthens. Typically, this would be due to a loss of a critical utility (e.g., HVAC on a hot/cold day, clean drinking water, sanitation services, as well as at-home health care services such as those with medical equipment requiring electricity, oxygen, etc.). Consideration should also include evacuation requirements for access and functional needs or special medial needs populations. Assessment of congregate care facilities and medical facilities requiring extensive evacuation support would fall into this category. Depending on the circumstances, non-radiological hazards may be the most important factor that determines high-priority evacuations.

- **Relocation areas**: Areas where long-term cleanup may be needed, such as those that exceed the relocation criteria defined in EPA PAGs. Identification of relocation areas during the early phase should also balance radiological hazards with evacuation or relocation-associated hazards. Furthermore, not all areas identified as potential relocation areas will need to be evacuated over the first few days beyond the initial response if continued shelter-in-place is feasible.

  - For the radiological hazard, the EPA PAG recommends 2 rem/yr annual projected dose in the first year, and 0.5 rem in the second and subsequent years, as a threshold for a relocation area. For RDD incidents involving isotopes with relatively long half-lives, it may be necessary to base relocation decisions on the second and subsequent year dose projections. In these cases, evacuation may be a low priority, as the hazard likely will not exceed PAGs for some time. In these scenarios, decisions on relocation may need to be informed by detailed multi-year dose assessment and modeling projections. Additional precautions may also be necessary if the material distributed emits alpha radiation.

  - Demographic-specific dose thresholds for populations especially vulnerable to radiation exposure and non-radiation hazards (such as pregnant people and children) may justify prioritizing assisted-evacuation or an earlier self-evacuation.

  - Unnecessary or rushed evacuations can pose safety and health risks that exceed those associated with radiation exposure. These added risks include separation of vulnerable individuals from their home-area support systems/network of family and acquaintances, traffic hazards, and other stressors associated with evacuation and relocation. Since rushed or unnecessary evacuations can pose safety and health risks, it may be sensible to delay evacuation in some areas of the designated relocation zones to a later time. However, regarding those areas where evacuation is delayed, resources should be rapidly mobilized to support community needs associated with a prolonged shelter-in-place, if the resources exist to do so. If evacuation is necessary, it is unlikely that responders will be operating in the area for a long enough period to provide essential commodities, medicines, and services, in addition to providing food or addressing other needs of sheltered populations.

- **Determine timeline:** As soon as possible, identify which areas in the above categories will require evacuation over the next few days following the initial response, and then execute SIP and the phased evacuation processes described in Activity 4.2.
    - Planners should be aware that state and local authorities that deal with mandatory evacuation vary greatly from one jurisdiction to the next. Planners should identify all and understand all potential legal authorities available in a given context when planning and prior to conducting an evacuation.
    - Depending on the area requiring evacuation, it is possible that an RDD could result in a considerable and urgent need for mass care services, including emergency shelter and housing. The decision-making process for timing phased evacuations should take into account the availability of mass care resources for people who do not have a primary or alternative housing option available to them.
- **Engage subject matter expert support:** To the extent practical, engage professionals and SMEs to support evacuation planning and inform decision-making. Resources to consider include mental health professionals, public health, the REAC/TS support network, radiation health professionals, and communications professionals.
- **Revise evacuation zone boundaries:** As additional characterization activities progress and greater technical knowledge about the event becomes available, be prepared to revise the relocation PAG boundaries and their associated evacuation zones. This revision may result in:
    - Some people who were evacuated being able to return to areas that were previously evacuated;
    - Evacuation of new or additional areas based on updated public health assessments; and/or
    - Implementation of short-term mitigation techniques (e.g., engineering, administrative, and environmental decontamination discussed in Focus Area 2) to reduce exposures to people evacuating, and/or people under prolonged shelter-in-place orders.

Activity 4.2: Mobilize and Execute a Phased Evacuation Over the Next Few Days

- **Establish evacuation zones:** Divide areas requiring evacuation into **evacuation zones**, as necessary and as appropriate for the jurisdiction, to enable a managed, time-phased, and prioritized evacuation. Figure 6 provides a simplified example of this process.

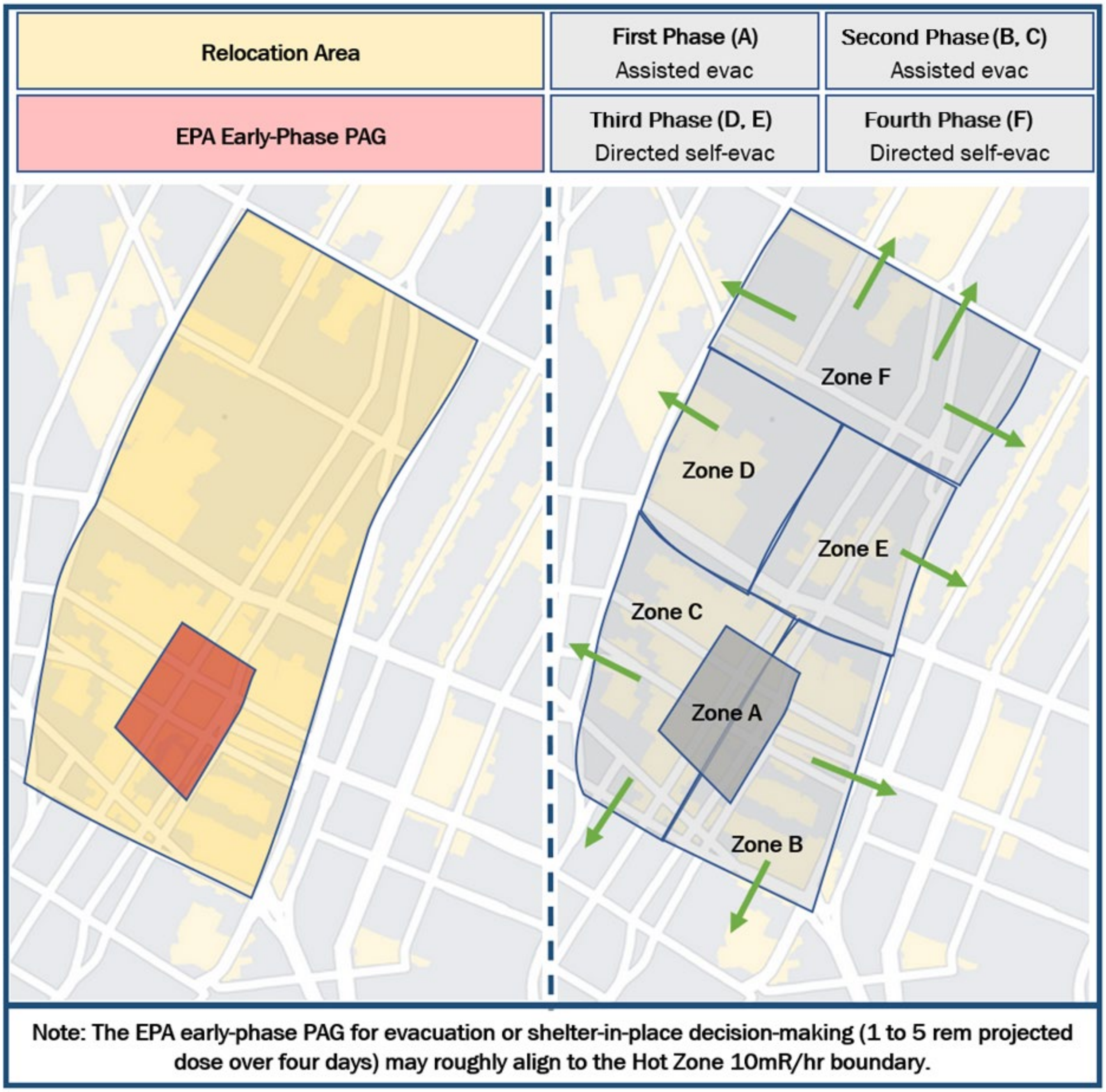

Figure 6: Example of Time-Phased Evacuations.

- **Prioritize areas of greatest exposure:** When dividing and prioritizing evacuation zones, consider the following factors:
    - Areas with higher exposure rates or greater non-radiological hazards should be prioritized for evacuation over other areas. Consider grouping areas with similar characteristics, such as where similar types of hazards are identified (e.g., same PAG values exceeded, and similar area category as described in Activity 4.1).
    - Recognizable geography and landmarks that facilitate responder and public identification of zones and movement through them. For example, this consideration

may mean identifying zones by zip code, voting precinct, fire service area, or locations of major roadways and public transportation.

- Demographic and environmental characteristics that could impact feasibility of mobilization, the amount of assisted evacuation required, or lengthen or shorten the time required to complete evacuation. For example, areas with:
  - Populations with disabilities and other medical, access, and functional needs;
  - Populations without vehicles;
  - Areas with high population density.

- **Identify the safest exit routes:** Send a survey team to conduct radiological monitoring and/or leverage existing survey data from Focus Area 1 to identify the safest routes out of each evacuation zone.
  - Establish evacuation corridors that are perpendicular to the plume centerline, identified through monitoring activities as described in Focus Area 1. This alignment will minimize potential exposure to radioactive contamination during the actual evacuation by reducing time spent in the contaminated area.
  - Radiation monitoring teams and all-hazard survey teams should identify contamination and other hazards that might need to be mitigated or removed, such as debris or disabled vehicles.
  - Radiation safety professionals should conduct an exposure/dose assessment for evacuees traversing the identified route and suggest adjustments, as needed. The FRMAC and the A-Team can assist with these assessments.[33,34]
- **Provide transportation assistance:** Identify and mobilize means for assisting evacuees with transportation. A combination of means will likely be necessary and should take into consideration any potential radiological (or other) hazards, including:
  - **On-foot:** For smaller-scale releases where pathway assessments have identified re-suspension to be a minor concern, or for circumstances where roadways are blocked by disabled/abandoned vehicles, emergency responder-directed on-foot evacuation may be feasible. Radiation health and safety experts should conduct exposure/dose assessments of the chosen routes out of the contaminated area. PPE may need to be

[33] More information about the FRMAC, can be found on the DOE Nevada National Security Site (NNSS) webpage on FRMAC: https://www.nnss.gov/pages/programs/frmac/FRMAC.html

[34] For more information about the A-Team, see the A-Team's website: https://cdn.ymaws.com/www.crcpd.org/resource/resmgr/ATeam/Ateam1.htm

provided to people traversing on foot. Responders should direct evacuees through identified evacuation paths.

- **Common-carrier/mass transit:** Common-carrier and use of mass transit resources can move a considerable number of people in a small amount of time and have the added benefit of minimizing roadway bottlenecks. An exposure pathway assessment for risk of resuspension should be conducted by radiation health and safety experts. PPE may need to be provided to evacuees and/or operators of the vehicle. This method is the most resource-intensive for response organizations. Additionally, if mass transit vehicles are re-used for multiple trips, end-of-route screening and gross decontamination may be necessary.

- **Personally owned vehicle (POV):** In most locations, POV transportation will be the first choice for any evacuation. However, POV transportation may not be available to everyone in the zone to be evacuated. In addition, use of POVs may result in further spread of radioactive contamination by re-suspension and physical transport on POV surfaces. Regardless of instructions provided, some people will use POVs to evacuate themselves from a contaminated area. Communities should plan for use of POVs, with or without authorization, for evacuation and plan their resources accordingly.

Key Terminology: Community Reception Center (CRC)

The Community Reception Center (CRC) concept was created by the CDC to provide public health officials with guidance for managing screening and decontamination of evacuees. More information on planning for CRC operations is included in Focus Area 5. The CRC:

- Handles initial, radiation contamination screening, decontamination, registration, and information.
- Collects information needed to track individuals for public health follow-up.

Recommended Resources: CRC Toolkit

The CDC's **CRC Toolkit** includes staffing requirements, necessary equipment lists, forms, drills and exercise toolkits, and electronic applications for use in CRC operations: https://www.cdc.gov/nceh/radiation/emergencies/populationmonitoring.htm

- CDC also offers a guide to repurpose existing Point of Distribution (POD) plans for CRC purposes. https://www.cdc.gov/nceh/radiation/emergencies/pdf/pod_to_crc_planning_tool-508.pdf

- **Screen evacuees:** If CRCs have been opened (See Focus Area 5), direct and/or transport evacuees to these locations for radioactive contamination screening. If CRCs are not available and resources permit, establish ad hoc screening and decontamination stations or checkpoints outside of the contaminated area and along the evacuation routes where evacuees can be rapidly screened, decontaminated (if necessary), and transported for medical treatment (if needed). These stations or checkpoints should:

- Expeditiously check for gross external radioactive contamination of evacuees and provide any necessary emergency medical attention for physical injuries or other medical conditions in addition to gross decontamination (where appropriate) (See Focus Area 5 for more information);
- Be staffed with security and basic first aid providers, when available;
- Provide basic provisions for evacuees traveling with pets and service animals (water and kennels, if available);
- Be operational in all weather conditions;
- If POVs are used, checkpoints should provide space for screening and/or isolating vehicles that may be contaminated;
- Review and record dosimetry of drivers who are transporting evacuees.

- **Provide public messaging:** Notify the public of the phased evacuation process.
  - Use targeted-messaging technologies and social media to communicate evacuation priorities to specific buildings and neighborhoods:
    - Wireless emergency alerts (WEAs) distributed using FEMA's Integrated Public Alert and Warning System (IPAWS) can be used to send geo-targeted instructions to people with cellular phones in most cases. Sending these alerts may also entail activation of the Emergency Alert System (EAS).
    - Consider utilizing internet streaming and low-power FM transmitter stations for individuals to receive continuously broadcasting information about the evacuation.
    - Some jurisdiction-specific emergency notification systems may also allow for targeted alerts based on address or other registration information. Many of these systems are subscriber-based and may be able to reach deaf and blind residents.
    - Outdoor public address systems and route alerting by public safety agencies may also be of use; however, consider the placement of these systems (distance and separation of devices) and whether they will provide sufficient targeted information for individuals in the affected areas.

    - Messages should include multiple languages appropriate for the targeted areas and be sent through multiple modalities to ensure they are understandable by people with low English proficiency or disabilities.

  - Provide the public with regular updates on:

    - Which areas and buildings are to be evacuated, when the evacuation should begin, and how people should evacuate.

    - Which areas and buildings are no longer under a shelter-in-place recommendation or order.

  - Establish perimeter access controls around the affected evacuation area(s) utilizing traffic control points, barricades, and law enforcement personnel to deny access where appropriate.

  - Ensure designated access points are provided with up-to-date information on ongoing response activities that can be shared with individuals attempting to gain access to the evacuation area(s).

Activity 4.3: Conduct Search, Rescue, and Canvassing Operations

- **Conduct search and rescue:** Continue to conduct search and rescue operations[35] in radioactively contaminated zones. Search and rescue operations can be conducted in parallel with phased evacuations or be initiated in advance as part of lifesaving operations during the initial response. Prioritize these activities in areas that are most contaminated (e.g., the HZ), contain life-threatening hazards (e.g., structural instability or fires), or require technical rescue (e.g., vehicle extraction, confined space rescue, high angle rescue).

- **Canvass the area:** Conduct a comprehensive canvassing operation of all buildings requiring evacuation within the contaminated area. This canvassing can happen concurrent with or following evacuation:

  - Convene task forces to enter and clear buildings in order to identify people who need evacuation assistance, medical assistance, or who are resistant to evacuation. Be cognizant of state and local laws and ordnances regarding evacuation orders; it may not be possible to require evacuation unless it is a declared state of emergency.

[35] Search and rescue operations to remove people from immediately dangerous situations should be conducted during the immediate response. However, there may be a need for additional search and rescue and urgent canvassing operations in the hot zone or other contaminated areas hours or days into the response if other hazards are present, such as a building collapse or fire.

- Use emergency responders with hazmat or Hazardous Waste Operations and Emergency Response (HAZWOPER) training and appropriate PPE to conduct canvassing surveys in heavily contaminated areas, such as the hot zone.
- If necessary, use non-HAZMAT-trained state and local government personnel to conduct canvassing in areas outside of the hot zone. As mentioned in Focus Area 2, these canvassing operations will require just-in-time radiation safety training, dosimetry, and a system for mitigating the spread of contamination.
- Use remote-canvassing technology to assess compliance with evacuation operations, to reduce personnel time spent in contaminated areas. Examples include:
  - Notification systems that allow for end-user feedback;
  - When remote telemetry is available, consider monitoring the usage of utilities such as telecommunications (internet services), power, and water usage;
  - Unmanned ground or aerial vehicles, or remote cameras.

Recommended Resources:

- *Planning Considerations: Evacuation and Shelter-in-Place – Guidance for State, Local, Tribal and Territorial Partners.* (U.S. Department of Homeland Security, July 2019) https://www.fema.gov/sites/default/files/2020-07/planning-considerations-evacuation-and-shelter-in-place.pdf
- *Handbook for Responding to a Radiological Dispersal Device: First Responders Guide – The First 12 Hours.* (Conference of Radiation Control Program Directors, September 2006) https://cdn.ymaws.com/www.crcpd.org/resource/resmgr/docs/rdd/rdd-handbook-forweb.pdf.
- *Protective Action Guides and Planning Guidance for Radiological Incidents*. PAG Manual*:* EPA-400/R-17/001. (U.S. Environmental Protection Agency, Office of Radiation and Indoor Air, Radiation Protection Division, 2017.) https://www.epa.gov/radiation/protective-action-guides-pags
- *Protective Action Area Map Templates. EPA-420 (EPA, 2017)* https://www.epa.gov/sites/default/files/2017-11/protective_action_area_map_templates_11202017_final_1.docx

Focus Area 5: Screen and Decontaminate

Guidance: *Provide early phase radiological screening and decontamination services for:*

- *responders including their equipment and vehicles;*
- *displaced and/or evacuating populations including special consideration of populations with disabilities and other access and functional needs and children or pregnant people, who are known to be more sensitive to the effects of radiation; and*
- *any accompanying pets and service animals, privately owned vehicles, personal belongings, and medical equipment.*

As soon as possible, provide population monitoring services to screen, decontaminate, and track individuals who have been exposed to radiation or contamination or may require medical care at a later time. If resources allow, provide radiological screening and decontamination of additional personal belongings, medical equipment, or vehicles removed from contaminated areas after an initial evacuation and prior to re-entry and re-occupancy.

Recommended Planning Partners:

- Emergency management
- Fire/HAZMAT teams
- Emergency Services
- Law enforcement
- SLTT Public health departments
- Local healthcare providers such as hospitals
- Behavioral health specialists
- Environmental protection
- Radiation safety
- Medical examiners and coroners
- Veterinarians
- Volunteer organizations such as the Community Emergency Response Team (CERT)

Key Terminology: CRC, Dosimetry, and Population Monitoring

Community Reception Center (CRC): Locations/facilities designed to screen for radioactive contamination, decontaminate, and register people.

Dosimetry: The science or technique of determining radiation dose. Strictly speaking, involving measured quantities, but also used informally to mean "dose assessment" (e.g., involving measurements and/or theoretical calculations).[36]

Population Monitoring: The process of evaluating and monitoring a population for radiologically related medical treatment, the presence of radioactive contamination on an individual's clothing or body (external contamination), intake of radioactive materials (internal contamination), radiation dose received, resulting health risk, and long-term health effects.[37]

Key Terminology: Gross, Technical, and Self-Decontamination

Gross Decontamination: Gross decontamination typically refers to non-targeted methods that remove large amounts of contamination, but may not ensure 100% removal, such as removing clothing and showering or hosing stations without run-off collection.

Technical Decontamination: Decontamination designed to reduce contamination to very low levels, typically close to background radiation levels. This level of decontamination may not be necessary for all scenarios and requires radiation detection equipment to confirm the success of decontamination.

Self-Decontamination: Decontamination carried out by individuals by themselves. Self-decontamination could include removal of outer layers of clothing, showering, or other methods.

Introduction

In the context of RDD incidents, screening refers to assessing people and objects for radioactive contamination. There are a variety of screening methods, each requiring different resources, training, and expertise. Screening methods may change throughout the response, based on resource availability and the goal of the decontamination effort (e.g., gross decontamination early in the incident versus technical decontamination later in the incident). When available, screening can be conducted with specialized instrumentation, such as portal monitors[38] to maximize screening throughput and handheld instruments to pinpoint contamination. All of the activities in this Focus Area build upon activities already started in the *First 100 Minutes Guidance*, including setup of screening and decontamination for responders and for populations in contaminated areas.

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[36] Derived from NCRP (2017) "Report No. 179, Guidance for Emergency Response Dosimetry", and reprinted with permission of the National Council on Radiation Protection and Measurements. Available online at: https://ncrponline.org/shop/reports/report-no-179-guidance-for-emergency-response-dosimetry-2017/

[37] Derived from CDC (2014) *Population Monitoring in Radiation Emergencies: A Guide for State and Local Public Health Planners, 2nd edition*. Available online at: https://emergency.cdc.gov/radiation/pdf/population-monitoring-guide.pdf

[38] Portal monitors are radiation detection devices used for the screening of individuals, vehicles, or objects, and are typically shaped as doorways to screen the entire object or person.

Decontamination is the process of removing radioactive contamination from a person or object. Like screening, decontamination method selection depends on resource availability. Decontamination methods include the use of wet wipes, dry brushing, showers, and vacuums to remove contamination from people and objects. In the absence of appropriate resources and/or time to conduct thorough decontamination (such as for people rapidly evacuating contaminated areas), changing outer clothing can dramatically and rapidly reduce contamination.[39]

Containment of Wastewater from Decontamination

During the early response, EPA guidance allows emergency responders to release contaminated water from decontamination activities directly into the environment.[40] However, once all imminent threats to human health and life are addressed, any contaminated water generated by decontamination should be captured and contained. As a result, emergency response staff should be prepared to capture or otherwise contain contaminated water during the intermediate and late phases of the response, as well as for the extent of recovery operations. Exactly when this capture of contaminated water or trash needs to begin will be dependent on the particulars of the incident and the resources available.

Screening and decontamination methods also will vary based on the characteristics of the populations and objects being considered, the number of people and objects that are contaminated, and the goal of the decontamination effort. Jurisdictions should work with HAZMAT and radiation experts, potentially including one or several ROSS, to develop the best decontamination approach using the resources available.

Screening and decontamination methods tend to begin with self-decontamination, then progress to gross and technical decontamination. As described in the *First 100 Minutes Guidance,* during the early response, first responders will perform quick screening and dry decontamination of individuals at designated exits from the Hot Zone to the extent practical, without unduly slowing down the self-evacuation process.[41] Priority during this period should be given to life safety and stabilizing the scene, as people self-evacuating from the affected area will be instructed to self-decontaminate when they reach their destination (and, therefore, should not need extensive support from first responders).

Assisted screening and decontamination also will likely occur at other locations during the early response – such as at designated hazard area entry/exit points and/or temporary shelters – and these efforts may either be targeted at very specific populations or be provided ad hoc based on available gross decontamination capabilities (e.g., decontamination capabilities of local fire

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[39] If changing clothing is not feasible, brushing or carefully shaking outer clothing may help remove significant amounts of contamination as well.

[40] EPA (2000) *First Responders' Environmental Liability Due to Mass Decontamination Runoff*. Available online at: https://www.epa.gov/sites/default/files/2013-11/documents/onepage.pdf.

[41] Dry decontamination refers to decontamination methods that do not utilize water, such as brushing off people or use of decontamination wipes.

departments). Hospitals also will need to establish screening and decontamination capability, but it should be reserved only for hospital staff and individuals requiring medical treatment. Contaminated individuals who do not require medical treatment should be either sent home to self-decontaminate or directed to a Community Reception Center (CRC), if established.

In the intermediate and late response phases, screening and decontamination should be increasingly consolidated into mass screening/decontamination centers to best utilize available resources. The best practice for mass screening/decontamination is the CRC. CRCs should be established at pre-identified locations, whenever possible, as the scenario permits. As more resources become available, decontamination will transition to the use of more technical decontamination procedures (showers, sinks), designed to reduce contamination as much as reasonably possible.

Typically, screening and decontamination are done together, where screening is used to identify who requires decontamination and verify removal of radioactive material after decontamination.[42] As a result, screening and decontamination are generally co-located. CRC site selection and layout, if not pre-identified during planning or the early response, should consider the population being screened. A non-exhaustive list of considerations is included below.

- Families should be kept together whenever possible. This consideration may be less important if populations are primarily from office buildings, prisons or other facilities or locations that typically only have adult populations.
- CRCs must be prepared to accommodate people with disabilities and other access and functional needs in the receiving population. This consideration will include ensuring all processes can accommodate wheelchairs or other mobility devices, medical equipment (e.g., portable oxygen containers), and service animals. Service animals should not be separated from their owners during the screening, decontamination, and registration process. Some populations may include a larger proportion of people requiring access and functional needs considerations, such as those evacuating from nursing homes or retirement communities.
- Sufficient parking or loading/unloading space must be provided for people arriving in private vehicles or by bus. If vehicles originate from contaminated areas, the CRC should establish appropriate vehicle screening and decontamination processes.
- The CRC should provide clean clothes and other resources following screening, decontamination, and registration if the population does not already have access to necessary resources. This consideration will be more important for socioeconomically disadvantaged populations or populations not arriving via personal vehicles.

Population categories for radiation screening and decontamination purposes are listed below; this list is not intended to be comprehensive. (Note the monitoring, screening, and decontamination of

[42] However, when no equipment is available for screening or nearly all people are likely contaminated, decontamination may be performed without screening.

buildings and CI facilities/systems are not covered in this section. These are addressed in Focus Area 6).

Screening and Decontamination Considerations: Populations

<u>Responders, Response Equipment and Response Vehicles</u>

Response personnel, equipment, and vehicles must be screened and decontaminated throughout the incident response and recovery process anytime they leave the contaminated area, because they may be repeatedly exposed to contamination. Failure to do so may pose risks to responders and the public, as well as spread contamination.

<u>The Public, Their Pets/Service Animals, and Other Belongings</u>

- **Immediate Evacuees:** Early in the response, screening and decontamination of the public will focus on populations that have been displaced by the incident after self-evacuating, either of their own volition or at the direction of authorities. Depending on the size and complexity of the incident, such populations may be screened and decontaminated multiple times. For instance, initial gross decontamination may take place at hazard zone entry/exit checkpoints. As people move out of contaminated areas, more thorough technical decontamination will occur at CRCs.
- **Phased Evacuees**: As the response continues, there may be phased evacuations of populations that were originally directed to shelter-in-place, producing a delayed group of evacuees for screening and, if necessary, decontamination. There also may be individuals who seek screening and decontamination despite not receiving official directions to do so.
- **People with Disabilities, Access and Functional Needs, and Other Special Populations**: Screening and decontamination procedures must be inclusive of the whole community. Populations that include people with mobility, sensory, intellectual, developmental, cognitive, or mental disabilities, as well as children, unaccompanied minors, transgender people, pregnant or nursing mothers, homeless people, and people who do not speak English are generally at greater risk because they may require assistance to follow and/or understand decontamination instructions.[43]
- **Pets & Service or Support Animals**: The Americans with Disabilities Act of 1990 (ADA) and the Pets Evacuation and Transportation Standards (PETS) Act of 2006 enacted following Hurricane Katrina, requires state and local agencies to accommodate household pets and service animals (PSAs) in disaster planning. Real-world incident after action reports indicate that people are more compliant with evacuation and shelter orders when their pets are

[43] For more information on providing for access and functional needs, see CDC's toolkit: https://www.cdc.gov/orr/readiness/resources/publications/afntoolkit.htm.

accommodated.[44,45,46] This consideration may be different for pets and service animals. Service animals should not be separated from their owners, but it may be necessary to separate pets to accommodate the scale of decontamination necessary. Beyond the legal requirements, screening and decontamination of pets and service or support animals by appropriately trained staff will also help mitigate the spread of contamination.

- **Medical equipment and personal belongings:** Responders should be prepared to manage a wide variety of personal belongings people will bring to decontamination facilities, including medical devices (e.g., wheelchairs and hearing aids), phones, religious items, wallets, identification, money, keys, and other items of monetary or emotional significance. Medical devices should be returned to owners as soon as is feasible. If resources are not available for staff to screen and decontaminate medical devices, it may be appropriate to provide instructions for owners to decontaminate critical life-saving equipment or to bag the equipment for later screening. Screening and decontamination will be required for all objects entering shelter facilities and exit contaminated areas (which may be much later in the response when personal property is retrieved).
- **Privately Owned Vehicles (POVs):** The public may use POVs for evacuation and reentry. Vehicle decontamination may be necessary depending on the type and level of contamination to mitigate the spread of contamination but should not restrict or inhibit evacuation from hazard zones.

Decedents

Decedents may be contaminated by radioactive material before or after death, so remains must be externally screened and decontaminated to protect medical examiners and coroners, as well as anyone who interacts with the decedents during funerals or other rituals. Additionally, cremation is not recommended for contaminated decedents, and burials must follow special protocols to prevent contamination spread.[47, 48]

Specific activities related to screening and decontamination are listed in Table 13: and discussed below. These activities largely represent extensions of activities started during the initial response, discussed in the *First 100 Minutes Guidance*, but include new aspects or considerations during the

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[44] Emergency Planning Committee. (2016) *Capitol Region Hazardous Materials Response Plan. Prepared for Connecticut Division of Emergency Management and Homeland Security*. Available online at: https://crcog.org/wp-content/uploads/2016/06/CR-HMERP-1.pdf.

[45] CDC (2014) *Population Monitoring in Radiation Emergencies: A Guide for State and Local Public Health Planners, 2nd edition*. Available online at: https://emergency.cdc.gov/radiation/pdf/population-monitoring-guide.pdf.

[46] In addition to the ADA, the disability non-discrimination provisions of the Rehabilitation Act of 1973 would apply to recipients of federal financial assistance.

[47] FEMA (2022) *Planning Guidance for Response to a Nuclear Detonation, 3rd Edition*. Available online at: https://www.fema.gov/sites/default/files/documents/fema_nuc-detonation-planning-guide.pdf.

[48] If a decedent can be fully decontaminated, there should be no restrictions regarding burial or other ritualized practices. In some cultures, death practices are highly structured and scheduled, so delays and complications should be avoided unless genuinely necessary.

evolving response and recovery. Early activities from the *First 100 Minutes Guidance* are not reproduced here, in consideration of brevity and readability.

Table 13: Summary of Focus Area 5 Activities

	Activity	Phase
5.1	Screen and Decontaminate Responders and their Equipment	**Early to Intermediate** (Hours to Days to Weeks)
5.2	Consolidate Screening/Decontamination Activities and Provide Comprehensive Population Monitoring Services to the Public	**Early to Intermediate** (Days to Weeks)
5.3	Screen and Decontaminate Personal Belongings and Civilian Vehicles	**Intermediate to Late** (Weeks to Years)

Activity 5.1: Screen and Decontaminate Responders and Their Equipment

- Establish screening and decontamination stations at entry/exit checkpoints on the perimeter of the contaminated area. These stations should be set up early in the response and sustained as long as radioactive contamination remains, likely throughout recovery.
    - Screen and decontaminate responders periodically. While screening and decontamination of first responders is an immediate necessity, it remains necessary for the entirety of the response and recovery effort.
    - As responders enter contaminated areas, they may become exposed to radiation, and potentially contaminated with radioactive materials. They must be screened and decontaminated when exiting contaminated areas to avoid the spread of contamination and minimize potential health risks.
    - Over time, radiation hazards will vary depending on the radioactive material involved and the type of work being performed in contaminated areas. Consequently, screening and decontamination methods and requirements may change throughout response and recovery. For example, building demolition or waste removal may generate more dust than search and rescue operations, requiring more thorough screening and decontamination.
- Screen and decontaminate response vehicles throughout response and recovery. Similar to responder personnel, response vehicle screening and decontamination should be a component of the earliest response efforts, if resources allow, and must be sustained beyond the immediate response phase.
    - Response vehicles, such as ambulances and police and fire vehicles, may be re-contaminated by radioactive material as they continually re-enter the contaminated area to conduct their missions. The screening and decontamination methods used

for vehicles likely will change as the response evolves. For example, while initial screening and decontamination may cover the entire vehicle, later in the response, screening may be limited to special areas such as the wheels and undercarriage of the vehicle.

  - Before response vehicles return to normal service, response vehicles should undergo additional screening and decontamination if they are no longer part of the response or recovery effort. For instance, a waste transport vehicle or an ambulance may return to serving the community outside the contaminated area.

- Choose screening and decontamination procedures based on the identified radionuclide. As mentioned in the RDD Incident Scenario Considerations section, screening and decontamination methods will vary depending on the particular radionuclides and the physical and chemical form of the radioactive material. Work with SMEs to identify appropriate methods based on the specifics of the incident.

- Modify and adjust screening and decontamination procedures throughout incident response and recovery. This action will be informed by the evolution of the radiological hazards present and knowledge thereof, the availability of additional resources, and the progress made against established response and recovery objectives.

- Screen and decontaminate decedents. This activity protects medical examiners and coroners, as well as anyone participating in funerary practices, and mitigates the longer-term environmental consequences of improperly buried contaminated human remains. For specific information regarding handling, screening, and decontaminating potentially contaminated decedents, please reference the decedent resources identified below.

Recommended Resources:

Responders[49]

- IAEA (2006) Manual for First Responders to a Radiological Emergency Preparedness and Response. Available online at: https://www.iaea.org/publications/7606/manual-for-first-responders-to-a-radiological-emergency.

Response Equipment

- FEMA (2002) *Contamination Monitoring Guidance for Portable Radiation Instruments Used for Emergency Response*. Available online at: https://remm.hhs.gov/FEMA-REP-22.pdf.

[49] This focuses on responder-specific resources, but resources about screening and decontaminating the general population also apply to responders. Those resources can be found in Activities 5.2-5.4.

Response Vehicles

- EPA (2019) *Management and Disposal of Vehicles Following a Wide Area Incident: Literature Review and Stakeholder Workshop*. Available online at: https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=345827&Lab=NHSRC&fed_org_id=1253&subject=Homeland%20Security%20Research&view=desc&sortBy=pubDateYear&showCriteria=1&count=25&searchall=%27indoor%20outdoor%20decontamination.

Decedents

- Appendix F: Medical Resources, Table 34:: Mortuary Examiner/Coroner Resources
- CDC (2021) *Guidelines for Handling Decedents Contaminated with Radioactive Materials*. Available online at: https://www.cdc.gov/nceh/radiation/emergencies/pdf/radiation-decedent-guidelines.pdf.
- NCRP (2008) *National Council on Radiation Protection and Measurements (NCRP) Report No. 161, Management of Persons Contaminated with Radionuclides*. Available online at: https://ncrponline.org/publications/reports/ncrp-report-161/.

Activity 5.2: Consolidate Screening/Decontamination Activities and Provide Comprehensive Population Monitoring Services to the Public

- Continue to amplify self-decontamination instructions to people who were within or near contaminated areas while mass screening/decontamination capabilities are established. Self-decontamination, as well as early screening and decontamination activities, are discussed in more detail in the *First 100 Minutes Guidance*.

Key Terminology: Ad Hoc Screening and Decontamination

Ad hoc screening and decontamination refer to the onsite and early screening and decontamination activities discussed in the *First 100 Minutes Guidance* as well as in Focus Area 4 (Evacuation). These screening and decontamination activities primarily exist to address early demand at or near the response and may rely entirely on gross decontamination. CRCs are designed to provide more services than ad hoc locations but take more time and resources to set up and operate.

- Consolidate ad hoc screening and decontamination activities for the public into CRCs. Early in the response, a variety of screening and decontamination activities may be occurring at shelters for evacuees or healthcare facilities for patients that require immediate medical treatment.
    - If large populations are contaminated, evacuated, or otherwise require screening, CRCs represent the best practice for providing mass population screening and decontamination services because they allow for a consolidation of such services

with very high throughput. The CDC has a simulation tool for CRCs called SimPLER (Simulation Program for Leveraging and Evaluating Resources) that allows planners to estimate throughput capacity, staffing needs, and potential planning bottlenecks.[50]

- If possible, locate CRCs at or near shelters or other disaster service locations.[51] This strategy can help avoid the need to establish resource-intensive screening and decontamination resources at every individual disaster service site. It also will help avoid situations where contaminated people inadvertently enter clean areas (e.g., at shelters) and disrupt operations.
  - Disaster service locations, such as shelters, should still maintain the capability for precautionary screening and gross decontamination, if possible. These locations may encounter people who have not been screened at a CRC – either because CRCs are not yet operational, or because a contaminated individual bypassed the CRC (or any other location where screening/decontamination is occurring) and arrived directly to the disaster services location.[52]
- CRCs (and any other location where screening/decontamination occurs) will likely receive many pets and service animals and must be prepared to screen and decontaminate them.
  - Note that service animals, which includes dogs and miniature horses, should not be separated from their owners during screening or decontamination.
  - FEMA's estimates show that cats and dogs are the most common household animals; federal guidance sets expectations for up to 50-65 pets for every 100 people.[53]
- During the later stages of response and recovery, people may arrive with more pets, service animals, medical equipment, personal belongings, and vehicles than initial evacuees, because they have had additional time to prepare prior to evacuation. CRC operations. This additional demand may also require additional CRCs to be established, or an adjustment to CRC procedures to allow greater throughput at established facilities.

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[50] SimPLER (Simulation Program for Leveraging and Evaluating Resources) can be accessed online at: https://ephtracking.cdc.gov/Applications/simPler/.

[51] CDC (2014) Population Monitoring in Radiation Emergencies: A Guide for State and Local Public Health Planners, 2nd Edition. Available online at: https://emergency.cdc.gov/radiation/pdf/population-monitoring-guide.pdf.

[52] See CDC guidance on operating shelters in radiological emergencies for more information on handling precautionary screening and decontamination: www.cdc.gov/nceh/radiation/emergencies/pdf/operating-public-shelters.pdf

[53] FEMA (2019) *Program Manual: Radiological Emergency Preparedness*. Available online at: https://www.fema.gov/sites/default/files/2020-06/FEMA_REP_Program_Manual_Dec_2019.pdf

- Localities should plan to establish several CRCs to accommodate the initial demand, as there will be many people who will want to be screened even if they were not near the incident site. Initial CRC operations should prioritize people who were in the contaminated area; however, those who are concerned about contamination, regardless of their risk or proximity to the incident, should not be dismissed or stigmatized. Screening concerned populations may reduce anxiety for those individuals and the community at large and may prevent them from gathering at sensitive response locations, such as hospitals, command posts, or public buildings in search of precautionary screening. Additionally, shelters, hotels, and other services may require documentation showing screening or decontamination before admitting displaced populations.

- Figure 7 shows an ideal flow of contaminated individuals once screening and decontamination activities have been consolidated into CRCs.

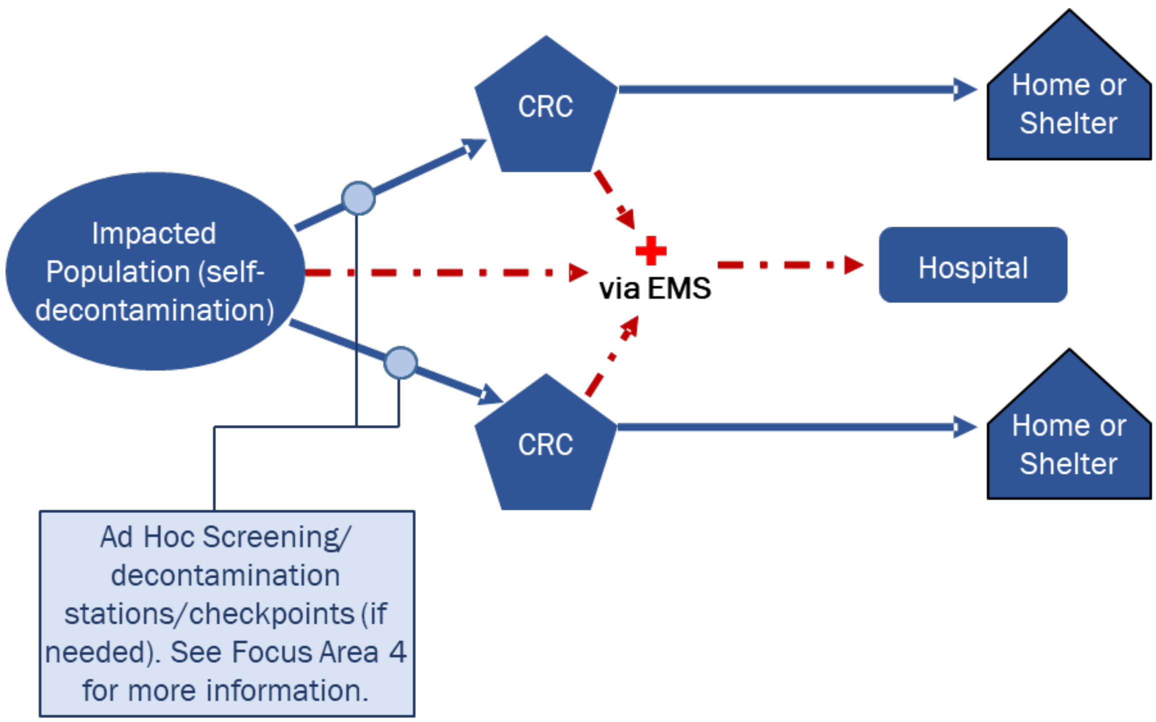

Figure 7: Model of Ideal Population Flow to Consolidate Screening at CRCs.

- Assess people for external contamination, internal contamination, and the need for medical follow-up, also called **population monitoring**.

  - If possible, population monitoring activities should be consolidated into CRCs, allowing them to act as a one-stop service center for screening, decontamination, and registration.

    - Depending on the specifics of the incident, population monitoring may require specialized equipment or expertise. Registration of all people who were in contaminated areas is important to allow follow-up at a later time. The CDC provides a free electronic tool, the CRC eTool, to simplify data collection at CRCs.[54]
        - At a minimum, registration at a CRC should include name, contact information (cell phone, email) and location at the time of the incident. Collecting this information will allow public health officials to contact people who were located in contaminated areas for follow-up.

- Recommend or require that people who are seeking non-lifesaving disaster services (e.g., disaster/assistance centers, family assistance centers, evacuation centers, shelters) first be screened for contamination at a CRC, if established.
    - Radiation safety measures should be integrated with infection control, public safety, and other protocols detailed in all-hazards plans at any locations where potentially contaminated individuals may be seeking mass care services or resources. The CDC document, *A Guide to Operating Public Shelters in a Radiation Emergency* (linked below), provides more detail on incorporating screening and decontamination into a shelter operation.
    - As mentioned in Focus Area 4, if CRCs are not yet established while phased evacuations are ongoing, use of screening and decontamination stations or checkpoints along evacuation routes, or screening/decontamination capabilities deployed to shelter intake locations, may be appropriate. See Focus Area 4.

Recommended Resources:

CRC and Shelter Operations

- CDC (2022) *CDC Community Reception Centers webpage (for the public).* Available online at: https://www.cdc.gov/nceh/radiation/emergencies/crcs.htm.
- CDC (2022) *Population Monitoring, Community Reception Centers (CRC), and Shelter Resources for Radiation Emergencies (for responders)*. Available online at: https://www.cdc.gov/nceh/radiation/emergencies/populationmonitoring.htm.
- CDC (2023) *Radiation Emergencies: What to Expect at a Community Reception Center (CRC)*. Available online at: https://www.cdc.gov/nceh/radiation/emergencies/crcs_ld.htm.

[54] The CDC Community Reception Center Electronic Data Collection Tool (CRC eTool) can be found online at: https://www.cdc.gov/nceh/radiation/emergencies/crcetool.htm

- CDC (2021) *SimPLER (Simulation Program for Leveraging and Evaluating Resources)*. Available online at: https://ephtracking.cdc.gov/Applications/simPler/.
- CDC (2023) *This is a T.E.S.T. CRC, A Tabletop Exercise Simulation Tool*. Available online at: https://www.cdc.gov/nceh/radiation/emergencies/training/crctest.htm.
- CDC (2015) *A Guide to Operating Public Shelters in a Radiation Emergency*. Available online at: www.cdc.gov/nceh/radiation/emergencies/pdf/operating-public-shelters.pdf.
- FEMA (2022) *Planning Guidance for Response to a Nuclear Detonation - Appendix 5.2: Strategies for Screening and Decontaminating People*: https://www.fema.gov/sites/default/files/documents/fema_nuc-detonation-planning-guide.pdf.
- CDC (2018) *Community Reception Center Electronic Data Collection Tool (CRC eTool)*. Available online at: https://www.cdc.gov/nceh/radiation/emergencies/crcetool.htm.

Population Monitoring:

- CDC (2014) *Population Monitoring in Radiation Emergencies: A Guide for State and Local Public Health Planners.* Available online at: www.cdc.gov/nceh/radiation/emergencies/pdf/population-monitoring-guide.pdf.
- REMM (2023) *Population Monitoring After Radiation Emergencies*. Available online at: https://remm.hhs.gov/surveillance.htm.

Screening and Decontamination of Pets & Service Animals

Published guidance for screening household pets and animals following RN disasters is quite limited, but the following resources provide some high-level information:

- CDC (2014) *Population Monitoring in Radiation Emergencies: A Guide for State and Local Public Health Planners*. Available online at: https://emergency.cdc.gov/radiation/pdf/population-monitoring-guide.pdf.
- REMM (2023) *Veterinarians: Information for Radiation Emergencies*. Available online at: https://remm.hhs.gov/remm_PetOwners.htm.
- CDC (2018) *Decontamination – Pets*. Available online at: https://www.cdc.gov/nceh/radiation/emergencies/selfdecon_pets.htm?CDC_AA_refVal=https%3A%2F%2Femergency.cdc.gov%2Fradiation%2Fselfdecon_pets.asp.
- FEMA (2022) *Planning Guidance for Response to a Nuclear Detonation - Appendix 5.3: Screening and Decontamination Service Animals and Pets*. Available online at: https://www.fema.gov/sites/default/files/documents/fema_nuc-detonation-planning-guide.pdf.

Activity 5.3: Screen and Decontaminate Personal Belongings and Civilian Vehicles Removed from Contaminated Areas

- Monitor established entry and exit points to screen and decontaminate objects and mitigate the spread of contamination and protect people from prolonged contamination exposure.
  - Before areas are reoccupied, people may have an opportunity to reenter and reclaim property, vehicles, and belongings left behind in contaminated areas (including residential and commercial areas). Screening and decontamination associated with retrieval of such items should be coordinated with remediation and reopening activities (Focus Areas 7 & 9, respectively) and will occur before contaminated areas are fully remediated or reopened.
  - Hazard zone entry and exit points should have screening equipment capable of accommodating a wide range of objects, including instruments such as portal monitors for vehicles and personnel, as well as pancake probes.[55] If removable contamination is anticipated, wipe sampling may be appropriate as well.
    - Screening levels should be developed for different types and sizes of objects depending on how they are used. For example, stuffed animals may require stricter screening levels, since children may rub them on their face or sleep with them in their beds. By contrast, photo albums may have higher screening levels as they are handled less frequently, and users spend less time in close proximity to them. Regardless, all screening levels should be designed for unrestricted release if possible (e.g., contamination is low enough that the item can be used or disposed of with minimal or no further controls or restrictions).[56]
  - Decontamination methods should be similarly designed to handle a wide range of objects, including a combination of wet decontamination (for plastic, metal, or other objects) and dry decontamination methods (such as dry wipes or vacuums). Most appropriate decontamination methods are dependent on both the radioactive material and the object being decontaminated.
    - People are likely to retrieve belongings with significant monetary or sentimental value (e.g., stuffed animals, photo albums, signed sports paraphernalia or other collectors' items, family heirlooms, etc.), which may be fragile or damaged by certain decontamination methods.
  - A process for handling items that cannot be sufficiently decontaminated should be developed ahead of time. While it is possible that insurance or disaster assistance

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[55] Pancake probes are popular hand-held radiation detectors, with flat circular components that resemble pancakes.
[56] IAEA (1992) *Monitoring Programmes for Unrestricted Release Related to Decommissioning of Nuclear Facilities.* Available online at: https://inis.iaea.org/collection/NCLCollectionStore/_Public/23/075/23075816.pdf.

may cover items of monetary value that cannot be sufficiently decontaminated, sentimental items will need a separate process (e.g., restricted release with special handling instructions or extended storage to allow radioactivity to decay).

Recommended Resources:

Personal Belongings

- NUSTL (2017) *Using Preventative Radiological Nuclear Detection Equipment for Consequence Management Missions*. Available online at: https://www.dhs.gov/publication/st-frg-using-preventative-radiological-nuclear-detection-equipment-consequence.
- FEMA (2002) *REP-22: Contamination Monitoring Guidance for Portable Instruments Used for Radiological Emergency Response to Nuclear Power Plant Accidents*. Available online at: https://remm.hhs.gov/FEMA-REP-22.pdf.

Vehicles (additional vehicle guidance is included with response equipment resources in 5.1)

- FEMA (2023) *Planning Guidance for Response to a Nuclear Detonation – Appendix 5.4: Handling Contaminated Vehicles*. Available online at: https://www.fema.gov/sites/default/files/documents/fema_nuc-detonation-planning-guide.pdf.

Strategy 4: Restore the Environment

Focus Area 6: Restore and Sustain Critical Infrastructure and Select Buildings

Guidance: *Implement a process to restore critical infrastructure (CI) select residential or commercial buildings impacted by blast effects and/or radiation contamination to bring the vital services they provide back on-line and prevent them from degrading while radiation remediation activities are completed. Successful restoration and sustainment require comprehensive data collection about the status of impacted CI and buildings and the need for decontamination, restoration, ongoing maintenance, and sustainment of other critical services. It will also require close coordination with law enforcement and diverse restoration and maintenance teams (e.g., plumbing, electrical, pest control) and utility workers operating under appropriate radiological safety guidelines.*

Recommended Planning Partners:

- Emergency management
- Public works
- Civil engineering
- Utilities/infrastructure owners/operators
- Environmental protection
- Radiation control
- Law enforcement
- Fire/HAZMAT

Key Terminology: Critical Infrastructure, Restoration, and Sustainment

Critical Infrastructure (CI) includes facilities, systems, and networks that provide key services to the public and are vital to public health and safety, such as transportation systems, telecommunications infrastructure, hospitals and medical facilities, power plants, and emergency services, among others.

Restoration includes the repair/rehabilitation of CI or commercial or residential buildings to bring them back to a state where they can function normally. This includes, for example, repairing blast damage to buildings from an explosive RDD or fixing damaged cell tower equipment to restore cell service in impacted areas.

Sustainment is the provision of services, logistics, maintenance, financial management, personnel services, interconnected utility, and health service support necessary to maintain CI and select residential or commercial buildings until contaminated areas are successfully remediated and reoccupied.

Introduction

The remediation process for cleaning up the contaminated area, including damaged and/or radiologically contaminated CI assets and systems and select residential and commercial buildings, could extend for weeks, months, or years depending on the nature of the incident. For this reason, a critical component of any radiological response and recovery plan includes restoration and sustainment of CI assets and systems that are critical to the response, including human health and safety, transportation of evacuees, etc., as well as commercial and residential structures that will need to be able to accommodate the return of displaced people once remediation activities are successfully completed. Returning CI to normal functionality quickly is important not only to facilitate the response and address critical health and safety needs but also the safe return of evacuees into remediated areas.

CI restoration and sustainment are important, since successful, safe, and timely remediation of contaminated areas will require functioning power, water, sewer, heat, transportation, and telecommunications services. In addition, CI systems often are part of extended networks that support a larger geographic area. Delays in restoration of damaged or contaminated CI or allowing key aspects of critical systems to deteriorate during the response and recovery effort likely will generate significant cascading effects beyond those areas immediately impacted by an RDD incident. For example, a drinking water aqueduct that passes through a highly contaminated area will need to be maintained so that uncontaminated areas served by the aqueduct can maintain water service and contaminated areas that are cleaned up on an earlier timetable can be more promptly reoccupied.

CI and select commercial and residential buildings will require continuous maintenance, repair, and upgrades to remain functional and prevent degradation to support eventual re-use/re-occupation. Failure to sustain affected CI and priority buildings may adversely impact the reoccupation timeline or result in expensive or even cost-prohibitive remediation for issues such as mold or pests that are unrelated to radioactive contamination.

Coordination Opportunity: Radiological Emergency Response Team (RERT)

Radiological Emergency Response Team (RERT), an EPA asset, can provide technical advice and assistance including radiological assessment and monitoring, public messaging, and risk assessment.

Table 14: Summary of Focus Area 6 Activities

	Activity	Phase
6.1	Gather Information on Impacted Critical Infrastructure and Select Buildings	Intermediate to Late (Days to Weeks)
6.2	Decontaminate Critical Infrastructure and Select Buildings	Intermediate to Late (Days to Months)
6.3	Establish Restoration/Sustainment Task Forces	Intermediate to Late (Weeks to Years)
6.4	Conduct Restoration/Sustainment Operations	Intermediate to Late (Months to Years)

Activity 6.1: Gather Information on Impacted Critical Infrastructure and Select Buildings

- Identify and document information on CI facilities/systems and select buildings in the contaminated area using the checklist provided below. To the extent possible, leverage available remote technologies and quickly accessible resources, such as government records, GIS databases, and subject matter expertise from agency partners (e.g., jurisdictional planning departments and utility owners/operators).

Example Building/Infrastructure Information to Gather and Verify

- Type of infrastructure and associated services provided (e.g., electrical, water, sewage, natural or compressed gas systems) along with number of customers supported
- Category/use associated with each building/infrastructure (e.g., residential, industrial/commercial, healthcare facility)
- Criticality of the building/infrastructure to community lifelines stabilization, including services provided to other interconnected CI
- Number and type of staff employed
- Characteristics of building construction (e.g., brick vs wood frame), HVAC system, and supporting utilities
- CI/building management/owner contact information
- Owner and tenant contact information (for both commercial and residential properties)
- Contact information for security, maintenance, and janitorial personnel
- Hazardous materials stored on-site and their locations

- Building/facility blueprints, including any remodeling or construction underway or recently completed, square footage, and layout (including number and types of rooms)
- Ways to access the property, including keys, proximity cards, security cards, passwords, and biometric systems
- Information on accessing and operating building systems, including HVAC, fire alarms and suppression systems, security systems, elevators, internal communication systems, and information technology infrastructure
- Unique features about the structure that could facilitate remediation activities, such as a helipad, loading dock, or parking structure
- Valuables stored or other specialized items on-site: (e.g., money, pharmaceuticals, firearms, etc.) that may require relocation or extra security measures
- Other hazards or concerns not listed
- Surrounding community demographics (e.g., population numbers and vulnerable populations served)

- Interview CI/building owners and operators to obtain information regarding the function of the infrastructure system and any hazards or operational concerns that may exist if maintenance is not conducted. CI may be owned and operated by a government agency (city, county, state or federal) or by private industry.
- Utilize CI and building information gathered to inform remediation priorities (See Focus Area 7).
- Establish a single database where CI and building information can be consolidated to facilitate long-term tracking and information management.

Planning Tip: Leverage Remote Resources

The property information obtained from owners, managers, and tenants may not be a complete record for all the properties involved. To minimize exposure to workers, leverage remotely accessible resources to the greatest extent possible. These resources may include:

- Municipal government records and databases (e.g., first responder, civil engineering, environmental protection, and planning departments)
- Social media and commercial news
- Commercial and government satellite images and personal photos taken of the area prior to the incident

- Dispatch teams to verify on-scene infrastructure damage and operating conditions if key information is missing or requires on-site verification. To limit exposure time, teams should conduct damage assessments from a vehicle or use remotely accessed resources (e.g., unmanned systems and camera feeds) where possible. Damage assessments should be planned and conducted with support from the Radiation/Safety Officer. Assessment personnel should have received appropriate radiation safety training and be outfitted with appropriate PPE prior to initiation of assessment activities. In addition to verifying information, on-site damage assessments can be used to identify:

  - Issues and hazards that require immediate attention, such as downed power lines, water leaks, gas leaks, or ruptured sewer lines;
  - Evidence of unauthorized entry such as theft, vandalism, or squatting;
  - Unsecured property, buildings and CI;
  - Damage to CI and select buildings along with potential cascading impacts;
  - Chemical or radiological hazards (e.g., stored hazardous materials such as chlorine inside buildings or in the proximity of CI);
  - Potential access problems for remediation workers (including abandoned vehicles that may be blocking key access points).

- Obtain permission from owners, operators, and tenants to allow access to private property to enable the conduct of remediation operations and related activities. Contingencies should also be put in place to enable the timely abatement or condemnation of property that has been abandoned or is deemed too unsafe to remediate.
- Obtain permission from law enforcement officials to access areas designated as crime scenes or as restricted access areas.
  - Coordination should take place with law enforcement to ensure that areas that had been designated as crime scenes or as restricted access areas can be accessed for restoration and sustainment operations.
  - Evidence collection within the area designated as the crime scene likely will need to be completed before restoration operations can begin.

Activity 6.2: **Decontaminate Critical Infrastructure and Select Buildings**

- Identify CI and buildings essential to support response and recovery operations that require early decontamination to maintain operating status. Priority decontamination of CI and other select buildings will reduce hazards and allow for safer access to perform maintenance or sustain operations while remediation is underway.

  - Consider both CI facilities/systems, such as water and electrical systems, and buildings, such as emergency operations centers, hospitals, and fire/police stations, when determining CI priorities for decontamination,

- Consider alternatives to decontamination for each identified CI or select building. Alternatives may include reduced staffing and maintenance schedules, remote operation of critical functions, moving infrastructure service load to unaffected equipment, or using alternate sites to house critical functions.

- Determine current contamination levels at locations where restoration/maintenance crews will be operating to decontaminate identified CI and select buildings. Follow appropriate dose rate guidelines during the decontamination process (See Focus Area 2 for more information).

- Consider the scalability of decontamination methods and the size and priority of the infrastructure that requires decontamination. Like other decontamination activities, decontamination methods for CI and select buildings depend on the area impacted, radionuclide involved, and decontamination resources available. Note that fully qualified, specialized decontamination staff may not be available to support such decontamination efforts until further into the response, leaving first responders with just-in-time training to conduct the initial gross decontamination.[57]

Recommended Resources: Radionuclide-Specific Guidance and Resources

Federal best practices and other literature describe cleanup efforts that can be tailored to the incident based on the involved radionuclide(s) and surface materials:

- EPA's Radiological Decontamination Query Tool provides a comparison of methods that could be used for cleanup.
- Joint Chiefs of Staff (2006). CBRN Decontamination: Multiservice Tactics, Techniques, and Procedures for Chemical, Biological, Radiological, and Nuclear Decontamination.
- EPA (2016). Current and Emerging Post-Fukushima Technologies, and Techniques, and Practices for Wide Area Radiological Survey, Remediation, and Waste Management. Washington, DC.

Activity 6.3: Establish Restoration/Sustainment Task Forces

- Convene operational task forces to conduct restoration and sustainment operations for each building or a group of buildings, as well as CI, identified in Activity 6.1 above. The sustainment task force core teams should develop a sustainment plan for each building, group of buildings, or

[57] FEMA 2022 Planning Guidance for Response to a Nuclear Detonation – Appendix 2.2

CI they are responsible for which they can subsequently use to create missions, tasks, and assignments.

- Identify qualified members of the sustainment task force. For commercial high-rise and industrial buildings, a range of skills will be needed to safely inspect, provide maintenance, and conduct repairs and other restoration activities. For CI systems, specially trained and qualified personnel will be required. Each task force should:
    - Have a core team that can track restoration/sustainment needs for their assigned CI facilities/systems and select buildings over time and conduct inspections to monitor their conditions.
    - Be fully qualified to access and perform restoration, repair, and/or maintenance on the specific infrastructure system or building to which they are assigned.
    - Be equipped to call upon specialized resources to conduct restoration and sustained maintenance, dependent on the specifics of the select building or CI facility/system in question. The blue box below lists the types of disciplines that may be needed to support sustainment task forces.
- Provide training so that task forces and other specialized resources may safely operate in the contaminated area.
    - A Radiation Health and Safety Officer (RHSO) should be consulted as part of each operation to determine the level of training needed, permissible length of operations in the contaminated area, and PPE and dosimeters required for the tasks being performed.
        - Ideally, several RHSOs would be integrated into the response to provide thorough oversight into activities involving the potential for radiation exposure. However, if there are insufficient RHSOs available, an acceptable alternative would be to utilize safety officers to fill most positions with RHSO(s) providing necessary oversight.
    - Planners should assume occupational radiation safety training will be necessary and identify appropriate training materials and qualified instructors ahead of time.
    - Ensure all personnel entering the established perimeters are properly trained in radiation safety, have appropriate PPE and dosimeters, are aware of dosage and stay-time limits and are included in a dosimetry monitoring program.

Sustainment Task Force

Core Team

- Audio, visual, and digital mapping team

- Incident Command System (ICS) trained personnel
- Property tracking/data collection team
- Safety officer
- Structural engineer
- Systems Engineer
- RHSO (a general safety officer with a RHSO available as reach back is a sufficient alternative)

Specialized Resources

- Animal control officer
- Building system expert (could involve HVAC, water, security systems, fire alarm, etc.)
- Carpenter
- Commercial IT systems expert
- Electrician
- Elevator repair
- Hazardous materials specialist
- Locksmith
- Pest control worker
- Plumber
- Tow truck operator

Activity 6.4: Conduct Restoration/Sustainment Operations

- Restoration/sustainment operations should be initiated as soon as the area has been secured, radioactive contamination has been measured and mapped, and sustainment task force workers have been provided radiation safety training, dosimeters, and PPE, as required.
- Restoration/sustainment operations should be continued as resources permit until operational functionality has been restored, as long as conditions on site can safely support such a tempo. Once a CI facility/system or select building has been assessed and decontamination and/or major repairs have been completed, efforts should shift to a focus on longer-term operations, sustainment, and periodic checks and maintenance.
- Direct initial restoration/sustainment efforts toward mitigating further damage due to immediate or potential hazards, followed by a systematic, methodical approach for maintenance, repair, and upgrades based on established incident priorities and operational objectives. Initial restoration/sustainment efforts may include:

- Assessing a building/structure's physical integrity;
- Determine if other hazardous conditions exist;
- Testing and running (where appropriate) critical systems such as HVAC, plumbing, and electricity;
- Assessing functionality of CI such as electrical substations, telephone and internet routing systems, and other utilities;
- Conducting preventative maintenance or repair to CI and select buildings Securing access to buildings and CI;
- Deploying rodent and pest control measures.

- Utilize FEMA's standard search and rescue marking system[58] and Post-disaster Building Safety Evaluation Guidance[59] to summarize the physical condition of CI facilities/systems or buildings. These systems are used to rapidly track search and rescue operations, mark searched buildings, identify hazards present and classify the conditions of buildings. Consider taking additional measurements or photographs/videos of areas or unique features that may require special focus or treatment to achieve sustainment and remediation. As part of the assessment, take automated digital measurements and videos of the entire interior, as the situation permits. This data adds to the analysis and plan for remediation described in Focus Area 7.

Recommended Resources: CI Restoration and Recovery

- FEMA (2019) National Response Framework, 4th Ed. https://www.fema.gov/sites/default/files/2020-04/NRF_FINALApproved_2011028.pdf.
- FEMA (2008) Critical Infrastructure and Key Resources Support Annex to the NRF. https://www.fema.gov/pdf/emergency/nrf/nrf-support-cikr.pdf.
- FEMA (2016) National Disaster Recovery Framework, 2nd Ed. https://www.fema.gov/sites/default/files/2020-06/national_disaster_recovery_framework_2nd.pdf.

[58] FEMA (2013) *National Urban Search and Rescue Response System Marking Standards Handbook*.
[59] FEMA (2019) *P-2055, Post-disaster Building Safety Evaluation Guidance – Report on the Current State of Practice, including Recommendations Related to Structural and Nonstructural Safety and Habitability.* Available online at: https://www.fema.gov/sites/default/files/2020-07/fema_p-2055_post-disaster_buildingsafety_evaluation_2019.pdf

Focus Area 7: Remediate

Guidance: *Execute the Optimization Process to define cleanup levels, remediation zones, and engage with key stakeholders. Develop remediation plans and perform remediation/clean up. Verify cleanup levels are met and release the area/site for reuse.*

Recommended Planning Partners:

- Admin/finance
- Emergency management
- Environmental protection
- Public health
- Occupational health and safety
- Public works
- Hazardous materials remediation experts
- Urban planners/zoning managers
- Transportation specialists
- Public/private partnerships
- Radiation subject matter experts

Introduction

The goal (or objective) of **remediation** is to reduce contamination to a level at which radiation exposure risk to people is low enough to open and release an area for re-occupancy for current and planned future uses. In some instances, it may not be feasible to remediate to a level where an area may be released for unrestricted use. In these cases, remediation may be conducted to reduce exposure risk to a level where specific activities can resume with minimal restrictions and/or protective actions. This focus area outlines the major steps necessary to begin the process for medium- to long-term remediation activities.

Key Terminology: Remediation

Remediation refers to the activities performed to remove/clean up contamination based on metrics and targets established using the Optimization Process.

For even a minor release of radioactive material, the remediation process may require significant time (months to years) and resources to complete. These requirements will be influenced by a combination of factors including, but not limited to:

- Type of contamination (isotopes, half-life, physical/chemical form);
- Desired speed of remediation;
- Total size of area requiring remediation;
- Complexity of the built environment and characteristics of the area (e.g., a park, a sidewalk, a store, a residential building, a critical infrastructure facility, etc.);
- Impacted population;
- Selected cleanup level;
- Public acceptance of the cleanup level decision;
- Technical feasibility of decontamination methods available; and
- Social factors such as economic and equity considerations.

To manage the complexity and resource intensiveness of the remediation process, planners should understand and ensure their plan accounts for these important factors. See Table 31: in Annex B for additional information on data sources used to inform remediation planning.

Wide area radiological remediation is likely beyond the capabilities of any one state or Federal agency and will involve a joint effort of all of government including Federal and STTL government. It will also involve NGOs, the private sector including expertise from the nuclear and environmental cleanup industries, and expertise from academia. Many states and several Federal agencies, including but not limited to EPA, USACE, USCG have remediation expertise and remediation contract support including contracts to support remediation planning and design and contracts to perform remediation. GSA also has contracts that can support remediation planning and design and to perform remediation. For an incident where there is widespread contamination over many square miles, it is likely that all levels of government and the private sector will support remediation. If jurisdictions are pursuing remediation independently, they might consider:

- Procuring contract support for planning and designing remediation within their jurisdiction. Procure remediation contract support for implementing remediation plans. Typically, these should be different contractors to avoid a conflict of interest.
- Determining if contractors under consideration specialize in specific remediation activities. For example, one contractor might be skilled at managing large, sprawling jobs with many sub-contracts, while another might be proficient at managing the waste component of a larger

remediation job. These factors should be taken into consideration when determining how multiple contractors work together or sub-contract.

- At a minimum, lead contractors should have experience in environmental cleanup, including radiologically experience.
- Jurisdictions may also consider permitting and vetting processes to provide a central list of private contractors for public use, such as for remediation on private property. Similar to other types of disasters, if a list of contractors is provided, care must be taken to comply with state and federal law related to government endorsement of (and competition among) contractors, as well as restrictions on the utilization of certain entities (such as debarment and suspension).

Key Terminology: Optimization

The International Commission on Radiological Protection defines Optimization as "The source-related process to keep the magnitude of individual doses, the number of people exposed, and the likelihood of potential exposure as low as reasonably achievable below the appropriate dose constraints, with economic and social factors being taken into account."[60]

REMEDIATION PROCESS

Through the remediation process, government officials will work with stakeholders in the affected community to determine which areas require remediation, the extent of that remediation, the methods to conduct necessary remediation, and a process to confirm that remediation goals were achieved.

Planners should be aware that many steps in the remediation process will be iterative and ongoing across protective action phases. Remediation zones, cleanup levels, decontamination techniques, and even public acceptance of the chosen course of action may evolve over time. These steps should be clearly articulated in radiological response and recovery plans, so that expectations are set for contractors, the government, and impacted stakeholders. The remediation process can be divided into five major steps (see Figure 8):

1. **Optimize Target Cleanup Level(s)**: The outcome of optimization is to determine a target cleanup level(s)[61] that is acceptable to government officials (including regulatory authorities) and stakeholders (including the public) within the affected community. For scenarios where a large site or area has been contaminated, planners will need to identify "remediation zones" to allow for phased remediation, promotion of remediation worker safety, and efficient

[60] ICRP (2006). "ICRP Publication 101b: The Optimisation of Radiological Protection: Broadening the Process.". Available online at: https://www.icrp.org/publication.asp?id=ICRP%20Publication%20101b

[61] Sometimes referred to as "release criterion," "release limit," "cleanup standard," "clearance levels," or "cleanup goals."

allocation of resources.[62] In most scenarios, optimization will entail extensive modeling, establishment of priorities and remediation goals, and planning for the speed, extent, and sequencing of remediation activities.

1. **Develop Remediation Plans**: During this step, radiation experts from Federal, STTL, and the private sector will develop plans which outline how remediation activities will be conducted and how the achievement of stated remediation goals, including clearance levels, will be verified. It is likely that contractor support will be required for remediation in almost all potential RDD scenarios.

2. **Perform Remediation/Cleanup**: Remediation will be performed by Federal and STTL personnel with contract support (altogether Remediation personnel). These personnel will perform a range of activities to including remediation, remediation management, radiological monitoring, health and safety, and contract oversight. Additional background information on the terminology, techniques, and technologies used to perform remediation is included in Annex D.

3. **Verify Cleanup Levels**: Government authorities and contract technical support personnel independent of the remediation contractor will verify that cleanup levels have been achieved in accordance with the remediation plan. If they are not, additional remediation will be conducted (possibly incorporating different techniques or a return to the optimization process). Alternatively, if additional remediation is not feasible or effective, access to the area/site may remain restricted.

4. **Release the Area/Site**: If desired cleanup levels are achieved, the area is released for public use, potentially with changes or restrictions to land-use. If cleanup levels are not achieved, access may be restricted. Focus Area 9 discusses the release process in further detail.

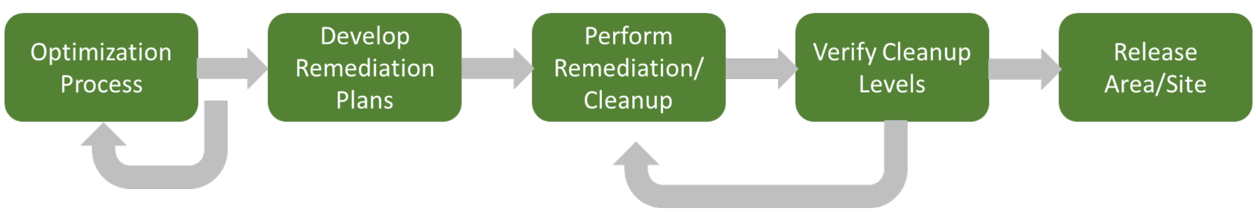

Figure 8: Remediation Process Flow Chart

[62] For more discussion, see NRCP (2014) *Report 175: Decision Making for Late-Phase Recovery from Major Nuclear or Radiological Incidents*.

Recommended Resources: Annex B

Refer to Annex B: Remediation Decontamination and Demolition Techniques and Technologies for an overview of the key concepts, methods, and techniques for remediation of environments contaminated with radiological materials due to an incident such as an RDD detonation.

Table 15: Summary of Focus Area 7 Activities

	Activity	Phase
7.1	Execute the Optimization Process for Defining Remediation Zones and Cleanup Levels	Intermediate to Late (Weeks to Months)
7.2	Develop Remediation Plans	Intermediate to Late (Weeks to Months)
7.3	Perform Remediation/Clean up	Late (Months to Years)
7.4	Verify Cleanup Level Compliance	Late (Months to Years)
7.5	Release Area/Site (Discussed in detail in Focus Area 9)	Late (Months to Years)

Recommended Resources: Codes for Calculating Dose and Cleanup Levels

There are numerous software codes used by radiation remediation experts that assist in calculating cleanup levels based on the radiological dose and risk to humans and the environment before remediation and through the alternative actions for remediation. These codes are commonly used in the nuclear industry and are readily available for emergency response.

Activity 7.1: Execute the Optimization Process for Defining Cleanup Levels and Remediation Zones

- **Identify Cleanup Level(s):** The government, aided by public health experts, radiation technical working groups (R-TWGs), conducts a cost-benefit analysis. This cost-benefit analysis should weigh the public health objective of reducing contamination and exposure to safe levels with the feasibility of the remediation effort required to meet those objectives. [63] The public health objective will leverage assessments of exposure pathways and dose conducted during activities described in Focus Area 2. The feasibility of the effort will vary based on the following factors:

- Technical feasibility of the proposed decontamination and other remediation methods to achieve the target cleanup levels. For example, some contaminated surfaces may need to be fully removed or destroyed, instead of rinsed or scrubbed, to achieve the cleanup level(s) selected. Alternative methods of reducing exposure risk also may be identified as more appropriate (e.g., establishing barriers and signage). See Annex D for an overview of the techniques and technologies used to conduct radiological remediation;
- Economic feasibility of the proposed cleanup levels, which includes the equipment, labor, and supporting infrastructure required to conduct the cleanup;
- Land-use/property-use implications for cleanup level(s) chosen. For example, a public park and an elementary school in a residential neighborhood will have different implications in terms of both public acceptance and exposure pathways and risk;
- Time requirements for cleanup and reoccupation;
- Quantity of waste generated and the cost of waste storage, transportation, and disposal. Generally, as the cleanup level is lowered (e.g., the level of acceptable residual radiation decreases), the volume of waste generated will increase; and.
- Social and economic considerations such as access to culturally significant sites, socioeconomic variables, and equity considerations.

Key Terminology: Remediation Zones

For releases that contaminate a large geographic area, it may be beneficial to establish Remediation Zones. These zones are specific areas within the contaminated area that will require decontamination and exposure reduction activities, usually with the intent of reopening them for future use. Initially, remediation zones should be areas that are determined to have similar (1) land-use and (2) levels of contamination. Designating areas into zones with similar

[63] Remediation planners translate the consensus cleanup level(s) into a value known as the "Derived Concentration Guideline Level" (DCGL). The DCGL represents the maximum allowable amount of residual contamination (for a given radionuclide) that results in a risk equal to the cleanup level determined. In other words, the DCGL establishes a ceiling on how much residual radioactivity is allowable after the cleanup is complete. More information can be found at: EPA (2023) *What is a Derived Concentration Guideline Level (DCGL)?* Available online at: https://www.epa.gov/radiation/what-derived-concentration-guideline-level-dcgl

characteristics can break the problem down into more manageable pieces, facilitate the prioritization of areas for remediation, and potentially ease the logistical and planning burden to conduct the cleanup itself.

- **Designate Remediation Zones, if needed:** Identify areas in the **contaminated area** that have a similar land-use and level of contamination. Land use can correspond to an exposure risk based on the amount of time people spend in an area, as well as the activities they engage in (See Table 16:). Using these criteria, divide these areas into **remediation zones.**
  - Assess land-use and exposure risk by categorizing buildings/areas by type as shown in Table 16:.
  - Assess levels of contamination, leveraging data from Focus Areas 1 and 2, which describe the extent and type of radiological contamination present. This assessment should incorporate data that describes the actual levels of contamination as well as the assessment of external and internal exposure pathways and dose.

Table 16: Example Land Use Types and their Exposure Implications

Land Use Type	Exposure Frequency	Exposure Duration	Considerations
Residential	24 hours/day 365 days/year	30 years	Highest exposure frequency and duration produces the highest dose for a given level of contamination and may require the most stringent remediation goals. This could increase the per-square-footage cost for remediation and waste disposal. Highest in cost.
Industrial, Commercial, Business[a]	8 hours/day 250 days/year	25 years	Workers may be allowed higher dose than public because of lower occupancy factor and personnel monitoring or dosimetry is possible. Remediation goals generally higher in radioactivity than residential, decreasing cost. However, this is dependent on workers and the public accepting a higher exposure.
Recreational[b]	168 hours/year	30 years	Situation dependent. May include use as a waste disposal site for buried radioactive waste.
Road, mass transit, wastewater treatment sites, and other infrastructure	Infrequent, but also, highly variable	30 years	While exposure frequency may be infrequent for most people, separate consideration is needed for workers (e.g., wastewater treatment plant workers, sanitation workers, subway and commuter train workers, taxi drivers, etc.) as well as exposure to members of the public who live, work, or routinely transit on or adjacent to contaminated infrastructure.

Sources:

"Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination." OSWER Directive 9200.4-18. (EPA. August 22, 1997.) https://semspub.epa.gov/work/06/640873.pdf

"Hanford Site Risk Assessment Methodology." DOE/RL-91-45, Rev. 3. (May 1995.) https://www.nrc.gov/docs/ML0534/ML053400188.pdf.

The examples cited here from CERCLA and legacy cleanup programs may not be directly applicable for an RDD scenario.

- **Engage with Key Stakeholders**: Identify key stakeholders. There are five general categories of stakeholders: government, the public, property owners/managers, businesses, and special interest groups, as defined in Table 17:
    - Communicate the expected remediation timeline, responsibilities, and cleanup levels for the respective remediation zones. Early communication with stakeholders such as owners and tenants will benefit the long-term cost and timeliness of cleanup.

Table 17: Key Stakeholders in the Optimization Process

Stakeholder	Description
Government	There are two primary types of government stakeholders: ▪ Government regulators and agencies who have a role in directing, executing, or facilitating the cleanup process. ▪ Government agencies whose operations or facilities are impacted by the incident.
Public/Community	Members of the public include residents, community organizations, neighborhood associations, and more, including individuals who are directly or indirectly impacted by the closure of contaminated areas. The community may also provide valuable input on prioritization of cleanup activities and other key decision factors.
Property Owners/ Property Managers	An individual or company that owns or is hired to oversee the day-to-day operations of a unit of real estate and are directly or indirectly impacted by the closure of contaminated areas. These individuals retain legal decision rights regarding their properties, even though they may not physically reside in the contamination zone (See Focus Area 7 for more information).
Businesses	Businesses are directly or indirectly impacted by the closure of areas. Recovery of businesses is also critical to enable reoccupation (discussed further in Focus Areas 9 & 10).

Stakeholder	Description
Special Interest Groups	Special interest groups, such as worker unions, environmental protection organizations, homeowners' association, business and trade groups, Parent-Teacher Associations, public health associations, and many others will be critically important trusted sources for communicating the health risks (or lack thereof) associated with the chosen cleanup levels and remediation zones. These groups may also provide valuable input on cleanup level decision criteria and/or prioritization of cleanup activities.

- **Revise Cleanup Levels, Technical Methods, and Remediation Zones:** Revisit the Optimization Process if needed (e.g., revisions to cleanup levels, technical methods, and remediation zones) once remediation begins based on changes to the estimated or actual technical, economic, and social feasibility of the proposed work. Additionally, other factors may warrant a return to the optimization process, such as changes to the risk and policy environments, lessons learned during early phase remediation, and availability of new technologies.

    - When technical, economic, and social feasibility of remediation are the reasons for revisiting the Optimization Process, the following are potential factors to adjust:

        - Increase or decrease cleanup levels: Changing cleanup levels can have a substantial impact on the entire remediation process. It can affect the feasibility of technical decontamination methods; the time required to perform remediation, the volume of waste produced, and possibly the classification of that waste. The cleanup standards chosen will likely be the most important factor determining the total cost of the remediation.

        - Adjust technical methods of remediation: As remediation continues, remediators may discover improved techniques for the particular area they are cleaning, allowing for changes to expectations for time and/or cleanup level.

        - Reduce, expand, or further divide remediation zone boundaries: Adjust remediation zones to align with desired cleanup levels. Shrinking and dividing remediation zone boundaries could allow for remediation operations to be organized in more manageable sizes, allowing for smaller, but prioritized areas to be reoccupied sooner.

        - Adjust land use to meet the feasible cleanup level: If the chosen cleanup strategies are too costly or require too much time, then either the target cleanup level and/or land-use may need to change.

Activity 7.2: Develop Remediation Plans

- **Coordinate the Development of Remediation Plans:** Remediation partners (including Federal and SLTT organizations, as applicable) should prepare a remediation plan for the remediation zone(s) within their jurisdictions.
    - The remediation plan will specify the cleanup levels, DCGLs, and specific decontamination techniques that will be used to achieve them. It should reference other plans that detail how work will be conducted safely by remediation workers and how confirmation of the cleanup levels will be achieved.
    - Plan components are summarized in Table 18:. It is possible that more than one remediation plan will be needed within a given remediation zone to cover specific buildings (e.g., such as "interior" vs. "exterior" cleanup operations).
- **Review and Approve Remediation Plans:** Identify and obtain necessary approvals.
    - As appropriate for the affected jurisdiction(s) and depending on the number and complexity of remediation plans that require oversight, government reviewers (e.g., R-TWG, incident commander, safety officer, emergency management agency, local/state health department, local/state environmental protection agencies, and/or other regulatory agencies) should review and approve remediation plans.
    - Jurisdictions may need to provide additional qualified contractor support to help with the technical workload to avoid the review process becoming a limiting factor in restoring more timely access to contaminated areas.

Table 18: Components of a Remediation Plan

Plan Component	Description
Data Quality Objectives (DQOs)	Process for defining objectives that ensure collection of the type, quantity, and quality of data needed to reach defensible decisions and credible estimates to support the remediation process.
Final Assessment/Survey Plan	Provides procedures and requirements used by regulatory agencies overseeing the remediation process. Purpose is to determine if desired cleanup levels have been achieved and identify what to do if they have not (e.g., continued remediation, adjust cleanup levels, and/or adjust land-use and institute long-term restrictions on human activity).

Plan Component	Description
Health & Safety Plan (HASP)	Required by the HAZWOPER regulations[64] and prepared and followed by any employer whose workers engage in hazardous waste operations. Addresses safety and health hazards of each phase of site operations and includes requirements and procedures concerning employee protection. Example guidelines for a HASP can be found in the DOE limited standard (DOE-EM-STD-5503-94).[65]
Sampling and Analysis Plan (SAP)	Provides a process for obtaining data of sufficient quality and quantity to satisfy data needs. ▪ **Field Sampling Plan**: which describes the number, type, and location of samples and the type of analyses.[66] ▪ **Quality Assurance Project Plan**: which describes policy, organization, functional activities, DQOs, and measures necessary to achieve adequate data for use in selecting the appropriate remedy.
Technical Decontamination Work Plan	Describes the actual methods and schedule for conducting the decontamination work.
Waste Management Plan	Provides an overview of the volume of waste estimated to be generated from remediation activities and type/class of waste produced. This plan should outline the specific operational methods and techniques the contractor(s) will use to safely contain, store, transport, and dispose of the various waste streams that result from their remediation work procedures. Covers all waste streams, not just radiologically contaminated waste. The plan should also include waste minimization strategies, worker health and safety precautions, dosimetry monitoring, and any treatment plans for waste.

Activity 7.3: Perform Remediation/Cleanup

- **Coordinate with regulatory agencies:** Oversight of remediation cleanup will involve Federal and SLTT health and safety, environmental and radiological regulatory agencies. Remediation will also entail frequent communication with R-TWG and affected jurisdictions.

- **Implement remediation plans:** Implement the remediation plans identified in Activity 7.2. Table 18. Considerations for performing remediation activities include:

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[64] OSHA (*1910.120 – Hazardous waste operations and emergency response.* Available online at: https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.120

[65] DOE (1994) "EM Health and Safety Plan, DOE-EM-STD-5503-94. DOE Standard. Available online at: https://www.standards.doe.gov/standards-documents/5000/5503-astd-1994/@@images/file

[66] DOE (2000) *Decommissioning Handbook: Procedures and Practices for Decommissioning.* Available online at: https://www.osti.gov/servlets/purl/1491121.

  - Maintaining regulatory and legal compliance while performing remediation activities, especially those related to worker safety and health.
  - The amount of waste to be generated by specific remediation actions. Managing waste streams is critical at this stage and are described further in Focus Area 9.
  - Whether the remediation actions themselves may generate further radiological hazards to the population, such as through the generation of dust or water runoff that is contaminated.

- **Provide wraparound services for remediation activities:** Provide security, project management, and ongoing public communication/outreach services to support remediation efforts as required.
- **Mitigate factors which may limit the speed and efficiency of remediation activities.** Such factors may include:
  - Personnel, equipment, and other resources to perform remediation may be limited until additional capacity can be identified, trained, and mobilized.
  - Availability of waste storage and disposal facilities may be limited until additional storage locations are identified (See Focus Area 8 for more information).
  - Access and right-of-entry to areas where remediation must be performed, such as obtaining necessary entry permits to conduct work on private property, could delay or complicate remediation work.
  - Feasibility of remediation approaches in different scenarios and contexts, such as working in an urban environment, may complicate remediation activities.
  - Public acceptance of remediation actions, methods, and processes may change over time, delaying and complicating remediation efforts.

Considerations for Engaging Remediation Contractor Support for Jurisdictions Pursuing Remediation on their Own

- Ensuring safety for those working in hazardous environments is a key priority..
- Remediation activities like power-washing, grinding concrete and asphalt, and other activities may result in resuspension and/or movement of radioactive material.
- Environmental considerations associated with different land use types (commercial, industrial, residential, agricultural, etc.) drive many remediation decisions.
- Federal agencies like EPA, DOE, NRC, and others with expertise in radiological hazards may be able to provide guidance for working with private sector remediation contractors. Remediation contractors may require special licensing and operate under other special rules and restrictions related to the hazardous nature of the work to be performed. Jurisdictions

should ensure that contractors are qualified and properly supervised to perform remediation work.

- Support of multiple contractors and subcontractors working in concert likely will be required.
- Contracted activities may represent a mix of government, contractor, and community-led activities. Some remediation work may be directed by the government (especially for public property), while other remediation work may be led by private sector entities and individual homeowners. It is likely that multiple aspects of remediation work will be ongoing concurrently.

Activity 7.4: Verify Cleanup Level Compliance

- **Conduct Data Verification, Validation, and Quality Assessment:** Evaluate survey plans and data to determine compliance with Derived Concentration Guideline Levels (DCGLs). The process for verifying cleanup levels is defined in a Final Assessment/Survey Plan. This assessment involves the Data Life Cycle[67], consisting of:
    - Data verification: Ensures the requirements stated in the remediation plans are implemented as prescribed.
    - Data validation: Ensures the results of the data collection activities support the objectives of the survey as documented in the Quality Assurance Project Plan or to permit a determination that these objectives should be modified.
    - Data Quality Assessment (DQA): Represents the scientific and statistical evaluation of data to determine if the data are of the right type, quality, and quantity to support their intended use. DQA helps complete the Data Life Cycle by providing the assessment needed to determine that the planning objectives are achieved.
- **Conduct a Final Assessment Survey:** As part of the Final Assessment/Survey Plan, a survey is conducted that will take readings to compare the residual radiation amounts to those that were assessed before the remediation actions were performed.
    - If achieved radiation levels are in excess of those projected during the planning phase, additional remediation activities may need to be performed and/or the remediation plan may need to be revised, potentially including a return to the Optimization Process.
- **Conduct Verification:** Independent verification should be conducted by a third party that has no vested interest in the outcome of the Remediation Process and is the last step to verify cleanup levels.

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[67] Data Life Cycle is further described in *MARSSIM* and EPA's *Data Quality Assessment: A Reviewer's Guide*.

- As with other steps of the process, verification is iterative and ongoing. Since radioactive material may move around in the environment, data collected during the verification phase is also useful as part of ongoing survey and dose assessment activities to further refine the collective picture of overall radioactive contamination.
- Especially for events of large scale or occurring in a highly populated area, it is likely that verification will be an important topic for public messaging. Populations are likely to ask for assurances that comprehensive surveys have been performed and that radioactivity levels have been reduced to acceptable target levels.
- Feedback from independent verification should be incorporated into the release report for Activity 7.5.

Recommended Resources: Radiological Data Assessment Guidance

- *Radiological Data Assessment Guidance.* The Data Quality Assessment Toolkit helps officials understand how much sampling and surveying is required, how trustworthy their collected data is, and when they have enough data to determine that it's safe. https://www.cbrnresponder.net/app/index#resources/documents/download/2308.
- *RESRAD*. The RESidual RADiation (RESRAD) family of codes is used to evaluate radiation exposure and associated risks and to derive cleanup criteria or authorized limits for radionuclide concentrations in the contaminated source medium (e.g., water). The RESRAD family of codes is widely used by regulatory agencies and the risk assessment community. https://resrad.evs.anl.gov/.

Activity 7.5: Release the Area/Site

- **Publish Release Report:** Transmit release report and associated documentation to applicable federal, state, and municipal regulatory agencies.
  - The Release Report documents the recommended future use of the formerly contaminated area/site.
  - If the site/area cannot be released for unrestricted use, the documentation identifies any controls (administrative or engineered) that are to remain in place, and for how long. For example, additional monitoring may be required, and the area/site re-evaluated periodically.
  - Note: Focus Area 9 provides guidance on reopening areas and considerations related to limited use.

- **Obtain Necessary Approvals and Concurrences:** Upon acceptance of the verification documents, applicable federal and state agencies will provide documentation that the contaminated area has been remediated to agreed-upon cleanup levels for the area.

- **Maintain Vital Records:** Records management of all verification documents is a key consideration for this activity, as these records will provide the baseline for future evaluations of what work has been performed, which locations material has been moved to for storage, and other historical data.

Potential Remediation Resources:

- See also Annex D: Remediation Decontamination and Demolition Techniques and Technologies
- *Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination*. OSWER Directive 9200.4-18. (U.S. Environmental Protection Agency, Office of Emergency and Remedial Response and Office of Radiation and Indoor Air,1997) https://semspub.epa.gov/work/06/640873.pdf#:~:text=Slope%20factors%20were%20developed%20by%20EPA%20for%20more,standard%20Agency%20risk%20language%20consistent%20with%20CERCLA%20guidance.
- *Protective Action Guides and Planning Guidance for Radiological Incidents*. PAG Manual*:* EPA-400/R-17/001. (U.S. Environmental Protection Agency, Office of Radiation and Indoor Air, Radiation Protection Division, 2017.) https://www.epa.gov/radiation/protective-action-guides-pags
- *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*. EPA 402-R-97-016, Revision 1. (U.S. Environmental Protection Agency, Office of Radiation and Indoor Air, Radiation Protection Division, August 2000)[68] https://www.epa.gov/sites/default/files/2017-09/documents/marssim_manual_rev1.pdf
- “Radiation at Superfund Sites,” www.epa.gov. (U. S. Environmental Protection Agency, 2021) https://www.epa.gov/superfund/radiation-superfund-sites. This page provides EPA remedial project managers with information and guidance on the cleanup of radioactive contamination at Superfund sites.
- *Radiation Site Cleanup Regulations: Technical Support Document for The Development of Radionuclide Cleanup Levels for Soil*. EPA 402-R-96-001a, Review Draft. (U.S. Environmental Protection Agency, Office of Radiation and Indoor Air, 1994.) https://www.epa.gov/sites/default/files/2015-05/documents/402-r-96-011a_intro.pdf

[68] This manual is currently being revised. For information on the development of Revision 2 visit: https://www.epa.gov/radiation/multi-agency-radiation-survey-and-site-investigation-manual-marssim-proposed-revision-2 .

- *Data Quality Assessment: A Reviewer's Guide*. EPA QA/G-9R, EPA/240/B-06/002. (U.S. Environmental Protection Agency, Office of Environmental Information, 2006.) https://www.epa.gov/sites/default/files/2015-08/documents/g9r-final.pdf.
- *Removal Action* (Title 40 Volume 29 section 300-415 (40 CFR 300.415), US Code of Federal Regulations.) https://www.gpo.gov/fdsys/granule/CFR-2012-title40-vol29/CFR-2012-title40-vol29-sec300-415.
- *Decommissioning Handbook: Procedures and Practices for Decommissioning*. DOE/EM-0383. (U.S. Department of Energy, 2000) https://www.osti.gov/servlets/purl/1491121.

Focus Area 8: Manage and Dispose of Waste

Guidance: *Conduct early-phase waste management and containment operations, including designating temporary waste storage sites and waste transportation procedures. Then, estimate the volume of waste and types of waste streams that will be generated by remediation work. Finally, develop a long-term waste disposal plan.*

Recommended Planning Partners:

- Environmental protection
- Transportation
- Radiation protection
- Public Health
- Waste management and remediation contractors

Introduction

An RDD detonation may involve a large area of radiological contamination including radioactive debris in the blast zone and radiologically contaminated soils, exterior and interior surfaces of buildings and other structures, paved surfaces, vegetation, automobiles, mass transit, etc. Cleanup of these contaminated surfaces may generate large quantities of radiological wastes. As response, recovery, and remediation activities are implemented, additional radiological waste may be produced over the course of the incident. Most, if not all, radioactive waste likely will be categorized as some form of low-level radioactive waste (LLRW) or potentially mixed waste (radioactive and hazardous waste), which includes explosion debris and other contaminated materials that may need to be relocated to allow the completion of critical response and recovery activities. Table 19: summarizes the different types of waste that may be generated as the result of an RDD incident along with potential disposal options. Disposing of some of this material may require coordination with law enforcement officials due to its potential evidentiary value.

Moving from the intermediate to late phase, remediation activities will generate considerable and diverse waste streams for disposal. Handling, packaging, transporting, and disposing of radioactively contaminated materials from an RDD incident are likely to account for a substantial portion of recovery costs and will involve adherence to complex regulatory requirements. Failure to anticipate such requirements will delay remediation and reoccupation of contaminated areas. Waste management will remain an important activity throughout all phases of RDD incident response and recovery.

Properly addressing the various waste-related issues stemming from an RDD incident will require the development and implementation of a comprehensive waste management and disposal plan. The most effective approach to RDD-related waste management includes extensive pre-incident waste management planning. EPA and DHS recommend that jurisdictions perform pre-incident waste planning for all hazardous, including nuclear radiological hazards. While most communities are familiar with solid and non-radiological hazardous waste management, the development of an appropriate plan to address the complexities associated with radiological waste and mixed waste will require specialized expertise. Tailorable pre-incident waste management plans – which could take the form of an annex to an existing all-hazards debris plan or a standalone plan that includes provisions for radioactive and mixed waste – are critical to avoid unnecessary challenges later in the response.

The EPA has developed an online decision support tool to facilitate development of a pre-incident waste management plan that could be tailored to the specifics of an actual incident.[69]

Remediation plans developed by remediation partners performing remediation work should be based on the parameters identified in the overarching waste management plans developed by the responding jurisdiction(s). Such plans should outline the specific operational methods and techniques that will be used to safely contain, store, transport, and dispose of the various waste streams that result from remediation work (see Table 19:). Remediation partners should also consider the cleanup levels and decontamination techniques selected through the Optimization Process, as these decisions can have a substantial impact on the amount and type of waste generated. Contractor remediation plans should be reviewed and approved by appropriate government agencies.

Key Terminology: Types of Waste

Radioactive waste is any type of waste that contains radioactivity, either intrinsically or through contamination with radioactive material. There are three classes of radioactive waste (A, B, and C), based on the amount of radioactivity present. Class A **low-level radioactive waste (LLRW)** is the most likely type of radioactive waste to result from an RDD. If radioactive waste is combined with hazardous but non-radioactive waste, it is considered **mixed waste.**

Table 19: Overview of Waste Types

Classification[70]	Examples of Waste Types	Potential Disposal or Storage Location(s)
Non-radiological solid waste	▪ Uncontaminated components of buildings and structures, vegetation, discarded items	Municipal or industrial landfills

[69] The EPA's online decision support tool is available at https://wasteplan.epa.gov/

[70] Waste classifications identified as part of EPA (2012) "Wide Area Recovery and Resiliency Program Waste Management Workshop.": Available online at: www.epa.gov/sites/production/files/2015-08/documents/warrp_workshop_report_0.pdf

Classification[70]	Examples of Waste Types	Potential Disposal or Storage Location(s)
Non-radiological hazardous waste	▪ Building supplies containing asbestos or Polychlorinated biphenyls (PCBs)[71] ▪ Specialized waste, e.g., medical waste or biological waste	Hazardous waste landfills
Class A low-level radioactive waste (LLRW)	▪ Rubble, soil, and other contaminated surfaces with lower radioactivity levels ▪ Likely most of the waste from the contaminated area	Temporary storage or permanent radioactive waste storage site
Class B/C radioactive waste	▪ Materials with higher radioactivity levels from the blast zone ▪ Likely a small fraction of total waste by volume and weight	Temporary storage or permanent radioactive waste storage site
Low-level mixed waste (hazardous waste and low-level radioactive waste)	▪ Low-level radioactive waste with asbestos (i.e., old steam pipes from demolished buildings) ▪ Low-level radioactive waste with PCBs (i.e., PCB transformer oils coating demolished building exteriors) ▪ Waste from water treatment or wastewater treatment (including sludges) that are determined to be radioactive ▪ Specialized waste (e.g., human or animal remains) that is determined to be radioactive ▪ Some mixed waste can be treated to remove the hazardous component, allowing it to be reclassified as LLRW.	Temporary storage or permanent radioactive waste storage site
Aqueous waste	▪ Stormwater runoff from the contaminated area ▪ Wastewater generated from decontamination activities	Discharge into large bodies of water, temporary storage, or permanent radioactive waste storage site

[71] PCBs are carcinogenic chemical compounds that were used in industrial and consumer products prior to being banned in 1979. (https://www.epa.gov/pcbs/learn-about-polychlorinated-biphenyls-pcbs)

Recommended Resources: EPA's Waste Management Guidance

- EPA's "Pre-incident All-hazards Waste Management Plan Guidelines: Four-step Waste Management Planning Process" available at: https://www.epa.gov/sites/default/files/2019-05/documents/4_steps_document.pdf.
- EPA also provides an All-Hazards Waste Management Planning (WMP) Tool, available online at https://wasteplan.epa.gov/.

Table 20: Summary of Focus Area 8 Activities

	Activity	Phase
8.1	Conduct Early-Phase Waste Management and Containment Operations	Early to Intermediate (Days to Weeks)
8.2	Estimate the Volume of Waste and Establish Waste Management Goals	Intermediate to Late (Weeks to Months)
8.3	Identify Long-Term Waste Disposal Options and Inter-Jurisdictional Transportation Requirements	Late (Months to Years)

Activity 8.1: Conduct Early-Phase Waste Management and Containment Operations

- Identify temporary waste/debris staging and storage locations both within and outside of the contaminated area (e.g., on-site and off-site locations away from the contaminated area that are pre-designated for waste disposal activities). This identification should be done as early as possible following recognition of an RDD incident. Considerations for selecting a temporary storage area are provided in the box below; these considerations should be included in pre-incident waste management planning whenever possible. Note, however, that pre-selection of specific storage or staging sites will likely be highly controversial and of potentially limited utility as the location of the RDD would be unknown. Additionally, the EPA has developed a GIS-based Waste Storage & Staging Tool that uses suitability analysis to aid in the selection of temporary storage and staging areas.[72]
    - Existing radioactive waste disposal sites may be insufficient for a major RDD incident. Accordingly, planners must identify suitable sites where radioactive and mixed waste

[72] EPA's Waste Storage & Staging Tool is a GIS-based decision support tool for identifying and prioritizing potential waste staging and storage sites and works in coordination with EPA's WEST. The tool can be downloaded from: https://github.com/USEPA/Waste_Staging_Tool

can be temporarily stored while waiting for additional permanent storage capacity to become available.[73]

- Temporary storage may also be necessary if decisions about final waste deposition are delayed. If the radioactive material has a short half-life, storage within the contaminated area may allow material to become significantly less radioactive while other remediation activities occur.

Criteria for a Temporary Storage Area

- Located away from heavily populated areas
- Convenient access to transportation routes for ingress/egress
- Features that reduce or prevent the spread of contamination from the waste into the environment (e.g., shelter from wind and rain; pest mitigation; impermeable floors)
- Minimal non-radiological hazards
- Accommodates box trucks/tractor trailers (e.g., loading docks; enough space for turning radius). Although not required, access to rail/train transportation at staging sites may help to reduce logistical burdens.
- Running water for dust control
- Electricity for lighting and air monitoring
- Security and controlled access
- Includes or is adjacent to work areas where waste can be surveyed for radioactivity, sorted, cut into smaller pieces, loaded into packages, etc.

- Use administrative and engineering controls (defined in Focus Area 2) to limit the spread of contamination generated by emergency response activities. Some controls, such as following radiological-HAZMAT procedures for bagging and containing contaminated PPE, require minimal resources and can be implemented very early in the response. Others, such as using physical barriers to contain or redirect contaminated runoff, will require more resources, and should be implemented as resources become available. Implementation of controls should be delayed if they divert resources from lifesaving and high-priority health protection activities. Appropriately package and transport waste generated from emergency response activities to the identified temporary storage location(s). At a minimum, expect waste streams from the following locations:

[73] EPA has developed numerous tools to address managing waste after an incident like an RDD. Access to the toolkit is available at: https://www.epa.gov/emergency-response-research/decision-support-tools-waste-management

  - CRCs, shelters, contaminated area access points, and other sites where decontamination is performed: Contaminated personal effects that could not be decontaminated, responder PPE, and wastewater run-off.
  - Residences and businesses: Clothing bagged by members of the public who are following self-decontamination instructions.
  - Hospitals and other medical facilities: Contaminated personal effects that could not be decontaminated, responder/healthcare provider PPE, wastewater run-off, responder vehicles, and medical equipment.
- Instruct each location where waste is generated on how to safely store radioactive waste until it can be picked up. To the extent possible, waste should be placed in sealed, waterproof containers (such as plastic bins or sealed plastic bags), positioned away from people and pets, and protected from weather.

Recommended Resources: Waste Management Tools

- RDD Waste Estimation Support Tool (WEST) available at: https://www.epa.gov/emergency-response-research/waste-estimation-support-tool-west.
- Waste Storage & Staging Tool available at: https://github.com/USEPA/Waste_Staging_Tool
- I-WASTE DST available at: https://iwaste.epa.gov/guidance.

Activity 8.2: Estimate the Volume of Waste and Establish Waste Management Goals

- Establish goals and expectations for waste management in the intermediate or late phase through coordination with remediation contractors, radiological technical working groups (R-TWGs) and regulatory government agencies.[74] This includes:
  - Establish waste acceptance criteria and waste segregation strategies by waste type (e.g., radioactive waste, mixed waste, hazardous waste) and waste characteristics (e.g., aqueous waste, combustible waste, compactible materials like PPE, non-compactable debris from buildings, or vegetation).
  - Develop strategies for mixed waste that could be treated to remove non-radiological contaminants.

[74] FEMA's recommendations for authorities involved in waste management decisions available online at: https://www.fema.gov/sites/default/files/2020-07/fema_incident-annex_nuclear-radiological.pdf

    - Define potential residual radioactivity levels that would make waste eligible for municipal disposal options (e.g., existing landfills for the area).
    - Define criteria for items that may be reused in contaminated areas (e.g., vehicles or trash bins) with minimal or no decontamination versus requiring final disposal.

- Weigh the costs and benefits of treatment against the costs of disposal or storage. It may be more cost effective to dispose of and replace some items rather than attempt decontamination (e.g., contaminated personal clothing collected at a CRC).
- Estimate the quantity and characteristics of the waste. EPA's Waste Estimation Support Tool (WEST) can be used for this process.
- While establishing goals and expectations for waste management, coordinate with remediation partners and government officials who are managing the optimization process.
    - The specific remediation techniques (e.g., washing, using strippable coatings, demolishing) selected by remediation partners and approved by the responding governmental authorities through the optimization process will have a significant influence on the volume and type of waste generated.
    - As discussed above and in Focus Area 8, remediation partners will develop a separate waste management plan that details how they manage radiological waste while conducting remediation.

Activity 8.3: Identify Long-Term Waste Disposal Options and Inter-Jurisdictional Transportation Requirements

- Identify options for the disposal of radioactive waste in coordination with local, state, and federal regulatory agencies, including the EPA and NRC. There are three primary options for disposal of radioactive waste; radiation technical experts will be able to determine which disposal options are best suited to the materials involved.
    - **Decay in storage.** Waste containing only short-lived radionuclides (generally those with a half-life of 90 days or less) can be temporarily stored in a dedicated facility or left in-place for ten half-lives and until the radioactivity has decayed to levels that are indistinguishable from background radiation. At that point, such waste is no longer considered to be "radioactive material" and may be released for disposal without regard to radioactivity. This waste may need to be disposed of based on other characteristics, such as hazardous waste. This approach is only feasible for a limited number of radionuclides which have a relatively short half-life (e.g., Iodine-131), but can be cost-effective and reduce concerns associated with transporting radioactive materials.

- **Transfer to a licensed disposal site.** Long-term disposal in a licensed radioactive waste disposal facility moves contaminated waste to locations where people and the environment will not be put at risk. An LLRW disposal facility is licensed by either the NRC or an Agreement State (states that have signed an agreement with the NRC authorizing the state to regulate certain uses of radioactive materials within the state). Low activity waste could also be disposed of in a RCRA C or D facility with low level radiological waste disposal authority. State authorities can grant approval for this type of disposal.

- **Discharge into the sanitary sewer system or into surface waters (e.g., river, ocean).** Depending on governing FSLTT regulations, aqueous waste may be discharged into the sanitary sewer system or large bodies of water (e.g., river, ocean, etc.). This approach is only an option if the radionuclide concentration in the effluent (in the case of discharges to the sanitary sewer system) or in the body of water remains below regulatory limits, which vary by state. This release of effluents below regulatory limits is a disposal methodology used by nuclear power plants and other radioactive materials licensees throughout the U.S. and in other nations.[75] While nuclear plants and other industrial releases of radionuclides (such as from nuclear medicine suppliers) are routine, considerable effort is often required to ensure compliance with applicable regulations (and obtain appropriate permits) so it may be difficult to plan for given the unknown nature of a radiological incident. If precipitation occurs during or shortly after a release, discharge into surface waters may happen naturally, as contaminated material is washed into water systems. In that case, affected sewer or surface water systems should be assessed for contamination, as described in Focus Area 1.

    - Additionally, there are commercial water treatment systems capable of treating radiologically contaminated water. If this treatment is a desired and feasible waste solution, remediation partners should request discharge criteria from state and federal regulators and procure and develop treatment capacity for this wastewater.

- Engage with the public to discuss waste management disposal options to support decision making for cost-effective and safe waste staging and disposal.

    - Engagement discerns priorities for public acceptance of cost-effective recommendations for waste staging and disposal.

- Select long-term waste disposal sites on site and/or off-site:

[75] NRC (2022) *Radioactive Effluent and Environmental Reports*. Available online at: https://www.nrc.gov/reactors/operating/ops-experience/tritium/plant-info.html

- Long-term storage on-site (i.e., within/near the contaminated area) may be a good option if there are portions of the contaminated area that will not be remediated and are otherwise suitable for storage, or if the radioactive waste contains short-lived radionuclides that will decay in storage.

- Waste may be transported to a disposition site outside the contaminated area. For a very limited radiological incident with a small waste volume, the four existing LLRW disposal facilities in the U.S. may be sufficient: Barnwell, South Carolina; Richland, Washington; Clive, Utah; and Andrew, Texas. However, in a situation involving a more significant release, supplements to existing commercial licensed radioactive waste disposal facilities may be required such as a combination of hazardous waste landfills, some solid waste landfills, DOE facilities, and construction of one or more new disposal facilities.

  - Off-site locations in another jurisdiction will require analysis of transportation routes and adherence to state and local regulations and ordnances governing the transportation of radioactive waste. If the site is far from the impacted jurisdiction, such as might be the case if the existing LLRW disposal facilities are used, then both the transport costs and level of effort to navigate regulations and ordinances for every state the waste transits through may be substantial.

- Implement protocols and procedures with regional partners for coordinating inter-jurisdictional transportation of LLRW, if the permanent off-site storage locations are outside of your jurisdiction.

  - Identify FSLTT stakeholders who have regulatory jurisdiction impacting the transportation of LLRW and designation of long-term storage sites, and/or can assist in coordinating transportation activities. These may include:

    - Local and state transportation agencies for transportation of hazardous, oversize, and overweight loads.

    - US Department of Transportation (DOT) for transportation of hazardous waste.

    - Law enforcement and/or fire departments for escort support.

    - EPA and NRC for storage-site designation and characteristics.

- Initiate the permit process for waste disposal and disposition.

  - Permits for final disposition, whether on-site or off-site, are required to meet FSLTT regulations.

  - Experienced remediation partners coordinate with regulatory FSLTT stakeholders.

Recommended Resources:

- EPA's booklet titled Radioactive Waste Disposal: An Environmental Perspective describes the different categories of waste, discusses disposal practices for each type and describes the way they are regulated: https://www.epa.gov/radiation/radioactive-waste-disposal-environmental-perspective.
- FEMA's recommendations for authorities involved in waste management decisions available at: https://www.fema.gov/sites/default/files/2020-07/fema_incident-annex_nuclear-radiological.pdf.
- NRC's Radioactive Waste Safety Research Program available at: https://www.nrc.gov/waste.html.

Strategy 5: Reopen and Recover

Focus Area 9: Reopen

Guidance: *Determine the reopening criteria for buildings and other affected infrastructure in the remediation zones, conduct final repairs/additional remediation, prepare the area for public, commercial, and residential access, and support a phased reopening of remediated areas.*

Recommended Planning Partners:

- Emergency management
- Environmental protection
- Building and code officials
- Human services
- Public health
- Occupational health and safety
- Law enforcement
- Recovery Support Functions
- Public works
- Urban planning and zoning

Introduction

"Reopening" refers to allowing residential re-habitation and/or industrial/business activities to safely resume in an area that was previously restricted from public access due to radioactive contamination or other impacts (such as blast damage) from the incident.

Once reopening criteria are established, buildings in remediation zones are cleared through the radiological remediation process and must be inspected to ensure all clearance and physical safety and structural integrity requirements are met. This inspection and clearance process may necessitate both cosmetic and functional repairs as well as additional final remediation measures.

Jurisdictions should consider implications for pre-incident planning, zoning, and code enforcement requirements, as these may need to be waived or modified in some way to reopen the affected areas.

Table 21: Summary of Focus Area 9 Activities

	Activity	Phase
9.1	Establish Reopening Criteria for Structures in Remediation Zones	Intermediate to Late (Weeks to Months)
9.2	Conduct Repairs/Final Remediation and Prepare for Reopening	Intermediate to Late (Weeks to Months)

Activity 9.1: Establish Reopening Criteria for Structures in Remediation Zones

- **Set parameters for reopening:** Establish requirements for reoccupation and reopening of residential-, industrial-, and commercial-use structures in remediation zones once they have achieved previously determined clearance goals, and law enforcement officials have released the areas previously designated as a crime scene. At a minimum, these requirements should incorporate:

  - **Physical condition of structures and surrounding area:** Data collected through area sustainment activities described in Focus Area 6 should show that structural and aesthetic conditions of areas in the remediation zone are consistent with relevant codes and standards as well as local community expectations. Structures that are not compliant will not be able to be re-occupied.

  - **Acceptable levels of residual contamination to determine reentry and/or relocation of impacted individuals, households, and businesses:** The optimization process (described in Focus Area 7) will establish target levels of residual radiation for contaminated areas. If the levels of residual radiation are above those permissible for unrestricted public use, then restrictions to land or property use will need to be identified and enforced. Any restrictions to access or land or property use should be driven by health and safety analyses of variables such as how the property will be utilized, whether people will be there continuously or only for limited periods (in order to project likely total absorbed doses), etc. Table 22: describes example criteria for land/property use adjustments that can be applied to areas based upon the residual levels of contamination following remediation activities. For example, two buildings may have similar residual radiation levels, but could be subject to different use restrictions based on the projected total amount of time people are reasonably expected to be inside the buildings in any given year.

  - **Habitability**: FEMA broadly defines “uninhabitable” as a dwelling that is not safe, sanitary, or fit to occupy. “Safe” refers to being secure from disaster-caused hazards or threats to occupants and “sanitary” refers to being free of disaster-caused health hazards.[76] Different jurisdictions have varied or more specific requirements, such as availability of water/wastewater treatment/disposal, heat, electricity, and other essential services. If an area has been evacuated for an extended period or has been included in a relocation effort, some structures may have suffered environmental or other damage due to deferred maintenance. Those structures would need to be repaired and rehabilitated prior to being reoccupied.

- **Availability/restoration of Community Lifelines**: FEMA has identified seven "Community Lifelines" which jurisdictions can use to better understand the impact of an emergency on the population and prioritize recovery activities. These same lifeline categories can also be used to evaluate the availability of critical utilities and services on which a typical community, neighborhood, and household relies. Since reoccupation is ultimately a voluntary process for the public and businesses, unresolved disruption of any of these lifelines can significantly impede a successful reopening. The FEMA Community Lifelines are categorized into the following groups: [77]
  - Safety and Security
  - Food, Water, Shelter
  - Health & Medical
  - Energy
  - Communications
  - Transportation
  - HAZMAT

[76] ((FEMA), 2021)
[77] FEMA (2019) "Community Lifelines Implementation Toolkit 2.0". Available online at: www.fema.gov/sites/default/files/2020-05/CommunityLifelinesToolkit2.0v2.pdf

Table 22: Notional Classification of Areas for Reopening, Based on Residual Contamination[78]

Area Use Classification	Dose Guide	Example Permitted Activities
Unrestricted use for residential activities (including agriculture, though compliance requirements might vary). Areas where evacuation orders and access restrictions are lifted, and the established goal(s) for radiation mitigation has been met.	15 mrem/year @ 24 hrs/day 365 days for 30 years	▪ Individuals can enter and live in the area. ▪ Maintenance, repair, and public and private transportation can resume. ▪ Business and social services can resume (e.g., grocery stores, food delivery, gas stations).
Limited use for industry and recreation. Areas where evacuation orders and public access restrictions are lifted, and the established goal(s) for radiation mitigation has been met but the remaining radiation level remains higher than what is considered safe for unrestricted use.	Industrial, commercial, or business: ▪ 15 mrem/year @ 8 hours/day ▪ 250 days/year for 25 years Recreational: ▪ 15 mrem/year @ 168 hours/year for 70 years	▪ Infrastructure repair work can resume with restrictions. ▪ Industrial, commercial, and recreational activities can resume with restrictions.
No Access for the public and radiation exposure controls are necessary. Areas where evacuation orders and access restrictions will remain in effect for months and years to come.	No entry allowed	▪ Individuals are not permitted to enter the area. ▪ Cleanup crews working in the area must be screened regularly for radiation exposure and wear PPE.

- **Prioritize areas to reopen first:** If necessary, implement a prioritization process for phased reopening. Relevant factors to consider include:
    - **Demographics & vulnerable populations:** Consider residents' relative need to relocate to previously contaminated structures, access to resources needed for relocation, and the need to maintain neighborhood/community identity and establish socioeconomic equity in repopulation decisions, consistent with applicable law.

[78] Based on dose limits provided in EPA (1997) OSWER 9200-4.18. "Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination.

- **Critical infrastructure**: Reoccupy remediation zones or parts of zones that contain CI, such as hospitals, power generation, municipal services, and business activities critical to the economic vitality of the affected area.
- **Contiguous neighborhoods/buildings**: Reoccupy remediation zones that are adjacent to one another to reduce resources needed to establish and maintain physical barriers to enable control of access into contaminated areas not yet remediated, allow for more flexible access to public transportation routes, and connect neighborhoods to essential services across the jurisdiction. Opening areas in groups or tranches can be more efficient than opening areas on a patchwork basis.

- **Publicize the progress of reopening activities:** Planners are encouraged to develop a centralized process for ensuring the transparency of building inspection and reopening activities, since this information will need to be communicated to public and private sector stakeholders. As time elapses, property ownership in the affected areas may transition to new owners. Jurisdictions should plan for this contingency and update tracking systems to accommodate changes in property ownership that occur while access to areas is restricted.
- **Bring critical public safety services back online:** Additionally, jurisdictions should consider the phased reintroduction of necessary public safety services (such as law enforcement and fire protection) as areas are reopened. This may require changes in staffing and other resources if a significant time period has elapsed and personnel changes have occurred in the interim.

Activity 9.2: Conduct Repairs/Final Remediation and Prepare for Reopening

- **Track the status of properties based upon reopening goals:** Develop a Property Readiness Registry for residential and commercial buildings that tracks critical milestones in a property's path to reopening, including the status of radiation remediation, habitability, scope of damage, needed repairs, and certifications. Table 23: provides an example.
  - This registry may be combined with or make use of the database developed to track area sustainment operations as discussed in Focus Area 6.
- **Help connect residents with contractors:** Identify a list of certified contractors, builders, building safety evaluators, and inspectors and provide it to the entities responsible for directing repairs/final remediation activities required to meet reopening criteria as described in Activity 9.1 ("responsible entities" may be government or private property owners, depending on the building or structure requiring repair/restoration).
  - Examples of relevant data sources include the U.S. Small Business Administration, state and local departments of revenue and licensing, professional societies, labor/trade unions, businesses (e.g., Home Depot, Lowes), and online sources (e.g., online yellow pages).

  - Leverage emergency reconstruction contracts and permitting mechanisms to accommodate fast-track contracting and permitting, as the situation permits based on established reopening criteria.

- **Update fencing and access controls:** Revise the boundaries, signage, and fencing for areas that are scheduled to reopen.

  - Display reopening signs and cautionary information prominently on and near reopened properties and along boundaries of reopened areas. If there are activity restrictions on areas that will be reopened, this information should also be included on reopening signage.

  - Mark specific streets and roads as the selected routes to direct returning residents and traffic.

  - As necessary, install gates and boom barriers at key entry points and deploy personnel to conduct entry check (including checking for permits).

- **Complete a final assessment:** Conduct a final assessment for habitability and other reoccupation requirements previously set.

Table 23: Notional Example of a Property Readiness Registry

Property Parcel ID	Dweller Current Location	Addre ss	Zone	Residual Radiation Classification	Damage Assessment from RDD	Habitability Assessment	Reoccupancy certification	Pending Actions	Estimated Time Before Reopening
120982	Temp shelter	56 1st Ave	Residential-Urban	Unrestricted	Minor damage fixed	Assessed	No	Inspect, certify	2–6 months
120982	Relocated to another state	57 1st Ave	Residential-Urban	Unrestricted	Minor damage remaining	Not assessed	No	Repair, inspect, certify	6–12 months
330094	Temp shelter	98 Industry Park Blvd	Industrial-Light	Limited	None	Assessed	Yes	Certify	Up to 2 weeks
278000	Relocated to another county	57098 Rural Trail	Residential-Rural	Restricted	Severe damage beyond repair	Not habitable	None	All restrictions remain, plan for potential rebuilding	12 months plus

Recommended Resources:

- *National Disaster Housing Strategy*. (FEMA,2009) www.fema.gov/pdf/emergency/disasterhousing/NDHS-core.pdf.
- *Post-Disaster Building Safety Evaluation Guidance*. (FEMA, 2019) www.fema.gov/sites/default/files/2020-07/fema_p-2055_post-disaster_buildingsafety_evaluation_2019.pdf..
- *FEMA Preliminary Damage Assessment Guide*. (FEMA, 2020) www.fema.gov/sites/default/files/2020-07/fema_preliminary-disaster-assessment_guide.pdf.
- *Risk Assessment Guidance for Superfund: Volume 1- Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals)* (EPA 1991) https://semspub.epa.gov/src/document/HQ/156739.
- *Preliminary Remediation Goals for Radionuclides on Outdoor Surfaces at Superfund Sites Calculator* (EPA/ORNL) https://epa-sprg.ornl.gov/.
- *EPA Protective Action Guides* (EPA) https://www.epa.gov/radiation/protective-action-guides-pags.
- *Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination: OSWER No. 9200.4-18 (EPA, 1997)* https://www.epa.gov/superfund/radiation-superfund-sites.

Focus Area 10: Enable Long Term Recovery

Guidance: *Transition from near- and medium-term response and recovery operations to a focus on sustainable, comprehensive, and long-term recovery. Leverage existing disaster recovery tools, processes, and systems to develop the coordinating structures and processes needed to align efforts across a wide range of SLTT, federal, private sector, and non-governmental organizations and stakeholders. Emphasize cross-functional and cross-sector collaboration and cooperation.*

Recommended Planning Partners:

- Emergency management
- Public safety and first responders
- Public health
- Recovery Support Functions
- Economic development organizations
- Human and social service agencies and NGOs
- Disaster recovery organizations, donors, and foundations, including Voluntary Organizations Active in Disaster (VOAD) organizations
- Local/state/federal/tribal government leaders

Introduction

Focus Area 10 describes special considerations for long-term recovery from an RDD incident. Over the long term, recovery can be managed by leveraging the same systems and processes utilized for other types of disasters. At the national level, these systems and processes are outlined in the NDRF. This Focus Area provides an alignment of the NDRF with key factors and issues that are likely to arise in the context of an RDD incident.

Recovery activities necessitated by RDD incidents can include long-term housing assistance associated with relocation, long-term health monitoring programs for the affected population, and long-term environmental consequence management in contaminated areas. While extended (multi-year) relocation of affected populations may be a factor in some RDD incidents, permanent resettlement is not likely to be needed on a significant scale in most potential scenarios.

The transition from emergency response to long-term recovery is accomplished by first stabilizing community lifelines. Then, existing pre-disaster recovery plans and processes can be mobilized and tailored, as needed, to kickstart the long-term recovery coordination process. The four key activities in this process are identified in Table 24: below.

Table 24: Summary of Focus Area 10 Activities

	Activity	Phase
10.1	Transition from Incident Response and Lifeline Stabilization to Recovery	Intermediate (Days to Months)
10.2	Execute Existing Disaster Recovery Plans and Identify a Recovery Coordinating Structure	Intermediate (Days to Months)
10.3	Engage Stakeholders Representing Recovery Core Capability Groups	Intermediate to Late (Days to Years)
10.4	Manage Recovery Efforts by Leveraging Recovery Support Functions	Intermediate to Late (Days to Years)

Activity 10.1: Transition from Incident Response and Lifeline Stabilization to Recovery

- **Complete lifeline stabilization efforts:** As immediate emergency response and life safety objectives are accomplished; operations will transition to incident stabilization efforts. Incident stabilization is driven using the Community Lifelines model. In this approach, response operations transition seamlessly to recovery operations through a structured process built around the seven Community Lifelines: Safety and Security; Food, Water, and Shelter; Health and Medical; Energy; Communications; Transportation; and HAZMAT. Figure 9 highlights this transition.

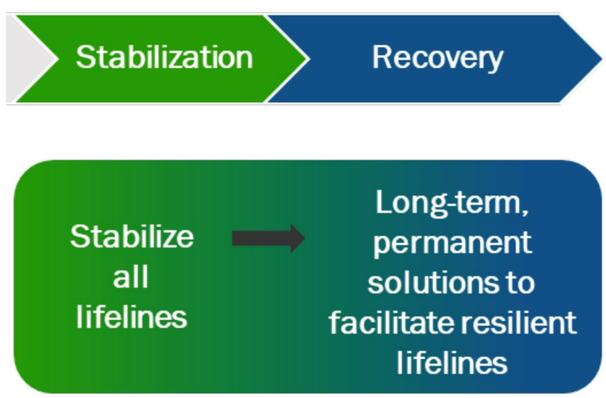

Figure 9: Transition from Response (Stabilization) to Recovery (Source: FEMA Community Lifelines Toolkit).[79]

[79] The FEMA Community Lifelines Toolkit can be found online at https://www.fema.gov/emergency-managers/practitioners/lifelines-toolkit

- **Engage the whole community to prioritize recovery efforts:** It is important to emphasize that the focus of the recovery process is "community" recovery, which includes activities in support of the affected population as well as activities in support of affected local governments, businesses, and critical infrastructure operators. To begin recovery operations, emergency managers should proactively engage the private sector, NGOs, and local government officials across relevant agencies to determine what special concerns and considerations should be addressed based on the specific impacts and protective actions that apply to the RDD incident.

- **Prepare recovery stakeholders to adopt a "recalibrated" posture:** In an RDD scenario, emergency managers will work with responding agencies to identify and address longer-term lifeline impacts in the same or similar manner that would occur for any other significant event. However, there are special factors in an RDD incident that should be given additional consideration.

    - Specifically, these factors are related to the prolonged evacuation or relocation requirements that may be associated with an RDD incident. In most cases, evacuees and survivors begin to re-enter affected disaster areas as soon as the immediate threat has abated. However, in an RDD scenario, re-entry may not be possible for weeks or years. This means that long-term support of the relocated population will require a recalibration of existing disaster recovery plans and processes.

    - Recovery stakeholders should be aware that assistance may need to be provided on a continual basis for an extended period of time. This assistance is unusual, because most assistance programs are usually intended to remain in place only long enough for the community to return to "baseline" and for individuals to re-establish themselves in their prior residences as quickly as possible. Agencies accustomed to providing assistance for a period of 4-6 weeks may now be required to sustain that assistance for 4-6 months (or longer). Similarly, when working with an evacuated or relocated population, agencies accustomed to providing services at individual affected residences might need to adapt their procedures and processes to offer services at shelters, temporary housing sites, or temporary residences (such as for evacuees who choose to stay with family and friends outside the affected area).

- **Identify and employ bridging resources and solutions:** In addressing community lifeline impacts, temporary resources may be deployed or activated to "bridge" the response over the near-term until a more viable solution can be identified and implemented for medium- and long-term recovery to progress. Additional concerns based on the unique circumstances of an RDD incident may impact the choice of bridging solutions used to stabilize the lifelines until long-term recovery can be substantially accomplished, a process generally requiring months to years. Some notional examples of these factors are included in Table 25: below.

- **Transition responsibility for recovery from the emergency response organization to the disaster recovery organization.** Once lifelines have been stabilized and essential services restored (even if in a modified manner or in a way that serves a population that has now been evacuated, relocated, or dispersed), the emergency response coordinating structure should make a deliberate handoff of responsibility to the disaster recovery coordinating structure. This transition will include (for example) transitioning responsibility for services and functions that have been affected by the RDD incident from the EOC to the Local Disaster Recovery Manager (LDRM) and the disaster recovery coordinating structure.

Table 25: Example Lifeline Stabilization Factors for an RDD Incident

Lifeline	Example Impacts and RDD-related Factors	Example Stabilization Strategies	Example Bridging Resources and Actions
Safety and Security	▪ Disruption of fire, law enforcement, and EMS coverage ▪ Overwhelming of the 911 system ▪ Loss of access to vital records	▪ Temporary curtailment or relocation of essential emergency services ▪ Establishment of dedicated hotlines and call-centers for RDD event-related information	▪ Provision of temporary public safety facilities ▪ Medium-term (weeks to months) mutual aid and backfill personnel for critical public safety functions ▪ Private sector contract support to provide telephone and internet support for affected individuals
Food, Water, and Shelter	▪ Loss of access to routine suppliers of food and basic commodities for evacuated and relocated individuals ▪ Possible ingestion pathway concerns related to radiological contamination ▪ Loss of access to housing	▪ Food assistance for evacuated and relocated populations ▪ Curtailment of agriculture in contaminated areas ▪ Shelter operations for evacuated populations	▪ D-SNAP temporary food assistance ▪ Provision of temporary housing for populations evacuated for an extended period or who must relocate until radiation remediation objectives have been achieved
Health and Medical	▪ Injuries/mental health effects due to direct and indirect effects of the RDD incident ▪ Loss of access to pharmacies and medical providers due to evacuation or relocation ▪ Evacuation or	▪ Establishment of expedient survivor tracking systems and processes for long term health surveillance purposes ▪ Provision of alternate facilities and capabilities to provide medical	▪ Disaster Medical Assistance Team (DMAT) augmentation for hospital decompression and standalone clinics ▪ Temporary transportation solution to help individuals access out-of-area to receive medical care for

Lifeline	Example Impacts and RDD-related Factors	Example Stabilization Strategies	Example Bridging Resources and Actions
	relocation of critical facilities (e.g., hospitals and nursing homes) affected by the event	care and/or pharmaceutical supply	chronic/routine conditions ▪ Private sector contract support for survivor tracking and surveillance
Energy	▪ Loss of access to critical energy facilities (e.g., ports or refineries) affected by the event	▪ Utilization of alternative energy suppliers ▪ Gross decontamination of infrastructure/area	▪ Provision of temporary fuel depots ▪ Re-routing fuel and energy flows ▪ Extended generator use
Communications	▪ Loss of access to critical communications nodes ▪ Loss of access to financial facilities like banks	▪ Coordination with public and private sector telecommunications providers to alter capabilities and wireless coverage	▪ Utilization of federal emergency communications support capabilities (e.g., Mobile Emergency Response Support (MERS)) ▪ Deployment of temporary communications systems for weeks-months
Transportation	▪ Loss of access to transportation capabilities such as surface buses and subway systems	▪ Provision of alternate transportation	▪ Utilization of mutual aid and private sector resources ▪ Re-tasking of existing transportation resources
Hazardous Materials	▪ Loss of access to critical controlled industrial chemical processes and storage areas	▪ Render-safe operations for hazmat to remain in place ▪ Temporary relocation of hazmat and transport to alternate facilities	▪ Utilization of mutual aid and private sector resources

Activity 10.2: Execute Existing Disaster Recovery Plans and Identify a Recovery Coordinating Structure

- **Leverage existing recovery plans and processes:** Most local communities maintain a pre-disaster recovery plan. Developed to be consistent with SLTT and federal guidance, these recovery plans outline roles and responsibilities such as the designation of a LDRM or equivalent disaster recovery coordinator. Frequently, a coordinating structure relying on a steering committee or recovery planning committee is also utilized. These plans also identify the stakeholders to be included and processes to be utilized in disaster recovery. Pre-disaster recovery plans should be tailored to address the unique concerns associated with a particular radiological incident.

- **Initiate recovery planning and coordination.** Most disaster recovery planning begins before the disaster occurs and relies upon projections and assumptions of likely disaster impacts, such as for a flood or a hurricane. An RDD scenario is likely to be a "no-notice" event, meaning there is little opportunity to conduct detailed recovery planning before the incident occurs. Recovery stakeholders will engage immediately to meet urgent needs, but will likely require additional data, modeling, and analysis of incident impacts, along with other technical inputs, to support medium- and long-range recovery planning. In the early phases of an RDD incident, the number of "unknowns"—such as information about contamination levels, plans for evacuating and relocating affected individuals, and plans for remediation activities and activities by law enforcement in areas designated as crime scenes—may limit or forestall more long-range and comprehensive recovery planning efforts. In an RDD scenario, identifying and quantifying these unknowns will inform communications with SMEs and response officials to gather the information and intelligence necessary to support the recovery planning process.

- **Identify a recovery coordinating structure.** As previously mentioned, most communities have a pre-defined disaster recovery coordinating structure outlining roles and responsibilities for key stakeholders and organizations.

    - At the federal level, a Federal Disaster Recovery Coordinator (FDRC) may be assigned to work under the auspices of the Federal Coordinating Officer (FCO). The FDRC would take the role of coordinating and streamlining efforts across all involved federal organizations and would take over responsibility from the incident gradually as the FCO accomplishes emergency response objectives over time. This structure is frequently mirrored at the state/tribal/territorial level with the appointment of a State, Tribal, or Territorial Disaster Recovery Coordinator (SDRC/TDRC). An example of this coordinating structure is provided in Figure 10 below. In addition, depending on the nature and extent of the damage from the incident, the federal government may have established a unified coordination group to assist in the response and recovery efforts.[80]

[80] See Response and Recovery FIOP, pp. 10-15 (1st ed. March 2023)

- Given that an RDD incident is likely to encompass an extended time horizon for long-term recovery, early appointments of FDRCs and SDRC/TRDRs are recommended.

- At the local level, pre-existing disaster recovery plans and processes should be rapidly reviewed to determine their feasibility in managing a complex, intensive, and lengthy disaster recovery process. Factors to consider include designation of full-time recovery coordinators for an RDD incident instead of relying exclusively on other personnel such as emergency managers who might traditionally perform LDRM duties in an expansion of their existing roles.

- Even though an RDD incident may be small in terms of total area of geographic impact, it is likely to garner a significant amount of attention. This attention means that even a "small" incident could involve recovery coordination requirements equivalent to or larger than an extremely large regional disaster or Type 1 incident.

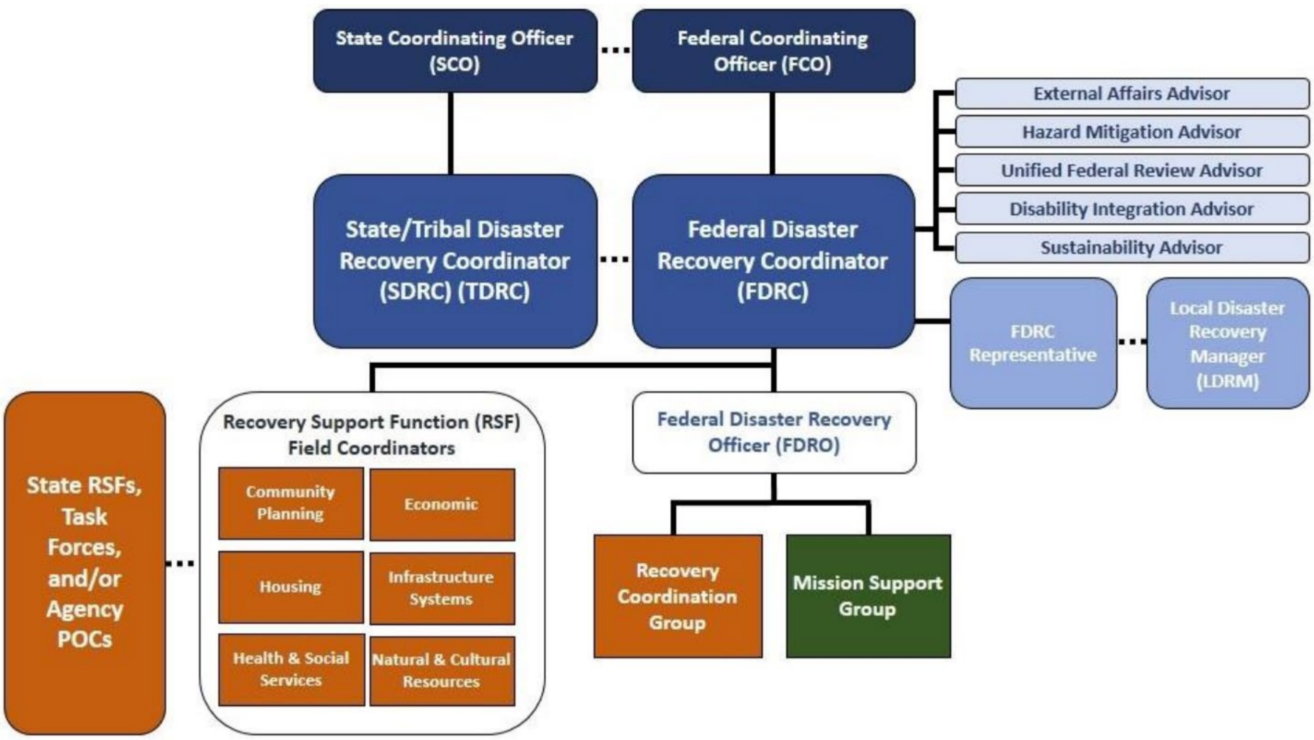

Figure 10: Interagency Recovery Coordination Structure (Source: FEMA, Recovery FIOP)[81]

[81] The FEMA Recovery Federal Interagency Operation Plan (FIOP), 2016, can be found online at: https://www.fema.gov/sites/default/files/documents/fema_recovery-fiop.pdf

Activity 10.3: Engage Stakeholders Representing Recovery Core Capability Groups

- **Identify stakeholders for recovery core capability delivery:** The NDRF relies upon coordination of recovery core capabilities through a Recovery Support Function (RSF) structure. In an RDD incident, recovery capabilities are likely to be employed for an extended period of time and in circumstances different from other hazards such as hurricanes or wildfires.
    - Identifying stakeholders and organizations that can support recovery capabilities will be crucial for ramping up long-term recovery efforts. Recovery core capabilities are defined in the NDRF; a crosswalk with likely RDD considerations is provided in Table 26:.
- **Determine which entities have a vested or regulatory interest in the recovery process.** Recovery capabilities include those organizations that have statutory, regulatory, or rules-based responsibilities and/or resources relevant to a particular disaster, including an RDD incident. For example, vested or interested entities could include, but not be limited to, historical and environmental protection agencies, cultural and heritage organizations, economic development entities, planning commissions and zoning authorities, and other organizations that have requirements for mandatory permitting, consulting, or approvals for recovery work to proceed. In an RDD incident, some of these entities may have modified or expanded roles. Identifying the degree to which each stakeholder across all the capabilities has a specific role related to the unique circumstances of the RDD incident will be crucial to developing a streamlined and efficient recovery coordination process.
- **Align processes and procedures.** Where possible, regulatory and permit-granting organizations should be encouraged to coordinate, consolidate, and streamline processes, record-keeping, and contact with survivors and other recovery stakeholders to provide a simplified recovery process flow. This alignment is even more important given a scenario in which survivors have been relocated outside of the affected areas and will likely be required to interact with many SLTT and federal agencies.

Table 26: Potential RDD Considerations for Recovery Core Capabilities

Recovery Core Capability	Potential RDD Considerations
Planning	May require professional planning support that can integrate with the technical aspects of the radiological HAZMAT optimization and remediation processes.
Public Information and Warning	May require extended commercial support for the maintenance of telephone and internet customer service-like portals for affected individuals, if large in number. May require augmentation to keep track of individuals who have evacuated or relocated out of the affected jurisdiction.

Recovery Core Capability	Potential RDD Considerations
Operational Coordination	Recovery planning is likely to be intensive and extend for a long time. Professional support in designing, managing, and facilitating the recovery coordinating structure and its business processes may be appropriate.
Economic Recovery	Given the potential for substantial economic impacts from an RDD incident, expertise in coordinating with the private sector (beyond the more traditional disaster recovery functions) may be needed. Additionally, specific matters associated with insurance coverages and various government assistance programs may require the engagement of SMEs and non-routine disaster recovery organizations.
Health and Social Services	Challenges with providing longer-term health and social services could be related to (1) the particular risks associated with an RDD incident, as well as (2) technical expertise and capabilities necessary to serve the affected population.
Housing	An RDD incident could potentially generate a requirement for extended disaster housing assistance in an area not otherwise accustomed to performance of a direct housing mission.
Infrastructure Systems	Coordination of infrastructure stakeholders in support of remediation and recovery processes will likely require substantial effort and bandwidth beyond that typically involved for a natural disaster of equivalent impact.
Natural and Cultural Resources	Ecological and environmental considerations in an RDD incident may substantially drive the involvement of natural and cultural resources entities beyond that traditionally encountered in a natural disaster.

Activity 10.4: Manage Recovery Efforts by Leveraging the Recovery Support Functions

- **Plan for extended recovery operations.** RDD incident recovery may last for years. It is important to take this long-term context into consideration at the very beginning of recovery planning efforts, so that relevant structures, systems, and processes can be established to endure for a significant period of time.

- **Utilize the recovery coordinating structure to interface with recovery support functions (RSFs) at the state/tribal/territorial and federal levels.** The RSF structure provides the mechanism for aligning efforts across all interested parties and stakeholders to accomplish recovery objectives as supported via recovery core capabilities. In other words, each RSF represents a different group of organizations, all of which share different capability sets within their respective areas of responsibility. The RSFs are listed in Table 27:.

    - In an RDD scenario, where complex challenges are likely to be encountered and endure for extended periods (years), leveraging the RSF structure to coordinate activities among interested parties can provide a robust, enduring, trackable, and manageable means to identify, troubleshoot, and solve problems.

- **Provide education and orientation for recovery stakeholders about the longer-term radiological hazards presented by an RDD incident.** Many organizations participating in the recovery process will have minimal-to-no technical expertise in radiological incident response and recovery. For the recovery process to proceed efficiently, consider providing a baseline training and orientation about radiological hazards (and especially the unique facts and circumstances of the RDD event in question) to attain a common level of awareness. This training is likely to be a useful measure to prevent misunderstandings and miscommunications, especially during the early phases of recovery.

- **Expand RSF participation to include representatives of organizations beyond the immediate RDD impact area.** An RDD incident of significance is likely to generate second- and third-order effects far beyond the detonation site, contaminated areas, or evacuation/relocation zones. This may be due to multiple factors including the stigma associated with radiological contamination, interruption of essential services and infrastructure, or loss of access to critical facilities in the affected area that serve a much larger population in a broader region. Additionally, even though an RDD incident may be hyper-localized in its physical impacts and effects, it may have a psychological impact on a much broader area. For this reason, it is advisable to proactively engage regional stakeholders early in the recovery process by incorporating them into the appropriate RSF coordinating groups.

Table 27: RSF – RDD Incident Crosswalk

Recovery Support Function	Description and RDD Special Considerations
Community Planning and Capacity Building	▪ Focuses on coordinating planning efforts. ▪ RDD Considerations: May involve a period of technical orientation and education among stakeholders regarding the specific hazards, risks, and challenges associated with a radiological incident, as well as a learning curve for understanding and interpreting technical data and reports such as dose assessments, the optimization process, and modeling.
Economic Recovery	▪ Focuses on addressing and mitigating impacts to the financial/commercial prosperity and vigor of the affected area's economy. ▪ RDD Considerations: Will likely entail extensive, direct, and targeted outreach on behalf of the recovery coordinating structure to engage with affected business, commercial, and private sector entities in the RDD impact area. This will necessarily include a liaison role on behalf of business and economic development interests to the rest of the recovery coordinating group, and could include facilitation of educational outreach and training for businesses about the radiological event and the technical aspects of its impact and the recovery process.
Health and Social Services	▪ Focuses on providing medical, social, welfare, and other adjacent support functions to individuals, households, families, and children.

Recovery Support Function	Description and RDD Special Considerations
	▪ RDD Considerations: Where disruption to health and social services agencies has occurred due to interruption of activities or relocation from existing facilities, coordination with other RSFs likely will be needed to ensure consistency and maintenance of a baseline level of support services to the affected population. Note that health and social services agencies may serve a large population in a geographic area exceeding that impacted directly by the RDD incident. In this case, the served population in this greater area of indirect impact could potentially increase the number of individuals to be considered several fold. One example is the loss of access to a critical facility like a hospital and the cascading impacts of that contingency on the surrounding areas. Additionally, people who were exposed to radiation contamination during the incident will need to participate in a long-term population monitoring program to enable identification and mitigation of enduring health effects associated with such exposure.
Housing	▪ Focuses on providing housing solutions to individuals displaced by a disaster or who are without access to adequate/safe housing. ▪ RDD Considerations: In a relocation scenario, an RDD incident is likely to generate the requirement for a direct housing mission (provision of temporary residences by a governmental entity like a state or FEMA). Even in an evacuation-only scenario, housing challenges such as loss of access to check for damages or to manage utilities and services could generate cascading effects in terms of housing repair/replacement requirements.
Infrastructure Systems	▪ Focuses on maintenance and restoration of CI and related services in the affected area. ▪ RDD Considerations: While direct impacts to infrastructure in a typical RDD scenario may be limited, second-order effects could generate longer-term infrastructure damage and failures, as well as longer-term health impacts on essential workers in CI industries. As with other areas of concern, this can be related to both loss of access to critical systems as well as particular variables associated with RDD incident impacting infrastructure systems such as water systems, subway transportation, etc.
Natural and Cultural Resources	▪ Focuses on providing cultural services during the recovery process as well as compliance with cultural and environmental rules and regulations. ▪ RDD Considerations: An RDD incident likely will present long-term environmental challenges. Remediation activities may generate significant quantities of radioactive waste that must be transported and stored in designated locations. Proactive engagement of cultural and environmental stakeholder organizations through this RSF is advisable to deconflict overlapping interests and avoid potential pitfalls throughout the recovery process.

Recommended Resources:

- Recovery from Chemical, Biological, and Radiological Incidents: Critical Infrastructure and Economic Impact Considerations (Sandia National Laboratories, 2012) https://www.osti.gov/servlets/purl/1177064.
- Incident Stabilization Guide (Operational Draft) (FEMA, 2020) https://www.fema.gov/sites/default/files/2020-05/IncidentStabilizationGuide.pdf.
- National Disaster Recovery Framework (NDRF) (FEMA) https://www.fema.gov/emergency-managers/national-preparedness/frameworks/recovery.
- Community Lifelines Implementation Toolkit (FEMA) https://www.fema.gov/emergency-managers/practitioners/lifelines-toolkit.
- Recovery Federal Interagency Operational Plan (FEMA, 2016) https://www.fema.gov/sites/default/files/documents/fema_recovery-fiop.pdf.
- Effective Coordination of Recovery Resources for State, Tribal, Territorial and Local Incidents (FEMA, 2015) https://www.fema.gov/sites/default/files/2020-07/fema_effective-coordination-recovery-resources-guide_020515.pdf.
- Holt, Mark. "Price-Anderson Act: Nuclear Power Industry Liability Limits and Compensation to the Public After Radioactive Releases." *In Focus.* (Congressional Research Service, February 25, 2018) https://crsreports.congress.gov/product/pdf/IF/IF10821.
- Faculty of Societal Safety Sciences, Kansai University. *The Fukushima and Tohoku Disaster: A Review of the Five-Year Reconstruction Efforts*. (Elsevier, 2018) www.sciencedirect.com/book/9780128140789/the-fukushima-and-tohoku-disaster.
- Nuclear/Radiological Incident Annex to the Response and Recovery FIOPs (FEMA) https://www.fema.gov/sites/default/files/2020-07/fema_incident-annex_nuclear-radiological.pdf.
- Federal Plan for Equitable Long-Term Recovery and Resilience for Social, Behavioral, and Community Health (HHS, 2022). https://health.gov/our-work/national-health-initiatives/equitable-long-term-recovery-and-resilience.

References

(FEMA), F. E. (2021). *Individual Assistance Program and Policy Guide (IAPPG)* (Version 1.1 ed.). Washington, DC: FEMA. Retrieved from https://www.fema.gov/sites/default/files/documents/fema_iappg-1.1.pdf

(February 2015). *A Guide to Operating Public Shelters in a Radiation Emergency.* Centers for Disease Control and Prevention. Retrieved from https://www.emergency.cdc.gov/radiation/pdf/operating-public-shelters.pdf

(August 1998). *Accidental Radioactive Contamination of Human Food and Animal Feeds: Recommendations for State and Local Agencies* . Center for Devices and Radiological Health, U.S. Food and Drug Administration. Retrieved from https://www.fda.gov/regulatory-information/search-fda-guidance-documents/accidental

Acute Radiation Syndrome (ARS): A Fact Sheet for the Public: Centers for Disease Control and Prevention. Retrieved from https://www.cdc.gov/nceh/radiation/emergencies/ars.htm

Agreement State Program. (n.d.). Retrieved from www.nrc.gov: https://www.nrc.gov/about-nrc/state-tribal/agreement-states.html

All Hazards Waste Management Planning (WMP) Tool. (n.d.). Environmental Protectuion Agency Retrieved from https://wasteplan.epa.gov/

Annex 3: Personal Protective Equipment Recommendations. (2017). In *Radiological Dispersal Device Response Guidance: Planning for the First 100 Minutes.* National Urban Security Technology Laboratory, U.S. Department of Homeland Security. Retrieved from https://www.dhs.gov/sites/default/files/publications/NUSTL_RDD-ResponsePlanningGuidance-Public_171215-508.pdf

Appendix A: Emergency Communications "Top 10" Planning Checklist (EPA-402-F-07-008). (2007). In *Communicating Radiation Risks: Crisis Communications for Emergency Responders* (pp. 63-66). Environmental Protection Agency. Retrieved from https://www.epa.gov/radiation/pag-public-communication-resources

ATSDR Rapid Response Registry: Retrieved from https://www.atsdr.cdc.gov/rapidresponse/

Calculate Your Radiation Dose [Online dose calculator tool]. (n.d.). (E. P. Agency, Producer) Retrieved from www.epa.gov: https://www.epa.gov/radiation/calculate-your-radiation-dose

(2016) Capitol Region Hazardous Materials Response Plan. Prepared for Connecticut Division of Emergency Management and Homeland Security. Emergency Planning Committee. Available online at: https://crcog.org/wp-content/uploads/2016/06/CR-HMERP-1.pdf.

(n.d.). *Catalog of Federal Disaster Recovery Assistance Programs.* Houston-Galveston Area Council. Retrieved from www.h-gac.com/getmedia/cd717db1-3bbf-4f72-ab5c-016901b6bd27/Catalog_of_Federal_Disaster_Assistance_Programs.pdf

(2006). CBRN Decontamination: Multiservice Tactics, Techniques, and Procedures for Chemical, Biological, Radiological, and Nuclear Decontamination. Joint Chiefs of Staff

Centers for Disease Control and Prevention. (2010). Community Reception Center Simulation Tool for Evaluation and Planning (CRC-STEP) . Retrieved from https://www.orau.gov/rsb/step/

Centers for Disease Control and Prevention. Community Reception Center Electronic Data Collection Tool (CRC eTool): Retrieved from https://www.cdc.gov/nceh/radiation/emergencies/crcetool.htm

Centers for Disease Control and Prevention Community Reception Centers webpage (for the public). Retrieved from https://www.cdc.gov/nceh/radiation/emergencies/crcs.htm

(2021) Centers for Disease Control: *SimPLER (Simulation Program for Leveraging and Evaluating Resources)*. Available online at: https://ephtracking.cdc.gov/Applications/simPler/.

(2020) *Psychological First Aid: Addressing Mental Health Distress during Disasters*. Centers for Disease Control and Prevention. Retrieved from https://emergency.cdc.gov/epic/learn/2020/webinar_20200422.asp

(n.d.) Cybersecurity & Infrastructure Security Agency. *Foreign Influence Operations and Disinformation*. Available online at: https://www.cisa.gov/topics/election-security/foreign-influence-operations-and-disinformation

(2013). *Communicating During and After a Nuclear Power Plant Incident.* Federal Emergency Managment Agency. Retrieved from https://www.fema.gov/sites/default/files/documents/fema_nuclear-power-plant-incident_communicating-during-after_june-2013.pdf

(July 2007). *Communicating Radiation Risks: Crisis Communication for Emergency Responders (EPA-402-F-07-008).* Environmental Protection Agency, Office of Radiation and Indoor Air. Retrieved from https://www.epa.gov/sites/default/files/2017-07/documents/epa_communicating_radiation_risks.pdf

(November 2019). *Community Lifelines Implementation Toolkit. Version 2.0.* Federal Emergency Management Agency, U.S. Department of Homeland Security. Retrieved from https://www.fema.gov/sites/default/files/2020-05/CommunityLifelinesToolkit2.0v2.pdf

Conference of Radiation Control Program Directors, Inc. (2006). *Handbook for Responding to a Radiological Dispersal Device: First Responders Guide - The First Twelve Hours.* Retrieved from https://dpbh.nv.gov/uploadedFiles/dpbhnvgov/content/Reg/Radiation-Incidents/Docs/RDD-Handbook-ForWeb.pdf

CRC-STEP: Community Reception Center Simulation Tool for Evaluation and Planning. (n.d.). (Centers for Disease Control and Prevention, U.S. Department of Health and Human Services) Retrieved from https://www.orau.gov/rsb/step/

(2018). *Crisis and Emergency Risk Communication: Community Engagement.* Centers for Disease Control and Prevention. Retrieved from https://emergency.cdc.gov/cerc/ppt/CERC_CommunityEngagement.pdf

(2008) Critical Infrastructure and Key Resources Support Annex to the NRF. Federal Emergency Management Agency. Retrieved from https://www.fema.gov/pdf/emergency/nrf/nrf-support-cikr.pdf

(2016). Current and Emerging Post-Fukushima Technologies, and Techniques, and Practices for Wide Area Radiological Survey, Remediation, and Waste Management. Environmental Protection Agency, Washington, DC.

(2006) *Data Quality Assessment: A Reviewer's Guide*. EPA QA/G-9R, EPA/240/B-06/002. Environmental Protection Agency, Office of Environmental Information. Retrieved from https://www.epa.gov/sites/default/files/2015-08/documents/g9r-final.pdf

(2000). *Decommissioning Handbook: Procedures and Practices for Decommissioning.* U.S. Department of Energy. Retrieved from https://www.osti.gov/biblio/1491121

(2008). *Decontamination and Decommissioning of Radiologically Contaminated Facilities.* Radionuclides Team, Interstate Technology & Regulatory Council (ITRC). Retrieved from https://connect.itrcweb.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=2a9bed64-15d2-4c53-8f2d-1d5100e5fc89

Decontamination – Pets. Centers for Disease Control and Prevention. Retrieved from https://www.cdc.gov/nceh/radiation/emergencies/selfdecon_pets.htm?CDC_AA_refVal=https%3A%2F%2Femergency.cdc.gov%2Fradiation%2Fselfdecon_pets.aspPlanning Guidance for Response to a Nuclear Detonation - Appendix 5.3: Screening and Decontamination

(October 2012). *Denver UASI All-Hazards Regional Recovery Framework, Version 1.1.* U.S. Department of Homeland Security. Retrieved from https://apps.dtic.mil/sti/pdfs/ADA581081.pdf

(November 2010). *Developing and Maintaining Emergency Operations Plans: Comprehensive Preparedness Guide (CPG) 101, Version 2.0.* U.S. Department of Homeland Security. Retrieved from https://www.fema.gov/pdf/about/divisions/npd/CPG_101_V2.pdf

(2011) DOE Standard Operating Procedure for Demolition of Facilities in Area IV at the Santa Susana Field Laboratory., Department of Energy

Educational Videos. (2021). Retrieved from Radiation Emergencies Resource Library, www.cdc.gov: https://www.cdc.gov/nceh/radiation/emergencies/protectiveactions.htm

(2015) *Effective Coordination of Recovery Resources for State, Tribal, Territorial and Local Incidents*, Federal Emergency Management Agency. Retrieved from https://www.fema.gov/sites/default/files/2020-07/fema_effective-coordination-recovery-resources-guide_020515.pdf

(August 22, 1997). *Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination (OSWER Directive 9200.4-18).* Environmental Protection Agency. Retrieved from https://semspub.epa.gov/work/06/640873.pdf

(1994) "EM Health and Safety Plan, DOE-EM-STD-5503-94. DOE Standard. Available online at: https://www.standards.doe.gov/standards-documents/5000/5503-astd-1994/@@images/file

(2019). *Fact Sheet: Safe, Sanitary, and Functional Homes.* Federal Emergency Management Agency. Retrieved from www.fema.gov/print/pdf/node/344142

Farm Service Agency Disaster Assistance Programs at a Glance. (2017). Retrieved from Disaster Assistance Fact Sheet: https://www.fsa.usda.gov/Assets/USDA-FSA-

Public/usdafiles/FactSheets/archived-fact-sheets/fsa_disaster_assistance_programs_at_a_glance_march2017.pdf

Federal Emergency Management Agency. (2008, August 1). Planning Guidance for Protection and Recovery Following Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) Incidents. *Federal Register, 73(149)*, 45029−45048. Retrieved from https://www.govinfo.gov/content/pkg/FR-2008-08-01/pdf/E8-17645.pdf

Federal Emergency Management Agency. (2019, November). Community Lifelines Implementation Toolkit 2.0. Retrieved from www.fema.gov/sites/default/files/2020-05/CommunityLifelinesToolkit2.0v2.pdf

(2020). *FEMA Preliminary Damage Assessment Guide.* Federal Emergency Management Agency. Retrieved from www.fema.gov/sites/default/files/2020-07/fema_preliminary-disaster-assessment_guide.pdf

(June 2014). Field Guide for Health and Safety Officers: Radiological Incidents, Part 1 Operational Guidance and Part 2 Background Information. New York City Department of Health and Mental Hygiene. Retrieved from https://remm.hhs.gov/fieldguide.htm

(2000) *First Responders' Environmental Liability Due to Mass Decontamination Runoff*. Environmental Protection Agency. Available online at: https://www.epa.gov/sites/default/files/2013-11/documents/onepage.pdf.

Getting Back Into your Home. (n.d.). Retrieved from https://www1.nyc.gov/assets/buildings/pdf/getting_back_into_your_home.pdf

(2020). *Guidance on Planning for Recovery Following a Nuclear or Radiological Emergency.* Health Canada. Retrieved from www.canada.ca/en/health-canada/services/publications/health-risks-safety/planning-recovery-nuclear-emergency.html

Guidelines for Handling Decedents Contaminated with Radioactive Materials. Centers for Disease Control and Prevention. Retrieved from https://www.cdc.gov/nceh/radiation/emergencies/pdf/radiation-decedent-guidelines.pdf

(September 2006). *Handbook for Responding to a Radiological Dispersal Device: First Responders Guide-The First 12 Hours.* Conference of Radiation Control Program Directors. Retrieved from https://tools.niehs.nih.gov/wetp/public/hasl_get_blob.cfm?ID=6229

(May 1995). *Hanford Site Risk Assessment Methodology (DOE/RL-91-45, Rev. 3).* Richland Operations Office, U.S. Department of Energy. Retrieved from https://www.nrc.gov/docs/ML0534/ML053400188.pdf

(1994). *Hazard Baseline Documentation (DOE-EM-STD-5503-94).* U.S. Department of Energy. Retrieved from https://www.standards.doe.gov/standards-documents/5000/5503-astd-1994/@@images/file

Heal, G., & Kunreuther, H. (2009). *Environmental Assets & Liabilities: Dealing with Catastrophic Risks.* University of Pennsylvania. Retrieved from sipa.columbia.edu/sites/default/files/migrated/documents/WP2008-11-06_GH%2CHK_EnvAssets.pdf

Heiser, J., & Sullivan, T. (2009). *Decontamination Technologies Task 3: Urban Remediation and Response Project.* Brookhaven National Laboratory. Retrieved from https://www.bnl.gov/isd/documents/45491.pdf

Holt, M. (2018, February 25). Price-Anderson Act: Nuclear Power Industry Liability Limits and Compensation to the Public After Radioactive Releases . *In Focus*. Retrieved from https://crsreports.congress.gov/product/pdf/IF/IF10821

Horney, J., Dwyer, C., Aminto, M., Berke, P., & Smith, G. (2017, January). Developing Indicators to Measure Post-Disaster Community Recovery in the United States. *Disasters, 41*(1), 124-149. Retrieved from https://doi.org/10.1111/disa.12190

Hurricane Sandy Recovery . (n.d.). Retrieved from NYC 311: https://portal.311.nyc.gov/article/?kanumber=KA-02808.

(2006). "ICRP Publication 101b: The Optimisation of Radiological Protection: Broadening the Process." ICRP Available online at: https://www.icrp.org/publication.asp?id=ICRP%20Publication%20101b

(2013). *Improved Nuclear Device Response and Recovery: Communicating in the Immediate Aftermath.* Federal Emergency Management Agency. Retrieved from https://www.fema.gov/sites/default/files/documents/fema_improvised-nuclear-device_communicating-aftermath_june-2013.pdf

(2020) *Incident Stabilization Guide* (Operational Draft). Federal Emergency Management Agency. Retrieved from https://www.fema.gov/sites/default/files/2020-05/IncidentStabilizationGuide.pdf

Infographics. (2021). Retrieved from Radiation Emergencies Resource Library, www.cdc.gov: https://www.cdc.gov/nceh/radiation/emergencies/resourcelibrary/infographics.htm

(2011). *Insurance Coverage for Nuclear Accidents.* Insurance Information Institute. Retrieved from www.iii.org/article/insurance-coverage-nuclear-accidents

Decontamination and Decommissioning of Radiologically Contaminated Facilities. Interstate Technology & Regulatory Council (ITRC), Retrieved from https://connect.itrcweb.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=2a9bed64-15d2-4c53-8f2d-1d5100e5fc89

(2021) Dosimetry. NRC Available online at*: https://www.nrc.gov/reading-rm/basic-ref/glossary/dosimetry.html*

Incident Waste Decision Support Tool (I-WASTE DST). Environmental Protection Agency. Retrieved from https://iwaste.epa.gov/guidance

(September 2012, September). *Key Planning Factors for Recovery from a Radiological Terrorism Incident.* Science and Technology Directorate, U.S. Department of Homeland Security. Retrieved from https://www.hsdl.org/?abstract&did=756119

Listing of Disaster Recovery Funding Sources. (2017, August 25). Washington State Military Department. Retrieved from https://mil.wa.gov/asset/5ba4208ddd3a7

Lloyd, E. R. (2007). *Open Air Demolition of Facilities Highly Contaminated with Plutonium.* Office of Environmental Management, U.S. Department of Energy. Retrieved from https://www.osti.gov/servlets/purl/908296

Management and Disposal of Vehicles Following a Wide Area Incident: Literature Review and Stakeholder Workshop Environmental Protection Agency. Retrieved from https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=345827&Lab=NHSRC&fed_org_id=1253&subject=Homeland%20Security%20Research&view=desc&sortBy=pubDateYear&showCriteria=1&count=25&searchall=%27indoor%20outdoor%20decontamination

Manual for First Responders to a Radiological Emergency Preparedness and Response. International Atomic Energy Agency. Retrieved from https://www.iaea.org/publications/7606/manual-for-first-responders-to-a-radiological-emergency

(1992) *Monitoring Programmes for Unrestricted Release Related to Decommissioning of Nuclear Facilities.* IAEA. Available online at: https://inis.iaea.org/collection/NCLCollectionStore/_Public/23/075/23075816.pdf.

Monitoring Radionuclides in Drinking Water and Food: Routinely and After a Release. (n.d.). Retrieved from Radiation Emergency Medical Management (REMM) website: https://remm.hhs.gov/radmonitor_water_food.htm

(2000 (NRC 2001)). *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM). Rev.1 (NUREG-1575, Rev.1, EPA 402-R-97-016, Rev.1)* . August 2000) : Radiation Protection Division, Office of Radiation and Indoor Air, U.S. Environmental Protection Agency also Nuclear Regulatory Commission. Retrieved from https://www.epa.gov/sites/default/files/2017-09/documents/marssim_manual_rev1.pdf

Musolino, S., Harper, F. T., Buddemeier, B., Brown, M., & Schlueck, R. (2013, July). Updated Emergency Response Guidance for the First 48 Hours after the Outdoor Detonation of an Explosive Radiological Dispersal Device. *Health Physics, 105*(1), 65-73. Retrieved from https://doi.org/10.1097/HP.0b013e31828a8fb1

National Council on Radiation Protection and Measurements. (2001). *Report 138, Management of Terrorist Events Involving Radioactive Material.* Bethesda, MD. Retrieved from https://ncrponline.org/shop/reports/report-no-138-management-of-terrorist-events-involving-radioactive-material-2001/

National Council on Radiation Protection and Measurements. (2005). *Commentary 19, Key Elements of Preparing Emergency Responders for Nuclear and Radiological Terrorism.* Bethesda, MD. Retrieved from https://ncrponline.org/shop/commentaries/commentary-no-19-key-elements-of-preparing-emergency-responders-for-nuclear-and-radiological-terrorism-2005/

National Council on Radiation Protection and Measurements. (2008). *Report 161.1, Management of Persons Contaminated with Radionuclides.* Bethesda, MD. Retrieved from https://ncrponline.org/shop/reports/report-no-161-i-management-of-persons-contaminated-with-radionuclides-handbook/

National Council on Radiation Protection and Measurements. (2010). *Report 165, Responding to a Radiological or Nuclear Terrorism Incident: A Decision-Makers Guide.* Bethesda, MD.

Retrieved from https://ncrponline.org/shop/reports/report-no-165-responding-to-a-radiological-or-nuclear-terrorism-incident-a-guide-for-decision-makers/

National Council on Radiation Protection and Measurements (2014) Report 175: Decision Making for Late-Phase Recovery from Major Nuclear or Radiological Incidents.

National Council on Radiation Protection and Measurements. (2017). *Report 179, Guidance for Emergency Response Dosimetry.* Bethesda, MD. Retrieved from https://ncrponline.org/shop/reports/report-no-179-guidance-for-emergency-response-dosimetry-2017/

National Council on Radiation Protection and Measurements. (n.d.). *Commentary 28, Implementation Guidance for Emergency Response Dosimetry.* Retrieved from https://ncrponline.org/shop/commentaries/commentary-no-28-implementation-guidance-for-emergency-response-dosimetry/

(January 2009). *National Disaster Housing Strategy.* Federal Emergency Managment Agency. Retrieved from www.fema.gov/pdf/emergency/disasterhousing/NDHS-core.pdf

(2016). *National Disaster Recovery Framework. Second Edition.* U.S. Department of Homeland Security. Retrieved from https://www.fema.gov/emergency-managers/national-preparedness/frameworks/recovery

(2019) National Response Framework, 4th Ed. Federal Emergency Management Agency. Retrieved from https://www.fema.gov/sites/default/files/2020-04/NRF_FINALApproved_2011028.pdf

(2013) National Urban Search and Rescue Response System Marking Standards Handbook. FEMA

(October 2016). *Nuclear/Radiological Incident Annex to the Response and Recovery Federal Interagency Operational Plans.* Federal Emergency Management Agency. Retrieved from https://www.fema.gov/sites/default/files/2020-07/fema_incident-annex_nuclear-radiological.pdf

OSHA (*1910.120 – Hazardous waste operations and emergency response.* Available online at: https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.120

(July 2019). *Planning Considerations: Evacuation and Shelter-in-Place – Guidance for State, Local, Tribal and Territorial Partners.* Federal Emergency Management Agency, U.S. Department of Homeland Security. Retrieved from fema.gov: https://www.fema.gov/sites/default/files/2020-07/planning-consi

Planning Guidance for Protection and Recovery Following Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) Incidents (FEMA–2004–0004). (2008, August 1). *Federal Register, 73*(149), pp. 45029–45048. Retrieved from https://www.govinfo.gov/content/pkg/FR-2008-08-01/pdf/E8-17645.pdf

Planning Guidance for Response to a Nuclear Detonation - Appendix 5.2: Strategies for Screening and Decontaminating People. Federal Emergency Management Agency. Retrieved from https://www.fema.gov/sites/default/files/documents/fema_nuc-detonation-planning-guide.pdf

Planning Guidance for Response to a Nuclear Detonation - Appendix 5.3: Screening and Decontamination. Federal Emergency Management Agency. Retrieved from https://www.fema.gov/sites/default/files/documents/fema_nuc-detonation-planning-guide.pdf

Planning Guidance for Response to a Nuclear Detonation - Appendix 5.4: Handling Contaminated Vehicles. Federal Emergency Management Agency. Retrieved from https://www.fema.gov/sites/default/files/documents/fema_nuc-detonation-planning-guide.pdf

Policies for Guiding Planning for Post-Disaster Recovery and Reconstruction. (2005). In *Planning for Post-Disaster Recovery and Reconstruction (PAS Report 383/384)* (pp. 43-74). American Planning Association. Retrieved from www.fema.gov/pdf/rebuild/ltrc/fema_apa_ch3.pdf

Population Monitoring After Radiation Emergencies. Department of Health and Human Services, Radiation Emergency Medical Management. Retrieved from: https://remm.hhs.gov/surveillance.htm

Population Monitoring, Community Reception Centers (CRC), and Shelter Resources for Radiation Emergencies (for responders). Centers for Disease Control and Prevention. Retrieved from https://www.cdc.gov/nceh/radiation/emergencies/populationmonitoring.htm

(April 2014). *Population Monitoring in Radiation Emergencies: A Guide for State and Local Public Health Planners.* Centers for Disease Control and Prevention. Retrieved from http://emergency.cdc.gov/radiation/pdf/population-monitoring-guide.pdf

(2019). *Post-Disaster Building Safety Evaluation Guidance (FEMA-P 2055).* Federal Emergency Management Agency. Retrieved from www.fema.gov/sites/default/files/2020-07/fema_p-2055_post-disaster_buildingsafety_evaluation_2019.pdf

(2010). *Post-Disaster Redevelopment Planning: A Guide for Florida Communities.* Florida Department of Community Affairs, Florida Division of Emergency Management. Retrieved from www.floridadisaster.org/globalassets/importedpdfs/post-disaster-redevelopment-planning-guidebook-lo.pdf

(2017). *Pre-Disaster Recovery Planning Guide for Local Governments.* Federal Emergency Management Agency. Retrieved from https://www.fema.gov/sites/default/files/2020-06/pre-disaster_recovery_planning_guide_local_governments.pdf

Pre-incident All-hazards Waste Management Plan Guidelines: Four-Step Waste Management Planning Process (EPA 530-F-19-006). (n.d.). Retrieved from www.epa.gov: https://www.epa.gov/sites/default/files/2019-05/documents/4_steps_document.pdf

Preliminary Remediation Goals for Radionuclides on Outdoor Surfaces at Superfund Sites Calculator Environmental Protection Agency/Oak Ridge National Laboratory. Retrieved from *https://epa-sprg.ornl.gov/*

Preventing and Treating Radiation Injuries and Illness. Centers for Disease Control and Prevention: Retrieved from https://www.cdc.gov/nceh/radiation/emergencies/symptoms.htm

(2019) *Program Manual: Radiological Emergency Preparedness*. FEMA Available online at: https://www.fema.gov/sites/default/files/2020-06/FEMA_REP_Program_Manual_Dec_2019.pdf

Protecting America: The Reauthorization of the Terrorism Risk Insurance Program. (2019). Hearings on H.R. 4634 Before the Committee on Financial Services, Subcommittee on Housing, Community Development and Insurance and the Subcommittee on National Security, International Development, and Monetary Policy, (statement of Baird Webel, Specialist in Financial Economics, Congressional Research Service). 116th Congress. Retrieved from https://www.congress.gov/116/meeting/house/110078/witnesses/HHRG-116-BA04-Wstate-WebelB-20

Protective Action Area Map Templates. (EPA-420). (2017). Retrieved from www.epa.gov: https://www.epa.gov/sites/default/files/2017-11/protective_action_area_map_templates_11202017_final_1.docx.

(2017) *PAG Manual: Protective Action Guidance and Planning for Radiological Incidents* U.S. Environmental Protection Agency. Retreived from https://www.epa.gov/radiation/protective-action-guides-pags

(2017). *Protective Action Guides and Planning Guidance for Radiological Incidents (EPA-400/R-17/001).* Radiation Protection Division, Office of Radiation and Indoor Air, U.S. Environmental Protection Agency. Retrieved from https://www.epa.gov/sites/default/files/2017-01/documents/epa_pag_manual_final_revisions_01-11-2017_cover_disclaimer_8.pdf

(2022, January). Protective Action Question & Answers for Radiological & Nuclear Emergencies: A companion document to the U.S. Environmental Protection Agency Protective Action Guide (PAG) Manual. U.S. Environmental Protection Agency. Retrieved from www.epa.gov: https://www.epa.gov/system/files/documents/2022-02/pags_comm_tool_2022.pdf

Quarantelli, E. L. (1999). The Disaster Recovery Process: What We Know and Do Not Know from Research. *Preliminary Paper #286*. Disaster Research Center, University of Delaware. Retrieved from udspace.udel.edu/bitstream/handle/19716/309/PP%20286.pdf?sequence=1&isAllowed=

Radiation at Superfund Sites. (2021). *www.epa.gov*. Retrieved from www.epa.gov: https://www.epa.gov/superfund/radiation-superfund-sites

Radiation Emergencies: What to Expect at a Community Reception Center (CRC). Centers for Disease Control and Prevention https://www.cdc.gov/nceh/radiation/emergencies/crcs_ld.htm

(1994) *Radiation Site Cleanup Regulations: Technical Support Document for the Development of Radionuclide Cleanup Levels for Soil.* EPA 402-R-96-001a, Review Draft. Environmental Protection Agency, Office of Radiation and Indoor Air. Retrieved from https://www.epa.gov/sites/default/files/2015-05/documents/402-r-96-011a_intro.pdf

(December 2022) *Radiological Data Assessment Guidance for Emergency* Response Retrieved from https://www.cbrnresponder.net/app/index#resources/documents/download/2308

(2022) Radioactive Effluent and Environmental Reports. NCC. Available online at: *https://www.nrc.gov/reactors/operating/ops-experience/tritium/plant-info.html*

Radioactive Waste. (n.d.). Retrieved from www.nrc.gov: https://www.nrc.gov/waste.html

Radioactive Waste Disposal: An Environmental Perspective. Environmental Protection Agency. Retrieved from https://www.epa.gov/radiation/radioactive-waste-disposal-environmental-perspective

(2017). *Radiological Dispersal Device (RDD) Response Guidance, Planning for the First 100 Minutes.* National Urban Security Technology Laboratory. U. S. Department of Homeland Security. Retrieved from www.dhs.gov/sites/default/files/publications/nustl_rdd-responseplanning

(2016) Recovery Federal Interagency Operational Plan. Federal Emergency Management Agency https://www.fema.gov/sites/default/files/documents/fema_recovery-fiop.pdf

(2012) *Recovery from Chemical, Biological, and Radiological Incidents: Critical Infrastructure and Economic Impact Considerations*. Sandia National Laboratories. Retrieved from https://www.osti.gov/servlets/purl/1177064

Removal Action (Title 40 Volume 29 section 300-415 (40 CFR 300.415), US Code of Federal Regulations. Retrieved from https://www.gpo.gov/fdsys/granule/CFR-2012-title40-vol29/CFR-2012-title40-vol29-sec300-415

REP-22: Contamination Monitoring Guidance for Portable Instruments Used for Radiological Emergency Response to Nuclear Power Plant Accidents Federal Emergency Management Agency: Retrieved from https://remm.hhs.gov/FEMA-REP-22.pdf

(1991) Risk Assessment Guidance for Superfund: Volume 1- Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals). Environmental Protection Agency. Retrieved from https://semspub.epa.gov/src/document/HQ/156739

Schwab, J. (Ed.). (2014). Planning for Post-Disaster Recovery: Next Generation. American Planning Association. Retrieved from www.fema.gov/sites/default/files/2020-06/apa_planning-for-post-disaster-recovery-next-generation_03-04-2015.pdf

Schwab, J. C. (Ed.). (2014, December). Planning for Post-Disaster Recovery: Next Generation (PAS Report 576). *www.fema.gov*. American Planning Association. Retrieved from www.fema.gov/sites/default/files/2020-06/apa_planning-for-post-disaster-recovery-next-generation_03-04-2015.pdf

Section 7.0 Communicating Radiation Risk to Shelter Staff and Residents. (2015). In *A Guide to Operating Public Shelters in a Radiation Emergency* (pp. 37-42). Centers for Disease Control and Prevention. Retrieved from https://emergency.cdc.gov/radiation/pdf/operating-public-shelters.pdf

Service Animals and Pets. FEMA. Retrieved from https://www.fema.gov/sites/default/files/documents/fema_nuc-detonation-planning-guide.pdf

Standards for Protection Against Radiation (10 CFR 20). (n.d.). *Code of Federal Regulations*. Retrieved from https://www.ecfr.gov/current/title-10/chapter-I/part-20

Karam, P.A. (2020), *Suggested Training and Experience Qualifications for Health and Safety Officers During a Radiological Incident*. Retrieved from PubMed (nih.gov) https://pubmed.ncbi.nlm.nih.gov/31842135

(2016). Technical Report for the Demonstration of Wide Area Radiological Decontamination and Mitigation Technologies for Building Structures and Vehicles. U.S. Environmental Protection Agency. Retrieved from https://cfpub.epa.gov/si/si_public_file_download.cfm?p_download_id=529008&Lab=NHSRC

(2007). *Technology Reference Guide for Radioactively Contaminated Media.* U.S. Environmental Protection Agency. Retrieved from https://www.epa.gov/sites/default/files/2015-05/documents/media.pdf

(2006) *Technology Reference Guide for Radiologically Contaminated Surfaces*, EnDyna Inc, Environmental Protection Agency

(2018). *The Fukushima and Tohoku Disaster: A Review of the Five-Year Reconstruction Efforts.* Faculty of Societal Safety Sciences, Kansai University. Elsevier. Retrieved from www.sciencedirect.com/book/9780128140789/the-fukushima-and-tohoku-disaster

Using Preventative Radiological Nuclear Detection Equipment for Consequence Management Missions. NUSTL. Retrieved from: https://www.dhs.gov/publication/st-frg-using-preventative-radiological-nuclear-detection-equipment-consequence

UK Recovery Handbooks Radiation Incidents 2015: Inhabited Areas Handbook. Version 4.1. (2015). Public Health England. Retrieved from https://www.gov.uk/government/publications/uk-recovery-handbooks-for-radiation-incidents-2015https://assets.publishing.se

Veterinarians: Information for Radiation Emergencies Department of Health & Human Services Radiation Emergency Medical Management. Retrieved from https://remm.hhs.gov/remm_PetOwners.htm

WARRP Waste Management Workshop. (2012, March 15-16). Retrieved from www.epa.gov: https://www.epa.gov/sites/production/files/2015-08/documents/warrp_workshop_report_0.pdf

Waste Estimation Support Tool (WEST). (n.d.). Retrieved from www.epa.gov: https://www.epa.gov/emergency-response-research/waste-estimation-support-tool-west

Waste Management Tool Kit.: Environmental Protection Agency. Retrieved from https://www.epa.gov/emergency-response-research/decision-support-tools-waste-management

Wastes. (n.d.). Retrieved from www.epa.gov: https://www.epa.gov/report-environment/wastes

Waste Storage & Staging Tool. Environmental Protection Agency. Retrieved from https://github.com/USEPA/Waste_Staging_Tool

Webel, B. (2019). Terrorism Risk Insurance: Overview and Issue Analysis for the 116th Congress. Congressional Research Service. Retrieved from https://fas.org/sgp/crs/terror/R45707.pdf

(2012) “Wide Area Recovery and Resiliency Program Waste Management Workshop.”: Environmental Protection Agency. Available online at: www.epa.gov/sites/production/files/2015-08/documents/warrp_workshop_report_0.pdf

WM Symposia: Education and Opportunity in Radwaste Management. (n.d.). Retrieved from https://www.xcdsystem.com/wmsym/2020/index.html

Annex A: Glossary of Terms

Term	Definition
1 km Transect	An initial survey at approximately 1 km from the point of release that is orthogonal to the prevailing wind direction. It is used to establish an indication of long-range contamination and to gather information on the location of the point of highest concentration to locate the actual plume centerline.
10-Point Monitoring Plan	An early and coherent set of field measurements to help local first responders prioritize subsequent monitoring of affected areas and provide data that are needed to refine dispersion modeling of deposition and dose projections for early protective action decision-making.
Agreement State	39 states in the United States that have signed an agreement with the NRC authorizing the state to regulate certain uses of radioactive materials within the state. Through the agreement, the states have the authority to license and inspect byproduct, source, or special nuclear materials used or possessed within their borders. Further information at: https://www.nrc.gov/about-nrc/state-tribal/agreement-states.html.
ALARA	As Low As Reasonably Achievable (ALARA); radiation safety concept for minimizing dose.
Background Radiation	The natural radiation that is always present in the environment. It includes cosmic radiation which comes from the sun and stars, terrestrial radiation which comes from the Earth, and internal radiation which exists in all living things. The typical average individual exposure in the United States from natural background sources is about 300 millirem per year.
Certified Health Physicist	An individual that has completed all the necessary requirements (education, experience, and 2-part examination) to be granted professional certification in the field of health physics (radiation safety) by the American Board of Health Physics.
Cleanup level	The radionuclide-specific activity concentration in a media (such as soil) agreed to by regulators and stakeholders that is appropriate for future land use and is protective of human health and the environment. The cleanup level may be set to meet a risk level (e.g., 1 in 10,000 to 1 in 1,000,000 (10^{-4}-10^{-6}) increased lifetime risk of getting cancer, based on EPA's Superfund cleanup regulations) or dose-based (e.g., 25 mrem/yr total effective dose equivalent, based on NRC's 10 CFR 20.1402).
Community lifeline	A lifeline enables the continuous operation of critical government and business functions and is essential to human health and safety or economic security. Lifelines are the most fundamental services in the community that, when stabilized, enable all other aspects of society to function.

Term	Definition
Community Reception Centers (CRCs)	A physical space that provides contamination screening and decontamination services to people displaced by a large-scale radiation incident. CRCs are established to assess people for exposure, contamination, and the need for decontamination and to register people for monitoring, radiological assessment, or medical management if necessary.
Community Reception Center (CRC) Toolkit	Includes staffing requirements, necessary equipment lists, forms, and electronic applications for use in CRC operations.
Contaminated Area	Consists of any place where radionuclides are on a surface or in the environment as a result of a release. For practical purposes, a baseline, above which an area is considered to have meaningful contamination, should be determined in advance, and then be re-assessed after an incident. Designation of the contaminated area will inform identification of areas that require remediation, as well as exposure mitigation actions to protect the public and responders.
Contamination	The National Fire Protection Association's Hazardous Materials Response Handbook defines contamination as "the direct transfer of hazardous material." Radioactive contamination is radioactive material where its presence is unwanted or unexpected. **External**: Unwanted radioactive material on the outside of the body, on the clothing, skin, hair, or body cavities such as the outer ear and eye. **Internal:** Unwanted radioactive material within the body following absorption through the skin, ingestion, inhalation, or through wounds.
Critical Infrastructure (CI)	Includes equipment, buildings, systems, and networks that provide key services to the public and are vital to public health and safety. Critical infrastructure includes transportation infrastructure, telecommunications infrastructure, hospitals and medical facilities, power plants, and emergency services, among others.
Dangerous Radiation Zone (DRZ)	For radiological safety, the Dangerous Radiation Zone is defined by the National Council of Radiation Protection and Measurements (NCRP) as an area where radiation levels exceed 10 R/hr (0.1 Gy/hr).

Term	Definition
Decontamination	The reduction or removal of radioactive **contamination** from a structure, object, or person. See DOE's *Radiological Control Manual.* **Gross Decontamination:** Gross decontamination typically refers to non-targeted methods that remove large amounts of contamination, but may not ensure 100% removal, such as removing clothing and showering or hosing stations without run-off collection. **Technical Decontamination:** Decontamination designed to reduce contamination to very low levels, typically close to background radiation levels. This level of decontamination may not be necessary for all scenarios and requires radiation detection equipment to confirm the success of decontamination. **Self-Decontamination:** Decontamination carried out by individuals by themselves. Self-decontamination could include removal of outer layers of clothing, showering, or other methods. **Ad hoc Screening and Decontamination:** Ad hoc screening and decontamination refer to the onsite and early screening and decontamination activities discussed in the *First 100 Minutes Guidance* as well as in Focus Area 4 (Evacuation). These screening and decontamination activities primarily exist to address early demand at or near the response and may rely entirely on gross decontamination. CRCs are designed to provide more services than ad hoc locations but take more time and resources to set up and operate.
Derived Concentration Guideline Level (DCGL)	A derived, radionuclide-specific activity concentration within a *survey unit* corresponding to the *release criterion*. *DCGLs* are derived from activity/dose relationships through various *exposure pathway* scenarios.
Detonation Site	The immediate area surrounding the detonation point out to 20-meters, cordoned off and left undisturbed unless entry is necessary for immediate life safety needs. Note: This site may be initially larger if dose rates exceed 10 R/hr (0.1 Gy/hr).
Disinformation	Deliberately created false information with the intention of misleading, harming, or manipulating a person, social group, organization, or country.
Dose Assessment	Systematic process to assess the amount of radiation energy (ionizing radiation) absorbed by an object or person per unit mass. Used to determine the potential health risk for people in the area and inform short-term mitigation actions (e.g., setting PAGs) as well as long-term mitigation actions (e.g., DCGL and cleanup levels). Dose assessments are tailored for person(s) receiving potential exposure (e.g., firefighter, remediation worker or someone living miles away from the contamination areas) and as such, can be retrospective or prospective.

Term	Definition
Dosimetry	The theory and application of the principles and techniques involved in measuring and recording doses of ionizing radiation.[82] Also refers to the measurement equipment given to individuals specifically to measure radiation dose to that individual.
Early Phase	The beginning of a radiological incident for which immediate decisions for effective use of protective actions are required and must therefore be based primarily on the status of the radiological incident and the prognosis for worsening conditions. This phase may last from hours to days.
Explosive Hazards Exclusion Zone	Determined by the responding Public Safety Bomb Technician, the area where explosive effects (heat, shockwave, fragmentation) will be affected based upon the suspected estimated net explosive weight in any suspected secondary devices. This area is normally cordoned off by law enforcement personnel and only bomb technician personnel are allowed into this area until cleared. For planning purpose, these zones are initially 300m in diameter until further is known about the hazardous device.
Exposure Pathway	The route by which radioactivity travels through the environment to eventually cause radiation exposure to a person or group. Pathways in the environment include air, water, and soil. Exposure pathways into a person include inhalation, ingestion, injection, and dermal exposure. Dose assessments use the exposure pathway in analyzing the dose to a person.
External Radiation	A source located on or outside the body that emits radiation that penetrates the epidermis and irradiates organs and tissues.
Evacuation	There are two evacuation terms to be aware of: **time-phased evacuation:** A time-phased evacuation is an evacuation according to a time schedule. Scheduling involves making decisions regarding the allocation of available capacity or resources (equipment, labor, and space) over time. Scheduling thus results in a time-phased plan, or schedule of activities. The schedule indicates what is to be done, when, by whom and with what equipment. **phased and prioritized evacuation:** A phased and prioritized evacuation is an evacuation that is conducted in the order or sequence that evacuates those in the highest risk category (from all hazards or medical conditions) first, followed by those in a decreasing risk order.
FSLTT	Federal, state, local, tribal, and territorial.

[82] NRC (2021) *Dosimetry*. Available online at: https://www.nrc.gov/reading-rm/basic-ref/glossary/dosimetry.html

Term	Definition
Gamma Spectroscopy	Quantitative measure of the energy spectra of gamma-emitting sources. There are a wide variety of gamma spectroscopy instruments, ranging from portable radionuclide identification devices (RIID) often carried by emergency responders to specialized high purity germanium (HPGe) detectors. Instruments are critical in evaluating the radiation dose rate at locations that are contaminated as well as conducting background measurement in a non-contaminated area.
Groundshine	External radiation from the fallout of radioactive particles deposited on the ground after passage of the aerosol plume.
Hazardous Waste	Waste with properties that make it dangerous or potentially harmful to human health or the environment, which is why it is so strictly regulated. Such waste can be liquids, solids, contained gases, or sludges. Hazardous wastes are either specifically listed as hazardous by EPA or a state or exhibit one or more of the following characteristics: ignitability, corrosivity, reactivity, or toxicity. Hazardous waste is regulated under the Resource Conservation and Recovery Act (RCRA) Subtitle C (See RCRA hazardous waste for the regulatory definition). From https://www.epa.gov/report-environment/wastes#:~:text=Many%20different%20types%20of%20waste,fossil%20fuel%20combustion%20waste%2C%20and; https://www.epa.gov/hw/defining-hazardous-waste-listed-characteristic-and-mixed-radiological-wastes.
Hot Spot	Any place where the level of radioactive contamination is considerably greater than the area around it.
Hot Zone	For radiological safety, the hot zone is defined by the National Council of Radiation Protection and Measurements (NCRP) as an area where radiation levels exceed 10 mR/hr (0.1 mGy/hr) or 60,000 dpm/cm^2 beta and gamma at 1.5 cm (~0.5 inch) and 6,000 dpm/cm^2 at 0.5 cm (~0.25 inch) with an alpha probe. Alpha probes should include predetermined conversion factors from cpm to dpm/cm^2.
Intermediate Phase	The period beginning after the source and releases have been brought under control (has not necessarily stopped but is no longer growing) and reliable environmental measurements are available for use as a basis for decisions on protective actions and extending until these additional protective actions are no longer needed. This phase may overlap the early phase and late phase and may last from weeks to months.

Term	Definition
Land Use	Land use is the term used to describe the human use of land. It represents the economic and cultural activities (e.g., agricultural, residential, industrial, mining, and recreational uses) that are practiced at a given place." Residential land use is an area that is zoned by the municipality for single-family or multifamily dwellings where businesses may or may not be conducted in the dwellings. - Industrial, Commercial, Business land use include areas designated for more intense operations and traffic. Recreational land use is typically owned by the municipality that are designated public areas, excluding residential dwellings. Agricultural land use is an area that includes residential areas as well as production of food that could be consumed by humans (an exposure pathway for consideration in dose assessments).
Late Phase	The period beginning when recovery actions designed to reduce radiation levels in the environment to acceptable levels are commenced and ending when all recovery actions have been completed. This phase may extend from months to years. A PAG level, or dose to avoid, is not appropriate for long-term cleanup.
Low Level Radioactive Waste (LLRW) Disposal Facility	LLRW destined for disposal must be transported to a commercially operated low-level radioactive waste disposal facility that is licensed by either the Nuclear Regulatory Commission (NRC) or by an Agreement State. LLRW disposal facilities must be designed, constructed, and operated to meet safety standards. The operator of the facility must also extensively characterize the site on which the facility is located and analyze how the facility will perform for thousands of years into the future.
Malinformation	Information based in fact but used out of context to mislead, harm, or manipulate. An example of malinformation is editing a video to remove important context to harm or mislead.
MARSSIM	The Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) provides detailed guidance on how to demonstrate that a site is in compliance with a radiation dose- or risk-based regulation (federal or state regulations). MARSSIM focuses on the demonstration of compliance during the final status survey following scoping, characterization, and any necessary remedial actions. Agencies that collaborate on MARSSIM include EPA, Nuclear Regulatory Commission, Department of Energy and Department of Defense.
Misinformation	False information that was not created or shared with the intention of causing harm.
Mitigation	Capabilities necessary to reduce loss of life and property by lessening the impact of disasters. Mitigation capabilities include, but are not limited to, community-wide risk reduction projects; efforts to improve the resilience of critical infrastructure and key resource lifelines; risk reduction for specific vulnerabilities from natural hazards or acts of terrorism; and initiatives to reduce future risks after a disaster has occurred.

Term	Definition
Mixed Waste	Waste that has a hazardous component and a radioactive component is called "mixed waste." The hazardous component of the mixed waste is regulated by EPA under RCRA. The radiological component of the mixed waste is regulated by DOE or NRC.
Near Field	The area surrounding the detonation point out to 500 meters and 1 kilometer downwind
Optimization[83]	The source-related process to keep the magnitude of individual doses, the number of people exposed, and the likelihood of potential exposure as low as reasonably achievable below the appropriate dose constraints, with economic and social factors being considered.
PAG	Protective Action Guide (PAG) is defined as the projected dose to an individual, resulting from a radiological incident at which a specific protective action to reduce or avoid that dose is warranted.
Plume	The column or cloud of smoke emanating from the mount of a continuously emitting chimney or smokestack is called a plume. In the case of an explosive RDD, the plume would be due to a "puff" release of material.
Population Monitoring	The process of evaluating and monitoring a population for radiologically related medical treatment, the presence of radioactive contamination on an individual's clothing or body (external contamination), intake of radioactive materials (internal contamination), radiation dose received, resulting health risk, and long-term health effects.
Public Safety Bomb Squad	An FSLTT bomb response team accredited by the FBI's Hazardous Devices School.
Public Safety Bomb Technician	A graduate of the FBI's Hazardous Devices School (HDS) bomb technician course with a current certification from HDS and assigned to a bomb response team.
Radiation Exposure	The quantity of energy absorbed in a tissue or organ from either an external radiation source or from radionuclides in the body.
Radiological Operations Support Specialist (ROSS)	An individual with radiological expertise and an understanding of the Incident Command System (ICS) available to SLTT emergency managers, responders, and decision-makers. ROSS are FEMA-typed and can be requested through mechanisms such as the Emergency Management Assistance Compact (EMAC).

[83] ICRP (2006). "ICRP Publication 101b: The Optimisation of Radiological Protection: Broadening the Process." Available online at: https://www.icrp.org/publication.asp?id=ICRP%20Publication%20101b

Term	Definition
Radiation Technical Working Groups (R-TWGs)	A group of Subject matter exerts, selected by the unified command (UC), that: "provides multi-agency, multi-disciplinary expert input on the cleanup options analysis, including advice on technical issues, analysis of relevant regulatory requirements and guidelines, risk analyses, and development of cleanup options." The technical working group provides expert technical input to the UC; it is not part of the decision-makers.
Radioactivity	The property possessed by some elements (such as uranium) of spontaneously emitting energy in the form of radiation as a result of the decay (or disintegration) of an unstable atom. It is the rate at which radioactive material emits radiation. Radioactivity is measured in curies (Ci), becquerels (Bq), or disintegrations per minute.
Radioactive Waste	Any type of waste that contains radioactivity, either intrinsically or through contamination with radioactive material. There are three classes of radioactive waste (A, B, and C), based on the amount of radioactivity present.
Radiological Incident	An incident involving the release or potential release of radionuclides, including such releases from nuclear facilities; radioactive materials being transported; radioactive materials in space vehicles affecting the United States; foreign, unknown, or unlicensed material; nuclear weapons; and deliberate attacks involving nuclear/radiological facilities, or materials, including RDDs and improvised nuclear devices that have actual, potential, or perceived consequences to the United States. This guidance has focused on a radioactive incident resulting from an RDD.
Radiological Survey	A systematic evaluation and documentation of radiological measurements with a correctly calibrated instrument or instruments that meet the sensitivity required by the objective of the evaluation.
Radiological Worker	An individual who is uniquely qualified to work with radioactive materials and enter radiological areas. A radiological worker receives training to meet state and federal regulations and is subject to evaluation of dose exposure to demonstrate that annual TEDE limits are not exceeded.
RCRA Hazardous Waste	A national regulatory designation for certain wastes under the RCRA. Some wastes are given this designation because they are specifically listed on one of four RCRA hazardous waste lists. Other wastes receive this designation because they exhibit at least one of four characteristics—ignitability, corrosivity, reactivity, or toxicity.
RDD	The combination of radioactive material and the means (whether active or passive) to disperse the material with malicious intent; however, fission reactions do not occur in the RDD or its dispersed material.

Term	Definition
Recovery	Those capabilities necessary to assist communities affected by a disaster to recover effectively, including, but not limited to, rebuilding infrastructure systems; providing adequate interim and long-term housing for survivors; restoring health, social, and community services; promoting economic development; and restoring natural and cultural resources.
Release	The term release is used in two ways: 1) an environmental release or 2) release from regulatory control. These meanings are typically discernable from context: Environmental release is the discharge of contaminants into the environment. Specifically, CERCLA section 101(22) defines "release" as any "...spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment (including the abandonment or discarding of barrels, containers, and other closed receptacles containing any hazardous substance or pollutant or contaminant) ....". See Radioactive Incident. Release of items, property, or land from regulatory control means release from a level of regulatory control with respect to radioactive contamination. Note that release from regulatory control includes de minimis quantities of radioactive materials that are below regulated amounts and transition to a lesser level of control (e.g., release with restrictions).
Remediation	The actual construction or implementation of selected technologies to treat, stabilize, contain, or remove contaminated media in accordance with planned recovery actions.
Remediation Zones	Remediation zones are specific areas within the Contaminated Area that will require decontamination and exposure reduction activities, usually with the intent of reopening them for future use. Initially, remediation zones should be areas that are determined to have similar (1) land-use and (2) levels of contamination. Designating areas into zones with similar characteristics can break the problem down into more manageable pieces, facilitate the prioritization of areas for remediation, and potentially ease the logistical and planning burden to conduct the cleanup itself.
Restoration	The repair of buildings or CI in order to bring them back to a state where they can function normally. This includes, for example, repairing blast damage to buildings from an explosive RDD or fixing damaged cell tower equipment to restore cell service in impacted areas.
Radiation Health and Safety Officer (RHSO)	The authority and responsibility of a RHSO is for the radiation protection program established during the early phase of a response. They are responsible for ensuring that radiation safety activities are being performed in accordance with approved procedures and regulatory requirements.
Screening	The process of rapidly identifying individuals potentially contaminated with radionuclides or exposed to external radiation.

Term	Definition
Secondary Device	An additional device emplaced to target first responders, other individuals, or infrastructure before, during or after a response. May or may not include radioactive material.
Shelter-in-Place Zone	The extent of an area defined by the UC or public health official to protect the public from an environmental radiation hazard. The initial shelter-in-place zone surrounds the detonation point out to 500 meters and 2 kilometers downwind.
Solid, Nonhazardous Waste	Waste from homes, institutions, and commercial sources consisting of everyday items such as product packaging, grass clippings, furniture, clothing, bottles and cans, food scraps, newspapers, appliances, consumer electronics, and batteries. Excluded from this category are municipal wastewater treatment sludges, industrial process wastes, automobile bodies, combustion ash, and construction and demolition debris. (From https://www.epa.gov/report-environment/wastes#:~:text=Many%20different%20types%20of%20waste,fossil%20fuel%20combustion%20waste%2C%20and.)
Stabilization	Temporary binding of particulate contamination to minimize migration and resuspension, providing reduction in both surface dose rate and inhalation risk to workers within the first 48-72 hours.
Sustainment	The provision for logistics, financial management, personnel services, and health service support necessary to maintain operations until successful mission completion (i.e., remediation of contaminated areas and reoccupation).
Temporary Storage Area	Location for the storage of waste before final disposition of the waste. These areas for storing waste, even temporarily, must meet local, state, and federal regulations, requires permitting, and requires regular inspection for the adequacy of the storage area for containment of waste.
Time, Distance, and Shielding	The three main principles to assist with limiting external, whole-body radiation exposure (see Focus Area 2 for more detail).
Trusted Source	These are regular people who are trusted by their community and can serve as nodes for dissemination of information to the public.
Unrestricted Release	Release of a *site* from regulatory control without requirements for future radiological restrictions. Also known as unrestricted use.
Warm Zone	The warm zone is a transition area between contaminated areas and uncontaminated areas where responders don and doff protective gear and decontamination activities take place.

Term	Definition
Whole Community	A focus on enabling the participation of a wider range of players from the private and nonprofit sectors, including NGOs and the public, in conjunction with the participation of federal, state, and local governmental partners to foster better coordination and working relationships. This term also highlights the inclusion of people with disabilities and others with access and functional needs, older adults, families, youth/children, and people with limited English proficiency.

Annex B: Critical Information and Key Data Needs by Strategy

Table 28: Strategy 1 - Characterize, Map, and Model

Information Objective	Significance
Radionuclide(s) present and their location	Allows for the determination of the type(s) of radiation, type of equipment needed to detect the radiation, maps of the incident, and energies of the emitted radiation and associated hazards.
Physical and chemical properties of the material distributed	Characteristics such as the particle size or solubility will inform personal protective equipment (PPE) decisions, cleanup techniques, contamination spread mitigation, and many other aspects of the response and recovery.
Primary (e.g., ballistic debris) and secondary (e.g., residual radioactivity/contamination) sources	Identification of RDD ballistic debris can inform the law enforcement investigation as well as the dose reconstruction for emergency responders.
Responder Data	Individual responder exposure/dosimetry data will support dose assessment and determine the need for follow-up medical monitoring/intervention.
Radiological Survey Data Sets	Key data to support data quality objectives, mapping, and use of information for hazard characterization and decision making.
Exposure pathways (See Table 7:)	Used to determine risk to the public and responders from inhalation, ingestion, and direct exposure of radioactive materials.
Categories of people for exposure pathway, dose assessment, and risk communication purposes (See Table 8:)	Identifies the members of each category (remediation workers, first responders, essential employees, and public), their level of risk/exposure, and how each group can be communicated with.
Factors to determine if gross/prompt environmental decontamination is appropriate	Considers the weather forecast, environmental factors (e.g., runoff, topography), and radionuclide properties to determine if gross/prompt decontamination is appropriate.

Table 29: Strategy 2 – Communicate

Information Objective	Significance
Technical information and data from other focus areas	Data needs and critical information from other focus areas will be the main driver for messaging (e.g., shelter-in-place orders) and outreach efforts (e.g., hosting public meetings to discuss remediation priorities) throughout all phases of response and recovery.
Roster of trusted sources in the community	Trusted sources will play an important role in message development, amplification, and community engagement. Identifying the trusted sources within a community and the means to reach them will facilitate their engagement in incident response and recovery.

Table 30: Strategy 3 – Monitor and Assist

Information Objective	Significance
Radiation exposure thresholds requiring evacuation	Evacuation should be conducted in a planned, orderly, phased approach based on risk to the population in the contaminated area. This data and EPA PAGs can be used to establish evacuation zones.
Other life-safety hazards in the contaminated area	Non-radiological hazards may exceed hazards from radioactive contamination and must be considered in determining priorities for evacuation.
Geographic information required to determine evacuation routes	Geographic information such as highways, waterways, access to public transportation, etc. inform determination of evacuation routes.
Demographic and environmental information required to determine evacuation routes	Population and type of individuals within the contaminated area: residents, workers, visitors, those with special needs (e.g., medical, language, mobility), etc.; population density; type of buildings (e.g., office, commercial, residential); and environmental conditions (e.g., temperature, wind velocity and direction, humidity) are important factors in determining evacuation zones and priorities for evacuation.
Available transportation resources for evacuation	The population within the contaminated area must be given accurate and timely information and instructions on how to evacuate. This may include mass transit, POVs, and other transportation resources.

Information Objective	Significance
Available personnel and resources for checkpoints, canvassing evacuated zones, conducting transportation of evacuees, providing emergency services (medical, law enforcement, fire)	Conducting a phased evacuation is an effort that requires the support of multiple personnel resources. Personnel resource limitations must be considered in conducting the phased evacuation.
Locations for CRCs and shelters	There are many considerations for picking CRC and shelter locations during an RDD incident. Some include: ▪ Pre-existing shelter agreements or locations identified as emergency service points (such as point of dispensing locations) that could help stand up a CRC or shelter more quickly. ▪ Locations of egress routes and ease of access following an incident. ▪ Whether radiological characterization data (see Focus Area 1) indicates the location is in a low-background area. ▪ Length of time needed for services. RDD incidents may require longer sheltering times than other types of incidents.
Calculations of exposed population's radiation exposure	Helps determine if radiation exposure levels warrant additional medical services. Consider: ▪ Locations and times of exposure in the Contaminated Area. ▪ Records on contamination levels when screened. ▪ Dosimetry data if available.
Quality of available water and food	May involve testing tap water, wastewater, food, and agricultural products for contamination levels. To test food, locations of all meat, dairy, food storage, greenhouses/gardens/farmland (including individual/neighborhood ones) in the jurisdiction need to be identified. Appropriate actions after determining safety could include communications or removing products from commerce.

Table 31: Strategy 4 – Restore the Environment

Information Objective	Significance
Safety and security hazards and other issues in the contaminated area	Addressing non-radiological hazards and other issues such as damaged infrastructure, criminal activity within the affected area, etc., may require expedited remediation as soon as it is safe for personnel to enter the contaminated area.

Information Objective	Significance
Building/infrastructure function, occupancy, and maintenance information with priority given to critical infrastructure and mitigating further damage and impacts resulting from functional disruption of facility/system	Helps prioritize restoration and sustainment of essential infrastructure, protect building contents, and monitor critical building functions such as HVAC systems, security, and fire alarm systems.
Cleanup levels for remediation	Cleanup levels are agreed upon by multiple parties and must address public health objectives and the technical, economic, and social feasibility of the available decontamination methods that will meet expectations for the residual radiation after remediation. Agreement on cleanup levels may require revisions as parties review and ultimately come to a consensus on the levels for remediation.
Remediation zone boundaries	As part of the Optimization Process, remediation zones are established that have similar land-use and levels of contamination. Remediation zones have similar characteristics, facilitate the prioritization of areas for remediation, and potentially ease the logistical and planning burden to conduct the cleanup itself. Consider geographic, demographic, and environmental characteristics in determining zone classifications.
Temporary waste/debris staging areas	In the early phase, waste and debris will be moved to temporary locations for staging and storage. This information will establish initial locations, allowing for segregation of waste types, securing the material, and managing spread of contamination from the waste and debris. Early efforts will help minimize waste volumes and recovery costs.
Estimates of the volume of waste for remediation and recovery	The volume of waste addressed/generated via remediation activities will drive plans for staging areas through final disposition. EPA's WEST provides planners with a process to estimate the quantity and characteristics of waste from an incident and decontamination activities for final disposition of waste by type of waste (e.g., non-hazardous solid waste vs. LLRW). Outcome of waste volume by waste type is important in exploring options to achieve waste management goals.
Options for final disposal plans	Final disposition options range from on-site (within the contaminated area) disposal to the use of off-site waste facilities. In planning for final disposal locations, consider types of waste and associated volumes, options for disposal sites, and feasibility of transportation to the final disposal location.

Table 32: Strategy 5 – Reopen and Recover

Information Objective	Significance
Pre-incident property records such as land/facility use, zoning, real estate value, and development plans	Information will help establish a baseline for the affected property, facilities, and land, and inform re-use and reopening decisions, especially regarding modifications to permitted use due to residual contamination.
Sustainment data about the integrity/damage of buildings and facilities, including the structural and aesthetic conditions of areas in the remediation zone	Information will inform the level and scope of repairs needed before reopening.
Residual contamination measurements of the property, facilities, and land in the remediation zone	Information directly informs reopening and re-use decisions. If the cleanup level for a facility, property, or land area is above that permissible for unrestricted public use, then an alternative land-use with restrictions will need to be identified, agreed upon, and implemented.
Habitability assessment data for each property collected as repairs continue	Habitability assessment results will directly influence whether a property is safe to be reoccupied and informs the reopening schedule.
Demographic characteristics, critical infrastructure, contiguous neighborhoods, and buildings in the remediated areas	Information will help prioritize reopening to address the needs of vulnerable populations. It will also help expedite the reopening of areas with collocated critical infrastructure as well as contiguous neighborhoods.
Availability of building materials and skilled workers	Information will help inform the schedule for repairs and habitability assessments.
Current zoning plans, building/facility demolition, debris removal, construction, land/property acquisition, and redevelopment plans	Information will inform the scope and level of recovery efforts needed for the affected community.
Information about major recovery projects such as housing and infrastructure rebuilding needs	Information will help prioritize recovery resources and focus the planning efforts for long-term, resource-intensive projects.
Baseline economic data to characterize pre-incident economic indicators and metrics	Information will help establish the pre-incident baseline about the community's economic wellbeing, which will in turn help quantify recovery success metrics (e.g., % of remediated areas has been reopened, number of new jobs and new businesses since reopening).

Information Objective	Significance
Availability of federal, state, and local government assistance programs, and applicable nonprofit and insurance programs	Information will identify the available resources that can be used for recovery and will also inform the recovery timeline.
Information about properties and parcels, building/facility demolition/abatement, debris removal, construction, and redevelopment planning and permits.	Information needed to establish ownership and identify vested interests among affected properties including businesses and private residences. Aligning recovery efforts will require ongoing assessment of how to efficiently apply recovery resources to targeted areas of need, which may include both public and private efforts and stakeholders such as commercial districts, HOAs, and individual homeowners.
Survey of government agencies and NGOs engaged in recovery activities and providing recovery support to survivors	Information likely will include entities such as nonprofit grantmaking foundations, VOAD agencies, government agencies which are providing direct or indirect health and social services, as well as other entities engaged in supporting recovery efforts. Some of these agencies may be local/regional, while others may be national-level organizations.
Economic data and economic development plans	Understanding the projected long-term economic development goals of the affected community, such as those outlined in the Comprehensive Economic Development Strategy (CEDS), will provide recovery planners with an understanding of how the economic trajectory of the affected community(ies) may be impacted by the RDD event.
Financial assistance data including federal, state, and local government assistance programs, and applicable nonprofit and insurance programs	Information is necessary to support disaster case management efforts. Establishing information sharing agreements among recovery stakeholders is crucial to the long-term success of disaster case management activities because it mitigates duplication of effort and duplication of benefits and enhances survivor access to the full spectrum of available recovery support programs and avenues of assistance.

Annex C: Radiological Communications Tools

Training Resources

ESSENTIALS OF ALERTS, WARNINGS, AND NOTIFICATIONS (CISA, 2020)

https://www.cisa.gov/sites/default/files/publications/CISA%20Essentials%20of%20AWNs_4.27.20%20-%20FINAL%20%28508c%29.pdf

Guide for using different types of emergency communications platforms, including information regarding when certain platforms are more appropriate and technical restrictions on message length and type.

MYTHS OF RADIATION: COMMUNICATING IN RADIATION EMERGENCIES (CDC, 2022)

https://www.cdc.gov/nceh/radiation/emergencies/radiationmyths.htm

Series of training videos that introduces participants to some common myths surrounding radiation and identifies communications strategies to combat these and other myths. The training uses Person-On-The-Street interviews to identify the myths and features a discussion between risk communication and radiation subject matter experts to set the record straight.

PSYCHOLOGICAL FIRST AID IN RADIATION DISASTERS (CDC, 2022)

https://www.orau.gov/rsb/pfaird/

Online audio and text training course that discusses first-hand experience from radiation emergencies and corresponding psychological mental health impacts. While primarily focused on psychological first aid in the immediate aftermath of an incident, the issues of fear of radiation and social stigma of victims will continue to impact communication needs during intermediate and later phases.

RADIATION RISK COMMUNICATION FOR PUBLIC HEALTH (WD4239) (CDC, 2021)

https://www.cdc.gov/nceh/radiation/emergencies/cerc.htm

Online training videos that highlight basic radiation concepts. Also provides several communication resources and lessons learned that can help professionals involved in emergency response prepare for and deliver clear messages during a radiological or nuclear disaster. Also highlights several myths and misunderstandings related to radiation exposure and contamination.

PUBLIC INFORMATION OFFICERS: INFORMATION FOR RADIATION EMERGENCIES (HHS, 2023)

Remm.hhs.gov/remm_pio.htm

A collection of resources for Public Information Officers (PIOs) and other public-facing officials for communicating during radiation emergencies.

Communication Planning Guides and Toolkits

"SECTION 7.0 COMMUNICATING RADIATION RISK TO SHELTER STAFF AND RESIDENTS" IN *A GUIDE TO OPERATING PUBLIC SHELTERS IN A RADIATION EMERGENCY* (CDC, 2015)

https://emergency.cdc.gov/radiation/pdf/operating-public-shelters.pdf

Section 7.0 details communication needs specific to operating a public shelter during a radiation emergency, including topics likely to arise (7.3) and communication strategies and tools (section 7.4). Additionally, section 7.5 includes links to general guidance for communicating for any type of radiation emergency as well as documents tailored to nuclear detonation and power plant response.

COMMUNICATING DURING AND AFTER A NUCLEAR POWER PLANT INCIDENT (FEMA, 2013)

https://www.fema.gov/sites/default/files/documents/fema_nuclear-power-plant-incident_communicating-during-after_june-2013.pdf

This guide is designed for use in the aftermath of a nuclear power plant incident. While several topics specific to nuclear power plan regulations and insurance laws are not relevant to RDD events, this document provides a useful supplement to the FEMA IND *Communicating in the Immediate Aftermath* guide, because the level of radiation released and structural damage in an RDD incident is more likely to resemble a nuclear power plant incident rather than an IND. For example, this guidance contains more questions and answers in the context of evacuation instructions.

COMMUNICATING RADIATION RISKS: COMMUNICATIONS FOR EMERGENCY RESPONDERS (EPA, 2022)

https://www.epa.gov/system/files/documents/2022-02/comm_rad_risks_11222.pdf

A comprehensive guide for communications during a radiation emergency, including FAQs along with plain language answers designed for simplicity of understanding during a crisis.

IMPROVISED NUCLEAR DEVICE RESPONSE AND RECOVERY – COMMUNICATING IN THE IMMEDIATE AFTERMATH (FEMA, 2013)

https://www.fema.gov/sites/default/files/documents/fema_improvised-nuclear-device_communicating-aftermath_june-2013.pdf

Designed for use in the immediate aftermath of an improvised nuclear device explosion but contains FAQs applicable to RDD response and recovery. One of the key distinctions between an RDD incident and an IND incident is that for the latter the likelihood of extensive spread and dispersal of radioactive material following the incident is much greater. Messaging from this document regarding specifics about the spread of contamination will need to be adapted accordingly.

RADRESPONDER'S PUBLIC RESOURCE DOCUMENTS

https://www.radresponder.net/#resources/documents/index

Serves as a one-stop-shop for many of the same communication tools that are showcased in this annex (e.g., messages, infographics, Q+As, etc.).

Protective Action Resources

PROTECTIVE ACTION AREA MAP TEMPLATES. EPA-420 (EPA, 2017)

https://www.epa.gov/sites/default/files/2017-11/protective_action_area_map_templates_11202017_final_1.docx.

Word document (.docx format) with customizable templates for providing protective action guidance quickly to a population in a specific geographical area during a radiological or nuclear emergency. Protective actions include evacuation areas, shelter-in-place, and food and drinking water guidance.

PROTECTIVE ACTION QUESTION & ANSWERS FOR RADIOLOGICAL & NUCLEAR EMERGENCIES: A COMPANION DOCUMENT TO THE U.S. ENVIRONMENTAL PROTECTION AGENCY PROTECTIVE ACTION GUIDE (PAG) MANUAL (EPA, 2022)

https://www.epa.gov/system/files/documents/2022-02/pags_comm_tool_2022.pdf.

Provides pre-scripted radiation emergency public safety messages intended to help emergency planners prepare public communications prior to and during a radiological emergency.

Radiation Education Materials

RADIATION EMERGENCIES RESOURCE LIBRARY (CDC, 2022)

https://www.cdc.gov/nceh/radiation/emergencies/index.htm

Provides a wide array of information for the public and for professionals, including infographics, educational videos, and a resource library.

Annex D: Remediation Techniques and Technologies

This annex provides an overview of the key concepts, methods, and techniques for remediation of environments contaminated with radiological materials following an RDD incident. The phrase "Deactivation, Decommission, Decontamination, and Demolition" (or "D4") is used by the radiological remediation sector that is responsible for closing nuclear facilities (e.g., a nuclear power plant). However, the remediation techniques and technologies relevant to nuclear facilities, which are usually confined and controlled, are not the same as in the context of a wide urban or rural area, as may be the case RDD response and recovery. For RDD incidents, the focus is on "decontamination and physical removal." "Decontamination" refers to activities that remove and/or destroy contamination from an undesirable place, such as a vehicle, or building. "Physical removal" deals with removing contaminated portions of objects, like roofing materials from buildings, whereas "demolition" involves demolishing buildings and other structures so they can be removed and stored as contaminated waste. Demolition is generally done in situations when decontamination is not feasible and/or the structural integrity has been damaged beyond repair due to the blast effects stemming from and RDD explosive detonation.

A combination of approaches will be used to achieve overall remediation of contaminated areas following an RDD incident. This annex is meant to supplement a planner's understanding of the factors that must be considered by experts and stakeholders when planning and executing the activities described in this *RDD Response and Recovery Guidance,* particularly when working with remediation contractors to develop a remediation plan for contaminated areas. Early decontamination efforts will rely on simple, rapid techniques (e.g., hosing down areas with water) that attempt to minimize exposures on the scene and to remove the contamination before it has time to sink into the porous structure of some materials. Later phase decontamination techniques may involve more complex technologies that require multiple applications. The background information in this annex is most relevant for the following Focus Areas:

- **Focus Area 2: Implement Radiation Exposure Mitigation**: Some decontamination techniques may be used during the early and intermediate phases to reduce the risk of unnecessary or dangerous exposure to emergency responders operating on the scene and the public as they evacuate.

- **Focus Area 7: Remediate**: The technical feasibility, cost, effectiveness, and environmental impact of various remediation techniques influences decision-making during the optimization process.

- **Focus Area 8: Manage and Dispose of Waste**: The volume, type, and form of waste generated is directly dependent upon the remediation techniques and cleanup levels that are chosen.

The decontamination techniques discussed in this section are focused on contaminated buildings and/or environments and are not appropriate for decontamination of people, pets, decedents, or personal belongings. Therefore, information in this annex is not relevant to Focus Area 5: Screen and Decontaminate.

Recommended Resources:

Additional references and tools discuss decontamination and physical removal in more detail. **Important Disclaimer:** Many of the resources provided below are written for or about the decommissioning of industrial sites (e.g., commercial nuclear power facilities). Not all procedures, techniques, or technologies discussed will be appropriate for remediating an urban area after an RDD detonation or other uncontrolled release of radioactive material. However, these resources can serve as a starting point for planners to better understand the menu of options that might be considered by remediation experts when they develop a remediation plan.

- A more in-depth overview of decontamination techniques and technologies is provided in EPAs Radiological Recovery Logistics tool (RRLT, 2022) or through the EPA's Radiological Decontamination Query Tool. RRLT is available at: https://www.epa.gov/sites/default/files/2020-02/documents/kaminski_radiological_recovery_logistics_tool_epa_decon_2019_posterv2.pdf. And the Radiological Decontamination Query Tool is available at: https://www.epa.gov/emergency-response-research/radiological-decontamination-query-tool.
- Understanding the options, cost, and overall effort to address the waste that will be generated through remediation. EPA's Waste Estimation Support Tool (WEST) is a planning tool that can help guide the considerations key to successful remediation: https://www.epa.gov/emergency-response-research/waste-estimation-support-tool-west.

Decontamination Techniques and Technologies

Techniques and technologies for decontamination of contaminated structures and environments structures fall into two major categories: chemical solutions and physical techniques. Although, as described below, specific approaches often employ techniques from both categories.

CHEMICAL SOLUTIONS

Chemical decontamination technologies use specific chemicals or solutions (e.g., detergent, acid, water) to wash or dissolve the radiological contaminants from the surface or, if the radiological contaminant is embedded in the surface, to dissolve the surface itself to remove the radioactive material. Advantages of using chemical solution techniques include the ability to decontaminate less accessible areas and provide a more time-sensitive option than physical removal. When selecting the most appropriate chemical decontamination method, careful consideration should be given to characteristics of the contaminated area and the interaction between the surface properties, contaminants, and chemical solutions (this will require expert knowledge). Chemical solutions can be tailored to target specific radionuclides and are available in different forms including liquids, foams, gels, and pastes. However, chemical solutions may produce large volumes of liquid waste and depending on the chemicals used, may also result in mixed wastes. Chemical decontamination technologies include:

- **Chemical Extracts***:* This process involves applying a coating to the surface that adheres to or dissolves the radioactive contaminants bound to the surface material. Extractants are sprayed or manually applied to the surface or scrubbed into porous material to remove surface contamination; and then after a treatment period, the extractant is rinsed or vacuumed away, along with the radioactive contaminants. Many different chemicals can be used as extractants and are selected based on the radionuclide and surface materials involved. Extractants may require collection of solid and liquid waste in a manner that contains further contamination.

- **Peelable Coatings**: Peelable coatings are chemical extractants applied as a liquid. After the coating dries, the solid layer is peeled away along with the radioactive contaminants. Peelable coatings limit contaminated waste to the coating itself.

PHYSICAL TECHNIQUES

Physical techniques, which also are referred to as mechanical techniques, involve vacuuming, sweeping, scrubbing, or abrading a surface to remove radiological contamination. Radionuclides may bind with the surfaces of objects and structures, requiring physically removing of the surface down to a point where the radiation is removed or significantly reduced. These include “wet” or “dry” technologies:

- **Pressure washing:** This technique uses a high-pressure water spray to remove radiological contamination and other materials (e.g., paint and dirt) from the surface of buildings, structures, or other large objects. Pressure washing techniques require additional planning to account for efficient use of water, the chemical or physical properties of the contaminant, and collection of contaminated water. Technologies for pressure washing should be evaluated based on the surface and material to be decontaminated; an appropriate pressure should be selected to remove the contamination without destroying the material. Evaluation of pressure washers should also consider containment of the spent wash water for further treatment. Conventional pressure washers, as well as devices that can generate very high pressure (5,000 to 20,000 psi; also called “hydrolasing”) are available. Chemical additives (e.g., detergents, acids) may improve the decontamination effectiveness and may be used for surface preparation.

- **Surface Scarification:** Devices that cut or chip away outer layers of walls or floors, leaving behind an uncontaminated but scarred surface. Devices include shavers and scabblers, which can be adjusted to set the depth of material removed. Dust and material are captured with exhaust hoses connected to HEPA air filters to minimize the spread of contamination and protect workers from dust inhalation hazards.

- **Surface Blasting**: This technique is similar to pressure washing but instead involves physical abrasion of the surface of walls or floors by directing a stream of abrasive material at the surface using pressurized air or water. Abrasives include grit, steel shot, glass beads, or chemical pellets (sodium bicarbonate or dry ice/carbon dioxide). Depending on the abrasive material involved, surface blasting can be destructive or nondestructive. Exhaust hoses connected to air filters are needed for collection of dust and abrasives. Wet surface blasting requires collection and treatment of the water.

The use of chemical or physical decontamination technologies should include plans for addressing worker health and safety as well as managing the waste generated. Considerations of worker health and safety may exclude some technologies from further consideration (e.g., working in confined spaces or unstable structures).

Demolition Techniques and Technologies

Demolition is the removal of building structures, slabs, or foundations. It presents an alternative technique to remediate a radiologically contaminated area should decontamination not be appropriate or technically feasible. Careful planning should be done to determine if the area or structure will be completely demolished, or if uncontaminated equipment or sections can be deconstructed, segregated, and disposed of separately or potentially reused. Criteria should be established for fixing and leaving contaminated material/equipment in place or removing prior to demolition – small, contaminated items may be better to remove beforehand. This assessment will benefit waste minimization efforts significantly, to reduce overall disposal volume, weight, and costs.

Demolition of radiologically contaminated structures can present unique challenges, such as generation of large, bulk contaminated debris or the need for additional techniques to mitigate the spread of contamination in the context of open-air demolition[84] (e.g., misting nozzles, application of fixatives, plastic wrap). The criteria for open air demolition (as opposed to demolition utilizing tents or enclosures), is based upon the potential offsite dose estimates from airborne radioactive contaminants and selecting a process that keeps the exposure as low as reasonably achievable. Other potential hazards including asbestos, lead, mercury, PCBs, pressurized tanks, etc. may exist. Additionally, items may need to be removed from the structure as part of the pre-demolition hazard assessment and planning phases.

Demolition is a technique that can be successfully applied to radioactively contaminated structures. With proper planning, the demolition team can determine the most appropriate demolition method depending on the size of structure(s), duration, location, and technologies available. Methods for demolition may involve removal activities within a building or removal of the entire building. Technologies for demolition are selected with the site-specific conditions mentioned above and are

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[84] Many references discuss considerations for open air demolition of radiologically contaminated facilities. For example: E R. Lloyd (2007) "Open Air Demolition of Facilities Highly Contaminated with Plutonium." Available online at: https://www.osti.gov/servlets/purl/908296.

best performed with qualified and workforces with experience in remediating radiological demolition at other sites within the U.S. (e.g., legacy waste sites or decommissioned nuclear facilities).

When planning demolition of radioactively contaminated structures, the following should be taken into consideration:

- Define the "end state" of demolition, with consideration for culturally or historically sensitive areas and critical infrastructure.
- Determine appropriate radiological control boundaries (areas where radiological contamination can be managed safely during demolition and separate from areas where the public are allowed) and plan for radiological monitoring before/after demolition.
- Implement contamination control measures such as fixatives or dust suppression. Monitor contamination during the demolition.
- Manage demolition materials and waste disposal.

Recommended Resources:

Important Disclaimer: Similar to the resources recommended above, many of the resources provided below are written for or about the decommissioning of industrial sites (e.g., commercial nuclear power facilities). Not all procedures, techniques, or technologies discussed will be appropriate for remediating an urban area after an RDD detonation or other uncontrolled release of radioactive material.

- *EPA's Technology Reference Guide for Radioactively Contaminated Media*. Provides a summary of information available for technologies demonstrated to be effective for treatment of radioactively contaminated media. Available online at: https://www.epa.gov/sites/default/files/2015-05/documents/402-r-06-003.pdf.
- EPA's Technical Report for the Demonstration of Wide Area Radiological Decontamination and Mitigation Technologies for Building Structures and Vehicles. Provides a summary of five wide-area radiological decontamination technologies (including strippable coatings, gels, and chemical foam technologies) demonstrated on an urban building**. Available Online at:** https://cfpub.epa.gov/si/si_public_file_download.cfm?p_download_id=529008&Lab=NHSRC.
- *EPA's Waste Management Tool Kit.* Decision Support Tools for Waste Management includes an extensive list of tools, identifies a location to download software, and provides further information on the tool kit's purpose and applicability. Includes WMP, I-WASTE, WEST, and Waste Storage and Staging Tool. Available online at:

https://www.epa.gov/emergency-response-research/decision-support-tools-waste-management.

- *Brookhaven National Laboratory, Decontamination Technologies Task 3: Urban Remediation and Response Project.* Provides an overview of the decontamination technologies that could be used to remediate areas and/or reduce waste disposal. This document was developed with RDD impacts in-mind. Available online at: https://www.bnl.gov/isd/documents/45491.pdf
- *Interstate Technology & Regulatory Council (ITRC), Decontamination and Decommissioning of Radiologically Contaminated Facilities*. Overview of the process, regulatory framework, costs, technologies, and health and safety considerations. Provides case studies of past decontamination efforts. Available online at: https://connect.itrcweb.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=2a9bed64-15d2-4c53-8f2d-1d5100e5fc89.
- *DOE Standard Operating Procedure for Demolition of Facilities in Area IV at the Santa Susana Field Laboratory.* A description of the process and procedure that would be used to demolish the DOE structures in an area of the Santa Susana Field Laboratory and manage disposal of materials generated by the removal of these structures.
- *WM Symposia*. A non-profit organization that annually sponsors an international conference on education and opportunity in radwaste management. Publishes conference proceedings, including the latest available techniques and technologies on decommissioning. Available online at: https://www.wmsym.org/.

Annex E: Radiological Software Tools

Software Tools for Radiological Recovery

CBRNResponder or RadResponder | Focus Area 1 | Collection/Mapping Tool

- CBRN Responder: https://www.cbrnresponder.net/
- RadResponder: https://www.radresponder.net/
- A single, secure platform sponsored by FEMA for all chemical, biological, radiological, and nuclear (CBRN) incident data sharing and multi-hazard event management.
- Serves as a hub and one-stop shop for all-hazard planning, preparedness, communication, and operational tools and resources.

VSP | Focus Areas 1 & 6 | Collection/Mapping Tool

- https://www.pnnl.gov/projects/visual-sample-plan
- Visual Sample Plan (VSP) has been developed by Pacific Northwest National Laboratory since 1997 with support from the U.S. Department of Energy (DOE), U.S. Environmental Protection Agency, U.S. Nuclear Regulatory Commission, and other government agencies.
- Windows desktop software tool for developing statistically defensible sampling plans and performing statistical analysis.
- Designed to answer how many samples or measurements should be taken, where they should be located, and what the resulting confidence in the decision is.
- Mapping and visualization of samples and data results.
- Implements statistical methods from MARSSIM and EPA's QA/G-4 guidance.

TurboFRMAC | Focus Area 2 | Radiation Protection Tool

- https://nirp.sandia.gov/Software/TurboFRMAC/TurboFRMAC.aspx
- The Federal Radiological Monitoring and Assessment Center (FRMAC) is a federal asset and interagency organization available on request by the Department of Homeland Security (DHS) to respond to nuclear and radiological incidents as described in the National Response Framework (NRF).

- TurboFRMAC is an analysis tool that quickly performs complex calculations to assess impacts to the public, workers, and the food supply from radiological hazards during an emergency response. It covers radiological incidents such as:
    - Radiological Dispersal Devices (RDDs),
    - Nuclear Power Plant Emergencies,
    - Fuel Handling Accidents,
    - Transportation Accidents, and
    - Nuclear Detonations.

RESRAD | Focus Area 2 | Radiation Protection Tool

- https://ramp.nrc-gateway.gov/codes/resrad
- Analyzes potential human and biota radiation exposures from environmental contamination. Evaluates radiation exposure and associated risks using pathway analysis. Derives cleanup criteria or authorized limits for radionuclide concentrations in the contaminated source media.

Radiation Protection Computer Code Analysis and Maintenance Program (RAMP) | Focus Area 2 | Radiation Protection Tool

- https://ramp.nrc-gateway.gov/
- RAMP = Radiation Protection Computer Code Analysis and Maintenance Program
- D develops, maintains, improves, distributes, and provides training on NRC-sponsored radiation protection and dose assessment codes. These codes calculate dose for environmental assessment, nuclear power plant licensing, emergency response, atmospheric assessment, and other dose assessment scenarios. The research mission is to develop technical bases to support regulatory decisions and ensure the code reflects International Regulations and Guidance documents.

Radiological Emergency Medical Management (REMM) | Focus Areas 2 & 5 | Interactive Clinical Tool

- https://remm.hhs.gov
- https://remm.hhs.gov/interactivetools.htm
- Provide just-in-time, evidence-based, usable information with sufficient background and context to make complex issues understandable to those without formal radiation medicine expertise.

- Includes resources, tools, and a REMM application for smartphones.

CRC Drill Toolkit, CRC-SimPLER, & 'This is a T.E.S.T. CRC' | Focus Area 5 | Community Reception Center Tool

- CRC Drill Toolkit website: https://www.cdc.gov/nceh/radiation/emergencies/crc/crctoolkit.htm
- CRC SimPLER website: https://ephtracking.cdc.gov/Applications/simPler/crc/home
- 'This is a T.E.S.T. CRC' website: https://www.cdc.gov/nceh/radiation/emergencies/training/crctest.htm
- CRC Drill Toolkit, CRC-SimPLER, and 'This is a T.E.S.T. CRC' were made by the Centers for Disease Control and Prevention (CDC).
- Planning and simulation tools for setting up CRCs for radiological emergencies during training or incidents:
    - Use your existing resources to identify bottlenecks and areas that could benefit from more resources
    - Information on studies of removal of radioactive contamination from various surfaces.

Radiation Decontamination Query Tool | Focus Area 7 | Remediation Tool

- https://www.epa.gov/emergency-response-research/radiological-decontamination-query-tool
- EPA tool that provides information on studies of removal of radioactive contamination from various surfaces.

Preliminary Remediation Goals (PRG) and Calculator | Focus Area 7 | Remediation Tool

- https://epa-prgs.ornl.gov/cgi-bin/radionuclides/rprg_search/ (can be downloaded too)
- EPA's Preliminary Remediation Goals for Radionuclide Contaminants at Superfund Sites Calculator
    - PRGs are risk-based, conservative screening values
- Recommended preliminary remediation goals (PRGs) are calculated on this website. PRGs are for contaminated soil, water, and air.

Rad Decon (in RadResponder) | Focus Area 7 | Radiation Decontamination Tool

- Website for the tool requires a RadResponder login for access (see https://www.radresponder.net/#resources/tools/index)
- Rad Decon tool was developed by DHS S&T and the EPA; FEMA adopted the Rad Decon tool into the RadResponder system in January 2018.
- Rad Decon tool is a "decision support" tool meant to provide a common basis of information for executive decision makers and subject matter experts. Guides users through setting parameters and priorities based on the conditions of a specific radiological event to prioritize decontamination strategies. Provides a list of possible solutions based on these common reference points.
- Toolis more associated with the early phase rather than the late phase of recovery.

Radiological Recovery Logistics Tool (RRLT) | Focus Area 7 | Remediation Tool

- Website for the tool is in production at the time of this report (July 2022)
- https://www.epa.gov/sites/default/files/2020-02/documents/kaminski_radiological_recovery_logistics_tool_epa_decon_2019_posterv2.pdf contains an overview of what the tool can do and why it is important
- Can be used during the response and recovery from a radiological or nuclear incident to effectively allocate appropriate commercial and public works equipment to mitigate, remove, and contain radiological contamination.

Waste Management Tool Kit | Focus Area 8 | Waste Tool

- https://www.epa.gov/emergency-response-research/decision-support-tools-waste-management
- EPA's Decision Support Tools for Waste Management includes an extensive list of tools, location to download software, with further information on the purpose and applicability
- Includes WMP, I-WASTE, WEST, and Waste Storage and Staging Tool (further information below)

Waste Management Planning (WMP) | Focus Area 8 | Waste Planning Tool

- https://wasteplan.epa.gov/
- Provided by the EPA to address the management of waste generated by all hazards, including nuclear incidents to terrorist attacks involving radiological agents.

Waste Estimation Support Tool (WEST) | Focus Area 8 & Annex B | Waste Estimation Tool

- https://www.epa.gov/emergency-response-research/waste-estimation-support-tool-west
- Designed to aid in estimating waste generated from remediation and cleanup activities following a radiological or biological incident. Website states that it is important for users have experience with geographic information systems (GIS), FEMA's Hazus-MH, and Microsoft Excel

Incident Waste Decision Support Tool (I-WASTE) | Focus Area 8 & Annex B |Waste Handling &, Transport

- https://iwaste.epa.gov/guidance
- Web based decision support tool that organizes information related to managing waste resulting from terrorist attacks and other emergencies
- Provides planners information on how to handle, transport, treat, and dispose of contaminated waste and debris.
- I-Waste includes a waste volume calculator

Waste Storage and Staging Tool | Focus Area 8 & Annex B | Waste Tool

- Available through https://github.com/USEPA/Waste_Staging_Tool
- Used to identify potential waste staging areas and storage sites
    - Conducts suitability analyses to determine implicating factors
    - (i.e., environments to avoid) and favorable characteristics
    - (i.e., certain topographic features and transportation-related infrastructure)

Annex F: Medical Resources

Table 33: Medical Care Resources

Resource	Source	Description	Link
Disaster Medical Assistance Team (DMAT)	HHS	DMATs are staffed with medical professionals who provide expert patient care. DMAT members include advanced practice clinicians (nurse practitioners/physician assistants), physicians, registered nurses, respiratory therapists, paramedics, pharmacists, safety specialists, logistical specialists, information technologists, and communication and administrative specialists.	www.phe.gov/Preparedness/responders/ndms/ndms-teams/Pages/dmat.aspx

Resource	Source	Description	Link
Emergency Radiation Medicine Response Pocket Guide	Armed Forces Radiobiology Research Institute (AFRRI)	Two-page document that includes a flow chart for radiation patient treatment, a table of ARS survivability (including phases), a brief table of symptom clusters, and brief descriptions of case confirmation, treatment considerations, decontamination considerations, reporting, understanding radiation exposure, and diagnosis.	afrri.usuhs.edu/sites/default/files/2020-07/afrri-pocket-guide.pdf

Resource	Source	Description	Link
Find a Burn Center	Private (American Burn Association)	An expert referral center for burn patients. Telemedicine consults may be available.	https://ameriburn.org/resources/find-a-burn-center/
Medical Management of Radiological Casualties	AFRRI	Succinctly describes emergency biodosimetry, ARS, medical management of skin injury, medical management of internally deposited radionuclides, other injuries from nuclear weapons, psychological support, delayed effect, decontamination techniques, etc.	afrri.usuhs.edu/sites/default/files/2020-07/4edmmrchandbook.pdf

Resource	Source	Description	Link
Medical Reserve Corps (MRC)	HHS Administration for Strategic Preparedness and Response (ASPR)	A national network of more than 200,000 volunteers, organized locally to improve the health and safety of their communities. Jurisdictions are responsible for organizing and managing their MRC cadre, unlike DMAT which is managed at the federal level.	https://aspr.hhs.gov/MRC/Pages/index.aspx
Protective Action Guide Manual	EPA	Radiation dose guidelines that would trigger public safety measures, such as evacuation or staying indoors, to minimize or prevent radiation exposure during an emergency.	https://www.epa.gov/radiation/protective-action-guides-pags
Radiation Emergencies	CDC	A collection of resources tailored to various audiences, including clinicians, public health professionals, laboratorians, etc. Clinician resources focus on patient management, PPE, triage, decontamination, ARS, internal contamination, cutaneous radiation syndrome (CRS), and countermeasure guidance.	www.cdc.gov/nceh/radiation/emergencies/index.htm?CDC_AA_refVal=https%3A%2F%2Femergency.cdc.g
Radiation Emergency Assistance Center/Training Site (REAC/TS)	DOE	Provides emergency response and subject matter expertise on medical management of radiation incidents. Also provides continuing medical education, outreach exercises, clinical information, and training opportunities. Also maintains a collection of radiation emergency medicine resources that support the medical response to radiological/nuclear incidents and the treatment of individuals injured by ionizing radiation. Includes dose estimation procedures, radiation countermeasure information, PPE guidance, and other information specifically for medical professionals.	orise.orau.gov/reacts
Radiation Injury Treatment Network (RITN)	Private Sector	Network of hospitals and medical providers with specific capabilities in treating radiation injuries. The RITN also provides training resources, adult and pediatric medical treatment recommendations, and medical referral assessment for ARS patients.	www.RITN.net

Resource	Source	Description	Link
Radiation Sickness	Mayo Clinic	Briefly and succinctly describes symptoms, diagnosis, and treatment of radiation sickness.	www.mayoclinic.org/diseases-conditions/radiation-sickness/diagnosis-treatment/drc-20377061
Radiation Treatment Injury Network (RITN)	Private	A consortium of US hospitals preparing for the medical surge resulting from a radiological incident. RITN hospitals prepare to provide specialized care to patients with Acute Radiation Syndrome (ARS) following a mass casualty radiological incident. RITN expertise is for “radiation only” injuries - trauma patients should be sent to other NDMS hospitals	ritn.net/treatment
REMM	HHS	An extensive tool for medical management during radiological incidents, REMM describes patient management, initial incident activities, management modifiers (based on injuries and medical needs), practical guidance (including use of blood products, decontamination procedures,and population monitoring), etc. Includes resources tailored to specific audiences, such as first responders, mental health professionals, hospital staff, etc. Additionally, most REMM information can be downloaded for use offline, during trainings and response.	remm.hhs.gov/index.html
Strategic National Stockpile	HHS ASPR	A federal cache of MCMs and supplies that can be accessed and deployed for large public health disasters.	https://aspr.hhs.gov/SNS/Pages/default.aspx
Topic Collection: Radiological and Nuclear	HHS ASPR	A collection of medical radiological and nuclear guidance and related research articles.	https://asprtracie.hhs.gov/technical-resources/32/radiological-and-nuclear/27

Table 34: Mortuary Examiner/Coroner Resources

Resource	Source	Description	Link
Disaster Mortuary Operational Response Teams(DMORT)	HHS	DMORTs provide technical assistance and consultation on fatalitymanagement and mortuary affairs. DMORTs can: ▪ track and document human remains and personal effects ▪ establish temporary morgue facilities ▪ assist with determination of cause and manner of death ▪ collect victim medical records, dental records, or DNA from next of kin for victim identification ▪ perform postmortem data collection ▪ document field retrieval and morgue operations ▪ perform forensic dental pathology and anthropology operations ▪ process and re-inter disinterred remains	www.phe.gov/Preparedness/responders/ndms/ndms-teams/Pages/dmort.aspx
Guidelines for Handling Decedents Contaminated with RadioactiveMaterials	CDC	Procedures and guidance focused on handling radioactive remains. Includes scenario-specific guidelines, addressing nuclear detonation scenarios, radiological dispersal devices (RDD) scenario, and radioactive sources in public places. Discusses relevant instruments, protective precautions for medical examiners/coroners on-scene, morgue procedures, autopsy and funeral home guidance, transportation guidance, etc.	www.cdc.gov/nceh

Resource	Source	Description	Link
Management of Dead Bodies after Disasters: A Field Manual for First Responders	PAHO, WHO, ICRC, IFRC[85]	Provides practical, easy-to-follow guidelines for first responder to promote dignified and proper management of dead bodies and facilitate their identification.	www.paho.org/disasters/dmdocuments/DeadBodiesFieldManual-2ndEd.pdf
Medical Examiner/ Coroner's Guide for Contaminated Deceased Body Management	American Journal of Forensic Medicine and Pathology	Provides information and suggestions for decontamination procedures; specifically developed for ME/C audience.	pubmed.ncbi.nlm.nih.gov/19901816
Model Procedure for Medical Examiner/ Coroner on the Handling of a Body/Human Remains that are Potentially Radiologically Contaminated	Transportation Emergency Preparedness Program (TEPP)	Identifies precautions and provides guidance for ME/Cs in handling body or human remains that are potentially contaminated with radioactive material from a transportation incident involving radioactive material.	www.hsdl.org/?view&did=764068
NCRP Report No. 161	National Council on Radiation Protection and Measurements (NCRP)	Offers guidance on handling persons contaminated with radionuclides.	ncrponline.org/publications/reports/ncrp-report-161

[85] Pan-American Health Organization (PAHO), World Health Organization (WHO), International Committee of the Red Cross (ICRC), International Federation of Red Cross and Red Crescent Societies (IFRC)

Resource	Source	Description	Link
Victim Information Center (VIC) Teams	HHS	VIC teams provide technical assistance for collection and management of postmortem data and related issues. VIC teams can: ▪ collect dental records, medical records, DNA, and other postmortem data ▪ provide subject matter expertise regarding mass fatality management and victim information procurement ▪ train partners to gather victim identification information from family interviews ▪ coordinate with FSLTT law enforcement ▪ gather data to facilitate victim identification ▪ manage the missing persons list ▪ update the Victim Identification Program (VIP) database ▪ coordinate the release of remains	www.phe.gov/Preparedness/responders/ndms/ndms-teams/Pages/vic.aspx

Annex G: Acronyms

ADA	Americans with Disabilities Act
AFRRI	Armed Forces Radiobiology Research Institute
ALARA	As Low As Reasonably Achievable
AMS	Aerial Measuring System
ARS	Acute Radiation Syndrome
ASPECT	Airborne Spectral Photometric Environmental Collection Technology
ASPR	Administration for Strategic Preparedness and Response
ATSDR	Agency for Toxic Substances and Disease Registry
CAM	Continuous Air Monitor
CBRN	Chemical, Biological, Radiological, and Nuclear
CDC	Centers for Disease Control and Prevention
CEDS	Comprehensive Economic Development Strategy
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CFR	Code of Federal Regulations
CI	Critical Infrastructure
CISA	Cybersecurity and Infrastructure Security Agency
CMHT	Consequence Management Home Team
CMRT	Consequence Management Response Team
CRC	Community Reception Center
CRC-STEP	Community Reception Center Simulation Tool for Evaluation and Planning
CRCPD	Conference of Radiation Control Program Directors
CRS	Cutaneous Radiation Syndrome

CST	Civil Support Team
DCGL	Derived Concentration Guideline Level
DHS	U.S. Department of Homeland Security
DMAT	Disaster Medical Assistance Team
DMORT	Disaster Mortuary Operational Response Teams
DOE	Department of Energy
DOT	Department of Transportation
D-SNAP	Disaster Supplemental Nutrition Assistance Program
DQA	Data Quality Assessment
DRZ	Dangerous Radiation Zone
DTRA	Defense Threat Reduction Agency
EAS	Emergency Alert System
EMAC	Emergency Management Assistance Compact
EMP	Electromagnetic Pulse
EMS	Emergency Medical Services
EOC	Emergency Operations Center
EPA	Environmental Protection Agency
ERTU	FBI Evidence Response Team Unit
FAQ	Frequently Asked Questions
FBI	Federal Bureau of Investigation
FCO	Federal Coordinating Officer
FDRC	Federal Disaster Recovery Coordinator
FEMA	Federal Emergency Management Agency
FERN	Food Emergency Response Network

FIOP	Federal Interagency Operational Plan for Response and Recovery
FRMAC	Federal Radiological Monitoring and Assessment Center
FSLTT	Federal, State, Local, Tribal, and Territorial
GIS	Geographic Information Systems
GM	Geiger Mueller
GPS	Global Positioning System
HASP	Health and Safety Plan
HAZMAT	Hazardous Material
HAZWOPER	Hazardous Waste Operations and Emergency Response
HEPA	High Efficiency Particulate Air
HERT	Hazardous Evidence Response Team
HHS	Department of Health and Human Services
HVAC	Heating, Ventilation and Air Conditioning Systems.
HZ	Hot Zone
IAEA	International Atomic Energy Agency
IAPPG	Individual Assistance Program and Policy Guide
ICRC	International Committee of the Rd Cross
ICRP	International Commission on Radiological Protection
ICS	Incident Command System
IFRC	International Federation of Red Cross and Red Crescent Societies
IMAAC	Interagency Modeling and Atmospheric Assessment Center
IND	Improvised Nuclear Device
IPAWS	Integrated Public Alert and Warning System
IT	Information Technology

ITRC	Interstate Technology & Regulatory Council
JIC	Joint Information Center
LDRM	Local Disaster Recovery Manager
LLRW	Low-Level Radioactive Waste
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
ME	Medical Examiner
MERS	Mobile Emergency Response Support
MRC	Medical Reserve Corps
NAREL	National Analytical Radiation Environmental Laboratory
NCRFO	National Center for Radiation Field Operations
NCRP	National Council on Radiation Protection and Measurements
NDA	National Defense Area
NDMS	National Disaster Medical System
NDRF	National Disaster Recovery Framework
NIMS	National Incident Management System
NNSA	National Nuclear Security Administration
NNSS	Nevada National Security Site
NRC	Nuclear Regulatory Commission
NRF	National Response Framework
NRIA	Nuclear Radiological Incident Annex
NSA	National Security Area
NUSTL	National Urban Security Technology Laboratory
NYC	New York City
ORNL	Oak Ridge National Laboratory

OSWER	Office of Solid Waste and Emergency Response
PAG	Protective Action Guidance
PAHO	Pan-American Health Organization
PAS	Post-Disaster Recovery and Reconstruction
PCB	Polychlorinated biphenyl
PETS	Pets Evacuation and Transportation Standards Act of 2006
POV	Personally Owned Vehicle
PPE	Personal Protective Equipment
PRD	Personal Radiation Detector
PRG	Preliminary Remediation Goals for Radionuclides
PTSD	Post-Traumatic Stress Disorder
RAMP	Radiation Protection Computer Code Analysis and Maintenance Program
RAP	Radiological Assistance Program
RCRA	Resource Conservation and Recovery Act
RDD	Radiological Dispersal Device
REAC/TS	Radiation Emergency Assistance Center/Training Site
REMM	Radiation Emergency Medical Management
REP	Radiological Emergency Preparedness
RERT	Radiological Emergency Response Team
R-HASP	Radiation Health and Safety Plan
RHSO	Radiation Health and Safety Officer
RIID	Radionuclide Identification Device
RITN	Radiation Injury Treatment Network
RN	Radiological and Nuclear

ROSS	Radiological Operations Support Specialist
RRLT	Radiological Recovery Logistics Tool
RSF	Recovery Support Function
RSO	Radiation Safety Officer
SAP	Sampling and Analysis Plan
SDRC	State Disaster Recovery Coordinator
SIP	Shelter-in-Place
SLTT	State, Local, Tribal, and Territorial
SME	Subject Matter Expert
SNS	Strategic National Stockpile
TDRC	Tribal, or Territorial Disaster Recovery Coordinator
TEDE	Total Effective Dose Equivalent
TEPP	Transportation Emergency Preparedness Program
TWG	Technical Working Groups
UC	Unified Command
UK	United Kingdom of Great Britain and Northern Ireland
U.S.	United States
USDA	United States Department of Agriculture
VBIED	Vehicle-borne Improvised Explosive Device
VIC	Victim Information Center
VIP	Victim Identification Program
VOAD	Voluntary Organization Active in Disaster
VSP	Visual Sample Plan
WEA	Wireless Emergency Alert

WEST	RDD Waste Estimation Support Tool
WHO	World Health Organization
WMD	Weapons of Mass Destruction
WMP	Waste Management Planning